# SUBMISSION FOR PERMANENT RULE

**1. Rule-Making Agency: NC Building Code Council**

**2. Rule citation & name (name not required for repeal):**
2024 North Carolina Residential Code Chapters 1-10, 25-33, 45, 46 and Appendices (230314 Item B-4)

**3. Action:**
☐ **ADOPTION** ☒ **AMENDMENT** ☐ **REPEAL** ☐ **READOPTION** ☐ **REPEAL through READOPTION**

| **4. Rule exempt from RRC review?** | **5. Rule automatically subject to legislative review?** |
|---|---|
| ☐ **Yes. Cite authority:** | ☐ **Yes. Cite authority:** |
| ☒ **No** | ☒ **No** |

**6. Notice for Proposed Rule:**

☒ **Notice Required**
**Notice of Text published on:** May 15, 2023 in NC Register, April 24, 2023 agency website
**Link to Agency notice:** https://www.ncosfm.gov/codes/building-code-council-bcc/bcc-hearing-notices
**Hearing on:** June 13, 2023
**Adoption by Agency on:** September 12, 2023
☐ **Notice not required under G.S.:**
**Adoption by Agency on:**

**7. Rule establishes or increases a fee? (See G.S. 12-3.1)**

☐ **Yes**
**Agency submitted request for consultation on:**
**Consultation not required. Cite authority:**

☒ **No**

**8. Fiscal impact. Check all that apply.**

☐ **This Rule was part of a combined analysis.**

☐ **State funds affected**
☐ **Local funds affected**
☐ **Substantial economic impact (≥$1,000,000)**
☐ **Approved by OSBM**
☒ **No fiscal note required**

**9. REASON FOR ACTION**

**9A. What prompted this action? Check all that apply:**

☒ **Agency**
☐ **Court order / cite:**
☐ **Federal statute / cite:**
☐ **Federal regulation / cite:**
☐ **Legislation enacted by the General Assembly**
**Cite Session Law:**
☐ **Petition for rule-making**
☐ **Other:**

**9B. Explain:** ~~This amendment~~The 2018 NC Residential Code Chapters 1-10, 25-33, 45, 46 and Appendices is amended to create the 2024 NC Residential Code Chapters 1-10, 25-33, 45, 46 and Appendices and is proposed to protect the public by updating the code to current standards of practice.

The delayed effective date of this Rule is January 1, 2025.
The Statutory authority for Rule-making is G. S. 143-136; 143-138.

**10. Rulemaking Coordinator: David Bruce Rittlinger**
**David B. Rittlinger**
**Phone: (919)647-0008**
**E-Mail: david.rittlinger@ncdoi.gov**

**Additional agency contact, if any:**
**Phone:**
**E-Mail:**

**11. Signature of Agency Head* or Rule-making Coordinator:**

***If this function has been delegated (reassigned) pursuant to G.S. 143B-10(a), submit a copy of the delegation with this form.**
**Typed Name: David Bruce Rittlinger**
**Title: ~~(Interim) Deputy commissioner of Engineering~~Division Chief of Codes & Interpretations & Chief Code Consultant**

**RRC AND OAH USE ONLY**

**Action taken:**

☐ RRC extended period of review:
☐ RRC determined substantial changes:
☐ Withdrawn by agency
☐ Subject to Legislative Review
☐ Other:

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~~The 2021 International Residential Code can be viewed for free at the following link:~~
~~https://codes.iccsafe.org/content/IRC2021P2~~

~~Errata to the 2021 International Residential Code can be viewed for free at the following link:~~
~~https://www.iccsafe.org/wp-content/uploads/1659714279_2021-International-Residential-Code-Errata-Complete.pdf~~

~~Amendments to the 2018 North Carolina Residential Code can be viewed for free at the following link:~~
~~https://www.ncosfm.gov/2017-2023-approved-amendments-230314residential-code~~

~~Of note, North Carolina General Assembly Session Law 2023-108 prohibits the NCBCC from amending Chapters 11 through 24 of the North Carolina Residential Code. Those chapters remain unchanged and are not included is this permanent rule change petition.~~

## ~~THIS DOCUMENT CONTAINS PROPOSED NORTH CAROLINA AMENDMENTS TO THE 2021 EDITION OF THE INTERNTATIONAL RESIDENTIAL CODE (IRC) CHAPTERS 1-10, 25-33, 45, 46 AND APPENDICES FOR THE PURPOSE OF ESTABLISHING THE 2024 EDITION OF THE NORTH CAROLINA RESIDENTIAL CODE CHAPTERS 1-10, 25-33, 45, 46 AND APPENDICES.~~

**~~UNDERLINED TEXT INDICATE NORTH CAROLINA PROPOSED AMENDMENTS TO THE 2021 INTERNATIONAL RESIDENTIAL CODE CHAPTERS 1-10, 25-33, 45, 46 AND APPENDICES FOR THE 2024 NORTH CAROLINA RESIDENTIAL CODE CHAPTERS 1-10, 25-33, 45, 46 AND APPENDICES.~~**

~~STRUCKTHROUGH TEXT INDICATES IRC TEXT THAT IS PROPOSED TO BE REMOVED FROM THE 2024 NORTH CAROLINA RESIDENTIAL CODE CHAPTERS 1-10, 25-33, 45, 46 AND APPENDICES.~~

~~TEXT THAT IS HIGHLIGHTED IN YELLOW INDICATES PROPOSED NORTH CAROLINA AMENDMENTS THAT ARE NEW OR DIFFERRENT THAN THE 2018 NORTH CAROLINA RESIDENTIAL CODE CHAPTERS 1-10, 25-33, 45, 46 AND APPENDICES.~~

Documents included:
1. Formatted Review Aide and 2024 North Carolina Residential Code Chapters 1-10, 25-33, 45, 46 and Appendices*

TEXT THAT IS ~~STRUCKTHROUGH~~ IS DELETED FROM THE 2018 EDITION TO CREATE THE 2024 EDITION.
TEXT THAT IS UNDERLINED IS NEW TEXT TO CREATE THE 2024 EDITION.

*Of note, publishing edits to the Cover page, North Carolina Building Code Council members and committees lists, North Carolina Department of Insurance contact information, Preface, Table of Contents and Index are not included as those are publishing edits that do not contain permanent rule content. These publishing edits contain NCBCC and NCDOI contact information, instructions on how to use the code, and guidance on where to find information in the code for the public-at-large. Coordination of the correct page numbers tied to the Table of Contents and Index cannot be accurately completed until the first draft of publishing is completed for NCDOI-OSFM Engineering & Codes staff review prior to completion of publishing by the International Code Council. NCDOI-OSFM Engineering & Codes staff will be coordinating the publication of all these publishing edits with the International Code Council once the proposed 2024 North Carolina Building Codes are approved. Chapters 11 through 24 are unchanged from the 2018 NCRC per NC General Assembly Session Law 2023-108 that became law on 8/16/23. Chapters 11 through 24 are not included in this submission. Chapter 34 through Chapter 44 are unchanged from the 2018 NCRC and are not included in this submission

# SUBMISSION FOR PERMANENT RULE

2. Appendix C Code Change Proposal North Carolina Building Code Council (230314 Item B-4) 2024 North Carolina Residential Code Chapters 1-10, 25-33, 45, 46 and Appendices (File: B-4 2024 NCRC Chapters 1-10 and 25-33 and 45-46 and Appendices). A link to the petition can be found here: https://www.ncosfm.gov/news/events/building-code-council-meeting-march-14-2023

3. 2017-2023 Approved Amendments to the 2018 North Carolina Residential Code (File: 2017-2023 Approved Amendments 230314_Residential Code). A link to these amendments can be found here: https://www.ncosfm.gov/2017-2023-approved-amendments-230314residential-code

**(see attached documents)**

*Part I—Administrative*

# CHAPTER 1
# SCOPE AND ADMINISTRATION

## SECTION R101
## SCOPE AND GENERAL REQUIREMENTS

**R101.1 Title.** These provisions shall be known as the North Carolina Residential Code for One- and Two-family Dwellings and shall be cited as such and will be referred to herein as “this code.” These regulations were adopted by the North Carolina Building Code Council on ~~June 13, 2017~~September 12, 2023 to be effective January 1, ~~2019.~~ 2025. References to the International Codes shall mean the North Carolina Codes. The North Carolina Amendments to the International Codes are underlined.

**R101.2 Scope.** The provisions of ~~the International Residential Code for One- and Two-family Dwellings~~this code shall apply to the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, removal and demolition of one or more detached one- and two-family dwellings and townhouses located on a parcel and not more than three stories above grade plane in height with a separate means of egress and their accessory structures not more than three stories above grade plane in height. Single family dwellings otherwise permitted by this code shall include bed and breakfast homes.

~~**Exceptions:**~~**Exception:**

~~1.~~ Live/work units complying with the requirements of Section ~~419~~508.5 of the International Building Code shall be permitted to be built as one- and two- family dwellings or townhouses. Fire suppression required by Section ~~419.5~~508.5.7 of the International Building Code where constructed under the International Residential Code for One- and Two-family Dwellings shall conform to Section ~~P2904.~~P2904 of the International Residential Code for One- and Two-family Dwellings.

~~2. Deleted.~~

**R101.2.1 Accessory buildings.** Accessory buildings with any dimension greater than 12 feet (3658 mm) shall meet the provisions of this code. Accessory buildings are permitted to be constructed without a masonry or concrete foundation, except in coastal high hazard or ocean hazard areas, provided all of the following conditions are met:

1. The accessory building shall not exceed 400 square feet (37 m2) or one story in height;
2. The building is supported on a wood foundation of minimum 2-inch by 6-inch (51-mm by 152-mm) or 3-inch by 4-inch (76-mm by 102-mm) mudsill of approved wood in accordance with Section R317; ~~and~~
3. The building is anchored to resist overturning and sliding by installing a minimum of one ground anchor at each corner of the building. The total resisting force of the anchors shall be equal to 20 psf (958 Pa) times the plan area of the building.

**R101.2.2 Accessory structures.** Only the following accessory structures shall meet the provisions of this code.

1. Decks, see Appendix M,
2. Gazebos,
3. Retaining walls, see Section R404.4,
4. Detached masonry chimneys located less than 10 feet (3048 mm) from other buildings or lot lines,
5. Swimming pools and spas, see Appendix ~~V,~~NC-A,
6. Detached carports,

    **Exception:** Portable, lightweight carports not exceeding 400 square feet (37 m2) or 12 feet (3658 mm) mean roof height.

7. Docks, piers, bulkheads, and waterway structures, see Section ~~R327.~~R331.
8. Ground mounted photovoltaic system, see Section R324.7

**R101.3 Purpose**. The purpose of this code is to establish minimum requirements to ~~safeguard the public~~provide a reasonable level of safety, health and general welfare through affordability, structural strength, means of egress ~~facilities,~~ stability, sanitation, light and ventilation, energy conservation and safety to life and property from fire and other hazards attributed to the built environment.

## SECTION R102
## APPLICABILITY

**R102.1 General.** Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable. Where, in any specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern.

**R102.2 Other laws.** The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law.

**R102.3 Application of references.** References to chapter or section numbers, or to provisions not specifically identified by number, shall be construed to refer to such chapter, section or provision of this code.

**R102.4 Referenced codes and standards.** The codes and standards referenced in this code shall be considered part of the requirements of this code to the prescribed extent of each such ~~reference.~~reference and as further regulated in Sections R102.4.1 and R102.4.2.

**Exception:** Where enforcement of a code provision would violate the conditions of the *listing* of the *equipment* or *appliance*, the conditions of the *listing* and manufacturer's instructions shall apply.

**R102.4.1 Conflicts.** ~~Deleted.~~Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.

**R102.4.2 Provisions in referenced codes and standards.** ~~Deleted.~~Where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code, the provisions of this code, as applicable, shall take precedence over the provisions in the referenced code or standard.

**R102.5 Appendices.** Provisions in the appendices shall not apply unless specifically referenced in the code text.

**R102.6 Partial invalidity.** In the event any part or provision of this code is held to be illegal or void, this shall not have the effect of making void or illegal any of the other parts or provisions.

**R102.7 Existing structures.** For requirements of existing structures, refer to the *North Carolina Administrative Code and Policies* and the *North Carolina Existing Building Code*.

**R102.7.1 Additions, alterations or repairs.** Additions, alterations or repairs to any structure shall conform to the requirements for a new structure without requiring the existing structure to comply with the requirements of this code, unless otherwise stated. Additions, alterations, repairs and relocations shall not cause an existing structure to become ~~unsafe or adversely affect the performance of the building.~~less compliant with the provisions of this code than the existing building or structure was prior to the addition, alteration or repair. Where the alteration causes the use or occupancy to be changed to one not within the scope of this code, the provisions of the International Existing Building Code shall apply.

## PART 2—ADMINISTRATION AND ENFORCEMENT

See the North Carolina Administrative Code and Policies for the administration and enforcement of the North Carolina State Building Codes as adopted by the Building Code Council and enforced by State and local code enforcement officials.

### ~~SECTION R103~~
### ~~DEPARTMENT OF BUILDING SAFETY~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

### ~~SECTION R104~~
### ~~DUTIES AND POWERS OF THE BUILDING OFFICIAL~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

### ~~SECTION R105~~
### ~~PERMITS~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

### ~~SECTION R106~~
### ~~CONSTRUCTION DOCUMENTS~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

### ~~SECTION R107~~
### ~~TEMPORARY STRUCTURES AND USES~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

### ~~SECTION R108~~
### ~~FEES~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

### ~~SECTION R109~~
### ~~INSPECTIONS~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

### ~~SECTION R110~~
### ~~CERTIFICATE OF OCCUPANCY~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

### ~~SECTION R111~~
### ~~SERVICE UTILITIES~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

## ~~SECTION R112~~
## ~~BOARD OF APPEALS~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

## ~~SECTION R113~~
## ~~VIOLATIONS~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

## ~~SECTION R114~~
## ~~STOP WORK ORDER~~

~~Deleted. See the *North Carolina Administrative Code and Policies*.~~

# CHAPTER 2
# DEFINITIONS

~~*Definitions in this chapter preceded by a bracketed letter correlate with the chapters for Energy [RE], Plumbing [RP], Fuel Gas [RG], and Mechanical [RM] of this code. Definitions that are not preceded by a bracket are general definitions utilized throughout this code.*~~

## SECTION R201
## GENERAL

**R201.1 Scope.** Unless otherwise expressly stated, the following words and terms shall, for the purposes of this code, have the meanings indicated in this chapter.

**R201.2 Interchangeability.** Words used in the present tense include the future; words in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural, the singular.

**R201.3 Terms defined in other codes.** Where terms are not defined in this code such terms shall have the meanings ascribed in other code publications of the ~~North Carolina Building~~ International Code Council.

**R201.4 Terms not defined.** Where terms are not defined through the methods authorized by this section, such terms shall have ordinarily accepted meanings such as the context implies.

## SECTION R202
## DEFINITIONS

**[RE] ABOVE-GRADE WALL.** A wall more than 50 percent above grade and enclosing *conditioned space*. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RP] ACCEPTED ENGINEERING PRACTICE.** Practice that conforms to accepted principles, tests or standards of nationally recognized technical or scientific authorities.

**[RP] ACCESS COVER.** A removable plate, usually secured by bolts or screws, to permit access to a pipe or pipe fitting for the purposes of inspection, repair or cleaning.

**[RB] ACCESS (TO).** That which enables a device, an *appliance* or equipment to be reached by *ready access* or by a means that first requires the removal or movement of a panel, door or similar obstruction.

**[RE] ACCESSIBLE.** Signifies access that requires the removal of an access panel or similar removable obstruction. For energy purposes, *accessible* means admitting close approach as a result of not being guarded by locked doors, elevation or other effective means (see "*accessible, readily*").

**ACCESSORY BUILDING.** ~~In one- and two-family *dwellings* not more than three stories *above grade plane* in height with a separate means of egress, a building, the use of which is incidental to that of the main building and that is detached and located on the same lot. An accessory building is a building that is roofed over and more than 50 percent of its exterior walls are enclosed. Examples of accessory buildings are garages, storage buildings, workshops, boat houses, treehouses, and similar structures.~~ A building that does not contain a sleeping room, the use of which is ~~accessoryincidental~~appurtenant to that of the dwelling, that is detached and located on the same lot as the dwelling and is roofed over with more than 50 percent of its exterior walls enclosed.

~~**ACCESSIBLE, READILY.** Signifies access without the necessity for removing a panel or similar obstruction.~~

**[RB] ACCESSORY STRUCTURE.** A detached structure that is ~~accessoryincidental~~appurtenant to the dwelling and not defined as an *accessory building*. Examples of accessory structures are fencing, decks, gazebos, arbors, retaining walls, barbecue pits, detached chimneys, playground equipment, yard art, *docks, piers*, etc.

~~**[RE] ACH50.** Air changes per hour of measured airflow in relation to the building volume while the building is maintained at a pressure difference of 50 Pascals.~~

**[RP] ADAPTER FITTING.** An *approved* connecting device that suitably and properly joins or adjusts pipes and fittings that do not otherwise fit together**.**

**[RB] ADDITION.** An extension or increase in floor ~~area~~area, number of stories or height of a building or structure. For energy purposes, an extension or increase in the *conditioned space* floor area or height of a building or structure. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] ADHERED STONE OR MASONRY VENEER.** Stone or masonry veneer secured and supported through the adhesion of an *approved* bonding material applied to an *approved* backing.

**[MP] AIR ADMITTANCE VALVE.** A one-way valve designed to allow air into the plumbing drainage system where a negative pressure develops in the piping. This device shall close by gravity and seal the terminal under conditions of zero differential pressure (no flow conditions) and under positive internal pressure. The purpose of an air admittance valve is to provide a method of allowing air to enter the plumbing drainage system without the use of a vent extended to open air and to prevent *sewer* gases from escaping into a building.

~~**[RE] AIR BARRIER.** For the definition applicable in Chapter 11, see Section N1101.6.~~

~~**[RE] AIR BARRIER MATERIAL.** Material(s) that have an air permeability not to exceed 0.004 cfm/ft2 under a pressure differential of 0.3 in. water (1.57 psf) (0.02 L/s.m2@75 Pa) when tested in accordance with ASTM E2178.~~
~~**[RE] AIR BARRIER SYSTEM.** Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier is a combination of *air barrier materials* and sealants.~~

**[MP] AIR BREAK (DRAINAGE SYSTEM).** An arrangement where a discharge pipe from a fixture, *appliance* or device drains indirectly into a receptor below the flood-level rim of the receptor and above the trap seal.

**[MP] AIR CIRCULATION, FORCED.** A means of providing space conditioning utilizing movement of air through ducts or plenums by mechanical means.

**[RG] AIR CONDITIONER, GAS-FIRED.** A gas-burning, automatically operated *appliance* for supplying cooled air, ~~and/or~~ dehumidified ~~air~~ air, or both chilled liquid.

**[RG] AIR CONDITIONING.** The treatment of air so as to control simultaneously the temperature, humidity, cleanness and distribution of the air to meet the requirements of a *conditioned space*.

**[MP] AIR-CONDITIONING SYSTEM.** A system that consists of heat exchangers, blowers, filters, supply, exhaust and return-air systems, and shall include any apparatus installed in connection therewith.

**[RG] AIR, EXHAUST.** Air being removed from any space or piece of *equipment* or *appliance* and conveyed directly to the atmosphere by means of openings or ducts. Relief air is classified as exhaust air.

**[MP] AIR GAP, DRAINAGE SYSTEM.** The unobstructed vertical distance through free atmosphere between the outlet of a waste pipe and the flood-level rim of the fixture or receptor into which it is discharging.

**[MP] AIR GAP, WATER-DISTRIBUTION SYSTEM.** The unobstructed vertical distance through free atmosphere between the lowest opening from a water supply discharge to the flood-level rim of a plumbing fixture.

**[RG] AIR-HANDLING UNIT.** A blower or fan used for the purpose of distributing supply air to a room, space or area.

**[RB] AIR-IMPERMEABLE INSULATION.** An insulation having an air permanence equal to or less than 0.02 L/s-m2 at 75 Pa pressure differential ~~as~~ tested ~~in accordance~~ with ASTM E2178 or E283 at the thickness applied.

**[RG] AIR, MAKEUP.** Any combination of outdoor and transfer air intended to replace exhaust air and exfiltration.

**[RM] AIR, OUTDOOR.** Ambient air that enters a building through a ventilation system, through intentional openings for natural ventilation, or by infiltration.

**[RM] AIR, TRANSFER.** Air moved from one indoor space to another.

**[RB] ALTERATION.** Any construction or renovation to an existing structure other than repair or addition that requires a permit. Also, a change in a building, electrical, gas, mechanical or plumbing system that involves an extension, addition or change to the arrangement, type or purpose of the original installation that requires a permit. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RP] ALTERNATE ON-SITE NON-POTABLE WATER.** Non-potable water from other than public utilities, on-site surface sources and subsurface natural freshwater sources. Examples of such water are gray water, on-site reclaimed water, collected rainwater, captured condensate and rejected water from reverse osmosis systems.

**[RP] ALTERNATIVE ENGINEERED DESIGN.** A plumbing system that performs in accordance with the intent of Chapters 29 through 33 and provides an equivalent level of performance for the protection of public health, safety and welfare. The system design is not specifically regulated by Chapters 29 through 33.

**[RB] ALTERNATING TREAD DEVICE.** A device that has a series of steps between 50 and 70 degrees (0.87 and 1.22 rad) from horizontal, usually attached to a center support rail in an alternating manner so that the user does not have both feet on the same level at the same time.

**[RB] ANCHORED STONE OR MASONRY VENEER.** Stone or masonry veneer secured with *approved* mechanical fasteners to an *approved* backing.

**[MP] ANCHORS.** See "*Supports*."

**[RG] ANODELESS RISER.** A transition assembly in which plastic *piping* is installed and terminated above ground outside of a building.

**[MP] ANTISIPHON.** A term applied to valves or mechanical devices that eliminate siphonage.

**[MP] APPLIANCE.** A device or apparatus that is manufactured and designed to utilize energy and for which this code provides specific requirements.

**[RG] APPLIANCE, AUTOMATICALLY CONTROLLED.** Appliances equipped with an automatic *burner* ignition and safety shut-off device and other automatic devices, ~~which~~ that accomplish complete turn-on and shut-off of the gas to the *main burner* or *burners*, and graduate the gas supply to the *burner* or *burners*, but do not affect complete shut-off of the gas.

**[RG] APPLIANCE, FAN-ASSISTED COMBUSTION.** An *appliance* equipped with an integral mechanical means to either draw or force products of combustion through the combustion chamber or heat exchanger.

**[RG] APPLIANCE, UNVENTED.** An *appliance* designed or installed in such a manner that the products of combustion are not conveyed by a vent or *chimney* directly to the outside atmosphere.

**[RG] APPLIANCE, VENTED.** An *appliance* designed and installed in such a manner that all of the products of combustion are conveyed directly from the *appliance* to the outside atmosphere through an *approved chimney* or vent system.

**[RB] APPROVED.** Acceptable to the ~~code~~ *building official*.

**[RB] APPROVED AGENCY.** An established and recognized agency that is regularly engaged in conducting tests, furnishing inspection services or furnishing product certification, and has been *approved* by the building official.

**[MP] APPROVED SOURCE.** An independent person, firm or corporation, *approved* by the *building official*, who is competent and experienced in the application of engineering principles to materials, methods or systems analyses.

**[RP] AREA DRAIN**. A receptacle designed to collect surface or storm water from an open area.

**[RB] ASPECT RATIO.** The ratio of longest to shortest perpendicular dimensions, or for wall sections, the ratio of height to length.

**[RP] ASPIRATOR**. A fitting or device supplied with water or other fluid under positive pressure that passes through an integral orifice or constriction, causing a vacuum. Aspirators are also referred to as suction apparatus, and are similar in operation to an ejector.

**[RG] ATMOSPHERIC PRESSURE.** The pressure of the weight of air and water vapor on the surface of the earth, approximately 14.7 pounds per square inch (psia) (101 kPa absolute) at sea level.

**[RB] ATTIC.** The unfinished space between the ceiling assembly and the *roof assembly*.

**[RB] ATTIC, HABITABLE.** A finished or unfinished habitable space within an attic. ~~attic area meeting the definition of *habitable space* and complying with all of the following requirements:~~

~~1. The occupiable floor area is not less than 70 square feet (6.5 m$^2$), in accordance with Section R304.~~

~~2. The occupiable floor area has a ceiling height in accordance with Section R305.~~

~~3. The occupiable space is enclosed by the roof assembly above, knee walls (if applicable) on the sides and the floor-ceiling assembly below.~~

**ATTIC STORAGE.** A floored area, regardless of size, within an attic space that is served by an attic access.

**Exception:** A floor walkway not less than 24 inches (610 mm) wide or greater than 48 inches (1219 mm) wide that serves as an access for the service of utilities or equipment, and a level service space not less than 30 inches

(762 mm) deep or greater than 48 inches (1219 mm) deep and not less than 30 inches (762 mm) wide or greater than 48 inches (1219 mm) wide at the front or service side of the appliance, shall not be considered as attic storage.

Such floored area shall be labeled at the attic access opening, "NOT FOR STORAGE." The lettering shall be a minimum of 2 inches (51 mm) in height.

**[RE] AUTOMATIC.** Self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current strength, pressure, temperature or mechanical configuration (see "Manual"). ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RG] AUTOMATIC IGNITION.** Ignition of gas at the *burner(s)* when the gas controlling device is turned on, including reignition if the flames on the *burner(s)* have been extinguished by means other than by the closing of the gas controlling device.

**[RP] BACKFLOW CONNECTION.** Any arrangement whereby backflow is possible.

**[MP] BACKFLOW, DRAINAGE.** A reversal of flow in the drainage system.

**[MP] BACKFLOW PREVENTER.** A backflow prevention assembly, a backflow prevention device or other means or method to prevent backflow into the potable water supply.

**[MP] BACKFLOW PREVENTER, REDUCED-PRESSURE-ZONE TYPE.** A backflow-prevention device consisting of two independently acting check valves, internally force loaded to a normally closed position and separated by an intermediate chamber (or zone) in which there is an automatic relief means of venting to atmosphere internally loaded to a normally open position between two tightly closing shutoff valves and with means for testing for tightness of the checks and opening of relief means.

**[MP] BACKFLOW, WATER DISTRIBUTION.** The flow of water or other liquids into the potable water-supply piping from any sources other than its intended source. Back-siphonage is one type of backflow.

**[MP] BACKPRESSURE.** Pressure created by any means in the water distribution system that by being in excess of the pressure in the water supply mains causes a potential backflow condition.

**[MP] BACKPRESSURE, LOW HEAD.** A pressure less than or equal to 4.33 psi (29.88 kPa) or the pressure exerted by a 10-foot (3048 mm) column of water.

**[MP] BACKSIPHONAGE.** The flowing back of used or contaminated water from piping into a potable water-supply pipe due to a negative pressure in such pipe.

**[MP] BACKWATER VALVE.** ~~A device installed in a drain or pipe to prevent backflow of sewage.~~ A device or valve installed in the *building drain* or *sewer* pipe where a *sewer* is subject to backflow, and that prevents drainage or waste from backing up into a lower level or fixtures and causing a flooding condition.

**[MP] BALANCED VENTILATION.** Any combination of concurrently operating mechanical exhaust and mechanical supply whereby the total mechanical exhaust airflow rate is within 10 percent of the total mechanical supply airflow rate.

**[MP] BALANCED VENTILATION SYSTEM.** A ventilation system where the total supply airflow and total exhaust airflow are simultaneously within 10 percent of their averages. The balanced ventilation system airflow is the average of the supply and exhaust airflows.

**BALCONY, EXTERIOR.** An exterior floor projecting from and supported by a structure without additional independent supports.

**[RG] BAROMETRIC DRAFT REGULATOR.** A balanced *damper* device attached to a *chimney*, vent *connector*, breeching or flue gas manifold to protect combustion *appliances* by controlling *chimney draft*. A double-acting *barometric draft regulator* is one whose balancing *damper* is free to move in either direction to protect combustion *appliances* from both excessive *draft* and backdraft.

**BASE FLOOD ELEVATION (BFE)** The elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year.

**[RB] BASEMENT.** ~~That portion of a building that is partly or completely below grade~~ A story that is not a story above grade plane (see "Story above grade plane").

**[RB] BASEMENT WALL.** The opaque portion of a wall that encloses one side of a *basement* and has an average below *grade* wall area that is 50 percent or more of the total opaque and nonopaque area of that enclosing side. For energy purposes, a wall 50 percent or more below grade and enclosing conditioned space. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] BASIC WIND SPEED.** Three-second gust speed at 33 feet (10 058 mm) above the ground in Exposure C (see Section R301.2.1) as given in Table R301.2(4) and R301.2(5).

**[RM] BATHROOM.** A room containing a bathtub, shower, spa or similar bathing fixture (see also "Toilet room.").

**[MP] BATHROOM GROUP.** A group of fixtures, including or excluding a bidet, consisting of a water closet, lavatory, and bathtub or shower. Such fixtures are located together on the same floor level.

**[RP] BATTERY OF FIXTURES**. Any group of two or more similar adjacent fixtures that discharge into a common horizontal waste or soil branch.

**BED AND BREAKFAST HOME.** A detached single-family *dwelling* occupied by the *dwelling* owner and containing eight or fewer guest rooms for rent for a period of less than one week.

**BEDROOM.** *Sleeping room*.

<u>**[MP] BEND.** A drainage fitting, designed to provide a change in direction of a drain pipe of less than the angle specified by the amount necessary to establish the desired slope of the line (see "*Elbow*" and "*Sweep*").</u>

**BOAT SLIP.** A berthing place for one or two watercraft where the watercraft can be securely moored to cleats, piling,

or other devices while the boats are in the water. Boat slips are commonly configured as "side-ties" or as single- or double-

loaded "U" shaped berths.

**[MP] BOILER.** A self-contained *appliance* from which hot water is circulated for heating purposes and then returned to the boiler, and that operates at water pressures not exceeding 160 pounds per square inch gage (psig) (1102 kPa gauge) and at water temperatures not exceeding 250°F (121°C).

**[RG] BOILER, LOW-PRESSURE.** A self-contained *appliance* for supplying steam or hot water.

**Hot water heating boiler.** A boiler in which no steam is generated, from which hot water is circulated for heating purposes and then returned to the boiler, and that operates at water pressures not exceeding 160 pounds per square inch gauge (psig) (1100 kPa gauge) and at water temperatures not exceeding 250°F (121°C) at or near the boiler outlet.

**Hot water supply boiler.** A boiler, completely filled with water, which furnishes hot water to be used externally to itself, and that operates at water pressures not exceeding 160 psig (1100 kPa gauge) and at water temperatures not exceeding 250°F (121°C) at or near the boiler outlet.

**Steam heating boiler.** A boiler in which steam is generated and that operates at a steam pressure not exceeding 15 psig (100 kPa gauge).

**[RB] BOND BEAM.** A horizontal grouted element within masonry in which reinforcement is embedded.

**[RG] BONDING JUMPER.** A conductor installed to electrically connect metallic gas *piping* to the grounding electrode system.

~~**[RE] BPI ENVELOPE PROFESSIONAL.** An individual that has passed the Building Performance Institute written and field examination requirements for the Building Envelope certification and has a current certification.~~

<u>**[RB] BRACED WALL LINE.** A straight line through the building plan that represents the location of the lateral resistance provided by the wall bracing.</u>

**[RB] BRACED WALL LINE, CONTINUOUSLY SHEATHED.** A *braced wall line* with structural sheathing applied to all sheathable surfaces including the areas above and below openings.

**[RB] BRACED WALL PANEL.** A full-height section of wall constructed to resist in-plane shear loads through interaction of framing members, sheathing material and anchors. The panel's length meets the requirements of its particular bracing method, and contributes toward the total amount of bracing required along its *braced wall line* in accordance with Section R602.10.1.

**[MP] BRANCH.** Any part of the piping system other than a riser, main or stack.

**[MP] BRANCH, FIXTURE.** See "*Fixture branch, drainage*."

**[MP] BRANCH, HORIZONTAL.** See "*Horizontal branch, drainage*."

**[MP] BRANCH INTERVAL.** A distance along a soil or waste stack corresponding, in general, to a story height, but not less than 8 feet (2438 mm) within which the horizontal branches from one floor or story of a structure are connected to the stack. Measurements are taken down the stack from the highest horizontal branch connection.

**[MP] BRANCH, MAIN.** A water-distribution pipe that extends horizontally off a main or riser to convey water to branches or fixture groups.

**[MP] BRANCH, VENT.** A vent connecting two or more individual vents with a vent stack or stack vent.

**[RM] BRAZED JOINT.** A gas-tight joint obtained by the joining of metal parts with metallic mixtures or alloys that melt at a temperature above 1,000ºF (538ºC), but lower than the melting temperature of the parts to be joined.

**[RG] BRAZING.** A metal-joining process wherein coalescence is produced by the use of a nonferrous filler metal having a melting point above 1,000°F (538°C), but lower than that of the base metal being joined. The filler material is distributed between the closely fitted surfaces of the joint by capillary action.

**BREAKAWAY WALL** A wall that is not part of the structural support of the building and is intended through its design and construction to collapse under specific lateral loading forces, without causing damage to the elevated portion of the building or supporting foundation system. Any walls below the lowest floor in a building in a V Zone should give way under wind and water loads without causing collapse, displacement, or other damage to the elevated portion of the building or the supporting pilings or columns.

**[RG] BROILER.** A general term including salamanders, barbecues and other appliances cooking primarily by radiated heat, excepting toasters.

**[RG] BTU.** Abbreviation for British thermal unit, which is the quantity of heat required to raise the temperature of 1 pound (454 g) of water 1°F (0.56°C) (1 *Btu* = 1055 J).

**[MP] BTU/H.** The *listed* maximum capacity of an *appliance*, absorption unit or burner expressed in British thermal units input per hour.

**[RB] BUILDING.** ~~Building shall mean any~~Any one- ~~and~~or two family dwelling or townhouse, or portion thereof, ~~including *townhouses*, that is~~ used, ~~or designed~~ or intended to be used for human habitation, for living, sleeping, cooking or eating purposes, or any combination thereof, ~~and shall include *accessory structures* thereto.~~or any accessory building. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[MP] BUILDING DRAIN.** The lowest piping that collects the discharge from all other drainage piping inside the house and extends to 10 feet (3048 mm) beyond the exterior walls of the building and conveys the drainage to the *building sewer*.

> **Exception:** Drain lines connecting to septic tanks within 25 feet (7620 mm) of the building foundation wall for one- and two-family dwellings with 4 water closets or less shall be considered to be building drain with a minimum size of 3 inches (76.2 mm).

**[RB] BUILDING, EXISTING.** Existing building is a building erected prior to the adoption of this code, or one for which a legal building *permit* has been issued.

**[RB] BUILDING-INTEGRATED PHOTOVOLTAIC ROOF PANEL (BIPV Roof Panel).** A *photovoltaic panel* that functions as a component of the building envelope.

**[RB] BUILDING OFFICIAL.** The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[MP] BUILDING SEWER.** That part of the drainage system that extends from the end of the *building drain* and conveys its discharge to a public sewer, private sewer, individual sewage-disposal system or other point of disposal.

> **Sanitary.** A *building sewer* that conveys sewage only.
> **Storm.** A *building sewer* that conveys storm water or other drainage, but not sewage.

**[RE] BUILDING SITE.** A continguous area of land that is under the ownership or control of one entity. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RP] BUILDING SUBDRAIN.** That portion of a drainage system that does not drain by gravity into the *building sewer*.

**[RE] BUILDING THERMAL ENVELOPE.** The *basement walls*, *exterior walls*, floor, roof and any other building element that enclose *conditioned spaces*. This boundary also includes the boundary between conditioned space and any exempt or unconditioned space. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] BUILDING-INTEGRATED PHOTOVOLTAIC PRODUCT.** A building product that incorporates *photovoltaic modules* and functions as a component of the building envelope.

**[RB] BUILDING-INTEGRATED PHOTOVOLTAIC ROOF PANEL (BIPV Roof Panel).** A *photovoltaic panel* that functions as a component of the building envelope.

**[RB] BUILT-UP ROOF COVERING.** Two or more layers of felt cemented together and surfaced with a cap sheet, mineral aggregate, smooth coating or similar surfacing material.

**[RG] BURNER.** A device for the final conveyance of the gas, or a mixture of gas and air, to the combustion zone.

**Induced-draft.** A *burner* that depends on *draft* induced by a fan that is an integral part of the *appliance* and is located downstream from the *burner*.

**Power.** A *burner* in which gas, air or both are supplied at pressures exceeding, for gas, the line pressure, and for air, atmospheric pressure, with this added pressure being applied at the *burner*.

**[RB] CAP PLATE.** The top plate of the double top plates used in *structural insulated panel* (SIP) construction. The cap plate is cut to match the *panel thickness* such that it overlaps the wood structural panel facing on both sides.

**[RB] CARBON MONOXIDE ALARM.** A single- or multiple-station alarm intended to detect carbon monoxide gas and alert occupants by a distinct audible signal. It incorporates a sensor, control components and an alarm notification appliance in a single unit.

**[RB] CARBON MONOXIDE DETECTOR.** A device with an integral sensor to detect carbon monoxide gas and transmit an alarm signal to a connected alarm control unit.

**[RB] CEILING HEIGHT.** The clear vertical distance from the finished floor to the finished ceiling.

**[RB] CEMENT PLASTER.** A mixture of Portland or blended cement, Portland cement or blended cement and hydrated lime, masonry cement or plastic cement and aggregate and other *approved* materials as specified in this code.

~~**[RE] C-FACTOR (THERMAL CONDUCTANCE).** The coefficient of heat transmission (surface to surface) through a building component or assembly, equal to the time rate of heat flow per unit area and the unit temperature difference between the warm side and cold side surfaces (Btu/h·ft$^2$·°F)[W/(m$^2$·K)].~~

~~**[RE] CFM25.** Cubic feet per minute of measured air flow while the building is maintained at a pressure difference of 25 pascals (0.1 inches w.p.).~~

~~**[RE] CFM50.** Cubic feet per minute of measured air flow while the building is maintained at a pressure difference of 50 pascals (0.2 inches w.p.).~~

**[RB] CHANGE OF OCCUPANCY.** A change in the use of a building or portion of a building that involves a change in the application of the requirements of this code.

**[RG] CHIMNEY.** A primary vertical structure containing one or more flues, for the purpose of carrying gaseous products of combustion and air from a fuel-burning *appliance* to the outside atmosphere.

**Factory-built chimney.** A *listed* and *labeled* chimney composed of factory-made components, assembled in the field in accordance with manufacturer's instructions and the conditions of the listing.

**Masonry chimney.** A field-constructed chimney composed of solid masonry units, bricks, stones or concrete.

**[MP] CHIMNEY CONNECTOR.** A pipe that connects a fuel-burning *appliance* to a chimney.

**[MP] CHIMNEY TYPES.**

**Residential-type appliance.** An *approved* chimney for removing the products of combustion from fuel-burning, residential-type *appliances* producing combustion gases not in excess of 1,000°F (538°C) under normal operating conditions, and capable of producing combustion gases of 1,400°F (760°C) during intermittent forces firing for periods up to 1 hour. All temperatures shall be measured at the *appliance* flue outlet. Residential-type *appliance* chimneys include masonry and factory-built types.

**[MP] CIRCUIT VENT.** A vent that connects to a *horizontal* drainage branch and vents two traps to not more than eight traps or trapped fixtures connected into a battery.

**[MP] CIRCULATING HOT WATER SYSTEM.** A specifically designed water distribution system where one or more pumps are operated in the service hot water piping to circulate heated water from the water-heating equipment to fixtures and back to the water-heating equipment. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RP] CISTERN**. A small covered tank for storing water for a home or farm. Generally, this tank stores rainwater to be utilized for purposes other than in the potable water supply, and such tank is placed underground in most cases.

**[RB] CLADDING.** The exterior materials that cover the surface of the building envelope that is directly loaded by the wind.

**CLEANOUT.** An ~~accessible~~ access opening in the drainage system ~~used~~ utilized for the removal of ~~possible~~ obstruction. Types of cleanouts include a removable plug or cap, and a removable fixture or fixture trap.

**[RG] CLEARANCE.** The minimum distance through air measured between the heat-producing surface of the mechanical *appliance*, device or *equipment* and the surface of the *combustible material* or assembly.

**[RE] CLIMATE ZONE.** A geographical region based on climatic criteria as specified in this code. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**CLOSED CRAWLSPACE.** A foundation without wall vents that uses air sealed walls, ground and foundation moisture
control, and mechanical drying potential to control crawl space moisture. Insulation may be located at the floor level or

at the exterior walls.

**[RB] CLOSET.** A small room or chamber used for storage.

**[RG] CLOTHES DRYER.** An *appliance* used to dry wet laundry by means of heated air.

**Type 1.** Factory-built package, multiple production. Primarily used in the family living environment. Usually the smallest unit physically and in function output.

**COASTAL HIGH HAZARD AREA.** An area of special flood hazard extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action from storms or seismic sources. The coastal high hazard area is identified as either V Zone or Coastal A Zone on Flood Insurance Rate Maps (FIRMs).

**[RG] CODE.** These regulations, subsequent amendments thereto, or any emergency rule or regulation that the administrative authority having *jurisdiction* has lawfully adopted.

**CODE OFFICIAL.** The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.

**[RB] COLLAPSIBLE SOILS.** Soils that exhibit volumetric reduction in response to partial or full wetting under load.

**[MP] COLLECTION PIPE.** Unpressurized pipe used within the collection system that drains on-site nonpotable water or rainwater to a storage tank by gravity.

**[RP] COMBINATION FIXTURE**. A fixture combining one sink and laundry tray or a two- or three-compartment sink or laundry tray in one unit.

**[MP] COMBINATION WASTE AND VENT SYSTEM.** A specially designed system of waste piping embodying the horizontal wet venting of one or more sinks, lavatories or floor drains by means of a common waste and vent pipe adequately sized to provide free movement of air above the flow line of the drain.

**[RG] COMBUSTIBLE ASSEMBLY.** Wall, floor, ceiling or other assembly constructed of one or more component materials that are not defined as noncombustible.

**[RB] COMBUSTIBLE MATERIAL.** Any material not defined as noncombustible.

**[RG] COMBUSTION.** In the context of this code, refers to the rapid oxidation of fuel accompanied by the production of heat or heat and light.

**COMBUSTION AIR.** ~~Air necessary for complete combustion of a fuel, including theoretical air and excess air.~~ The air provided to fuel-burning equipment including air for fuel combustion, draft hood dilution and *ventilation* of the equipment enclosure.

**[RG] COMBUSTION CHAMBER.** The portion of an *appliance* within which combustion occurs.

**[RG] COMBUSTION PRODUCTS.** Constituents resulting from the combustion of a fuel with the oxygen of the air, including the inert gases, but excluding excess air.

**[MP] COMMON VENT.** A vent connecting at the junction of two *fixture drains* or to a fixture *branch* and serving as a vent for both fixtures.

**[RB] COMPRESSIBLE SOILS.** Soils that exhibit volumetric reduction in response to the application of load even in the absence of wetting or drying.

~~**[RP] CONCEALED FOULING SURFACE.** Any surface of a plumbing fixture that is not readily visible and is not scoured or cleansed with each fixture operation.~~

**[RG] CONCEALED LOCATION.** A location that cannot be accessed without damaging permanent parts of the building structure or finish surface. Spaces above, below or behind readily removable panels or doors shall not be considered as concealed.

**[RG] CONCEALED PIPING.** *Piping* that is located in a *concealed location* (see "*Concealed location*").

**[MP] CONDENSATE.** The liquid that separates from a gas due to a reduction in temperature; for example, water that condenses from flue gases and water that condenses from air circulating through the cooling coil in air conditioning equipment.

**[MP] CONDENSING APPLIANCE.** An *appliance* that condenses water generated by the burning of fuels.

**[RB] CONDITIONED AIR.** Air treated to control its temperature, relative humidity or quality.

**[RE] CONDITIONED FLOOR AREA.** The horizontal projection of the floors associated with *conditioned space*.~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**CONDITIONED CRAWL SPACE.** A conditioned crawl space is a foundation without wall vents that encloses an intentionally heated or cooled space. Insulation is located at the exterior walls.

**[RE] CONDITIONED SPACE.** A space within a building that is provided with heating or cooling equipment or systems capable of maintaining, through design or heat loss/gain, 50°F (10°C) during the heating season or 85°F (29°C) during the cooling season, or communicates directly with a conditioned space. Spaces within the building thermal envelope are considered conditioned space. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RG] CONNECTOR, APPLIANCE (Fuel).** Rigid metallic *pipe* and fittings, semirigid metallic *tubing* and fittings or a *listed* and *labeled* device that connects an *appliance* to the *gas piping system*.

**[RG] CONNECTOR, CHIMNEY OR VENT.** The *pipe* that connects an *appliance* to a chimney or vent.

**[RB] CONSTRUCTION DOCUMENTS.** Written, graphic and pictorial documents prepared or assembled for describing the design, location and physical characteristics of the elements of a project necessary for obtaining a building *permit*. Construction drawings shall be drawn to an appropriate scale.

**CONTAMINATION.** ~~An~~ A hazard impairment of the quality of the potable water that creates an actual hazard to the public health through poisoning or through the spread of disease by sewage, industrial fluids or waste.

~~**[RE] CONTINUOUS AIR BARRIER.** For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RE] CONTINUOUS INSULATION (ci).** Insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[MP] CONTINUOUS WASTE.** A drain from two or more similar adjacent fixtures connected to a single trap.

**[RG] CONTROL.** A manual or automatic device designed to regulate the gas, air, water or electrical supply to, or operation of, a mechanical system.

**[MP] CONTROL, LIMIT.** An automatic control responsive to changes in liquid flow or level, pressure, or temperature for limiting the operation of an *appliance*.

**[MP] CONTROL, PRIMARY SAFETY.** A safety control responsive directly to flame properties that senses the presence or absence of flame and, in event of ignition failure or unintentional flame extinguishment, automatically causes shutdown of mechanical equipment.

**[MP] CONVECTOR.** A system incorporating a heating element in an enclosure in which air enters an opening below the heating element, is heated and leaves the enclosure through an opening located above the heating element.

**[RG] CONVERSION BURNER.** A unit consisting of a *burner* and its *controls* for installation in an *appliance* originally utilizing another fuel.

**[RG] COPPER ALLOY.** A homogeneous mixture of not less than two metals where not less than 50 percent of the finished metal is copper.

**[RB] CORE.** The lightweight middle section of a *structural insulated panel*, composed of foam plastic insulation, that provides the link between the two facing shells.

**[RB] CORROSION RESISTANCE.** The ability of a material to withstand deterioration of its surface or its properties where exposed to its environment.

**CORROSION RESISTANCE AREA.** *Areas within hurricane prone regions defined as that area east of the Intracoastal Waterway from the NC/SC state line north to Beaufort Inlet and from that point to include the barrier islands to the NC/VA state line.*

**[RB] COURT.** A space, open and unobstructed to the sky, located at or above *grade* level on a *lot* and bounded on three or more sides by walls or a building.

**[RB] CRAWL SPACE.** An underfloor space that is not a *basement*.

**[RE] CRAWL SPACE WALL.** The opaque portion of a wall that encloses a crawl space and is partially or totally below grade. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] CRIPPLE WALL.** A framed wall extending from the top of the foundation to the underside of the floor framing of the first *story above grade plane*.

**[RB] CRIPPLE WALL CLEAR HEIGHT.** The vertical height of a *cripple wall* from the top of the foundation to the underside of floor framing above.

**[RP] CRITICAL LEVEL (C-L).** An elevation (height) reference point that determines the minimum height at which a backflow preventer or vacuum breaker is installed above the *flood level rim* of the fixture or receptor served by the device. The critical level is the elevation level below which there is a potential for backflow to occur. If the critical level marking is not indicated on the device, the bottom of the device shall constitute the critical level.

**[MP] CROSS CONNECTION.** ~~Any connection between two otherwise separate piping systems that allows a flow from one system to the other.~~ Any physical connection or arrangement between two otherwise separate piping systems, one of which contains potable water and the other either water of unknown or questionable safety or steam, gas or chemical, whereby there exists the possibility for flow from one system to the other, with the direction of flow depending on the pressure differential between the two systems (see "Backflow").

**[RB] CROSS-LAMINATED TIMBER.** A prefabricated engineered wood product consisting of not less than three layers of solid-sawn lumber or *structural composite lumber* where the adjacent layers are cross-oriented and bonded with structural adhesive to form a solid wood element.

**[RG] CUBIC FOOT.** The amount of gas that occupies 1 cubic foot (0.02832 $m^3$) when at a temperature of 60°F (16°C), saturated with water vapor and under a pressure equivalent to that of 30 inches of mercury (101 kPa).

~~**[RE] CURTAIN WALL.** For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] DALLE GLASS.** A decorative composite glazing material made of individual pieces of glass that are embedded in a cast matrix of concrete or epoxy.

**[RG] DAMPER.** A manually or automatically controlled device to regulate *draft* or the rate of flow of air or combustion gases.

**[MP] DAMPER, VOLUME.** A device that will restrict, retard or direct the flow of air in any duct, or the products of combustion of heat-producing equipment, vent connector, vent or chimney.

**DAMPPROOFING.** A coating or the application of coatings applied to retard the penetration of water vapor and moisture through or into walls or into interior spaces.

**DEAD END.** A *branch* leading from a soil, waste or vent pipe; a *building drain*; or a *building sewer*, and terminating at a *developed length* of 2 feet (610 mm) or more by means of a plug, cap or other closed fitting.

**[RB] DEAD LOADS.** The weight of the materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, *stairways*, built-in partitions, finishes, cladding, and other similarly incorporated architectural and structural items, and fixed service equipment.

**DECK.** An exterior floor system supported on at least two opposing sides by an adjoining structure or posts, piers, or other independent supports.

**[RG] DECORATIVE APPLIANCE, VENTED.** A *vented appliance* wherein the primary function lies in the aesthetic effect of the flames.

**[RG] DECORATIVE APPLIANCES FOR INSTALLATION IN VENTED FIREPLACES.** A *vented appliance* designed for installation within the fire chamber of a vented *fireplace*, wherein the primary function lies in the aesthetic effect of the flames.

**[RB] DECORATIVE GLASS.** A carved, leaded or Dalle glass or glazing material with a purpose that is decorative or artistic, not functional; with coloring, texture or other design qualities or components that cannot be removed without destroying the glazing material; and with a surface, or assembly into which it is incorporated, that is divided into segments.

**[RG] DEMAND.** The maximum amount of gas input required per unit of time, usually expressed in cubic feet per hour, or *Btu*/h (1 *Btu*/h = 0.2931 W).

**[RE] DEMAND RECIRCULATION WATER SYSTEM.** A water distribution system where pump(s) prime the service hot water piping with heated water upon a demand for hot water. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RG] DESIGN FLOOD ELEVATION.** The elevation of the "design flood," including wave height, relative to the datum specified on the community's legally designated flood hazard map. In areas designated as Zone AO, the *design flood elevation* shall be the elevation of the highest existing grade of the *building's* perimeter plus the depth number (in feet) specified on the flood hazard map. In areas designated as Zone AO where a depth number is not specified on the map, the depth number shall be taken as being equal to 2 feet (610 mm).

**[MP] DESIGN PROFESSIONAL.** See "*Registered design professional*."

**[RM] DESIGN WORKING PRESSURE.** The maximum allowable working pressure for which a specific part of a system is designed.

**[MP] DEVELOPED LENGTH.** The length of a pipeline measured along the center line of the pipe and fittings.

**[MP] DIAMETER.** Unless specifically stated, the term "diameter" is the nominal diameter as designated by the *approved* material standard.

**[RB] DIAPHRAGM.** A horizontal or nearly horizontal system acting to transmit lateral forces to the vertical resisting elements. Where the term "*diaphragm*" is used, it includes horizontal bracing systems.

**[MP] DILUTION AIR.** Air that enters a draft hood or draft regulator and mixes with flue gases.

**[MP] DIRECT SYSTEM.** A solar thermal system in which the gas or liquid in the solar collector loop is not separated from the load.

**[MP] DIRECT-VENT APPLIANCE.** A fuel-burning *appliance* with a sealed combustion system that draws all air for combustion from the outside atmosphere and discharges all flue gases to the outside atmosphere.

[RP] DISCHARGE PIPE. A pipe that conveys the discharge from plumbing fixtures or appliances.

**[RM] DISCRETE PRODUCT.** Products that are noncontinuous, individual, distinct pieces such as, but not limited to, electrical, plumbing and mechanical products and duct straps, duct fittings, duct registers and pipe hangers.

**DOCK.** A structure extending alongshore or out from the shore into a body of water, usually accommodating multiple
boat slips, to which boats may be moored in order to load or unload people or cargo.

**[MP] DRAFT.** The pressure difference existing between the *appliance* or any component part and the atmosphere, that causes a continuous flow of air and products of combustion through the gas passages of the *appliance* to the atmosphere.

**Induced draft.** The pressure difference created by the action of a fan, blower or ejector, that is located between the *appliance* and the chimney or vent termination.

**Natural draft.** The pressure difference created by a vent or chimney because of its height, and the temperature difference between the flue gases and the atmosphere.

**[MP] DRAFT HOOD.** A device built into an *appliance*, or a part of the vent connector from an *appliance*, that is designed to provide for the ready escape of the flue gases from the *appliance* in the event of no draft, backdraft or stoppage beyond the draft hood; prevent a backdraft from entering the *appliance*; and neutralize the effect of stack action of the chimney or gas vent on the operation of the *appliance*.

**[MP] DRAFT REGULATOR.** A device that functions to maintain a desired draft in the *appliance* by automatically reducing the draft to the desired value.

**[RB] DRAFT STOP.** A material, device or construction installed to restrict the movement of air within open spaces of concealed areas of building components such as crawl spaces, floor-ceiling assemblies, roof-ceiling assemblies and *attics*.

**[MP] DRAIN.** Any pipe that carries soil and waterborne wastes in a building drainage system.

**[MP] DRAINAGE FITTING.** The type of fitting or fittings utilized in the drainage system. Drainage fittings are similar to cast-iron fittings, except that instead of having a bell and spigot, drainage fittings are recessed and tapped to eliminate ridges on the inside of the installed pipe.

[RP] DRAINAGE SYSTEM. Piping within a *public* or *private* premise that conveys sewage, rainwater or other liquid waste to a point of disposal. A drainage system does not include the mains of a *public sewer* system or a private or public sewage treatment or disposal plant.

**Building gravity.** A drainage system that drains by gravity into the *building sewer*.

**Sanitary.** A drainage system that carries sewage and excludes storm, surface and ground water**.**

**Storm.** A drainage system that carries rainwater, surface water, subsurface water and similar liquid waste**.**

**[MP] DRAIN-BACK SYSTEM.** A solar thermal system in which the fluid in the solar collector loop is drained from the collector into a holding tank under prescribed circumstances.

**[RG] DRIP.** The container placed at a low point in a system of *piping* to collect *condensate* and from which the *condensate* is removable.

**[RE] DUCT.** A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RG] DUCT FURNACE.** A warm-air *furnace* normally installed in an air distribution duct to supply warm air for heating. This definition shall apply only to a warm-air heating *appliance* that depends for air circulation on a blower not furnished as part of the *furnace*.

**DUCT SYSTEM.** A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling *equipment* and *appliances*. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RM] DUCTLESS MINI-SPLIT SYSTEM.** A heating and cooling system that is comprised of one or multiple indoor evaporator/air-handling units and an outdoor condensing unit that is connected by refrigerant piping and electrical wiring. A ductless mini-split system is capable of cooling or heating one or more rooms without the use of a traditional ductwork system.

**DURHAM FITTING.** A special type of drainage fitting for use in the durham systems installations in which the joints are made with recessed and tapered threaded fittings, as opposed to bell and spigot lead/oakum or solvent/cemented or soldered joints. The tapping is at an angle (not 90 degrees) to provide for proper slope in otherwise rigid connections.

**DURHAM SYSTEM.** A term used to describe soil or waste systems where all piping is of threaded pipe, tube or other such rigid construction using recessed drainage fittings to correspond to the types of piping.

**[RB] DWELLING.** Any building that contains one or two *dwelling units* (duplex) on the same parcel of land, used, intended, or designed to be built, used, rented, leased, let or hired out to be occupied, or that are occupied for living purposes.

**[RB] DWELLING UNIT.** A single unit providing complete independent living facilities for ~~one or more persons,~~ a single family, including permanent provisions for living, sleeping, eating, cooking and sanitation.

**[MP] DWV.** Abbreviated term for drain, waste and vent piping as used in common plumbing practice.

**[RP] EFFECTIVE OPENING.** The minimum cross-sectional area at the point of water-supply discharge, measured or expressed in terms of diameter of a circle and if the opening is not circular, the diameter of a circle of equivalent cross-sectional area. (This is ~~used in the determination of the~~ applicable to air gap.)

**EGRESS ROOF ACCESS WINDOW.** A skylight or roof window designed and installed to satisfy the emergency escape and rescue opening requirements in Section R310.2.

**[MP] ELBOW.** A pressure pipe fitting designed to provide an exact change in direction of a pipe run. An elbow provides a sharp turn in the flow path (see "Bend" and "Sweep").

**[RM] ELECTRIC HEATING APPLIANCE.** An *appliance* that produces heat energy to create a warm environment by the application of electric power to resistance elements, refrigerant compressors or dissimilar material junctions.

**[RB] EMERGENCY ESCAPE AND RESCUE OPENING.** An operable exterior window, door or other similar device that provides for a means of escape and access for rescue in the event of an emergency. (See also "Grade floor emergency escape and rescue opening.")

**[RE] ENERGY ANALYSIS.** A method for estimating the annual energy use of the *proposed design* and *standard reference design* based on estimates of energy use. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RE] ENERGY COST.** The total estimated annual cost for purchased energy for the building functions regulated by this code, including applicable demand charges. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RM] ENERGY RECOVERY VENTILATION SYSTEM.** Systems that employ air-to-air heat exchangers to recover energy from or reject energy to *exhaust air* for the purpose of preheating, pre-cooling, humidifying or dehumidifying outdoor *ventilation air* prior to supplying such air to a space, either directly or as part of an HVAC system.

**[RE] ENERGY SIMULATION TOOL.** An *approved* software program or calculation-based methodology that projects the annual energy use of a building. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] ENERGY STORAGE SYSTEMS (ESS).** One device or multiple devices, assembled together, capable of storing electrical energy to be supplied at a future time.

**[RB] ENGINEERED WOOD RIM BOARD.** A full-depth *structural composite lumber*, wood structural panel, structural glued laminated timber or prefabricated wood I-joist member designed to transfer horizontal (shear) and vertical (compression) loads, provide attachment for *diaphragm* sheathing, siding and exterior deck ledgers and provide lateral support at the ends of floor or roof joists or rafters.

**[RM] ENVIRONMENTAL AIR.** Air that is conveyed to or from occupied areas through ducts ~~which~~ that are not part of the heating or air-conditioning system, such as ventilation for human usage, domestic kitchen range exhaust, bathroom exhaust, domestic clothes dryer exhaust.

**[MP] EQUIPMENT.** Piping, ducts, vents, control devices and other components of systems other than *appliances* that are permanently installed and integrated to provide control of environmental conditions for buildings. This definition shall also include other systems specifically regulated in this code.

**[RM]EQUIPMENT, EXISTING.** Any *equipment* regulated by this code which was legally installed prior to the effective date of this code, or for which a permit to install has been issued.

**[MP] EQUIVALENT LENGTH.** For determining friction losses in a piping system, the effect of a particular fitting equal to the friction loss through a straight piping length of the same nominal diameter.

**[RE] ERI REFERENCE DESIGN.** A version of the rated design that meets the minimum requirements of the 2006 *International Energy Conservation Code.* ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] ESCARPMENT.** With respect to topographic wind effects, a cliff or steep slope generally separating two levels or gently sloping areas.

**[MP] ESSENTIALLY NONTOXIC TRANSFER FLUIDS.** Fluids having a Gosselin rating of 1, including propylene glycol; mineral oil; polydimethy oil oxane; hydrochlorofluorocarbon, chlorofluorocarbon and hydrofluorocarbon refrigerants; and FDA-approved boiler water additives for steam boilers.

**[MP] ESSENTIALLY TOXIC TRANSFER FLUIDS.** Soil, water or graywater and fluids having a Gosselin rating of 2 or more including ethylene glycol, hydrocarbon oils, ammonia refrigerants and hydrazine.

**[MP] EVAPORATIVE COOLER.** A device used for reducing air temperature by the process of evaporating water into an airstream.

**[MP] EXCESS AIR.** Air that passes through the combustion chamber and the *appliance* flue in excess of what is theoretically required for complete combustion.

**[RG] EXCESS FLOW VALVE (EFV).** A valve designed to activate when the fuel gas passing through it exceeds a prescribed flow rate.

**[RM] EXFILTRATION.** Uncontrolled outward air leakage from conditioned spaces through unintentional openings in ceilings, floors and walls to unconditioned spaces or the outdoors caused by pressure differences across these openings resulting from wind, the stack effect created by temperature differences between indoors and outdoors, and imbalances between supply and exhaust airflow rates.

**[MP] EXHAUST HOOD, FULL OPENING.** An exhaust hood with an opening not less than the diameter of the connecting vent.

**[RM] EXHAUST SYSTEM.** An assembly of connected ducts, *plenums*, fittings, registers, grilles and hoods through which air is conducted from the space or spaces and exhausted to the outdoor atmosphere.

**[MP] EXISTING INSTALLATIONS.** Any plumbing system regulated by this code that was legally installed prior to the effective date of this code, or for which a *permit* to install has been issued.

**[RB] EXPANSIVE SOILS.** Soils that exhibit volumetric increase or decrease (swelling or shrinking) in response to partial or full wetting or drying under load.

**[RB] EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS).** EIFS are nonstructural, nonload-bearing exterior wall cladding systems that consist of an insulation board attached either adhesively or mechanically, or both, to the substrate; an integrally reinforced base coat; and a textured protective finish coat.

**[RB] EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS) WITH DRAINAGE.** An EIFS that incorporates a means of drainage applied over a *water-resistive barrier*.

**[RG] EXTERIOR MASONRY CHIMNEYS.** Masonry chimneys exposed to the outdoors on one or more sides below the roof line.

**[RB] EXTERIOR WALL.** An above-*grade* wall that defines the exterior boundaries of a building. Includes between-floor spandrels, peripheral edges of floors, roof and *basement* knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and *basement walls* with an average below-*grade* wall area that is less than 50 percent of the total opaque and nonopaque area of that enclosing side. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] EXTERIOR WALL COVERING.** A material or assembly of materials applied on the exterior side of exterior walls for the purpose of providing a weather-resistive barrier, insulation or for aesthetics, including but not limited to, veneers, siding, exterior insulation and finish systems, architectural *trim* and embellishments such as cornices, soffits, and fascias.

**[RB] FACING.** The wood structural panel facings that form the two outmost rigid layers of the *structural insulated panel*.

**[MP] FACTORY-BUILT CHIMNEY.** A *listed* and *labeled* chimney composed of factory-made components assembled in the field in accordance with the manufacturer's instructions and the conditions of the *listing*.

**[MP] FACTORY-MADE AIR DUCT.** A *listed and labeled* duct manufactured in a factory and assembled in the field in accordance with the manufacturer's instructions and conditions of the *listing*.

**FAMILY.** Family is an individual, two or more persons related by blood, marriage or law, or a group of not more than any ~~five~~ eight persons living together in a dwelling unit. Servants having common housekeeping facilities with a family consisting of an individual, or more persons related by blood, marriage or law, are a part of the family for this code.

**FARM BUILDING**. Any building not used for sleeping purposes that is not accessed by the general public and is used primarily for a farm purpose. Farm purposes includes structures or buildings for equipment, storage and processing of agricultural products or commodities such as: crops, fruits, vegetables, ornamental or flowering plants, dairy, timber, livestock, poultry and all other such forms of agricultural products by the specific farm on which the structure or building is located. Farm purposes do not include structures or buildings for uses such as education facilities, research facilities, or aircraft hangers. Limited use of farm buildings for public and private events is permitted by law per N.C.G.S. 143-138 (b4)(1a) and 160D-903(a).
**[RP] FAUCET.** A valve end of a water pipe through which water is drawn from or held within the pipe.

**[RE] FENESTRATION.** ~~Skylights, roof windows, vertical windows (whether fixed or moveable); opaque doors; glazed doors; glass block; and combination opaque and glazed doors.~~Products classified as either vertical fenestration or skylights and sloped glazing, installed in such a manner as to preserve the weather-resistant barrier of the wall or roof in which they are installed. Fenestration includes products with glass or other transparent or translucent materials. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~
~~**[RE] FENESTRATION PRODUCT, FIELD-FABRICATED.** A fenestration product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site-built fenestration.~~
**[RE] FENESTRATION PRODUCT, SITE-BUILT.** A fenestration designed to be made up of field-glazed or fieldassembled units using specific factory cut or otherwise factory- formed framing and glazing units. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~
**[RE] FENESTRATION, VERTICAL.** Windows ~~(fixed or moveable)~~that are fixed or movable, opaque doors, glazed doors, glazed block and combination ~~opaque/glazed~~opaque and glazed doors ~~composed of glass or other transparent or translucent glazing materials and installed at a slope of a least 60 degrees (1.05 rad) from horizontal.~~ installed in a wall at less than 15 degrees (0.26 rad) from vertical. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

~~**[RE] FENESTRATION PRODUCT, SITE-BUILT.** For the definition applicable in Chapter 11, see Section N1101.6.~~

~~**[RE] F-FACTOR.** The perimeter heat loss factor for slabon- grade floors (Btu/h·ft·°F) [W/(m·K)].~~
~~**FIBER-CEMENT SIDING.** A manufactured, fiber-reinforcing product made with an inorganic hydraulic or calcium silicate binder formed by chemical reaction and reinforced with discrete organic or inorganic non asbestos fibers, or both. Additives that enhance manufacturing or product performance are permitted. Fiber-cement siding products have either smooth or textured faces and are intended for *exterior wall* and related applications.~~

**[RB] FIBER-CEMENT (BACKERBOARD, SIDING, SOFFIT, TRIM AND UNDERLAYMENT) PRODUCTS.** Manufactured thin section composites of hydraulic cementitious matrices and discrete nonasbestos fibers.

**[RP] FILL VALVE.** A water supply valve, opened or closed by means of a float or similar device, utilized to supply water to a tank. An antisiphon fill valve contains an antisiphon device in the form of an *approved air gap* or vacuum breaker that is an integral part of the fill valve unit and that is positioned on the discharge side of the water supply control valve.

**[RB] FIRE SEPARATION DISTANCE.** The distance measured from the building face to one of the following:

1. To the closest interior *lot line*.
2. To the centerline of a street, an alley or public way.
3. To an imaginary line between two buildings on the *lot*.

The distance shall be measured at a right angle from the face of the wall.

**[RB] FIREBLOCKING.** Building materials or materials *approved* for use as fireblocking, installed to resist the free passage of flame to other areas of the building through concealed spaces.

**[RB] FIREPLACE.** An assembly consisting of a hearth and fire chamber and smoke chamber, beginning at the hearth and ending at the top of the smoke chamber, of noncombustible material and provided with a chimney, for use with solid fuels.
~~**Factory-built fireplace.** A *listed* and *labeled* fireplace and chimney system composed of factory-made components, and assembled in the field in accordance with manufacturer's instructions and the conditions of the listing.~~
~~**Masonry chimney.** A field-constructed chimney composed of solid masonry units, bricks, stones or concrete, beginning at the top of the smoke chamber and ending at the flue termination.~~
~~**Masonry fireplace.** A field-constructed fireplace composed of *solid masonry* units, bricks, stones or concrete, beginning at the hearth and ending at the top of the smoke chamber.~~
~~**Smoke chamber.** That part of a masonry fireplace that extends from the top of the firebox to the start of the chimney flue lining. A smoke chamber shall have a damper and a smoke shelf.~~

**[MP] FIREPLACE STOVE.** A free-standing, chimney-connected solid-fuel-burning heater designed to be operated with the fire chamber doors in either the open or closed position.

**[RB] FIREPLACE THROAT.** The opening between the top of the firebox and the smoke chamber.

**[RB] FIRE-RETARDANT-TREATED WOOD.** ~~Pressure treated lumber and plywood that~~ Wood products that, when impregnated with chemicals by a pressure process or other means during manufacture, exhibit reduced surface burning characteristics and resist propagation of fire.
**Other means during manufacture.** A process where the wood raw material is treated with a fire-retardant formulation while undergoing creation as a finished product.
**Pressure process.** A process for treating wood using an initial vacuum followed by the introduction of pressure above atmospheric.

**[MP] FIXTURE.** See "*Plumbing fixture*."

**[MP] FIXTURE BRANCH, DRAINAGE.** A drain serving two or more fixtures that discharges into another drain or to a *stack*.

**[MP] FIXTURE BRANCH, WATER-SUPPLY.** A water-supply pipe between the fixture supply and a main water-distribution pipe or fixture group main.

**[MP] FIXTURE DRAIN.** The drain from the trap of a fixture to the junction of that drain with any other drain pipe.

**[MP] FIXTURE FITTING.**

**Supply fitting.** A fitting that controls the volume or directional flow or both of water and that is either attached to or accessed from a fixture or is used with an open or atmospheric discharge.

**Waste fitting.** A combination of components that conveys the sanitary waste from the outlet of a fixture to the connection of the sanitary drainage system.

**[MP] FIXTURE GROUP, MAIN.** The main water-distribution pipe (or secondary branch) serving a plumbing fixture grouping such as a bath, kitchen or laundry area to which two or more individual fixture branch pipes are connected.

**[MP] FIXTURE SUPPLY.** The water-supply pipe connecting a fixture or fixture fitting to a *branch* water supply pipe or directly to a main water supply pipe branch.

**[MP] FIXTURE UNIT, DRAINAGE (d.f.u.).** A measure of probable discharge into the drainage system by various types of plumbing fixtures, used to size DWV piping systems. The drainage fixture-unit value for a particular fixture depends on its volume rate of drainage discharge, on the time duration of a single drainage operation and on the average time between successive operations.

**[MP] FIXTURE UNIT, WATER-SUPPLY (w.s.f.u.).** A measure of the probable hydraulic demand on the water supply by various types of plumbing fixtures used to size water-piping systems. The water-supply fixture-unit value for a particular fixture depends on its volume rate of supply, on the time duration of a single supply operation and on the average time between successive operations.

**[RG] FLAME SAFEGUARD.** A device that will automatically shut off the fuel supply to a *main burner* or group of *burners* when the means of ignition of such *burners* becomes inoperative, and when flame failure occurs on the *burner* or group of *burners*.

**[RB] FLAME SPREAD.** The propagation of flame over a surface.

**[RB] FLAME SPREAD INDEX.** A comparative measure, expressed as a dimensionless number, derived from visual measurements of the spread of flame versus time for a material tested in accordance with ASTM E84 or UL 723.

**[RG] FLASHBACK ARRESTOR CHECK VALVE.** A device that will prevent the backflow of one gas into the supply system of another gas and prevent the passage of flame into the gas supply system.

**[MP] FLEXIBLE AIR CONNECTOR.** A conduit for transferring air between an air duct or plenum and an air terminal unit, an air inlet or an air outlet. Such conduit is limited in its use, length and location.

**[RB] FLIGHT.** A continuous run of rectangular treads or *winders* or combination thereof from one landing to another.

**FLOOD HAZARD AREA.** For definition, see Section R322.

**[MP] FLOOD-LEVEL RIM.** The edge of the receptor or fixture from which water overflows.

**FLOOD PLAIN.** Land below base flood elevation, which of record has in the past been flooded by storm water-surface runoffs, or tidal influx, and as defined by the Corps of Engineers' maps, the Federal Emergency Management Agency maps.

**[MP] FLOOR DRAIN.** A plumbing fixture for recess in the floor having a floor-level strainer intended for the purpose of the collection and disposal of wastewater used in cleaning the floor and for the collection and disposal of accidental spillage to the floor.

**[RG] FLOOR FURNACE.** A completely self-contained *furnace* suspended from the floor of the space being heated, taking air for combustion from outside such space, and with means for lighting the *appliance* from such space.

> **Fan type.** A floor furnace equipped with a fan that provides the primary means for circulating air.
> **Gravity type.** A floor furnace depending primarily ~~upon~~ on circulation of air by gravity. This classification shall also include floor furnaces equipped with booster-type fans that do not materially restrict free circulation of air by gravity flow when such fans are not in operation.

**[MP] FLOW PRESSURE.** The static pressure reading in the water-supply pipe near the faucet or water outlet while the faucet or water outlet is open and flowing at capacity.

**[MP] FLUE.** See "*Vent*."

**[MP] FLUE, APPLIANCE.** The passages within an *appliance* through which combustion products pass from the combustion chamber to the flue collar.

**[MP] FLUE COLLAR.** The portion of a fuel-burning *appliance* designed for the attachment of a draft hood, vent connector or venting system.

**[RM] FLUE CONNECTION (BREECHING).** A passage for conducting the products of *combustion* from a fuel-fired *appliance* to the vent or *chimney* (see also *Chimney connector* and *Vent connector*).

**[MP] FLUE GASES.** Products of combustion plus excess air in *appliance* flues or heat exchangers.

**[RG] FLUE LINER (LINING).** A system or material used to form the inside surface of a flue in a *chimney* or vent, for the purpose of protecting the surrounding structure from the effects of *combustion products* and for conveying *combustion products* without leakage to the atmosphere.

**[MP] FLUSH VALVE.** A device located at the bottom of a flush tank that is operated to flush water closets.

**[MP] FLUSHOMETER TANK.** A device integrated within an air accumulator vessel that is designed to discharge a predetermined quantity of water to fixtures for flushing purposes.

**[MP] FLUSHOMETER VALVE.** A valve attached to a pressurized water supply pipe and so designed that when activated it opens the line for direct flow into the fixture at a rate and quantity to operate the fixture properly, and then gradually closes to reseal fixture traps and avoid water hammer.

**[RB] FOAM BACKER BOARD.** Foam plastic used in siding applications where the foam plastic is a component of the siding.

**[RB] FOAM PLASTIC INSULATION.** A plastic that is intentionally expanded by the use of a foaming agent to produce a reduced-density plastic containing voids consisting of open or closed cells distributed throughout the plastic for thermal insulating or acoustic purposes and that has a density less than 20 pounds per cubic foot (320 kg/$m^3$) unless it is used as interior *trim*.

**[RB] FOAM PLASTIC INTERIOR TRIM.** Exposed foam plastic used as picture molds, chair rails, crown moldings, baseboards, *handrails*, ceiling beams, door *trim* and window *trim* and similar decorative or protective materials used in fixed applications.

~~**[RP] FLUSH TANK.** A tank designed with a fill valve and flush valve to flush the contents of the bowl or usable portion of the fixture.~~

**[RB] FUEL CELL POWER SYSTEM, STATIONARY.** A stationary energy generation system that converts the chemical energy of a fuel and oxidant to electric energy (DC or AC electricity) by an electrochemical process.

**Field-fabricated fuel cell power system.** A *stationary fuel cell power system* that is assembled at the job site and is not a preengineered or prepackaged factory-assembled fuel cell power system.

**Preengineered fuel cell power system.** A *stationary fuel cell power system* consisting of components and modules that are produced in a factory, and shipped to the job site for assembly.

**Prepackaged fuel cell power system.** A *stationary fuel cell power system* that is factory assembled as a single, complete unit and shipped as a complete unit for installation at the job site.

**[RG] FUEL GAS.** A natural gas, manufactured gas, *liquefied petroleum gas* or mixtures of these gases.

**[RM] FUEL OIL.** Kerosene or any hydrocarbon oil having a flash point not less than 100ºF (38ºC).

**[RM] FUEL-OIL PIPING SYSTEM.** A closed piping system that connects a combustible liquid from a source of supply to a fuel-oil-burning *appliance*.

**[MP] FUEL-PIPING SYSTEM.** All piping, tubing, valves and fittings used to connect fuel utilization equipment to the point of fuel delivery.

~~**[RE] FULLY ENCLOSED ATTIC FLOOR SYSTEM.** The ceiling insulation is enclosed on all six sides by an air barrier system, such as taped drywall below, solid framing joists on the sides, solid blocking on the ends, and solid sheathing on top that totally enclose the insulation.~~

**[MP] FULL-OPEN VALVE.** A water control or shutoff component in the water supply system piping that, where adjusted for maximum flow, the flow path through the component's closure member is not a restriction in the component's through-flow area.

**[MP] FULLWAY VALVE.** A valve that in the full open position has an opening cross-sectional area that is not less than 85 percent of the cross-sectional area of the connecting pipe.

**[MP] FURNACE.** A vented heating *appliance* designed or arranged to discharge heated air into a *conditioned space* or through a duct or ducts.

**[RG] FURNACE, CENTRAL.** A self-contained *appliance* for heating air by transfer of heat of *combustion* through metal to the air, and designed to supply heated air through ducts to spaces remote from or adjacent to the *appliance* location.

~~**Downflow furnace.** A furnace designed with airflow discharge vertically downward at or near the bottom of the furnace.~~

~~**Forced-air furnace with cooling unit.** A single-package unit, consisting of a gas-fired forced-air furnace of one of the types listed below combined with an electrically or fuel gas-powered summer air-conditioning system, containedin a common casing.~~

~~**Forced-air type.** A central furnace equipped with a fan or blower that provides the primary means for circulation of air.~~

~~**Gravity furnace with booster fan.** A furnace equipped with a booster fan that does not materially restrict free circulation of air by gravity flow when the fan is not in operation.~~

~~**Gravity type.** A central furnace depending primarily on circulation of air by gravity.~~

~~**Horizontal forced-air type.** A furnace with airflow through the *appliance* essentially in a horizontal path.~~

~~**Multiple-position furnace.** A furnace designed so that it can be installed with the airflow discharge in the upflow, horizontal or downflow direction.~~

~~**Upflow furnace.** A furnace designed with airflow discharge vertically upward at or near the top of the furnace. This classification includes "highboy" furnaces with the blower mounted below the heating element and "lowboy" furnaces with the blower mounted beside the heating element.~~

**[RG] FURNACE PLENUM.** An air compartment or chamber to which one or more ducts are connected and that forms part of an air distribution system.

**[RM] FURNACE ROOM.** A room primarily utilized for the installation of fuel-burning, space-heating and water-heating appliances other than boilers (see also Boiler room).

**[RM] FUSIBLE PLUG.** A device arranged to relieve pressure by operation of a fusible member at a predetermined temperature.

**[RG] GAS CONVENIENCE OUTLET.** A permanently mounted, manually operated device that provides the means for connecting an *appliance* to, and disconnecting an *appliance* from, the supply *piping*. The device includes an integral, manually operated valve with a nondisplaceable valve member and is designed so that disconnection of an *appliance* only occurs when the manually operated valve is in the closed position.

**[RG] GAS PIPING.** An installation of pipe, valves or fittings installed on a premises or in a building and utilized to convey fuel gas.

**[RB] GLASS MAT GYPSUM PANEL.** A gypsum panel consisting of a noncombustible core primarily of gypsum, surfaced with glass mat partially or completely embedded in the core.

**[RB] GLAZING AREA.** The interior surface area of all glazed fenestration, including the area of sash, curbing or other framing elements, that enclose *conditioned space*. Includes the area of glazed fenestration assemblies in walls bounding conditioned *basements*.

**[RB] GRADE.** The finished ground level adjoining the building at all exterior walls.

**[MP] GRADE, PIPING.** See "*Slope*."

~~**[RB] GRADE FLOOR OPENING.** A window or other opening located such that the sill height of the opening is not more than 44 inches (1118 mm) above or below the finished ground level adjacent to the opening.~~

**[RB] GRADE FLOOR EMERGENCY ESCAPE AND RESCUE OPENING.** An emergency escape and rescue opening located such that the bottom of the clear opening is not more than 44 inches (1118 mm) above or below the finished ground level adjacent to the opening. (See also "*Emergency escape and rescue opening*.")

**[RB] GRADE PLANE.** A reference plane representing the average of the finished ground level adjoining the building at all exterior walls. Where the finished ground level slopes away from the exterior walls, the reference plane shall be established by the lowest points within the area between the building and the *lot line* or, where the *lot line* is more than 6 feet (1829 mm) from the building between the structure and a point 6 feet (1829 mm) from the building.

**[MP] GRAYWATER.** Waste discharged from lavatories, bathtubs, showers, clothes washers and laundry trays.

**[MP] GRIDDED WATER DISTRIBUTION SYSTEM.** A water distribution system where every water distribution pipe is interconnected so as to provide two or more paths to each fixture supply pipe.

**[RB] GROSS AREA OF EXTERIOR WALLS.** The normal projection of all *exterior walls*, including the area of all windows and doors installed therein.

**[MP] GROUND-SOURCE HEAT PUMP LOOP SYSTEM.** Piping buried in horizontal or vertical excavations or placed in a body of water for the purpose of transporting heat transfer liquid to and from a heat pump. Included in this definition are closed loop systems in which the liquid is recirculated and open loop systems in which the liquid is drawn from a well or other source.

**[RB] GUARD.** A building component or a system of building components located near the open sides of elevated walking surfaces that minimizes the possibility of a fall from the walking surface to the lower level.

**[RB] GUESTROOM.** Any room or rooms used or intended to be used by one or more guests for living or sleeping purposes.

**[RB] GYPSUM BOARD.** The generic name for a family of sheet products consisting of a noncombustible core primarily of gypsum with paper surfacing. Gypsum wallboard, gypsum sheathing, gypsum base for gypsum *veneer* plaster, exterior gypsum soffit board, predecorated gypsum board and water-resistant gypsum backing board complying with the standards listed in Section R702.3 and Part IX of this code are types of gypsum board.

**[RB] GYPSUM PANEL PRODUCT.** The general name for a family of sheet products consisting essentially of gypsum.

**[RB] GYPSUM SHEATHING.** Gypsum panel products specifically manufactured with enhanced water resistance for use as a substrate for exterior surface materials.

**[RB] GYPSUM WALLBOARD.** A gypsum board used primarily as interior surfacing for building structures.

**[RB] HABITABLE SPACE.** A space in a building for living, sleeping, eating or cooking. Bathrooms, toilet rooms, closets, halls, storage or utility spaces and similar areas are not considered *habitable spaces*.

**[RB] HANDRAIL.** A horizontal or sloping rail intended for grasping by the hand for guidance or support.

**[MP] HANGERS.** See "*Supports*."

**[MP] HAZARDOUS LOCATION.** Any location considered to be a fire hazard for flammable vapors, dust, combustible fibers or other highly combustible substances.

**HAZARDOUS LOCATION, GLAZING.** See Section R308.4.

**[MP] HEAT PUMP.** An *appliance* having heating or heating and cooling capability and that uses refrigerants to extract heat from air, liquid or other sources.

~~**[RE] HEATING DEGREE DAYS (HDD).** The sum, on an annual basis, of the difference between 65°F (18°C) and the mean temperature for each day as determined from "NOAA Annual Degree Days to Selected Bases Derived from the 1960-1990 Normals" or other weather data sources acceptable to the code official.~~

**HEATED SLAB.** Slab-on-grade construction in which the heating elements, hydronic tubing, or hot air distribution system is in contact with, or placed within or under, the slab. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RM] HEAT TRANSFER LIQUID.** The operating or thermal storage liquid in a mechanical system, including water or other liquid base, and additives at the concentration present under operating conditions used to move heat from one location to another. Refrigerants are not included as heat transfer liquids.

**[RB] HEIGHT, BUILDING.** The vertical distance from *grade plane* to the average height of the highest roof surface.

**[RB] HEIGHT, STORY.** The vertical distance from top to top of two successive tiers of beams or finished floor surfaces; and, for the topmost *story*, from the top of the floor finish to the top of the ceiling joists or, where there is not a ceiling, to the top of the roof rafters.

~~**HEAT TRAP.** An arrangement of piping and fittings, such as elbows, or a commercially available heat trap that prevents thermosyphoning of hot water during standby periods.~~

~~**[RE] HERS RATER.** An individual that has completed training and been certified by RESNET (Residential Energy Services Network) Accredited Rating Provider and has a current certification.~~

**[RE] HIGH-EFFICACY LAMPS.** Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of:

1. 60 lumens per watt for lamps over 40 watts;
2. 50 lumens per watt for lamps over 15 watts to 40 watts; and
3. 40 lumens per watt for lamps 15 watts or less.

~~**[RE] HIGH-EFFICACY LIGHT SOURCES.** For the definition applicable in Chapter 11, see Section N1101.6.~~

**[MP] HIGH-TEMPERATURE (H.T.) CHIMNEY.** A high-temperature chimney complying with the requirements of UL 103. A Type H.T. chimney is identifiable by the markings "Type H.T." on each chimney pipe section.

**[RB] HILL.** With respect to topographic wind effects, a land surface characterized by strong relief in any horizontal direction.

**[RB] HISTORIC BUILDING.** ~~Any~~ A building or structure that is one or more of the following:

1. Listed, or certified as eligible for listing by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places, in the National Register of Historic Places.
2. Designated as historic or contributing resource under an applicable state or local law.
3. Certified as a contributing resource within a National Register-listed, state designated or locally designated historic district.

~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RM] HOOD, FULL OPENING.** An exhaust hood with an opening not less than the diameter of the connecting vent.

**[MP] HORIZONTAL BRANCH, DRAINAGE.** ~~A drain pipe extending laterally from a soil or waste stack or *building drain*, that receives the discharge from one or more *fixture drains*.~~ A drainage *branch* pipe extending laterally from a soil or waste *stack* or *building drain*, with or without vertical sections or *branches*, that receives the discharge from two or more *fixture drains* or *branches* and conducts the discharge to the soil or waste *stack* or to the *building drain*.

**[MP] HORIZONTAL PIPE.** Any pipe or fitting that makes an angle of less than 45 degrees (0.79 rad) with the horizontal.

**HOT WATER.** Water at a temperature greater than ~~110°F (43°C)~~ 120ºF (49ºC).

**[RG] HOUSE PIPING.** See *"Piping system."*

**HUMIDISTAT.** A regulatory device, actuated by changes in humidity, used for automatic control of relative humidity.

**[RB] HURRICANE-PRONE REGIONS.** Areas vulnerable to hurricanes, defined as the U.S. Atlantic Ocean coast where the ultimate design wind speed, *Vult*, is greater than 115 miles per hour (51 m/s), and Hawaii, Puerto Rico, Guam, Virgin Islands and America Samoa.

**[MP] HYDROGEN-GENERATING APPLIANCE.** A self-contained package or factory-matched packages of integrated systems for generating gaseous hydrogen. Hydrogen-generating *appliances* utilize electrolysis, reformation, chemical or other processes to generate hydrogen.

**[RG] IGNITION PILOT.** A *pilot* that operates during the lighting cycle and discontinues during *main burner* operation.

**[MP] IGNITION SOURCE.** A flame, spark or hot surface capable of igniting flammable vapors or fumes. Such sources include *appliance* burners, burner ignitions and electrical switching devices.

**[RB] IMPACT PROTECTIVE SYSTEM.** Construction that has been shown by testing to withstand the impact of test missiles and that is applied, attached, or locked over exterior glazing.

**[MP] INDIRECT SYSTEM.** A solar thermal system in which the gas or liquid in the solar collector loop circulates between the solar collector and a heat exchanger and such gas or liquid is not drained from the system or supplied to the load during normal operation.

**[RP] INDIRECT WASTE PIPE.** A waste pipe that discharges into the drainage system through an ~~*air break* or~~ *air gap* into a trap, fixture or receptor.

**[RP] INDIRECT WASTE RECEPTOR.** A plumbing fixture designed to collect and dispose of liquid waste from other plumbing fixtures, plumbing equipment or appliances that are required to discharge to the drainage system through an air gap. The following types of fixtures fall within the classification of indirect liquid waste receptors: floor sinks, mop receptors, service sinks and standpipe drains with integral air gaps.

**[MP] INDIVIDUAL SEWAGE DISPOSAL SYSTEM.** A system for disposal of sewage by means of a septic tank or mechanical treatment, designed for use apart from a public sewer to serve a single establishment or building.

**[MP] INDIVIDUAL VENT.** A pipe installed to vent a single *fixture* trap that connects with the vent system above the fixture served or terminates in the open air.

**[MP] INDIVIDUAL WATER SUPPLY.** A water supply that serves one or more families, and that is not an *approved* public water supply.

**[RE] INFILTRATION.** The uncontrolled inward air leakage into a building caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RG] INFRARED RADIANT HEATER.** A heater that directs a substantial amount of its energy output in the form of infrared radiant energy into the area to be heated. Such heaters are of either the vented or unvented type.

**[RB] INSULATED SIDING.** A type of continuous insulation, with manufacturer-installed insulating material as an integral part of the cladding product, having a minimum *R* value of R-2. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] INSULATED VINYL SIDING.** A vinyl cladding product, with manufacturer-installed foam plastic insulating material as an integral part of the cladding product, having a thermal resistance of not less than R-2.

**[RB] INSULATING CONCRETE FORM (ICF).** A concrete forming system using stay-in-place forms of rigid foam plastic insulation, a hybrid of cement and foam insulation, a hybrid of cement and wood chips, or other insulating material for constructing cast-in-place concrete walls.

**[RE] INSULATING SHEATHING.** ~~An insulating board~~A rigid panel or board insulation material having a thermal resistance of not less than R-2 of the core ~~material.~~material with properties suitable for use on walls, floors, roofs or foundations. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RM] INTERLOCK.** A device actuated by another device with which it is directly associated, to govern succeeding operations of the same or allied devices. A circuit in which a given action cannot occur until after one or more other actions have taken place.

**[RB] INTERMODAL SHIPPING CONTAINER.** A six-sided steel unit originally constructed as a general cargo container used for the transport of goods and materials.

**[RP] JOINT.**

**Expansion.** A loop, return bend or return offset that provides for the expansion and contraction in a piping system and is utilized in tall buildings or where there is a rapid change of temperature, as in power plants, steam rooms and similar occupancies.

**Flexible.** Any joint between two pipes that permits one pipe to be deflected or moved without movement or deflection of the other pipe.

**Mechanical**. See "Mechanical joint."

**Slip.** A type of joint made by means of a washer or a special type of packing compound in which one pipe is slipped into the end of an adjacent pipe.

**[RM] JOINT, FLANGED.** A joint made by bolting together a pair of flanged ends.

**[RG] JOINT, FLARED.** A metal-to-metal compression joint in which a conical spread is made on the end of a tube that is compressed by a flare nut against a mating flare.

**[RG] JOINT, MECHANICAL.** A general form of gastight joints obtained by the joining of metal parts through a positive-holding mechanical construction, such as a press-connect joint, flanged joint, threaded joint, flared joint or compression joint.

**[RG] JOINT, PLASTIC ADHESIVE.** A joint made in thermoset plastic *piping* by the use of an adhesive substance ~~which~~ that forms a continuous bond between the mating surfaces without dissolving either one of them.

**[RM] JOINT, PLASTIC HEAT FUSION.** A joint made in thermoplastic piping by heating the parts sufficiently to permit fusion of the materials when the parts are pressed together.

**[RM] JOINT, PLASTIC SOLVENT CEMENT.** A joint made in thermoplastic piping by the use of a solvent or solvent cement ~~which~~ that forms a continuous bond between the mating surfaces.
**[RM] JOINT, SOLDERED.** A gas-tight joint obtained by the joining of metal parts with metallic mixtures of alloys ~~which~~ that melt at temperatures between 400ºF (204ºC) and 1,000ºF (538ºC).

**[RM] JOINT, WELDED.** A gas-tight joint obtained by the joining of metal parts in molten state.

**[RB] JURISDICTION.** The governmental unit that has adopted this code ~~under due legislative authority~~.

**[RB] KITCHEN.** An area used, or designated to be used, for the preparation of food.

**[RB] LABEL.** An identification applied on a product by the manufacturer that contains the name of the manufacturer, the function and performance characteristics of the product or material, and the name and identification of an *approved agency* and that indicates that the representative sample of the product or material has been tested and evaluated by an *approved agency*. (See also "*Manufacturer's designation*" and "*Mark*.")

**[RB] LABELED.** Appliances, *equipment*, materials or products to which have been affixed a *label*, seal, symbol or other identifying *mark* of a nationally recognized testing laboratory, approved inspection agency or other organization as approved by the North Carolina Building Code Council concerned with product evaluation that maintains periodic inspection of the production of the *labeled* items and whose labeling indicates either that the appliance, *equipment*, material or product meets identified standards or has been tested and found suitable for a specified purpose. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~
~~**LAMP.** The device in a lighting fixture that provides illumination, typically a bulb, fluorescent tube, or light emitting diode (LED).~~

**LAUNDRY TRAY**. a fixed tub with running water and drainpipe for washing clothes and other household linens, also called set tub.

**LAVATORY.** A hand-washing plumbing fixture located in a bathroom, or toilet room.

**[RP] LEAD-FREE PIPE AND FITTINGS.** Containing not more than a weighted average of 0.25-percent lead when used with respect to the wetted surfaces of pipes, pipe fittings, plumbing fittings, and fixtures.

**[RP] LEAD-FREE SOLDER AND FLUX.** Containing not more than 0.2-percent lead**.**

**[RP] LEADER.** An exterior drainage pipe for conveying storm water from roof or gutter drains to an *approved* means of disposal.

**[RG] LIQUEFIED PETROLEUM GAS or LPG (LP-GAS).** *Liquefied petroleum gas* composed predominately of propane, propylene, butanes or butylenes, or mixtures thereof that is gaseous under normal atmospheric conditions, but is capable of being liquefied under moderate pressure at normal temperatures.

**[RG] LEAK CHECK.** An operation performed on a gas *piping system* to verify that the system does not leak.

**[RB] LIGHT-FRAME CONSTRUCTION.** Construction whose vertical and horizontal structural elements are primarily formed by a system of repetitive wood or cold-formed steel framing members.

**[RB] LISTED.** Appliances, *equipment*, materials, products or services included in a list published by an organization acceptable to the code official and concerned with evaluation of products or services that maintains periodic inspection of production of *listed equipment* or materials or periodic evaluation of services and whose listing states either that the appliance, *equipment*, material, product or service meets identified standards or has been tested and found suitable for a specified purpose. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] LIVE LOADS.** Those loads produced by the use and occupancy of the building or other structure and do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load or dead load.

**[RB] LIVE/WORK UNIT.** A dwelling unit in which more than 10 percent and less than 50 percent of the space includes a nonresidential use that is operated by the tenant.

**[MP] LIVING SPACE.** Space within a *dwelling unit* utilized for living, sleeping, eating, cooking, bathing, washing and sanitation purposes.

**[MP] LOCAL EXHAUST.** An exhaust system that uses one or more fans to exhaust air from a specific room or rooms within a dwelling.

**[MP] LOCKING-TYPE TAMPER-RESISTANT CAP.** A cap designed to be unlocked by a specially designed tool or key to prevent removal of the cap by means of hand-loosening or by commonly available tools.

**[RB] LODGING HOUSE.** A one-family dwelling where one or more occupants are primarily permanent in nature, and rent is paid for guestrooms.

**[RG] LOG LIGHTER.** A manually operated solid-fuel ignition *appliance* for installation in a vented solid-fuel-burning *fireplace*.

**[RB] LOT.** A measured portion or parcel of land considered as a unit having fixed boundaries.

**[RB] LOT LINE.** ~~A line dividing one *lot* from another, or from a street or any public place.~~ The line that bounds a plot of ground described as a lot in the title to the property.

**[RM] LOW-PRESSURE HOT-WATER-HEATING BOILER.** A boiler furnishing hot water at pressures not exceeding 160 psi (1103 kPa) and at temperatures not exceeding 250ºF (121ºC).

**[RM] LOW-PRESSURE STEAM-HEATING BOILER.** A boiler furnishing steam at pressures not exceeding 15 psi (103 kPa).

**[MP] LOCAL EXHAUST.** An exhaust system that uses one or more fans to exhaust air from a specific room or rooms within a dwelling.

**[MP] LOCKING-TYPE TAMPER-RESISTANT CAP.** A cap designed to be unlocked by a specially designed tool or key to prevent removal of the cap by means of hand-loosening or by commonly available tools.

**[RB] LODGING HOUSE**. A one-family dwelling where one or more occupants are primarily permanent in nature, and rent is paid for guestrooms.

**[RE] LOW-VOLTAGE LIGHTING.** Lighting equipment powered through a transformer such as a cable conductor, a rail conductor and track lighting. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**LOWEST FLOOR.** The lowest floor of the lowest enclosed area (including basement). An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access or storage in an area other than a basement area is not considered a building's lowest floor, provided that unenclosed areas below the lowest floor of elevated buildings be free of obstructions and that enclosed areas be enclosed by open lattice-work, insect screening or non-supporting breakaway walls in accordance with the National Flood Insurance Program located in *coastal high hazard areas*.

**[MP] MACERATING TOILET SYSTEMS.** A system comprised of a sump with macerating pump and with connections for a water closet and other plumbing fixtures, that is designed to accept, grind and pump wastes to an *approved* point of discharge.

**[MP] MAIN.** The principal pipe artery to which branches may be connected.

**[RG] MAIN BURNER.** A device or group of devices essentially forming an integral unit for the final conveyance of gas or a mixture of gas and air to the combustion zone, and on which combustion takes place to accomplish the function for which the *appliance* is designed.

**[MP] MAIN SEWER.** See "*Public sewer*."

**[MP] MANIFOLD WATER DISTRIBUTION SYS-TEMS.** A fabricated piping arrangement in which a large supply main is fitted with multiple branches in close proximity in which water is distributed separately to fixtures from each branch.

**[RE] MANUAL.** Capable of being operated by personal intervention (see "Automatic"). ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] MANUFACTURED HOME.** A structure, transportable in one or more sections, that in the traveling mode is 8 body feet (2438 body mm) or more in width or 40 body feet (12 192 body mm) or more in length, or, where erected on site, is 320 square feet (30 $m^2$) or more, and that is built on a permanent chassis and designed to be used as a *dwelling* with or without a permanent foundation where connected to the required utilities, and includes the plumbing, heating, air-conditioning and electrical systems contained therein; except that such term shall include any structure that meets all the requirements of this paragraph except the size requirements and with respect to which the manufacturer voluntarily files a certification required by the secretary (HUD) and complies with the standards established under this title. For mobile homes built prior to June 15, 1976, a *label* certifying compliance to the Standard for Mobile Homes, NFPA 501, in effect at the time of manufacture is required. For the purpose of these provisions, a mobile home shall be considered to be a *manufactured home*.

~~**[RE] MASS WALL.** Masonry or concrete walls having a mass greater than or equal to 30 pounds per square foot (146 kg/$m^2$), solid wood walls having a mass greater than or equal to 20 pounds per square foot (98 kg/$m^2$), and any other walls having a heat capacity greater than or equal to 6 Btu/$ft^2$ · °F [123 J/($m^2$ · K)].~~

**[RB] MANUFACTURER'S DESIGNATION.** An identification applied on a product by the manufacturer indicating that a product or material complies with a specified standard or set of rules. (See also "*Mark*" and "*Label*.")

**[RB] MANUFACTURER'S INSTALLATION INSTRUCTIONS.** Printed instructions included with equipment as part of the conditions of their *listing* and *labeling*.

**[RB] MARK.** An identification applied on a product by the manufacturer indicating the name of the manufacturer and the function of a product or material. (See also "*Manufacturer's designation*" and "*Label*.")

**[RB] MASONRY, SOLID.** Masonry consisting of *solid masonry* units laid contiguously with the joints between the units filled with mortar.

**[RB] MASONRY CHIMNEY.** A field-constructed chimney composed of *solid masonry* units, bricks, stones or concrete.

**[RB] MASONRY HEATER.** A masonry heater is a solid fuel burning heating *appliance* constructed predominantly of concrete or *solid masonry* having a mass of not less than 1,100 pounds (500 kg), excluding the chimney and foundation. It is designed to absorb and store a substantial portion of heat from a fire built in the firebox by routing exhaust gases through internal heat exchange channels in which the flow path downstream of the firebox includes not less than one 180-degree (3.14-rad) change in flow direction before entering the chimney and that deliver heat by radiation through the masonry surface of the heater.

**[RB] MASONRY UNIT.** Brick, tile, stone, architectural cast stone, glass block or concrete block conforming to the requirements specified in Section 2103 of the *International Building Code*.

**Clay.** A building unit larger in size than a brick, composed of burned clay, shale, fire clay or mixtures thereof.

**Concrete.** A building unit or block larger in size than 12 inches by 4 inches by 4 inches (305 mm by 102 mm by 102 mm) made of cement and suitable aggregates.

**Glass.** Nonload-bearing masonry composed of glass units bonded by mortar.

**Hollow.** A *masonry unit* with a net cross-sectional area in any plane parallel to the loadbearing surface that is less than 75 percent of its gross cross-sectional area measured in the same plane.

**Solid.** A *masonry unit* with a net cross-sectional area in every plane parallel to the loadbearing surface that is 75 percent or more of its cross-sectional area measured in the same plane.

**[RB] MEAN ROOF HEIGHT.** The average of the roof eave height and the height to the highest point on the roof surface, except that eave height shall be used for roof angle of less than or equal to 10 degrees (0.18 rad).

**[MP] MECHANICAL DRAFT SYSTEM.** A venting system designed to remove flue or vent gases by mechanical means, that consists of an induced draft portion under nonpositive static pressure or a forced draft portion under positive static pressure.

**Forced draft venting system.** A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under positive static pressure.

**Induced draft venting system.** A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under nonpositive static vent pressure.

**Power venting system.** A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under positive static vent pressure.

**[MP] MECHANICAL EXHAUST SYSTEM.** A system for removing air from a room or space by mechanical means.

**[MP] MECHANICAL JOINT.**

1. A connection between pipes, fittings or pipes and fittings that is not welded, brazed, caulked, soldered, solvent cemented or heat fused.
2. A general form of gastight or liquid-tight connections obtained by the joining of parts through a positive holding mechanical construction such as, but not limited to, flanged, screwed, clamped or flared connections.

**[MP] MECHANICAL SYSTEM.** A system specifically addressed and regulated in this code and composed of components, devices, *appliances* and *equipment*.

**[RB] METAL ROOF PANEL.** An interlocking metal sheet having an installed weather exposure of not less than 3 square feet (0.28 $m^2$) per sheet.

**[RB] METAL ROOF SHINGLE.** An interlocking metal sheet having an installed weather exposure less than 3 square feet (0.28 $m^2$) per sheet.

**METER.** The instrument installed to measure the volume of gas delivered through it or a measuring device used to collect data and indicate water usage.

**[RB] MEZZANINE.** An intermediate level or levels between the floor and ceiling of any *story*.

**[RB] MODIFIED BITUMEN ROOF COVERING.** One or more layers of polymer modified asphalt sheets. The sheet materials shall be fully adhered or mechanically attached to the substrate or held in place with an *approved* ballast layer.

**MSL**. Mean Sea Level as defined by National Geodetic Vertical Datum.

**[RG] MODULATING.** Modulating or throttling is the action of a *control* from its maximum to minimum position in either predetermined steps or increments of movement as caused by its actuating medium.

**[RB] MULTIPLE-STATION SMOKE ALARM.** Two or more single-station alarm devices that are capable of interconnection such that actuation of one causes all integral or separate audible alarms to operate.

**[RB] NAILABLE SUBSTRATE.** A product or material such as framing, sheathing or furring, composed of wood or wood-based materials, or other materials and fasteners providing equivalent fastener withdrawal resistance.

**[MP] NATURAL DRAFT SYSTEM.** A venting system designed to remove flue or vent gases under nonpositive static vent pressure entirely by natural draft.

**[RM] NATURAL VENTILATION.** The movement of air into and out of a space through intentionally provided openings, such as windows and doors, or through nonpowered ventilators.

**[RB] NATURALLY DURABLE WOOD.** The heartwood of the following species with the exception that an occasional piece with corner sapwood is permitted if 90 percent or more of the width of each side on which it occurs is heartwood.

**Decay resistant.** Redwood, cedar, black locust and black walnut.

**Termite resistant.** Alaska yellow cedar, redwood, Eastern red cedar and Western red cedar including all sapwood of Western red cedar.

**[RB] NONCOMBUSTIBLE MATERIAL.** ~~Materials~~ A material that pass ~~the test procedure for defining non combustibility of elementary materials set forth in~~ ASTM E136.

**[RB] NOSING.** The leading edge of treads of stairs and of landings at the top of *stairway* flights.

**[RM] OCCUPIABLE SPACE.** An enclosed space intended for human activities, excluding those spaces intended primarily for other purposes, such as storage rooms and *equipment* rooms, that are only intended to be occupied occasionally and for short periods of time.

**[RB] OCCUPIED SPACE.** The total area of all buildings or structures on any *lot* or parcel of ground projected on a horizontal plane, excluding permitted projections as allowed by this code.

**OCEAN HAZARD AREA.** An area, as identified by the North Carolina Coastal Resources Commission, near the shoreline of the Atlantic Ocean that has been identified as subject to at least one of the following hazards: (A) Historical or predicted future trends of long-term erosion, (B) erosion expected to occur during a coastal storm reaching the base flood elevation, or (C) shoreline fluctuations due to tidal inlets.

**[MP] OFFSET.** A combination of fittings that makes two changes in direction, bringing one section of the pipe out of line and into a line parallel with the other section.

**[RG] OFFSET (VENT).** A combination of *approved* bends that make two changes in direction bringing one section of the vent out of line, but into a line parallel with the other section.

**[MP] ON-SITE NONPOTABLE WATER REUSE SYSTEMS.** Water systems for the collection, treatment, storage, distribution, and reuse of nonpotable water generated on site, including but not limited to graywater systems. This definition does not include rainwater harvesting systems.

~~**[RE] ON-SITE RENEWABLE ENERGY.** Includes solar photovoltaic; active solar thermal that employs collection panels, heat transfer mechanical components; wind; small hydro; tidal; wave energy; geothermal (core earth); biomass energy systems; landfill gas and bio-fuel based electrical production. On-site energy shall be generated on or adjacent to the project site and shall not be delivered to the project through the utility service.~~
~~**[RP] OPEN AIR.** Outside the structure.~~

~~**[RE] OPAQUE DOOR.** For the definition applicable in Chapter 11, see Section N1101.6.~~

**[MP] OFFSET.** A combination of fittings that makes two changes in direction, bringing one section of the pipe out of line and into a line parallel with the other section.

**[RG] OFFSET (VENT).** A combination of *approved* bends that make two changes in direction bringing one section of the vent out of line, but into a line parallel with the other section.

**[MP] ON-SITE NONPOTABLE WATER REUSE SYSTEMS.** Water systems for the collection, treatment, storage, distribution, and reuse of nonpotable water generated on site, including but not limited to graywater systems. This definition does not include rainwater harvesting systems.

**[RB] PAN FLASHING.** Corrosion-resistant flashing at the base of an opening that is integrated into the building exterior wall to direct water to the exterior and is premanufactured, fabricated, formed or applied at the job site.

**[RM] PANEL HEATING.** A method of radiant space heating in which heat is supplied by large heated areas of room surfaces. The heating element usually consists of warm water piping, warm air ducts, or electrical resistance elements embedded in or located behind ceiling, wall or floor surfaces.

**[RB] PANEL THICKNESS.** Thickness of core plus two layers of structural wood panel facings.

**[MP] PELLET FUEL-BURNING APPLIANCE.** A closed combustion, vented *appliance* equipped with a fuel feed mechanism for burning processed pellets of solid fuel of a specified size and composition.

**[MP] PELLET VENT.** A vent *listed* and *labeled* for use with a *listed* pellet fuel-burning *appliance*.

**[RB] PERFORMANCE CATEGORY.** A designation of wood structural panels as related to the panel performance used in Chapters 4, 5, 6 and 8.

**[RB] PERMIT.** An official document or certificate issued by the *building official* that authorizes performance of a specified activity.

**[RB] PERSON.** An individual, heirs, executors, administrators or assigns, and a firm, partnership or corporation, its or their successors or assigns, or the agent of any of the aforesaid.

**[RB] PHOTOVOLTAIC MODULE.** A complete, environmentally protected unit consisting of solar cells, optics and other components, exclusive of a tracker, designed to generate DC power where exposed to sunlight.

**[RB] PHOTOVOLTAIC PANEL.** A collection of *photovoltaic modules* mechanically fastened together, wired, and designed to provide a field-installable unit.

**[RB] PHOTOVOLTAIC PANEL SYSTEM.** A system that incorporates discrete photovoltaic panels that convert solar radiation into electricity, including rack support systems.

**[RB] PHOTOVOLTAIC SHINGLES.** A *roof covering* that resembles shingles and that incorporates *photovoltaic modules*.

**PIER.** An elevated deck structure, usually pile supported, extending out into the water from the shore.

**[RG] PILOT.** A small flame that is utilized to ignite the gas at the *main burner* or *burners*.

**PIPE SIZES.** For the purposes of determining the minimum size of pipe required, cross-sectional areas are the essential characteristic, not the pipe diameter. When the Code instructs to "increase by one pipe size," some pipe sizes may not be commercially available. The following pipe sizes are presumed to be commercially available: 1/2, 3/4, 1, 1-1/4, 1-1/2, 2, 2-1/2, 3, 3-1/2, 4, 4-1/2, 5, 6, 7, 8, 9, 10.

**[RG] PIPING.** Where used in this code, *"piping"* refers to either *pipe* or *tubing*, or both.

**Pipe.** A rigid conduit of iron, steel, copper, copper-alloy or plastic.

**Tubing.** Semirigid conduit of copper, copper-alloy, aluminum, plastic or steel.

**[RG] PIPING SYSTEM.** The fuel *piping*, valves and fittings from the outlet of the *point of delivery* to the outlets of the *appliance* shutoff valves.

**[MP] PITCH.** See "*Slope*."

**PLANS.** Construction documents.

**[RB] PLASTIC COMPOSITE.** A generic designation that refers to wood-plastic composites and plastic lumber.

**[RG] PLASTIC, THERMOPLASTIC.** A plastic that is capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature.

**[RB] PLATFORM CONSTRUCTION.** A method of construction by which floor framing bears on load bearing walls that are not continuous through the *story* levels or floor framing.

**[MP] PLENUM.** An enclosed portion of the building structure, other than an *occupiable space* being conditioned, that is designed to allow air movement, and thereby serve as part of an air distribution system.

**[MP] PLUMBING.** The practice, materials and fixtures utilized in the installation, maintenance, extension and alteration of all piping, fixtures, plumbing appliances and plumbing appurtenances, within or adjacent to any structure, in connection with sanitary drainage or storm drainage facilities; venting systems; and public or private water supply systems. For the purpose of this code, plumbing refers to those installations, repairs, maintenance and *alterations* regulated by Chapters 25 through 33.

**[MP] PLUMBING APPLIANCE.** An energized household *appliance* with plumbing connections, such as a dishwasher, food waste disposer, clothes washer or water heater. These devices have their operation or control dependent on one or more energized components, such as motors, controls or heating elements. Such devices are manually adjusted or controlled by the owner or operator, or are operated automatically through one or more of the following actions: a time cycle, a temperature range, a pressure range, a measured volume or weight.

**[MP] PLUMBING APPURTENANCE.** A manufactured device, prefabricated assembly or on-the-job assembly of component parts that is an adjunct to the basic piping system and plumbing fixtures. An appurtenance demands no additional water supply and does not add any discharge load to a fixture or to the drainage system. Examples include filters, relief valves and aerators.

**[MP] PLUMBING FIXTURE.** A receptacle or device that is either permanently or temporarily connected to the water distribution system of the premises and demands a supply of water therefrom; or discharges wastewater, liquid-borne waste materials or sewage either directly or indirectly to a drainage system of the premises; or requires both a water supply connection and a discharge to the drainage system of the premises.

**[MP] PLUMBING SYSTEMS.** Includes the water distribution pipes; plumbing fixtures and traps; water-treating or water-using equipment; soil, waste and vent pipes; and building drains; in addition to their respective connections, devices and appurtenances within a structure or premises; and the water service, building sewer and building storm sewer serving such structure or premises.

**[RG] POINT OF DELIVERY.** For natural gas systems, the *point of delivery* is the outlet of the service meter assembly or the outlet of the service regulator or service shutoff valve where a meter is not provided. Where a system shutoff valve is provided ~~at~~ after the outlet of the service meter assembly, such valve shall be considered to be downstream of the *point of delivery*. For undiluted liquefied petroleum gas systems, the point of delivery shall be considered to be the outlet of the first regulator that reduces pressure.

**[MP] POLLUTION.** An impairment of the quality of the potable water to a degree that does not create a hazard to the public health and that does adversely and unreasonably affect the aesthetic qualities of such potable water for domestic use.

**[RB] POLYPROPYLENE SIDING.** A shaped material, made principally from polypropylene homopolymer, or copolymer, that in some cases contains fillers or reinforcements, that is used to clad exterior walls or buildings.

**[MP] PORTABLE-FUEL-CELL APPLIANCE.** A fuel cell generator of electricity that is not fixed in place. A portable-fuel-cell *appliance* utilizes a cord and plug connection to a grid-isolated load and has an integral fuel supply.

**[RB] POSITIVE ROOF DRAINAGE.** The drainage condition in which consideration has been made for the loading deflections of the *roof deck*, and additional slope has been provided to ensure drainage of the roof within 48 hours of precipitation.

**[MP] POTABLE WATER.** Water free from impurities present in amounts sufficient to cause disease or harmful physiological effects and conforming in bacteriological and chemical quality of the Public Health Service Drinking Water Standards or to the ~~requirements~~ regulations of the public health authority having *jurisdiction*.

**[RB] PRECAST CONCRETE.** A structural concrete element cast elsewhere than its final position in the structure.

**[RB] PRECAST CONCRETE FOUNDATION WALLS.** Preengineered, *precast concrete* wall panels that are designed to withstand specified stresses and used to build below-*grade* foundations.

**[RM] ~~PRESS~~ PRESS-CONNECT JOINT.** A permanent mechanical joint incorporating an elastomeric seal or an elastomeric seal and corrosion-resistant grip ring. The joint is made with a pressing tool and jaw or ring approved by the fitting manufacturer.

**[RG] PRESSURE DROP.** The loss in pressure due to friction or obstruction in pipes, valves, fittings, *regulators* and *burners*.

**[RM] PRESSURE RELIEF DEVICE.** A pressure-actuated valve or rupture member designed to relieve excessive pressure automatically.

**[RG] PRESSURE TEST.** An operation performed to verify the gastight integrity of *gas piping* following its installation or modification.

**[MP] PRESSURE-RELIEF VALVE.** A pressure-actuated valve held closed by a spring or other means and designed to automatically relieve pressure at the pressure at which it is set.

**PRIMARY STRUCTURAL FRAME**. The primary structural frame shall include all of the following structural members:

1. The columns.

2. Structural members having direct connections to the columns, including girders, beams, trusses and spandrels.
3. Members of the floor construction and roof construction having direct connections to the columns.
4. Members that are essential to the vertical stability of the *primary structural frame* under gravity loading.

**PRIVATE POND.** A body of water owned entirely by a single property owner and located on the same parcel of land as a detached single-family dwelling.

**[RM] PROTECTIVE ASSEMBLY (REDUCED CLEARANCE).** Any noncombustible assembly that is *labeled* or constructed in accordance with Table M1306.2 and is placed between combustible materials or assemblies and mechanical *appliances*, devices or *equipment*, for the purpose of reducing required airspace *clearances*. Protective assemblies attached directly to a combustible assembly shall not be considered as part of that combustible assembly.

**[RE] PROPOSED DESIGN.** A description of the proposed building used to estimate annual energy use for determining compliance based on total building performance. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[MP] PUBLIC SEWER.** A common sewer directly controlled by public authority.

**[MP] PUBLIC WATER MAIN.** A water-supply pipe for public use controlled by public authority.

**[RB] PUBLIC WAY.** Any street, alley or other parcel of land open to the outside air leading to a public street, that has been deeded, dedicated or otherwise permanently appropriated to the public for public use and that has a clear width and height of not less than 10 feet (3048 mm).

**[MP] PURGE.** To clear of air, gas or other foreign substances.

**[MP] PUSH-FIT JOINTS.** A type of mechanical joint consisting of elastomeric seals and corrosion-resistant tube grippers. Such joints are permanent or removable depending on the design.

**[MP] QUICK-CLOSING VALVE.** A valve or faucet that closes automatically where released manually or controlled by mechanical means for fast-action closing.

**[RM] RADIANT HEATER.** A heater designed to transfer heat primarily by direct radiation.

**[RP] RAINWATER.** Water from natural precipitation.

**[RB] RAMP.** A walking surface that has a running slope steeper than 1 unit vertical in 20 units horizontal (5-percent slope).

~~**[RE] *R*-VALUE (THERMAL RESISTANCE).** The inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other for a unit temperature difference between the two surfaces, under steady state conditions, per unit area (h · ft2 · °F/Btu) [m2 · k/w].~~

**[RE] RATED DESIGN.** A description of the proposed *building,* used to determine the energy rating index. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**READY ACCESS (TO).** That which enables a device, *appliance* or *equipment* to be directly reached, without requiring the removal or movement of any panel, door or similar obstruction ~~[see "Access (to)"]~~.

~~**[RM] RECIRCULATED AIR.** Air removed from a conditioned space and intended for reuse as supply air.~~

~~**[RE] REFLECTIVE DUCT INSULATION.** A thermal insulation assembly consisting of one or more surfaces that have an emittance of 0.1 or less, and that bound an enclosed air space or spaces.~~

~~**[RG] REGULATOR.** A device for controlling and maintaining a uniform gas supply pressure, either pounds-to-inches water column (MP regulator) or inches-to-inches water column (*appliance regulator*).~~

~~**[RG] REGULATOR, GAS APPLIANCE.** A *pressure regulator* for controlling pressure to the manifold of the gas *appliance*.~~

~~**Adjustable.**~~

~~1. Spring-type, limited adjustment. A regulator in which the regulating force acting upon the diaphragm is derived principally from a spring, the loading of which is adjustable over a range of not more than 15 percent of the outlet pressure at the midpoint of the adjustment range.~~

~~2. Spring-type, standard adjustment. A regulator in which the regulating force acting upon the diaphragm is derived principally from a spring, the loading of which is adjustable. The adjustment means shall be concealed.~~

~~**Multistage.** A regulator for use with a single gas whose adjustment means is capable of being positioned manually or automatically to two or more predetermined outlet pressure settings. Each of these settings shall be adjustable or~~

~~nonadjustable. The regulator may modulate outlet pressures automatically between its maximum and minimum predetermined outlet pressure settings.~~

~~**Nonadjustable.**~~

~~1. Spring-type, nonadjustable. A regulator in which the regulating force acting upon the diaphragm is derived principally from a spring, the loading of which is not field adjustable.~~

~~2. Weight-type. A regulator in which the regulating force acting upon the diaphragm is derived from a weight or combination of weights.~~

**[MP] RECEPTOR.** A fixture or device that receives the discharge from indirect waste pipes.

**[MP] RECLAIMED WATER.** Nonpotable water that has been derived from the treatment of wastewater by a facility or system licensed or permitted to produce water meeting the *jurisdiction's* water requirements for its intended uses. Also known as "recycled water."

**[RP] REDUCED PRESSURE PRINCIPLE BACKFLOW PREVENTION ASSEMBLY.** A backflow prevention device consisting of two independently acting check valves, internally force-loaded to a normally closed position and separated by an intermediate chamber (or zone) in which there is an automatic relief means of venting to the atmosphere, internally loaded to a normally open position between two tightly closing shutoff valves and with a means for testing for tightness of the checks and opening of the relief means.

**[MP] REFRIGERANT.** A substance used to produce refrigeration by its expansion or evaporation.

**[MP] REFRIGERANT COMPRESSOR.** A specific machine, with or without accessories, for compressing a given refrigerant vapor.

**[MP] REFRIGERATING SYSTEM.** A combination of interconnected parts forming a closed circuit in which refrigerant is circulated for the purpose of extracting, then rejecting, heat. A direct refrigerating system is one in which the evaporator or condenser of the refrigerating system is in direct contact with the air or other substances to be cooled or heated. An indirect refrigerating system is one in which a secondary coolant cooled or heated by the refrigerating system is circulated to the air or other substance to be cooled or heated.

**[RB] REGISTERED DESIGN PROFESSIONAL.** An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or *jurisdiction* in which the project is to be constructed. Design by a registered design professional is not required where exempt under North Carolina general statutes or licensure laws.

**[RG] REGULATOR, LINE GAS PRESSURE.** A device placed in a gas line between the *service pressure regulator* and the *appliance* for controlling, maintaining or reducing the pressure in that portion of the *piping system* downstream of the device.

**[RG] REGULATOR, MEDIUM-PRESSURE (MP Regulator).** A line *pressure regulator* that reduces gas pressure from the range of greater than 0.5 psig (3.4 kPa) and less than or equal to 5 psig (34.5 kPa) to a lower pressure.

**[RG] REGULATOR, MONITORING.** A pressure regulator set in series with another pressure regulator for the purpose of preventing an overpressure in the downstream piping system.

**[RG] REGULATOR, PRESSURE.** A device placed in a gas line for reducing, controlling and maintaining the pressure in that portion of the *piping system* downstream of the device.

**[RG] REGULATOR, SERVICE PRESSURE.** For natural gas systems, a device installed by the serving gas supplier to reduce and limit the service line pressure to delivery pressure. For undiluted liquefied petroleum gas systems, the regulator located upstream from all line gas pressure regulators, where installed, and downstream from any first stage or a high pressure regulator in the system.

**[RG] RELIEF OPENING.** The opening provided in a *draft hood* to permit the ready escape to the atmosphere of the flue products from the *draft hood* in the event of no *draft*, backdraft or stoppage beyond the *draft hood*, and to permit air into the *draft hood* in the event of a strong chimney updraft.

**[RG] RELIEF VALVE (DEVICE).** A safety valve designed to forestall the development of a dangerous condition by relieving either pressure, temperature or vacuum in the hot water supply system.

**[RG] RELIEF VALVE, PRESSURE.** An *automatic valve* that opens and closes a relief vent, depending on whether the pressure is above or below a predetermined value.

**[RG] RELIEF VALVE, TEMPERATURE.**

**Manual reset type.** A valve that automatically opens a *relief* vent at a predetermined temperature and that must be manually returned to the closed position.

**Reseating or self-closing type.** An *automatic valve* that opens and closes a relief vent, depending on whether the temperature is above or below a predetermined value.

**[MP] RELIEF VALVE, VACUUM.** A device to prevent excessive buildup of vacuum in a pressure vessel.

**[RP] RELIEF VENT.** A vent whose primary function is to provide circulation of air between drainage and vent systems.

**[RB] REPAIR.** The ~~restoration~~ restoration, replacement or renewal of any part of an existing building for the purpose of its maintenance or to correct damage. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] REROOFING.** The process of recovering or replacing an existing roof covering. See "Roof recover." ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

~~**[RE] RESIDENTIAL BUILDING.** For the definition applicable in Chapter 11, see Section N1101.6.~~

**[MP] RETURN AIR.** Air removed from an *approved conditioned space* or location and recirculated or exhausted.

**[RM] RETURN AIR SYSTEM.** An assembly of connected ducts, *plenums*, fittings, registers and grilles through which air from the space or spaces to be heated or cooled is conducted back to the supply unit (see also *Supply air system*).

**[RB] RIDGE.** With respect to topographic wind effects, an elongated crest of a *hill* characterized by strong relief in two directions.

**[RP] RIM.** An unobstructed open edge of a fixture.

**[RG] RISER, GAS.** A vertical *pipe* supplying fuel gas.

~~**[RB] RISER.**~~
~~1. The vertical component of a step or stair.~~
~~2. A water pipe that extends vertically one full *story* or more to convey water to branches or to a group of fixtures.~~

**[MP] RISER (PLUMBING).** A water pipe that extends vertically one full *story* or more to convey water to branches or to a group of fixtures.

**[RB] RISER (STAIR).** The vertical component of a step or *stair*.

**[RB] ROOF ASSEMBLY.** A system designed to provide weather protection and resistance to design loads. The system consists of a roof covering and roof deck or a single component serving as both the roof covering and the roof deck. A roof assembly ~~includes the roof deck, vapor retarder, substrate or~~ can include an underlayment, thermal barrier, ignition barrier, insulation, or a vapor ~~retarder, and roof covering.~~retarder. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] ROOF COATING.** A fluid-applied, adhered coating used for roof maintenance or *roof repair*, or as a component of a *roof covering* system or *roof assembly*.

**[RB] ROOF COVERING.** The covering applied to the *roof deck* for weather resistance, fire classification or appearance.

**[RB] ROOF COVERING SYSTEM.** See "*Roof assembly*."

**[RB] ROOF DECK.** The flat or sloped surface not including its supporting members or vertical supports.

**[RB] ROOF RECOVER.** The process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] ROOF REPAIR.** Reconstruction or renewal of any part of an existing roof for the purposes of its maintenance. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] ROOF REPLACEMENT.** The process of removing the existing *roof covering*, repairing any damaged substrate and installing a new *roof covering*. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

~~**[RB] ROOFTOP STRUCTURE.** An enclosed structure on or above the roof of any part of a building.~~

**[MP] ROOM HEATER.** A free-standing heating *appliance* installed in the space being heated and not connected to ducts.

**[RG] ROOM HEATER, UNVENTED.** ~~An unvented heating *appliance* designed for stationary installation and utilized to provide comfort heating. Such *appliances* provide radiant heat or convection heat by gravity or fan circulation directly from the heater and do not utilize ducts.~~ See "*Unvented room heater*."

**[RG] ROOM HEATER, VENTED.** A free-standing heating unit used for direct heating of the space in and adjacent to that in which the unit is located. (See "Vented room heater.")

**[MP] ROUGH-IN.** The installation of the parts of the plumbing system that must be completed prior to the installation of fixtures. This includes DWV, water supply and built-in fixture supports.

**[RB] RUNNING BOND.** The placement of *masonry units* such that head joints in successive courses are horizontally offset not less than one-quarter the unit length.

~~**[RE] *R*-VALUE (THERMAL RESISTANCE).** For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RG] SAFETY SHUTOFF DEVICE.** See "*Flame safeguard*."

**[MP] SANITARY SEWER.** A sewer that carries sewage and excludes storm, surface and groundwater.

**SCREEN ENCLOSURE.** A building or part thereof, in whole or in part self-supporting, and having walls of insect screening with or without removable vinyl or acrylic wind break panels 10 mil or less with a Class A Flame Spread, and a roof.

**[RB] SCUPPER.** An opening in a wall or parapet that allows water to drain from a roof.

**[RB] SEISMIC DESIGN CATEGORY (SDC).** A classification assigned to a structure based on its occupancy category and the severity of the design earthquake ground motion at the site.

**[RM] SELF-CONTAINED EQUIPMENT.** Complete, factory-assembled and tested, heating, air-conditioning or refrigeration *equipment* installed as a single unit, and having all working parts, complete with motive power, in an enclosed unit of said machinery.

**[MP] SEPTIC TANK.** A watertight receptor that receives the discharge of a building sanitary drainage system and is constructed so as to separate solids from the liquid, digest organic matter through a period of detention, and allow the liquids to discharge into the soil outside of the tank through a system of open joint or perforated piping or a seepage pit.

~~**SCREW LAMP HOLDERS.** A lamp base that requires a screw-in-type lamp, such as a compact-fluorescent, incandescent, or tungsten-halogen bulb.~~

~~**[RP] SELF-CLOSING FAUCET.** A faucet containing a valve that automatically closes upon deactivation of the opening means.~~

~~**SEMI-CONDITIONED SPACE.** A space within the building thermal envelope that is not directly heated and/or cooled.~~

**[RG] SERVICE METER ASSEMBLY.** The meter, valve, regulator, piping, fittings and equipment installed by the service gas supplier before the *point of delivery*.

**SERVICE WATER HEATING.** Supply of hot water for purposes other than comfort heating. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[MP] SEWAGE.** Any liquid waste containing animal matter, vegetable matter or other impurity in suspension or solution. Any liquid waste containing animal or vegetable matter in suspension or solution, including liquids containing chemicals in solution.

**[RP] SEWAGE EJECTOR.** A device for lifting sewage by entraining the sewage in a high-velocity jet of steam, air or water.

**[MP] SEWAGE PUMP.** A permanently installed mechanical device for removing sewage or liquid waste from a sump.

**[RP] SEWER.**

**Building sewer.** See "Building sewer."

**Public sewer.** That part of the drainage system of pipes, installed and maintained by a city, township, county, public utility company or other public entity, and located on public property, in the street or in an approved dedicated easement of public or community use.

**Sanitary sewer**. A *sewer* that carries sewage and excludes storm, surface and ground water.

**Storm sewer.** A *sewer* that conveys rainwater, surface water, subsurface water and similar liquid wastes**.**

**SHAFT.** An enclosed space extending through one or more stories of a building, connecting vertical openings in successive floors, or floors and the roof.

**SHAFT ENCLOSURE.** The walls or construction forming the boundaries of a shaft.

**[RB] SHALL.** The term, where used in the code, is construed as mandatory.

**[RB] SHEAR WALL.** A general term for walls that are designed and constructed to resist racking from seismic and wind by use of masonry, concrete, cold-formed steel or wood framing in accordance with Chapter 6 of this code and the associated limitations in Section R301.2 of this code.

**[RB] SHINGLE FASHION.** A method of installing roof or wall coverings, *water-resistive barriers*, flashing or other building components such that upper layers of material are placed overlapping lower layers of material to provide drainage and protect against water intrusion at unsealed penetrations and joints or in combination with sealed joints.

**SIDE VENT.** A vent connecting to the drain pipe through a fitting at an angle less than 45 degrees (0.79 rad) to the horizontal.

**[RB] SINGLE-PLY MEMBRANE.** A roofing membrane that is field applied using one layer of membrane material (either homogeneous or composite) rather than multiple layers.

**[RB] SINGLE-STATION SMOKE ALARM.** An assembly incorporating the detector, control equipment and alarm sounding device in one unit that is operated from a power supply either in the unit or obtained at the point of installation.

~~**[RE] SITE-RECOVERED ENERGY.** Waste energy recovered at the building site that is used to off-set consumption of purchased fuel or electrical energy supplies.~~

**[RE] SKYLIGHT.** Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees (1.05 rad) from horizontal. Glazing material in skylights, including unit skylights, solariums, sunrooms, roofs and sloped walls is included in this definition. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] SKYLIGHT, UNIT.** A factory assembled, glazed fenestration unit, containing one panel of glazing material, that allows for natural daylighting through an opening in the *roof assembly* while preserving the weather-resistant barrier of the roof.

**[RB] SKYLIGHT AND SLOPED GLAZING.** Glass or other transparent or translucent glazing material installed at a slope of 15 degrees (0.26 rad) or more from vertical. Glazing materials in skylights, including unit skylights, tubular daylighting devices, solariums, sunrooms, roofs and sloped walls are included in this definition. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**SLEEPING ROOM.** A room designated as sleeping or bedroom on the plans and permit application.

**[RB] SLEEPING UNIT.** A single unit that provides rooms or spaces for one or more persons, includes permanent provisions for sleeping and can include provisions for living, eating and either sanitation or kitchen facilities but not both. Such rooms and spaces that are also part of a *dwelling unit* are not sleeping units.

**[MP] SLIP JOINT.** A mechanical-type joint used primarily on fixture traps. The joint tightness is obtained by compressing a friction-type washer such as rubber, nylon, neoprene, lead or special packing material against the pipe by the tightening of a (slip) nut.

**[MP] SLOPE.** The fall (pitch) of a line of pipe in reference to a horizontal plane. In drainage, the slope is expressed as the fall in units vertical per units horizontal (percent) for a length of pipe.

**[RB] SMOKE-DEVELOPED INDEX.** A comparative measure, expressed as a dimensionless number, derived from measurements of smoke obscuration versus time for a material tested in accordance with ASTM E84 or UL 723.

**[MP] SOIL STACK OR PIPE.** A pipe that conveys sewage containing fecal material to the *building drain* or *building sewer*.

~~**[RE] SOLAR ENERGY SOURCE.** A source of thermal, chemical, or electrical energy derived from direct conversion of incident solar radiation at the building site.~~

**[RB] SOLAR ENERGY SYSTEM.** A system that converts solar radiation to usable energy, including *photovoltaic panel systems* and *solar thermal systems*.

**[RE] SOLAR HEAT GAIN COEFFICIENT (SHGC).** The ratio of the solar heat gain entering the space through the fenestration assembly to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation that is then reradiated, conducted or convected into the space. This value is related to the shading coefficient (SC) by the formula SHGC = 0.87 × SC. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[MP] SOLAR THERMAL COLLECTOR.** Components in a *solar thermal system* that collect and convert solar radiation to thermal energy.

**[MP] SOLAR THERMAL SYSTEM.** A system that converts solar radiation to thermal energy for use in heating or cooling.

~~**[RP] SPILLPROOF VACUUM BREAKER.** An assembly consisting of one check valve force-loaded closed and an airinlet vent valve force-loaded open to atmosphere, positioned downstream of the check valve, and located between and including two tightly closing shutoff valves and a test cock.~~

**[RB] SOLID MASONRY.** Load-bearing or nonload-bearing construction using *masonry units* where the net cross-sectional area of each unit in any plane parallel to the bearing surface is not less than 75 percent of its gross cross-sectional area. *Solid masonry* units shall conform to ASTM C55, C62, C73, C145 or C216.

**[RG] SPECIFIC GRAVITY.** As applied to gas, *specific gravity* is the ratio of the weight of a given volume to that of the same volume of air, both measured under the same condition.

**[RB] SPLINE.** A strip of wood structural panel cut from the same material used for the panel facings, used to connect two structural insulated panels. The strip (spline) fits into a groove cut into the vertical edges of the two structural insulated panels to be joined. Splines are used behind each facing of the structural insulated panels being connected as shown in Figure ~~R613.8~~ R610.8.

**[MP] STACK.** A general term for any vertical line of soil, waste, vent or inside conductor piping that extends through at least one story with or without offsets as directly as possible to its vent terminal.

**[RB] STACK BOND.** The placement of *masonry units* in a bond pattern is such that head joints in successive courses are vertically aligned. For the purpose of this code, requirements for stack bond shall apply to all masonry laid in other than *running bond*.`

**[RP] STACK VENT.** The extension of soil or waste stack above the highest horizontal drain connected ~~to the *stack*~~.
**[RP] STACK VENTING.** A method of venting a fixture or fixtures through the soil or waste *stack*.

**[RB] STAIR.** A change in elevation, consisting of one or more *risers*.

**[RB] STAIRWAY.** One or more flights of stairs, either interior or exterior, with the necessary landings and connecting platforms to form a continuous and uninterrupted passage from one level to ~~another within or attached to a building, porch or deck~~ another.

**[RB] STAIRWAY, SPIRAL.** A stairway with a plan view of closed circular form and uniform section-shaped treads radiating from a minimum-diameter circle.

**[RE] STANDARD REFERENCE DESIGN.** A version of the *proposed design* that meets the minimum requirements of this code and is used to determine the maximum annual energy use requirement for compliance based on total building performance. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~
~~**STORY, ATTIC.** Any story situated wholly or partly in the roof, so designated, arranged or built as to be used for storage or habitation. If an attic that is accessible by a fixed stairway has a 7-foot clear height for greater than 50 percent of the floor area of the story below, then the space shall be considered as a story.~~

**[RB] STANDARD TRUSS.** Any construction that does not permit the roof-ceiling insulation to achieve the required *R*-value over the exterior walls.

**[MP] STATIONARY FUEL CELL POWER PLANT.** A self-contained package or factory-matched packages that constitute an automatically operated assembly of integrated systems for generating useful electrical energy and recoverable thermal energy that is permanently connected and fixed in place.

**[RM] STEAM-HEATING BOILER.** A boiler operated at pressures not exceeding 15 psi (103 kPa) for steam.

**[MP] STORM SEWER, DRAIN.** A pipe used for conveying rainwater, surface water, subsurface water and similar liquid waste.

**[RB] STORM SHELTER.** A building, structure or portion thereof, constructed in accordance with ICC 500 and designated for use during a severe wind storm event, such as a hurricane or tornado.

**[RB] STORY.** That portion of a building included between the upper surface of a floor and the upper surface of the floor or roof next above. A flood-resistant enclosure, designed to break away so as not to cause collapse, shall not be considered as a story when determining height.

**[RB] STORY ABOVE GRADE PLANE.** Any *story* having its finished floor surface entirely above *grade plane*, except that a *basement* shall be considered as a *story above grade plane* where the finished surface of the floor above the *basement* meets any one of the following:

1. More than 6 feet (1829 mm) *above grade plane.*
2. More than 12 feet (3658 mm) above the finished ground level at any point.
3. More than 6 feet (1829 mm) above the finished ground level for more than 50 percent of the total building perimeter.

**[RB] STRUCTURAL COMPOSITE LUMBER.** Structural members manufactured using wood elements bonded together with exterior adhesives.

Examples of structural composite lumber are:

**Laminated strand lumber (LSL).** A composite of wood strand elements with wood fibers primarily oriented along the length of the member, where the least dimension of the wood strand elements is 0.10 inch (2.54 mm) or less and their average lengths are not less than 150 times the least dimension of the wood strand elements.

**Laminated veneer lumber (LVL).** A composite of wood veneer elements with wood fibers primarily oriented along the length of the member, where the veneer element thicknesses are 0.25 inch (6.4 mm) or less.

**Oriented strand lumber (OSL).** A composite of wood strand elements with wood fibers primarily oriented along the length of the member, where the least dimension of the wood strand elements is 0.10 inch (2.54 mm) or less and their average lengths are not less than 75 times and less than 150 times the least dimension of the wood strand elements.

**Parallel strand lumber (PSL).** A composite of wood strand elements with wood fibers primarily oriented along the length of the member, where the least dimension of the wood strand elements is 0.25 inch (6.4 mm) or less and their average lengths are not less than 300 times the least dimension of the wood strand elements.

**[RB] STRUCTURAL INSULATED PANEL (SIP).** A structural sandwich panel that consists of a lightweight foam plastic core securely laminated between two thin, rigid wood structural panel facings.

**[RB] STRUCTURE.** That which is built or constructed.

**[RB] SUBSOIL DRAIN.** A drain that collects subsurface water or seepage water and conveys such water to a place of disposal.

**[MP] SUMP.** A tank or pit that receives sewage or waste, located below the normal *grade* of the gravity system and that must be emptied by mechanical means.

**[MP] SUMP PUMP.** An automatic water pump powered by an electric motor for the removal of drainage, except raw sewage, from a sump, pit or low point. The pump is selected for the specific head and volume of the load and is usually operated by level controllers.

**SUMP PUMP, SINGLE POINT-OF-USE.** An automatic water pump powered by an electric motor for the removal of drainage, except raw sewage, from a single fixture trap. The pump is selected for the specific head and volume of the load and is usually operated by level controllers.

**[RP] SUMP VENT.** A vent from pneumatic sewage ejectors, or similar equipment, that terminates separately to the open air.

**[RB] SUNROOM.** A one-story structure attached to a *dwelling* with a *glazing area* in excess of 40 percent of the gross area of the structure's *exterior walls* and roof. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[MP] SUPPLY AIR.** Air delivered to a *conditioned space* through ducts or plenums from the heat exchanger of a heating, cooling or ventilating system.

**[RM] SUPPLY AIR.** That air delivered to each or any space supplied by the air distribution system or the total air delivered to all spaces supplied by the air distribution system, which is provided for ventilating, heating, cooling, humidification, dehumidification and other similar purposes.

**[RM] SUPPLY AIR SYSTEM.** An assembly of connected ducts, *plenums*, fittings, registers and grilles through which air, heated or cooled, is conducted from the supply unit to the space or spaces to be heated or cooled (see also *Return air system*).

**[MP] SUPPORTS.** Devices for supporting, hanging and securing pipes, fixtures and equipment.

**[RP] SWEEP.** A ~~cast iron~~ drainage fitting designed to provide a change in direction of a drain pipe of less than the angle specified by the amount necessary to establish the desired slope of the line. Sweeps provide a longer turning radius than bends and a less turbulent flow pattern. (see "Bend" and "Elbow"). Sweeps can be plastic or metal.

**[RG] SYSTEM SHUTOFF.** A valve installed after the *point of delivery* to shut off the entire piping system.

**[MP] TEMPERATURE- AND PRESSURE-RELIEF (T AND P) VALVE.** A combination relief valve designed to function as both a temperature-relief and pressure-relief valve.

**[MP] TEMPERATURE-RELIEF VALVE.** A temperature-actuated valve designed to discharge automatically at the temperature at which it is set.

**[RP] TEMPERED WATER.** Water having a temperature range between 85°F (29°C) and 110°F (43°C).

**[RB] TERMITE-RESISTANT MATERIAL.** Pressure-preservative-treated wood in accordance with the AWPA standards in Section R317.1, naturally durable termite-resistant wood, steel, concrete, masonry or other *approved* material.

**[RB] THERMAL ISOLATION.** Physical and space conditioning separation from *conditioned space(s)* consisting of existing or new walls, doors or windows. The *conditioned space(s)* shall be controlled as separate zones for heating and cooling or conditioned by separate *equipment*. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RE] THERMAL RESISTANCE, *R*-VALUE.** See "*R-value*."

**[RE] THERMAL TRANSMITTANCE, *U*-FACTOR.** See "*U-factor*."

~~**[RE] THERMOSTAT.** For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RG] THERMOSTAT.** **(See types that follow.)**
**Electric switch type.** A device that senses changes in temperature and controls electrically, by means of separate components, the flow of gas to the *burner(s)* to maintain selected temperatures.
**Integral gas valve type.** An automatic device, actuated by temperature changes, designed to control the gas supply to the *burner(s)* in order to maintain temperatures between predetermined limits, and in which the thermal actuating element is an integral part of the device.
1. Graduating thermostat. A thermostat in which the motion of the valve is approximately in direct proportion to the effective motion of the thermal element induced by temperature change.
2. Snap-acting thermostat. A thermostat in which the thermostatic valve travels instantly from the closed to the open position, and vice versa.

**[MP] THIRD-PARTY CERTIFICATION AGENCY.** An *approved* agency operating a product or material certification system that incorporates initial product testing, assessment and surveillance of a manufacturer's quality control system.

**[MP] THIRD-PARTY CERTIFIED.** Certification obtained by the manufacturer indicating that the function and performance characteristics of a product or material have been determined by testing and ongoing surveillance by an *approved* third-party certification agency. Assertion of certification is in the form of identification in accordance with the requirements of the third-party certification agency.

~~**[RB] THIRD-PARTY TESTED.** Procedure by which an approved testing laboratory provides documentation that a product material or system conforms to specified requirements.~~

**[RG] TOILET, GAS-FIRED.** A packaged and completely assembled *appliance* containing a toilet that incinerates refuse instead of flushing it away with water.

~~**TOILET ROOM.** A room containing a water closet and, frequently, a lavatory, but not a bathtub, shower, spa or similar bathing fixture.~~

**[RB] TOWNHOUSE.** A single-family *dwelling unit* constructed in a group of two or more attached units separated by property lines, or three or more attached units separated by assumed property lines based on the location of the double wall or common wall in which each unit extends from foundation to roof and with a *yard* or public way on not less than two sides.

**[RB] TOWNHOUSE UNIT.** A single-family *dwelling unit* in a *townhouse* that extends from foundation to roof and that has a *yard* or *public way* on not less than two sides.

**[MP] TRAP.** A fitting, either separate or built into a fixture, that provides a liquid seal to prevent the emission of sewer gases without materially affecting the flow of sewage or wastewater through it.

**[MP] TRAP ARM.** That portion of a *fixture drain* between a trap weir and the vent fitting.

**[MP] TRAP PRIMER.** A device or system of piping to maintain a water seal in a trap, typically installed where infrequent use of the trap would result in evaporation of the trap seal, such as floor drains.

**[MP] TRAP SEAL.** The trap seal is the maximum vertical depth of liquid that a trap will retain, measured between the crown weir and the top of the dip of the trap.

**[RB] TRIM.** Picture molds, chair rails, baseboards, *handrails*, door and window frames, and similar decorative or protective materials used in fixed applications.

**[RB] TRUSS DESIGN DRAWING.** The graphic depiction of an individual truss, that describes the design and physical characteristics of the truss.

**[RB] TUBULAR DAYLIGHTING DEVICE (TDD).** A nonoperable fenestration unit primarily designed to transmit daylight from a roof surface to an interior ceiling via a tubular conduit. The basic unit consists of an exterior glazed weathering surface, a light-transmitting tube with a reflective interior surface, and an interior-sealing device such as a translucent ceiling panel. The unit may be factory assembled, or field assembled from a manufactured kit.

**[MP] TYPE L VENT.** A *listed* and *labeled* vent conforming to UL 641 for venting oil-burning *appliances listed* for use with Type L vents or with gas *appliances listed* for use with Type B vents.

**[RE] *U*-FACTOR, THERMAL TRANSMITTANCE.** The coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/h·ft$^2$·°F)[W/(m$^2$·K)]. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] UNDERLAYMENT.** One or more layers of felt, sheathing paper, nonbituminous saturated felt, or other *approved* material over which a roof covering, with a slope of 2 units vertical in 12 units horizontal (17-percent slope) or greater, is applied.

**[RG] UNIT HEATER.**

~~**High-static pressure type.** A self-contained, automatically controlled, vented *appliance* having integral means for circulation of air against 0.2 inch w.c. (50 Pa) or greater static pressure. Such *appliance* is equipped with provisions for attaching an outlet air duct and, where the *appliance* is for indoor installation remote from the space to be heated, is also equipped with provisions for attaching an inlet air duct.~~

~~**Low-static pressure type.** A self-contained, automatically controlled, vented appliance, intended for installation in the space to be heated without the use of ducts, having integral means for circulation of air. Such units are allowed to be equipped with louvers or face extensions made in accordance with the manufacturer's specifications.~~

A self-contained, automatically controlled, vented, fuel-gas-burning, space-heating *appliance*, intended for installation in the space to be heated without the use of ducts, and having integral means for circulation of air.

**[RG] UNVENTED ROOM HEATER.** An unvented heating *appliance* designed for stationary installation and utilized to provide comfort heating. Such *appliances* provide radiant heat or convection heat by gravity or fan circulation directly from the heater and do not utilize ducts.

**[RP] VACUUM.** Any pressure less than that exerted by the atmosphere.

**[MP] VACUUM BREAKER.** A device that prevents back-siphonage of water by admitting atmospheric pressure through ports to the discharge side of the device.

**[RG] VALVE.** A device used in piping to control the gas supply to any section of a system of *piping* or to an *appliance*.
**Appliance shutoff.** A *valve* located in the *piping system*, used to isolate individual *appliances* for purposes such as service or replacement.
**Automatic.** An automatic or semiautomatic device consisting essentially of a *valve* and an operator that control the gas supply to the *burner(s)* during operation of an *appliance*. The operator shall be actuated by application of gas pressure on a flexible diaphragm, by electrical means, by mechanical means or by other *approved* means.
**Automatic gas shutoff.** A *valve* used in conjunction with an automatic gas shutoff device to shut off the gas supply to a water-heating system. It shall be constructed integrally with the gas shutoff device or shall be a separate assembly.
**Individual main burner.** A *valve* that controls the gas supply to an individual *main burner*.
**Main burner control.** A *valve* that controls the gas supply to the *main burner* manifold.
**Manual main gas-control.** A manually operated *valve* in the gas line for the purpose of completely turning on or shutting off the gas supply to the *appliance*, except to *pilot* or pilots that are provided with independent shutoff.
**Manual reset.** An automatic shutoff valve installed in the gas supply *piping* and set to shut off when unsafe conditions occur. The device remains closed until manually reopened.
**Service shutoff.** A valve, installed by the serving gas supplier between the ~~service meter or~~ source of supply and the ~~customer *piping system*~~ *point of delivery*, to shut off the entire *piping system*.

**[RB] VAPOR DIFFUSION PORT.** An assembly constructed or installed within a *roof assembly* at an opening in the *roof deck* to convey water vapor from an unvented attic to the outside atmosphere.

**[RB] VAPOR PERMEABLE.** The property of having a moisture vapor permeance rating of 5 perms ($2.9 \times 10^{-10}$ kg/Pa × s × $m^2$) or greater, where tested in accordance with Procedure A or Procedure B of ASTM E96. A vapor permeable material permits the passage of moisture vapor.

**[RB] VAPOR RETARDER CLASS.** A measure of the ability of a material or assembly to limit the amount of moisture that passes through that material or assembly. Vapor retarder class shall be defined using the desiccant method with Procedure A of ASTM E96 as follows:

Class I: ≤ 0.1 perm rating

Class II: > 0.1 to ≤ 1.0 perm rating

Class III: > 1.0 to ≤ 10 perm rating

**[MP] VENT.** A passageway for conveying flue gases from fuel-fired *appliances*, or their vent connectors, to the outside atmosphere.

**[RG] VENT.** A *pipe* or other conduit composed of factory-made components, containing a passageway for conveying *combustion products* and air to the atmosphere, *listed* and *labeled* for use with a specific type or class of *appliance*.

**Special gas vent.** A vent *listed* and *labeled* for use with *listed* Category II, III and IV gas *appliances*.

**Type B vent.** A vent *listed* and *labeled* for use with *appliances* with *draft hoods* and other Category I *appliances* that are *listed* for use with Type B vents.

**Type BW vent.** A vent *listed* and *labeled* for use with wall *furnaces*.

**Type L vent.** A vent *listed* and *labeled* for use with *appliances* that are *listed* for use with Type L or Type B vents.

**[RG] VENT PIPING.**

**Breather.** *Piping* run from a pressure-regulating device to the outdoors, designed to provide a reference to *atmospheric pressure*. If the device incorporates an integral pressure *relief* mechanism, a breather vent can also serve as a *relief* vent.

**Relief.** *Piping* run from a pressure-regulating or pressure-limiting device to the outdoors, designed to provide for the safe venting of gas in the event of excessive pressure in the *gas piping system*.

**[MP] VENT COLLAR.** See "*Flue collar*."

**[MP] VENT CONNECTOR.** That portion of a venting system that connects the flue collar or draft hood of an *appliance* to a vent.

**[MP] VENT DAMPER DEVICE, AUTOMATIC.** A device intended for installation in the venting system, in the outlet of an individual, automatically operated fuel-burning *appliance* and that is designed to open the venting system automatically where the *appliance* is in operation and to close off the venting system automatically where the *appliance* is in a standby or shutdown condition.

**[MP] VENT GASES.** Products of combustion from fuel-burning *appliances*, plus excess air and dilution air, in the venting system above the draft hood or draft regulator.

**[RP] VENT PIPE.** See "Vent system."

**[MP] VENT STACK.** A vertical vent pipe installed to provide circulation of air to and from the drainage system and that extends through one or more stories.

**[MP] VENT SYSTEM.** A pipe or pipes installed to provide a flow of air to or from a plumbing drainage system, or to provide a circulation of air within such system to protect trap seals from siphonage and backpressure.

**[RG] VENTED APPLIANCE CATEGORIES.** *Appliances* that are categorized for the purpose of vent selection are classified into the following four categories:

**Category I.** An *appliance* that operates with a nonpositive vent static pressure and with a vent gas temperature that avoids excessive *condensate* production in the vent.

**Category II.** An *appliance* that operates with a nonpositive *vent* static pressure and with a vent gas temperature that is capable of causing excessive *condensate* production in the vent.

**Category III.** An *appliance* that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive *condensate* production in the vent.

**Category IV.** An *appliance* that operates with a positive vent static pressure and with a vent gas temperature that is capable of causing excessive *condensate* production in the vent.

**[RG] VENTED ROOM HEATER.** A vented self-contained, free-standing, nonrecessed *appliance* for furnishing warm air to the space in which it is installed, directly from the heater without duct connections.

**[RG] VENTED WALL FURNACE.** A self-contained vented *appliance* complete with grilles or equivalent, designed for incorporation in or permanent attachment to the structure of a building, mobile home or travel trailer, and furnishing heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing. This definition shall exclude *floor furnaces, unit heaters* and *central furnaces* as herein defined.

**[RM] VENTILATION AIR.** That portion of supply air that comes from the outside (outdoors), plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

**[RG] VENTING SYSTEM.** A continuous open passageway from the *flue collar* or *draft hood* of an *appliance* to the outdoor atmosphere for the purpose of removing flue or vent gases. A venting system is usually composed of a vent or a chimney and *vent connector*, if used, assembled to form the open passageway.

**Forced draft venting system.** A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under positive static vent pressure.

**Induced draft venting system.** A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under nonpositive static vent pressure.

**Mechanical draft venting system.** A venting system designed to remove flue or vent gases by mechanical means, that consists of an induced draft portion under non-positive static pressure or a forced draft portion under positive static pressure.

**Natural draft venting system.** A venting system designed to remove flue or vent gases under nonpositive static vent pressure entirely by natural draft.

**VENTILATION.** The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RM] VENTILATION AIR.** That portion of supply air that comes from the outside (outdoors), plus any recirculated air that has been treated to maintain the desired quality of air within a designated space. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[MP] VENTING.** Removal of combustion products to the outdoors.

**[MP] VENTING SYSTEM.** A continuous open passageway from the flue collar of an *appliance* to the outside atmosphere for the purpose of removing flue or vent gases. A venting system is usually composed of a vent or a chimney and vent connector, if used, assembled to form the open passageway.

**[MP] VERTICAL PIPE.** Any pipe or fitting that makes an angle of 45 degrees (0.79 rad) or more with the horizontal.

**[RB] VINYL SIDING.** A shaped material, made principally from rigid polyvinyl chloride (PVC), that is used to cover exterior walls of buildings.

~~**[RE] VERTICAL FENESTRATION.** Windows (fixed or moveable), opaque doors, glazed doors, glazed block and combination opaque/glazed doors composed of glass or other transparent or translucent glazing materials and installed at a slope of a least 60 degrees (1.05 rad) from horizontal.~~

**[RE] VISIBLE TRANSMITTANCE [VT].** The ratio of visible light entering the space through the fenestration product assembly to the incident visible light. Visible transmittance includes the effects of glazing material and frame and is expressed as a number between 0 and 1. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**WALL, ABOVE-GRADE.** A wall more than 50 percent above-grade and enclosing *conditioned space*. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts.

**WALL, CRAWLSPACE.** The opaque portion of a wall that encloses a crawl space and is partially or totally below grade.

**[RB] WALL, RETAINING.** A wall not laterally supported at the top, that resists lateral soil load and other imposed loads.

**[RG] WALL HEATER, UNVENTED TYPE.** A room heater of the type designed for insertion in or attachment to a wall or partition. Such heater does not incorporate concealed venting arrangements in its construction and discharges all products of *combustion* through the front into the room being heated.

**WALL VENTED CRAWL SPACE.** A foundation that uses foundation wall vents as a primary means to control space moisture. Insulation is located at the floor level.

**[RB] WALLS.** Walls shall be defined as follows:

**Load-bearing wall.** A wall supporting any vertical load in addition to its own weight.

**Nonbearing wall.** A wall which does not support vertical loads other than its own weight.

**[MP] WASTE.** Liquidborne waste ~~that is free of~~ does not contain fecal matter.

**[MP] WASTE PIPE OR STACK.** Piping that conveys only liquid sewage not containing fecal material.

**[MP] WASTE RECEPTOR.** A floor sink, standpipe, hub drain or a floor drain that receives the discharge of one or more indirect waste pipes.

**[MP] WATER DISTRIBUTION SYSTEM.** Piping that conveys water from the service to the plumbing fixtures, *appliances*, appurtenances, equipment, devices or other systems served, including fittings and control valves.

**WATER-HAMMER ARRESTOR.** A device utilized to absorb the pressure surge (water hammer) that occurs when water flow is suddenly stopped in a water supply system

**[MP] WATER HEATER.** Any heating *appliance* or equipment that heats potable water and supplies such water to the potable hot water distribution system.

**[MP] WATER MAIN.** A water supply pipe or system of pipes, installed and maintained by a city, township, county, public utility company or other public entity, on public property, in the street or in an approved dedicated easement of public or community use.

**[MP] WATER OUTLET.** ~~A valved discharge opening, including a hose bibb, through which water is removed from the potable water system supplying water to a plumbing fixture or plumbing *appliance* that requires either an *air gap* or backflow prevention device for protection of the supply system.~~ A discharge opening through which water is supplied to a fixture, into the atmosphere, such as a hose bibb, (except into an open tank that is part of the water supply system), to a boiler or heating system, or to any devices or equipment requiring water to operate but which are not part of the plumbing system.

**[RP] WATER PIPE.**

**Riser.** A water supply pipe that extends one full story or more to convey water to *branches* or to a group of fixtures.

**Water distribution pipe.** A pipe within the structure or on the premises that conveys water from the water service pipe, or from the meter when the meter is at the structure, to the points of utilization.

**Water service pipe.** The pipe from the water main or other source of potable water supply, or from the meter when the meter is at the public right of way, to the water distribution system of the building served. Water service pipe shall terminate 5 feet (1524 mm) outside the foundation wall.

**[MP] WATER SERVICE PIPE.** ~~The outside pipe from the water main or other source of potable water supply to the water distribution system inside the building, terminating at the service valve.~~ Water service pipe shall terminate 5 feet (1524 mm) outside the foundation wall.

**[MP] WATER SUPPLY SYSTEM.** The water service pipe, the water-distributing pipes and the necessary connecting pipes, fittings, control valves and appurtenances in or adjacent to the building or premises.

**[RB] WATER-RESISTIVE BARRIER.** A material behind an exterior wall covering that is intended to resist liquid water that has penetrated behind the exterior covering from further intruding into the exterior wall assembly.

**[RP] WEIGHTED AVERAGE LEAD CONTENT.** The weighted average lead content of a pipe, pipe fitting, plumbing fitting, or fixture shall be calculated by using the following formula: For each wetted component, the percentage of lead in the component shall be multiplied by the ratio of the wetted surface area of that component to the total wetted surface area of the entire product to arrive at the weighted percentage of lead of the component. The weighted percentage of lead of each wetted component shall be added together, and the sum of these wetted percentages shall constitute the weighted average lead content of the product. For lead content of materials that are provided as a range, the maximum content of the range shall be used.

**[MP] WET VENT.** A vent that receives the discharge of wastes from other fixtures.

**[RP] WHIRLPOOL BATHTUB.** A plumbing appliance consisting of a bathtub fixture that is equipped and fitted with a circulating piping system designed to accept, circulate and discharge bathtub water upon each use.

**[MP] WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM.** An exhaust system, supply system, or combination thereof that is designed to mechanically exchange indoor air for outdoor air where operating continuously or through a programmed intermittent schedule to satisfy the whole-house ventilation rate.

~~For the definition applicable in Chapter 11, see Section N1101.6.~~

**[RB] WINDBORNE DEBRIS REGION.** Areas within *hurricane-prone regions* defined as that area east of the Intracoastal Waterway from the North Carolina/South Carolina state line north to Beaufort Inlet and from that point to include the barrier islands to the North Carolina/Virginia state line.

**[RB] WINDER.** A tread with nonparallel edges.

**[RB] WOOD STRUCTURAL PANEL.** A panel manufactured from veneers; or wood strands or wafers; bonded together with waterproof synthetic resins or other suitable bonding systems. Examples of wood structural panels are plywood, orientated strand board (OSB) or composite panels.

**[RB] YARD.** An open space, other than a court, unobstructed from the ground to the sky, except where specifically provided by this code, on the *lot* on which a building is situated.

**YARD HYDRANT**. A freeze proof yard hydrant is an outdoor water supply outlet that has a valve and outlet above ground and a drain opening below the frost level.

~~**WATERPROOFING.** A coating or the application of coatings applied to prevent the penetration of water through or into walls or into interior spaces.~~

~~**WINDOW.** See "*Fenestration*."~~

**ZONE.** A space or group of spaces within a building with heating or cooling requirements that are sufficiently similar so that desired conditions can be maintained throughout using a single controlling device. ~~For the definition applicable in Chapter 11, see Section N1101.6.~~

# CHAPTER 3
# BUILDING PLANNING

## SECTION R301
## DESIGN CRITERIA

**R301.1 Application.** Buildings and structures, and parts thereof, shall be constructed to safely support all loads, including dead loads, *live loads*, roof loads, flood loads, snow loads, wind loads and seismic loads as prescribed by this code. The construction of buildings and structures in accordance with the provisions of this code shall result in a system that provides a complete load path that meets the requirements for the transfer of loads from their point of origin through the load-resisting elements to the foundation. Buildings and structures constructed as prescribed by this code are deemed to comply with the requirements of this section.

**R301.1.1 Alternative provisions.** As an alternative to the requirements in Section R301.1, the following standards are permitted subject to the limitations of this code and the limitations therein. Where engineered design is used in conjunction with these standards, the design shall comply with the *International Building Code*.

1. AWC *Wood Frame Construction Manual* (WFCM).
2. AISI *Standard for Cold-Formed Steel Framing—Prescriptive Method for One- and Two-Family Dwellings* (AISI S230).
3. ICC *Standard on the Design and Construction of Log Structures* (ICC 400).
4. Sunrooms complying with AAMA/NPEA/NSA 2100.

**R301.1.2 Construction systems.** The requirements of this code are based on platform and balloon-frame construction for light-frame buildings. The requirements for concrete and masonry buildings are based on a balloon framing system. Other framing systems must have equivalent detailing to ensure force transfer, continuity and compatible deformations.

**R301.1.3 Engineered design.** Where a building of otherwise conventional construction contains structural elements exceeding the limits of Section R301 or otherwise not conforming to this code, these elements shall be designed in accordance with accepted engineering practice. The extent of such design need only demonstrate compliance of nonconventional elements with other applicable provisions and shall be compatible with the performance of the conventional framed system. Engineered design in accordance with the *International Building Code* is permitted for buildings and structures, and parts thereof, included in the scope of this code.

**R301.1.4 Intermodal shipping containers.** Intermodal shipping containers that are repurposed for use as buildings or structures shall be designed in accordance with the structural provisions in Section 3115 of the *International Building Code*.

**R301.2 Climatic and geographic design criteria.** Buildings shall be constructed in accordance with the provisions of this code as limited by the provisions of this section. Additional criteria shall be established by the local *jurisdiction* and set forth in Table ~~R301.2(1)~~ R301.2.

**R301.2.1 Wind design criteria.** Buildings and portions thereof shall be constructed in accordance with the wind provisions of this code using the ultimate design wind speed in Table ~~R301.2(1)~~ R301.2 as determined from Tables R301.2(4) and R301.2(5). Where different construction methods and structural materials are used for various portions of a building, the applicable requirements of this section for each portion shall apply. Where not otherwise specified, the wind loads listed in Tables R301.2(2) and R301.2(6) adjusted for height and exposure using Table ~~R301.2(3)~~ R301.2.1(2) shall be used to determine design load performance requirements for wall coverings, curtain walls, roof coverings, exterior windows, skylights, garage doors and exterior doors. Asphalt shingles shall be designed for wind speeds in accordance with Section R905.2.4. Metal roof shingles shall be designed for wind speeds in accordance with Section R905.4.4. A continuous load path shall be provided to transmit the applicable uplift forces in Section R802.11.1 from the roof assembly to the foundation. Where ultimate design wind speeds in Figure R301.2(2) are less than the lowest wind speed indicated in the prescriptive provisions of this code, the lowest wind speed indicated in the prescriptive provisions of this code shall be used.

**Exception:** Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall be exempt from the loads listed in Table R301.2(2) and the height and exposure factors listed in Table R301.2(3). Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state “Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s).” Decals shall be placed such that the decal is visible when the panel is installed.

**R301.2.1.1 Wind limitations and wind design required.** Construction in regions where the ultimate wind speeds from Tables R301.2(4) and R301.2(5) equal or exceed 130 miles per hour (58 m/s) shall be designed in accordance with one of the following:
1. ~~AF&PA~~ AWC *Wood Frame Construction Manual* (WFCM).
2. ICC *Standard for Residential Construction in High-Wind Regions* (ICC 600).
3. ASCE *Minimum Design Loads for Buildings and Other Structures* (ASCE 7).
4. Deleted.
5. *International Building Code.*
6. Concrete construction shall be designed in accordance with the provisions of this code.
7. Structural insulated panel (SIP) walls shall be designed in accordance with the provisions of this code.
8. Chapters 45 and 46.

The elements of design not addressed by the methods in Items 1 through 8 shall be in accordance with the provisions of this code. Where ASCE 7 or the *International Building Code* is used for the design of the building, the wind speed map and exposure category requirements as specified in ASCE 7 and the *International Building Code* shall be used.

**R301.2.1.1.1 Sunrooms.** Deleted.

**R301.2.1.2 Protection of openings.** Exterior glazing in buildings located in windborne debris regions shall be protected from windborne debris. Glazed opening protection for windborne debris shall meet the requirements of the Large Missile Test of ASTM E1996 and ASTM E1886 as modified in Section 301.2.1.2.1. Garage door glazed opening protection for windborne debris shall meet the requirements of an *approved* impact-resisting standard or ANSI/DASMA 115.
**Exceptions:**
1. Wood structural panels with a thickness of not less than 7/16 inch (11 mm) and a span of not more than 8 feet (2438 mm) shall be permitted for opening protection. Panels shall be precut and attached to the framing surrounding the opening containing the product with the glazed opening. Panels shall be predrilled as required for the anchorage method ~~so that they can~~ and shall be secured with the attachment hardware provided. Attachments shall be designed to resist the component and cladding loads determined in accordance with either Table R301.2(2) or ASCE 7, with the permanent corrosion-resistant attachment hardware provided. Attachment in accordance with Table R301.2.1.2 is permitted for buildings with a *mean roof height* of 45 feet (13 728 mm) or less where the ultimate design wind speed, $V_{ult}$, is 180 mph (290 kph) or less.
2. Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall not be required to be protected, provided the spaces are separated from the building interior by a wall and all openings in the wall separating the unit from the balcony, deck or porch are protected in accordance with this section. Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state “Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s).” Decals shall be placed such that the decal is visible when the panel is installed.

**TABLE ~~R301.2(1)~~ R301.2**
**CLIMATIC AND GEOGRAPHIC DESIGN CRITERIA**

| ROOF LOAD (psf) | WIND SPEED (mph) | SEISMIC DESIGN CATEGORY | SUBJECT TO DAMAGE FROM | | | WINTER DESIGN TEMP | ICE BARRIER UNDERLAYMENT REQUIRED | FLOOD HAZARDS[b] | AIR FREEZING INDEX | MEAN ANNUAL TEMP |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Weathering[a] | Frost line depth[d] | Termite[c] | | | | | |
| 20 | Tables R301.2(4) & (5) | Table R301.2(7) | Moderate | Minimum 12 inches | Moderate-Heavy | Local | Local | Local | Local | Local |

For SI: 1 pound per square foot = 0.0479 kPa, 1 mile per hour = 0.447 m/s.

a) Weathering may require a higher strength concrete or grade of masonry than necessary to satisfy the structural requirements of this code. The grade of masonry units shall be determined from ASTM C34, C55, C62, C73, C90, C129, C145, C216 or C652.

b) The jurisdiction shall fill in this part of the table with (a) the date of the jurisdiction's entry into the National Flood Insurance Program (date of adoption of the first code or ordinance for management of flood hazard areas), (b) the date(s) of the currently effective FIRM and FBFM or other flood hazard map adopted by the community, as may amended.

c) Protection is required in all of North Carolina in accordance with Section R318

d) Check with local jurisdiction for frost line depth.

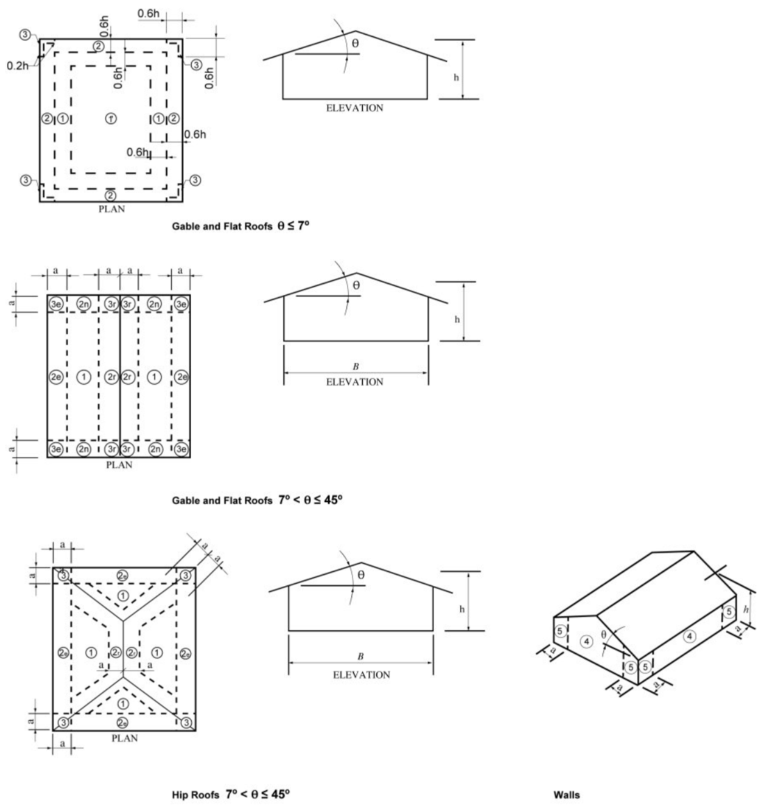



**FIGURE ~~R301.2(2)~~ R301.2.1 COMPONENT AND CLADDING PRESSURE ZONES**

**TABLE R301.2(2)**
**COMPONENT AND CLADDING LOADS FOR A BUILDING WITH A MEAN ROOF HEIGHT OF 30 FEET LOCATED IN EXPOSURE B (ASD) (psf)[a, b, c, d, e, f]**

| | ZONE | EFFECTIVE WIND AREA (feet$^2$) | ULTIMATE DESIGN WIND SPEED, $V_{ULT}$ (mph) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 110 | | 115 | | 120 | | 130 | | 140 | | 150 | | 160 | | 170 | | 180 | |
| Roof 0 to 7 degrees | 1 | 10 | 10.0 | -13.0 | 10.0 | -14.0 | 10.0 | -15.0 | 10.0 | -18.0 | 10.0 | -21.0 | 9.9 | -24.0 | 11.2 | -27.0 | 12.6 | -31.0 | 14.2 | -35.0 |
| | 1 | 20 | 10.0 | -12.0 | 10.0 | -13.0 | 10.0 | -15.0 | 10.0 | -17.0 | 10.0 | -20.0 | 9.2 | -23.0 | 10.6 | -26.0 | 11.9 | -30.0 | 13.3 | -34.1 |
| | 1 | 50 | 10.0 | -12.0 | 10.0 | -13.0 | 10.0 | -14.0 | 10.0 | -17.0 | 10.0 | -19.0 | 8.5 | -22.0 | 10.0 | -26.0 | 10.8 | -29.0 | 12.2 | -32.9 |
| | 1 | 100 | 10.0 | -11.0 | 10.0 | -13.0 | 10.0 | -14.0 | 10.0 | -16.0 | 10.0 | -19.0 | 7.8 | -22.0 | 10.0 | -25.0 | 10.0 | -28.0 | 11.3 | -32.0 |
| | 2 | 10 | 10.0 | -21.0 | 10.0 | -23.0 | 10.0 | -26.0 | 10.0 | -30.0 | 10.0 | -35.0 | 9.9 | -40.0 | 11.2 | -46.0 | 12.6 | -52.0 | 14.2 | -58.7 |
| | 2 | 20 | 10.0 | -19.0 | 10.0 | -21.0 | 10.0 | -23.0 | 10.0 | -27.0 | 10.0 | -31.0 | 9.2 | -36.0 | 10.6 | -41.0 | 11.9 | -46.0 | 13.3 | -52.4 |
| | 2 | 50 | 10.0 | -16.0 | 10.0 | -18.0 | 10.0 | -19.0 | 10.0 | -23.0 | 10.0 | -26.0 | 8.5 | -30.0 | 10.0 | -34.0 | 10.8 | -39.0 | 12.2 | -44.1 |
| | 2 | 100 | 10.0 | -14.0 | 10.0 | -15.0 | 10.0 | -16.0 | 10.0 | -19.0 | 10.0 | -22.0 | 7.8 | -26.0 | 10.0 | -30.0 | 10.0 | -33.0 | 11.3 | -37.9 |
| | 3 | 10 | 10.0 | -33.0 | 10.0 | -36.0 | 10.0 | -39.0 | 10.0 | -46.0 | 10.0 | -53.0 | 9.9 | -61.0 | 11.2 | -69.0 | 12.6 | -78.0 | 14.2 | -88.3 |
| | 3 | 20 | 10.0 | -27.0 | 10.0 | -29.0 | 10.0 | -32.0 | 10.0 | -38.0 | 10.0 | -44.0 | 9.2 | -50.0 | 10.6 | -57.0 | 11.9 | -65.0 | 13.3 | -73.1 |
| | 3 | 50 | 10.0 | -19.0 | 10.0 | -21.0 | 10.0 | -23.0 | 10.0 | -27.0 | 10.0 | -32.0 | 8.5 | -36.0 | 10.0 | -41.0 | 10.8 | -47.0 | 12.2 | -53.1 |
| | 3 | 100 | 10.0 | -14.0 | 10.0 | -15.0 | 10.0 | -16.0 | 10.0 | -19.0 | 10.0 | -22.0 | 7.8 | -26.0 | 10.0 | -30.0 | 10.0 | -33.0 | 11.3 | -37.9 |
| Roof > 7 to 27 degrees | 1 | 10 | 10.0 | -11.0 | 10.0 | -13.0 | 10.0 | -14.0 | 10.5 | -16.0 | 12.2 | -19.0 | 14.0 | -22.0 | 15.9 | -25.0 | 17.9 | -28.0 | 20.2 | -32.0 |
| | 1 | 20 | 10.0 | -11.0 | 10.0 | -12.0 | 10.0 | -13.0 | 10.0 | -16.0 | 11.1 | -18.0 | 12.8 | -21.0 | 14.5 | -24.0 | 16.4 | -27.0 | 18.4 | -31.1 |
| | 1 | 50 | 10.0 | -11.0 | 10.0 | -12.0 | 10.0 | -13.0 | 10.0 | -15.0 | 10.0 | -18.0 | 11.1 | -20.0 | 12.7 | -23.0 | 14.3 | -26.0 | 16.0 | -29.9 |
| | 1 | 100 | 10.0 | -10.0 | 10.0 | -11.0 | 10.0 | -12.0 | 10.0 | -15.0 | 10.0 | -17.0 | 9.9 | -20.0 | 11.2 | -22.0 | 12.6 | -25.0 | 14.2 | -29.0 |
| | 2 | 10 | 10.0 | -20.0 | 10.0 | -22.0 | 10.0 | -24.0 | 10.5 | -29.0 | 12.2 | -33.0 | 14.0 | -38.0 | 15.9 | -44.0 | 17.9 | -49.0 | 20.2 | -55.8 |
| | 2 | 20 | 10.0 | -19.0 | 10.0 | -20.0 | 10.0 | -22.0 | 10.0 | -26.0 | 11.1 | -31.0 | 12.8 | -35.0 | 14.5 | -40.0 | 16.4 | -45.0 | 18.4 | -51.2 |
| | 2 | 50 | 10.0 | -16.0 | 10.0 | -18.0 | 10.0 | -20.0 | 10.0 | -23.0 | 10.0 | -27.0 | 11.1 | -31.0 | 12.7 | -35.0 | 14.3 | -40.0 | 16.0 | -45.4 |
| | 2 | 100 | 10.0 | -15.0 | 10.0 | -16.0 | 10.0 | -18.0 | 10.0 | -21.0 | 10.0 | -24.0 | 9.9 | -28.0 | 11.2 | -32.0 | 12.6 | -36.0 | 14.2 | -40.9 |
| | 3 | 10 | 10.0 | -30.0 | 10.0 | -33.0 | 10.0 | -36.0 | 10.5 | -43.0 | 12.2 | -49.0 | 14.0 | -57.0 | 15.9 | -65.0 | 17.9 | -73.0 | 20.2 | -82.4 |
| | 3 | 20 | 10.0 | -28.0 | 10.0 | -31.0 | 10.0 | -34.0 | 10.0 | -40.0 | 11.1 | -46.0 | 12.8 | -53.0 | 14.5 | -60.0 | 16.4 | -68.0 | 18.4 | -77.0 |
| | 3 | 50 | 10.0 | -26.0 | 10.0 | -28.0 | 10.0 | -31.0 | 10.0 | -36.0 | 10.0 | -42.0 | 11.1 | -48.0 | 12.7 | -55.0 | 14.3 | -62.0 | 16.0 | -69.9 |
| | 3 | 100 | 10.0 | -24.0 | 10.0 | -26.0 | 10.0 | -28.0 | 10.0 | -33.0 | 10.0 | -39.0 | 9.9 | -44.0 | 11.2 | -51.0 | 12.6 | -57.0 | 14.2 | -64.6 |
| Roof > 27 to 45 degrees | 1 | 10 | 11.9 | -13.0 | 13.1 | -14.0 | 14.2 | -15.0 | 16.7 | -18.0 | 19.4 | -21.0 | 22.2 | -24.0 | 25.3 | -27.0 | 28.5 | -31.0 | 32.0 | -35.0 |
| | 1 | 20 | 11.6 | -12.0 | 12.7 | -13.0 | 13.8 | -14.0 | 16.2 | -17.0 | 18.8 | -20.0 | 21.6 | -23.0 | 24.6 | -26.0 | 27.7 | -29.0 | 31.1 | -33.2 |
| | 1 | 50 | 11.2 | -11.0 | 12.2 | -12.0 | 13.3 | -13.0 | 15.6 | -16.0 | 18.1 | -18.0 | 20.8 | -21.0 | 23.6 | -24.0 | 26.7 | -27.0 | 29.9 | -30.8 |
| | 1 | 100 | 10.9 | -10.0 | 11.9 | -11.0 | 12.9 | -12.0 | 15.1 | -15.0 | 17.6 | -17.0 | 20.2 | -20.0 | 22.9 | -22.0 | 25.9 | -25.0 | 29.0 | -29.0 |
| | 2 | 10 | 11.9 | -15.0 | 13.1 | -16.0 | 14.2 | -18.0 | 16.7 | -21.0 | 19.4 | -24.0 | 22.2 | -28.0 | 25.3 | -32.0 | 28.5 | -36.0 | 32.0 | -40.9 |
| | 2 | 20 | 11.6 | -14.0 | 12.7 | -16.0 | 13.8 | -17.0 | 16.2 | -20.0 | 18.8 | -23.0 | 21.6 | -27.0 | 24.6 | -30.0 | 27.7 | -34.0 | 31.1 | -39.1 |
| | 2 | 50 | 11.2 | -13.0 | 12.2 | -15.0 | 13.3 | -16.0 | 15.6 | -19.0 | 18.1 | -22.0 | 20.8 | -25.0 | 23.6 | -29.0 | 26.7 | -32.0 | 29.9 | -36.8 |
| | 2 | 100 | 10.9 | -13.0 | 11.9 | -14.0 | 12.9 | -15.0 | 15.1 | -18.0 | 17.6 | -21.0 | 20.2 | -24.0 | 22.9 | -27.0 | 25.9 | -31.0 | 29.0 | -35.0 |
| | 3 | 10 | 11.9 | -15.0 | 13.1 | -16.0 | 14.2 | -18.0 | 16.7 | -21.0 | 19.4 | -24.0 | 22.2 | -28.0 | 25.3 | -32.0 | 28.5 | -36.0 | 32.0 | -40.9 |
| | 3 | 20 | 11.6 | -14.0 | 12.7 | -16.0 | 13.8 | -17.0 | 16.2 | -20.0 | 18.8 | -23.0 | 21.6 | -27.0 | 24.6 | -30.0 | 27.7 | -34.0 | 31.1 | -39.1 |
| | 3 | 50 | 11.2 | -13.0 | 12.2 | -15.0 | 13.3 | -16.0 | 15.6 | -19.0 | 18.1 | -22.0 | 20.8 | -25.0 | 23.6 | -29.0 | 26.7 | -32.0 | 29.9 | -36.8 |
| | 3 | 100 | 10.9 | -13.0 | 11.9 | -14.0 | 12.9 | -15.0 | 15.1 | -18.0 | 17.6 | -21.0 | 20.2 | -24.0 | 22.9 | -27.0 | 25.9 | -31.0 | 29.0 | -35.0 |
| Wall | 4 | 10 | 13.1 | -14.0 | 14.3 | -15.0 | 15.5 | -16.0 | 18.2 | -19.0 | 21.2 | -22.0 | 24.3 | -26.0 | 27.7 | -30.0 | 31.2 | -33.0 | 35.0 | -37.9 |
| | 4 | 20 | 12.5 | -13.0 | 13.6 | -14.0 | 14.8 | -16.0 | 17.4 | -19.0 | 20.2 | -22.0 | 23.2 | -25.0 | 26.4 | -28.0 | 29.7 | -32.0 | 33.4 | -36.4 |
| | 4 | 50 | 11.7 | -12.0 | 12.8 | -14.0 | 13.9 | -15.0 | 16.3 | -17.0 | 19.0 | -20.0 | 21.7 | -23.0 | 24.7 | -27.0 | 27.9 | -30.0 | 31.3 | -34.3 |
| | 4 | 100 | 11.1 | -12.0 | 12.1 | -13.0 | 13.2 | -14.0 | 15.5 | -17.0 | 18.0 | -19.0 | 20.6 | -22.0 | 23.5 | -25.0 | 26.5 | -29.0 | 29.8 | 32.7 |
| | 4 | 500 | 10.0 | -10.0 | 10.6 | -11.0 | 11.6 | -12.0 | 13.6 | -15.0 | 15.8 | -17.0 | 18.1 | -20.0 | 20.6 | -22.0 | 23.2 | -25.0 | 26.1 | -29.0 |
| | 5 | 10 | 13.1 | -17.0 | 14.3 | -19.0 | 15.5 | -20.0 | 18.2 | -24.0 | 21.2 | -28.0 | 24.3 | -32.0 | 27.7 | -37.0 | 31.2 | -41.0 | 35.0 | -46.8 |
| | 5 | 20 | 12.5 | -16.0 | 13.6 | -17.0 | 14.8 | -19.0 | 17.4 | -22.0 | 20.2 | -26.0 | 23.2 | -30.0 | 26.4 | -34.0 | 29.7 | -39.0 | 33.4 | -43.7 |
| | 5 | 50 | 11.7 | -14.0 | 12.8 | -16.0 | 13.9 | -17.0 | 16.3 | -20.0 | 19.0 | -23.0 | 21.7 | -27.0 | 24.7 | -31.0 | 27.9 | -35.0 | 31.3 | -39.5 |
| | 5 | 100 | 11.1 | -13.0 | 12.1 | -14.0 | 13.2 | -16.0 | 15.5 | -19.0 | 18.0 | -22.0 | 20.6 | -25.0 | 23.5 | -28.0 | 26.5 | -32.0 | 29.8 | -36.4 |
| | 5 | 500 | 10.0 | -10.0 | 10.6 | -11.0 | 11.6 | -12.0 | 13.6 | -15.0 | 15.8 | -17.0 | 18.1 | -20.0 | 20.6 | -22.0 | 23.2 | -25.0 | 26.1 | -29.0 |

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m$^2$, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa.

a. The effective wind area shall be equal to the span length multiplied by an effective width. This width shall be permitted to be not less than one-third the span length. For cladding fasteners, the effective wind area shall not be greater than the area that is tributary to an individual fastener.

b. For effective areas between those given, the load shall be interpolated or the load associated with the lower effective area shall be used.

c. Table values shall be adjusted for height and exposure by multiplying by the adjustment coefficient in Table R301.2(3).

d. See Figure R301.2(2) for location of zones.

e. Plus and minus signs signify pressures acting toward and away from the building surfaces.

f. Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall be exempt from the loads listed in Table R301.2(2) and the height and exposure factors listed in Table R301.2(3). Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state "Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s)." Decals shall be placed such that the decal is visible when the panel is installed.

**TABLE R301.2.1(1)**

**COMPONENT AND CLADDING LOADS FOR A BUILDING WITH A MEAN ROOF HEIGHT OF 30 FEET LOCATED IN EXPOSURE B (ASD) (psf)[a, b, c, d, e, f, g, h]**

| | ZONE | EFFECTIVE WIND AREAS (square feet) | ULTIMATE DESIGN WIND SPEED, $V_{ult}$ | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 90.0 | | 95.0 | | ~~105.0~~ 100.0 | | ~~115.0~~ 105.0 | | ~~130.0~~ 110.0 | | ~~150.0~~ 115.0 | | ~~170.0~~ 120.0 | | ~~95.0~~ 130.0 | | ~~105.0~~ 140.0 | | ~~115.0~~ 150.0 | | ~~130.0~~ 160.0 | | ~~150.0~~ 170.0 | | ~~170.0~~ 180.0 | |
| | | | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg |
| Flat and gable roof 0 to 7 degrees | 1 | 10.0 | 3.6 | -13.9 | 4.0 | -15.5 | 4.4 | -17.2 | 4.8 | -19.0 | 5.3 | -20.8 | 5.8 | -22.7 | 6.3 | -24.8 | 7.4 | -29.1 | 8.6 | -33.7 | 9.9 | -38.7 | 11.2 | -44.0 | 12.7 | -49.7 | 14.2 | -55.7 |
| | 1 | 20.0 | 3.3 | -13.0 | 3.7 | -14.5 | 4.1 | -16.0 | 4.5 | -17.7 | 5.0 | -19.4 | 5.4 | -21.2 | 5.9 | -23.1 | 7.0 | -27.1 | 8.1 | -31.4 | 9.3 | -36.1 | 10.5 | -41.1 | 11.9 | -46.4 | 13.3 | -52.0 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 50.0 | 3.0 | -11.8 | 3.4 | -13.1 | 3.8 | -14.5 | 4.1 | -16.0 | 4.5 | -17.6 | 5.0 | -19.2 | 5.4 | -20.9 | 6.3 | -24.5 | 7.4 | -28.4 | 8.4 | -32.6 | 9.6 | -37.1 | 10.8 | -41.9 | 12.2 | -47.0 |
| | 1 | 100.0 | 2.8 | -10.8 | 3.1 | -12.1 | 3.5 | -13.4 | 3.8 | -14.7 | 4.2 | -16.2 | 4.6 | -17.7 | 5.0 | -19.2 | 5.9 | -22.6 | 6.8 | -26.2 | 7.8 | -30.0 | 8.9 | -34.2 | 10.0 | -38.6 | 11.3 | -43.3 |
| | 2 | 10.0 | 3.6 | -18.4 | 4.0 | -20.5 | 4.4 | -22.7 | 4.8 | -25.0 | 5.3 | -27.4 | 5.8 | -30.0 | 6.3 | -32.7 | 7.4 | -38.3 | 8.6 | -44.5 | 9.9 | -51.0 | 11.2 | -28.1 | 12.7 | -65.6 | 14.2 | -73.5 |
| | 2 | 20.0 | 3.3 | -17.2 | 3.7 | -19.2 | 4.1 | -21.2 | 4.5 | -23.4 | 5.0 | -25.7 | 5.4 | -28.1 | 5.9 | -30.6 | 7.0 | -35.9 | 8.1 | -41.6 | 9.3 | -47.8 | 10.5 | -54.3 | 11.9 | -61.4 | 13.3 | -68.8 |
| | 2 | 50.0 | 3.0 | -15.6 | 3.4 | -17.4 | 3.8 | -19.3 | 4.1 | -21.3 | 4.5 | -23.3 | 5.0 | -25.5 | 5.4 | -27.8 | 6.3 | -32.6 | 7.4 | -37.8 | 8.4 | -43.4 | 9.6 | -49.4 | 10.8 | -55.8 | 12.2 | -62.5 |
| | 2 | 100.0 | 2.8 | -14.4 | 3.1 | -16.1 | 3.5 | -17.8 | 3.8 | -19.7 | 4.2 | -21.6 | 4.6 | -23.6 | 5.0 | -25.7 | 5.9 | -30.1 | 6.8 | -35.0 | 7.8 | -40.1 | 8.9 | -45.7 | 10.0 | -51.5 | 11.3 | -57.8 |
| | 3 | 10.0 | 3.6 | -25.0 | 4.0 | -27.9 | 4.4 | -30.9 | 4.8 | -34.1 | 5.3 | -37.4 | 5.8 | -40.9 | 6.3 | -44.5 | 7.4 | -52.2 | 8.6 | -60.6 | 9.9 | -69.6 | 11.2 | -79.1 | 12.7 | -89.4 | 14.2 | -100.2 |
| | 3 | 20.0 | 3.3 | -22.6 | 3.7 | -25.2 | 4.1 | -28.0 | 4.5 | -30.8 | 5.0 | -33.8 | 5.4 | -37.0 | 5.9 | -40.3 | 7.0 | -47.2 | 8.1 | -54.8 | 9.3 | -62.9 | 10.5 | -71.6 | 11.9 | -80.8 | 13.3 | -90.6 |
| | 3 | 50.0 | 3.0 | -19.4 | 3.4 | -21.7 | 3.8 | -24.0 | 4.1 | -26.5 | 4.5 | -29.0 | 5.0 | -31.7 | 5.4 | -34.6 | 6.3 | -40.6 | 7.4 | -47.0 | 8.4 | -54.0 | 9.6 | -61.4 | 10.8 | -69.4 | 12.2 | -77.8 |
| | 3 | 100.0 | 2.8 | -17.4 | 3.1 | -19.0 | 3.5 | -21.0 | 3.8 | -23.2 | 4.2 | -25.5 | 4.6 | -27.8 | 5.0 | -30.3 | 5.9 | -35.6 | 6.8 | -41.2 | 7.8 | -47.3 | 8.9 | -53.9 | 10.0 | -60.8 | 11.3 | -68.2 |
| Gable roof > 7 to 20 degrees | 1, 2e | 10.0 | 5.4 | -16.2 | 6.0 | -18.0 | 6.7 | -19.9 | 7.4 | -22.0 | 8.1 | -24.1 | 8.8 | -26.4 | 9.6 | -28.7 | 11.3 | -33.7 | 13.1 | 39.1 | 15.0 | 44.9 | 17.1 | -51.0 | 19.3 | -57.6 | 21.6 | -64.6 |
| | 1, 2e | 20.0 | 4.9 | -16.2 | 5.4 | -18.0 | 6.0 | -19.9 | 6.6 | -22.0 | 7.2 | -24.1 | 7.9 | -26.4 | 8.6 | -28.7 | 10.1 | -33.7 | 11.7 | -39.1 | 13.5 | -44.9 | 15.3 | -51.0 | 17.3 | -57.6 | 19.4 | -64.6 |
| | 1, 2e | 50.0 | 4.1 | -9.9 | 4.6 | -11.0 | 5.1 | -12.2 | 5.6 | -13.4 | 6.1 | -14.7 | 6.7 | -16.1 | 7.3 | -17.5 | 8.6 | -20.6 | 10.0 | -23.8 | 11.4 | -27.4 | 13.0 | -31.1 | 14.7 | -35.2 | 16.4 | -39.4 |
| | 1, 2e | 100.0 | 3.6 | -5.0 | 4.0 | -5.6 | 4.4 | -6.2 | 4.8 | -6.9 | 5.3 | -7.5 | 5.8 | -8.2 | 6.3 | -9.0 | 7.4 | -10.5 | 8.6 | -12.2 | 9.9 | -14.0 | 11.2 | -15.9 | 12.7 | -18.0 | 14.2 | -20.2 |
| | 2n, 2r, 3e | 10.0 | 5.4 | -23.6 | 6.0 | -26.3 | 6.7 | -29.1 | 7.4 | -32.1 | 8.1 | -35.2 | 8.8 | -38.5 | 9.6 | -41.9 | 11.3 | -49.2 | 13.1 | -57.0 | 15.0 | -65.4 | 17.1 | -74.5 | 19.3 | -84.1 | 21.6 | -94.2 |
| | 2n, 2r, 3e | 20.0 | 4.9 | -20.3 | 5.4 | -22.7 | 6.0 | -25.1 | 6.6 | -27.7 | 7.2 | -30.4 | 7.9 | -33.2 | 8.6 | -36.2 | 10.1 | -42.4 | 11.7 | -49.2 | 13.5 | -56.5 | 15.3 | -64.3 | 17.3 | -72.6 | 19.4 | -81.4 |
| | 2n, 2r, 3e | 50.0 | 4.1 | -16.0 | 4.6 | -17.9 | 5.1 | -19.8 | 5.6 | -21.8 | 6.1 | -24.0 | 6.7 | -26.2 | 7.3 | -28.5 | 8.6 | -33.5 | 10.0 | -38.8 | 11.4 | -44.6 | 13.0 | -50.7 | 14.7 | -57.2 | 16.4 | -64.2 |
| | 2n, 2r, 3e | 100.0 | 3.6 | -12.8 | 4.0 | -14.3 | 4.4 | -15.8 | 4.8 | -17.4 | 5.3 | -19.1 | 5.8 | -20.9 | 6.3 | -22.8 | 7.4 | -26.7 | 8.6 | -31.0 | 9.9 | -35.6 | 11.2 | -40.5 | 12.7 | -45.7 | 14.2 | -51.3 |
| | 3r | 10.0 | 5.4 | -28.0 | 6.0 | -30.2 | 6.7 | -34.6 | 7.4 | -38.1 | 8.1 | -41.8 | 8.8 | -45.7 | 9.6 | -49.8 | 11.3 | -58.4 | 13.1 | -67.8 | 15.0 | -77.8 | 17.1 | -88.5 | 19.3 | -99.9 | 21.6 | -112.0 |
| | 3r | 20.0 | 4.9 | -24.0 | 5.4 | -26.7 | 6.0 | -29.6 | 6.6 | -32.7 | 7.2 | -35.9 | 7.9 | -39.2 | 8.6 | -42.7 | 10.1 | -50.1 | 11.7 | -58.1 | 13.5 | -66.7 | 15.3 | -75.9 | 17.3 | -85.6 | 19.4 | -96.0 |
| | 3r | 50.0 | 4.1 | -18.7 | 4.6 | -20.8 | 5.1 | -23.1 | 5.6 | -25.4 | 6.1 | -27.9 | 6.7 | -30.5 | 7.3 | -33.2 | 8.6 | -39.0 | 10.0 | -45.2 | 11.4 | -51.9 | 13.0 | -59.0 | 14.7 | -66.6 | 16.4 | -74.7 |
| | 3r | 100.0 | 3.6 | -14.7 | 4.0 | -16.3 | 4.4 | -18.1 | 4.8 | -20.0 | 5.3 | -21.9 | 5.8 | -24.0 | 6.3 | -26.1 | 7.4 | -30.6 | 8.6 | -35.5 | 9.9 | -40.8 | 11.2 | -46.4 | 12.7 | -52.3 | 14.2 | -58.7 |
| Gable roof > 20 to 27 degrees | 1, 2e | 10.0 | 6.5 | -12.4 | 7.3 | -13.9 | 8.0 | -15.4 | 8.9 | -16.9 | 9.7 | -18.6 | 10.6 | -20.3 | 11.6 | -22.1 | 13.6 | -26.0 | 15.8 | -30.1 | 18.1 | -34.6 | 20.6 | -39.3 | 23.3 | -44.4 | 26.1 | -49.9 |
| | 1, 2e | 20.0 | 5.6 | -12.4 | 6.3 | -13.9 | 7.0 | -15.4 | 7.7 | -16.9 | 8.4 | -18.6 | 9.2 | -20.3 | 10.0 | -22.1 | 11.7 | -26.0 | 13.6 | -30.1 | 15.6 | -34.6 | 17.8 | -39.3 | 20.1 | -44.4 | 22.5 | -49.8 |
| | 1, 2e | 50.0 | 4.4 | -10.6 | 5.0 | -11.8 | 5.5 | -3.1 | 6.1 | -14.4 | 6.6 | -15.8 | 7.3 | -17.3 | 7.9 | -18.8 | 9.3 | -22.1 | 10.8 | -25.6 | 12.3 | -29.4 | 14.0 | -33.5 | 15.9 | -37.8 | 17.8 | -42.4 |
| | 1, 2e | 100.0 | 3.6 | -9.1 | 4.0 | -10.2 | 4.4 | -11.3 | 4.8 | -12.4 | 5.3 | -13.6 | 5.8 | -14.9 | 6.3 | -16.2 | 7.4 | -19.0 | 8.6 | -22.1 | 9.9 | -25.3 | 11.2 | -28.8 | 12.7 | -32.5 | 14.2 | -36.5 |
| | 2n, 2r, 3e | 10.0 | 6.5 | -19.9 | 7.3 | -22.1 | 8.0 | -24.5 | 8.9 | -27.0 | 9.7 | -29.7 | 10.6 | -32.4 | 11.6 | -35.3 | 13.6 | -41.4 | 15.8 | -48.0 | 18.1 | -55.2 | 20.6 | -62.8 | 23.3 | -70.8 | 26.1 | -79.4 |
| | 2n, 2r, 3e | 20.0 | 5.6 | -17.4 | 6.3 | -19.4 | 7.0 | -21.5 | 7.7 | -23.7 | 8.4 | -26.0 | 9.2 | -28.4 | 10.0 | -31.0 | 11.7 | -36.3 | 13.6 | -42.1 | 15.6 | -48.4 | 17.8 | -55.0 | 20.1 | -62.1 | 22.5 | -69.6 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2n, 2r, 3e | 50.0 | 4.4 | -14.2 | 5.0 | -15.8 | 5.5 | -17.5 | 6.1 | -19.3 | 6.6 | -21.1 | 7.3 | -23.1 | 7.9 | -25.2 | 9.3 | -29.5 | 10.8 | -34.2 | 12.3 | -39.3 | 14.0 | -44.7 | 15.9 | -50.5 | 17.8 | -56.6 |
| | 2n, 2r, 3e | 100.0 | 3.6 | -11.7 | 4.0 | -13.0 | 4.4 | -14.5 | 4.8 | -15.9 | 5.3 | -17.5 | 5.8 | -19.1 | 6.3 | -20.8 | 7.4 | -24.4 | 8.6 | -28.3 | 9.9 | -32.5 | 11.2 | -37.0 | 12.7 | -41.8 | 14.2 | -46.8 |
| | 3r | 10.0 | 6.5 | -23.6 | 7.3 | -26.3 | 8.0 | -29.1 | 8.9 | -32.1 | 9.7 | -35.2 | 10.6 | -38.5 | 11.6 | -41.9 | 13.6 | -49.2 | 15.8 | -57.0 | 18.1 | -65.4 | 20.6 | -74.5 | 23.3 | -84.1 | 26.1 | -94.2 |
| | 3r | 20.0 | 5.6 | -19.9 | 6.3 | -22.1 | 7.0 | -24.5 | 7.7 | -27.0 | 8.4 | -29.7 | 9.2 | -32.4 | 10.0 | -35.3 | 11.7 | -41.4 | 13.6 | -48.0 | 15.6 | -55.2 | 17.8 | -62.8 | 20.1 | -70.8 | 22.5 | -79.4 |
| | 3r | 50.0 | 4.4 | -14.7 | 5.0 | -16.3 | 5.5 | -18.1 | 6.1 | -20.0 | 6.6 | -21.9 | 7.3 | -24.0 | 7.9 | -26.1 | 9.3 | -30.6 | 10.8 | -35.5 | 12.3 | -40.8 | 14.0 | -46.4 | 15.9 | -52.3 | 17.8 | -58.7 |
| | 3r | 100.0 | 3.6 | -14.7 | 4.0 | -16.3 | 4.4 | -18.1 | 4.8 | -20.0 | 5.3 | -21.9 | 5.8 | -24.0 | 6.3 | -26.1 | 7.4 | -30.6 | 8.6 | -35.5 | 9.9 | -40.8 | 11.2 | -46.4 | 12.7 | -52.3 | 14.2 | -58.7 |

*(continued)*

**TABLE R301.2.1(1)—continued**

**COMPONENT AND CLADDING LOADS FOR A BUILDING WITH A MEAN ROOF HEIGHT OF 30 FEET LOCATED IN EXPOSURE B (ASD) (psf) [a, b, c, d, e, f, g, h]**

| | ZONE | EFFECTIVE WIND AREAS (square feet) | ULTIMATE DESIGN WIND SPEED, $V_{ult}$ | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 90.0 | | 95.0 | | 100.0 | | 105.0 | | 110.0 | | 115.0 | | 120.0 | | 130.0 | | 140.0 | | 150.0 | | 160.0 | | 170.0 | | 180.0 | |
| | | | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg |
| Gable roof > 27 to 45 degrees | 1, 2e, 2r | 10.0 | 8.0 | -14.7 | 8.9 | -16.3 | 9.9 | -18.1 | 10.9 | -20.0 | 12.0 | -21.9 | 13.1 | -24.0 | 14.2 | -26.1 | 16.7 | -30.6 | 19.4 | -35.5 | 22.2 | -40.8 | 25.3 | -16.4 | 28.5 | -52.3 | 32.0 | -58.7 |
| | 1, 2e, 2r | 20.0 | 7.1 | -12.4 | 7.9 | -13.9 | 8.8 | -15.4 | 9.7 | -16.9 | 10.6 | -18.6 | 11.6 | -20.3 | 12.6 | -22.1 | 14.8 | -26.0 | 17.2 | -30.1 | 19.8 | -34.6 | 22.5 | -39.3 | 25.4 | -44.4 | 28.5 | -49.8 |
| | 1, 2e, 2r | 50.0 | 5.9 | -9.5 | 6.6 | -10.6 | 7.3 | -11.7 | 8.1 | -12.9 | 8.9 | -14.2 | 9.7 | -15.5 | 10.5 | -16.9 | 12.4 | -19.8 | 14.3 | -22.9 | 16.5 | -26.3 | 18.7 | -30.0 | 21.1 | -33.8 | 23.7 | -37.9 |
| | 1, 2e, 2r | 100.0 | 5.0 | -7.3 | 5.6 | -8.1 | 6.2 | -9.0 | 6.9 | -9.9 | 7.5 | -10.8 | 8.2 | -11.9 | 9.0 | -12.9 | 10.5 | -15.1 | 12.2 | -17.6 | 14.0 | -20.2 | 15.9 | -22.9 | 18.0 | -25.9 | 20.2 | -29.0 |
| | 2n, 3r | 10.0 | 8.0 | -16.2 | 8.9 | -18.0 | 9.9 | -19.9 | 10.9 | -22.0 | 12.0 | -24.1 | 13.1 | -26.4 | -14.2 | -28.7 | 16.7 | -33.7 | 19.4 | -39.1 | 22.2 | -44.9 | 25.3 | -51.0 | 28.5 | -57.6 | 32.0 | -64.6 |
| | 2n, 3r | 20.0 | 7.1 | -14.4 | 7.9 | -16.1 | 8.8 | -17.8 | 9.7 | -19.7 | 10.6 | -21.6 | 11.6 | -23.6 | 12.6 | -25.7 | 14.8 | -30.1 | 17.2 | -34.9 | 19.8 | -40.1 | 22.5 | -45.6 | 25.4 | -51.5 | 28.5 | -57.8 |
| | 2n, 3r | 50.0 | 5.9 | -12.2 | 6.6 | -13.5 | 7.3 | -15.0 | 8.1 | -16.5 | 8.9 | -18.2 | 9.7 | -19.9 | 10.5 | -21.6 | 12.4 | -25.4 | 14.3 | -29.4 | 16.5 | -33.8 | 18.7 | -38.4 | 21.1 | -43.4 | 23.7 | -48.6 |
| | 2n, 3r | 100.0 | 5.0 | -10.4 | 5.6 | -11.6 | 6.2 | -12.9 | 6.9 | -14.2 | 7.5 | -15.6 | 8.2 | -17.1 | 9.0 | -18.6 | 10.5 | -21.8 | 12.2 | -25.3 | 14.0 | -29.0 | 15.9 | -33.0 | 18.0 | -37.3 | 20.0 | -41.8 |
| | 3e | 10.0 | 8.0 | -19.9 | 8.9 | -22.1 | 9.9 | -24.5 | 10.9 | -27.0 | 12.0 | -29.7 | 13.1 | -32.4 | 14.2 | -35.3 | 16.7 | -41.4 | 19.4 | -48.0 | 22.2 | -55.2 | 25.3 | -62.8 | 28.8 | -70.8 | 32.0 | -79.4 |
| | 3e | 20.0 | 7.1 | -17.6 | 7.9 | -19.6 | 8.8 | -21.8 | 9.7 | -24.0 | 10.6 | -26.3 | 11.6 | -28.8 | 12.6 | -31.3 | 14.8 | -36.8 | 17.2 | -42.7 | 19.8 | -49.0 | 22.5 | -55.7 | 25.4 | -62.9 | 28.5 | -70.5 |
| | 3e | 50.0 | 5.9 | -14.7 | 6.6 | -16.3 | 7.3 | -18.1 | 8.1 | -20.0 | 8.9 | -21.9 | 9.7 | -24.0 | 10.5 | -26.1 | 12.4 | -30.6 | 14.3 | -35.5 | 16.6 | -40.8 | 18.7 | -46.4 | 21.1 | -52.3 | 23.7 | -58.7 |
| | 3e | 100.0 | 5.0 | -12.4 | 5.6 | -13.9 | 6.2 | -15.4 | 6.9 | -16.9 | 7.5 | -18.6 | 8.2 | -20.3 | 9.0 | -22.1 | 10.5 | -26.0 | 12.2 | -30.1 | 14.0 | -34.6 | 15.9 | -39.3 | 18.0 | -44.4 | 20.2 | -49.8 |
| Hipped roof > 7 to 20 degrees[g] | 1 | 10.0 | 6.5 | -14.7 | 7.3 | -16.3 | 8.0 | -18.1 | 8.9 | -20.0 | 9.7 | -21.9 | 10.6 | -24.0 | 11.6 | -26.1 | 13.6 | -30.6 | 15.8 | -35.5 | 18.1 | -40.8 | 20.6 | -46.4 | 23.3 | -52.3 | 26.1 | -58.7 |
| | 1 | 20.0 | 5.6 | -14.7 | 6.3 | -16.3 | 7.0 | -18.1 | 7.7 | -20.0 | 8.4 | -21.9 | 9.2 | -24.0 | 10.0 | -26.1 | 11.7 | -30.6 | 13.6 | -35.5 | 15.6 | -40.8 | 17.8 | -46.4 | 20.1 | -52.3 | 22.5 | -58.7 |
| | 1 | 50.0 | 4.4 | -11.3 | 5.0 | -12.6 | 5.5 | -14.0 | 6.1 | -15.4 | 6.6 | -16.9 | 7.3 | -18.5 | 7.9 | -20.2 | 9.3 | -23.7 | 10.8 | -27.4 | 12.3 | -31.5 | 14.0 | -35.8 | 15.9 | -40.4 | 17.8 | -45.3 |
| | 1 | 100.0 | 3.6 | -8.7 | 4.0 | -9.7 | 4.4 | -10.8 | 4.8 | -11.9 | 5.3 | -13.1 | 5.8 | -14.3 | 6.3 | -15.5 | 7.4 | -18.2 | 8.6 | -21.2 | 9.9 | -24.3 | 11.2 | -27.6 | 12.7 | -31.2 | 14.2 | -35.0 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2r | 10.0 | 6.5 | -19.1 | 7.3 | -21.3 | 8.0 | -23.6 | 8.9 | -26.0 | 9.7 | -28.6 | 10.6 | -31.2 | 11.6 | -34.0 | 13.6 | -39.9 | 15.8 | -46.3 | 18.1 | -53.1 | 20.6 | -60.4 | 23.3 | -68.2 | 26.1 | -76.5 |
| | 2r | 20.0 | 5.6 | -17.2 | 6.3 | -19.2 | 7.0 | -21.3 | 7.7 | -23.4 | 8.4 | -25.7 | 9.2 | -28.1 | 10.0 | -30.6 | 11.7 | -35.9 | 13.6 | -41.7 | 15.6 | -47.9 | 17.8 | -54.4 | 20.1 | -61.5 | 22.5 | -68.9 |
| | 2r | 50.0 | 4.4 | -14.7 | 5.0 | -16.4 | 5.5 | -18.2 | 6.1 | -20.0 | 6.6 | -22.0 | 7.3 | -24.0 | 7.9 | -26.1 | 9.3 | -30.7 | 10.8 | -35.6 | 12.3 | -40.9 | 14.0 | -46.5 | 15.9 | -52.5 | 17.8 | -58.8 |
| | 2r | 100.0 | 3.6 | -12.8 | 4.0 | -14.3 | 4.4 | -15.8 | 4.8 | -17.4 | 5.3 | -19.1 | 5.8 | -20.9 | 6.3 | -22.8 | 7.4 | -26.7 | 8.6 | -31.0 | 9.9 | -35.6 | 11.2 | -40.5 | 12.7 | -45.7 | 14.2 | -51.3 |
| | 2e, 3 | 10.0 | 6.5 | -20.6 | 7.3 | -22.9 | 8.0 | -25.4 | 8.9 | -28.0 | 9.7 | -30.8 | 10.6 | -33.6 | 11.6 | -36.6 | 13.6 | -43.0 | 15.8 | -49.8 | 18.1 | -57.2 | 20.6 | -65.1 | 23.3 | -73.5 | 26.1 | -82.4 |
| | 2e, 3 | 20.0 | 5.6 | -18.5 | 6.3 | -20.6 | 7.0 | -22.9 | 7.7 | -25.2 | 8.4 | -27.7 | 9.2 | -30.3 | 10.0 | -32.9 | 11.7 | -38.7 | 13.6 | -44.8 | 15.6 | -51.5 | 17.8 | -58.6 | 20.1 | -66.1 | 22.5 | -74.1 |
| | 2e, 3 | 50.0 | 4.4 | -15.8 | 5.0 | -17.6 | 5.5 | -19.5 | 6.1 | -21.5 | 6.6 | -23.6 | 7.3 | -25.8 | 7.9 | -28.0 | 9.3 | -32.9 | 10.8 | -38.2 | 12.3 | -43.8 | 14.0 | -49.9 | 15.9 | -56.3 | 17.8 | -63.1 |
| | 2e, 3 | 100.0 | 3.6 | -13.7 | 4.0 | -15.3 | 4.0 | -16.9 | 4.8 | -18.7 | 5.3 | -20.5 | 5.8 | -22.4 | 6.3 | -24.4 | 7.4 | -28.6 | 8.6 | -33.2 | 9.9 | -38.1 | 11.2 | -43.3 | 12.7 | -48.9 | 14.2 | -54.8 |
| Hipped roof > 20 to 27 degrees | 1 | 10.0 | 6.5 | -11.7 | 7.3 | -13.0 | 8.0 | -14.5 | 8.9 | -15.9 | 9.7 | -17.5 | 10.6 | -19.1 | 11.6 | -20.8 | 13.6 | -24.4 | 15.8 | -28.3 | 18.1 | -32.5 | 20.6 | -37.0 | 23.3 | -41.8 | 26.1 | -46.8 |
| | 1 | 20.0 | 5.6 | -10.4 | 6.3 | -11.6 | 7.0 | -12.8 | 7.7 | -14.1 | 8.4 | -15.5 | 9.2 | -16.9 | 10.0 | -18.4 | 11.7 | -21.6 | 13.6 | -25.1 | 15.6 | -28.8 | 17.8 | -32.8 | 20.1 | -37.0 | 22.5 | -41.5 |
| | 1 | 50.0 | 4.4 | -8.6 | 5.0 | -9.6 | 5.5 | -10.6 | 6.1 | -11.7 | 6.6 | -12.8 | 7.3 | -14.0 | 7.9 | -15.3 | 9.3 | -17.9 | 10.8 | -20.8 | 12.3 | -23.9 | 14.0 | -27.2 | 15.9 | -30.7 | 17.8 | -34.4 |
| | 1 | 100.0 | 3.6 | -7.3 | 4.0 | -8.1 | 4.4 | -9.0 | 4.8 | -9.9 | 5.3 | -10.8 | 5.8 | -11.9 | 6.3 | -12.9 | 7.4 | -15.1 | 8.6 | -17.6 | 9.9 | -20.2 | 11.2 | -22.9 | 12.7 | -25.9 | 14.2 | -29.0 |
| | 2e, 2r, 3 | 10.0 | 6.5 | -16.2 | 7.3 | -18.0 | 8.0 | -19.9 | 8.9 | -22.0 | 9.7 | -24.1 | 10.6 | -26.4 | 11.6 | -28.7 | 13.6 | -33.7 | 15.8 | -39.1 | 18.1 | -44.9 | 20.6 | -51.0 | 23.3 | -57.6 | 26.1 | -64.6 |
| | 2e, 2r, 3 | 20.0 | 5.6 | -14.4 | 6.3 | -16.1 | 7.0 | -17.8 | 7.7 | -19.7 | 8.4 | -21.6 | 9.2 | -23.6 | 10.0 | -25.7 | 11.7 | -30.1 | 13.6 | -34.9 | 15.6 | -40.1 | 17.8 | -45.6 | 20.1 | -51.5 | 22.5 | -57.8 |
| | 2e, 2r, 3 | 50.0 | 4.4 | -12.2 | 5.0 | -13.5 | 5.5 | -15.0 | 6.1 | -16.5 | 6.6 | -18.2 | 7.3 | -19.9 | 7.9 | -21.6 | 9.3 | -25.4 | 10.8 | -29.4 | 12.3 | -33.8 | 14.0 | -38.4 | 15.9 | -43.4 | 17.8 | -48.6 |
| | 2e, 2r, 3 | 100.0 | 3.6 | -10.4 | 4.0 | -11.6 | 4.4 | -12.9 | 4.8 | -14.2 | 5.3 | -15.6 | 5.8 | -17.1 | 6.3 | -18.6 | 7.4 | -21.8 | 8.6 | -25.3 | 9.9 | -29.0 | 11.2 | -33.0 | 12.7 | -37.3 | 14.2 | -41.8 |

*(continued)*

**TABLE R301.2.1(1)—continued**

**COMPONENT AND CLADDING LOADS FOR A BUILDING WITH A MEAN ROOF HEIGHT OF 30 FEET LOCATED IN EXPOSURE B (ASD) (psf) [a, b, c, d, e, f, g, h]**

| | ZONE | EFFECTIVE WIND AREAS (square feet) | ULTIMATE DESIGN WIND SPEED, $V_{ult}$ | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 90.0 | | 95.0 | | ~~105.0~~ 100.0 | | ~~115.0~~ 105.0 | | ~~130.0~~ 110.0 | | ~~150.0~~ 115.0 | | ~~170.0~~ 120.0 | | ~~95.0~~ 130.0 | | ~~105.0~~ 140.0 | | ~~115.0~~ 150.0 | | ~~130.0~~ 160.0 | | ~~150.0~~ 170.0 | | ~~170.0~~ 180.0 | |
| | | | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg | | |
| Hipped roof > 27 to 45 degrees | 1 | 10.0 | 6.2 | -12.4 | 6.9 | -13.9 | 7.7 | -15.4 | 8.5 | -16.9 | 9.3 | -18.6 | 10.2 | -20.3 | 11.1 | -22.1 | 13.0 | -26.0 | 15.1 | -30.1 | 17.3 | -34.6 | 19.7 | -39.3 | 22.2 | -44.4 | 24.9 | -49.8 |
| | 1 | 20.0 | 5.4 | -11.0 | 6.0 | -12.3 | 6.7 | -13.6 | 7.4 | -15.0 | 8.1 | -16.5 | 8.9 | -18.0 | 9.6 | -19.6 | 11.3 | -23.0 | 13.1 | -26.7 | 15.1 | -30.7 | 17.1 | -34.9 | 19.4 | -39.4 | 21.7 | -44.2 |
| | 1 | 50.0 | 4.4 | -9.2 | 4.9 | -10.2 | 5.4 | -11.3 | 5.9 | -12.5 | 6.5 | -13.7 | 7.1 | -15.0 | 7.7 | -16.3 | 9.1 | -19.2 | 10.5 | -22.2 | 12.1 | -25.5 | 13.8 | -29.0 | 15.5 | -32.8 | 17.4 | -36.7 |
| | 1 | 100.0 | 3.6 | -7.8 | 4.0 | -8.7 | 4.4 | -9.6 | 4.8 | -10.6 | 5.3 | -11.6 | 5.8 | -12.7 | 6.3 | -13.8 | 7.4 | -16.2 | 8.6 | -18.8 | 9.9 | -21.6 | 11.2 | -24.6 | 12.7 | -27.8 | 14.2 | -31.1 |
| | 2e | 10.0 | 6.2 | -14.8 | 6.9 | -16.5 | 7.7 | -18.3 | 8.5 | -20.2 | 9.3 | -22.1 | 10.2 | -24.2 | 11.1 | -26.3 | 13.0 | -30.9 | 15.1 | -35.9 | 17.3 | -41.2 | 19.7 | -46.8 | 22.2 | -52.9 | 24.9 | -59.3 |
| | 2e | 20.0 | 5.4 | -11.7 | 6.0 | -13.0 | 6.7 | -14.5 | 7.4 | -15.9 | 8.1 | -17.5 | 8.9 | -19.1 | 9.6 | -20.8 | 11.3 | -24.4 | 13.1 | -28.3 | 15.1 | -32.5 | 17.1 | -37.0 | 19.4 | -41.8 | 21.7 | -46.8 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2e | 50.0 | 4.4 | -7.3 | 4.9 | -8.1 | 5.4 | -9.0 | 5.9 | -9.9 | 6.5 | -10.8 | 7.1 | -11.9 | 7.7 | -12.9 | 9.1 | -15.1 | 10.5 | -17.6 | 12.1 | -20.2 | 13.8 | -22.9 | 15.5 | -25.9 | 17.4 | -29.0 |
| | 2e | 100.0 | 3.6 | -7.3 | 4.0 | -8.1 | 4.4 | -9.0 | 4.8 | -9.9 | 5.3 | -10.8 | 5.8 | -11.9 | 6.3 | -12.9 | 7.4 | -15.1 | 8.6 | -17.6 | 9.9 | -20.2 | 11.2 | -22.9 | 12.7 | -25.9 | 14.2 | -29.0 |
| | 2r | 10.0 | 6.2 | -18.7 | 6.9 | -20.9 | 7.7 | -23.1 | 8.5 | -25.5 | 9.3 | -28.0 | 10.2 | -30.6 | 11.1 | -33.3 | 13.0 | -39.1 | 15.1 | -45.4 | 17.3 | -52.1 | 19.7 | -59.2 | 22.2 | -66.9 | 24.9 | -75.0 |
| | 2r | 20.0 | 5.4 | -15.7 | 6.0 | -17.5 | 6.7 | -19.4 | 7.4 | -21.4 | 8.1 | -23.5 | 8.9 | -25.7 | 9.6 | -28.0 | 11.3 | -32.8 | 13.1 | -38.1 | 15.1 | -43.7 | 17.1 | -49.8 | 19.4 | -56.2 | 21.7 | -63.0 |
| | 2r | 50.0 | 4.4 | -11.7 | 4.9 | -13.1 | 5.4 | -14.5 | 5.9 | -16.0 | 6.5 | -17.5 | 7.1 | -19.2 | 7.7 | -20.9 | 9.1 | -24.5 | 10.5 | -28.4 | 12.1 | -32.6 | 13.8 | -37.1 | 15.5 | -41.9 | 17.4 | -47.0 |
| | 2r | 100.0 | 3.6 | -8.7 | 4.0 | -9.7 | 4.4 | -10.8 | 4.8 | -11.9 | 5.3 | -13.1 | 5.8 | -14.3 | 6.3 | -15.5 | 7.4 | -18.2 | 8.6 | -21.2 | 9.9 | -24.3 | 11.2 | -27.6 | 12.7 | -31.2 | 14.2 | -35.0 |
| | 3 | 10.0 | 6.2 | -20.0 | 6.9 | -22.3 | 7.7 | -24.7 | 8.5 | -27.2 | 9.3 | -29.9 | 10.2 | -32.7 | 11.1 | -35.6 | 13.0 | -41.7 | 15.1 | -48.4 | 17.3 | -55.6 | 19.7 | -63.2 | 22.2 | -71.4 | 24.9 | -80.0 |
| | 3 | 20.0 | 5.4 | -15.0 | 6.0 | -16.8 | 6.7 | -18.6 | 7.4 | -20.5 | 8.1 | -22.5 | 8.9 | -24.6 | 9.6 | -26.7 | 11.3 | -31.4 | 13.1 | -36.4 | 15.1 | -41.8 | 17.1 | -47.5 | 19.4 | -53.7 | 21.7 | -60.2 |
| | 3 | 50.0 | 4.4 | -8.7 | 4.9 | -9.7 | 5.4 | -10.8 | 5.9 | -11.9 | 6.5 | -13.1 | 7.1 | -14.3 | 7.7 | -15.5 | 9.1 | -18.2 | 10.5 | -21.2 | 12.1 | -24.3 | 13.8 | -27.6 | 15.5 | -31.2 | 17.4 | -35.0 |
| | 3 | 100.0 | 3.6 | -8.7 | 4.0 | -9.7 | 4.4 | -10.8 | 4.8 | -11.9 | 5.3 | -13.1 | 5.8 | -14.3 | 6.3 | -15.5 | 7.4 | -18.2 | 8.6 | -21.2 | 9.9 | -24.3 | 11.2 | -27.6 | 12.7 | -31.2 | 14.2 | -35.0 |
| Wall | 4 | 10.0 | 8.7 | -9.5 | 9.7 | -10.6 | 10.8 | -11.7 | 11.9 | -12.9 | 13.1 | -14.2 | 14.3 | -15.5 | 15.5 | -16.9 | 18.2 | -19.8 | 21.2 | -22.9 | 24.3 | -26.3 | 27.6 | -30.0 | 31.2 | -33.8 | 35.0 | -37.9 |
| | 4 | 20.0 | 8.3 | -9.1 | 9.3 | -10.1 | 10.3 | -11.2 | 11.4 | -12.4 | 12.5 | -13.6 | 13.6 | -14.8 | 14.8 | -16.2 | 17.4 | -19.0 | 20.2 | -22.0 | 23.2 | -25.3 | 26.4 | -28.7 | 29.8 | -32.4 | 33.4 | -36.4 |
| | 4 | 50.0 | 7.8 | -8.6 | 8.7 | -9.5 | 9.7 | -10.6 | 10.7 | -11.7 | 11.7 | -12.8 | 12.8 | -14.0 | 13.9 | -15.2 | 16.3 | -17.9 | 18.9 | -20.7 | 21.7 | -23.8 | 24.7 | -27.1 | 27.9 | -30.6 | 31.3 | -34.3 |
| | 4 | 100.0 | 7.4 | -8.2 | 8.3 | -9.1 | 9.2 | -10.1 | 10.1 | -11.1 | 11.1 | -12.2 | 12.1 | -13.3 | 13.2 | -14.5 | 15.5 | -17.1 | 18.0 | -19.8 | 20.6 | -22.7 | 23.5 | -25.8 | 26.5 | -29.2 | 29.7 | -32.7 |
| | 4 | 500.0 | 6.5 | -7.3 | 7.3 | -8.1 | 8.0 | -9.0 | 8.9 | -9.9 | 9.7 | -10.8 | 10.6 | -11.9 | 11.6 | -12.9 | 13.5 | -15.1 | 15.8 | -17.6 | 18.1 | -20.2 | 20.6 | -22.9 | 23.3 | -25.9 | 26.1 | -29.0 |
| | 5 | 10.0 | 8.7 | -11.7 | 9.7 | -13.0 | 10.8 | -14.5 | 11.9 | -15.9 | 13.1 | -17.5 | 14.3 | -19.1 | 15.5 | -20.8 | 18.2 | -24.4 | 21.2 | -28.3 | 24.3 | -32.5 | 27.6 | -37.0 | 31.2 | -41.8 | 35.0 | -46.8 |
| | 5 | 20.0 | 8.3 | -10.9 | 9.3 | -12.2 | 10.3 | -13.5 | 11.4 | -14.9 | 12.5 | -16.3 | 13.6 | -17.8 | 14.8 | -19.4 | 17.4 | -22.8 | 20.2 | -26.4 | 23.2 | -30.3 | 26.4 | -34.5 | 29.8 | -39.0 | 33.4 | -43.7 |
| | 5 | 50.0 | 7.8 | -9.9 | 8.7 | -11.0 | 9.7 | -12.2 | 10.7 | -13.4 | 11.7 | -14.7 | 12.8 | -16.1 | 13.9 | -17.5 | 16.3 | -20.6 | 18.9 | -23.9 | 21.7 | -27.4 | 24.7 | -31.2 | 27.9 | -35.2 | 31.3 | -39.5 |
| | 5 | 100.0 | 7.4 | -9.1 | 8.3 | -10.1 | 9.2 | -11.2 | 10.1 | -12.4 | 11.1 | -13.6 | 12.1 | -14.8 | 13.2 | -16.1 | 15.5 | -19.0 | 18.0 | -22.0 | 20.6 | -25.2 | 23.5 | -28.7 | 26.5 | -32.4 | 29.7 | -36.3 |
| | 5 | 500.0 | 6.5 | -7.3 | 7.3 | -8.1 | 8.0 | -9.0 | 8.9 | -9.9 | 9.7 | -10.8 | 10.6 | -11.9 | 11.6 | -12.9 | 13.6 | -15.1 | 15.8 | -17.6 | 18.1 | -20.2 | 20.6 | -22.9 | 23.3 | -25.9 | 26.1 | -29.0 |

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m$^2$, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa.

a. The effective wind area shall be equal to the span length multiplied by an effective width. This width shall be not less than one-third the span length. For cladding fasteners, the effective wind areas shall not be greater than the area that is tributary to an individual fastener.

b. For effective areas between those given, the load shall be interpolated or the load associated with the lower effective areas shall be used.

c. Table values shall be adjusted for height and exposure by multiplying by the adjustment coefficient in Table R301.2.1(2).

d. See Figure R318.4 for locations of termite infestation probability zones.

e. Plus and minus signs signify pressures acting toward and away from the building surfaces.

f. Positive and negative design wind pressures shall not be less than 10 psf.

g. Where the ratio of the building mean roof height to the building length or width is less than 0.8, uplift loads shall be permitted to be calculated in accordance with ASCE 7.

h. Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall be exempt from the loads listed in Table R301.2(2) and the height and exposure factors listed in Table R301.2(3). Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state "Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s)." Decals shall be placed such that the decal is visible when the panel is installed.

**TABLE ~~R301.2.1(3)~~ R301.2.1(2)**

**HEIGHT AND EXPOSURE ADJUSTMENT COEFFICIENTS FOR Table ~~R301.2.1(2)~~ R301.2.1(1)**

| MEAN ROOF HEIGHT | EXPOSURE | | |
|---|---|---|---|
| | B | C | D |
| 15 | ~~1.00~~ 0.82 | 1.21 | 1.47 |
| 20 | ~~1.00~~ 0.89 | 1.29 | 1.55 |
| 25 | ~~1.00~~ 0.94 | 1.35 | 1.61 |
| 30 | 1.00 | 1.40 | 1.66 |
| 35 | 1.05 | 1.45 | 1.70 |
| 40 | 1.09 | 1.49 | 1.74 |
| 45 | 1.12 | 1.53 | 1.78 |
| 50 | 1.16 | 1.56 | 1.81 |
| 55 | 1.19 | 1.59 | 1.84 |
| 60 | 1.22 | 1.62 | 1.87 |

**TABLE R301.2(4)**
**ULTIMATE DESIGN WIND SPEEDS BY COUNTY (mph)**

| | | | |
|---|---|---|---|
| Counties not listed | 115 | | |
| | | | |
| Alleghany | special mountain region | Johnston | 120 |
| Ashe | special mountain region | Jones | 140 |
| Avery | special mountain region | Lenoir | 130 |
| Beaufort | 130 | Madison | special mountain region |
| Bertie[a] | 120/130 | Martin[g] | 120/130 |
| Bladen[b] | 130/140 | Mitchell | special mountain region |
| Brunswick[c] | 140/150 | New Hanover[h] | 140/150 |
| Buncombe | special mountain region | Onslow[i] | 130/140/150 |
| Camden | 130 | Pamlico | 140 |
| Carteret | 150 | Pasquotank | 130 |
| Chowan | 130 | Pender[j] | 130/140/150 |
| Columbus | 140 | Perquimans | 130 |
| Craven | 140 | Pitt | 130 |
| Cumberland[d] | 120/130 | Richmond | 120 |
| Currituck | 130 | Robeson | 130 |
| Dare[e] | 130/140 | Sampson | 130 |
| Duplin | 130 | Scotland | 120 |
| Gates | 120 | Swain | special mountain region |
| Graham | special mountain region | Tyrell | 130 |
| Greene | 130 | Washington | 130 |
| Harnett | 120 | Watauga | special mountain region |
| Haywood | special mountain region | Wayne | 130 |
| Hoke | 120 | Wilson | 120 |
| Hyde[f] | 130/140 | Yancey | special mountain region |
| Jackson | special mountain region | | |

For SI: 1 foot = 304.8, 1 mile per hour = 0.44 m/s.
a. Bertie County—120 mph zone west of Hwy. 17, 130 mph zone east of Hwy. 17.
b. Bladen County—130 mph zone west of Hwy. 701, 140 mph zone east of Hwy. 701.
c. Brunswick County—140 mph zone west of Hwy. 17, 150 mph zone east of Hwy. 17, 150 mph on Bald Head Island.
d. Cumberland County—120 mph zone west of I-95, 130 mph zone east of I-95.
e. Dare County—130 mph zone west of U.S. Route 264, 140 mph zone east of U.S. Route 264.
f. Hyde County—130 mph zone west of U.S. Route 264, 140 mph zone east of U.S. Route 264.
g. Martin County—120 mph zone west of Hwy. 17, 130 mph zone east of Hwy 17.
h. New Hanover County—140 mph zone west of Hwy. 17, 150 mph zone east of Hwy. 17.
i. Onslow County—130 mph zone west of Hwy. 17, 140 mph zone east of Hwy 17 to the Intracoastal Waterway, 150 mph zone east of the Intracoastal Waterway.
j. Pender County—140 mph zone in the Township of Topsail west of the Intracoastal Waterway, 150 mph zone east of the Intracoastal Waterway, 130 mph zone in the remainder of the county.

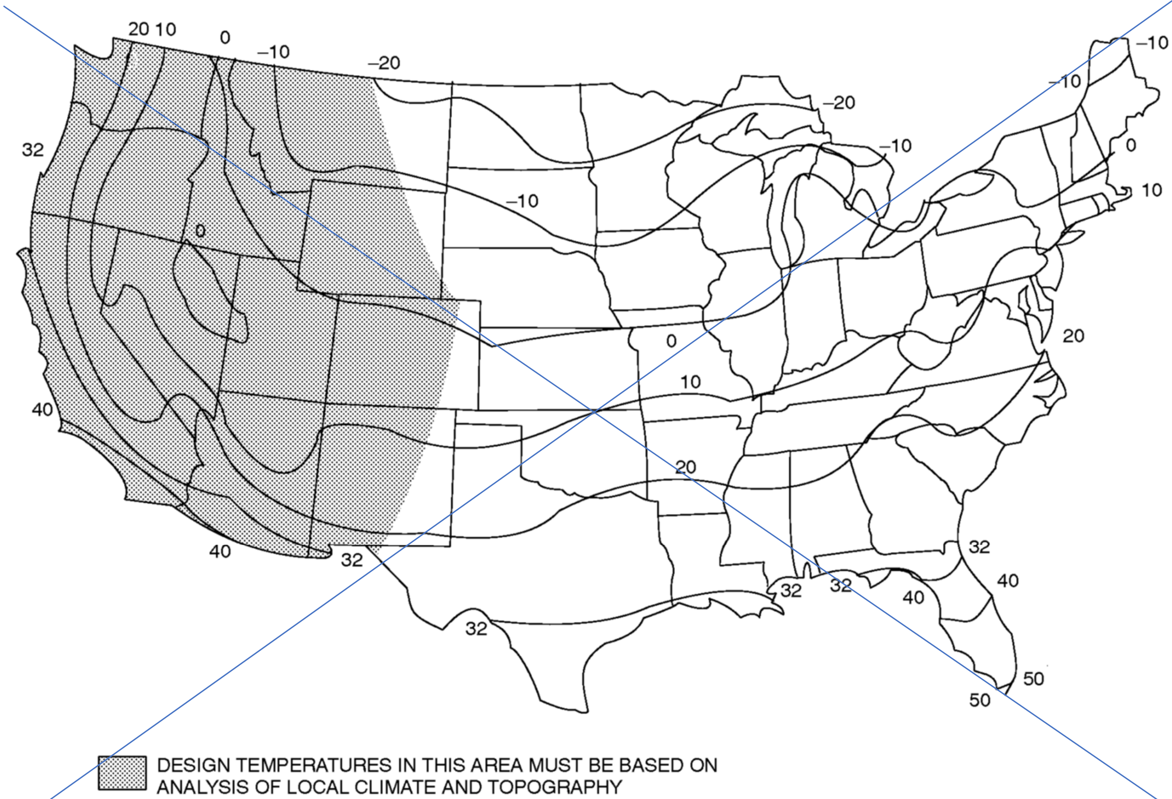
**TABLE R301.2(4)**
**ULTIMATE DESIGN WIND SPEEDS BY COUNTY (mph)**

| | | | |
|---|---|---|---|
| Counties not listed | 115 | | |
| | | | |
| Alleghany | special mountain region | Johnston | 120 |
| Ashe | special mountain region | Jones | 140 |
| Avery | special mountain region | Lenoir | 130 |
| Beaufort | 130 | Madison | special mountain region |
| Bertie | 120 | Martin[f] | 120/130 |
| Bladen[a] | 130/140 | Mitchell | special mountain region |
| Brunswick | 150 | New Hanover | 150 |
| Buncombe | special mountain region | Onslow[g] | 140/150 |
| Camden | 130 | Pamlico | 140 |
| Carteret | 150 | Pasquotank | 130 |
| Chowan | 130 | Pender[h] | 140/150 |
| Columbus | 140 | Perquimans | 130 |
| Craven | 140 | Pitt | 130 |
| Cumberland[b] | 120/130 | Richmond | 120 |

| | | | |
|---|---|---|---|
| Currituck | 130 | Robeson | 130 |
| Dare[c] | 130/140 | Sampson | 130 |
| Duplin[d] | 130/140 | Scotland | 120 |
| Gates | 120 | Swain | special mountain region |
| Graham | special mountain region | Tyrell | 130 |
| Greene | 130 | Washington | 130 |
| Harnett | 120 | Watauga | special mountain region |
| Haywood | special mountain region | Wayne | 130 |
| Hoke | 120 | Wilson | 120 |
| Hyde[e] | 130/140 | Yancey | special mountain region |
| Jackson | special mountain region | | |

For SI: 1 foot = 304.8, 1 mile per hour = 0.44 m/s.

a) Bladen County – 130 mph zone west of Hwy. 701, 140 mph zone east of Hwy. 701.
b) Cumberland County – 120 mph zone west of I-95, 130 mph zone east of I-95.
c) Dare County - 130 mph zone west of U.S. Route 264, 140 mph zone east of U.S. Route 264.
d) Duplin County - 130 mph zone west of U.S. Route 41, 140 mph zone east of U.S. Route 41
e) Hyde County – 130 mph zone west of U.S. Route 264, 140 mph zone east of U.S. Route 264.
f) Martin County – 120 mph zone west of Hwy. 17, 130 mph zone east of Hwy 17,
g) Onslow County – 150 mph zone in the Township of Swansboro and Stump Sound, 150 mph zone east of the Intracoastal Waterway, 140 mph zone in the remainder of the county
h) Pender County – 150 mph zone in the Township of Topsail, 140 mph zone in the remainder of the county.




For SI: °C = [(°F)-32]/1.8.

~~FIGURE R301.2(1)~~
~~ISOLINES OF THE 97 1/2 -PERCENT WINTER (DECEMBER, JANUARY AND FEBRUARY) DESIGN TEMPERATURES (°F)~~

**TABLE R301.2(6)**
**DESIGN PRESSURES FOR DOORS AND WINDOWS [a,b,c,d,e]**
**POSITIVE AND NEGATIVE (psf)**

| VELOCITY (mph) | MEAN ROOF HEIGHT (feet) | | |
|---|---|---|---|
| | 15 | 25 | 35 |
| 115 | ~~15~~ 16 | ~~17~~ 18 | ~~19~~ 20 |
| 120 | ~~20~~ 17 | ~~23~~ 20 | ~~25~~ 22 |

For SI: 1 foot = 304.8, 1 mile per hour = 0.44 m/s.

a. Alternative design pressures may be determined by using *North Carolina Building Code*, ASCE-7, or the *International Building Code*.
b. If window or door is more than 4 feet (1219 mm) from a corner, the pressure from this table shall be permitted to be multiplied by 0.87. This adjustment does not apply to garage doors.
c. For windows and doors in structures with a roof slope of 10 degrees (0.0745 rad) or less (2:12) from the table may be multiplied by 0.90.
d. Design pressure ratings based on standards listed in Section R609 are adequate documentation of capacity to resist pressures from the table.
e. Design pressures are for windows and doors located in Exposure Category B.

**TABLE R301.2(7)**
**COUNTIES IN SEISMIC DESIGN CATEGORY C**

| | |
|---|---|
| Transylvania | Jackson |
| Madison | Macon |
| Cherokee | Henderson |
| Clay | Buncombe |
| ~~Columbus~~ | ~~Brunswick~~ |
| Graham | Swain |
| Haywood | ~~Scotland~~ |
| ~~Robeson~~ | |

Note: Counties not listed are in Seismic Design Category A or B.

**R301.2.1.2.1 Application of ASTM E1996.** The text of Section 2.2 of ASTM E1996 shall be substituted as follows:

2.2 ASCE Standard:

ASCE 7-10 American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*

The text of Section 6.2.2 of ASTM E1996 shall be substituted as follows:

6.2.2 Unless otherwise specified, select the wind zone based on the ultimate design wind speed, $V_{ult}$, as follows:

6.2.2.1 Wind Zone 1–130 mph ≤ ultimate design wind speed, $V_{ult}$ < 140 mph.

6.2.2.2 Wind Zone 2–140 mph ≤ ultimate design wind speed, $V_{ult}$ < 150 mph at greater than 1 mile (1.6 km) from the coastline. The coastline shall be measured from the mean high-water mark.

6.2.2.3 Wind Zone 3–150 mph (67 m/s) ≤ ultimate design wind speed, $V_{ult}$ ≤ 170 mph (76 m/s), or 140 mph (54 m/s) ≤ ultimate design wind speed, $V_{ult}$ ≤ 170 mph (76 m/s) and within 1 mile (1.6 km) of the coastline. The coastline shall be measured from the mean high-water mark.

6.2.2.4 Wind Zone 4–ultimate design wind speed, $V_{ult}$ > 170 mph (76 m/s).

**TABLE R301.2.1.2**
**WINDBORNE DEBRIS PROTECTION FASTENING SCHEDULE FOR WOOD STRUCTURAL PANELS[a, b, c, d]**

| FASTENER TYPE | FASTENER SPACING (inches)[a, b] | | |
|---|---|---|---|
| | Panel span ≤ 4 feet | 4 feet < panel span ≤ 6 feet | 6 feet < panel span ≤ 8 feet |
| No. 8 wood screw | 16 | 10 | 8 |
| No. 10 wood screw | 16 | 12 | 9 |
| $^{1}/_{4}$-inch lag screw | 16 | 16 | 16 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 4.448 N, 1 mile per hour = 0.447 m/s.

a. This table is based on 180 mph ultimate design wind speeds, $V_{ult}$, and a 45-foot *mean roof height*.

b. Fasteners shall be installed at opposing ends of the wood structural panel. Fasteners shall be located not less than 1 inch from the edge of the panel.

c. Fasteners shall penetrate through the *exterior wall* covering with an embedment length of not less than 2 inches into the building frame. Fasteners shall be located not less than $2^{1}/_{2}$ inches from the edge of concrete block or concrete.

d. Panels attached to masonry or masonry/stucco shall be attached using vibration-resistant anchors having an ultimate withdrawal capacity of not less than 1,500 pounds.

**R301.2.1.3 Wind speed conversion.** Where referenced documents are based on nominal design wind speeds and do not provide the means for conversion between ultimate design wind speeds and nominal design wind speeds, the ultimate design wind speeds, $V_{ult}$, of ~~Figure R301.2(2)~~ Tables R301.2(4) and R301.2(5) shall be converted to nominal design wind speeds, $V_{asd}$, using Table R301.2.1.3.

**TABLE R301.2.1.3**
**WIND SPEED CONVERSIONS[a]**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{ult}$ | 110 | 115 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 |
| $V_{asd}$ | 85 | 89 | 93 | 101 | 108 | 116 | 124 | 132 | 139 | 147 | 155 |

For SI: 1 mile per hour = 0.447 m/s.

a. Linear interpolation is permitted.

**R301.2.1.4 Exposure category.** For each wind direction considered, an exposure category that adequately reflects the characteristics of ground surface irregularities shall be determined for the site at which the building or structure is to be constructed. For a site located in the transition zone between categories, the category resulting in the largest wind forces shall apply. Account shall be taken of variations in ground surface roughness that arise from natural topography and vegetation as well as from constructed features. For a site where multiple detached one- and two-family *dwellings*, townhouses or other structures are to be constructed as part of a subdivision or master-planned community, or are otherwise designated as a developed area by the authority having *jurisdiction*, the exposure category for an individual structure shall be based on the site conditions that will exist at the time when all adjacent structures on the site have been constructed, provided that their construction is expected to begin within 1 year of the start of construction for the structure for which the exposure category is determined. For any given wind direction, the exposure in which a specific building or other structure is sited shall be assessed as being one of the following categories:

1. Exposure B. Urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family *dwellings* or larger. Exposure B shall be assumed unless the site meets the definition of another type exposure.

2. Exposure C. Open terrain with scattered obstructions, including surface undulations or other irregularities, having heights generally less than 30 feet (9144 mm) extending more than 1,500 feet (457 m) from the building site in any quadrant. This exposure shall apply to any building located within Exposure B type terrain where the building is directly adjacent to open areas of Exposure C type terrain in any quadrant for a distance of more than 600 feet (183 m). This category includes flat, open country and grasslands.
3. Exposure D. Flat, unobstructed areas exposed to wind flowing over open water, smooth mud flats, salt flats and unbroken ice for a distance of not less than 5,000 feet (1524 m). This exposure shall apply only to those buildings and other structures exposed to the wind coming from over the unobstructed area. Exposure D extends downwind from the edge of the unobstructed area a distance of 600 feet (183 m) or 20 times the height of the building or structure, whichever is greater.

**R301.2.1.5 Topographic wind effects.** Deleted.

**R301.2.1.5.1 Simplified topographic wind speed-up method.** Deleted.

**R301.2.2 Townhouse ~~Seismic~~ seismic provisions.** ~~The seismic provisions of this code shall apply to *townhouses* in Seismic Design Category C.~~ Townhouses in Seismic Design Category C, shall be constructed in accordance with the requirements of this section and other seismic requirements of this code.

~~**R301.2.2.2 Seismic Design Category C.** Townhouse structures assigned to Seismic Design Category C shall conform to the requirements of this section.~~

**R301.2.2.1 Determination of seismic design category.** Buildings shall be assigned a seismic design category in accordance with Table R301.2(7).

**R301.2.2.1.1 Alternate determination of seismic design category.** Deleted.

**R301.2.2.1.2 Alternative determination of Seismic Design Category E.** Deleted.

~~**R301.2.2.2.1**~~ **R301.2.2.2 Weights of materials.** Average dead loads shall not exceed 15 pounds per square foot (720 Pa) for the combined roof and ceiling assemblies (on a horizontal projection) or 10 pounds per square foot (480 Pa) for floor assemblies, except as further limited by Section R301.2.2. Dead loads for walls above *grade* shall not exceed:
1. Fifteen pounds per square foot (720 Pa) for exterior light-frame wood walls.
2. Deleted.
3. Ten pounds per square foot (480 Pa) for interior light-frame wood walls.
4. Deleted.
5. Eighty pounds per square foot (3830 Pa) for 8-inch-thick (203 mm) masonry walls.
6. Eighty-five pounds per square foot (4070 Pa) for 6-inch-thick (152 mm) concrete walls.
7. Ten pounds per square foot (480 Pa) for SIP walls.

**Exceptions:**
1. Deleted.
2. Light-frame walls with stone or masonry veneer shall be permitted in accordance with the provisions of Sections R702.1 and R703.
3. Fireplaces and chimneys shall be permitted in accordance with Chapter 10.

~~**R301.2.2.2.2**~~ **R301.2.2.3 Stone and masonry veneer.** Anchored stone and masonry veneer shall comply with the requirements of Sections R702.1 and R703.

~~**R301.2.2.2.3**~~ **R301.2.2.4 Masonry construction.** Masonry construction shall comply with the requirements of Section R606.12.

~~**R301.2.2.2.4**~~ **R301.2.2.5 Concrete construction.** *Townhouses* with above-*grade* exterior concrete walls shall comply with the requirements of PCA 100 or shall be designed in accordance with ACI 318.

~~R301.2.2.2.5~~ R301.2.2.6 **Irregular ~~buildings~~ Townhouses.** The seismic provisions of this code shall not be used for irregular ~~structures~~ structures, or portions thereof, located in Seismic Design Category C and considered to be irregular in accordance with this section. A building or portion of a building shall be considered to be irregular where one or more of the conditions defined in Items 1 through 8 occur. Irregular structures, or ~~Irregular~~ irregular portions of structures shall be designed in accordance with accepted engineering practice to the extent the irregular features affect the performance of the remaining structural system. Where the forces associated with the irregularity are resisted by a structural system designed in accordance with accepted engineering practice, design of the remainder of the building shall be permitted using the provisions of this code. ~~A building or portion of a building shall be considered to be irregular where one or more of the following conditions occur:~~

1. ~~Where~~ **Shear wall or braced wall offsets out of plane.** Conditions where exterior shear wall lines or *braced wall panels* are not in one plane vertically from the foundation to the uppermost *story* in which they are required.

**Exception:** For wood light-frame construction, floors with cantilevers or setbacks not exceeding four times the nominal depth of the wood floor joists are permitted to support *braced wall panels* that are out of plane with *braced wall panels* below provided that:

1. Floor joists are nominal 2 inches by 10 inches (51 mm by 254 mm) or larger and spaced not more than 16 inches (406 mm) on center.
2. The ratio of the back span to the cantilever is not less than 2 to 1.
3. Floor joists at ends of *braced wall panels* are doubled.
4. For wood-frame construction, a continuous rim joist is connected to ends of cantilever joists. When spliced, the rim joists shall be spliced using a galvanized metal tie not less than 0.058 inch (1.5 mm) (16 gage) and 1 1/2 inches (38 mm) wide fastened with six 16d nails on each side of the splice or a block of the same size as the rim joist of sufficient length to fit securely between the joist space at which the splice occurs fastened with eight 16d nails on each side of the splice; and
5. Gravity loads carried at the end of cantilevered joists are limited to uniform wall and roof loads and the reactions from headers having a span of 8 feet (2438 mm) or less.

2. **Lateral support of roofs and floors.** Conditions ~~Where~~ where a section of floor or roof is not laterally supported by shear walls or *braced wall lines* on all edges.

**Exception:** Portions of floors that do not support shear walls or *braced wall panels* above, or roofs, shall be permitted to extend not more than 6 feet (1829 mm) beyond a shear wall or *braced wall line*.

3. **Shear wall or braced wall offsets in plane.** ~~Where~~ Conditions where the end of a *braced wall panel* occurs over an opening in the wall below and ends at a horizontal distance greater than 1 foot (305 mm) from the edge of the opening. This provision is applicable to shear walls and *braced wall panels* offset in plane and to *braced wall panels* offset out of plane as permitted by the exception to Item 1.

**Exception:** For wood light-frame wall construction, one end of a *braced wall panel* shall be permitted to extend more than 1 foot (305 mm) over an opening not more than 8 feet (2438 mm) in width in the wall below provided that the opening includes a header in accordance with the following:

1. The building width, loading condition and framing member species limitations of Table R602.7(1) shall apply;
~~And~~
2. The header is composed of:
~~2.~~ 2.1 Not less than one 2 × 12 or two 2 × 10 for an opening not more than 4 feet (1219 mm) wide; ~~or~~
~~3.~~ 2.2 Not less than two 2 × 12 or three 2 × 10 for an opening not more than 6 feet (1829 mm) in width; ~~or~~
~~4.~~ 2.3 Not less than three 2 × 12 or four 2 × 10 for an opening not more than 8 feet (2438 mm) in width; ~~and~~
~~5.~~ 3. The entire length of the *braced wall panel* does not occur over an opening in the wall below.

4. **Floor and roof opening.** ~~Where~~ Conditions where an opening in a floor or roof exceeds the lesser of 12 feet (3658 mm) or 50 percent of the least floor or roof dimension.
5. **Floor level offset.** ~~Where~~ Conditions where portions of a floor level are vertically offset.

**Exceptions:**

1. Framing supported directly by continuous foundations at the perimeter of the building.
2. For wood light-frame construction, floors shall be permitted to be vertically offset when the floor

framing is lapped or tied together as required by Section R502.6.1.
6. **Perpendicular shear wall and wall bracing.** ~~Where~~ Conditions where shear walls and *braced wall lines* do not occur in two perpendicular directions.
7. **Wall bracing in stories containing masonry or concrete construction.** ~~Where~~ Conditions where stories above *grade plane* partially or completely braced by wood wall framing in accordance with Section R602 include masonry or concrete construction. Where this irregularity applies, the entire *story* shall be designed in accordance with accepted engineering practice.

**Exception:** Fireplaces, chimneys and masonry veneer as permitted by this code.

8. **Hillside *light-frame construction*.** Conditions in which all of the following apply:
   - 8.1. The grade slope exceeds 1 unit vertical in 5 units horizontal where averaged across the full length of any side of the dwelling.
   - 8.2. The tallest cripple wall clear height exceeds 7 feet (2134 mm), or where a post and beam system occurs at the dwelling perimeter, the post and beam system tallest post clear height exceeds 7 feet (2134 mm).
   - 8.3. Of the total plan area below the lowest framed floor, whether open or enclosed, less than 50 percent is living space having interior wall finishes conforming to Section R702.

Where Item 8 is applicable, design in accordance with accepted engineering practice shall be provided for the floor immediately above the cripple walls or post and beam system and all structural elements and connections from this diaphragm down to and including connections to the foundation and design of the foundation to transfer lateral loads from the framing above.

**Exception:** *Light-frame construction* in which the lowest framed floor is supported directly on concrete or masonry walls over the full length of all sides except the downhill side of the dwelling need not be considered an irregular dwelling under Item 8.

~~**R301.2.2.3 Seismic Design Categories D0, D1 and D2.** Deleted.~~

~~**R301.2.2.4 Seismic Design Category E.** Deleted.~~

**R301.2.2.7 Height limitations.** Wood-framed buildings shall be limited to three *stories* above *grade plane* or the limits given in Table R602.10.3(3). *Mezzanines* as defined in Section R202 that comply with Section R325 shall not be considered as *stories*. *Structural insulated panel* buildings shall be limited to two *stories* above *grade plane*.

**R301.2.2.8 Cold-formed steel framing in Seismic Design Categories $D_0$, $D_1$ and $D_2$.** Deleted.

**R301.2.2.9 Masonry chimneys.** Deleted.

**R301.2.2.10 Anchorage of water heaters.** Deleted.

**R301.2.3 Snow loads.** Deleted.

**R301.2.4 Floodplain construction.** Buildings and structures constructed in whole or in part in flood hazard areas (including A or V Zones) as established in Table R301.2, and substantial improvement and *repair* of substantial damage of buildings and structures in flood hazard areas, shall be designed and constructed in accordance with Section R322. Buildings and structures that are located in more than one flood hazard area shall comply with the provisions associated with the most restrictive flood hazard area. Buildings and structures located in whole or in part in identified floodways shall be designed and constructed in accordance with ASCE 24.

**R301.2.4.1 Alternative provisions.** As an alternative to the requirements in Section R322, ASCE 24 is permitted subject to the limitations of this code and the limitations therein.

**R301.3 Story height.** The wind and seismic provisions of this code shall apply to buildings with *story heights* not exceeding the following:
1. For wood wall framing, the *story height* shall not exceed 11 feet 7 inches (3531 mm) and the laterally unsupported bearing wall stud height permitted by Table R602.3(5).

**Exception:** A *story height* not exceeding 13 feet 7 inches (4140 mm) is permitted provided that the maximum wall stud clear height does not exceed 12 feet (3658 mm), the wall studs are in accordance with Exception 2 or 3 of Section R602.3.1 or an engineered design is provided for the wall framing members, and wall bracing for the building is in accordance with Section R602.10. Studs shall be laterally supported at the top and bottom plate in accordance with Section R602.3.

2. Deleted.
3. For masonry walls, the *story height* shall be not more than 13 feet 7 inches (4140 mm) and the bearing wall clear height shall be not greater than 12 feet (3658 mm).
**Exception:** An additional 8 feet (2438 mm) of bearing wall clear height is permitted for gable end walls.
4. For insulating concrete form walls, the maximum story height shall not exceed 11 feet 7 inches (3531 mm) and the maximum unsupported wall height per *story* as permitted by Section R608 tables shall not exceed 10 feet (3048 mm).
5. For structural insulated panel (SIP) walls, the story height shall be not greater than 11 feet 7 inches (3531 mm) and the bearing wall height per *story* as permitted by Section R610 tables shall not exceed 10 feet (3048 mm).

For walls other than wood-framed walls, individual ~~Individual~~ walls or wall studs shall be permitted to exceed these limits as permitted by Chapter 6 provisions, provided that the *story heights* of this section are not exceeded. An engineered design shall be provided for the wall or wall framing members where the limits of Chapter 6 are exceeded. Where the *story height* limits of this section are exceeded, the design of the building, or the noncompliant portions thereof, to resist wind and seismic loads shall be in accordance with the *International Building Code*.

**R301.4 Dead load.** The actual weights of materials and construction shall be used for determining dead load with consideration for the dead load of fixed service equipment.

**R301.5 Live load.** The minimum uniformly distributed *live load* shall be as provided in Table R301.5.

**R301.6 Roof load.** The roof shall be designed for the *live load* indicated Table R301.2.

**R301.7 Deflection.** The allowable deflection of any structural member under the *live load* listed in Sections R301.5 and R301.6 or wind loads determined by Section R301.2.1 shall not exceed the values in Table R301.7.

**TABLE R301.5**
**MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS**
**(in pounds per square foot)**

| USE | LIVE LOAD |
|---|---|
| Uninhabitable attics without storage[b] | 10 |
| Uninhabitable attics with limited storage[b, g] | 20 |
| Habitable attics and attics served with fixed stairs | 30 |
| Balconies (exterior) and decks[e] | 40 |
| Fire escapes | 40 |
| Guards and handrails[d] | 200[h] |
| Guard in-fill components[f] | 50[h] |
| Passenger vehicle garages[a] | 50[a] |
| Rooms other than sleeping rooms | 40 |
| Sleeping rooms | 30 |
| Stairs | 40[c] |

For SI: 1 pound per square foot = 0.0479 kPa, 1 square inch = 645 $mm^2$, 1 pound = 4.45 N.

a. Elevated garage floors shall be capable of supporting a 2,000-pound load applied over a 20-square-inch area.

b. Uninhabitable *attics* without storage are those where the clear height between joists and rafters is not more than 42 inches, or where there are not two or more adjacent trusses with web configurations capable of accommodating an assumed rectangle 42 inches in height by 24 inches in width, or greater, within the plane of the trusses. This live load need not be assumed to act concurrently with any other live load requirements.

c. Individual stair treads shall be designed for the uniformly distributed live load or a 300-pound concentrated load acting over an area of 4 square inches, whichever produces the greater stresses.

d. A single concentrated load applied in any direction at any point along the top.

e. See Appendix M for decks attached to *exterior walls*.

f. *Guard* in-fill components (all those except the handrail), balusters and panel fillers shall be designed to withstand a horizontally applied normal load of 50 pounds on an area equal to 1 square foot. This load need not be assumed to act concurrently with any other live load requirement.

g. Uninhabitable *attics* with limited storage are those where the clear height between joists and rafters is not greater than 42 inches, or where there are two or more adjacent trusses with web configurations capable of accommodating an assumed rectangle 42 inches in height by 24 inches in width, or greater, within the plane of the trusses.

The live load need only be applied to those portions of the joists or truss bottom chords where all of the following conditions are met:

1. The *attic* area is accessible from an opening not less than 20 inches in width by 30 inches in length that is located where the clear height in the *attic* is not less than 30 inches.
2. The slopes of the joists or truss bottom chords are not greater than 2 inches vertical to 12 units horizontal.
3. Required insulation depth is less than the joist or truss bottom chord member depth.

The remaining portions of the joists or truss bottom chords shall be designed for a uniformly distributed concurrent live load of not less than 10 pounds per square foot.

h. Glazing used in handrail assemblies and *guards* shall be designed with a safety factor of 4. The safety factor shall be applied to each of the concentrated loads applied to the top of the rail, and to the load on the in-fill components. These loads shall be determined independent of one another, and loads are assumed not to occur with any other live load.

**TABLE R301.5**
**MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS (in pounds per square foot)**

| USE | UNIFORM LOAD (psf) | CONCENTRATED LOAD (lb) |
|---|---|---|
| Uninhabitable attics without storage[b] | 10 | — |
| Uninhabitable attics with limited storage[b, g] | 20 | — |
| Habitable attics and attics served with fixed stairs | 30 | — |
| Balconies (exterior) and decks[e] | 40 | — |
| Fire escapes | 40 | — |
| Guards | — | 200[h, i] |

| | | |
|---|---|---|
| Guard in-fill components[f] | — | 50[h] |
| Handrail[d] | 200[h] | — |
| Passenger vehicle garages[a] | 50[a] | 2,000[a] |
| Areas other than sleeping areas | 40 | — |
| Sleeping areas | 30 | — |
| Stairs | 40[c] | 300[c] |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 square inch = 645 $mm^2$, 1 pound = 4.45 N.

a. Elevated garage floors shall be capable of supporting the uniformly distributed live load or a 2,000-pound concentrated load applied on an area of $4^1/_2$ inches by $4^1/_2$ inches, whichever produces the greater stresses.

b. Uninhabitable attics without storage are those where the clear height between joists and rafters is not more than 42 inches, or where there are not two or more adjacent trusses with web configurations capable of accommodating an assumed rectangle 42 inches in height by 24 inches in width, or greater, within the plane of the trusses. This *live load* need not be assumed to act concurrently with any other live load requirements.

c. Individual stair treads shall be ~~designed for~~ capable of supporting the uniformly distributed live load or a 300-pound concentrated load applied on an area of ~~4 square inches~~ 2 inches by 2 inches, whichever produces the greater stresses.

d. A single concentrated load applied in any direction at any point along the top. For a guard not required to serve as a handrail, the load need not be applied to the top element of the guard in a direction parallel to such element.

e. See ~~Appendix M~~ Chapter 47 for decks attached to exterior walls.

f. Guard in-fill components (all those except the handrail), balusters and panel fillers shall be designed to withstand a horizontally applied normal load of 50 pounds on an area equal to 1 square foot. This load need not be assumed to act concurrently with any other live load requirement.

g. Uninhabitable attics with limited storage are those where the clear height between joists and rafters is 42 inches or greater, or where there are two or more adjacent trusses with web configurations capable of accommodating an assumed rectangle 42 inches in height by 24 inches in width, or greater, within the plane of the trusses.

The live load need only be applied to those portions of the joists or truss bottom chords where all of the following conditions are met:

1. The attic area is accessed from an opening not less than 20 inches in width by 30 inches in length that is located where the clear height in the attic is not less than 30 inches.
2. The slopes of the joists or truss bottom chords are not greater than 2 ~~inches~~ units vertical in 12 units horizontal.
3. Required insulation depth is less than the joist or truss bottom chord member depth.

The remaining portions of the joists or truss bottom chords shall be designed for a uniformly distributed concurrent live load of not less than 10 pounds per square foot.

h. Glazing used in handrail assemblies and guards shall be designed with a ~~safety~~ load adjustment factor of 4. The ~~safety~~ load adjustment factor shall be applied to each of the concentrated loads applied to the top of the rail, and to the load on the in-fill components. These loads shall be determined independent of one another, and loads are assumed not to occur with any other live load.

i. Where the top of a guard system is not required to serve as a handrail, the single concentrated load shall be applied at any point along the top, in the vertical downward direction and in the horizontal direction away from the walking surface. Where the top of a guard is also serving as the handrail, a single concentrated load shall be applied in any direction at any point along the top. Concentrated loads shall not be applied concurrently.

**TABLE R301.7**
**ALLOWABLE DEFLECTION OF STRUCTURAL MEMBERS[b, c]**

| STRUCTURAL MEMBER | ALLOWABLE DEFLECTION |
|---|---|
| Rafters having slopes greater than 3:12 with finished ceiling not attached to rafters | *L*/180 |
| Interior walls and partitions | *H*/180 |
| Floors | *L*/360[f] |
| Ceilings with brittle finishes (including plaster and stucco) | *L*/360 |
| Ceilings with flexible finishes (including gypsum board) | *L*/240 |
| All other structural members | *L*/240 |
| Exterior walls—wind loads[a] with plaster or stucco finish | *H*/360 |

| | |
|---|---|
| Exterior walls—wind loads[a] with other brittle finishes | *H*/240 |
| Exterior walls—wind loads[a] with flexible finishes | *H*/120[d] |
| Lintels supporting masonry veneer walls[e] | *L*/600 |

**Note:** *L* = span length, *H* = span height.

a. For the purpose of the determining deflection limits herein, the wind load shall be permitted to be taken as 0.7 times the component and cladding (ASD) loads obtained from Table R301.2.1(1).

b. For cantilever members, *L* shall be taken as twice the length of the cantilever.

c. For aluminum structural members or panels used in roofs or walls of sunroom additions or patio covers, not supporting edge of glass or sandwich panels, the total load deflection shall not exceed *L*/60. For continuous aluminum structural members supporting edge of glass, the total load deflection shall not exceed *L*/175 for each glass lite or *L*/60 for the entire length of the member, whichever is more stringent. For sandwich panels used in roofs or walls of sunroom additions or patio covers, the total load deflection shall not exceed *L*/120.

d. Deflection for exterior walls with interior gypsum board finish shall be limited to an allowable deflection of *H*/180.

e. Refer to Section R703.8.2. The dead load of supported materials shall be included when calculating the deflection of these members.

f. When floor spans exceed 20 feet, joists, built-up beams and trusses shall not be spaced greater than 24 inches and deflection shall not exceed L/480.

**R301.8 Nominal sizes.** For the purposes of this code, dimensions of lumber specified shall be deemed to be nominal dimensions unless specifically designated as actual dimensions.

## SECTION R302
## FIRE-RESISTANT CONSTRUCTION

**R302.1 Exterior walls.** Construction, projections, openings and penetrations of *exterior walls* of *dwellings* and accessory buildings shall comply with Table R302.1.

**Exceptions:**

1. Walls, projections, openings or penetrations in walls perpendicular to the line used to determine the *fire separation distance*. *Townhouse* eave projections shall comply with Sections ~~R302.2.5 and R302.2.6~~ R302.2.7 and R302.2.8.
2. Walls of *dwellings* and *accessory buildings* located on the same *lot*.
3. Detached tool sheds and storage sheds, playhouses and similar structures exempted from permits are not required to provide wall protection based on location on the *lot*. Projections beyond the *exterior wall* shall not extend over the *lot line*.
4. Detached garages accessory to a *dwelling* located within ~~2~~ 3 feet (~~610~~ 915 mm) of a *lot line* are permitted to have non-fire-resistance rated roof eave projections not exceeding ~~4~~ 16 inches (~~102~~ 407 mm).
5. Foundation vents installed in compliance with this code are permitted.

**R302.1.1 Soffit protection.** In construction using vinyl or aluminum soffit material, the following application shall apply. Soffit assemblies located on buildings with less than a ~~10~~ 5 feet (~~3048~~ 1524 mm) fire separation distance shall be securely attached to framing members and applied over fire-retardant-treated wood, 23/32-inch (18.3 mm) wood sheathing or 5/8-inch (15.9 mm) exterior grade or moisture resistant gypsum board. Venting requirements shall be provided in both soffit and underlayments. Vents shall be either nominal 2-inch (51 mm) continuous or equivalent intermittent and shall not exceed the minimum net free air requirements established in Section R806.2 by more than 50 percent. *Townhouse* construction shall meet the additional requirements of Sections ~~R302.2.5 and R302.2.6~~ R302.2.7 and R302.2.8.

**Exceptions:**

1. Any portion of soffits having ~~10~~ 5 feet (~~3048~~ 1524 mm) or more *fire separation distance*.
2. Roof rake lines where the soffit does not communicate to the attic are not required to be protected per this section.
3. Soffits with less than 3 feet (914 mm) *fire separation distance* shall meet the projection fire rating requirements of Table R302.1.
4. Soffits between buildings located on the same lot.

TABLE R302.1
EXTERIOR WALLS

| EXTERIOR WALL ELEMENT | | MINIMUM FIRE-RESISTANCE RATING | MINIMUM FIRE SEPARATION DISTANCE |
|---|---|---|---|
| Walls | Fire-resistance rated | 1 hour—tested in accordance with ASTM E119 or UL 263 with exposure from both sides | < 3 feet |
| | Not fire-resistance rated | 0 hours | ≥ 3 feet |
| Projections | Fire-resistance rated | 1 hour on the underside | < 3 feet |
| | Not fire-resistance rated | 0 hours | 3 feet |
| Openings in walls | Not allowed | N/A | < 3 feet |
| | Unlimited | 0 hours | 3 feet |
| Penetrations | All | Comply with Section R302.4 | < 3 feet |
| | | None required | 3 feet |

For SI: 1 foot = 304.8 mm.
N/A = Not Applicable.

~~TABLE R302.1(1)~~ TABLE R302.1(1)

EXTERIOR WALLS

| EXTERIOR WALL ELEMENT | | MINIMUM FIRE-RESISTANCE RATING | MINIMUM FIRE SEPARATION DISTANCE |
|---|---|---|---|
| Walls | Fire-resistance rated | 1 hour—tested in accordance with ASTM E119, UL 263 with exposure from both sides | < 3 feet<br>< 5 feet[c] |
| | Not fire-resistance rated | 0 hours | 3 feet<br>> 5 feet[c] |
| Projections | Fire-resistance rated | 1 hour on the underside, or heavy timber, or fire-retardant-treated wood[a, b] | < 3 feet<br>< 5 feet[c] |
| | Not fire-resistance rated | 0 hours | > 3feet<br>> 5 feet[c] |
| Openings in walls | Not allowed | NA | < 3 feet<br>< 5 feet[c] |
| | Unlimited | 0 hours | 3 feet<br>> 5 feet[c] |
| Penetrations | All | Comply with Section R302.4 | < 3 feet<br>< 5 feet[c] |
| | | None required | 3 feet<br>> 5 feet[c] |

For SI: 1 foot = 304.8 mm.
NA = Not Applicable.
a. The fire-resistance rating shall be permitted to be reduced to 0 hours on the underside of the eave overhang if fireblocking is provided from the wall top plate to the underside of the roof sheathing.
b. The fire-resistance rating shall be permitted to be reduced to 0 hours on the underside of the rake overhang where gable vent openings are not installed.
c. Fire separation distance requirement for multiple dwellings on a single parcel.

**R302.2 Townhouses.** ~~Each *townhouse* shall be considered a separate building and shall be separated by fire-resistance rated wall assemblies meeting the requirements of Section R302.1 for exterior walls.~~ Walls separating *townhouse units* shall be constructed in accordance with Section R302.2.1 or R302.2.2 and shall comply with Sections 302.2.3 through 302.2.5.

~~**Exception:** If an automatic residential fire sprinkler is installed, a common 1-hour fire-resistance-rated wall assembly tested in accordance with ASTM E119 or UL 263 is permitted for townhouses if such walls do not contain plumbing or mechanical equipment, ducts or vents in the cavity of the common wall. The wall shall be rated for fire exposure from both sides and shall extend to and be tight against exterior wall sheathing and the underside of the roof sheathing. Electrical installations shall be installed in accordance with Section R302.4.~~

**R302.2.1 Double walls.** Each *townhouse unit* shall be separated from other *townhouse units* by two 1-hour fire-resistance-rated wall assemblies tested in accordance with ASTM E119, UL 263 or Section 703.2.2 of the *2024 North Carolina Building Code.*

**R302.2.2 Common walls.** Common walls separating *townhouse units* shall be assigned a fire-resistance rating in accordance with Item 1 or 2 and shall be rated for fire exposure from both sides. Common walls shall extend to and be tight against the exterior sheathing of the exterior walls, or the inside face of exterior walls without stud cavities, and the underside of the roof sheathing. The common wall shared by two *townhouse units* shall be constructed without plumbing or mechanical equipment, ducts or vents, other than water-filled fire sprinkler piping in the cavity of the common wall. Penetrations of the membrane of common walls for electrical outlet boxes shall be in accordance with Section R302.4.

1. Where an automatic sprinkler system in accordance with Section P2904 is provided, the common wall shall be not less than a 1-hour fire-resistance-rated wall assembly tested in accordance with ASTM E119, UL 263 or Section 703.2.2 of the *International Building Code*.
2. Where an automatic sprinkler system in accordance with Section P2904 is not provided, the common wall shall be not less than a 2-hour fire-resistance-rated wall assembly tested in accordance with ASTM E119, UL 263 or Section 703.2.2 of the *International Building Code*.

**Exception:** Common walls are permitted to extend to and be tight against the inside of the exterior walls if the cavity between the end of the common wall and the exterior sheathing is filled with a minimum of two 2-inch nominal thickness wood studs.

~~**R302.2.1**~~ **R302.2.3 Continuity.** The fire-resistance-rated wall or assembly separating ~~*townhouses*~~ *townhouse units* shall be continuous from the foundation to the underside of the roof sheathing, deck or slab, or exterior wall sheathing. The fire-resistance rating shall extend the full length of the wall or assembly from exterior sheathing to exterior sheathing, including wall extensions through and separating attached enclosed *accessory structures*.

~~**R302.2.2**~~ **R302.2.4 Parapets for townhouses.** Parapets constructed in accordance with Section ~~R302.2.3~~ R302.2.5 shall be constructed for *townhouses* as an extension of exterior walls or common walls separating townhouse units in accordance with the following:

1. Where roof surfaces adjacent to the wall or walls are at the same elevation, the parapet shall extend not less than 30 inches (762 mm) above the roof surfaces.
2. Where roof surfaces adjacent to the wall or walls are at different elevations and the higher roof is not more than 30 inches (762 mm) above the lower roof, the parapet shall extend not less than 30 inches (762 mm) above the lower roof surface.

**Exception:** A parapet is not required in the preceding two cases where the roof covering complies with a minimum Class C rating as tested in accordance with ASTM E108 or UL 790 and the roof decking or sheathing is of noncombustible materials or ~~*approved*~~ fire-retardant-treated wood for a distance of 4 feet (1219 mm) on each side of the wall or walls, or one layer of 5/8-inch (15.9 mm) Type X gypsum board is installed directly beneath the roof decking or sheathing, supported by not less than nominal 2-inch (51 mm) ledgers attached to the sides of the roof framing members, for a distance of not less than 4 feet (1219 mm) on each side of the wall or walls and any openings or penetrations in the roof are not within 4 feet (1219 mm) of the common walls. Fire-retardant-treated wood shall meet the requirements of Sections R802.1.5 and R803.2.1.2.

3. A parapet is not required where roof surfaces adjacent to the wall or walls are at different elevations and the higher roof is more than 30 inches (762 mm) above the lower roof. The common wall construction from the lower roof to the underside of the higher roof deck shall have not less than a 1-hour fire-resistance rating. The wall shall be rated for exposure from both sides.

~~**R302.2.3**~~ **R302.2.5 Parapet construction.** Parapets shall have the same fire-resistance rating as that required for the supporting wall or walls. On any side adjacent to a roof surface, the parapet shall have noncombustible faces for the uppermost 18 inches (457 mm), to include counterflashing and coping materials. Where the roof slopes toward a parapet at slopes greater than 2 units vertical in 12 units horizontal (16.7-percent slope), the parapet shall extend to the same height as any portion of the roof within a distance of 3 feet (914 mm), and the height shall be not less than 30 inches (762 mm).

~~R302.2.4~~ R302.2.6 **Structural independence.** Each ~~individual~~ *townhouse* *unit* shall be structurally independent.
**Exceptions:**
1. Foundations supporting *exterior walls* or common walls.
2. Structural roof and wall sheathing from each unit fastened to the common wall framing.
3. Nonstructural wall and roof coverings.
4. Flashing at termination of roof covering over common wall.
5. *Townhouses* separated by a common wall as provided in Section ~~R302.2~~ R302.2.2, Item 1 or 2.
6. *Townhouse units* protected by a fire sprinkler system complying with Section P2904 or NFPA 13D.

~~R302.2.5~~ R302.2.7 **Townhouse eave protection.** In *townhouse* construction (with three or more attached dwellings) projections extending into the fire separation distance shall have not less than 1-hour fire-resistive-construction on the underside. Soffit material beyond the fire separation distance shall be securely attached to framing members and shall be constructed using either noncombustible soffit material; fire-retardant-treated soffit material; vinyl soffit installed over 3/4-inch (19 mm) wood sheathing or 5/8-inch (15.9 mm) gypsum board; or aluminum soffit installed over 3/4-inch (19 mm) wood sheathing or 5/8-inch (15.9 mm) gypsum board. Venting requirements shall be provided in both soffit and underlayments. Vents shall be either nominal 2-inch (51 mm) continuous or equivalent intermittent and shall not exceed the minimum net free air requirements established in Section R806.2 by more than 50 percent. Vents in soffit are not allowed within 4 feet (1219 mm) of fire walls or property lines.

~~R302.2.6~~ R302.2.8 **Townhouse eave projections.** Overhang projections not exceeding 12 inches (305 mm) shall be allowed to extend beyond the property line in townhouse buildings provided all the following conditions are met:
1. Required fire-resistant-rated wall assembly is tight to roof deck;
2. Eaves shall be protected with roof decking and fascia of noncombustible materials or approved fireretardant-treated wood; and
3. Eaves shall have not less than one layer of 5/8-inch (15.9 mm) Type X gypsum board or equivalent fire resistive construction on the underside.

~~R302.2.7~~ R302.2.9 **Sound transmission.** See Appendix K.

**R302.3 Two-family dwellings.** *Dwelling units* in two-family dwellings shall be separated from each other by wall and floor assemblies having not less than a 1-hour fire-resistance rating where tested in accordance with ASTM E119, UL 263 or Section 703.2.2 of the *International Building Code*. Such separation shall be provided regardless of whether a *lot line* exists between the two *dwelling units* or not. Fire-resistance-rated floor/ceiling and wall assemblies shall extend to and be tight against the exterior wall, and wall assemblies shall extend from the foundation to the underside of the roof sheathing.

**Exceptions:**

1. A fire-resistance rating of $^{1}/_{2}$ hour shall be permitted in buildings equipped throughout with an automatic sprinkler system installed in accordance with ~~NFPA 13~~ Section P2904.
2. Wall assemblies need not extend through attic spaces where the ceiling is protected by not less than $^{5}/_{8}$-inch (15.9 mm) Type X gypsum board, an attic draft stop constructed as specified in Section R302.12.1 is provided above and along the wall assembly separating the *dwellings* and the structural framing supporting the ceiling is protected by not less than $^{1}/_{2}$-inch (12.7 mm) gypsum board or equivalent.

**R302.3.1 Supporting construction.** Where floor assemblies are required to be fire-resistance rated by Section R302.3, the supporting construction of such assemblies shall have an equal or greater fire-resistance rating.

**R302.4 Dwelling unit rated penetrations.** Penetrations of wall or floor-ceiling assemblies required to be fire-resistance rated in accordance with Section R302.2 or R302.3 shall be protected in accordance with this section.

**R302.4.1 Through penetrations.** Through penetrations of fire-resistance-rated wall or floor assemblies shall comply with Section R302.4.1.1 or R302.4.1.2.

~~**Exception:**~~

**Exceptions:**

1. Where the penetrating items are steel, ferrous or copper pipes, tubes or conduits, the annular space shall be protected as follows:

    ~~1~~ 1.1. In concrete or masonry wall or floor assemblies, concrete, grout or mortar shall be permitted where installed to the full thickness of the wall or floor assembly or the thickness required to maintain the fire-resistance rating, provided that both of the following are complied with:

        ~~1.1~~ 1.1.1. The nominal diameter of the penetrating item is not more than 6 inches (152 mm).

        ~~1.2~~ 1.1.2. The area of the opening through the wall does not exceed 144 square inches (92 900 $mm^2$).

    ~~2.~~ 1.2. The material used to fill the annular space shall prevent the passage of flame and hot gases sufficient to ignite cotton waste where subjected to ASTM E119 or UL 263 time temperature fire conditions under a positive pressure differential of not less than 0.01 inch of water (3 Pa) at the location of the penetration for the time period equivalent to the fire-resistance rating of the construction penetrated.

2. The annular space created by the penetration of water-filled fire sprinkler piping, provided that the annular space is filled using a material complying with Item 1.2 of Exception 1.

**R302.4.1.1 Fire-resistance-rated assembly.** Penetrations shall be installed as tested in the *approved* fire-resistance-rated assembly.

**R302.4.1.2 Penetration firestop system.** Penetrations shall be protected by an *approved* penetration firestop system installed as tested in accordance with ASTM E814 or UL 1479, with a positive pressure differential of not less than 0.01 inch of water (3 Pa) and shall have an F rating of not less than the required fire-resistance rating of the wall or floor-ceiling assembly penetrated.

**R302.4.2 Membrane penetrations.** Membrane penetrations shall comply with Section R302.4.1. Where walls are required to have a fire-resistance rating, recessed fixtures shall be installed so that the required fire-resistance rating will not be reduced.

**Exceptions:**

1. Membrane penetrations of not more than 2-hour fire-resistance-rated walls and partitions by steel electrical boxes that do not exceed 16 square inches (0.0103 $m^2$) in area provided that the aggregate area of the openings through the membrane does not exceed 100 square inches (0.0645 $m^2$) in any 100 square feet (9.29 $m^2$) of wall area. The annular space between the wall membrane and the box shall not exceed $^1/_8$ inch (3.1 mm). Such boxes on opposite sides of the wall shall be separated by one of the following:

    1.1. By a horizontal distance of not less than 24 inches (610 mm) where the wall or partition is constructed with individual noncommunicating stud cavities.

    1.2. By a horizontal distance of not less than the depth of the wall cavity where the wall cavity is filled with cellulose loose-fill, rockwool or slag mineral wool insulation.

    1.3. By solid fireblocking in accordance with Section R302.11.

    1.4. By protecting both boxes with *listed* putty pads.

    1.5. By other *listed* materials and methods.

2. Membrane penetrations by *listed* electrical boxes of any materials provided that the boxes have been tested for use in fire-resistance-rated assemblies and are installed in accordance with the instructions included in the *listing*. The annular space between the wall membrane and the box shall not exceed $^1/_8$ inch (3.1 mm) unless *listed* otherwise. Such boxes on opposite sides of the wall shall be separated by one of the following:

    2.1. By the horizontal distance specified in the *listing* of the electrical boxes.

    2.2. By solid fireblocking in accordance with Section R302.11.

    2.3. By protecting both boxes with *listed* putty pads.

    2.4. By other *listed* materials and methods.

3. The annular space created by the penetration of a fire sprinkler or water-filled fire sprinkler piping, provided that ~~it~~ the annular space is covered by a metal escutcheon plate.
4. Ceiling membrane penetrations by *listed* luminaires or by luminaires protected with *listed* materials that have been tested for use in fire-resistance-rated assemblies and are installed in accordance with the instructions included in the *listing*.

**TABLE R302.6**

**DWELLING-GARAGE SEPARATION[b]**

| SEPARATION | MATERIAL |
|---|---|
| From the residence and attics | Not less than $^{1}/_{2}$-inch gypsum board or equivalent applied to the garage side |
| From habitable rooms above the garage[a] | Not less than $^{5}/_{8}$-inch Type X gypsum board or equivalent |
| Structure(s) supporting floor/ceiling assemblies used for separation required by this section | Not less than $^{1}/_{2}$-inch gypsum board or equivalent |
| Garages located less than 3 feet from a dwelling unit on the same lot | Not less than $^{1}/_{2}$-inch gypsum board or equivalent applied to the interior side of exterior walls that are within this area |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. For dwelling units constructed prior to the 2012 *North Carolina Residential Code* edition, 1/2 inch or greater existing gypsum board on the bottom side of the garage ceiling shall be acceptable. Joints shall be taped.

b. Residential aircraft hangar shall comply with North Carolina Building Code section 412.5.

**R302.5 Dwelling-garage opening and penetration protection.** Openings and penetrations through the walls or ceilings separating the *dwelling* from the garage shall be in accordance with Sections R302.5.1 through R302.5.3.

**R302.5.1 Opening protection.** Openings from a private garage directly into a room used for sleeping purposes shall not be permitted. Other openings between the garage and residence shall be equipped with solid wood doors not less than $1^{3}/_{8}$ inches (35 mm) in thickness, solid or honeycomb-core steel doors not less than $1^{3}/_{8}$ inches (35 mm) thick, or 20-minute fire-rated doors. ~~Doors shall be self-latching and equipped with a self-closing or automatic-closing device.~~

**Exception:** A disappearing/pull-down stairway to uninhabited attic space with minimum 3/8-inch (9.53 mm) (nominal) fire-retardant-treated structural panel is equivalent to the separation requirement from attics in Table R302.6.

**R302.5.2 Duct penetration.** Ducts in the garage and ducts penetrating the walls or ceilings separating the *dwelling* from the garage shall be constructed of a minimum No. 26 gage (0.48 mm) sheet steel or other *approved* material and shall not have openings into the garage.

**R302.5.3 Other penetrations.** Penetrations through the separation required in Section R302.6 shall be protected as required by Section R302.11, Item 4.

**R302.6 Dwelling-garage fire separation.** The garage shall be separated as required by Table R302.6. Openings in garage walls shall comply with Section R302.5. Attachment of gypsum board shall comply with Table R702.3.5. The wall separation provisions of Table R302.6 shall not apply to garage walls that are perpendicular to the adjacent *dwelling unit* wall.

**R302.7 Under-stair protection.** Enclosed ~~space under stairs that is *accessed* by a door or access panel~~ accessible space under stairs shall have walls, under-stair surface and any soffits protected on the enclosed side with $^{1}/_{2}$-inch (12.7 mm) gypsum board.

**R302.8 Foam plastics.** For requirements for foam plastics, see Section R316.

**R302.8.1 Interior finish.** Foam plastics used as interior finishes shall comply with Section R316.5.10.

**R302.9 Flame spread index and smoke-developed index for wall and ceiling finishes.** Flame spread and smoke-developed ~~indexes~~ indices for wall and ceiling finishes shall be in accordance with Sections R302.9.1 through R302.9.4.

**R302.9.1 Flame spread index.** Wall and ceiling finishes shall have a flame spread index of not greater than 200.

**Exception:** Flame spread index requirements for finishes shall not apply to *trim* defined as picture molds, chair rails, baseboards and *handrails*; to doors and windows or their frames; or to materials that are less than $^1/_{28}$ inch (0.91 mm) in thickness cemented to the surface of walls or ceilings if these materials exhibit flame spread index values not greater than those of paper of this thickness cemented to a noncombustible backing.

**R302.9.2 Smoke-developed index.** Wall and ceiling finishes shall have a *smoke-developed index* of not greater than 450.

**R302.9.3 Testing.** Tests shall be made in accordance with ASTM E84 or UL 723.

**R302.9.4 Alternative test method.** As an alternative to having a flame spread index of not greater than 200 and a *smoke-developed index* of not greater than 450 where tested in accordance with ASTM E84 or UL 723, wall and ceiling finishes shall be permitted to be tested in accordance with NFPA 286. Materials tested in accordance with NFPA 286 shall meet the following criteria:

The interior finish shall comply with the following:

1. During the 40 kW exposure, flames shall not spread to the ceiling.
2. The flame shall not spread to the outer extremity of the sample on any wall or ceiling.
3. Flashover, as defined in NFPA 286, shall not occur.
4. The peak heat release rate throughout the test shall not exceed 800 kW.
5. The total smoke released throughout the test shall not exceed 1,000 $m^2$.

**R302.9.5 High-density polyethylene (HDPE) and polypropylene (PP).** Where high-density polyethylene or polypropylene is used as an interior finish material, it shall be tested in accordance with NFPA 286 and comply with the criteria in Section R302.9.4.

**R302.10 Flame spread index and smoke-developed index for insulation.** Flame spread and *smoke-developed index* for insulation shall be in accordance with Sections R302.10.1 through R302.10.5.

**R302.10.1 Insulation.** ~~Insulation~~ Insulating materials ~~including facings, such as vapor retarders and vapor-permeable membranes~~ installed within floor-ceiling assemblies, roof-ceiling assemblies, wall assemblies, crawl spaces and *attics* shall comply with the requirements of this section. They shall exhibit ~~shall have~~ a flame spread index not to exceed 25 ~~with an accompanying~~ and a *smoke-developed index* not to exceed 450 where tested in accordance with ASTM E84 or UL 723. Insulating materials, where tested in accordance with the requirements of this section, shall include facings, where used, such as vapor retarders, *vapor permeable* membranes and similar coverings.

**Exceptions:**

1. Where such materials are installed in concealed spaces, the flame spread index and *smoke-developed index* limitations do not apply to the facings, provided that the facing is installed in substantial contact with the unexposed surface of the ceiling, floor or wall finish.
2. Cellulose fiber loose-fill insulation that is not spray applied ~~complying with the requirments~~ and that complies with the requirements of Section R302.10.3 shall not be required to meet ~~a~~ the flame spread index requirements but shall be required to meet a *smoke-developed index* of not more than 450 where tested in accordance with CAN/ULC S102.2.
3. Foam plastic insulation shall comply with Section R316.

**R302.10.2 Loose-fill insulation.** Loose-fill insulation materials that cannot be mounted in the ASTM E84 or UL 723 apparatus without a screen or artificial supports shall comply with the flame spread and smoke-developed limits of Section R302.10.1 where tested in accordance with CAN/ULC S102.2.

**Exception:** Cellulosic fiber loose-fill insulation shall not be required to be tested in accordance with CAN/ULC S102.2, provided that such insulation complies with the requirements of Sections R302.10.1 and R302.10.3.

**R302.10.3 Cellulosic fiber loose-fill insulation.** Cellulosic fiber loose-fill insulation shall comply with CPSC 16 CFR, Parts 1209 and 1404. Each package of such insulating material shall be clearly *labeled* in accordance with CPSC 16 CFR, Parts 1209 and 1404.

**R302.10.4 Exposed attic insulation.** Exposed insulation materials installed on attic floors shall have a critical radiant flux of not less than 0.12 watt per square centimeter.

**R302.10.5 Testing.** Tests for critical radiant flux shall be made in accordance with ASTM E970.

**R302.11 Fireblocking.** In combustible construction, fireblocking shall be provided to cut off both vertical and horizontal concealed draft openings and to form an effective fire barrier between stories, and between a top story and the roof space.

Fireblocking shall be provided in wood-framed construction in the following locations:

1. In concealed spaces of stud walls and partitions, including furred spaces and parallel rows of studs or staggered studs, as follows:
    1.1. Vertically at the ceiling and floor levels.
    1.2. Horizontally at intervals not exceeding 10 feet (3048 mm) in furred spaces, parallel rows of studs, or staggered studs.
2. At interconnections between concealed vertical and horizontal spaces such as occur at soffits, drop ceilings and cove ceilings.
3. In concealed spaces between stair stringers at the top and bottom of the run. Enclosed spaces under stairs shall comply with Section R302.7.
4. At openings around vents, pipes, ducts, cables and wires at ceiling and floor level, with an *approved* material to resist the free passage of flame and products of combustion. The material filling this annular space shall not be required to meet the ASTM E136 requirements.
5. For the fireblocking of chimneys and fireplaces, see Section R1003.19.
6. Fireblocking of cornices of a two-family *dwelling* is required at the line of *dwelling unit* separation.

**R302.11.1 Fireblocking materials.** Except as provided in Section R302.11, Item 4, fireblocking shall consist of the following materials.

1. Two-inch (51 mm) nominal lumber.
2. Two thicknesses of 1-inch (25.4 mm) nominal lumber with broken lap joints.
3. One thickness of $^{23}/_{32}$-inch (18.3 mm) *wood structural panels* with joints backed by $^{23}/_{32}$-inch (18.3 mm) *wood structural panels*.
4. One thickness of $^{3}/_{4}$-inch (19.1 mm) particleboard with joints backed by $^{3}/_{4}$-inch (19.1 mm) particleboard.
5. One-half-inch (12.7 mm) gypsum board.
6. One-quarter-inch (6.4 mm) cement-based millboard.
7. Batts or blankets of mineral wool or glass fiber or other *approved* materials installed in such a manner as to be securely retained in place.
8. Cellulose insulation installed as tested in accordance with ASTM E119 or UL 263, for the specific application.

**R302.11.1.1 Batts or blankets of mineral or glass fiber.** Batts or blankets of mineral or glass fiber or other *approved* nonrigid materials shall be permitted for compliance with the 10-foot (3048 mm) horizontal fireblocking in walls constructed using parallel rows of studs or staggered studs.

**R302.11.1.2 Unfaced fiberglass.** Unfaced fiberglass batt insulation used as fireblocking shall fill the entire cross section of the wall cavity to a height of not less than 16 inches (406 mm) measured vertically. Where piping, conduit or similar obstructions are encountered, the insulation shall be packed tightly around the obstruction.

**R302.11.1.3 Loose-fill insulation material.** Loose-fill insulation material shall not be used as a fireblock unless specifically tested in the form and manner intended for use to demonstrate its ability to remain in place and to retard the spread of fire and hot gases.

**R302.11.2 Fireblocking integrity.** The integrity of fireblocks shall be maintained.

**R302.12 Draftstopping.** In combustible construction where there is usable space both above and below the concealed space of a floor-ceiling assembly, draftstops shall be installed so that the area of the concealed space does not exceed 1,000 square feet (92.9 $m^2$). Draftstopping shall divide the concealed space into approximately equal areas. Where the assembly is enclosed by a floor membrane above and a ceiling membrane below, draftstopping shall be provided in floor-ceiling assemblies under the following circumstances:

1. Ceiling is suspended under the floor framing.
2. Floor framing is constructed of truss-type open-web or perforated members.

**R302.12.1 Materials.** Draftstopping materials shall be not less than $^1/_2$-inch (12.7 mm) gypsum board, $^3/_8$-inch (9.5 mm) *wood structural panels* or other *approved* materials adequately supported. Draftstopping shall be installed parallel to the floor framing members unless otherwise *approved* by the *building official*. The integrity of the draftstops shall be maintained.

**R302.13 Fire protection of floors.** Deleted.

**R302.14 Combustible insulation clearance.** Combustible insulation shall be separated not less than 3 inches (76 mm) from recessed luminaires, fan motors and other heat-producing devices.

**Exception:** Where heat-producing devices are *listed* for lesser clearances, combustible insulation complying with the listing requirements shall be separated in accordance with the conditions stipulated in the listing.

Recessed luminaires installed in the *building thermal envelope* shall meet the requirements of Section N1102.4.5 of this code.

## SECTION R303
## LIGHT, VENTILATION AND HEATING

**R303.1 Habitable rooms.** Habitable rooms shall have an aggregate glazing area of not less than 8 percent of the floor area of such rooms. Natural *ventilation* shall be through windows, skylights, doors, louvers or other *approved* openings to the outdoor air. Such openings shall be provided with ready access or shall otherwise be readily controllable by the building occupants. The openable area to the outdoors shall be not less than 4 percent of the floor area being ventilated.

**Exceptions:**

1. For habitable rooms, ~~The~~ the glazed areas need not be openable where the opening is not required by Section R310 and a whole-house mechanical *ventilation* system is installed in accordance with Section ~~M1507~~ M1505.
2. For kitchens, the glazed areas need not be openable where the opening is not required by Section R310 and a local exhaust system is installed in accordance with Section M1505.

~~2.~~ 3. The glazed areas need not be installed in rooms where Exception 1 is satisfied and artificial light is provided that is capable of producing an average illumination of 6 footcandles (65 lux) over the area of the room at a height of 30 inches (762 mm) above the floor level.

~~3.~~ 4. Use of *sunroom* and patio covers, as defined in Section R202, shall be permitted for natural *ventilation* if in excess of 40 percent of the exterior *sunroom* walls are open, or are enclosed only by insect screening.

**R303.2 Adjoining rooms.** For the purpose of determining light and *ventilation* requirements, ~~any~~ rooms shall be considered to be a portion of an adjoining room where not less than one-half of the area of the common wall is open and unobstructed and provides an opening of not less than one-tenth of the floor area of the interior room and not less than 25 square feet (2.3 $m^2$).

**Exception:** Openings required for light or *ventilation* shall be permitted to open into a *sunroom* with thermal isolation or a patio cover, provided that there is an openable area between the adjoining room and the *sunroom* or patio cover of not less than one-tenth of the floor area of the interior room and not less than 20 square feet (2 $m^2$). The minimum openable area to the outdoors shall be based ~~upon~~ on the total floor area being ventilated.

**R303.3 Bathrooms.** Bathrooms, water closet compartments and other similar rooms shall be provided with aggregate glazing area in windows of not less than 3 square feet (0.3 $m^2$), one-half of which ~~must~~ shall be openable.

**Exception:** The glazed areas shall not be required where artificial light and a local exhaust system are provided. The minimum local exhaust rates shall be determined in accordance with Section ~~M1505~~ M1507. Exhaust air from the space shall be exhausted directly to the outdoors.

**R303.4 Mechanical ventilation.** ~~Deleted.~~ Buildings and *dwelling units* complying with Section N1102.4.1 shall be provided with mechanical ventilation in accordance with Section M1505, or with other *approved* means of ventilation.

**R303.5 Opening location.** Outdoor intake and exhaust openings shall be located in accordance with Sections R303.5.1 and R303.5.2.

**R303.5.1 Intake openings.** Mechanical and gravity outdoor air intake openings shall be located not less than 10 feet (3048 mm) from any hazardous or noxious contaminant, such as vents, chimneys, plumbing vents, streets, alleys, parking lots and loading docks.

For the purpose of this section, the exhaust from *dwelling unit* toilet rooms, bathrooms and *kitchens* shall not be considered as hazardous or noxious.

**Exceptions:**

1. The 10-foot (3048 mm) separation is not required where the intake opening is located 3 feet (914 mm) or greater below the contaminant source.
2. Vents and chimneys serving fuel-burning *appliances* shall be terminated in accordance with the applicable provisions of Chapters 18 and 24.
3. Clothes dryer exhaust ducts shall be terminated in accordance with Section M1502.3.

**R303.5.2 Exhaust openings.** Exhaust air shall not be directed onto walkways.

**R303.6 Outside opening protection.** Air exhaust and intake openings that terminate outdoors shall be protected with corrosion-resistant screens, louvers or grilles having an opening size of not less than $^1/_4$ inch (6 mm) and a maximum opening size of $^1/_2$ inch (13 mm), in any dimension. Openings shall be protected against local weather conditions. Outdoor air exhaust and intake openings shall meet the provisions for exterior wall opening protectives in accordance with this code.

**R303.7 Interior stairway illumination.** Interior *stairways* shall be provided with an artificial light source to illuminate the landings and treads. The light source shall be capable of illuminating treads and landings to levels of not less than 1 footcandle (11 lux) as measured at the center of treads and landings. There shall be a wall switch at each floor level to control the light source where the *stairway* has six or more *risers*.

**Exception:** A switch is not required where remote, central or automatic control of lighting is provided.

**R303.8 Exterior stairway illumination.** Exterior *stairways* shall be provided with an artificial light source located at the top landing of the *stairway*. Exterior *stairways* providing access to a *basement* from the outdoor *grade* level shall be provided with an artificial light source located at the bottom landing of the *stairway*.

**R303.9 Required glazed openings.** Required glazed openings shall open directly onto a street or public alley, or a *yard* or court located on the same *lot* as the building.

**Exceptions:**

1. Required glazed openings that face into a roofed porch where the porch abuts a street, *yard* or court and the longer side of the porch is not less than 65 percent unobstructed and the ceiling height is not less than 7 feet (2134 mm).
2. Eave projections shall not be considered as obstructing the clear open space of a *yard* or court.
3. Required glazed openings that face into the area under a deck, balcony, bay or floor cantilever where a clear vertical space not less than 36 inches (914 mm) in height is provided.

**R303.9.1 Sunroom additions.** ~~Deleted.~~ Required glazed openings shall be permitted to open into *sunroom additions* or patio covers that abut a street, *yard* or court if in excess of 40 percent of the exterior *sunroom* walls are open, or are enclosed only by insect screening, and the ceiling height of the *sunroom* is not less than 7 feet (2134 mm).

**R303.10 Required heating.** Where the winter design temperature in Table R301.2 is below 60°F (16°C), every *dwelling unit* shall be provided with heating facilities capable of maintaining a room temperature of not less than 68°F (20°C) at a point 3 feet (914 mm) above the floor and 2 feet (610 mm) from exterior walls in habitable rooms at the design temperature. The installation of one or more portable space heaters shall not be used to achieve compliance with this section.

**Exception:** Unconditioned *sunrooms* that are thermally isolated from the dwelling.

## SECTION R304
## MINIMUM ROOM AREAS

**R304.1 Minimum area.** Habitable rooms shall have a floor area of not less than 70 square feet (6.5 $m^2$).

**Exception:** Kitchens.

**R304.2 Minimum dimensions.** Habitable rooms shall be not less than 7 feet (2134 mm) in any horizontal dimension.

**Exception:** Kitchens.

**R304.3 Height effect on room area.** Portions of a room with a sloping ceiling measuring less than 5 feet (1524 mm) or a furred ceiling measuring less than 7 feet (2134 mm) from the finished floor to the finished ceiling shall not be considered as contributing to the minimum required habitable area for that room.

## SECTION R305
## CEILING HEIGHT

**R305.1 Minimum height.** *Habitable space*, hallways and portions of *basements* containing these spaces shall have a ceiling height of not less than 7 feet (2134 mm). Bathrooms, toilet rooms and laundry rooms shall have a ceiling height of not less than 6 feet 8 inches (2032 mm).

**Exceptions:**

1. For rooms with sloped ceilings, the required floor area of the room shall have a ceiling height of not less than 5 feet (1524 mm) and not less than 50 percent of the required floor area shall have a ceiling height of not less than 7 feet (2134 mm).
2. The ceiling height above bathroom and toilet room fixtures shall be such that the fixture is capable of being used for its intended purpose. A shower or tub equipped with a showerhead shall have a ceiling height of not less than 6 feet 8 inches (2032 mm) above an area of not less than 30 inches (762 mm) by 30 inches (762 mm) at the showerhead.
3. Beams, girders, ducts or other obstructions in *basements* containing *habitable space* shall be permitted to project to within 6 feet 4 inches (1931 mm) of the finished floor.
4. Beams and girders spaced apart not less than 36 inches (914 mm) in clear finished width shall project not more than 78 inches (1981 mm) from the finished floor.

**R305.1.1 Basements.** Portions of *basements* that do not contain *habitable space* or hallways shall have a ceiling height of not less than 6 feet 8 inches (2032 mm).

**Exception:** At beams, girders, ducts or other obstructions, the ceiling height shall be not less than 6 feet 4 inches (1931 mm) from the finished floor.

## SECTION R306
## SANITATION

**R306.1 Toilet facilities.** Every *dwelling unit* shall be provided with a water closet, lavatory, and a bathtub or shower.

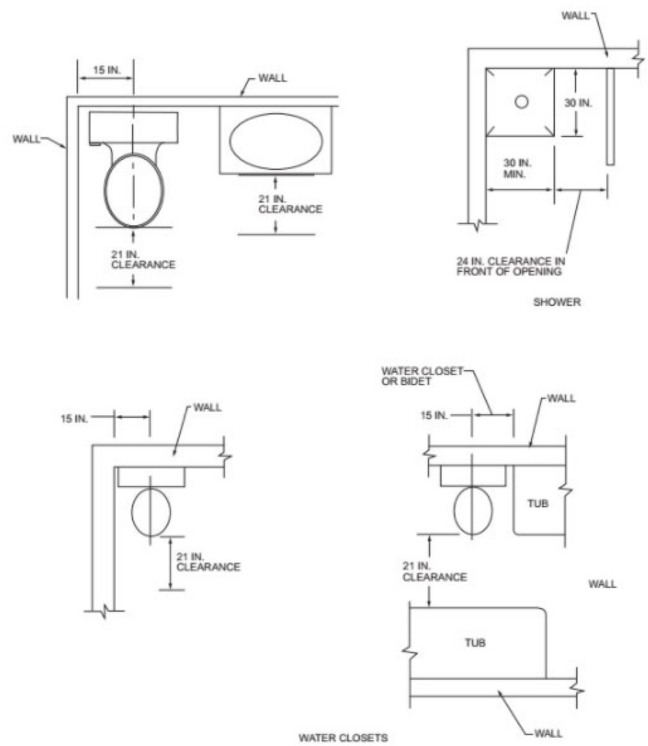
**R306.2 Kitchen.** Each *dwelling unit* shall be provided with a kitchen area and every kitchen area shall be provided with a sink.

**R306.3 Sewage disposal.** Plumbing fixtures shall be connected to a sanitary sewer or to an *approved* private sewage disposal system.

**R306.4 Water supply to fixtures.** Plumbing fixtures shall be connected to an *approved* water supply. Kitchen sinks, lavatories, bathtubs, showers, bidets, laundry tubs and washing machine outlets shall be provided with hot and cold water.

## SECTION R307
## TOILET, BATH AND SHOWER SPACES

**R307.1 Space required.** Fixtures shall be spaced in accordance with Figure R307.1, and in accordance with the requirements of Section P2705.1.




For SI: 1 inch = 25.4 mm.

FIGURE R307.1MINIMUM FIXTURE CLEARANCES

**R307.2 Bathtub and shower spaces.** Bathtub and shower floors and walls above bathtubs with installed shower heads and in shower compartments shall be finished with a nonabsorbent surface. Such wall surfaces shall extend to a height of not less than 6 feet (1829 mm) above the floor.

## SECTION R308
## GLAZING

**R308.1 Identification.** Except as indicated in Section R308.1.1 each pane of glazing installed in hazardous locations as defined in Section R308.4 shall be provided with a manufacturer's designation specifying who applied the designation, ~~designing~~ the type of glass and the safety glazing standard with which it complies, ~~which~~ and that is visible in the final installation. The designation shall be acid etched, sandblasted, ceramic-fired, laser etched, embossed, or be of a type that once applied cannot be removed without being destroyed. A *label* shall be permitted in lieu of the manufacturer's designation.

**Exceptions:**

1. For other than tempered glass, manufacturer's designations are not required provided that the *building official* approves the use of a certificate, affidavit or other evidence confirming compliance with this code.
2. Tempered spandrel glass is permitted to be identified by the manufacturer with a removable paper designation.

**R308.1.1 Identification of multiple assemblies.** Multipane assemblies having individual panes not exceeding 1 square foot (0.09 $m^2$) in exposed area shall have not less than one pane in the assembly identified in accordance with Section R308.1. Other panes in the assembly shall be *labeled* "CPSC 16 CFR 1201" or "ANSI Z97.1" as appropriate.

**R308.2 Louvered windows or jalousies.** Regular, float, wired or patterned glass in jalousies and louvered windows shall be not less than nominal $^3/_{16}$ inch (5 mm) thick and not more than 48 inches (1219 mm) in length. Exposed glass edges shall be smooth.

**R308.2.1 Wired glass prohibited.** Wired glass with wire exposed on longitudinal edges shall not be used in jalousies or louvered windows.

**R308.3 Human impact loads.** Individual glazed areas, including glass mirrors in hazardous locations such as those indicated as defined in Section R308.4, shall pass the test requirements of Section R308.3.1.

**Exceptions:**

1. Louvered windows and jalousies shall comply with Section R308.2.
2. Mirrors and other glass panels mounted or hung on a surface that provides a continuous backing support.
3. Glass unit masonry complying with Section R607.

**R308.3.1 Impact test.** Where required by other sections of the code, glazing shall be tested in accordance with CPSC 16 CFR 1201. Glazing shall comply with the test criteria for Category II unless otherwise indicated in Table R308.3.1(1).

**Exception:** Glazing not in doors or enclosures for hot tubs, whirlpools, saunas, steam rooms, bathtubs and showers shall be permitted to be tested in accordance with ANSI Z97.1. Glazing shall comply with the test criteria for Class A unless otherwise indicated in Table R308.3.1(2).

**TABLE R308.3.1(1)**
**MINIMUM CATEGORY CLASSIFICATION OF GLAZING USING CPSC 16 CFR 1201**

| EXPOSED SURFACE AREA OF ONE SIDE OF ONE LITE | GLAZING IN STORM OR COMBINATION DOORS (Category Class) | GLAZING INDOORS (Category Class) | GLAZED PANELS REGULATED BY SECTION R308.4.3 (Category Class) | GLAZED PANELS REGULATED BY SECTION R308.4.2 (Category Class) | GLAZING INDOORS AND ENCLOSURES REGULATED BY SECTION 308.4.5 (Category Class) | SLIDING GLASS DOORS PATIO TYPE (Category Class) |
|---|---|---|---|---|---|---|
| 9 square feet or less | I | I | NR | I | II | II |
| More than 9 square feet | II | II | II | II | II | II |

For SI: 1 square foot = 0.0929 $m^2$.
NR = No Requirement.

**TABLE R308.3.1(2)**
**MINIMUM CATEGORY CLASSIFICATION OF GLAZING USING ANSI Z97.1**

| EXPOSED SURFACE AREA OF ONE SIDE OF ONE LITE | GLAZED PANELS REGULATED BY SECTION R308.4.3 (Category Class) | GLAZED PANELS REGULATED BY SECTION R308.4.2 (Category Class) | DOORS AND ENCLOSURES REGULATED BY SECTION R308.4.5[a] (Category Class) |
|---|---|---|---|
| 9 square feet or less | No requirement | B | A |
| More than 9 square feet | A | A | A |

For SI: 1 square foot = 0.0929 $m^2$.
a. Use is permitted only by the exception to Section R308.3.1.

**R308.4 Hazardous locations.** The locations specified in Sections R308.4.1 through R308.4.7 shall be considered to be specific hazardous locations for the purposes of glazing.

**R308.4.1 Glazing in doors.** Glazing in fixed and operable panels of swinging, sliding and bifold doors shall be considered to be a hazardous location.

**Exceptions:**

1. Glazed openings of a size through which a 3-inch-diameter (76 mm) sphere is unable to pass.
2. Decorative glazing.

**R308.4.2 Glazing adjacent to doors.** Glazing in an individual fixed or operable panel in the same plane as the door shall be considered to be a hazardous location where the bottom exposed edge of the glazing is less than 60 inches (1524 mm) above the floor or walking surface and it meets either of the following conditions:

1. Where the glazing is within 24 inches (610 mm) of either side of the door in the plane of the door in a closed position.
2. Deleted.

**Exceptions:**

1. Decorative glazing.
2. Where there is an intervening wall or other permanent barrier between the door and the glazing.
3. Where access through the door is to a closet or storage area 3 feet (914 mm) or less in depth. Glazing in this application shall comply with Section R308.4.3.
4. Glazing that is adjacent to the fixed panel of patio doors.

**R308.4.3 Glazing in windows.** Glazing in an individual fixed or operable panel that meets all of the following conditions shall be considered to be a hazardous location:

1. The exposed area of an individual pane is larger than 9 square feet (0.836 $m^2$).
2. The bottom edge of the glazing is less than 18 inches (457 mm) above the floor.
3. The top edge of the glazing is more than 36 inches (914 mm) above the floor.
4. One or more walking surfaces are within 36 inches (914 mm), measured horizontally and in a straight line, of the glazing.

**Exceptions:**

1. Decorative glazing.
2. Where glazing is adjacent to a walking surface and a horizontal rail ~~is installed on the accessible side(s) of the glazing~~ 34 to 38 inches (864 to 965 mm) above the walking surface. The rail shall be capable of withstanding a horizontal load of 50 pounds per linear foot (730 N/m) without contacting the glass and have a cross-sectional height of not less than $1^1/_2$ inches (38 mm).
3. Outboard panes in insulating glass units and other multiple glazed panels where the bottom edge of the glass is 25 feet (7620 mm) or more above *grade*, a roof, walking surfaces or other horizontal [within 45 degrees (0.79 rad) of horizontal] surface adjacent to the glass exterior.

**R308.4.4 Glazing in guards and railings.** Glazing in *guards* and railings, including structural baluster panels and nonstructural in-fill panels, regardless of area or height above a walking surface shall be considered to be a hazardous location.

**R308.4.4.1 Structural glass baluster panels.** *Guards* with structural glass baluster panels shall be installed with an attached top rail or *handrail*. The top rail or *handrail* shall be supported by not less than three glass baluster panels, or shall be otherwise supported to remain in place should one glass baluster panel fail.

**Exception:** An attached top rail or *handrail* is not required where the glass baluster panels are laminated glass with two or more glass plies of equal thickness and of the same glass type.

**R308.4.5 Glazing and wet surfaces.** Glazing in walls, enclosures or fences containing ~~or facing~~ hot tubs, spas, whirlpools, saunas, steam rooms, bathtubs, showers and indoor or outdoor swimming pools where the bottom exposed edge of the glazing is less than 60 inches (1524 mm) measured vertically above any standing or walking surface shall be considered to be a hazardous location. This shall apply to single glazing and each pane in multiple glazing.

**Exception:** Glazing that is more than 60 inches (1524 mm), measured horizontally, ~~and in a straight line~~ from the water's edge. ~~of a bathtub, hot tub, spa, whirlpool or swimming pool or from the edge of a shower, sauna or steam room.~~

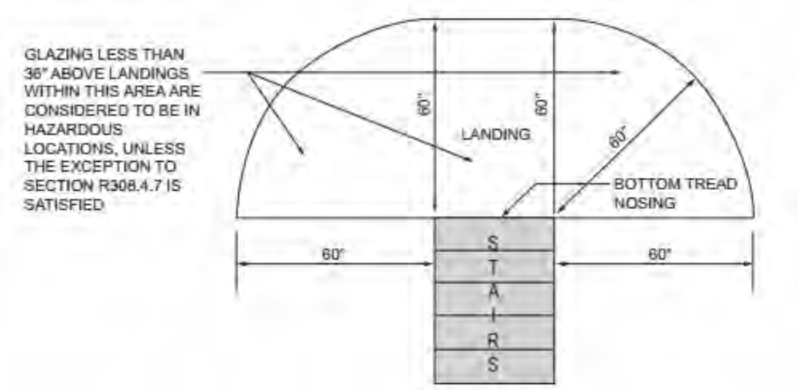
**R308.4.6 Glazing adjacent to stairs and ramps.** Glazing where the bottom exposed edge of the glazing is less than 36 inches (914 mm) above the plane of the adjacent walking surface of *stairways*, landings between flights of stairs and *ramps* shall be considered to be a hazardous location.

**Exceptions:**

1. Where ~~a~~ glazing is adjacent to a walking surface and a horizontal rail is installed ~~on the accessible side(s) of the glazing~~ at 34 to 38 inches (864 to 965 mm) above the walking surface. The rail shall be capable of withstanding a horizontal load of 50 pounds per linear foot (730 N/m) without contacting the glass and have a cross-sectional height of not less than $1^1/_2$ inches (38 mm).
2. Glazing 36 inches (914 mm) or more measured horizontally from the walking surface.
3. Where a change in elevation is 8¼ inches (210 mm) or less at an exterior door.

**R308.4.7 Glazing adjacent to the bottom stair landing.** Glazing adjacent to the landing at the bottom of a *stairway* where the glazing is less than 36 inches (914 mm) above the landing and within a 60-inch (1524 mm) horizontal arc less than 180 degrees (3.14 rad) from the bottom tread *nosing* shall be considered to be a hazardous location. (See Figure R308.4.7.)

**Exception:** Where the ~~The~~ glazing is protected by a *guard* complying with Section R312 and the plane of the glass is more than 18 inches (457 mm) from the *guard*.




**For SI: 1 inch = 25.4 mm.**

**FIGURE R308.4.7**
**~~PROHIBITED~~ HAZARDOUS GLAZING LOCATIONS AT BOTTOM STAIR LANDINGS**

**R308.5 Site-built windows.** Site-built windows shall comply with Section 2404 of the *International Building Code.*

**R308.6 Skylights and sloped glazing.** *Skylights and sloped glazing* shall comply with the following sections.

**R308.6.1 Definitions.** The following terms are defined in Chapter 2:

**SKYLIGHT, UNIT.**

**SKYLIGHTS AND SLOPED GLAZING.**
**TUBULAR DAYLIGHTING DEVICE (TDD).**

**R308.6.2 Materials.** ~~The following type of glazing~~ Glazing materials shall be ~~permitted~~ limited to ~~be used~~ the following:

1. Laminated glass with not less than a 0.015-inch (0.38 mm) polyvinyl butyral interlayer for glass panes 16 square feet (1.5 $m^2$) or less in area located such that the highest point of the glass is not more than 12 feet (3658 mm) above a walking ~~surface or other accessible area~~ surface; for higher or larger sizes, the interlayer thickness shall be not less than 0.030 inch (0.76 mm).
2. Fully tempered glass.
3. Heat-strengthened glass.
4. Wired glass.
5. *Approved* rigid plastics.

**R308.6.3 Screens, general.** For fully tempered or heat-strengthened glass, a retaining screen meeting the requirements of Section R308.6.7 shall be installed below the glass, except for fully tempered glass that meets ~~either condition~~ Condition 1 or 2 listed in Section R308.6.5.

**R308.6.4 Screens with multiple glazing.** Where the inboard pane is fully tempered, heat-strengthened or wired glass, a retaining screen meeting the requirements of Section R308.6.7 shall be installed below the glass, except for ~~either condition~~ Condition 1 or 2 listed in Section R308.6.5. Other panes in the multiple glazing shall be of any type listed in Section R308.6.2.

**R308.6.5 Screens not required.** Screens shall not be required where laminated glass complying with Item 1 of Section R308.6.2 is used as single glazing or the inboard pane in multiple glazing. Screens shall not be required where fully tempered glass is used as single glazing or the inboard pane in multiple glazing and either of the following conditions is met:

1. ~~Glass~~ The glass area is 16 square feet (1.49 $m^2$) or ~~less. Highest~~ less; the highest point of glass is not more than 12 feet (3658 mm) above a walking ~~surface or other accessible area.~~ surface; the nominal glass thickness is not more than $^3/_{16}$ inch (4.8 ~~mm),~~ mm); and for multiple glazing only the other pane or panes are fully tempered, laminated or wired glass.
2. ~~Glass~~ The glass area is greater than 16 square feet (1.49 ~~$m^2$). Glass~~ $m^2$); the glass is sloped 30 degrees (0.52 rad) or less from ~~vertical,~~ vertical; and the highest point of glass is not more than 10 feet (3048 mm) above a walking ~~surface or other accessible area.~~ surface.

**R308.6.6 Glass in greenhouses.** Any glazing material is permitted to be installed without screening in the sloped areas of greenhouses, provided that the greenhouse height at the ridge does not exceed 20 feet (6096 mm) above *grade*.

**R308.6.7 Screen characteristics.** The screen and its fastenings shall: be capable of supporting twice the weight of the glazing; be firmly and substantially fastened to the framing members; be installed within 4 inches (102 mm) of the glass; and have a mesh opening of not ~~more~~ greater than 1 inch by 1 inch (25 mm by 25 mm).

**R308.6.8 Curbs for skylights.** *Unit skylights* installed in a roof with a pitch ~~flatter~~ of less than three units vertical in 12 units horizontal (25-percent slope) shall be mounted on a curb extending not less than 4 inches (102 mm) above the plane of the roof, unless otherwise specified in the manufacturer's installation instructions.

**R308.6.9 Testing and labeling.** *Unit skylights* and *tubular daylighting devices* shall be tested by an *approved* independent laboratory, and bear a *label* identifying manufacturer, performance grade rating and *approved* inspection agency to indicate compliance with the requirements of AAMA/WDMA/CSA 101/I.S.2/A440.

**R308.6.9.1 Comparative analysis for glass-glazed unit skylights.** Structural wind load design pressures for glass-glazed *unit skylights* different than the size tested in accordance with Section R308.6.9 shall be permitted to be different than the design value of the tested unit where determined in accordance with one of the following comparative analysis methods:

1. Structural wind load design pressures for glass-glazed *unit skylights* smaller than the size tested in accordance with Section R308.6.9 shall be permitted to be higher than the design value of the tested unit provided that such higher pressures are determined by accepted engineering analysis. Components of the smaller unit shall be the same as those of the tested unit. Such calculated design pressures shall be validated by an additional test of the glass-glazed *unit skylight* having the highest allowable design pressure.
2. In accordance with WDMA I.S.11.

## SECTION R309 GARAGES AND CARPORTS

**R309.1 Floor surface.** Garage floor surfaces shall be of *approved noncombustible material*.

The area of floor used for parking of automobiles or other vehicles shall be sloped to facilitate the movement of liquids to a drain or toward the main vehicle entry doorway.

**R309.2 Carports.** Carports shall be open on not less than two sides. Carport floor surfaces shall be of *approved noncombustible material*. Carports not open on two or more sides shall be considered to be a garage and shall comply with the provisions of this section for garages.

~~**Exception:** Asphalt surfaces shall be permitted at ground level in carports.~~

The area of floor used for parking of automobiles or other vehicles shall be sloped to facilitate the movement of liquids to a drain or toward the main vehicle entry doorway.

**Exception:** Asphalt surfaces shall be permitted at ground level in carports.

**R309.3 Flood hazard areas.** ~~For buildings~~ Garages and carports located in flood hazard areas as established by Table R301.2(1)~~, garage floors shall be:~~ shall be constructed in accordance with Section R322.
~~1. Elevated to or above the design flood elevation as determined in accordance with Section R322; or~~
~~2. Located below the design flood elevation provided that the floors are at or above *grade* on not less than one side, are used solely for parking, building access or storage, meet the requirements of Section R322 and are otherwise constructed in accordance with this code.~~

**R309.4 Automatic garage door openers.** Automatic garage door openers, if provided, shall be *listed* and *labeled* in accordance with UL 325.

**R309.5 Fire sprinklers.** Deleted.

## SECTION R310 EMERGENCY ESCAPE AND RESCUE OPENINGS

**R310.1 Emergency escape and rescue opening required.** *Basements, habitable attics* and every sleeping room shall have not less than one operable *emergency escape and rescue opening*. Where *basements* contain one or more sleeping rooms, an *emergency escape and rescue opening* shall be required in each sleeping room. *Emergency escape and rescue openings* shall open directly into a *public way*, or to a *yard* or court having a minimum width of 36 inches (914 mm) that opens to a *public way*.

~~**Exception:**~~

**Exceptions:**

1. *Storm shelters* and *basements* used only to house mechanical *equipment* not exceeding a total floor area of 200 square feet (18.58 $m^2$).
2. Where the *dwelling unit* or *townhouse unit* is equipped with an automatic sprinkler system installed in accordance with Section P2904, sleeping rooms in *basements* shall not be required to have *emergency escape and rescue openings* provided that the *basement* has one of the following:
   2.1. One means of egress complying with Section R311 and one *emergency escape and rescue opening*.
   2.2. Two means of egress complying with Section R311.
3. A *yard* shall not be required to open directly into a *public way* where the *yard* opens to an unobstructed path from the *yard* to the *public way*. Such path shall have a width of not less than 36 inches (914 mm).

**R310.1.1 Operational constraints and opening control devices.** *Emergency escape and rescue openings* shall be operational from the inside of the room without the use of keys, tools or special knowledge. Window opening control devices ~~complying with ASTM F 2090 shall be permitted for use~~ and fall prevention devices complying with ASTM F2090 shall be permitted for use on windows serving as a required *emergency escape and rescue opening*.

**R310.2 Emergency escape and rescue openings.** *Emergency escape and rescue openings* shall have minimum dimensions ~~as specified in this section~~ in accordance with Sections R310.2.1 through R310.2.4.

**R310.2.1 Minimum ~~opening area~~ size.** *Emergency escape and rescue openings* shall have a minimum net clear openable area of 4 square feet (0.372 $m^2$) and must have a minimum total glazing area of not less than 5 square feet (0.465 m2) in the case of a ground floor level window and not less than 5.7 square feet (0.530 m2) in the case of an upper story window.

**R310.2.2 Minimum dimensions.** The minimum net clear opening height dimension shall be ~~24~~ 22 inches (~~610~~ 559 mm). The minimum net clear opening width dimension shall be 20 inches (508 mm). The net clear opening dimensions shall be the result of normal operation of the opening.

**~~R310.2.2~~ R310.2.3 ~~Window sill height.~~ Maximum height from floor.** ~~Where a window is provided as the emergency~~ Emergency escape and rescue openings ~~opening, it~~ shall have ~~a sill height of not more than~~ the bottom of the clear opening not greater than 44 inches (1118 mm) above the finished floor.~~; where the sill height is below grade, it shall be provided with a window well in accordance with Section R310.2.3.~~

~~**R310.2.3 Window wells.** The horizontal area of the window well shall be not less than 9 square feet (0.9 m2), with a horizontal projection and width of not less than 36 inches (914 mm). The area of the window well shall allow the emergency escape and rescue opening to be fully opened.~~
~~**Exception:** The ladder or steps required by Section R310.2.3.1 shall be permitted to encroach not more than 6 inches (152 mm) into the required dimensions of the window well.~~
~~**R310.2.3.1 Ladder and steps.** Window wells with a vertical depth greater than 44 inches (1118 mm) shall be equipped with a permanently affixed ladder or steps usable with the window in the fully open position. Ladders or steps required by this section shall not be required to comply with Sections R311.7 and R311.8. Ladders or rungs shall have an inside width of not less than 12 inches (305 mm), shall project not less than 3 inches (76 mm) from the wall and shall be spaced not more than 18 inches (457 mm) on center vertically for the full height of the window well.~~

~~**R310.2.3.2 Drainage.** Deleted.~~

**R310.2.4 Emergency escape and rescue openings under decks, porches and cantilevers.** *Emergency escape and rescue openings* installed under decks ~~and~~, porches and cantilevers ~~provided that the location of the deck allows the emergency escape and rescue openings to~~ shall be fully ~~opened~~ openable and ~~provides~~ provide a path not less than 36 inches (914 mm) in height and 36 inches (914 mm) in width to a *yard* or court.

~~**R310.2.5 Replacement windows.** Replacement windows installed in buildings meeting the scope of this code shall be exempt from the maximum sill height requirements of Sections R310.1 and Sections R310.2.1 and R310.2.2, provided the replacement window meets the following conditions:~~
~~1. The replacement window is the manufacturer's largest standard size window that will fit within the existing frame or existing rough opening. The replacement window is of the same operating style as the existing window or a style that provides for an equal or greater window opening area than the existing window.~~
~~2. The replacement window is not part of a change of occupancy.~~

**R310.2.5 Egress roof access window**. Egress roof access windows shall be deemed to meet the requirements of Section R310 where installed such that the bottom of the opening is not more than 44 inches (1118 mm) above the floor, provided the egress roof access window complies with the minimum opening area requirements of Section R310.2.1.

**R310.3 Emergency escape and rescue doors.** Where a door is provided as the required emergency escape and rescue opening, it shall be ~~permitted to be~~ a side-hinged door or a ~~slider~~ sliding door. ~~Where the opening is below the adjacent ground elevation, it shall be provided with a bulkhead enclosure.~~

**R310.3.1 Minimum door opening size.** The minimum net clear height opening for any door that serves as an emergency and escape rescue opening shall be ~~in accordance with Section R310.2.1.~~ 22 inches (559 mm). The minimum net clear opening width dimension shall be 20 inches (508 mm).

~~**R310.3.2 Bulkhead enclosures.** Bulkhead enclosures shall provide direct access from the *basement*. The bulkhead enclosure shall provide the minimum net clear opening equal to the door in the fully open position.~~
~~**R310.3.2.1 Drainage.** Deleted.~~

**R310.4 Area wells.** An *emergency escape and rescue opening* where the bottom of the clear opening is below the adjacent grade shall be provided with an area well in accordance with Sections R310.4.1 through R310.4.4.

**R310.4.1 Minimum size.** The horizontal area of the area well shall be not less than 9 square feet (0.9 $m^2$), with a horizontal projection and width of not less than 36 inches (914 mm). The size of the area well shall allow the *emergency escape and rescue opening* to be fully opened.

**Exception:** The ladder or steps required by Section R310.4.2 shall be permitted to encroach not more than 6 inches (152 mm) into the required dimensions of the area well.

**R310.4.2 Ladder and steps.** Area wells with a vertical depth greater than 44 inches (1118 mm) shall be equipped with an *approved*, permanently affixed ladder or steps. The ladder or steps shall not be obstructed by the *emergency escape and rescue opening* where the window or door is in the open position. Ladders or steps required by this section shall not be required to comply with Section R311.7.

**R310.4.2.1 Ladders.** Ladders and rungs shall have an inside width of not less than 12 inches (305 mm), shall project not less than 3 inches (76 mm) from the wall and shall be spaced not more than 18 inches (457 mm) on center vertically for the full height of the area well.

**R310.4.2.2 Steps.** Steps shall have an inside width of not less than 12 inches (305 mm), a minimum tread depth of 5 inches (127 mm) and a maximum *riser* height of 18 inches (457 mm) for the full height of the area well.

**R310.4.3 Drainage.** Area wells shall be designed for proper drainage.

**Exception:** A drainage system for area wells is not required where the foundation is on well-drained soil or sand-gravel mixture soils in accordance with the United Soil Classification System, Group I Soils, as detailed in Table R405.1.

**~~R310.4~~ R310.4.4 Bars, grilles, covers and screens.** ~~Bars~~ Where bars, grilles, covers, screens or similar devices are ~~permitted to be~~ placed over *emergency escape and rescue openings*, bulkhead enclosures or ~~window~~ area wells that serve such openings, ~~provided that~~ the minimum net clear opening size shall comply with Sections ~~R310.1.1 to R310.2.3 and such~~ R310.2 through R310.2.2 and R310.4.1. Such devices shall be releasable or removable from the inside without the use of a key or tool, ~~special knowledge~~ or force greater than that required for the normal operation of the escape and rescue opening.

**R310.5 Replacement windows for emergency escape and rescue openings.** Replacement windows installed in buildings meeting the scope of this code shall be exempt from ~~the maximum sill height requirements of Sections R310.1 and Sections R310.2.1 and R310.2.2~~ Sections R310.2 and R310.4.4, provided that the replacement window meets the following conditions:

~~1. The replacement window is the manufacturer's largest standard size window that will fit within the existing frame or existing rough opening. The replacement window is of the same operating style as the existing window or a style that provides for an equal or greater window opening area than the existing window.~~

~~2. The replacement window is not part of a change of occupancy.~~

1. The replacement window is the manufacturer's largest standard size window that will fit within the existing frame or existing rough opening.
2. The replacement window is of the same operating style as the existing window or a style that provides for an equal or greater window opening area than the existing window.
3. The rough opening has not been reconstructed or modified in any manner. If the opening is reconstructed or modified in any manner, then the opening must comply with the current code requirements for emergency escape and rescue openings.

**~~R310.5~~ R310.6 Dwelling additions.** Where *dwelling additions* ~~occur that~~ contain sleeping rooms, an *emergency escape and rescue opening* shall be provided in each new sleeping room. Where *dwelling additions* ~~occur that~~ have *basements*, an *emergency escape and rescue opening* shall be provided in the new *basement*.

**Exceptions:**

1. An *emergency escape and rescue opening* is not required in a new *basement* that contains a sleeping room with an *emergency escape and rescue opening*.
2. An *emergency escape and rescue opening* is not required in a new *basement* where there is an *emergency escape and rescue opening* in an existing *basement* that is ~~accessible~~ *accessed* from the new *basement*.

**~~R310.6~~ R310.7 Alterations or repairs of existing basements.** ~~An emergency escape and rescue opening is not required where existing *basements* undergo alterations or repairs.~~ New sleeping rooms created in an existing *basement* shall be provided with *emergency escape and rescue openings* in accordance with Section R310.1. Other than new sleeping rooms, where existing basements undergo alterations or repairs, an *emergency escape and rescue opening* is not required.

~~**Exception:** New sleeping rooms created in an existing *basement* shall be provided with emergency escape and rescue openings in accordance with Section R310.1.~~

## SECTION R311
## MEANS OF EGRESS

**R311.1 Means of egress.** ~~All *dwellings*~~ *Dwellings and accessory buildings* shall be provided with a means of egress ~~as provided in~~ in accordance with this section. The means of egress shall provide a continuous and unobstructed path of vertical and horizontal egress travel from all portions of the *dwelling and accessory buildings* to the exterior of the *dwelling* at the required exterior egress door without requiring travel through a garage.
~~**Exception:**~~ **Exceptions:**

1. Equipment service platforms may be served by ladders constructed in accordance with Section R310.2.3.1.
2. Detached garages and storage buildings

**R311.2 Egress door.** Not less than one ~~exterior~~ egress door shall be provided for each *dwelling unit*. The egress door shall be side-hinged, and shall provide a clear width of not less than 32 inches (813 mm) where measured between the face of the door and the stop, with the door open 90 degrees (1.57 rad). The clear height of the door opening shall be not less than 78 inches (1981 mm) in height measured from the top of the threshold to the bottom of the stop. Other

~~exterior~~ doors shall not be required to comply with these minimum dimensions. All interior egress doors and a minimum of one exterior ~~Egress~~ egress door shall be readily openable from ~~inside the dwelling~~ the side from which egress is to be made without the use of a key or special knowledge or effort.

**R311.3 Floors and landings at exterior doors.** There shall be a landing or floor on each side of each exterior door. The width of each landing shall be not less than the door served. ~~Every Landing~~ Landings shall have a dimension of not less than 36 inches (914 mm) measured in the direction of travel. The slope at exterior landings shall not exceed $^{1}/_{4}$ unit vertical in 12 units horizontal (2 percent).

**Exception:** Exterior balconies less than 60 square feet (5.6 $m^2$) and only ~~accessible~~ *accessed* from a door are permitted to have a landing that is less than 36 inches (914 mm) measured in the direction of travel.

**R311.3.1 Floor elevations at the required egress doors.** Landings or finished floors at the required egress door shall be not more than $1^{1}/_{2}$ inches (38 mm) lower than the top of the threshold.

**Exception:** The ~~exterior~~ landing or floor on the exterior side shall be not more than 8 1/4 inches (210 mm) below the top of the threshold provided that the door does not swing over the landing or floor.

Where exterior landings or floors serving the required egress door are not at *grade*, they shall be provided with access to *grade* by means of a ramp in accordance with Section R311.8 or a stairway in accordance with Section R311.7.

**R311.3.2 Floor elevations for ~~at~~ other exterior doors.** Doors other than the required egress door shall be provided with landings or floors not more than $7^{3}/_{4}$ inches (196 mm) below the top of the threshold.

**Exception:** A top landing is not required where a *stairway* of not more than two *risers* is located on the exterior side of the door, provided that the door does not swing over the *stairway*.

**R311.3.3 Storm and screen doors.** Storm and screen doors shall be permitted to swing over exterior stairs and landings.

**R311.4 Vertical egress.** ~~Deleted.~~ Egress from habitable levels including habitable attics and *basements* that are not provided with an egress door in accordance with Section R311.2 shall be by a *ramp* in accordance with Section R311.8 or a *stairway* in accordance with Section R311.7.

**R311.5 ~~Construction.~~ Landing, deck, balcony and stair construction and attachment.** Exterior landings, decks, balconies, stairs and similar facilities shall be positively anchored to the primary structure to resist both vertical and lateral forces or shall be designed to be self-supporting. Attachment shall not be accomplished by use of toenails or nails subject to withdrawal.

~~**R311.5.1 Attachment.** Deleted.~~

**R311.6 Hallways.** The width of a hallway shall be not less than 3 feet (914 mm). measured from the finished surface of the walls.

**R311.6.1 Interior egress doors.** All doors providing egress from habitable rooms shall have nominal dimensions of 2 feet 6 inches (782 mm) width by 6 feet 8 inches (2032 mm) height. Interior egress doors shall be readily openable from the side from which egress is to be made without the use of a key or special knowledge or effort.

**R311.7 Stairways.** Where required by this code or provided, *stairways* shall comply with this section.

**Exceptions:**

1. Stairways not within or serving a building, porch or deck.
2. Stairways leading to nonhabitable attics.
3. **Stairways leading to *crawl spaces*.**

**R311.7.1 Width.** *Stairways* shall be not less than 36 inches (914 mm) in clear width at all points above the permitted *handrail* height and below the required headroom height. ~~Handrails shall not project more than $4^{1}/_{2}$ inches (114 mm) on either side of the stairway and the~~ The clear width of ~~the stairway~~ *stairways* at and below the *handrail* height, including treads and landings, shall be not less than $31^{1}/_{2}$ inches (787 mm) where a *handrail* is ~~provided~~ installed on one side and 27 inches (698 mm) where *handrails* are installed on both sides.

**Exceptions:**

1. The width of *spiral stairways* shall be in accordance with Section R311.7.10.1.
2. Stairways not required for egress shall be permitted to be a minimum width of 26 inches (660 mm).

**R311.7.2 Headroom.** The headroom in *stairways* shall be not less than 6 feet 8 inches (2032 mm) measured vertically from the sloped line adjoining the tread *nosing* or from the floor surface of the landing or platform on that portion of the *stairway*.

**Exceptions:**

1. Where the *nosings* of treads at the side of a flight extend under the edge of a floor opening through which the *stair* passes, the floor opening shall ~~be allow to~~ not project horizontally into the required headroom ~~not~~ more than $4^{3}/_{4}$ inches (121 mm).
2. The headroom for spiral *stairways* shall be in accordance with Section R311.7.10.1.

**R311.7.3 Vertical rise.** A flight of stairs shall not have a vertical rise greater than ~~147 inches~~ 12 feet 7 inches (~~3734~~ 3835 mm) between floor levels or landings.

**R311.7.4 Walkline.** ~~Deleted.~~ The walkline across winder treads shall be concentric to the curved direction of travel through the turn and located 12 inches (305 mm) from the side where the winders are narrower. The 12 inch (305 mm) dimension shall be measured from the widest point of the clear stair width at the walking surface of the winder. If winders are adjacent within the flight, the point of the widest clear stair width of the adjacent winders shall be used.

**R311.7.5 Stair treads and risers.** *Stair* treads and *risers* shall meet the requirements of this section. For the purposes of this section, dimensions and dimensioned surfaces shall be exclusive of carpets, rugs or runners.

**R311.7.5.1 Risers.** The *riser* height shall be not more than 8 ¼ inches (210 mm). The *riser* height shall be measured vertically between leading edges of the adjacent treads. The greatest *riser* height within any flight of stairs shall not exceed the smallest by more than $^{3}/_{8}$ inch (9.5 mm). At open *risers*, openings located more than 30 inches (762 mm), as measured vertically, to the floor or *grade* below shall not permit the passage of a 4-inch-diameter (102 mm) sphere. The top and bottom riser of interior stairs shall not exceed the smallest riser within that stair run by more than 3/4 inch (19 mm). The height of the top and bottom riser of the interior stairs shall be measured from the permanent finished surface (carpet excluded). Where the bottom riser of an exterior stair adjoins an exterior walk, porch, driveway, patio, garage floor, or finish grade, the height of the riser may be less than the height of the adjacent risers.

**Exceptions:**

1. The opening between adjacent treads is not limited on *spiral stairways*.
2. The *riser* height of *spiral stairways* shall be in accordance with Section R311.7.10.1.

**R311.7.5.2 Treads.** The tread depth shall be not less than 9 inches (229 mm). The tread depth shall be measured horizontally between the vertical planes of the foremost projection of adjacent treads and at a right angle to the tread's leading edge. The greatest tread depth within any flight of stairs shall not exceed the smallest by more than $^3/_8$ inch (9.5 mm).

**R311.7.5.2.1 Winder treads.** Winder treads shall have a tread depth of not less than 9 inches (229 mm) measured ~~between the vertical planes of the foremost projection of adjacent treads at the intersections with the walkline.~~ as above a point 12 inches (305 mm) from the side where the treads are narrower. Winder treads shall have a tread depth of not less than 4 inches (102 mm) at any point. ~~within the clear width of the stair.~~ Within any flight of stairs, the ~~largest~~ greatest winder tread depth at the 12 inch (305 mm) walkline shall not exceed the smallest ~~winder tread~~ by more than $^3/_8$ inch (9.5 mm). Consistently shaped winders at the walkline shall be allowed within the same flight of stairs as rectangular treads and shall not be required to be within $^3/_8$ inch (9.5 mm) of the rectangular tread depth.

**Exception:** The tread depth at *spiral stairways* shall be in accordance with Section R311.7.10.1.

**R311.7.5.3 Nosings.** ~~The~~ *Nosings* at treads, landings and floors of *stairways* shall have a radius of curvature at the *nosing* ~~shall be~~ not greater than $^9/_{16}$ inch (14 mm) or a bevel not greater than $^1/_2$ inch (12.7 mm). A *nosing* projection not less than $^3/_4$ inch (19 mm) and not more than $1^1/_4$ inches (32 mm) shall be provided on ~~stairways with solid raisers.~~ *stairways*. The greatest *nosing* projection shall not exceed the smallest *nosing* projection by more than $^3/_8$ inch (9.5 mm) ~~between two stories, including the nosing at the level of floors and landings. Beveling of nosings shall not exceed 1/2 inch (12.7 mm).~~within a *stairway*.

**Exception:** A *nosing* projection is not required where the tread depth is not less than 11 inches (279 mm).

**R311.7.5.4 Exterior plastic composite stair treads.** *Plastic composite* exterior stair treads shall comply with the provisions of this section and the requirements of ASTM D7032.

**R311.7.6 Landings for stairways.** There shall be a floor or landing at the top and bottom of each stairway. A flight of stairs shall not have a vertical rise larger than 12 feet 7 inches (3835 mm) between floor levels or landings. The width of each landing shall not be less than the width of the stairway served. Every landing shall have a minimum dimension of 36 inches (914 mm) measured in the direction of travel.

**Exception:** A floor or landing is not required at the top of an interior flight of stairs, including stairs in an enclosed garage, provided that a door does not swing over the stairs.

**R311.7.7 Stairway walking surface.** The walking surface of treads and landings of *stairways* shall be sloped not steeper than 1 unit vertical in 48 units horizontal (2-percent slope).

**R311.7.8 Handrails.** *Handrails* shall be provided on not less than one side of ~~each continuous run of tread or~~ flight of stairs with four or more *risers*.

**R311.7.8.1 Height.** *Handrail* height, measured vertically from the sloped plane adjoining the tread *nosing*, or finish surface of ramp slope, shall be not less than 34 inches (864 mm) and not more than 38 inches (965 mm).

**Exceptions:**

1. The use of a volute, turnout, ~~or~~ starting easing or starting newel shall be allowed over the lowest tread.
2. Where *handrail* fittings or bendings are used to provide continuous transition between flights, transitions at *winder* treads, the transition from *handrail* to *guard*, or used at the start of a flight, the *handrail* height at the fittings or bendings shall be permitted to exceed 38 inches (965 mm).

**R311.7.8.2 ~~Continuity.~~ Handrail projection.** Handrails ~~for stairways~~ shall ~~be continuous for the full length of the flight, from a point directly above the top riser~~ not project more than 41/2 inches (114 mm) on either side of the ~~flight to a point directly above the lowest riser~~ stairway.

**Exceptions:**

~~1. Handrails shall be permitted to be interrupted by a newel post at the turn.~~

~~2. The use of a volute, turnout, starting easing or starting newel shall be allowed over the lowest tread. Where nosings of landings, floors or passing flights project into the stairway reducing the clearance at passing handrails, handrails shall project not more than 61/2 inches (165 mm) into the stairway, provided that the stair width and handrail clearance are not reduced to less than that required.~~

Where *nosings* of landings, floors or passing flights project into the *stairway* reducing the clearance at passing *handrails*, *handrails* shall project not more than $6^1/_2$ inches (165 mm) into the *stairway*, provided that the stair width and *handrail* clearance are not reduced to less than that required.

**R311.7.8.3 Handrail clearance.**

Handrails adjacent to a wall shall have a space of not less than 11/2 inches (38 mm) between the wall and the handrails.

**R311.7.8.4 Continuity.** Handrails shall be continuous for the full length of the flight, from a point directly above the top riser of the flight to a point directly above the lowest riser of the flight. Handrail ends shall be returned toward a wall, guard walking surface continuous to itself, or terminate to a post.

**Exceptions:**

1. *Handrail* continuity shall be permitted to be interrupted by a newel post at a turn in a flight with winders, at a landing, or over the lowest tread.
2. A volute, turnout or starting easing shall be allowed to terminate over the lowest tread and over the top landing.
3. Two or more separate rails shall be considered continuous if the termination of the rails occurs within 6 inches (152 mm) of each other. If transitioning between a wall-mounted handrail and a guardrail/handrail, the wall-mounted rail shall return into the wall.

**~~R311.7.8.3~~ R311.7.8.5 Grip size.** Required *handrails* shall be of one of the following types or provide equivalent graspability.

1. Type I. *Handrails* with a circular cross section shall have an outside diameter of not less than $1^1/_4$ inches (32 mm) and not greater than 2 inches (51 mm). If the *handrail* is not circular, it shall have a perimeter ~~dimension~~ of not less than 4 inches (102 mm) and not greater than $6^1/_4$ inches (160 mm) ~~with~~ and a cross section ~~of dimension~~ of not more than $2^1/_4$ inches (57 mm). Edges shall have a radius of not less than 0.01 inch (0.25 mm).
2. Type II. *Handrails* with a perimeter greater than $6^1/_4$ inches (160 mm) shall have a graspable finger recess area on both sides of the profile. The finger recess shall begin within ~~a distance of~~ $^3/_4$ inch (19 mm) measured vertically from the tallest portion of the profile and ~~achieve~~ have a depth of not less than $^5/_{16}$ inch (8 mm) within $^7/_8$ inch (22 mm) below the widest portion of the profile. This required depth shall continue for not less than $^3/_8$ inch (10 mm) to a level that is not less than $1^3/_4$ inches (45 mm) below the tallest portion of the profile. The width of the *handrail* above the recess shall be not less than $1^1/_4$ inches (32 mm) and not more than $2^3/_4$ inches (70 mm). Edges shall have a radius of not less than 0.01 inch (0.25 mm).

Exception: Exterior handrails (garages and areas exposed to the weather) shall not be more than 31/2 inches (89 mm) in cross-section dimension.

**~~R311.7.8.4~~ R311.7.8.6 Exterior plastic composite handrails.** *Plastic composite* exterior *handrails* shall comply with the requirements of ASTM D7032.

**R311.7.9 Illumination.** *Stairways* shall be provided with illumination in accordance with Sections R303.7 and R303.8.

**R311.7.10 Special stairways.** *Spiral stairways* and bulkhead enclosure *stairways* and bowed tread stairways shall comply with the requirements of Section R311.7 except as specified in Sections R311.7.10.1 and ~~R311.7.10.2.~~ R311.7.10.3.

**R311.7.10.1 Spiral stairways.** ~~Spiral stairways are permitted, provided that the~~ The clear width at and below the ~~handrail is~~ *handrails* at *spiral stairways* shall be not less than 26 inches (660 mm) and the walkline radius ~~is~~ shall be not greater than $24^1/_2$ inches (622 mm). Each tread shall have a depth of not less than $6^3/_4$ inches (171 mm) at the walkline. ~~All treads~~ Treads shall be identical, and the rise shall be not more than $9^1/_2$ inches (241 mm). Headroom shall be not less than 6 feet 6 inches (1982 mm).

**R311.7.10.2 Bulkhead enclosure stairways.** *Stairways* serving bulkhead enclosures, not part of the required building egress, providing access from the outside *grade* level to the *basement* shall be exempt from the requirements of Sections R311.3 and R311.7 where the height from the *basement* finished floor level to *grade* adjacent to the *stairway* is not more than 8 feet (2438 mm) and the *grade* level opening to the *stairway* is covered by a bulkhead enclosure with hinged doors or other *approved* means.

**R311.7.10.3 Bowed tread stairways.** Bowed tread stairways are permitted provided they are uniform in bowed tread depth along the entire width of the tread with not more than 3/8-inch (9.5 mm) variance from greatest to smallest tread in the stairway flight. At no point shall the tread be less than 9 inches (229 mm) with a nosing as listed in Sections R311.7.5.2 and R311.7.5.3, respectively.

**R311.7.10.3.1 Standard stairway application.** The bottom three treads in a standard straight run stairway application as listed under Section R311.7.5.2 are permitted to bow provided that, at no point along the width of the tread, they are less than 9 inches (229 mm) as measured under Section R311.7.5.2 and each bowed tread is uniform with other bowed treads with no more than 3/8-inch (9.5 mm) variance from greatest to least. Nosing is required as listed in Section R311.7.5.3.

**R311.7.10.3.2 Bowed tread circular stairways.**
Bowed treads in a circular stairway are permitted provided they are uniform, as per winder treads as listed in Section 311.7.5.2.1, measured at a point 12 inches (305 mm) from the side where the treads are narrower. At this walk line, bowed treads must be uniform with other circular stairway treads with the greatest tread not to exceed the smallest by more than 3/8 inch (9.5 mm). Nosing is required as listed in Section R311.7.5.3.

**R311.7.11 Alternating tread devices.** Deleted.

**R311.7.12 Ship's ladders.** Ship's ladders shall not be used as an element of a means of egress. Ship's ladders shall be permitted provided that a required means of egress *stairway* or *ramp* serves the same space at each adjoining level or where a means of egress is not required. The clear width at and below the *handrails* shall be not less than 20 inches (508 mm).

**Exception:** Ship's ladders are allowed to be used as an element of a means of egress for lofts, *mezzanines* and similar areas of 200 gross square feet (18.6 $m^2$) or less that do not provide exclusive access to a kitchen or bathroom.

**R311.7.12.1 Treads of ship's ladders.** Treads shall have a depth of not less than 5 inches (127 mm). The tread shall be projected such that the total of the tread depth plus the *nosing* projection is not less than $8^1/_2$ inches (216 mm). The *riser* height shall be not more than $9^1/_2$ inches (241 mm).

**R311.7.12.2 Handrails of ship's ladders.** *Handrails* shall be provided on both sides of ship's ladders and shall comply with Sections R311.7.8.2 through ~~R311.7.8.4~~ R311.7.8.6. *Handrail* height shall be uniform, not less than 30 inches (762 mm) and not more than 34 inches (864 mm).

**R311.8 Ramps.** Where required by this code or provided, *ramps* shall comply with this section.

**Exception: Ramps not within or serving a building, porch or deck.**

**R311.8.1 Maximum slope.** *Ramps* serving the egress door required by Section R311.2 shall have a slope of not more than 1 unit vertical in 12 units horizontal (8.3-percent slope).

~~All other~~ Other *ramps* shall have a maximum slope of 1 unit vertical in 8 units horizontal (12.5 percent).

**Exception:** Where it is technically infeasible to comply because of site constraints, *ramps* shall have a slope of not more than 1 unit vertical in 8 units horizontal (12.5 percent).

**R311.8.1 Maximum slope.** *Ramps* serving the egress door required by Section R311.2 shall have a slope of not more than 1 unit vertical in 12 units horizontal (8.3-percent slope).

Other *ramps* shall have a maximum slope of 1 unit vertical in 8 units horizontal (12.5 percent).

**Exception:** Where it is technically infeasible to comply because of site constraints, *ramps* shall have a slope of not more than 1 unit vertical in 8 units horizontal (12.5 percent).

**R311.8.2 Landings required.** There shall be a floor or landing at the top and bottom of each *ramp*, where doors open onto *ramps*, and where *ramps* change directions. The width of the landing perpendicular to the *ramp* slope shall be not less than the width of the *ramp*. The depth of the landing in the direction of the ramp slope shall be not less than 36 inches (914 mm).

**R311.8.3 Handrails required.** *Handrails* shall be provided on not less than one side of *ramps* exceeding a slope of 1 unit vertical in 12 units horizontal (8.33-percent slope).

**R311.8.3.1 Height.** *Handrail* height, measured above the finished surface of the *ramp* slope, shall be not less than 34 inches (864 mm) and not more than 38 inches (965 mm).

**R311.8.3.2 Grip size.** *Handrails* on *ramps* shall comply with Section ~~R311.7.8.3~~ R311.7.8.5.

**R311.8.3.3 Continuity.** *Handrails* where required on *ramps* shall be continuous for the full length of the *ramp*. *Handrail* ends shall be returned or shall terminate in newel posts or safety terminals. *Handrails* adjacent to a wall shall have a space of not less than $1^1/_2$ inches (38 mm) between the wall and the *handrails*.

## SECTION R312
## GUARDS AND WINDOW FALL PROTECTION

**R312.1 Guards.** *Guards* shall be provided in accordance with Sections R312.1.1 through R312.1.4.

**R312.1.1 Where required.** *Guards* shall be ~~located along~~ provided for those portions of open-sided walking surfaces, including floors, stairs, *ramps* and landings that are located more than 30 inches (762 mm) measured vertically to the floor or *grade* below at any point within 36 inches (914 mm) horizontally to the edge of the open side. Insect screening shall not be considered as a *guard*.

**R312.1.2 Height.** Required *guards* at open-sided walking surfaces, including stairs, porches, balconies or landings, shall be not less than 36 inches (914 mm) in height as measured vertically above the adjacent walking surface or the line connecting the ~~leading edges of the treads~~ *nosings*.

**Exceptions:**

1. *Guards* on the open sides of stairs shall have a height of not less than 34 inches (864 mm) measured vertically from a line connecting the ~~leading edges of the treads~~ *nosings*.
2. Where the top of the *guard* serves as a *handrail* on the open sides of stairs, the top of the *guard* shall be not less than 34 inches (864 mm) and not more than 38 inches (965 mm) as measured vertically from a line connecting the ~~leading edges of the treads~~ *nosings*.

**R312.1.3 Opening limitations.** Required *guards* shall not have openings from the walking surface to the required *guard* height that allow passage of a sphere 4 inches (102 mm) in diameter.

**Exceptions:**

1. The triangular openings at the open side of *stair*, formed by the *riser*, tread and bottom rail of a *guard*, shall not allow passage of a sphere 6 inches (153 mm) in diameter.
2. *Guards* on the open side of stairs shall not have openings that allow passage of a sphere $4^3/_8$ inches (111 mm) in diameter.

**R312.1.4 Exterior plastic composite guards.** *Plastic composite* exterior *guards* shall comply with the requirements of Section R317.4.

**R312.2 Window fall protection.** Window fall protection shall be provided in accordance with Sections R312.2.1 and R312.2.2.

**R312.2.1 Window ~~sills~~ opening height.** In *dwelling units*, where the ~~top~~ bottom of the ~~sill~~ clear opening of an operable window opening is located less than 24 inches (610 mm) above the finished floor and greater than 72 inches (1829 mm) above the finished *grade* or other surface below on the exterior of the building, the operable window shall comply with one of the following:

1. Operable ~~windows~~ window ~~with~~ openings ~~that~~ will not allow a 4-inch-diameter (102 mm) sphere to pass through the ~~opening~~ where the ~~opening is~~ openings are in ~~its~~ their largest opened position.
2. Operable windows ~~that~~ are provided with window opening control devices or fall prevention devices that comply with ASTM F2090.

~~3. Operable windows that are provided with window opening control devices that comply with Section R312.2.2.~~

**R312.2.2 ~~Window opening control devices~~ Emergency escape and rescue openings.** ~~Window opening control devices shall comply with ASTM F2090.~~ Where an operable window serves as an *emergency escape and rescue opening*, a window opening control device or fall prevention device, after operation to release the control device or fall prevention device allowing the window to fully open, shall not reduce the net clear opening area of the window unit to less than the area required by Sections R310.2.1 and R310.2.2.

## SECTION R313
## AUTOMATIC FIRE SPRINKLER SYSTEMS
## Deleted.

~~**R313.1 Townhouse automatic fire sprinkler systems.** An automatic residential fire sprinkler system shall be installed in *townhouses*.~~

~~**Exceptions:**~~

~~1. Townhouses constructed with a common 2-hour fire-resistance-rated wall assembly tested in accordance with ASTM E119 or UL 263, provided such walls do not contain plumbing or mechanical equipment, ducts or vents in the cavity of the common wall. The wall shall be rated for fire exposure from both sides and shall extend to and be tight against exterior wall sheathing and the underside of the roof sheathing. Electrical installations shall be installed in accordance with the *North Carolina Electrical Code*. Penetrations for electrical outlet boxes shall be in accordance with Section R302.4.~~

~~2. An automatic residential fire sprinkler system shall not be required where *additions* or *alterations* are made to existing *townhouses* that do not have an automatic residential fire sprinkler system installed.~~

~~**R313.1.1 Design and installation.** Automatic residential fire sprinkler systems for *townhouses* shall be designed and installed in accordance with Section P2904 or NFPA 13D.~~

~~**R313.2 One- and two-family dwellings automatic fire systems.** Deleted.~~

~~**R314.2.2 Alterations, repairs and additions.** Where *alterations*, *repairs* or *additions* requiring a building *permit* occur, or where one or more sleeping rooms are added or created in existing dwellings the individual *dwelling unit* shall be equipped with smoke alarms located as required for new *dwellings*.~~

~~**Exceptions:**~~

1. ~~Work involving the exterior surfaces of *dwellings*, such as the replacement of roofing or siding, the addition or replacement of windows or doors, or the addition of a porch or deck. are exempt from the requirements of this section.~~
2. ~~Installation, *alteration* or repairs of plumbing or mechanical systems. are exempt from the requirements of this section.~~

## SECTION R314
## SMOKE ALARMS

**R314.1 General.** Smoke alarms shall comply with NFPA 72 and Section R314.

**R314.1.1 Listings.** Smoke alarms shall be *listed* in accordance with UL 217. Combination smoke and carbon monoxide alarms shall be *listed* in accordance with UL 217 and UL 2034.

**R314.2 Where required.** Smoke alarms shall be provided in accordance with this section.

**R314.2.1 New construction.** Smoke alarms shall be provided in *dwelling units*.

**R314.2.2 Alterations, repairs and additions.** Where *alterations*, *repairs* or *additions* requiring a building *permit* occur, the individual *dwelling unit* shall be equipped with smoke alarms located as required for new *dwellings*.

**Exceptions:**

1. Work involving the exterior surfaces of *dwellings*, such as the replacement of roofing or siding, the addition or replacement of windows or doors, or the addition of a porch or deck.
2. Installation, *alteration* or repairs of plumbing or mechanical systems.

**R314.3 Location.** Smoke alarms shall be installed in the following locations:

1. In each sleeping room.
2. Outside each separate sleeping area in the immediate vicinity of the bedrooms.
3. On each additional story of the *dwelling*, including *basements* and *habitable attics* and not including crawl spaces and uninhabitable *attics*. In *dwellings* or *dwelling units* with split levels and without an intervening door between the adjacent levels, a smoke alarm installed on the upper level shall suffice for the adjacent lower level provided that the lower level is less than one full *story* below the upper level.
4. Not less than 3 feet (914 mm) horizontally from the door or opening of a bathroom that contains a bathtub or shower unless this would prevent placement of a smoke alarm required by ~~Section R314.3~~ this section.
5. Deleted.

**R314.3.1 Installation near cooking appliances.** Smoke alarms shall not be installed in the following locations unless this would prevent placement of a smoke alarm in a location required by Section R314.3.

1. Ionization smoke alarms shall not be installed less than 20 feet (6096 mm) horizontally from a permanently installed cooking *appliance*.
2. Ionization smoke alarms with an alarm-silencing switch shall not be installed less than 10 feet (3048 mm) horizontally from a permanently installed cooking *appliance*.
3. Photoelectric smoke alarms shall not be installed less than 6 feet (1828 mm) horizontally from a permanently installed cooking *appliance*.
4. Deleted.

**R314.4 Interconnection.** Where more than one smoke alarm is required to be installed within an individual *dwelling unit* in accordance with Section R314.3, the alarm devices shall be interconnected in such a manner that the actuation of one alarm will activate all of the alarms in the individual *dwelling unit*. Physical interconnection of smoke alarms shall not be required where *listed* wireless alarms are installed and all alarms sound upon activation of one alarm.

~~**Exception:** Interconnection of smoke alarms in existing areas shall not be required where *alterations* or repairs do not result in removal of interior wall or ceiling finishes exposing the structure.~~

**R314.5 Combination alarms.** Combination smoke and carbon monoxide alarms shall be permitted to be used in lieu of smoke alarms.

**R314.6 Power source.** Smoke alarms shall receive their primary power from the building wiring where such wiring is served from a commercial source and, where primary power is interrupted, shall receive power from a battery. Wiring shall be permanent and without a disconnecting switch other than those required for overcurrent protection.

**Exceptions:**

1. Smoke alarms shall be permitted to be battery operated where installed in buildings without commercial power.
2. Smoke alarms installed in accordance with Section R314.2.2 shall be permitted to be battery powered.

**R314.7 Fire alarm systems.** Fire alarm systems shall be permitted to be used in lieu of smoke alarms and shall comply with Sections R314.7.1 through R314.7.4.

**R314.7.1 General.** Fire alarm systems shall comply with the provisions of this code and the household fire warning equipment provisions of NFPA 72. Smoke detectors shall be *listed* in accordance with UL 268.

**R314.7.2 Location.** Smoke detectors shall be installed in the locations specified in Section R314.3.

**R314.7.3 Permanent fixture.** Where a household fire alarm system is installed, it shall become a permanent fixture of the occupancy, owned by the homeowner.

**R314.7.4 Combination detectors.** Combination smoke and carbon monoxide detectors shall be permitted to be installed in fire alarm systems in lieu of smoke detectors, provided that they are *listed* in accordance with UL 268 and UL 2075.

## SECTION R315
## CARBON MONOXIDE ALARMS

**R315.1 General.** Carbon monoxide alarms shall comply with Section R315.

**R315.1.1 Listings.** Carbon monoxide alarms shall be *listed* in accordance with UL 2034. Combination carbon monoxide and smoke alarms shall be *listed* in accordance with UL 217 and UL 2034.

**R315.2 Where required.** Carbon monoxide alarms shall be provided in accordance with Sections R315.2.1 and R315.2.2.

**R315.2.1 New construction.** For new construction, carbon monoxide alarms shall be provided in *dwelling units* where either or both of the following conditions exist.

1. The *dwelling unit* contains a fuel-fired *appliance* or fireplace.
2. The *dwelling unit* has an attached garage with an opening that communicates with the *dwelling unit*.

**R315.2.2 Alterations, repairs and additions.** Where *alterations*, *repairs* or *additions* requiring a building *permit* occur, or where one or more sleeping rooms are added or created in existing dwellings, or where fuel-fired appliances or fireplaces are added or replaced, shall be equipped with carbon monoxide alarms located as required for new *dwellings*.

**Exceptions:**

1. Work involving the exterior surfaces of *dwellings*, such as the replacement of roofing or siding, or the addition or replacement of windows or doors, or the addition of a porch or deck~~.~~ or the installation of a fuel-fired appliance that cannot introduce carbon monoxide to the interior of the dwelling. ~~is exempt from the requirements of this section.~~
2. Deleted.

3. Deleted.

**R315.3 Location.** Carbon monoxide alarms in *dwelling units* shall be installed outside of each separate sleeping area in the immediate vicinity of the bedrooms. Where a fuel-burning *appliance* is located within a bedroom or its attached bathroom, a carbon monoxide alarm shall be installed within the bedroom.

**R315.4 Combination alarms.** Combination carbon monoxide and smoke alarms shall be permitted to be used in lieu of carbon monoxide alarms.

**R315.5 Interconnectivity.** Where more than one carbon monoxide alarm is required to be installed within an individual *dwelling unit* in accordance with Section R315.3, the alarm devices shall be interconnected in such a manner that the actuation of one alarm will activate all of the alarms in the individual *dwelling unit*. Physical interconnection of carbon monoxide alarms shall not be required where *listed* wireless alarms are installed and all alarms sound upon activation of one alarm.

**Exception:** Interconnection of carbon monoxide alarms in existing areas shall not be required where *alterations* or *repairs* do not result in removal of interior wall or ceiling finishes exposing the structure, unless there is an attic, *crawl space* or *basement* available that could provide access for interconnection without the removal of interior finishes.

**~~R315.5~~ R315.6 Power source.** Carbon monoxide alarms shall receive their primary power from the building wiring where such wiring is served from a commercial source and, where primary power is interrupted, shall receive power from a battery. Wiring shall be permanent and without a disconnecting switch other than those required for overcurrent protection.

**Exceptions:**

1. Carbon monoxide alarms shall be permitted to be battery operated where installed in buildings without commercial power.
2. Carbon monoxide alarms installed in accordance with Section R315.2.2 shall be permitted to be battery powered.

**~~R315.6~~ R315.7 Carbon monoxide detection systems.** Carbon monoxide detection systems shall be permitted to be used in lieu of carbon monoxide alarms and shall comply with Sections ~~R315.6.1~~ R315.7.1 through ~~R315.6.4~~ R315.7.4.

**~~R315.6.1~~ R315.7.1 General.** Household carbon monoxide detection systems shall comply with NFPA 720. Carbon monoxide detectors shall be *listed* in accordance with UL 2075.

**~~R315.6.2~~ R315.7.2 Location.** Carbon monoxide detectors shall be installed in the locations specified in Section R315.3. These locations supersede the locations specified in NFPA 720.

**~~R315.6.3~~ R315.7.3 Permanent fixture.** Where a household carbon monoxide detection system is installed, it shall become a permanent fixture of the occupancy and owned by the homeowner.

**~~R315.6.4~~ R315.7.4 Combination detectors.** Combination carbon monoxide and smoke detectors ~~shall be permitted to be~~ installed in carbon monoxide detection systems in lieu of carbon monoxide ~~detectors, provided that they are~~ detectors shall be *listed* in accordance with UL 268 and UL 2075.

## SECTION R316
## FOAM PLASTIC

**R316.1 General.** The provisions of this section shall govern the materials, design, application, construction and installation of foam plastic materials.

**R316.2 Labeling and identification.** Packages and containers of foam plastic insulation and foam plastic insulation components delivered to the job site shall bear the *label* of an *approved agency* showing the manufacturer's name, the product listing, product identification and information sufficient to determine that the end use will comply with the requirements.

**R316.3 Surface burning characteristics.** Unless otherwise allowed in Section R316.5, foam plastic, or foam plastic cores used as a component in manufactured assemblies, used in building construction shall ~~have a flame spread index of not more than 75 and shall have a smoke-developed index of not more than 450 when tested in the maximum thickness and density intended for use in accordance with ASTM E84 or UL 723.~~ comply with Section R316.3.1 or R316.3.2. Loose-fill-type foam plastic insulation shall be tested as board stock for the flame spread index and *smoke-developed index*.

~~**Exception:** Foam plastic insulation more than 4 inches (102 mm) thick shall have a flame spread index of not more than 75 and a smoke-developed index of not more than 450 where tested at a thickness of not more than 4 inches (102 mm), provided that the end use is *approved* in accordance with Section R316.6 using the thickness and density intended for use.~~

**Exception:** Spray foam plastic insulation more than 4 inches (102 mm) in thickness shall have a flame spread index of not more than 25 and a *smoke-developed index* of not more than 450 where tested at a thickness of 4 inches (102 mm) and at the density intended for use. Such spray foam plastic shall be separated from the interior of a building by $^1/_2$-inch (12.7 mm) gypsum wallboard or by a material that has been tested in accordance with NFPA 275, and shall meet the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test.

**R316.3.1 Foam plastic insulation 4 inches thick or less.** Foam plastic insulation installed at 4 inches (102 mm) in thickness or less shall have a flame spread index of not more than 75 and a *smoke-developed index* of not more than 450 where tested in the maximum thickness and density intended for use in accordance with ASTM E84 or UL 723.

**R316.3.2 Foam plastic insulation more than 4 inches thick.** Foam plastic insulation installed at more than 4 inches (102 mm) in thickness shall have a flame spread index of not more than 75 and a *smoke-developed index* of not more than 450 where tested at a thickness of 4 inches (102 mm) in accordance with ASTM E84 or UL 723, provided that the end use is *approved* in accordance with Section R316.6 using the thickness and density intended for use.

**R316.4 Thermal barrier.** Unless otherwise allowed in Section R316.5, foam plastic shall be separated from the interior of a building by an *approved* thermal barrier of not less than $^1/_2$-inch (12.7 mm) gypsum wallboard, $^{23}/_{32}$-inch (18.2 mm) *wood structural panel* or a material that is tested in accordance with and meets the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of NFPA 275.

**R316.5 Specific requirements.** The following requirements shall apply to these uses of foam plastic unless specifically *approved* in accordance with Section R316.6 or by other sections of the code or the requirements of Sections R316.2 through R316.4 have been met.

**R316.5.1 Masonry or concrete construction.** The thermal barrier specified in Section R316.4 is not required in a masonry or concrete wall, floor or roof ~~when~~ where the foam plastic insulation is separated from the interior of the building by not less than a 1-inch (25 mm) thickness of masonry or concrete.

**R316.5.2 Roofing.** The thermal barrier specified in Section R316.4 is not required where the foam plastic in a roof assembly or under a roof covering is installed in accordance with the code and the manufacturer's instructions and is separated from the interior of the building by one of the following:

1) tongue-and-groove wood planks or wood structural panel
2) Wood structural sheathing, in accordance with Section R803, that is not less than 15/32 inch (11.9 mm) thick bonded with exterior glue, identified as Exposure 1 and with edges supported by blocking or tongue-and-groove joints or an equivalent material.

The smoke-developed index for roof applications shall not be limited.

**R316.5.3 Attics.** The thermal barrier specified in Section R316.4 is not required where all of the following apply:

1. *Attic* access is required by Section R807.1.
2. The space is entered only for purposes of repairs or maintenance.

3. The foam plastic insulation has been tested in accordance with Section R316.6 or the foam plastic insulation is protected against ignition using one of the following ignition barrier materials:
    3.1. $1^1/_2$-inch-thick (38 mm) mineral fiber insulation.
    3.2. $^1/_4$-inch-thick (6.4 mm) *wood structural panels*.
    3.3. $^3/_8$-inch (9.5 mm) particleboard.
    3.4. $^1/_4$-inch (6.4 mm) hardboard.
    3.5. $^3/_8$-inch (9.5 mm) gypsum board.
    3.6. Corrosion-resistant steel having a base metal thickness of 0.016 inch (0.406 mm).
    3.7. $1^1/_2$-inch-thick (38 mm) cellulose insulation~~; or~~.
    3.8. $^1/_4$-inch (6.4 mm) fiber-cement panel, soffit or backer board.

The ignition barrier is not required where the foam plastic insulation has been tested in accordance with Section R316.6.

**R316.5.4 Crawl spaces.** The thermal barrier specified in Section R316.4 is not required where all of the following apply:

1. *Crawl space* access is required by Section ~~R408.4~~. R408.8 and Section R409.1.2
2. Entry is made only for purposes of repairs or maintenance.
3. The foam plastic insulation has been tested in accordance with Section R316.6 or the foam plastic insulation is protected against ignition using one of the following ignition barrier materials:
    3.1. $1^1/_2$-inch-thick (38 mm) mineral fiber insulation.
    3.2. $^1/_4$-inch-thick (6.4 mm) *wood structural panels*.
    3.3. $^3/_8$-inch (9.5 mm) particleboard.
    3.4. $^1/_4$-inch (6.4 mm) hardboard.
    3.5. $^3/_8$-inch (9.5 mm) gypsum board.
    3.6. Corrosion-resistant steel having a base metal thickness of 0.016 inch (0.406 mm)~~; or~~.
    3.7. $^1/_4$-inch (6.4 mm) fiber-cement panel, soffit or backer board.

**R316.5.5 Foam-filled exterior doors.** Foam-filled exterior doors are exempt from the requirements of Sections R316.3 and R316.4.

**R316.5.6 Foam-filled garage doors.** Foam-filled garage doors in attached or detached garages are exempt from the requirements of Sections R316.3 and R316.4.

**R316.5.7 Foam backer board.** The thermal barrier specified in Section R316.4 is not required where siding backer board foam plastic insulation has a thickness of not more than 0.5 inch (12.7 mm) and a potential heat of not more than 2000 Btu per square foot (22 720 kJ/m$^2$) when tested in accordance with NFPA 259 ~~provided that;~~ and it complies with one or more of the following:

1. The foam plastic insulation is separated from the interior of the building by not less than 2 inches (51 mm) of mineral fiber insulation.
2. The foam plastic insulation is installed over existing exterior wall finish in conjunction with re-siding.
3. The foam plastic insulation has been tested in accordance with Section R316.6.

**R316.5.8 Re-siding.** The thermal barrier specified in Section R316.4 is not required where the foam plastic insulation is installed over existing exterior wall finish in conjunction with re-siding provided that the foam plastic has a thickness of not more than 0.5 inch (12.7 mm) and a potential heat of not more than 2000 Btu per square foot (22 720 kJ/m$^2$) when tested in accordance with NFPA 259.

**R316.5.9 Interior trim.** The thermal barrier specified in Section R316.4 is not required for exposed foam plastic interior *trim*, provided that all of the following are met:

1. The density is not less than 20 pounds per cubic foot (320 kg/m$^3$).

2. The thickness of the *trim* is not more than 0.5 inch (12.7 mm) and the width is not more than 8 inches (204 mm).
3. The interior *trim* shall not constitute more than 10 percent of the aggregate wall and ceiling area of any room or space.
4. The flame spread index does not exceed 75 when tested ~~per~~ in accordance with ASTM E84 or UL 723. The *smoke-developed index* is not limited.

**R316.5.10 Interior finish.** Foam plastics ~~shall be permitted~~ used as interior ~~finish where approved in accordance~~ finishes shall comply with Section R316.6~~. Foam plastics that are used as an interior finish~~ and shall meet the flame spread index and *smoke-developed index* requirements of Sections R302.9.1 and R302.9.2.

**R316.5.11 Sill plates and headers.** Foam plastic ~~shall be permitted to~~ spray applied to sill plates and headers or installed in the perimeter joist space without the thermal barrier specified in Section R316.4 ~~subject to~~ shall comply with all of the following:

1. The thickness of the foam plastic shall be not more than $3^1/_4$ inches (83 mm).
2. The density of the foam plastic shall be in the range of 0.5 to 2.0 pounds per cubic foot (8 to 32 kg/m$^3$).
3. The foam plastic shall have a flame spread index of 25 or less and an accompanying *smoke-developed index* of 450 or less when tested in accordance with ASTM E84 or UL 723.

**R316.5.12 Sheathing.** Foam plastic insulation used as sheathing shall comply with Section R316.3 and Section R316.4. Where the foam plastic sheathing is exposed to the *attic* space at a gable or kneewall, the provisions of Section R316.5.3 shall apply. Where foam plastic insulation is used as exterior wall sheathing on framed wall assemblies, it shall comply with Section R316.8.

**R316.5.13 Floors.** The thermal barrier specified in Section R316.4 is not required to be installed on the walking surface of a structural floor system that contains foam plastic insulation ~~when~~ where the foam plastic is covered by not less than a nominal $^1/_2$-inch-thick (12.7 mm) *wood structural panel* or equivalent. The thermal barrier specified in Section R316.4 is required on the underside of the structural floor system that contains foam plastic insulation ~~when~~ where the underside of the structural floor system is exposed to the interior of the building.

**R316.6 Specific approval.** Foam plastic not meeting the requirements of Sections R316.3 through R316.5 shall be specifically *approved* on the basis of one of the following *approved* tests: NFPA 286 with the acceptance criteria of Section R302.9.4, FM 4880, UL 1040 or UL 1715, or fire tests related to actual end-use configurations. Approval shall be based on the actual end-use configuration and shall be performed on the finished foam plastic assembly in the maximum thickness intended for use. Assemblies tested shall include seams, joints and other typical details used in the installation of the assembly and shall be tested in the manner intended for use.

**R316.7 Termite damage.** The use of foam plastics in areas of "~~very~~ moderate-heavy" termite infestation probability shall be in accordance with Section R318.4.

**R316.8 Wind resistance.** Foam plastic insulation complying with ASTM C578 and ASTM C1289 and used as exterior wall sheathing on framed wall assemblies shall comply with SBCA FS 100 for wind pressure resistance unless installed directly over a sheathing material that is separately capable of resisting the wind load or otherwise exempted from the scope of SBCA FS 100.

## SECTION R317
## PROTECTION OF WOOD AND
## WOOD-BASED PRODUCTS AGAINST DECAY

**R317.1 Location required.** Protection of wood and wood-based products from decay shall be provided in the following locations by the use of *naturally durable wood* or wood that is preservative-treated in accordance with AWPA U1. ~~for the species, product, preservative and end use. Preservatives shall be listed in Section 4 of AWPA U1.~~

1. <u>In crawl spaces or unexcavated areas located within the periphery of the building foundation,</u> ~~Wood~~ <u>wood</u> joists or the bottom of a wood structural floor ~~when~~ <u>where</u> closer than 18 inches (457 mm) <u>to exposed ground,</u> ~~or~~ wood girders ~~when~~ <u>where</u> closer than 12 inches (305 mm) to exposed ground.~~, and wood columns where closer than 8 inches (204 mm) to exposed ground.~~ ~~in crawl spaces or unexcavated area located within the periphery of the building foundation.~~
2. Wood framing members that rest on concrete or masonry exterior foundation walls and are less than 8 inches (203 mm) from the exposed ground.
3. Sills and sleepers on a concrete or masonry slab that is in direct contact with the ground unless separated from such slab by an impervious moisture barrier.
4. The ends of wood girders entering exterior masonry or concrete walls having clearances of less than $^1/_2$ inch (12.7 mm) on tops, sides and ends.
5. Wood siding, sheathing and wall framing on the exterior of a building having a clearance of less than 6 inches (152 mm) from the ground or less than 2 inches (51 mm) measured vertically from concrete steps, porch slabs, patio slabs and similar horizontal surfaces exposed to the weather.
6. Wood structural members supporting moisture-permeable floors or roofs that are exposed to the weather, such as concrete or masonry slabs, unless separated from such floors or roofs by an impervious moisture barrier.
7. Wood furring strips or other wood framing members attached directly to the interior of exterior masonry walls or concrete walls below *grade* except where an *approved* vapor retarder is applied between the wall and the furring strips or framing members.
8. All portions of a porch, screen porch or deck from the bottom of the header down, including posts, guardrails, pickets, steps, and floor structure. Coverings that would prevent moisture or water accumulation on the surface or at joints between members are allowed.

Exception: Columns complying with Section R317.1.3, Exception 3.

**R317.1.1 Field treatment.** <u>Deleted.</u>

**R317.1.2 Ground contact.** All wood in contact with the ground, embedded in concrete in direct contact with the ground or embedded in concrete exposed to the weather that supports permanent structures intended for human occupancy shall be *approved* pressure-preservative-treated wood suitable for ground contact use, except that untreated wood used entirely below groundwater level or continuously submerged in fresh water shall not be required to be pressure-preservative treated.

~~**R317.1.3 Geographical areas.** Deleted.~~

~~**R317.1.4**~~ **<u>R317.1.3</u> Wood columns.** Wood columns shall be *approved* wood of natural decay resistance or *approved* pressure-preservative-treated wood.

**Exceptions:**

1. Columns in basements when supported by a concrete floor with an approved impervious moisture barrier installed between the slab and earth.
2. Columns exposed to the weather when all of the following conditions are met:
   a. The column is supported by piers or metal pedestals projecting 1 inch (25.4 mm) above a concrete floor or 6 inches (152 mm) above exposed earth and the earth is covered by an approved impervious moisture barrier;
   b. There are no joints in or between structural members (from the header to the base of the column);
   c. The column is protected from exposure to surface moisture at the top by a roof, eave, or overhang; and
   d. The exterior surface of the column is full sealed (paint, sealer, etc.) against moisture intrusion.
3. Columns in enclosed crawl spaces or unexcavated areas located within the periphery of the building when supported by a concrete pier or metal pedestal at a height more than 8 inches (203 mm) from exposed earth and the earth is covered by an impervious moisture barrier.

**R317.2 Quality mark.** Lumber and plywood required to be pressure-preservative treated in accordance with Section R318.1 shall bear the quality *mark* of an *approved* inspection agency that maintains continuing supervision, testing and inspection over the quality of the product and that has been *approved* by an accreditation body that complies with the requirements of the American Lumber Standard Committee treated wood program.

**R317.2.1 Required information.** The required quality *mark* on each piece of pressure-preservative-treated lumber or plywood shall contain the following information:

1. Identification of the treating plant.
2. Type of preservative.
3. The minimum preservative retention.
4. End use for which the product was treated.
5. Standard to which the product was treated.
6. Identity of the *approved* inspection agency.
7. The designation "Dry," if applicable.

**Exception:** Quality *mark*s on lumber less than 1 inch (25 mm) nominal thickness, or lumber less than nominal 1 inch by 5 inches (25 mm by 127 mm) or 2 inches by 4 inches (51 mm by 102 mm) or lumber 36 inches (914 mm) or less in length shall be applied by stamping the faces of exterior pieces or by end labeling not less than 25 percent of the pieces of a bundled unit.

**R317.3 Fasteners and connectors in contact with preservative-treated and fire-retardant-treated wood.** Fasteners, including nuts and washers, and connectors in contact with preservative-treated wood and fire-retardant-treated wood shall be in accordance with this section. The coating weights for zinc-coated fasteners shall be in accordance with ASTM A153. Stainless steel driven fasteners shall be in accordance with the material requirements of ASTM F1667.

~~**R317.1.5 Exposed glued-laminated timbers.** The portions of glued-laminated timbers that form the structural supports of a building or other structure and are exposed to weather and not properly protected by a roof, eave or similar covering shall be pressure treated with preservative, or be manufactured from naturally durable or preservative treated wood.~~

**R317.3.1 Fasteners for preservative-treated wood.** Fasteners, including nuts and washers, for preservative-treated wood shall be of hot-dipped, zinc-coated galvanized steel, stainless steel, silicon bronze or copper. Staples shall be of stainless steel. Coating types and weights for connectors in contact with preservative-treated wood shall be in accordance with the connector manufacturer's recommendations. In the absence of manufacturer's recommendations, ~~a minimum of~~ not less than ASTM A653 type G185 zinc-coated galvanized steel, or equivalent, shall be used.

**Exceptions:**

1. $^{1}/_{2}$-inch-diameter (12.7 mm) or greater steel bolts.
2. Fasteners other than ~~nails~~ nails, staples and timber rivets shall be permitted to be of mechanically deposited zinc-coated steel with coating weights in accordance with ASTM B695, Class 55 minimum.
3. Plain carbon steel fasteners in SBX/DOT and zinc borate preservative-treated wood in an interior, dry environment shall be permitted.

**R317.3.2 Fastenings for wood foundations.** Fastenings, including nuts and washers, for wood foundations shall be as required in ~~AF&PA~~ AWC PWF.

**R317.3.3 Fasteners for fire-retardant-treated wood used in exterior applications or wet or damp locations.** Fasteners, including nuts and washers, for fire-retardant-treated wood used in exterior applications or wet or damp locations shall be of hot-dipped, zinc-coated galvanized steel, stainless steel, silicon bronze or copper. Fasteners other than nails, staples and timber rivets shall be permitted to be of mechanically deposited zinc-coated steel with coating weights in accordance with ASTM B695, Class 55 minimum.

**R317.3.4 Fasteners for fire-retardant-treated wood used in interior applications.** Fasteners, including nuts and washers, for fire-retardant-treated wood used in interior locations shall be in accordance with the manufacturer's recommendations. In the absence of the manufacturer's recommendations, Section R317.3.3 shall apply.

**R317.4 Plastic composites.** *Plastic composite* exterior deck boards, stair treads, *guards* and *handrails* containing wood, cellulosic or other biodegradable materials shall comply with the requirements of ASTM D7032.

## SECTION R318
## PROTECTION AGAINST
## SUBTERRANEAN TERMITES

**R318.1 Subterranean termite control methods.** In areas subject to damage from termites as indicated by Table R301.2, ~~method of~~ protection shall be by one, or a combination, of the following methods:

1. Chemical termiticide treatment in accordance with Section R318.2.
2. Termite-baiting system installed and maintained in accordance with the *label*~~.~~, and according to the rules adopted by the North Carolina Structural Pest Control Committee ~~(02 NOAC 34).~~(02 NCAC 34).
3. Pressure-preservative-treated wood in accordance with ~~the provisions of Section R317.1.~~ AWPA U1.
4. *Naturally durable termite-resistant wood*.
5. Deleted. ~~Physical barriers in accordance with Section R318.3 and used in locations as specified in Section R317.1.~~
6. Deleted. ~~Cold-formed steel framing in accordance with Sections R505.2.1 and R603.2.1.~~

**R318.1.1 Quality mark.** Lumber and plywood required to be pressure-preservative treated in accordance with Section R318.1 shall bear the quality *mark* of an *approved* inspection agency that maintains continuing supervision, testing and inspection over the quality of the product and that has been *approved* by an accreditation body that complies with the requirements of the American Lumber Standard Committee treated wood program.

**R318.1.2 Field treatment.** Deleted.

**R318.2 Chemical ~~soil~~ termiticide treatment.** Chemical termiticide treatment shall include soil treatment or field-applied wood treatment. The concentration, rate of application and method of treatment of the chemical termiticide shall be in strict accordance with the termiticide *label*. and applied according to the rules adopted by the North Carolina Structural Pest Control Committee (02 NOAC 34).

**R318.3 Barriers.** Deleted. ~~*Approved* physical barriers, such as metal or plastic sheeting or collars specifically designed for termite prevention, shall be installed in a manner to prevent termites from entering the structure. Shields placed on top of an exterior foundation wall are permitted to be used only if in combination with another method of protection.~~

**R318.4 Foam plastic protection.** This section shall apply to both treated and untreated foam plastic.

**R318.4.1 Foundation walls.** All foam plastic shall be a minimum of 8 inches (203 mm) above grade. See ~~Appendix O~~ Appendix NC-D.

Exception: Foam plastic less than 8 inches (203 mm) above or in contact with grade shall be installed in accordance with Section 318.4.5 and ~~Appendix O~~ Appendix NC-D.

**R318.4.2 Termite control.** When foam plastic is in contact with the ground, subterranean termite control shall be in accordance with Section 318.1.

**R318.4.3 Slab on grade (nonstructural).** Foam plastic shall be installed along the vertical edge and underneath the slab as specified in Section R318.4.5.

**R318.4.4 Slab on grade (structural).** All slabs that distribute the wall loads to the foundation shall be insulated as specified in this section. Foam plastic shall be installed along the vertical edge and underneath grade as specified in ~~Appendix O Figure O-3~~. Appendix NC-D, Figure NCD-3.

**R318.4.5 Foam plastic in contact with ground.** Foam plastic in contact with the ground shall comply with Sections R318.4.5.1 through R318.4.5.4.

**R318.4.5.1 Inspection and treatment gaps.** Foam plastic in contact with the ground shall not be continuous to the bottom of the weather-resistant siding. A clear and unobstructed 2-inch (51 mm) minimum inspection gap shall be maintained from the bottom of the weather-resistant siding to the top of any foam plastic. A minimum 4-inch (102 mm) treatment gap shall be provided beginning not more than 6 inches (152 mm) below grade. The top and bottom edges of the foam plastic installed between the inspection gap and the treatment gap shall be cut at a 45-degree (0.79 rad) angle. See ~~Appendix O~~ Appendix NC-D.

Exception: For additional requirements for insulting concrete form (ICF) foundations see Section R404.1.3.3.6.1.

**R318.4.5.2 Protection of exposed foam plastic.** Exposed foam plastic shall be protected from physical damage. The required inspection gap foam plastic and treatment gap shall be on the exterior with a cementitious coating that extends at least 2 inches (51 mm) below the foam plastic onto the surface of the foundation wall. See ~~Appendix O~~ Appendix NC-D.

**R318.4.5.3 Waterproofing foam plastic between inspection gap and treatment gap.** Waterproofing shall be installed over the required cementitious coating from 6 inches (152 mm) above grade to the treatment gap in accordance with manufacturer's installation instructions.

**R318.4.5.4 Dampproofing of below grade walls.** Any foam plastic applied below the treatment gap shall be installed after required foundation wall dampproofing is in place. See Section R406 and ~~Appendix O~~ Appendix NC-D.

## SECTION R319
## SITE ADDRESS

**R319.1 Address identification.** Buildings shall be provided with *approved* address identification. The address identification shall be legible and placed in a position that is visible from the street or road fronting the property. Address identification characters shall contrast with their background. Address numbers shall be Arabic numbers or alphabetical letters. Numbers shall not be spelled out. Each character shall be not less than 4 inches (102 mm) in height with a stroke width of not less than 0.5 inch (12.7 mm). Where required by the fire code official, address identification shall be provided in additional *approved* locations to facilitate emergency response. Where access is by means of a private road and the building address cannot be viewed from the *public way*, a monument, pole or other sign or means shall be used to identify the structure. Address identification shall be maintained.

## SECTION R320
## ACCESSIBILITY

**R320.1 Scope.** Where there are four or more *dwelling units* or *sleeping units* in a single structure, the provisions of Chapter 11 of the *International Building Code* for Group R-3 shall apply.

**Exception:** Owner-occupied *lodging houses* with eight or fewer guestrooms are not required to be accessible.

~~**R320.1.1 Guestrooms.** Deleted.~~

**R320.2 Live/work units.** In *live/work units,* the nonresidential portion shall be accessible in accordance with Sections 508.5.9 and 508.5.11 of the *International Building Code*. In a structure where there are four or more *live/work units,* the dwelling portion of the *live/work unit* shall comply with Section 1108.6.2.1 of the *International Building Code*.

## SECTION R321
## ELEVATORS AND PLATFORM LIFTS

**R321.1 Elevators.** Where provided, passenger elevators, limited-use and limited-application elevators or private residence elevators shall comply with ASME A17.1/CSA B44.

**R321.1.1 Clearance Between Hoistways Doors and Car Doors or Gates** The clearance between the hoistway doors or gates and the hoistway edge of the landing sill shall not exceed 3/4 inch (19 mm). The distance between the hoistway face of the landing door or gate and the car door or gate shall not exceed 4 inches (101.6 mm) as follows:

1. Horizontal sliding car doors and gates shall be designed and installed to withstand a force of 75 pounds applied horizontally on an area 4 inches by 4 inches at right angles to and at any location on the car door without permanent deformation. The deflection may not exceed 3/4 inch and may not displace the door from its guides or tracks. The force must be applied while the door is in the fully closed position.

2. Folding car doors shall be designed and installed to withstand a force of 75 pounds applied horizontally using a 4-inch-diameter sphere at any location within the folds on the car door without permanent deformation. The deflection may not exceed 3/4 inch and may not displace the door from its guides. The force must be applied while the door is in the fully closed position.

**Exception:** A permanent installation of a nonremovable, hoistway door space guard, a full height door baffle or door baffle that is at least 31.75" in height is allowed. The door space guard, full height door baffle or 31.75" door baffle must be designed and installed to withstand a force of 75 pounds applied horizontally using a 4-inch-diameter sphere at any location of the space guard without permanent deformation while allowing no more than 3/4"sill.

**R321.2 Platform lifts.** Where provided, platform lifts shall comply with ASME A18.1.

**R321.3 Accessibility.** Deleted.

**R321.4 Certification** The installer shall certify that the following conditions have been met.

1. The elevator or platform lift has been installed in accordance with the manufacturer's installation instructions.
2. The elevator meets the requirements of ASME A17.1/CSA B44.
3. The elevator or platform lift meets the requirements of the North Carolina Electrical Code. Before a Certificate of Occupancy is issued, the permit holder shall provide the code enforcement official a letter of certification from the installer, evidencing compliance with the above conditions. Any maintenance requirements required by the manufacturer must be stated and affixed to the component.

## SECTION R322
## FLOOD-RESISTANT CONSTRUCTION

**R322.1 General.** Buildings and structures constructed in whole or in part in flood hazard areas, including A or V Zones and Coastal A Zones, as established in Table R301.2, and substantial improvement and ~~restoration~~ *repair* of substantial damage of buildings and structures in flood hazard areas, shall be designed and constructed in accordance with the provisions contained in this section. Buildings and structures that are located in more than one flood hazard area shall comply with the provisions associated with the most restrictive flood hazard area. Buildings and structures located in whole or in part in identified floodways shall be designed and constructed in accordance with ASCE 24. See additional provisions in Chapter 46.

**R322.1.1 Alternative provisions.** As an alternative to the requirements in Section R322, ASCE 24 is permitted subject to the limitations of this code and the limitations therein.

**R322.1.2 Structural systems.** Structural systems of buildings and structures shall be designed, connected and anchored to resist flotation, collapse or permanent lateral movement due to structural loads and stresses from flooding equal to the design flood elevation.

**R322.1.3 Flood-resistant construction.** Buildings and structures erected in areas prone to flooding shall be constructed by methods and practices that minimize flood damage.

**R322.1.4 Establishing the design flood elevation.** The design flood elevation shall be used to define flood hazard areas. At a minimum, the design flood elevation shall be the higher of the following:

1. The base flood elevation at the depth of peak elevation of flooding, including wave height, that has a 1-percent (100-year flood) or greater chance of being equaled or exceeded in any given year. ~~; or~~
2. The elevation of the design flood associated with the area designated on a flood hazard map adopted by the community, or otherwise legally designated.

**R322.1.4.1 Determination of design flood elevations.** If design flood elevations are not specified, the *building official* is authorized to require the applicant to comply with either of the following:

1. Obtain and reasonably use data available from a federal, state or other source~~; or~~.
2. Determine the design flood elevation in accordance with accepted hydrologic and hydraulic engineering practices used to define special flood hazard areas. Determinations shall be undertaken by a *registered design professional* who shall document that the technical methods used reflect currently accepted engineering practice. Studies, analyses and computations shall be submitted in sufficient detail to allow thorough review and *approval*.

**R322.1.4.2 Determination of impacts.** In riverine flood hazard areas where design flood elevations are specified but floodways have not been designated, the applicant shall demonstrate that the effect of the proposed buildings and structures on design flood elevations, including fill, when combined with other existing and anticipated flood hazard area encroachments, will not increase the design flood elevation more than 1 foot (305 mm) at any point within the *jurisdiction*.

**R322.1.5 Lowest floor.** The lowest floor shall be the lowest floor of the lowest enclosed area, including *basement*, and excluding any unfinished flood-resistant enclosure that is useable solely for vehicle parking, building access or limited storage provided that such enclosure is not built so as to render the building or structure in violation of this section.

**R322.1.6 Protection of mechanical, plumbing and electrical systems.** Electrical systems, *equipment* and components; heating, ventilating, air-conditioning; plumbing *appliances* and plumbing fixtures; *duct systems*; and other service *equipment* shall be located at or above the elevation required in Section R322.2 or R322.3. If replaced as part of a substantial improvement, electrical systems, *equipment* and components; heating, ventilating, air-conditioning and plumbing *appliances* and plumbing fixtures; *duct systems*; and other service *equipment* shall meet the requirements of this section. Systems, fixtures, and *equipment* and components shall not be mounted on or penetrate through walls intended to break away under flood loads.

**Exception:** Locating electrical systems, *equipment* and components; heating, ventilating, air-conditioning; plumbing *appliances* and plumbing fixtures; *duct systems*; and other service *equipment* is permitted below the elevation required in Section R322.2 or R322.3 provided that they are designed and installed to prevent water from entering or accumulating within the components and to resist hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to the ~~design flood~~ required elevation in accordance with ASCE 24. Electrical wiring systems are permitted to be located below the required elevation provided that they conform to the provisions of the electrical part of this code for wet locations.

**R322.1.7 Protection of water supply and sanitary sewage systems.** New and replacement water supply systems shall be designed to minimize or eliminate infiltration of flood waters into the systems in accordance with the plumbing provisions of this code. New and replacement sanitary sewage systems shall be designed to minimize or eliminate infiltration of floodwaters into systems and discharges from systems into floodwaters in accordance with the plumbing provisions of this code and Chapter 3 of the *International Private Sewage Disposal Code.*

**R322.1.8 Flood-resistant materials.** Building materials and installation methods used for flooring and interior and exterior walls and wall coverings below the elevation required in Section R322.2 or R322.3 shall be flood damage-resistant materials that conform to the provisions of FEMA TB-2.

**R322.1.9 Manufactured homes.** Deleted. ~~The bottom of the frame of new and replacement *manufactured homes* on foundations that conform to the requirements of Section R322.2 or R322.3, as applicable, shall be elevated to~~

~~or above the elevations specified in Section R322.2 (flood hazard areas including A Zones) or R322.3 in coastal high-hazard areas (V Zones and Coastal A Zones). The anchor and tie-down requirements of the applicable state or federal requirements shall apply. The foundation and anchorage of *manufactured homes* to be located in identified floodways shall be designed and constructed in accordance with ASCE 24.~~

**R322.1.10 As-built elevation documentation.** A *registered design professional* shall prepare and seal documentation of the elevations specified in Section R322.2 or R322.3.

**R322.2 Flood hazard areas (including A Zones).** Areas that have been determined to be prone to flooding and that are not subject to high-velocity wave action shall be designated as flood hazard areas. Flood hazard areas that have been delineated as subject to wave heights between $1^1/_2$ feet (457 mm) and 3 feet (914 mm) or otherwise designated by the *jurisdiction* shall be designated as Coastal A Zones and are subject to the requirements of Section R322.3. Buildings and structures constructed in whole or in part in flood hazard areas shall be designed and constructed in accordance with Sections R322.2.1 through R322.2.4.

**R322.2.1 Elevation requirements.**

1. Buildings and structures in flood hazard areas, <u>not</u> including flood hazard areas designated as Coastal A Zones, shall have the lowest floors elevated to or above the base flood elevation plus 1 foot (305 mm), or the design flood elevation, whichever is higher.
2. In areas of shallow flooding (AO Zones), buildings and structures shall have the lowest floor (including *basement*) elevated to a height above the highest adjacent *grade* of not less than the depth number specified in feet (mm) on the FIRM plus 1 foot (305 mm), or not less than 3 feet (915 mm) if a depth number is not specified.
3. *Basement* floors that are below *grade* on all sides shall be elevated to or above base flood elevation plus 1 foot (305 mm), or the design flood elevation, whichever is higher.
4. <u>Garage and carport floors shall comply with one of the following:</u>
   - <u>4.1. They shall be elevated to or above the elevations required in Item 1 or Item 2, as applicable.</u>
   - <u>4.2. They shall be at or above *grade* on not less than one side. Where a garage or carport is enclosed by walls, the garage or carport shall be used solely for parking, building access or storage.</u>

**Exception:** Enclosed areas below the ~~design flood~~ elevation <u>required in this section</u>, including *basements* with floors that are not below *grade* on all sides, shall meet the requirements of Section R322.2.2.

**R322.2.2 Enclosed area below ~~design flood~~ <u>required</u> elevation.** Enclosed areas, including *crawl spaces*, that are below the ~~design flood~~ elevation <u>required in Section R322.2.1</u> shall:

1. Be used solely for parking of vehicles, building access or storage.
2. Be provided with flood openings that meet the following criteria and are installed in accordance with Section R322.2.2.1:
   - 2.1. The total net area of <u>nonengineered</u> openings shall be not less than 1 square inch (645 $mm^2$) for each square foot (0.093 $m^2$) of enclosed area where the enclosed area is measured on the exterior of the enclosure walls, or the openings shall be designed as engineered openings and the *construction documents* shall include a statement by a *registered design professional* that the design of the openings will provide for equalization of hydrostatic flood forces on exterior walls by allowing for the automatic entry and exit of floodwaters as specified in Section ~~2.6.2.2~~ <u>2.7.2.2</u> of ASCE 24.
   - 2.2. Openings shall be not less than 3 inches (76 mm) in any direction in the plane of the wall.
   - 2.3. The presence of louvers, blades, screens and faceplates or other covers and devices shall allow the automatic flow of floodwater into and out of the enclosed areas and shall be accounted for in the determination of the net open area.

**R322.2.2.1 Installation of openings.** The walls of enclosed areas shall have openings installed such that:

1. There shall be not less than two openings on different sides of each enclosed area; if a building has more than one enclosed area, each area shall have openings.
2. The bottom of each opening shall be not more than 1 foot (305 mm) above the higher of the final interior grade or floor and the finished exterior grade immediately under each opening.
3. Openings shall be permitted to be installed in doors and windows; doors and windows without installed openings do not meet the requirements of this section.

**R322.2.3 Foundation design and construction.** Foundation walls for buildings and structures erected in flood hazard areas shall meet the requirements of Chapter 4.

**Exception:** Unless designed in accordance with Section R404:

1. The unsupported height of 6-inch (152 mm) plain masonry walls shall be not more than 3 feet (914 mm).
2. The unsupported height of 8-inch (203 mm) plain masonry walls shall be not more than 4 feet (1219 mm).
3. The unsupported height of 8-inch (203 mm) reinforced masonry walls shall be not more than 8 feet (2438 mm).

For the purpose of this exception, unsupported height is the distance from the finished *grade* of the under-floor space to the top of the wall.

**R322.2.4 Tanks.** Deleted.

**R322.3 Coastal high-hazard areas (including V Zones and Coastal A Zones, where designated).** ~~Areas that have been determined to be subject to wave heights in excess of 3 feet (914 mm) or subject to high-velocity wave action or wave-induced erosion shall be designated as coastal high-hazard areas. Flood hazard areas that have been designated as subject to wave heights between 1$^1/_2$ feet (457 mm) and 3 feet (914 mm) or otherwise designated by the *jurisdiction* shall be designated as Coastal A Zones. Buildings and structures constructed in whole or in part in coastal high-hazard areas and Coastal A Zones, where designated, shall be designed and constructed in accordance with Sections R322.3.1 through R322.3.10.~~ <u>See Chapter 46.</u>

**R322.3.1 Location and site preparation.** <u>Deleted.</u>

1. ~~New buildings and buildings that are determined to be substantially improved pursuant to Section R105.3.1.1 shall be located landward of the reach of mean high tide.~~
2. ~~For any alteration of sand dunes and mangrove stands, the *building official* shall require submission of an engineering analysis that demonstrates that the proposed alteration will not increase the potential for flood damage.~~

**R322.3.2 Elevation requirements.** <u>Deleted.</u>

1. ~~Buildings and structures erected within coastal high-hazard areas and Coastal A Zones, shall be elevated so that the bottom of the lowest horizontal structural members supporting the lowest floor, with the exception of piling, pile caps, columns, grade beams and bracing, is elevated to or above the base flood elevation plus 1 foot (305 mm) or the design flood elevation, whichever is higher.~~
2. ~~*Basement* floors that are below *grade* on all sides are prohibited.~~
3. ~~Garages used solely for parking, building access or storage, and carports shall comply with Item 1 or shall be at or above *grade* on not less than one side and, if enclosed with walls, such walls shall comply with Item 6.~~
4. ~~The use of fill for structural support is prohibited.~~
5. ~~Minor grading, and the placement of minor quantities of fill, shall be permitted for landscaping and for drainage purposes under and around buildings and for support of parking slabs, pool decks, patios and walkways.~~
6. ~~Walls and partitions enclosing areas below the elevation required in this section shall meet the requirements of Sections R322.3.5 and R322.3.6.~~

**R322.3.3 Foundations.** <u>Deleted.</u> ~~Buildings and structures erected in coastal high-hazard areas and Coastal A Zones shall be supported on pilings or columns and shall be adequately anchored to such pilings or columns and shall comply with the following:~~

~~**1.** The space below the elevated building shall be either free of obstruction or, if enclosed with walls, the walls shall meet the requirements of Section R322.3.5.~~

~~2. Pilings shall have adequate soil penetrations to resist the combined wave and wind loads (lateral and uplift) and pile embedment shall include consideration of decreased resistance capacity caused by scour of soil strata surrounding the piling.~~

~~3. Columns and their supporting foundations shall be designed to resist combined wave and wind loads, lateral and uplift, and shall include consideration of decreased resistance capacity caused by scour of soil strata surrounding the columns. Spread footing, mat, raft or other foundations that support columns shall not be permitted where soil investigations that are required in accordance with Section R401.4 indicate that soil material under the spread footing, mat, raft or other foundation is subject to scour or erosion from wave-velocity flow conditions. If permitted, spread footing, mat, raft or other foundations that support columns shall be designed in accordance with ASCE 24.~~

~~4. Flood and wave loads shall be those associated with the design flood. Wind loads shall be those required by this code.~~

~~5. Foundation designs and *construction documents* shall be prepared and sealed in accordance with Section R322.3.9.~~

~~**Exception:** In Coastal A Zones, stem wall foundations supporting a floor system above and backfilled with soil or gravel to the underside of the floor system shall be permitted provided that the foundations are designed to account for wave action, debris impact, erosion and local scour. Where soils are susceptible to erosion and local scour, stem wall foundations shall have deep footings to account for the loss of soil.~~

**R322.3.4 Concrete slabs.** Deleted. ~~Concrete slabs used for parking, floors of enclosures, landings, decks, walkways, patios and similar uses that are located beneath structures, or slabs that are located such that if undermined or displaced during base flood conditions could cause structural damage to the building foundation, shall be designed and constructed in accordance with one of the following:~~

~~1. To be structurally independent of the foundation system of the structure, to not transfer flood loads to the main structure, and to be frangible and break away under flood conditions prior to base flood conditions. Slabs shall be a maximum of 4 inches (102 mm) thick, shall not have turned-down edges, shall not contain reinforcing, shall have isolation joints at pilings and columns, and shall have control or construction joints in both directions spaced not more than 4 feet (1219 mm) apart.~~

~~2. To be self-supporting, structural slabs capable of remaining intact and functional under base flood conditions, including erosion and local scour, and the main structure shall be capable of resisting any added flood loads and effects of local scour caused by the presence of the slabs.~~

**R322.3.5 Walls below required elevation.** Deleted. ~~Walls and partitions are permitted below the elevation required in Section R322.3.2, provided that such walls and partitions are not part of the structural support of the building or structure and:~~

~~1. Electrical, mechanical and plumbing system components are not to be mounted on or penetrate through walls that are designed to break away under flood loads; and~~

~~2. Are constructed with insect screening or open lattice; or~~

~~3. Are designed to break away or collapse without causing collapse, displacement or other structural damage to the elevated portion of the building or supporting foundation system. Such walls, framing and connections shall have a resistance of not less than 10 (479 Pa) and not more than 20 pounds per square foot (958 Pa) as determined using allowable stress design; or~~

~~4. Where wind loading values of this code exceed 20 pounds per square foot (958 Pa), as determined using allowable stress design, the *construction documents* shall include documentation prepared and sealed by a *registered design professional* that:~~

~~4.1. The walls and partitions below the required elevation have been designed to collapse from a water load less than that which would occur during the base flood.~~

~~4.2. The elevated portion of the building and supporting foundation system have been designed to withstand the effects of wind and flood loads acting simultaneously on structural and nonstructural building components. Water-loading values used shall be those associated with the design flood. Wind-loading values shall be those required by this code.~~

~~5. Walls intended to break away under flood loads as specified in Item 3 or 4 have flood openings that meet the criteria in Section R322.2.2, Item 2.~~

**R322.3.6 Enclosed areas below required elevation.** Deleted. ~~Enclosed areas below the elevation required in Section R322.3.2 shall be used solely for parking of vehicles, building access or storage.~~

**R322.3.6.1 Protection of building envelope.** Deleted. ~~An exterior door that meets the requirements of Section R609 shall be installed at the top of stairs that provide access to the building and that are enclosed with walls designed to break away in accordance with Section R322.3.5.~~

**R322.3.7 Stairways and ramps.** Deleted. ~~*Stairways* and *ramps* that are located below the lowest floor elevations specified in Section R322.3.2 shall comply with one or more of the following:~~

~~1. Be designed and constructed with open or partially open *risers* and *guards*.~~

~~2. *Stairways* and *ramps* not part of the required means of egress shall be designed and constructed to break away during design flood conditions without causing damage to the building or structure, including foundation.~~

~~3. Be retractable, or able to be raised to or above the lowest floor elevation, provided that the ability to be retracted or raised prior to the onset of flooding is not contrary to the means of egress requirements of the code.~~

~~4. Be designed and constructed to resist flood loads and minimize transfer of flood loads to the building or structure, including foundation.~~

~~Areas below *stairways* and *ramps* shall not be enclosed with walls below the required in Section R322.3.2 elevation unless such walls are constructed in accordance with Section R322.3.5.~~

**R322.3.8 Decks and porches.** Deleted. ~~Attached decks and porches shall meet the elevation requirements of Section R322.3.2 and shall either meet the foundation requirements of this section or shall be cantilevered from or knee braced to the building or structure. Self-supporting decks and porches that are below the elevation required in Section R322.3.2 shall not be enclosed by solid, rigid walls, including walls designed to break away. Self-supporting decks and porches shall be designed and constructed to remain in place during base flood conditions or shall be frangible and break away under base flood conditions.~~

**R322.3.9 Construction documents.** Deleted. ~~The *construction documents* shall include documentation that is prepared and sealed by a *registered design professional* that the design and methods of construction to be used meet the applicable criteria of this section.~~

**R322.3.10 Tanks.** Deleted. ~~Underground tanks shall be anchored to prevent flotation, collapse and lateral movement under conditions of the base flood. Above-ground tanks shall be installed at or above the elevation required in Section R322.3.2. Where elevated on platforms, the platforms shall be cantilevered from or knee braced to the building or shall be supported on foundations that conform to the requirements of Section R322.3.~~

## SECTION R323
## STORM SHELTERS

**R323.1 General.** This section applies to *storm shelters* where constructed as separate detached buildings or where constructed as safe rooms within buildings for the purpose of providing refuge from storms that produce high winds, such as tornados and hurricanes. In addition to other applicable requirements in this code, storm shelters shall be constructed in accordance with ICC 500.

**R323.1.1 Sealed documentation.** The *construction documents* for all structural components and *impact protective systems* of the *storm shelter* shall be prepared and sealed by a *registered design professional* indicating that the design meets the criteria of ICC 500.

**Exception:** *Storm shelters*, structural components and impact-protective systems that are *listed* and *labeled* to indicate compliance with ICC 500.

## SECTION R324
## SOLAR ENERGY SYSTEMS

**R324.1 General.** Solar energy systems shall comply with the provisions of this section.

**R324.2 Solar thermal systems.** Solar thermal systems shall be designed and installed in accordance with Chapter 23.

**R324.3 Photovoltaic systems.** Photovoltaic (PV) systems shall be designed and installed in accordance with Sections R324.3.1 through ~~R324.6.1~~ R324.7.1 and the manufacturer's installation instructions. The electrical portion of solar PV systems shall be designed and installed in accordance with NFPA 70. ~~Inverters shall be listed and labeled in accordance with UL 1741. Systems connected to the utility grid shall use inverters listed for utility interaction.~~

**R324.3.1 Equipment listings.** *Photovoltaic panels* and modules shall be *listed* and *labeled* in accordance with UL 1703 or with both UL 61730-1 and UL 61730-2. Inverters shall be *listed* and *labeled* in accordance with UL 1741. Systems connected to the utility grid shall use inverters *listed* for utility interaction. Mounting systems *listed* and *labeled* in accordance with UL 2703 shall be installed in accordance with the manufacturer's installation instructions and their listings.

**R324.4 Rooftop-mounted photovoltaic systems.** ~~Deleted.~~ Rooftop-mounted *photovoltaic panel systems* installed on or above the roof covering shall be designed and installed in accordance with this section.

**R324.4.1 Structural requirements.** Rooftop-mounted *photovoltaic panel systems* shall be designed to structurally support the system and withstand applicable gravity loads in accordance with Chapter 3. The roof on which these systems are installed shall be designed and constructed to support the loads imposed by such systems in accordance with Chapter 8.

**R324.4.1.1 Roof load.** Portions of roof structures not covered with *photovoltaic panel systems* shall be designed for dead loads and roof loads in accordance with Sections R301.4 and R301.6. Portions of roof structures covered with *photovoltaic panel systems* shall be designed for the following load cases:

1. Dead load (including *photovoltaic panel* weight) plus ~~snow~~ roof load in accordance with Table R301.2.
2. Dead load (excluding *photovoltaic panel* weight) plus roof *live load* ~~or snow load~~, whichever is greater, in accordance with Section R301.6.

**R324.4.1.2 Wind load.** Rooftop-mounted *photo-voltaic panel* or *module* systems and their supports shall be designed and installed to resist the component and cladding loads specified in Table R301.2.1(1), adjusted for height and exposure in accordance with Table R301.2.1(2).

**R324.4.2 Fire classification.** Rooftop-mounted *photovoltaic panel systems* shall have the same fire classification as the *roof assembly* required in Section R902.

**R324.4.3 Roof penetrations.** Roof penetrations shall be flashed and sealed in accordance with Chapter 9.

**R324.5 Building-integrated photovoltaic systems.** ~~Deleted.~~ Building-integrated photovoltaic (BIPV) systems that serve as roof coverings shall be designed and installed in accordance with Section R905.

**R324.5.1 Photovoltaic shingles.** Photovoltaic shingles shall comply with Section R905.16.

**R324.5.2 Fire classification.** *Building-integrated photovoltaic systems* shall have a fire classification in accordance with Section R902.3.

**R324.5.3 BIPV roof panels.** BIPV roof panels shall comply with Section R905.17.

**R324.6 Roof access and pathways.** Roof access, pathways and setback requirements shall be provided in accordance with Sections R324.6.1 through R324.6.2.1. Access and minimum spacing shall be required to provide emergency access to the roof, to provide pathways to specific areas of the roof, provide for smoke ventilation opportunity areas, and to provide emergency egress from the roof.

**Exceptions:**

1. Detached, nonhabitable structures, including but not limited to detached garages, parking shade structures, carports, solar trellises and similar structures, shall not be required to provide roof access.
2. Roof access, pathways and setbacks need not be provided where the code official has determined that rooftop operations will not be employed.
3. These requirements shall not apply to roofs with slopes of 2 units vertical in 12 units horizontal (17-percent slope) or less.

4. BIPV systems *listed* in accordance with Section 690.12(B)(2) of NFPA 70, where the removal or cutting away of portions of the BIPV system during fire-fighting operations has been determined to not expose a fire fighter to electrical shock hazards.

**R324.6.1 Pathways.** Not fewer than two pathways, on separate roof planes from lowest roof edge to ridge and not less than 36 inches (914 mm) wide, shall be provided on all buildings. Not fewer than one pathway shall be provided on the street or driveway side of the roof. For each roof plane with a photovoltaic array, a pathway not less than 36 inches wide (914 mm) shall be provided from the lowest roof edge to ridge on the same roof plane as the photovoltaic array, on an adjacent roof plane, or straddling the same and adjacent roof planes. Pathways shall be over areas capable of supporting fire fighters accessing the roof. Pathways shall be located in areas with minimal obstructions such as vent pipes, conduit, or mechanical equipment.

**R324.6.2 Setback at ridge.** For photovoltaic arrays occupying not more than 33 percent of the plan view total roof area, not less than an 18-inch (457 mm) clear setback is required on both sides of a horizontal ridge. For photovoltaic arrays occupying more than 33 percent of the plan view total roof area, not less than a 36-inch (914 mm) clear setback is required on both sides of a horizontal ridge.

**R324.6.2.1 Alternative setback at ridge.** Where an automatic sprinkler system is installed within the dwelling in accordance with NFPA 13D or Section P2904, setbacks at ridges shall comply with one of the following:

1. For photovoltaic arrays occupying not more than 66 percent of the plan view total roof area, not less than an 18-inch (457 mm) clear setback is required on both sides of a horizontal ridge.
2. For photovoltaic arrays occupying more than 66 percent of the plan view total roof area, not less than a 36-inch (914 mm) clear setback is required on both sides of a horizontal ridge.

**R324.6.3 Emergency escape and rescue openings.** Panels and modules installed on dwellings shall not be placed on the portion of a roof that is below an *emergency escape and rescue opening*. A pathway not less than 36 inches (914 mm) wide shall be provided to the emergency escape and rescue opening.

**Exception:** BIPV systems *listed* in accordance with Section 690.12(B)(2) of NFPA 70, where the removal or cutting away of portions of the BIPV system during fire-fighting operations has been determined to not expose a fire fighter to electrical shock hazards.

~~**R324.6**~~ **R324.7 Ground-mounted photovoltaic systems.** Ground-mounted photovoltaic systems shall be designed and installed in accordance with Section R301.

~~**R324.6.1**~~ **R324.7.1 Fire separation distances.** Ground-mounted photovoltaic systems shall be subject to the *fire separation distance* requirements determined by the local *jurisdiction*.

## SECTION R325
## MEZZANINES

**R325.1 General.** *Mezzanines* shall comply with Sections R325 through R325.5.

**R325.2 Mezzanines.** The clear height above and below *mezzanine* floor construction shall be not less than 7 feet (2134 mm).

**R325.3 Area limitation.** The aggregate area of a *mezzanine* or *mezzanines* shall be not greater than one-third of the floor area of the room or space in which they are located. The enclosed portion of a room shall not be included in a determination of the floor area of the room in which the *mezzanine* is located.

**Exception:** The aggregate area of a *mezzanine* located within a *dwelling unit* equipped with an automatic sprinkler system in accordance with Section P2904 shall not be greater than one-half of the floor area of the room, provided that the *mezzanine* meets all of the following requirements:

1. Except for enclosed closets and bathrooms, the *mezzanine* is open to the room in which such *mezzanine* is located.

2. The opening to the room is unobstructed except for walls not more than 42 inches (1067 mm) in height, columns and posts.
3. The exceptions to Section R325.5 are not applied.

**R325.4 Means of egress.** The means of egress for *mezzanines* shall comply with the applicable provisions of Section R311.

**R325.5 Openness.** *Mezzanines* shall be open and unobstructed to the room in which they are located except for walls not more than 36 inches (914 mm) in height, columns and posts.

**Exceptions:**

1. *Mezzanines* or portions thereof are not required to be open to the room in which they are located, provided that the aggregate floor area of the enclosed space is not greater than 10 percent of the *mezzanine* area.

2. In buildings that are not more than two stories above *grade plane* and equipped throughout with an automatic sprinkler system in accordance with Section R313, a *mezzanine* shall not be required to be open to the room in which the *mezzanine* is located.

## SECTION R326
## HABITABLE ATTICS

**R326.1 General.** Habitable attics shall comply with Sections R326.2 and R326.3.

**R326.2 Minimum dimensions.** A habitable attic shall have a floor area in accordance with Section R304 and a ceiling height in accordance with Section R305.

**R326.3 Story above grade plane.** A habitable attic shall be considered a story above *grade plane*.

**Exceptions:** A habitable attic shall not be considered to be a story above *grade plane* provided that the habitable attic meets all the following:

1. The aggregate area of the habitable attic is either of the following:
   1.1. Not greater than ~~one-third~~ 50 percent of the floor area of the story below.

2. The occupiable space is enclosed by the roof assembly above, knee walls, if applicable, on the sides and the floor-ceiling assembly below.
3. The floor of the habitable attic does not extend beyond the exterior walls of the story below.

**R326.4 Means of egress.** The means of egress for habitable attics shall comply with the applicable provisions of Section R311.

## SECTION R327
## SWIMMING POOLS, SPAS AND HOT TUBS

**R327.1 General.** The design and construction of pools and spas shall comply with ~~Appendix V~~ Appendix NC-A.

## SECTION R328
## ENERGY STORAGE SYSTEMS

**R328.1 General.** *Energy storage systems (ESS)* shall comply with the provisions of this section.

**Exceptions:**

1. *ESS listed* and *labeled* in accordance with UL 9540 and marked "For use in residential dwelling units" where installed in accordance with the manufacturer's instructions and NFPA 70.
2. ESS less than 1 kWh (3.6 megajoules).

**R328.2 Equipment listings.** *Energy storage systems (ESS)* shall be *listed* and *labeled* in accordance with UL 9540.

**Exception:** Where *approved*, repurposed unlisted battery systems from electric vehicles are allowed to be installed outdoors or in detached sheds located not less than 5 feet (1524 mm) from exterior walls, property lines and public ways.

**R328.3 Installation.** *ESS* shall be installed in accordance with the manufacturer's instructions and their *listing*.

**R328.3.1 Spacing.** Individual units shall be separated from each other by not less than 3 feet (914 mm) except where smaller separation distances are documented to be adequate based on large-scale fire testing complying with UL 9540A.

**R328.4 Locations.** *ESS* shall be installed only in the following locations:

1. Detached garages and detached accessory structures.
2. Attached garages separated from the *dwelling unit* living space in accordance with Section R302.6.
3. Outdoors or on the exterior side of exterior walls located not less than 3 feet (914 mm) from doors and windows directly entering the *dwelling unit*.
4. Enclosed utility closets, basements, storage or utility spaces within *dwelling units* with finished or noncombustible walls and ceilings. Walls and ceilings of unfinished wood-framed construction shall be provided with not less than $^{5}/_{8}$-inch (15.9 mm) Type X gypsum wallboard.

*ESS* shall not be installed in sleeping rooms, or closets or spaces opening directly into sleeping rooms.

**R328.5 Energy ratings.** Individual *ESS* units shall have a maximum rating of 20 kWh. The aggregate rating of the *ESS* shall not exceed:

1. 40 kWh within utility closets, basements and storage or utility spaces.
2. 80 kWh in attached or detached garages and detached accessory structures.
3. 80 kWh on exterior walls.
4. 80 kWh outdoors on the ground.

**R328.6 Electrical installation.** *ESS* shall be installed in accordance with NFPA 70. Inverters shall be *listed* and *labeled* in accordance with UL 1741 or provided as part of the UL 9540 listing. Systems connected to the utility grid shall use inverters *listed* for utility interaction.

**R328.7 Fire detection.** Rooms and areas within *dwelling units*, basements and attached garages in which *ESS* are installed shall be protected by smoke alarms in accordance with Section R314. A heat detector, *listed* and interconnected to the smoke alarms, shall be installed in locations within *dwelling units* and attached garages where smoke alarms cannot be installed based on their listing.

**R328.8 Protection from impact.** *ESS* installed in a location subject to vehicle damage shall be protected by *approved* barriers.

**R328.9 Ventilation.** Indoor installations of *ESS* that produce hydrogen or other flammable gases during charging shall be provided with mechanical *ventilation* in accordance with Section M1307.4.

**R328.10 Electric vehicle use.** The temporary use of an *owner* or occupant's electric-powered vehicle to power a *dwelling unit* while parked in an attached or detached garage or outdoors shall comply with the vehicle manufacturer's instructions and NFPA 70.

**R328.11 Documentation and labeling.** The following information shall be provided:

1. A copy of the manufacturer's installation, operation, maintenance and decommissioning instructions shall be provided to the owner or placed in a conspicuous location near the *ESS* equipment.

2. A label on the installed system containing the contact information for the qualified maintenance and service providers.

## SECTION R329
## STATIONARY ENGINE GENERATORS

**R329.1 General.** Stationary engine generators shall be *listed* and *labeled* in accordance with UL 2200 and shall comply with this section. The connection of stationary engine generators to the premise wiring system shall be by means of a *listed* transfer switch.

**R329.2 Installation.** The installation of stationary engine generators shall be in an *approved* location and in accordance with the listing, the manufacturer's installation instructions and Chapters 34 through 43.

## SECTION R330
## STATIONARY FUEL CELL POWER SYSTEMS

**Deleted.**

## SECTION ~~R327~~ R331
## DOCKS, PIERS, BULKHEADS AND WATERWAY STRUCTURES

**~~R327.1~~ R331.1 General.** Docks, piers, bulkheads and waterway structures shall be constructed in accordance with Chapter 36 of the North Carolina Building Code.

~~**Exception:** Structures complying with the following are not required to meet the provisions of Chapter 36 of the *North Carolina Building Code* or this code.~~

~~1. Fixed piers associated with a one- or two-family dwelling meeting all of the following:~~

~~1.1. A maximum of four boat slips for a single owner of a one- or two-family dwelling or two adjacent, riparian owners.~~

~~1.2. A maximum height of 15 feet (4572 mm) measured from deck to mud line at any location along the pier.~~

~~1.3. A maximum normal pool depth of 13 feet (3962 mm) on lakes and ponds and a maximum mean low water depth of 7 feet (2134 mm) in other locations.~~

~~1.4. A maximum walkway width of 6 feet (1829 mm).~~

~~1.5. A maximum pile spacing of 8 feet (2438 mm), in both directions.~~

~~1.6. A maximum of 576 square feet (53.5 $m^2$) for non-walkways areas.~~

~~1.7. A maximum boat slip length of 40 feet (12.2 m).~~

~~1.8. A maximum roofed area of 576 square feet. (53.5 $m^2$) with an additional maximum 2 foot (610 mm) overhang.~~

~~1.9. Constructed with no enclosed or multilevel structures.~~

~~1.10. Supporting a boatlift with a maximum design capacity no greater than 16,000 pounds (71.2 kN).~~

~~2. Floating docks associated with a one- or two-family dwelling meeting all of the following:~~

~~2.1. A maximum of four boat slips for a single owner of a one- or two-family dwelling or two adjacent, riparian owners.~~

~~2.2. A maximum normal pool depth of 20 feet (6096 mm) for docks with guide piles on lakes and ponds and a maximum mean low water depth of 10 feet (3048 mm) for docks with guide piles in other locations.~~

~~2.3. A maximum boat slip length of 40 feet (12.2 m).~~

~~2.4. Finger piers, crosswalks or other floating surfaces having a minimum width of 3 feet (914 mm) wide to a maximum of 6 feet (1829 mm) wide, except for a single 8-foot by 16-foot (2438-mm by 4877-mm) section.~~

~~2.5. When constructed with a roof and the following conditions exist:~~

~~i. Ultimate design wind speed is 115 mph (51 m/s) or less;~~

~~ii. Roof load is 20 psf (0.96 kPa) or less;~~

~~iii. A maximum eave height of 10 feet (3048 mm);~~

~~iv. A maximum roof slope of 4:12;~~

~~v. A maximum roofed area of 576 square feet. (53.5 $m^2$) with an additional maximum 2 foot (610 mm) overhang;~~

~~vi. A minimum boat slip width of 12 feet (3658 mm);~~
~~vii. A minimum floating dock width of 4 feet (1219 mm) along both sides of the boat slip;~~
~~viii. A maximum dead load of 12 psf (0.57 kPa);~~
~~ix. Floating structures supporting roof structures are balanced or anchored to reduce the possibility of tipping.~~
~~2.6. Constructed with no enclosed or multilevel structures.~~
~~2.7. Supports a boat lift with a maximum design capacity no greater than 16,000 pounds (71.2 kN).~~

**Exceptions:** Structures complying with the following are not required to meet the provisions of this code.

1. Docks and Piers built over private ponds.
2. Fixed in place walkways, docks, and piers not covered in Exception 1 and not exceeding 144 square feet for single family dwelling.
3. Minor repairs to existing docks, piers and waterway structures.

## SECTION R332
## LICENSED RESIDENTIAL CARE

**R332.1 General.** Buildings in which more than three people are harbored for medical, charitable or other care or treatment shall be classified as residential care facilities. The state agency having jurisdiction shall classify the facility as a residential care home, small residential care facility or small nonambulatory care facility.

**R332.1.1 Fire extinguishers.** Fire extinguishers shall be installed in licensed residential care facilities in accordance with the North Carolina Fire Prevention Code.

**R332.1.2 Means of egress.** Where two means of egress exits are required, the exits or exit access doors shall be so located and constructed to minimize the possibility that both may be blocked by any one fire or other emergency condition.

**R332.2 Residential Care Facilities.** Homes keeping no more than six adults or six unrestrained children who are able to respond and evacuate the facility without verbal or physical assistance, determined by the state agency having jurisdiction to be licensable, shall be classified as Single-Family Residential and comply with the requirements of this section.

**R332.2.1 Means of egress.** Each normally occupied story of the facility shall have two remotely located means of egress exits. The exits or exit access doors shall be so located and constructed to minimize the possibility that both may be blocked by any one fire or other emergency condition.

**R332.2.2 Smoke Detection Systems.** Smoke detectors shall be provided on all levels.

**R332.2.3 Interior finishes.** Interior wall and ceiling finishes shall be Class A, B or C.

**R332.2.4 Heating appliances.** Unvented fuel-fired heaters and portable electric heaters shall be prohibited.

**R332.3 Licensed Small Residential Care Facilities.** The following facilities when determined by the State Agency having jurisdiction to be licensable, shall be classified as Single-Family Residential and comply with the requirements of this section.

1. Residential Care Facilities keeping no more than six adults or six unrestrained children with no more than three who are unable to respond and evacuate without verbal or physical assistance.
2. Residential Care Facilities keeping no more than five adults or five children who are unable to respond and evacuate without verbal or physical assistance, when certifiable for Medicaid reimbursement, and when staffed 24-hours per day with at least two staff awake at all times.
3. Residential Care Facilities keeping no more than nine adults or nine children who are able to respond and evacuate without verbal or physical assistance.

**R332.3.1 Fire Resistance Construction.** The building shall be of one-hour fire resistant rated construction including all walls, partitions, floors and ceilings. Bedroom doors shall be 1.75 inches solid wood core.

**Exception:** No rating shall be required if the building is NFPA 13D sprinklered with a wet pipe system with a 30-minute water supply. Bathrooms, toilets, closets, pantries, storage spaces, attached garages, and utility spaces shall be sprinklered. The sprinkler system shall be monitored per North Carolina Fire Code, Section 903.4 (Section 903.4, Exception 1 is not applicable in this occupancy)

**R332.3.2 Building height and area.** Buildings shall not exceed two stories in height and shall not exceed 7,000 square feet (650 $m^2$) per story for dwellings applying the exception in Section ~~R332.2.1~~R332.3.1 and 12,000 square feet (1114.8 $m^2$) per story for all other dwellings. For purposes of this section, attics and basements used as habitable spaces shall be considered as stories.

**R332.3.3 Quantity of exits.** Each normally occupied story of the facility shall have two remotely located exits. The exits doors shall be so located and constructed to minimize the possibility that both may be blocked by any one fire or other emergency condition.

**R332.3.4 Egress stairs.** Required facility egress stairways shall be either exterior unenclosed or interior enclosed on each level with one-hour fire-resistant rated construction and self-closing 20-minute labeled doors. Other interior stairways shall be enclosed on one floor level with one-hour fire resistant walls and self-closing 20-minute labeled doors.

**R332.3.5 Smoke and heat detectors.** Smoke detectors shall be provided on all levels. Heat detectors shall be installed in all attic spaces. The heat detectors shall be connected to the fire alarm and detection system.

**R332.3.6 Incidental accessory occupancies.** Any incidental use area, as defined by North Carolina Building Code, Table 508.2.5, shall be enclosed with one-hour fire-resistant rated construction and self-closing 20-minute labeled door or provided with an automatic sprinkler system and smoke resistant separation from other areas.

**R332.3.7 Fire alarm systems.** A building fire alarm system shall be provided in accordance with NFPA 72. Provisions shall be made to activate the internal evacuation alarm at all required exits.

**R332.3.8 Interior finishes.** Interior wall and ceiling membranes shall be gypsum wallboard, plaster or other non-combustible material.

**R332.3.9 Heating appliances.** Unvented fuel-fired heaters, floor furnaces, and portable electric heaters shall not be installed.

**R332.3.10 Occupants.** Occupants younger than six-years of age shall sleep on the level of exit discharge with adult supervision.

**R332.4 Small Non-ambulatory Care Facilities.** Facilities keeping no more than six adults or six children who are unable to respond and evacuate without verbal or physical assistance, when determined by the State Agency having jurisdiction to be licensable shall comply with the requirements of R332.3 for Licensed Small Residential Care Facilities.

**R332.4.1 Automatic sprinkler systems.** The building shall be sprinklered with a wet pipe system in accordance with NFPA 13D with a 30-minute water supply including bathrooms, toilets, closets, pantries, storage spaces, attached garages, and utility spaces. The sprinkler system shall be monitored per North Carolina Fire Code, Section 903.4. North Carolina Fire Code, Section 903.4, Exception 1 shall not apply to this section.

## SECTION R333
## LICENSED ADULT AND CHILD DAY CARE

**R333.1 Means of egress.**

**R333.1.1 Location.** Rooms where occupants receive care shall be on the level of exit discharge.

**R333.1.2 Quantity of Exits.** Adult and child day care facilities shall have two or more remote means of egress.

**Exception:** A room where occupants receive care and comply with all of the following:

a. Located on the level of exit discharge, and

b. Has an exit door directly to the exterior.

**R333.1.3 Walls and Ceilings.** All walls and ceilings in rooms which are used for day care purposes and are part of an egress (exiting) path shall have interior membranes of noncombustible construction such as but not limited to plaster or gypsum wallboard or shall comply with Section 803 of the North Carolina Building Code.

**R333.2 Portable Fire Extinguishers.** At least one 2-A:10-B:C fire extinguisher shall be provided per floor with a maximum of 40 feet travel distance to the extinguisher.

## SECTION R334
## DEMOLITION

**R334.1 Demolition.** Where a building or structure regulated by this code has been demolished or removed, the lot shall not create a new hazard to the site or to adjoining properties. All utilities shall be properly terminated.

# CHAPTER 4
# FOUNDATIONS

**R401.1 Application.** The provisions of this chapter shall control the design and construction of the foundation and foundation spaces for buildings. In addition to the provisions of this chapter, the design and construction of foundations in flood hazard areas as established by Table R301.2 shall meet the provisions of Section R322. Wood foundations shall be designed and installed in accordance with AWC PWF.

**Exception:** The provisions of this chapter shall be permitted to be used for wood foundations only in the following situations:

1. In buildings that have ~~no~~ not more than two floors and a roof.
2. Where interior *basement* and foundation walls are constructed at intervals not exceeding 50 feet (15 240 mm).

Wood foundations in Seismic Design Category $D_0$, $D_1$ or $D_2$ shall be designed in accordance with accepted engineering practice.

**R401.2 Requirements.** Foundation construction shall be capable of accommodating all loads in accordance with Section R301 and of transmitting the resulting loads to the supporting soil. Fill soils that support footings and foundations shall be designed, installed and tested in accordance with accepted engineering practice. ~~Gravel fill used as footings for wood and precast concrete foundations shall comply with Section R403.~~

**R401.3 Drainage.** Surface drainage shall be diverted to a storm sewer conveyance or other *approved* point of collection that does not create a hazard. *Lots* shall be graded to drain surface water away from foundation walls. The *grade* shall fall ~~a minimum of~~ not fewer than 6 inches (152 mm) within the first 10 feet (3048 mm).

**Exception:** Where *lot lines*, walls, slopes or other physical barriers prohibit 6 inches (152 mm) of fall within 10 feet (3048 mm), drains or swales shall be constructed to ensure drainage away from the structure. Impervious surfaces within 10 feet (3048 mm) of the building foundation shall be sloped ~~a minimum of~~ not less than 2 percent away from the building.

**R401.4 Soil tests.** Where quantifiable data created by accepted soil science methodologies indicate *expansive* soils, *compressible* soils, shifting soils or other questionable soil characteristics are likely to be present, the *building official* shall determine whether to require a soil test to determine the soil's characteristics at a particular location. This test shall be done by an *approved agency* using an *approved* method.

**R401.4.1 Geotechnical evaluation.** The load bearing values greater than 2000 psf (95.8 kPa) in Table R401.4.1 require an engineering evaluation.

**TABLE R401.4.1**
**PRESUMPTIVE LOAD-BEARING VALUES OF FOUNDATION MATERIALS[a]**

| CLASS OF MATERIAL | LOAD-BEARING PRESSURE (pounds per square foot) |
|---|---|
| Crystalline bedrock | 12,000 |
| Sedimentary and foliated rock | 6000 |
| Sandy gravel and/or gravel (GW and GP) | 5000 |
| Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC) | 3000 |
| Clay, sandy, silty clay, clayey silt, silt and sandy siltclay (CL, ML, MH and CH) | 2000b |

For SI: 1 pound per square foot = 0.0479 kPa.

a. Where soil tests are required by Section R401.4, the allowable bearing capacities of the soil shall be part of the recommendations.

b. Where the building official determines that in-place soils with an allowable bearing capacity of less than ~~1,500~~ 2000 psf are likely to be present at the site, the allowable bearing capacity shall be determined by a soils investigation.

**R401.4.2 Compressible or shifting soil.** Instead of a complete geotechnical evaluation, where top or subsoils are compressible or shifting, they shall be removed to a depth and width sufficient to ensure stable moisture content in each active zone and shall not be used as fill or stabilized within each active zone by chemical, dewatering or presaturation.

## SECTION R402
## MATERIALS

**R402.1 Wood foundations.** Wood foundation systems shall be designed and installed in accordance with the provisions of this code.

**R402.1.1 Fasteners.** Fasteners used below *grade* to attach plywood to the exterior side of exterior *basement* or crawl-space wall studs, or fasteners used in knee wall construction, shall be of Type 304 or 316 stainless steel. Fasteners used above *grade* to attach plywood and all lumber-to-lumber fasteners except those used in knee wall construction shall be of Type 304 or 316 stainless steel, silicon bronze, copper, hot-dipped galvanized (zinc coated) steel nails, or hot-tumbled galvanized (zinc coated) steel nails. Electro-galvanized steel nails and galvanized (zinc coated) steel staples shall not be permitted.

**R402.1.2 Wood treatment.** ~~All lumber~~ Lumber and plywood shall be pressure-preservative treated and dried after treatment in accordance with AWPA U1 (Commodity Specification A, ~~Use Category 4B and Section 5.2),~~ Special Requirement 4.2), and shall bear the *label* of an accredited agency. Where lumber or plywood is cut or drilled after treatment, the treated surface shall be field treated with copper naphthenate, the concentration of which shall contain ~~a minimum of~~ not less than 2-percent copper metal, by repeated brushing, dipping or soaking until the wood ~~absorbs no~~ cannot absorb more preservative.

**R402.2 Concrete.** Concrete shall have a minimum specified compressive strength of $f'_c$, as shown in Table R402.2. Concrete subject to moderate or severe weathering as indicated in Table R301.2 shall be air entrained as specified in Table R402.2. The maximum weight of fly ash, other pozzolans, silica fume, slag or blended cements that is included in concrete mixtures for garage floor slabs and for exterior porches, carport slabs and steps that will be exposed to deicing chemicals shall not exceed the percentages of the total weight of cementitious materials specified in Section 19.3.3.4 of ACI 318. Materials used to produce concrete and testing thereof shall comply with the applicable standards listed in Chapters 19 and 20 of ACI 318 or ACI 332.

**TABLE R402.2**

**MINIMUM SPECIFIED COMPRESSIVE STRENGTH OF CONCRETE**

| TYPE OR LOCATION OF CONCRETE CONSTRUCTION | MINIMUM SPECIFIED COMPRESSIVE STRENGTH[a] ($f'_c$) | | |
|---|---|---|---|
| | Weathering Potential[b] | | |
| | Negligible | Moderate | Severe |
| Basement walls, foundations and other concrete not exposed to the weather | 2,500 | 2,500 | 2,500[c] |
| Basement slabs and interior slabs on grade, except garage floor slabs | 2,500 | 2,500 | 2,500[c] |

| | | | |
|---|---|---|---|
| Basement walls, foundation walls, exterior walls and other vertical concrete work exposed to the weather | 2,500 | 3,000[d] | 3,000[d] |
| Porches, carport slabs and steps exposed to the weather, and garage floor slabs | 2,500 | 3,000[d, e, f] | 3,500[d, e, f] |

For SI: 1 pound per square inch = 6.895 kPa.

a. Strength at 28 days psi.

b. See Table R301.2 for weathering potential.

c. Concrete in these locations that is subject to freezing and thawing during construction shall be air-entrained concrete in accordance with Note d.

d. Concrete shall be air-entrained. Total air content (percent by volume of concrete) shall be not less than 5 percent or more than 7 percent.

e. See Section R402.2 for maximum cementitious materials content.

f. For garage floors with a steel-troweled finish, reduction of the total air content (percent by volume of concrete) to not less than 3 percent is permitted if the specified compressive strength of the concrete is increased to not less than 4,000 psi.

**R402.2.1 Materials for concrete.** Materials for concrete shall comply with the requirements of Section R608.5.1.

**R402.3 Precast concrete.** *Precast concrete* foundations shall be designed in accordance with Section R404.5 and shall be installed in accordance with the provisions of this code and the manufacturer's instructions.

**R402.3.1 Precast concrete foundation materials.** Materials used to produce *precast concrete* foundations shall meet the following requirements:

1. All concrete used in the manufacture of *precast concrete* foundations shall have a minimum compressive strength of 5,000 psi (34 470 kPa) at 28 days. Concrete exposed to a freezing and thawing environment shall be air entrained with a minimum total air content of 5 percent.
2. Structural reinforcing steel shall meet the requirements of ASTM A615, A706M or A996M. The minimum yield strength of reinforcing steel shall be 40,000 psi (Grade 40) (276 MPa). Steel reinforcement for *precast concrete foundation walls* shall have a minimum concrete cover of $^3/_4$ inch (19.1 mm).
3. Panel-to-panel connections shall be made with Grade II steel fasteners.
4. The use of nonstructural fibers shall conform to ASTM C1116.
5. Grout used for bedding precast foundations placed ~~upon~~ on concrete footings shall meet ASTM C1107.

**R402.4 Masonry.** Masonry systems shall be designed and installed in accordance with this chapter and shall have a minimum specified compressive strength of 1,500 psi (10.3 MPa).

## SECTION R403
## FOOTINGS

**R403.1 General.** All exterior walls shall be supported on continuous solid or fully grouted masonry or concrete footings, crushed stone footings, wood foundations, or other *approved* structural systems ~~which~~ that shall be of sufficient design to accommodate all loads according to Section R301 and to transmit the resulting loads to the soil within the limitations as determined from the character of the soil. Footings shall be supported on undisturbed natural soils or engineered fill. Concrete footing shall be designed and constructed in accordance with the provisions of Section R403 or in accordance with ACI 332. Discontinuous footings shall be permitted to be constructed in accordance with ACI 332 for concrete foundation walls and Appendix NC-C for masonry foundation walls.

**TABLE R403.1(1)**
**MINIMUM WIDTH OF CONCRETE, PRECAST OR MASONRY FOOTINGS (inches)[a]**

| | LOAD-BEARING VALUE OF SOIL (psf) | | | |
|---|---|---|---|---|
| | 1,500 | 2,000 | 3,000 | 4,000 |
| | Conventional light-frame construction | | | |
| 1-story | 12[b] | 12[b] | 12 | 12 |
| 2-story | 15[b] | 12[b] | 12 | 12 |
| 3-story | 23 | 17 | 12 | 12 |
| | 4-inch brick veneer over light frame or 8-inch hollow concrete masonry | | | |
| 1-story | 12[b] | 12[b] | 12 | 12 |
| 2-story | 15[b] | 15[b] | 12 | 12 |
| 3-story | 32 | 24 | 16 | 12 |
| | 8-inch solid or fully grouted masonry | | | |
| 1-story | 16 | 12[b] | 12 | 12 |
| 2-story | 29 | 21 | 14 | 12 |
| 3-story | 42 | 32 | 21 | 16 |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.
a. Where minimum footing width is 12 inches, use of a single wythe of solid or fully grouted 12-inch nominal concrete masonry units is permitted.
b. A minimum footing width of 12 inches is acceptable for monolithic slab foundations.

**TABLE R403.1(1) [a,b,c,d]**
**MINIMUM WIDTH OF CONCRETE, PRECAST OR MASONRY FOOTINGS (INCHES)**

| | LOAD-BEARING VALUE OF SOIL (psf) | | | |
|---|---|---|---|---|
| | 1500 | 2000 | 3000 | 4000 |
| | Light-frame wood construction | | | |
| 1-STORY - Slab-on-grade | 12 | 12 | 12 | 12 |
| 1-STORY - Crawl space | 14 | 12 | 12 | 12 |
| 1-STORY - plus basement wall | 17 | 13 | 12 | 12 |
| 2-STORY - Slab-on-grade | 13 | 12 | 12 | 12 |
| 2-STORY - Crawl space | 18 | 13 | 12 | 12 |
| 2-STORY - plus basement wall | 21 | 16 | 12 | 12 |
| 3-STORY - Slab-on-grade | 16 | 12 | 12 | 12 |
| 3-STORY - Crawl space | 21 | 16 | 12 | 12 |
| 3-STORY - plus basement wall | 24 | 18 | 12 | 12 |
| | Light-frame wood construction with brick veneer or 8-inch hollow concrete masonry | | | |
| 1-STORY - Slab-on-grade | 12 | 12 | 12 | 12 |
| 1-STORY - Crawl space | 17 | 13 | 12 | 12 |
| 1-STORY - plus basement wall | 20 | 15 | 12 | 12 |
| 2-STORY - Slab-on-grade | 19 | 14 | 12 | 12 |
| 2-STORY - Crawl space | 24 | 18 | 12 | 12 |
| 2-STORY - plus basement wall | 27 | 20 | 14 | 12 |
| 3-STORY - Slab-on-grade | 25 | 19 | 13 | 12 |
| 3-STORY - Crawl space | 30 | 23 | 15 | 12 |
| 3-STORY - plus basement wall | 33 | 25 | 17 | 13 |
| | 8 inch grout-filled concrete masonry | | | |
| 1-STORY - Slab-on-grade | 15 | 12 | 12 | 12 |
| 1-STORY - Crawl space | 20 | 15 | 12 | 12 |

| | | | | |
|---|---|---|---|---|
| **1-STORY - plus basement wall** | 23 | 17 | 12 | 12 |
| **2-STORY - Slab-on-grade** | 23 | 18 | 12 | 12 |
| **2-STORY - Crawl space** | 28 | 21 | 14 | 12 |
| **2-STORY - plus basement wall** | 31 | 24 | 16 | 12 |
| **3-STORY - Slab-on-grade** | 32 | 24 | 16 | 12 |
| **3-STORY - Crawl space** | 37 | 28 | 19 | 14 |
| **3-STORY - plus basement wall** | 40 | 30 | 20 | 15 |

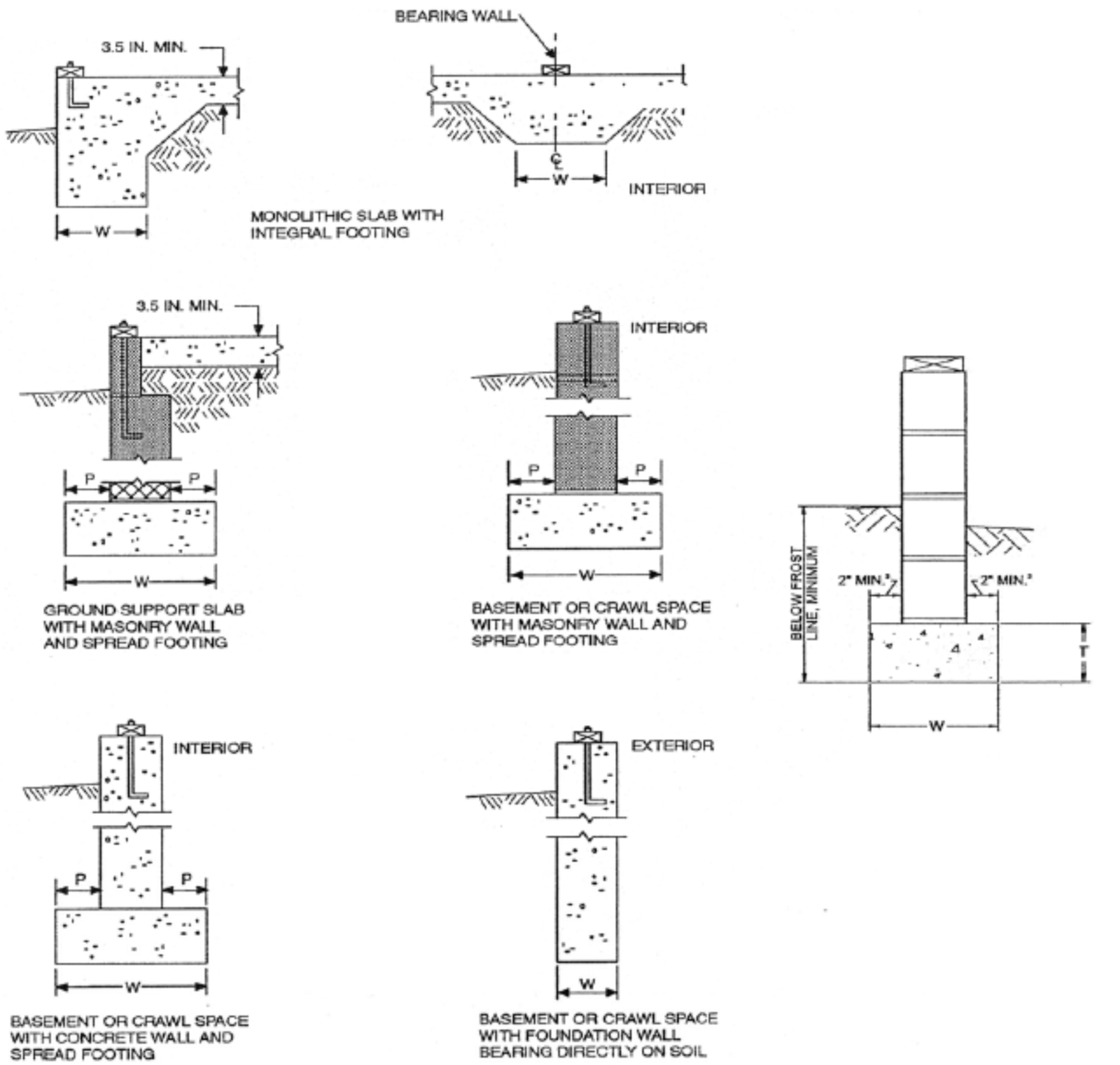
The table is based on the following conditions and loads:
Building width: 36 feet; Wall height: 9 feet; Crawl space wall height: 10 feet; Basement wall height: 10 feet
Basement wall height: 8 feet
Dead loads: 20 psf roof and ceiling assembly, 10 psf floor assembly, 15 psf wall assembly
Roof Live load: 20 psf
Live Load: 40 psf first floor, 30 psf second and third floor each

a. The table assumed a clear-span roof, such as a truss
b. The table assumed a center-bearing wall carrying the load with floor tributary length no more than 9 feet
c. Linear interpolation of footing width is permitted between the soil bearing pressures in the table. Extrapolation is not permitted.
d. Table does not include habitable attic floor load.

**TABLE R403.1(2)**
**PIER[a] AND FOOTING[b] SIZES FOR SUPPORT OF GIRDERS**

| AREA[e] | 1 (ONE) STORY | | 2 (TWO) STORY | | 2 1/2 (TWO & ONE HALF) STORY | |
|---|---|---|---|---|---|---|
| | Pier[c, d] | Footing | Pier[c, d] | Footing | Pier[c, d] | Footing |
| 50 | 8″ × 16″ | 1′-4″ × 2′-0″ × 8″ | 8″ × 16″ | 1′-4″ × 2′-6″ × 8″ | 8″ × 16″ | 1′-4″ × 2′-6″ × 8″ |
| 100 | 8″ × 16″ | 1′-4″ × 2′-0″ × 8″ | 8″ × 16″ | 2′-0″ × 2′-0″ × 10″ | 16″ × 16" | 2′-6″ × 2′-6″ × 10″ |
| 150 | 8″ × 16″ | 2′-0" × 2′-0″ × 8″ | 16″ × 16″ | 2′-8″ × 2′-8″ × 10″ | 16″ × 16″ | 3′-0″ × 3′-0″ × 10″ |
| 200 | 8″ × 16″ | 2′-4" × 2′-4″ × 10″ | 16″ × 16″ | 3′-0″ × 3′-0″ × 10″ | 16″ × 16″ | 4′-0″ × 4′-0″ × 1′-0″ |
| 250 | — | — | 16″ × 16″ | 3′-4″ × 3′-4″ × 1′-0" | 16″ × 24″ | 4′-0″ × 4′-0″ × 1′-0″ |
| 300 | — | — | 16″ × 16″ | 3′-8″ × 3′-8″ × 1′-0" | 16″ × 24″ | 4′-6″ × 4′-6″ × 1′-0″ |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.
a. Pier sizes are based on hollow CMU capped with 4 inches of solid masonry or concrete for 1 (one) story and 8 inches of solid masonry or concrete for 2 (two), 2 1/2 (two and one half) or 3 (three) story houses or shall have cavities of the top course filled with concrete or grout or other approved methods. Mortar shall be Type S. A minimum footing width of 12 inches is acceptable for monolithic slab foundations.
b. Footing sizes are based on 2000 psf allowable soil bearing and 2500 psi concrete. This table is based on the limitations of a tributary area using dimensional framing lumber only.
c. Centers of piers shall bear in the middle one-third of the footings. Girders must have full bearing on piers. Footings shall be full thickness over the entire area of the footing.
d. Pier sizes given are minimum. For height/thickness limitations see Section R606.7.
e. Area at first level supported by pier and footing in square feet.




For SI: 1 inch = 25.4 mm.

W = Width of footing, T = Thickness of footing and P = Projection per Section R403.1.1.

Notes:

a. Foundations shall extend not less than 12 inches below finished grade and in no case less than the frost line depth.

b. Footing sizes are based on soil with an allowable soil pressure of 2,000 pounds per square foot. Footings on soil with a lower allowable soil pressure shall be designed in accordance with accepted engineering practice.

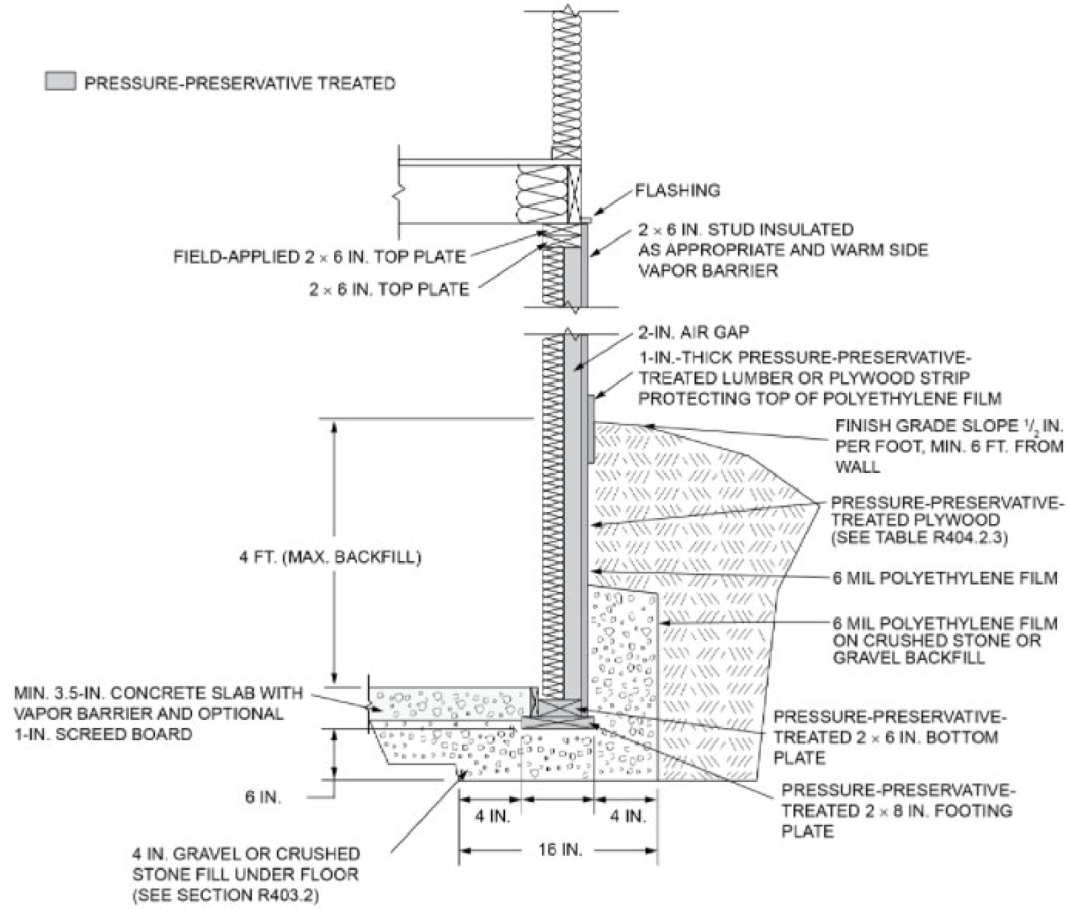
c. Footing projections shall not exceed the footing thickness.

d. For minimum footing width (W) see Table R403.1(1).

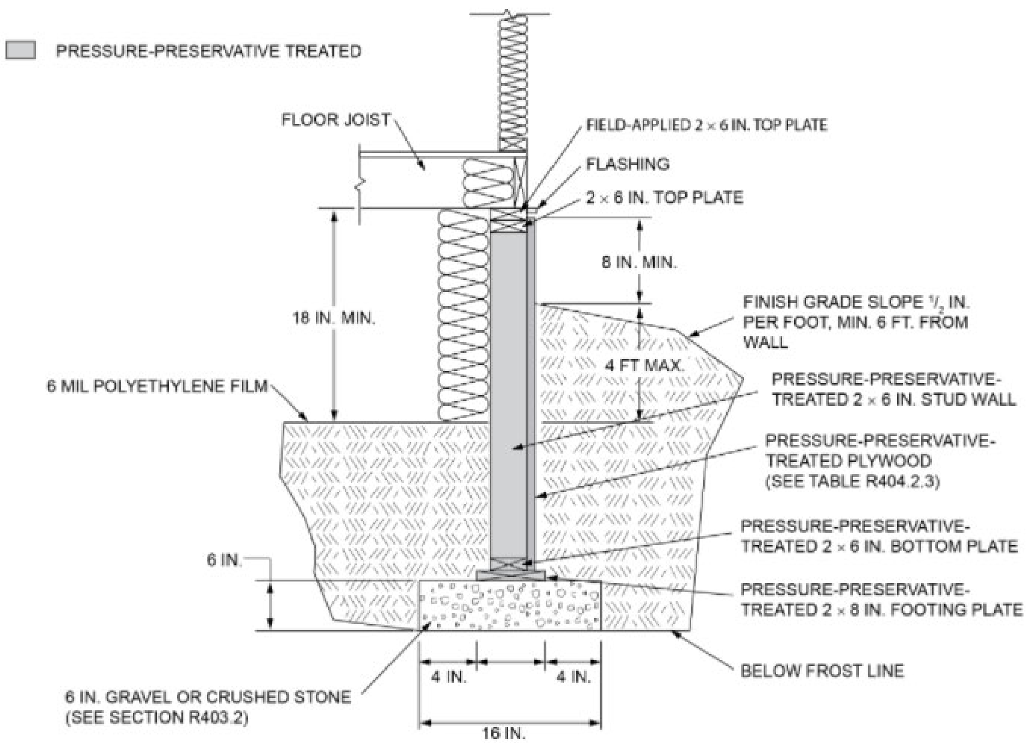
e. Minimum footing thickness (T) is: 6" for 1 story, 8" for 2 story and 10" for 3 story.

f. Install anchor bolts per Section R403.1.6.

**FIGURE R403.1(1)**
**CONCRETE AND MASONRY FOUNDATION DETAILS**[a, b, c, d, e, f]



PRESSURE-PRESERVATIVE TREATED
FLASHING
FIELD-APPLIED 2 × 6 IN. TOP PLATE
2 × 6 IN. TOP PLATE
2 × 6 IN. STUD INSULATED AS APPROPRIATE AND WARM SIDE VAPOR BARRIER
2-IN. AIR GAP
1-IN.-THICK PRESSURE-PRESERVATIVE-TREATED LUMBER OR PLYWOOD STRIP PROTECTING TOP OF POLYETHYLENE FILM
FINISH GRADE SLOPE 1/2 IN. PER FOOT, MIN. 6 FT. FROM WALL
PRESSURE-PRESERVATIVE-TREATED PLYWOOD (SEE TABLE R404.2.3)
4 FT. (MAX. BACKFILL)
6 MIL POLYETHYLENE FILM
6 MIL POLYETHYLENE FILM ON CRUSHED STONE OR GRAVEL BACKFILL
MIN. 3.5-IN. CONCRETE SLAB WITH VAPOR BARRIER AND OPTIONAL 1-IN. SCREED BOARD
PRESSURE-PRESERVATIVE-TREATED 2 × 6 IN. BOTTOM PLATE
6 IN.
4 IN.
4 IN.
PRESSURE-PRESERVATIVE-TREATED 2 × 8 IN. FOOTING PLATE
16 IN.
4 IN. GRAVEL OR CRUSHED STONE FILL UNDER FLOOR (SEE SECTION R403.2)

PRESSURE-PRESERVATIVE TREATED
FLOOR JOIST
FIELD-APPLIED 2 × 6 IN. TOP PLATE
FLASHING
2 × 6 IN. TOP PLATE
8 IN. MIN.
18 IN. MIN.
FINISH GRADE SLOPE 1/2 IN. PER FOOT, MIN. 6 FT. FROM WALL
4 FT MAX.
6 MIL POLYETHYLENE FILM
PRESSURE-PRESERVATIVE-TREATED 2 × 6 IN. STUD WALL
PRESSURE-PRESERVATIVE-TREATED PLYWOOD (SEE TABLE R404.2.3)
6 IN.
PRESSURE-PRESERVATIVE-TREATED 2 × 6 IN. BOTTOM PLATE
PRESSURE-PRESERVATIVE-TREATED 2 × 8 IN. FOOTING PLATE
BELOW FROST LINE
4 IN.
4 IN.
6 IN. GRAVEL OR CRUSHED STONE (SEE SECTION R403.2)
16 IN.

**R403.1.1 Minimum size.** ~~Minimum sizes for concrete and masonry footings~~ The minimum width, W, and thickness, T, for concrete footings shall be ~~as set forth~~ in accordance with Tables R403.1(1) ~~through R403.1(3)~~ and Figure R403.1(1) ~~or R403.1.3~~, but not less than 12 inches (305 mm) in width and 6 inches (152 mm) in depth. The footing width shall be based on the load-bearing value of the soil in accordance with Table R401.4.1. ~~Spread footings shall be at least 6 inches (152 mm) in thickness, T.~~ Footing projections, P, shall be not less than 2 inches (51 mm) and shall not exceed the thickness of the footing. Footing thickness and projection for fireplaces shall be in accordance with Section R1001.2. The size of footings supporting piers and columns shall be based on the tributary load in accordance with Table R403.1(2). ~~and allowable soil pressure in accordance with Table R401.4.1.~~ Footings for wood foundations shall be in accordance with the details set forth in Section R403.2, and Figures R403.1(2) and R403.1(3). Footings for precast foundations shall be in accordance with the details set forth in Section R403.4, Table R403.4, and Figures R403.4(1) and R403.4(2).

**R403.1.2 Continuous footing in Seismic Design Categories $D_0$, $D_1$ and $D_2$.** Deleted.

**R403.1.3 Footing and stem wall reinforcing in Seismic Design Categories $D_0$, $D_1$ and $D_2$.** Deleted.

**R403.1.3.1 Concrete stem walls with concrete footings.** Deleted.

**R403.1.3.2 Masonry stem walls with concrete footings.** Deleted.

**R403.1.3.3 Slabs-on-ground with turned-down footings.** Deleted.

**R403.1.3.4 Interior bearing and *braced wall panel* footings in Seismic Design Categories $D_0$, $D_1$ and $D_2$.** Deleted.

**R403.1.3.5 Reinforcement.** Deleted.

**R403.1.3.5.1 Steel reinforcement.** Deleted.

**R403.1.3.5.2 Location of reinforcement in wall.** Deleted.

**R403.1.3.5.3 Support and cover.** Deleted.

**R403.1.3.5.4 Lap splices.** Deleted.

**R403.1.3.6 Isolated concrete footings.** Deleted.

**R403.1.4 Minimum depth.** All foundation systems and exterior footings shall extend below the frost line specified in Table R301.2(1). In no case shall the bottom of the exterior footings be less than 12 inches (305 mm) below the finished grade.

**Exception:** Footings and foundations erected on solid rock shall not be required to extend below the frost line.

**R403.1.4.1 Frost protection**. ~~Deleted.~~ See Section R403.1.4.

**R403.1.5 Slope.** The top surface of footings shall be level (1/2 inch in 10 feet) or shall be brought level, under the width of the wall, with masonry units with full mortar joints. The bottom surface of footings shall not have a slope exceeding 1 unit vertical in 10 units horizontal (10-percent slope). Footings shall be stepped where it is necessary to change the elevation of the top surface of the footings or where the slope of the bottom surface of the footings will exceed 1 unit vertical in 10 units horizontal (10-percent slope).

**R403.1.6 Foundation anchorage.** Wood sill plates and wood walls supported directly on continuous foundations shall be anchored to the foundation in accordance with this section.

Wood sole plates at all exterior walls on monolithic slabs, wood sole plates of *braced wall panels* at building interiors on monolithic slabs and all wood sill plates shall be anchored to the foundation with minimum $^1/_2$-inch-diameter (12.7 mm) anchor bolts spaced ~~a maximum~~ not greater than 6 feet (1829 mm) on center or *approved* anchors or anchor straps spaced as required to provide equivalent anchorage to $^1/_2$-inch-diameter (12.7 mm) anchor bolts. Bolts shall extend ~~a minimum of~~ not less than 7 inches (178 mm) into concrete or grouted cells of *concrete masonry units*. The bolts shall be located in the middle third of the width of the plate. A nut and washer shall be tightened on each anchor bolt. There shall be ~~a minimum of~~ not fewer than two bolts per plate section with one bolt located not more than 12 inches (305 mm) from the corner. Interior bearing wall sole plates on monolithic slab foundation that are not part of a *braced wall panel* shall be positively anchored with *approved* fasteners. Sill plates and sole plates shall be protected against decay and termites where required by Sections R317 and R318. Anchor bolts shall be permitted to be located while concrete is still plastic and before it has set. Where anchor bolts resist placement or the consolidation of concrete around anchor bolts is impeded, the concrete shall be vibrated to ensure full contact between the anchor bolts and concrete.

**Exceptions:**

1. Walls 24 inches (610 mm) total length or shorter connecting offset *braced wall panels* shall be anchored to the foundation with ~~a minimum of~~ not fewer than one anchor bolt located in the center third of the plate section and shall be attached to adjacent *braced wall panels* at corners as shown in Item 9 of Table R602.3(1).
2. Connection of walls 12 inches (305 mm) total length or shorter connecting offset *braced wall panels* to the foundation without anchor bolts shall be permitted. The wall shall be attached to adjacent *braced wall panels* at corners as shown in Item 9 of Table R602.3(1).

**R403.1.6.1 Foundation anchorage in Seismic Design Category C.** In addition to the requirements of Section R403.1.6, the following requirements shall apply to wood light-frame *townhouses* in Seismic Design Category C.

1. Plate washers conforming to Section R602.11.1 shall be provided for all anchor bolts over the full length of required *braced wall lines* except where *approved* anchor straps are used. Properly sized cut washers shall be permitted for anchor bolts in wall lines not containing *braced wall panels*.
2. Interior braced wall plates shall have anchor bolts spaced at not more than 6 feet (1829 mm) on center and located not more than 12 inches (305 mm) from the corner.
3. Interior bearing wall sole plates shall have anchor bolts spaced at not more than 6 feet (1829 mm) on center and located not more than 12 inches (305 mm) from the corner.
4. The maximum anchor bolt spacing shall be 4 feet (1219 mm) for buildings over two *stories* in height.
5. Deleted.
6. Where continuous wood foundations in accordance with Section R404.2 are used, the force transfer shall have a capacity equal to or greater than the connections required by Section R602.11.1 or the *braced wall panel* shall be connected to the wood foundations in accordance with the *braced wall panel*-to-floor fastening requirements of Table R602.3(1).

**R403.1.7 Footings on or adjacent to slopes.** Deleted.

**R403.1.8 Foundations on expansive soils.** Deleted.

**R403.1.9 Excavations near footings or foundations.**
Excavations shall not remove lateral support from any footing or foundation without first shoring, underpinning or protecting the footing or foundation against settlement or lateral translation. Where footings of adjacent buildings or structures are undercut by excavations measured from the bottom of the adjacent existing footing at a 45 degree angle (0.79 rad) within 10 feet (3048 mm) as shown in Figure R403.1.9, the footings shall require evaluation by a *registered design professional.*

**Exception:** *Accessory buildings* not exceeding 400 square feet (37 $m^2$) exempt from providing a masonry or concrete foundation in accordance with Section R101.2.1.

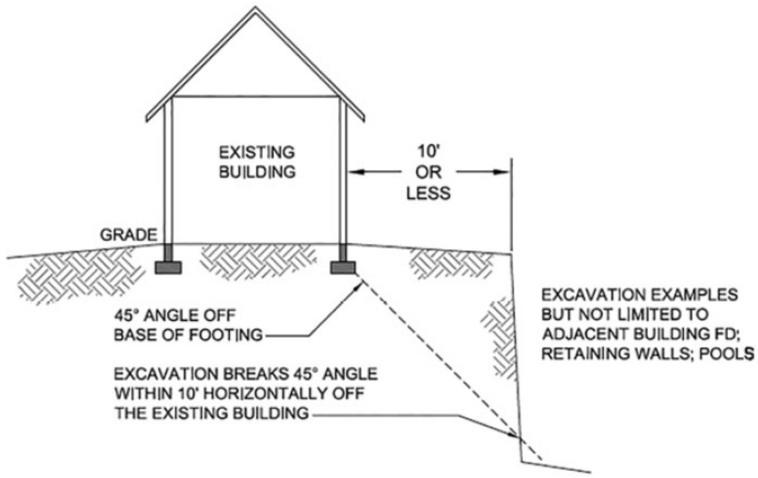



**FIGURE R403.1.9**
**EXCAVATIONS NEAR FOOTINGS OR FOUNDATIONS**

**R403.2 Footings for wood foundations.** Footings for wood foundations shall be in accordance with Figures R403.1(2) and R403.1(3). Gravel shall be washed and well graded. The maximum size stone shall not exceed $^{3}/_{4}$ inch (19.1 mm). Gravel shall be free from organic, clayey or silty soils. Sand shall be coarse, not smaller than $^{1}/_{16}$-inch (1.6 mm) grains and shall be free from organic, clayey or silty soils. Crushed stone shall have a maximum size of $^{1}/_{2}$ inch (12.7 mm).

**R403.3 Frost-protected shallow foundations.** Deleted.

**R403.4 Footings for precast concrete foundations.** Footings for *precast concrete* foundations shall comply with Section ~~R403.4.~~ R403.4.1 and R403.4.2.

**R403.4.1 Crushed stone footings.** Clean crushed stone shall be free from organic, clayey or silty soils. Crushed stone shall be angular in nature and meet ASTM C33, with the maximum size stone not to exceed $^{1}/_{2}$ inch (12.7 mm) and the minimum stone size not to be smaller than $^{1}/_{16}$ inch (1.6 mm). Crushed stone footings for precast foundations shall be installed in accordance with Figure R403.4(1) and Table R403.4. Crushed stone footings shall be consolidated using a vibratory plate in ~~a maximum of~~ not greater than 8-inch (203 mm) lifts. Crushed stone footings shall be limited to *Seismic Design Categories* A, B and C.

**TABLE R403.4**
**MINIMUM DEPTH (D) AND WIDTH (W) OF CRUSHED STONE FOOTINGS[a, b] (inches)**

| NUMBER OF STORIES | UNIFORM WALL LOAD | DEPTH (D) AND WIDTH (W) | LOAD-BEARING VALUE OF SOIL (psf) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1500 | | | 2000 | | | 2500 | | | 3000 | | | 3500 | | | 4000 | | |
| | | | MH, CH, CL, ML[c] | | | SC, GC, SM, GM, SP, SW[c] | | | | | | GP, GW[c] | | | | | | | | |
| | | | Wall width (inches) | | | Wall width (inches) | | | Wall width (inches) | | | Wall width (inches) | | | Wall width (inches) | | | Wall width (inches) | | |
| | | | 8 | 10 | 12 | 8 | 10 | 12 | 8 | 10 | 12 | 8 | 10 | 12 | 8 | 10 | 12 | 8 | 10 | 12 |
| Conventional light-frame construction | | | | | | | | | | | | | | | | | | | | |
| 1-story | 1,100 plf | D | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | | W | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2-story | 1,800 plf | D | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | | W | 15 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 |
| 3-story | 2,900 plf | D | 14 | 12 | 10 | 9 | 7 | 5 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | | W | 25 | 24 | 24 | 19 | 19 | 18 | 15 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 |
| 4-inch brick veneer over light-frame or 8-inch hollow concrete masonry | | | | | | | | | | | | | | | | | | | | |
| 1-story | 1,500 plf | D | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | | W | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 |
| 2-story | 2,700 plf | D | 12 | 11 | 9 | 8 | 6 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | | W | 22 | 23 | 23 | 18 | 17 | 17 | 14 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 |
| 3-story | 4,000 plf | D | 21 | 20 | 18 | 14 | 13 | 11 | 10 | 8 | 7 | 7 | 6 | 4 | 5 | 4 | 4 | 4 | 4 | 4 |
| | | W | 33 | 34 | 33 | 25 | 26 | 25 | 20 | 20 | 21 | 17 | 17 | 17 | 14 | 15 | 17 | 13 | 15 | 17 |
| 8-inch solid or fully grouted masonry | | | | | | | | | | | | | | | | | | | | |
| 1-story | 2,000 plf | D | 7 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | | W | 17 | 17 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 |
| 2-story | 3,600 plf | D | 19 | 17 | 15 | 12 | 11 | 9 | 9 | 7 | 5 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | | W | 30 | 30 | 30 | 22 | 23 | 23 | 19 | 19 | 18 | 15 | 15 | 17 | 13 | 15 | 17 | 13 | 15 | 17 |
| 3-story | 5,300 plf | D | 30 | 29 | 27 | 21 | 19 | 18 | 16 | 14 | 12 | 12 | 10 | 8 | 9 | 8 | 6 | 7 | 6 | 4 |
| | | W | 43 | 44 | 44 | 33 | 32 | 33 | 27 | 27 | 26 | 22 | 22 | 22 | 19 | 20 | 19 | 17 | 17 | 17 |

For SI: 1 inch = 25.4 mm, 1 plf = 14.6 N/m, 1 pound per square foot = 47.9 N/m$^2$.

a. Linear interpolation of stone depth between wall widths is permitted within each Load-Bearing Value of Soil (psf).

b. Crushed stone must be consolidated in 8-inch lifts with a plate vibrator.

c. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.

**R403.4.2 Concrete footings.** Concrete footings shall be installed in accordance with Section R403.1 and Figure R403.4(2).

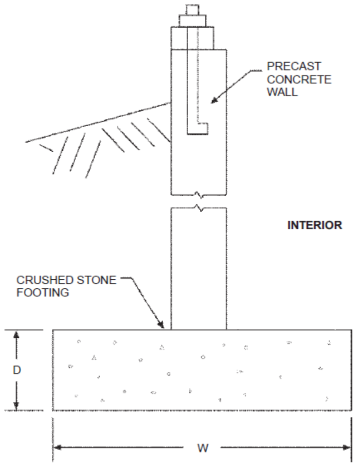



FIGURE R403.4(1)
BASEMENT OR CRAWL SPACE WITH PRECAST
FOUNDATION WALL BEARING ON CRUSHED STONE

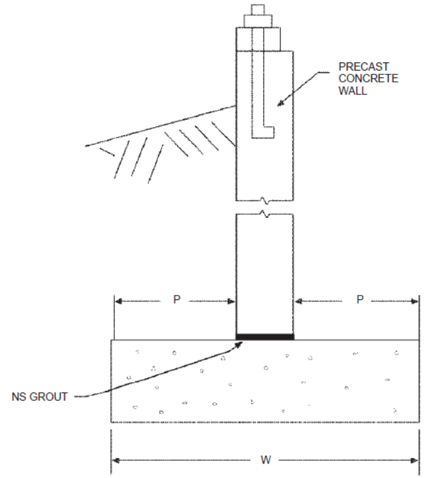



FIGURE R403.4(2)
BASEMENT OR CRAWL SPACE WITH PRECAST
FOUNDATION WALL ON SPREAD FOOTING

## SECTION R404
## FOUNDATION AND RETAINING WALLS

**R404.1.2 Design of masonry foundation walls.** Masonry foundation walls shall be designed and constructed in accordance with the provisions of this section or in accordance with the provisions of TMS 402~~/ACI 530/ASCE 5~~. ~~When~~ Where TMS 402~~/ACI 530/ASCE 5~~ or the provisions of this section are used to design masonry foundation walls, project drawings, typical details and specifications are not required to bear the seal of the architect or engineer responsible for design, unless otherwise required by the state law of the *jurisdiction* having authority.

**R404.1 Concrete and masonry foundation walls.** Concrete foundation walls shall be selected and constructed in accordance with the provisions of Section R404.1.3. Masonry foundation walls shall be selected and constructed in accordance with the provisions of Section R404.1.2.

**R404.1.1 Design required.** Concrete or masonry foundation walls shall be designed in accordance with accepted engineering practice where either of the following conditions exists:

1. Walls are subject to hydrostatic pressure from ground water.
2. Walls supporting more than 48 inches (1219 mm) of unbalanced backfill that do not have permanent lateral support at the top or bottom.

**TABLE R404.1.1(1)**
**PLAIN MASONRY FOUNDATION WALLS[f]**

| MAXIMUM **UNSUPPORTED** WALL HEIGHT (feet) | MAXIMUM UNBALANCED BACKFILL HEIGHT[c] (feet) | PLAIN MASONRY[a] MINIMUM NOMINAL WALL THICKNESS (inches) | | |
|---|---|---|---|---|
| | | Soil classes[b] | | |
| | | GW, GP, SW and SP | GM, GC, SM, SM-SC and ML | SC, MH, ML-CL and inorganic CL |
| 5 | 4 | 6 solid[d] or 8 | 6 solid[d] or 8 | 6 solid[d] or 8 |
| | 5 | 6 solid[d] or 8 | 8 | 10 |
| 6 | 4 | 6 solid[d] or 8 | 6 solid[d] or 8 | 6 solid[d] or 8 |
| | 5 | 6 solid[d] or 8 | 8 | 10 |
| | 6 | 8 | 10 | 12 |

| | | | | |
|---|---|---|---|---|
| 7 | 4 | 6 solid[d] or 8 | 8 | 8 |
| | 5 | 6 solid[d] or 8 | 10 | 10 |
| | 6 | 10 | 12 | 10 solid[d] |
| | 7 | 12 | 10 solid[d] | 12 solid[d] |
| 8 | 4 | 6 solid[d] or 8 | 6 solid[d] or 8 | 8 |
| | 5 | 6 solid[d] or 8 | 10 | 12 |
| | 6 | 10 | 12 | 12 solid[d] |
| | 7 | 12 | 12 solid[d] | Note e |
| | 8 | 10 grout[d] | 12 grout[d] | Note e |
| 9 | 4 | 6 grout[d] or 8 solid[d] or 12 | 6 grout[d] or 8 solid[d] | 8 grout[d] or 10 solid[d] |
| | 5 | 6 grout[d] or 10 solid[d] | 8 grout[d] or 12 solid[d] | 8 grout[d] |
| | 6 | 8 grout[d] or 12 solid[d] | 10 grout[d] | 10 grout[d] |
| | 7 | 10 grout[d] | 10 grout[d] | 12 grout |
| | 8 | 10 grout[d] | 12 grout | Note e |
| | 9 | 12 grout | Note e | Note e |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Mortar shall be Type M or S and masonry shall be laid in running bond. Ungrouted hollow masonry units are permitted except where otherwise indicated.

b. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.

c. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground level. Where an interior concrete slab-on-grade is provided and is in contact with the interior surface of the foundation wall, measurement of the unbalanced backfill height from the exterior finish ground level to the top of the interior concrete slab is permitted.

d. Solid indicates solid masonry unit; grout indicates grouted hollow units.

e. Wall construction shall be in accordance with Table R404.1.1(2), R404.1.1(3) or R404.1.1(4), or a design shall be provided.

f. The use of this table shall be prohibited for soil classifications not shown.

**TABLE R404.1.1(2)**

**8-INCH MASONRY FOUNDATION WALLS WITH REINFORCING WHERE d ≥ 5 INCHES[a, c, f]**

| **MAXIMUM UNSUPPORTED** WALL HEIGHT | HEIGHT OF UNBALANCED BACKFILL[e] | MINIMUM VERTICAL REINFORCEMENT AND SPACING (INCHES)[b, c] | | |
|---|---|---|---|---|
| | | Soil classes and lateral soil load[d] (psf per foot below grade) | | |
| | | GW, GP, SW and SP soils 30 | GM, GC, SM, SM-SC and ML soils 45 | SC, ML-CL and inorganic CL soils 60 |
| 6 feet 8 inches | 4 feet (or less) | #4 at 48 | #4 at 48 | #4 at 48 |
| | 5 feet | #4 at 48 | #4 at 48 | #4 at 48 |
| | 6 feet 8 inches | #4 at 48 | #5 at 48 | #6 at 48 |
| 7 feet 4 inches | 4 feet (or less) | #4 at 48 | #4 at 48 | #4 at 48 |
| | 5 feet | #4 at 48 | #4 at 48 | #4 at 48 |
| | 6 feet | #4 at 48 | #5 at 48 | #5 at 48 |
| | 7 feet 4 inches | #5 at 48 | #6 at 48 | #6 at 40 |

| | | | | |
|---|---|---|---|---|
| 8 feet | 4 feet (or less) | #4 at 48 | #4 at 48 | #4 at 48 |
| | 5 feet | #4 at 48 | #4 at 48 | #4 at 48 |
| | 6 feet | #4 at 48 | #5 at 48 | #5 at 48 |
| | 7 feet | #5 at 48 | #6 at 48 | #6 at 40 |
| | 8 feet | #5 at 48 | #6 at 48 | #6 at 32 |
| 8 feet 8 inches | 4 feet (or less) | #4 at 48 | #4 at 48 | #4 at 48 |
| | 5 feet | #4 at 48 | #4 at 48 | #5 at 48 |
| | 6 feet | #4 at 48 | #5 at 48 | #6 at 48 |
| | 7 feet | #5 at 48 | #6 at 48 | #6 at 40 |
| | 8 feet 8 inches | #6 at 48 | #6 at 32 | #6 at 24 |
| 9 feet 4 inches | 4 feet (or less) | #4 at 48 | #4 at 48 | #4 at 48 |
| | 5 feet | #4 at 48 | #4 at 48 | #5 at 48 |
| | 6 feet | #4 at 48 | #5 at 48 | #6 at 48 |
| | 7 feet | #5 at 48 | #6 at 48 | #6 at 40 |
| | 8 feet | #6 at 48 | #6 at 40 | #6 at 24 |
| | 9 feet 4 inches | #6 at 40 | #6 at 24 | #6 at 16 |
| 10 feet | 4 feet (or less) | #4 at 48 | #4 at 48 | #4 at 48 |
| | 5 feet | #4 at 48 | #4 at 48 | #5 at 48 |
| | 6 feet | #4 at 48 | #5 at 48 | #6 at 48 |
| | 7 feet | #5 at 48 | #6 at 48 | #6 at 32 |
| | 8 feet | #6 at 48 | #6 at 32 | #6 at 24 |
| | 9 feet | #6 at 40 | #6 at 24 | #6 at 16 |
| | 10 feet | #6 at 32 | #6 at 16 | #6 at 16 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/mm.

a. Mortar shall be Type M or S and masonry shall be laid in running bond.

b. Alternative reinforcing bar sizes and spacings having an equivalent cross-sectional area of reinforcement per lineal foot of wall shall be permitted provided the spacing of the reinforcement does not exceed 72 inches in Seismic Design Categories A, B and C.~~, and 48 inches in Seismic Design Categories $D_0$, $D_1$ and $D_2$.~~

c. Vertical reinforcement shall be Grade 60 minimum. The distance, *d*, from the face of the soil side of the wall to the center of vertical reinforcement shall be not less than 5 inches.

d. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist conditions without hydrostatic pressure. Refer to Table R405.1.

e. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground level. Where an interior concrete slab-on-grade is provided and is in contact with the interior surface of the foundation wall, measurement of the unbalanced backfill height from the exterior finish ground level to the top of the interior concrete slab is permitted.

f. The use of this table shall be prohibited for soil classifications not shown.

**TABLE R404.1.1(3)**

**10-INCH MASONRY FOUNDATION WALLS WITH REINFORCING WHERE $d \geq 6.75$ INCHES[a, c, f]**

| | | MINIMUM VERTICAL REINFORCEMENT AND SPACING (INCHES)[b, c] |
|---|---|---|

| **MAXIMUM UNSUPPORTED** WALL HEIGHT | HEIGHT OF UNBALANCED BACKFILL[e] | Soil classes and later soil load[d] (psf per foot below grade) | | |
|---|---|---|---|---|
| | | GW, GP, SW and SP soils 30 | GM, GC, SM, SM-SC and ML soils 45 | SC, ML-CL and inorganic CL soils 60 |
| 6 feet 8 inches | 4 feet (or less) | #4 at 56 | #4 at 56 | #4 at 56 |
| | 5 feet | #4 at 56 | #4 at 56 | #4 at 56 |
| | 6 feet 8 inches | #4 at 56 | #5 at 56 | #5 at 56 |
| 7 feet 4 inches | 4 feet (or less) | #4 at 56 | #4 at 56 | #4 at 56 |
| | 5 feet | #4 at 56 | #4 at 56 | #4 at 56 |
| | 6 feet | #4 at 56 | #4 at 56 | #5 at 56 |
| | 7 feet 4 inches | #4 at 56 | #5 at 56 | #6 at 56 |
| 8 feet | 4 feet (or less) | #4 at 56 | #4 at 56 | #4 at 56 |
| | 5 feet | #4 at 56 | #4 at 56 | #4 at 56 |
| | 6 feet | #4 at 56 | #4 at 56 | #5 at 56 |
| | 7 feet | #4 at 56 | #5 at 56 | #6 at 56 |
| | 8 feet | #5 at 56 | #6 at 56 | #6 at 48 |
| 8 feet 8 inches | 4 feet (or less) | #4 at 56 | #4 at 56 | #4 at 56 |
| | 5 feet | #4 at 56 | #4 at 56 | #4 at 56 |
| | 6 feet | #4 at 56 | #4 at 56 | #5 at 56 |
| | 7 feet | #4 at 56 | #5 at 56 | #6 at 56 |
| | 8 feet 8 inches | #5 at 56 | #6 at 48 | #6 at 32 |
| 9 feet 4 inches | 4 feet (or less) | #4 at 56 | #4 at 56 | #4 at 56 |
| | 5 feet | #4 at 56 | #4 at 56 | #4 at 56 |
| | 6 feet | #4 at 56 | #5 at 56 | #5 at 56 |
| | 7 feet | #4 at 56 | #5 at 56 | #6 at 56 |
| | 8 feet | #5 at 56 | #6 at 56 | #6 at 40 |
| | 9 feet 4 inches | #6 at 56 | #6 at 40 | #6 at 24 |
| 10 feet | 4 feet (or less) | #4 at 56 | #4 at 56 | #4 at 56 |
| | 5 feet | #4 at 56 | #4 at 56 | #4 at 56 |
| | 6 feet | #4 at 56 | #5 at 56 | #5 at 56 |
| | 7 feet | #5 at 56 | #6 at 56 | #6 at 48 |
| | 8 feet | #5 at 56 | #6 at 48 | #6 at 40 |
| | 9 feet | #6 at 56 | #6 at 40 | #6 at 24 |
| | 10 feet | #6 at 48 | #6 at 32 | #6 at 24 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/mm.
a. Mortar shall be Type M or S and masonry shall be laid in running bond.

b. Alternative reinforcing bar sizes and spacings having an equivalent cross-sectional area of reinforcement per lineal foot of wall shall be permitted provided the spacing of the reinforcement does not exceed 72 inches in Seismic Design Categories A, B and C~~, and 48 inches in Seismic Design Categories $D_0$, $D_1$ and $D_2$.~~
c. Vertical reinforcement shall be Grade 60 minimum. The distance, *d*, from the face of the soil side of the wall to the center of vertical reinforcement shall be not less than 6.75 inches.
d. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist conditions without hydrostatic pressure. Refer to Table R405.1.
e. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground level. Where an interior concrete slab-on-grade is provided and is in contact with the interior surface of the foundation wall, measurement of the unbalanced backfill height from the exterior finish ground level to the top of the interior concrete slab is permitted.
f. The use of this table shall be prohibited for soil classifications not shown.

**TABLE R404.1.1(4)**

**12-INCH MASONRY FOUNDATION WALLS WITH REINFORCING WHERE d ≥ 8.75 INCHES[a, c, f]**

| **MAXIMUM UNSUPPORTED** WALL HEIGHT | HEIGHT OF UNBALANCED BACKFILL[e] | MINIMUM VERTICAL REINFORCEMENT AND SPACING (INCHES)[b, c] | | |
|---|---|---|---|---|
| | | Soil classes and lateral soil load[d] (psf per foot below grade) | | |
| | | GW, GP, SW and SP soils 30 | GM, GC, SM, SM-SC and ML soils 45 | SC, ML-CL and inorganic CL soils 60 |
| 6 feet 8 inches | 4 feet (or less) | #4 at 72 | #4 at 72 | #4 at 72 |
| | 5 feet | #4 at 72 | #4 at 72 | #4 at 72 |
| | 6 feet 8 inches | #4 at 72 | #4 at 72 | #5 at 72 |
| 7 feet 4 inches | 4 feet (or less) | #4 at 72 | #4 at 72 | #4 at 72 |
| | 5 feet | #4 at 72 | #4 at 72 | #4 at 72 |
| | 6 feet | #4 at 72 | #4 at 72 | #5 at 72 |
| | 7 feet 4 inches | #4 at 72 | #5 at 72 | #6 at 72 |
| 8 feet | 4 feet (or less) | #4 at 72 | #4 at 72 | #4 at 72 |
| | 5 feet | #4 at 72 | #4 at 72 | #4 at 72 |
| | 6 feet | #4 at 72 | #4 at 72 | #5 at 72 |
| | 7 feet | #4 at 72 | #5 at 72 | #6 at 72 |
| | 8 feet | #5 at 72 | #6 at 72 | #6 at 64 |
| 8 feet 8 inches | 4 feet (or less) | #4 at 72 | #4 at 72 | #4 at 72 |
| | 5 feet | #4 at 72 | #4 at 72 | #4 at 72 |
| | 6 feet | #4 at 72 | #4 at 72 | #5 at 72 |
| | 7 feet | #4 at 72 | #5 at 72 | #6 at 72 |
| | 8 feet 8 inches | #5 at 72 | #7 at 72 | #6 at 48 |
| 9 feet 4 inches | 4 feet (or less) | #4 at 72 | #4 at 72 | #4 at 72 |
| | 5 feet | #4 at 72 | #4 at 72 | #4 at 72 |
| | 6 feet | #4 at 72 | #5 at 72 | #5 at 72 |
| | 7 feet | #4 at 72 | #5 at 72 | #6 at 72 |
| | 8 feet | #5 at 72 | #6 at 72 | #6 at 56 |
| | 9 feet 4 inches | #6 at 72 | #6 at 48 | #6 at 40 |

| | | | | |
|---|---|---|---|---|
| 10 feet | 4 feet (or less) | #4 at 72 | #4 at 72 | #4 at 72 |
| | 5 feet | #4 at 72 | #4 at 72 | #4 at 72 |
| | 6 feet | #4 at 72 | #5 at 72 | #5 at 72 |
| | 7 feet | #4 at 72 | #6 at 72 | #6 at 72 |
| | 8 feet | #5 at 72 | #6 at 72 | #6 at 48 |
| | 9 feet | #6 at 72 | #6 at 56 | #6 at 40 |
| | 10 feet | #6 at 64 | #6 at 40 | #6 at 32 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/mm.

a. Mortar shall be Type M or S and masonry shall be laid in running bond.

b. Alternative reinforcing bar sizes and spacings having an equivalent cross-sectional area of reinforcement per lineal foot of wall shall be permitted provided the spacing of the reinforcement does not exceed 72 inches in Seismic Design Categories A, B and C~~, and 48 inches in Seismic Design Categories $D_0$, $D_1$ and $D_2$.~~

c. Vertical reinforcement shall be Grade 60 minimum. The distance, *d*, from the face of the soil side of the wall to the center of vertical reinforcement shall be not less than 8.75 inches.

d. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist conditions without hydrostatic pressure. Refer to Table R405.1.

e. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground levels. Where an interior concrete slab-on-grade is provided and in contact with the interior surface of the foundation wall, measurement of the unbalanced backfill height is permitted to be measured from the exterior finish ground level to the top of the interior concrete slab is permitted.

f. The use of this table shall be prohibited for soil classifications not shown.

### TABLE R404.1.2(1)
### MINIMUM HORIZONTAL REINFORCEMENT FOR CONCRETE BASEMENT WALLS[a, b]

| MAXIMUM UNSUPPORTED ~~HEIGHT OF BASEMENT~~ WALL HEIGHT (feet) | LOCATION OF HORIZONTAL REINFORCEMENT |
|---|---|
| ≤ 8 | One No. 4 bar within 12 inches of the top of the wall story and one No. 4 bar near mid-height of the wall story. |
| > 8 | One No. 4 bar within 12 inches of the top of the wall story and one No. 4 bar near third points in the wall story. |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa.

a. Horizontal reinforcement requirements are for reinforcing bars with a minimum yield strength of 40,000 psi and concrete with a minimum concrete compressive strength of 2,500 psi.

b. See Section R404.1.3.2 for minimum reinforcement required for foundation walls supporting above-grade concrete walls.

### TABLE R404.1.2(2)
### MINIMUM VERTICAL REINFORCEMENT FOR 6-INCH NOMINAL FLAT CONCRETE BASEMENT WALLS[b, c, d, e, g, h, i, j, k]

| MAXIMUM UNSUPPORTED WALL HEIGHT (feet) | MAXIMUM UNBALANCED BACKFILL HEIGHT[f] (feet) | MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches) | | |
|---|---|---|---|---|
| | | Soil classes[a] and design lateral soil (psf per foot of depth) | | |
| | | GW, GP, SW, SP 30 | GM, GC, SM, SM-SC and ML 45 | SC, ML-CL and inorganic CL 60 |
| 8 | 4 | NR | NR | NR |

| | | | | |
|---|---|---|---|---|
| | 5 | NR | 6 @ 39 | 6 @ 48 |
| | 6 | 5 @ 39 | 6 @ 48 | 6 @ 35 |
| | 7 | 6 @ 48 | 6 @ 34 | 6 @ 25 |
| | 8 | 6 @ 39 | 6 @ 25 | 6 @ 18 |
| 9 | 4 | NR | NR | NR |
| | 5 | NR | 5 @ 37 | 6 @ 48 |
| | 6 | 5 @ 36 | 6 @ 44 | 6 @ 32 |
| | 7 | 6 @ 47 | 6 @ 30 | 6 @ 22 |
| | 8 | 6 @ 34 | 6 @ 22 | 6 @ 16 |
| | 9 | 6 @ 27 | 6 @ 17 | DR |
| 10 | 4 | NR | NR | NR |
| | 5 | NR | 5 @ 35 | 6 @ 48 |
| | 6 | 6 @ 48 | 6 @ 41 | 6 @ 30 |
| | 7 | 6 @ 43 | 6 @ 28 | 6 @ 20 |
| | 8 | 6 @ 31 | 6 @ 20 | DR |
| | 9 | 6 @ 24 | 6 @ 15 | DR |
| | 10 | 6 @ 19 | DR | DR |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.1571 $kPa^2/m$, 1 pound per square inch = 6.895 kPa.
NR = Not Required.
DR = Design Required.

a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.
b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.3.7.2.
c. Vertical reinforcement with a yield strength of less than 60,000 psi and~~/or~~ bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).
d. Deflection criterion is *L*/240, where *L* is the height of the basement wall in inches.
e. Interpolation is not permitted.
f. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
g. NR indicates ~~no~~ vertical wall reinforcement is not required, except for 6-inch-nominal walls formed with stay-in-place forming systems in which case vertical reinforcement shall be No. 4@48 inches on center.
h. See Section R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.
i. See Table R608.3 for tolerance from nominal thickness permitted for flat walls.
j. DR means design is required in accordance with the applicable building code, or ~~where there is no~~ in the absence of a code, in accordance with ACI 318.
k. The use of this table shall be prohibited for soil classifications not shown.

**TABLE R404.1.2(3)**
**MINIMUM VERTICAL REINFORCEMENT FOR 8-INCH (203 mm) NOMINAL FLAT CONCRETE BASEMENT WALLS[b, c, d, e, f, h, i, j]**

| MAXIMUM UNSUPPORTED WALL HEIGHT (feet) | MAXIMUM UNBALANCED BACKFILL HEIGHT[g] (feet) | MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches) | | |
|---|---|---|---|---|
| | | Soil classes[a] and design lateral soil (psf per foot of depth) | | |
| | | GW, GP, SW, SP 30 | GM, GC, SM, SM-SC and ML 45 | SC, ML-CL and inorganic CL 60 |
| 8 | 4 | NR | NR | NR |
| | 5 | NR | NR | NR |
| | 6 | NR | NR | 6 @ 37 |

| | | | | |
|---|---|---|---|---|
| | 7 | NR | 6 @ 36 | 6 @ 35 |
| | 8 | 6 @ 41 | 6 @ 35 | 6 @ 26 |
| 9 | 4 | NR | NR | NR |
| | 5 | NR | NR | NR |
| | 6 | NR | NR | 6 @ 35 |
| | 7 | NR | 6 @ 35 | 6 @ 32 |
| | 8 | 6 @ 36 | 6 @ 32 | 6 @ 23 |
| | 9 | 6 @ 35 | 6 @ 25 | 6 @ 18 |
| 10 | 4 | NR | NR | NR |
| | 5 | NR | NR | NR |
| | 6 | NR | NR | 6 @ 35 |
| | 7 | NR | 6 @ 35 | 6 @ 29 |
| | 8 | 6 @ 35 | 6 @ 29 | 6 @ 21 |
| | 9 | 6 @ 34 | 6 @ 22 | 6 @ 16 |
| | 10 | 6 @ 27 | 6 @ 17 | 6 @ 13 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.1571 $kPa^2/m$, 1 pound per square inch = 6.895 kPa.
NR = Not Required.

a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.
b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi, concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.3.7.2.
c. Vertical reinforcement with a yield strength of less than 60,000 psi and~~/or~~ bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).
d. NR indicates ~~no~~ vertical reinforcement is not required.
e. Deflection criterion is *L*/240, where *L* is the height of the basement wall in inches.
f. Interpolation is not permitted.
g. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
h. See Section R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.
i. See Table R608.3 for tolerance from nominal thickness permitted for flat walls.
j. The use of this table shall be prohibited for soil classifications not shown.

**TABLE R404.1.2(4)**
**MINIMUM VERTICAL REINFORCEMENT FOR 10-INCH NOMINAL FLAT CONCRETE BASEMENT WALLS[b, c, d, e, f, h, i, j]**

| MAXIMUM UNSUPPORTED WALL HEIGHT (feet) | MAXIMUM UNBALANCED BACKFILL HEIGHT[g] (feet) | MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches) | | |
|---|---|---|---|---|
| | | Soil classes[a] and design lateral soil (psf per foot of depth) | | |
| | | GW, GP, SW, SP 30 | GM, GC, SM, SM-SC and ML 45 | SC, ML-CL and inorganic CL 60 |
| 8 | 4 | NR | NR | NR |
| | 5 | NR | NR | NR |
| | 6 | NR | NR | NR |
| | 7 | NR | NR | NR |
| | 8 | 6 @ 48 | 6 @ 35 | 6 @ 28 |

| | | | | |
|---|---|---|---|---|
| 9 | 4 | NR | NR | NR |
| | 5 | NR | NR | NR |
| | 6 | NR | NR | NR |
| | 7 | NR | NR | 6 @ 31 |
| | 8 | NR | 6 @ 31 | 6 @ 28 |
| | 9 | 6 @ 37 | 6 @ 28 | 6 @ 24 |
| 10 | 4 | NR | NR | NR |
| | 5 | NR | NR | NR |
| | 6 | NR | NR | NR |
| | 7 | NR | NR | 6 @ 28 |
| | 8 | NR | 6 @ 28 | 6 @ 28 |
| | 9 | 6 @ 33 | 6 @ 28 | 6 @ 21 |
| | 10 | 6 @ 28 | 6 @ 23 | 6 @ 17 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.1571 kPa$^2$/m, 1 pound per square inch = 6.895 kPa.
NR = Not Required.

a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.
b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.3.7.2.
c. Vertical reinforcement with a yield strength of less than 60,000 psi and~~/or~~ bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).
d. NR indicates ~~no~~ vertical reinforcement is not required.
e. Deflection criterion is *L*/240, where *L* is the height of the basement wall in inches.
f. Interpolation is not permitted.
g. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
h. See Section R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.
i. See Table R608.3 for tolerance from nominal thickness permitted for flat walls.
j. The use of this table shall be prohibited for soil classifications not shown.

**TABLE R404.1.2(5)**
**MINIMUM VERTICAL WALL REINFORCEMENT FOR 6-INCH WAFFLE-GRID BASEMENT WALLS[b, c, d, e, g, h, i, j]**

| MAXIMUM UNSUPPORTED WALL HEIGHT (feet) | MAXIMUM UNBALANCED BACKFILL HEIGHT[f] (feet) | MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches) | | |
|---|---|---|---|---|
| | | Soil classes[a] and design lateral soil (psf per foot of depth) | | |
| | | GW, GP, SW, SP 30 | GM, GC, SM, SM-SC and ML 45 | SC, ML-CL and inorganic CL 60 |
| 8 | 4 | 4 @ 48 | 4 @ 46 | 6 @ 39 |
| | 5 | 4 @ 45 | 5 @ 46 | 6 @ 47 |
| | 6 | 5 @ 45 | 6 @ 40 | DR |
| | 7 | 6 @ 44 | DR | DR |
| | 8 | 6 @ 32 | DR | DR |
| 9 | 4 | 4 @ 48 | 4 @ 46 | 4 @ 37 |
| | 5 | 4 @ 42 | 5 @ 43 | 6 @ 44 |
| | 6 | 5 @ 41 | 6 @ 37 | DR |

| | | | | |
|---|---|---|---|---|
| | 7 | 6 @ 39 | DR | DR |
| | > 8 | DR[i] | DR | DR |
| 10 | 4 | 4 @ 48 | 4 @ 46 | 4 @ 35 |
| | 5 | 4 @ 40 | 5 @ 40 | 6 @ 41 |
| | 6 | 5 @ 38 | 6 @ 34 | DR |
| | 7 | 6 @ 36 | DR | DR |
| | > 8 | DR | DR | DR |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.1571 $kPa^2/m$, 1 pound per square inch = 6.895 kPa.
DR = Design Required.
a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.
b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.3.7.2.
c. Maximum spacings shown are the values calculated for the specified bar size. Where the bar used is Grade 60 and the size specified in the table, the actual spacing in the wall shall not exceed a whole-number multiple of 12 inches (12, 24, 36 and 48) that is less than or equal to the tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi and bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).
d. Deflection criterion is *L*/240, where *L* is the height of the basement wall in inches.
e. Interpolation is not permitted.
f. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
g. See Section R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.
h. See Table R608.3 for thicknesses and dimensions of waffle-grid walls.
i. DR means design is required in accordance with the applicable building code, or in the absence of a code, in accordance with ACI 318.
j. The use of this table shall be prohibited for soil classifications not shown.

**TABLE R404.1.2(6)**
**MINIMUM VERTICAL REINFORCEMENT FOR 8-INCH WAFFLE-GRID BASEMENT WALLS[b, c, d, e, f, h, i, j, k]**

| MAXIMUM UNSUPPORTED WALL HEIGHT (feet) | MAXIMUM UNBALANCED BACKFILL HEIGHT[g] (feet) | MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches) | | |
|---|---|---|---|---|
| | | Soil classes[a] and design lateral soil (psf per foot of depth) | | |
| | | GW, GP, SW, SP 30 | GM, GC, SM, SM-SC and ML 45 | SC, ML-CL and inorganic CL 60 |
| 8 | 4 | NR | NR | NR |
| | 5 | NR | 5 @ 48 | 5 @ 46 |
| | 6 | 5 @ 48 | 5 @ 43 | 6 @ 45 |
| | 7 | 5 @ 46 | 6 @ 43 | 6 @ 31 |
| | 8 | 6 @ 48 | 6 @ 32 | 6 @ 23 |
| 9 | 4 | NR | NR | NR |
| | 5 | NR | 5 @ 47 | 5 @ 46 |
| | 6 | 5 @ 46 | 5 @ 39 | 6 @ 41 |
| | 7 | 5 @ 42 | 6 @ 38 | 6 @ 28 |
| | 8 | 6 @ 44 | 6 @ 28 | 6 @ 20 |
| | 9 | 6 @ 34 | 6 @ 21 | DR |
| 10 | 4 | NR | NR | NR |
| | 5 | NR | 5 @ 46 | 5 @ 44 |

| | | | | |
|---|---|---|---|---|
| | 6 | 5 @ 46 | 5 @ 37 | 6 @ 38 |
| | 7 | 5 @ 38 | 6 @ 35 | 6 @ 25 |
| | 8 | 6 @ 39 | 6 @ 25 | DR |
| | 9 | 6 @ 30 | DR | DR |
| | 10 | 6 @ 24 | DR | DR |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.1571 $kPa^2/m$, 1 pound per square inch = 6.895 kPa.
NR = Not Required.
DR = Design Required.
a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.
b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.3.7.2.
c. Maximum spacings shown are the values calculated for the specified bar size. Where the bar used is Grade 60 (420 MPa) and the size specified in the table, the actual spacing in the wall shall not exceed a whole-number multiple of 12 inches (12, 24, 36 and 48) that is less than or equal to the tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi and bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).
d. NR indicates vertical reinforcement is not required.
e. Deflection criterion is *L*/240, where *L* is the height of the basement wall in inches.
f. Interpolation shall not be permitted.
g. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
h. See Section R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.
i. See Table R608.3 for thicknesses and dimensions of waffle-grid walls.
j. DR means design is required in accordance with the applicable building code, or in the absence of a code, in accordance with ACI 318.
k. The use of this table shall be prohibited for soil classifications not shown.

**TABLE R404.1.2(7)**
**MINIMUM VERTICAL REINFORCEMENT FOR 6-INCH (152 mm) SCREEN-GRID BASEMENT WALLS[b, c, d, e, g, h, i, j]**

| MAXIMUM UNSUPPORTED WALL HEIGHT (feet) | MAXIMUM UNBALANCED BACKFILL HEIGHT[f] (feet) | MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches) | | |
|---|---|---|---|---|
| | | Soil classes[a] and design lateral soil (psf per foot of depth) | | |
| | | GW, GP, SW, SP 30 | GM, GC, SM, SM-SC and ML 45 | SC, ML-CL and inorganic CL 60 |
| 8 | 4 | 4 @ 48 | 4 @ 48 | 5 @ 43 |
| | 5 | 4 @ 48 | 5 @ 48 | 5 @ 37 |
| | 6 | 5 @ 48 | 6 @ 45 | 6 @ 32 |
| | 7 | 6 @ 48 | DR | DR |
| | 8 | 6 @ 36 | DR | DR |
| 9 | 4 | 4 @ 48 | 4 @ 48 | 4 @ 41 |
| | 5 | 4 @ 48 | 5 @ 48 | 6 @ 48 |
| | 6 | 5 @ 45 | 6 @ 41 | DR |
| | 7 | 6 @ 43 | DR | DR |
| | > 8 | DR | DR | DR |
| 10 | 4 | 4 @ 48 | 4 @ 48 | 4 @ 39 |
| | 5 | 4 @ 44 | 5 @ 44 | 6 @ 46 |
| | 6 | 5 @ 42 | 6 @ 38 | DR |
| | 7 | 6 @ 40 | DR | DR |

| | | | | |
|---|---|---|---|---|
| | > 8 | DR | DR | DR |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.1571 kPa$^2$/m, 1 pound per square inch = 6.895 kPa.
DR = Design Required.

a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.

b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi, concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.3.7.2.

c. Maximum spacings shown are the values calculated for the specified bar size. Where the bar used is Grade 60 and the size specified in the table, the actual spacing in the wall shall not exceed a whole-number multiple of 12 inches (12, 24, 36 and 48) that is less than or equal to the tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi and bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).

d. Deflection criterion is *L*/240, where *L* is the height of the basement wall in inches.

e. Interpolation is not permitted.

f. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.

g. See Sections R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.

h. See Table R608.3 for thicknesses and dimensions of screen-grid walls.

i. DR means design is required in accordance with the applicable building code, or in the absence of a code, in accordance with ACI 318.

j. The use of this table shall be prohibited for soil classifications not shown.

**TABLE R404.1.2(8)**

**MINIMUM VERTICAL REINFORCEMENT FOR 6-, 8-, 10- AND 12-INCH NOMINAL FLAT BASEMENT WALLS[b, c, d, e, f, h, i, k, n, o]**

| MAXIMUM UNSUPPORTED WALL HEIGHT (feet) | MAXIMUM UNBALANCED BACKFILL HEIGHT[g] (feet) | MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Soil classes[a] and design lateral soil (psf per foot of depth) | | | | | | | | | | | |
| | | GW, GP, SW, SP 30 | | | | GM, GC, SM, SM-SC and ML 45 | | | | SC, ML-CL and inorganic CL 60 | | | |
| | | Minimum nominal wall thickness (inches) | | | | | | | | | | | |
| | | 6 | 8 | 10 | 12 | 6 | 8 | 10 | 12 | 6 | 8 | 10 | 12 |
| 5 | 4 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | 5 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| 6 | 4 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | 5 | NR | NR | NR | NR | NR | NR[l] | NR | NR | 4 @ 35 | NR[l] | NR | NR |
| | 6 | NR | NR | NR | NR | 5 @ 48 | NR | NR | NR | 5 @ 36 | NR | NR | NR |
| 7 | 4 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | 5 | NR | NR | NR | NR | NR | NR | NR | NR | 5 @ 47 | NR | NR | NR |
| | 6 | NR | NR | NR | NR | 5 @ 42 | NR | NR | NR | 6 @ 43 | 5 @ 48 | NR[l] | NR |
| | 7 | 5 @ 46 | NR | NR | NR | 6 @ 42 | 5 @ 46 | NR[l] | NR | 6 @ 34 | 6 @ 48 | NR | NR |
| 8 | 4 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | 5 | NR | NR | NR | NR | 4 @ 38 | NR[l] | NR | NR | 5 @ 43 | NR | NR | NR |
| | 6 | 4 @ 37 | NR[l] | NR | NR | 5 @ 37 | NR | NR | NR | 6 @ 37 | 5 @ 43 | NR[l] | NR |
| | 7 | 5 @ 40 | NR | NR | NR | 6 @ 37 | 5 @ 41 | NR[l] | NR | 6 @ 34 | 6 @ 43 | NR | NR |
| | 8 | 6 @ 43 | 5 @ 47 | NR[l] | NR | 6 @ 34 | 6 @ 43 | NR | NR | 6 @ 27 | 6 @ 32 | 6 @ 44 | NR |
| 9 | 4 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | 5 | NR | NR | NR | NR | 4 @ 35 | NR[l] | NR | NR | 5 @ 40 | NR | NR | NR |
| | 6 | 4 @ 34 | NR[l] | NR | NR | 6 @ 48 | NR | NR | NR | 6 @ 36 | 6 @ 39 | NR[l] | NR |
| | 7 | 5 @ 36 | NR | NR | NR | 6 @ 34 | 5 @ 37 | NR | NR | 6 @ 33 | 6 @ 38 | 5 @ 37 | NR[l] |
| | 8 | 6 @ 38 | 5 @ 41 | NR[l] | NR | 6 @ 33 | 6 @ 38 | 5 @ 37 | NR[l] | 6 @ 24 | 6 @ 29 | 6 @ 39 | 4 @ 48[m] |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9 | 6 @ 34 | 6 @ 46 | NR | NR | 6 @ 26 | 6 @ 30 | 6 @ 41 | NR | 6 @ 19 | 6 @ 23 | 6 @ 30 | 6 @ 39 |
| 10 | 4 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | 5 | NR | NR | NR | NR | 4 @ 33 | NR[l] | NR | NR | 5 @ 38 | NR | NR | NR |
| | 6 | 5 @ 48 | NR[l] | NR | NR | 6 @ 45 | NR | NR | NR | 6 @ 34 | 5 @ 37 | NR | NR |
| | 7 | 6 @ 47 | NR | NR | NR | 6 @ 34 | 6 @ 48 | NR | NR | 6 @ 30 | 6 @ 35 | 6 @ 48 | NR[l] |
| | 8 | 6 @ 34 | 5 @ 38 | NR | NR | 6 @ 30 | 6 @ 34 | 6 @ 47 | NR[l] | 6 @ 22 | 6 @ 26 | 6 @ 35 | 6 @ 45[m] |
| | 9 | 6 @ 34 | 6 @ 41 | 4 @ 48 | NR[l] | 6 @ 23 | 6 @ 27 | 6 @ 35 | 4 @ 48[m] | DR | 6 @ 22 | 6 @ 27 | 6 @ 34 |
| | 10 | 6 @ 28 | 6 @ 33 | 6 @ 45 | NR | DR[j] | 6 @ 23 | 6 @ 29 | 6 @ 38 | DR | 6 @ 22 | 6 @ 22 | 6 @ 28 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.1571 $kPa^2/m$, 1 pound per square inch = 6.895 kPa.
NR = Not Required.
DR = Design Required.

a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.
b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi.
c. Vertical reinforcement with a yield strength of less than 60,000 psi and bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).
d. NR indicates vertical wall reinforcement is not required, except for 6-inch nominal walls formed with stay-in-place forming systems in which case vertical reinforcement shall be No. 4@48 inches on center.
e. Allowable deflection criterion is $L/240$, where $L$ is the unsupported height of the basement wall in inches.
f. Interpolation is not permitted.
g. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
h. Vertical reinforcement shall be located to provide a cover of $1^{1}/_{4}$ inches measured from the inside face of the wall. The center of the steel shall not vary from the specified location by more than the greater of 10 percent of the wall thickness or $^{3}/_{8}$ inch.
i. Concrete cover for reinforcement measured from the inside face of the wall shall be not less than $^{3}/_{4}$ inch. Concrete cover for reinforcement measured from the outside face of the wall shall be not less than $1^{1}/_{2}$ inches for No. 5 bars and smaller, and not less than 2 inches for larger bars.
j. DR means design is required in accordance with the applicable building code, or in the absence of a code, in accordance with ACI 318.
k. Concrete shall have a specified compressive strength, $f'_c$, of not less than 2,500 psi at 28 days, unless a higher strength is required by Note l or m.
l. The minimum thickness is permitted to be reduced 2 inches, provided that the minimum specified compressive strength of concrete, $f'_c$, is 4,000 psi.
m. A plain concrete wall with a minimum nominal thickness of 12 inches is permitted, provided that the minimum specified compressive strength of concrete, $f'_c$, is 3,500 psi.
n. See Table R608.3 for tolerance from nominal thickness permitted for flat walls.
o. The use of this table shall be prohibited for soil classifications not shown.

**~~TABLE R404.1.2(5)~~ TABLE R404.1.2(9)**
**MINIMUM SPACING FOR ALTERNATE BAR SIZE AND~~/OR~~ ALTERNATE GRADE OF STEEL[a, b, c]**

| BAR SPACING FROM APPLICABLE TABLE IN SECTION R404.1.3.2 (inches) | BAR SIZE FROM APPLICABLE TABLE IN SECTION R404.1.3.2 | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #4 | | | | | #5 | | | | | #6 | | | | |
| | Alternate bar size and~~/or~~ alternate grade of steel desired | | | | | | | | | | | | | | |
| | Grade 60 | | Grade 40 | | | Grade 60 | | Grade 40 | | | Grade 60 | | Grade 40 | | |
| | #5 | #6 | #4 | #5 | #6 | #4 | #6 | #4 | #5 | #6 | #4 | #5 | #4 | #5 | #6 |
| | Maximum spacing for alternate bar size and~~/or~~ alternate grade of steel (inches) | | | | | | | | | | | | | | |
| 8 | 12 | 18 | 5 | 8 | 12 | 5 | 11 | 3 | 5 | 8 | 4 | 6 | 2 | 4 | 5 |
| 9 | 14 | 20 | 6 | 9 | 13 | 6 | 13 | 4 | 6 | 9 | 4 | 6 | 3 | 4 | 6 |
| 10 | 16 | 22 | 7 | 10 | 15 | 6 | 14 | 4 | 7 | 9 | 5 | 7 | 3 | 5 | 7 |
| 11 | 17 | 24 | 7 | 11 | 16 | 7 | 16 | 5 | 7 | 10 | 5 | 8 | 3 | 5 | 7 |
| 12 | 19 | 26 | 8 | 12 | 18 | 8 | 17 | 5 | 8 | 11 | 5 | 8 | 4 | 6 | 8 |
| 13 | 20 | 29 | 9 | 13 | 19 | 8 | 18 | 6 | 9 | 12 | 6 | 9 | 4 | 6 | 9 |
| 14 | 22 | 31 | 9 | 14 | 21 | 9 | 20 | 6 | 9 | 13 | 6 | 10 | 4 | 7 | 9 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 23 | 33 | 10 | 16 | 22 | 10 | 21 | 6 | 10 | 14 | 7 | 11 | 5 | 7 | 10 |
| 16 | 25 | 35 | 11 | 17 | 23 | 10 | 23 | 7 | 11 | 15 | 7 | 11 | 5 | 8 | 11 |
| 17 | 26 | 37 | 11 | 18 | 25 | 11 | 24 | 7 | 11 | 16 | 8 | 12 | 5 | 8 | 11 |
| 18 | 28 | 40 | 12 | 19 | 26 | 12 | 26 | 8 | 12 | 17 | 8 | 13 | 5 | 8 | 12 |
| 19 | 29 | 42 | 13 | 20 | 28 | 12 | 27 | 8 | 13 | 18 | 9 | 13 | 6 | 9 | 13 |
| 20 | 31 | 44 | 13 | 21 | 29 | 13 | 28 | 9 | 13 | 19 | 9 | 14 | 6 | 9 | 13 |
| 21 | 33 | 46 | 14 | 22 | 31 | 14 | 30 | 9 | 14 | 20 | 10 | 15 | 6 | 10 | 14 |
| 22 | 34 | 48 | 15 | 23 | 32 | 14 | 31 | 9 | 15 | 21 | 10 | 16 | 7 | 10 | 15 |
| 23 | 36 | 48 | 15 | 24 | 34 | 15 | 33 | 10 | 15 | 22 | 10 | 16 | 7 | 11 | 15 |
| 24 | 37 | 48 | 16 | 25 | 35 | 15 | 34 | 10 | 16 | 23 | 11 | 17 | 7 | 11 | 16 |
| 25 | 39 | 48 | 17 | 26 | 37 | 16 | 35 | 11 | 17 | 24 | 11 | 18 | 8 | 12 | 17 |
| 26 | 40 | 48 | 17 | 27 | 38 | 17 | 37 | 11 | 17 | 25 | 12 | 18 | 8 | 12 | 17 |
| 27 | 42 | 48 | 18 | 28 | 40 | 17 | 38 | 12 | 18 | 26 | 12 | 19 | 8 | 13 | 18 |
| 28 | 43 | 48 | 19 | 29 | 41 | 18 | 40 | 12 | 19 | 26 | 13 | 20 | 8 | 13 | 19 |
| 29 | 45 | 48 | 19 | 30 | 43 | 19 | 41 | 12 | 19 | 27 | 13 | 20 | 9 | 14 | 19 |
| 30 | 47 | 48 | 20 | 31 | 44 | 19 | 43 | 13 | 20 | 28 | 14 | 21 | 9 | 14 | 20 |
| 31 | 48 | 48 | 21 | 32 | 45 | 20 | 44 | 13 | 21 | 29 | 14 | 22 | 9 | 15 | 21 |
| 32 | 48 | 48 | 21 | 33 | 47 | 21 | 45 | 14 | 21 | 30 | 15 | 23 | 10 | 15 | 21 |
| 33 | 48 | 48 | 22 | 34 | 48 | 21 | 47 | 14 | 22 | 31 | 15 | 23 | 10 | 16 | 22 |
| 34 | 48 | 48 | 23 | 35 | 48 | 22 | 48 | 15 | 23 | 32 | 15 | 24 | 10 | 16 | 23 |
| 35 | 48 | 48 | 23 | 36 | 48 | 23 | 48 | 15 | 23 | 33 | 16 | 25 | 11 | 16 | 23 |
| 36 | 48 | 48 | 24 | 37 | 48 | 23 | 48 | 15 | 24 | 34 | 16 | 25 | 11 | 17 | 24 |
| 37 | 48 | 48 | 25 | 38 | 48 | 24 | 48 | 16 | 25 | 35 | 17 | 26 | 11 | 17 | 25 |
| 38 | 48 | 48 | 25 | 39 | 48 | 25 | 48 | 16 | 25 | 36 | 17 | 27 | 12 | 18 | 25 |
| 39 | 48 | 48 | 26 | 40 | 48 | 25 | 48 | 17 | 26 | 37 | 18 | 27 | 12 | 18 | 26 |
| 40 | 48 | 48 | 27 | 41 | 48 | 26 | 48 | 17 | 27 | 38 | 18 | 28 | 12 | 19 | 27 |
| 41 | 48 | 48 | 27 | 42 | 48 | 26 | 48 | 18 | 27 | 39 | 19 | 29 | 12 | 19 | 27 |
| 42 | 48 | 48 | 28 | 43 | 48 | 27 | 48 | 18 | 28 | 40 | 19 | 30 | 13 | 20 | 28 |
| 43 | 48 | 48 | 29 | 44 | 48 | 28 | 48 | 18 | 29 | 41 | 20 | 30 | 13 | 20 | 29 |
| 44 | 48 | 48 | 29 | 45 | 48 | 28 | 48 | 19 | 29 | 42 | 20 | 31 | 13 | 21 | 29 |
| 45 | 48 | 48 | 30 | 47 | 48 | 29 | 48 | 19 | 30 | 43 | 20 | 32 | 14 | 21 | 30 |
| 46 | 48 | 48 | 31 | 48 | 48 | 30 | 48 | 20 | 31 | 44 | 21 | 32 | 14 | 22 | 31 |
| 47 | 48 | 48 | 31 | 48 | 48 | 30 | 48 | 20 | 31 | 44 | 21 | 33 | 14 | 22 | 31 |
| 48 | 48 | 48 | 32 | 48 | 48 | 31 | 48 | 21 | 32 | 45 | 22 | 34 | 15 | 23 | 32 |

For SI: 1 inch = 25.4 mm.

a. This table is for use with tables in Section R404.1.3.2 that specify the minimum bar size and maximum spacing of vertical wall reinforcement for foundation walls and above-grade walls. Reinforcement specified in tables in Section R404.1.3.2 is based on Grade 60 steel reinforcement.

b. Bar spacing shall not exceed 48 inches on center and shall be not less than one-half the nominal wall thickness.

c. For Grade 50 steel bars (ASTM A996, Type R), use spacing for Grade 40 bars or interpolate between Grades 40 and 60.

**R404.1.2.1 Masonry foundation walls.** *Concrete masonry* and *clay masonry* foundation walls shall be constructed as set forth in Table R404.1.1(1), R404.1.1(2), R404.1.1(3) or R404.1.1(4) and shall comply with applicable provisions of Section R606. Rubble stone masonry foundation walls shall be constructed in accordance with Sections R404.1.8 and ~~R606.3.2~~ R606.4.2. Rubble stone masonry walls shall not be used in *townhouses* in Seismic Design Category C.

**R404.1.3 Concrete foundation walls.** Concrete foundation walls that support light-frame walls shall be designed and constructed in accordance with the provisions of this section, ACI 318, ACI 332 or PCA 100. Concrete foundation walls that support above-grade concrete walls that are within the applicability limits of Section R608.2 shall be designed and constructed in accordance with the provisions of this section, ACI 318, ACI 332 or PCA 100. Concrete foundation walls that support above-grade concrete walls that are not within the applicability limits of Section R608.2 shall be designed and constructed in accordance with the provisions of ACI 318, ACI 332 or PCA 100. ~~When~~ Where ACI 318, ACI 332, PCA 100 or the provisions of this section are used to design concrete foundation walls, project drawings, typical details and specifications are not required to bear the seal of the architect or engineer responsible for design, unless otherwise required by the state law of the *jurisdiction* having authority.

**R404.1.3.1 Concrete cross section.** Concrete walls constructed in accordance with this code shall comply with the shapes and minimum concrete cross-sectional dimensions required by Table R608.3. Other types of forming systems resulting in concrete walls not in compliance with this section and Table R608.3 shall be designed in accordance with ACI 318.

**R404.1.3.2 Reinforcement for foundation walls.** Concrete foundation walls shall be laterally supported at the top and bottom. Horizontal reinforcement shall be provided in accordance with Table R404.1.2(1). Vertical reinforcement shall be provided in accordance with Table R404.1.2(2), R404.1.2(3), R404.1.2(4), R404.1.2(5), R404.1.2(6), R404.1.2(7) or R404.1.2(8). Vertical reinforcement for flat *basement* walls retaining 4 feet (1219 mm) or more of unbalanced backfill is permitted to be determined in accordance with Table R404.1.2(9). For *basement* walls supporting above-grade concrete walls, vertical reinforcement shall be the greater of that required by Tables R404.1.2(2) through R404.1.2(8) or by Section R608.6 for the above-grade wall. In buildings assigned to Seismic Design Category $D_0$, $D_1$ or $D_2$, concrete foundation walls shall also comply with Section R404.1.4.2.

**R404.1.3.2.1 Concrete foundation stem walls supporting above-grade concrete walls.** Foundation stem walls that support above-grade concrete walls shall be designed and constructed in accordance with this section.

1. Stem walls not laterally supported at top. Concrete stem walls that are not monolithic with slabs-on-ground or are not otherwise laterally supported by slabs-on-ground shall comply with this section. Where unbalanced backfill retained by the stem wall is less than or equal to 18 inches (457 mm), the stem wall and above-grade wall it supports shall be provided with vertical reinforcement in accordance with Section R608.6 and Table R608.6(1), R608.6(2) or R608.6(3) for above-grade walls. Where unbalanced backfill retained by the stem wall is greater than 18 inches (457 mm), the stem wall and above-grade wall it supports shall be provided with vertical reinforcement in accordance with Section R608.6 and Table R608.6(1).
2. Stem walls laterally supported at top. Concrete stem walls that are monolithic with slabs-on-ground or are otherwise laterally supported by slabs-on-ground shall be vertically reinforced in accordance with Section R608.6 and Table R608.6(1), R608.6(2) or R608.6(3) for above-grade walls. Where the unbalanced backfill retained by the stem wall is greater than 18 inches (457 mm), the connection between the stem wall and the slab-on-ground, and the portion of the slab-on-ground providing lateral support for the wall shall be designed in accordance with PCA 100 or with accepted engineering practice. Where the unbalanced backfill retained by the stem wall is greater than 18 inches (457 mm), the minimum nominal thickness of the wall shall be 6 inches (152 mm).

**R404.1.3.2.2 Concrete foundation stem walls supporting light-frame above-grade walls.** Concrete foundation stem walls that support light-frame above-grade walls shall be designed and constructed in accordance with this section.

1. Stem walls not laterally supported at top. Concrete stem walls that are not monolithic with slabs-on-ground or are not otherwise laterally supported by slabs-on-ground and retain 48 inches (1219 mm) or less of unbalanced fill, measured from the top of the wall, shall be constructed in accordance with Section R404.1.3. Foundation stem walls that retain more than 48 inches (1219 mm) of unbalanced fill, measured from the top of the wall, shall be designed in accordance with Sections R404.1.1 and R404.4.
2. Stem walls laterally supported at top. Concrete stem walls that are monolithic with slabs-on-ground or are otherwise laterally supported by slabs-on-ground shall be constructed in accordance with Section R404.1.3. Where the unbalanced backfill retained by the stem wall is greater than 48 inches (1219 mm), the connection between the stem wall and the slab-on-ground, and the portion of the slab-on-ground providing lateral support for the wall, shall be designed in accordance with PCA 100 or in accordance with accepted engineering practice.

**R404.1.3.3 Concrete, materials for concrete, and forms.** Materials used in concrete, the concrete itself and forms shall conform to requirements of this section or ACI 318.

**R404.1.3.3.1 Compressive strength.** The minimum specified compressive strength of concrete, $f'_c$, shall comply with Section R402.2 and shall be not less than 2,500 psi (17.2 MPa) at 28 days in buildings assigned to Seismic Design Category A, B or C and 3,000 psi (20.5 MPa) in buildings assigned to Seismic Design Category $D_0$, $D_1$ or $D_2$.

**R404.1.3.3.2 Concrete mixing and delivery.** Mixing and delivery of concrete shall comply with ASTM C94 or ASTM C685.

**R404.1.3.3.3 Maximum aggregate size.** The nominal maximum size of coarse aggregate shall not exceed one-fifth the narrowest distance between sides of forms, or three-fourths the clear spacing between reinforcing bars or between a bar and the side of the form.

**Exception:** ~~When~~ Where *approved*, these limitations shall not apply where removable forms are used and workability and methods of consolidation permit concrete to be placed without honeycombs or voids.

**R404.1.3.3.4 Proportioning and slump of concrete.** Proportions of materials for concrete shall be established to provide workability and consistency to permit concrete to be worked readily into forms and around reinforcement under conditions of placement to be employed, without segregation or excessive bleeding. Slump of concrete placed in removable forms shall not exceed 6 inches (152 mm).

**Exception:** ~~When~~ Where *approved*, the slump is permitted to exceed 6 inches (152 mm) for concrete mixtures that are resistant to segregation, and are in accordance with the form manufacturer's recommendations.

Slump of concrete placed in stay-in-place forms shall exceed 6 inches (152 mm). Slump of concrete shall be determined in accordance with ASTM C143.

**R404.1.3.3.5 Consolidation of concrete.** Concrete shall be consolidated by suitable means during placement and shall be worked around embedded items and reinforcement and into corners of forms. Where stay-in-place forms are used, concrete shall be consolidated by internal vibration.

**Exception:** ~~When~~ Where *approved* for concrete to be placed in stay-in-place forms, self-consolidating concrete mixtures with slumps equal to or greater than 8 inches (203 mm) that are specifically designed for placement without internal vibration need not be internally vibrated.

**R404.1.3.3.6 Form materials and form ties.** Forms shall be made of wood, steel, aluminum, plastic, a composite of cement and foam insulation, a composite of cement and wood chips, or other *approved* material suitable for supporting and containing concrete. Forms shall be accurately positioned and secured before placing concrete and shall provide sufficient strength to contain concrete during the concrete placement operation.

Form ties shall be steel, solid plastic, foam plastic, a composite of cement and wood chips, a composite of cement and foam plastic, or other suitable material capable of resisting the forces created by fluid pressure of fresh concrete.

**R404.1.3.3.6.1 Stay-in-place forms.** Stay-in-place concrete forms shall comply with this section.

1. Surface burning characteristics. The flame-spread index and *smoke-developed index* of forming material, other than foam plastic, left exposed on the interior shall comply with Section R302. The surface burning characteristics of foam plastic used in *insulating concrete forms* shall comply with Section R316.3.
2. Interior covering. Stay-in-place forms constructed of rigid foam plastic shall be protected on the interior of the building as required by Section R316. Where gypsum board is used to protect the foam plastic, it shall be installed with a mechanical fastening system. Use of adhesives in addition to mechanical fasteners is permitted.
3. Exterior wall covering. Stay-in-place forms constructed of rigid foam plastics shall be protected from sunlight and physical damage by the application of an *approved* exterior wall covering complying with this code. Exterior surfaces of other stay-in-place forming systems shall be protected in accordance with this code.
4. Termite ~~harzards.~~ protection. ~~In areas where hazard of termite damage is very heavy in accordance with Figure R301.2(6),~~ Foam plastic insulation shall be permitted below grade on foundation walls in accordance with ~~one of the following conditions~~ Section R318.4.

    ~~4.1. Where in addition to the requirements in Section R318.1, an *approved* method of protecting the foam plastic~~
    ~~and structure from subterranean termite damage is provided.~~
    ~~4.2. The structural members of walls, floors, ceilings and roofs are entirely of noncombustible materials or~~
    ~~pressure-preservative-treated wood.~~
    ~~4.3. On the interior side of *basement walls*.~~

5. Flat ICF wall system forms shall conform to ASTM E2634.

**R404.1.3.3.7 Reinforcement.**

**R404.1.3.3.7.1 Steel reinforcement.** Steel reinforcement shall comply with the requirements of ASTM A615, A706M or A996. ASTM A996 bars produced from rail steel shall be Type R. In buildings assigned to Seismic Design Category A, B or C, the minimum yield strength of reinforcing steel shall be 40,000 psi (Grade 40) (276 MPa).

**R404.1.3.3.7.2 Location of reinforcement in wall.** The center of vertical reinforcement in *basement* walls determined from Tables R404.1.2(2) through ~~R404.1.2(4)~~ R404.1.2(7) shall be located at the centerline of the wall. Vertical reinforcement in *basement* walls determined from Table R404.1.2(8) shall be located to provide a maximum cover of $1^1/_4$ inches (32 mm) measured from the inside face of the wall. Regardless of the table used to determine vertical wall reinforcement, the center of the steel shall not vary from the specified location by more than the greater of 10 percent of the wall thickness and $^3/_8$ inch (10 mm). Horizontal and vertical reinforcement shall be located in foundation walls to provide the minimum cover required by Section R404.1.3.3.7.4.

**R404.1.3.3.7.3 Wall openings.** Vertical wall reinforcement required by Section R404.1.3.2 that is interrupted by wall openings shall have additional vertical reinforcement of the same size placed within 12 inches (305 mm) of each side of the opening.

**R404.1.3.3.7.4 Support and cover.** Reinforcement shall be secured in the proper location in the forms with tie wire or other bar support system to prevent displacement during the concrete placement operation. Steel reinforcement in concrete cast against the earth shall have a minimum cover of 3 inches (75 mm). Minimum cover for reinforcement in concrete cast in removable forms that will be exposed to the earth or weather shall be $1^1/_2$ inches (38 mm) for No. 5 bars and smaller, and 2 inches (50 mm) for No. 6 bars and larger. For concrete cast in removable forms that will not be exposed to the earth or weather, and for concrete cast in stay-in-place forms, minimum cover shall be $^3/_4$ inch (19 mm). The minus tolerance for cover shall not exceed the smaller of one-third the required cover or $^3/_8$ inch (10 mm).

**R404.1.3.3.7.5 Lap splices.** Vertical and horizontal wall reinforcement shall be the longest lengths practical. Where splices are necessary in reinforcement, the length of lap splice shall be in accordance with Table R608.5.4(1) and Figure R608.5.4(1). The maximum gap between noncontact parallel bars at a lap splice shall not exceed the smaller of one-fifth the required lap length and 6 inches (152 mm) [See Figure R608.5.4(1)].

**R404.1.3.3.7.6 Alternate grade of reinforcement and spacing.** Where tables in Section R404.1.3.2 specify vertical wall reinforcement based on minimum bar size and maximum spacing, which are based on Grade 60 (414 MPa) steel reinforcement, different size bars or bars made from a different grade of steel are permitted provided that an equivalent area of steel per linear foot of wall is provided. Use of ~~Table R401.1.2(5)~~ Table R404.1.2(9) is permitted to determine the maximum bar spacing for different bar sizes than specified in the tables or bars made from a different grade of steel. Bars shall not be spaced less than one-half the wall thickness, or more than 48 inches (1219 mm) on center.

**R404.1.3.3.7.7 Standard hooks.** Where reinforcement is required by this code to terminate with a standard hook, the hook shall comply with Section R608.5.4.5 and Figure R608.5.4(3).

**R404.1.3.3.7.8 Construction joint reinforcement.** Construction joints in foundation walls shall be made and located to not impair the strength of the wall. Construction joints in plain concrete walls, including walls required to have ~~a minimum of~~ not less than No. 4 bars at 48 inches (1219 mm) on center by Sections R404.1.3.2 and R404.1.4.2, shall be located at points of lateral support, and not fewer than one No. 4 bar shall extend across the construction joint at a spacing not to exceed 24 inches (610 mm) on center. Construction joint reinforcement shall have ~~a minimum of~~ not less than 12 inches (305 mm) embedment on both sides of the joint. Construction joints in reinforced concrete walls shall be located in the middle third of the span between lateral supports, or located and constructed as required for joints in plain concrete walls.

**Exception:** Use of vertical wall reinforcement required by this code is permitted in lieu of construction joint reinforcement provided that the spacing does not exceed 24 inches (610 mm), or the combination of wall reinforcement and No. 4 bars described ~~above~~ in this section does not exceed 24 inches (610 mm).

**R404.1.3.3.8 Exterior wall coverings.** Requirements for installation of masonry veneer, stucco and other wall coverings on the exterior of concrete walls and other construction details not covered in this section shall comply with the requirements of this code.

**R404.1.3.4 Requirements for Seismic Design Category C.** Concrete foundation walls supporting above-grade concrete walls in *townhouses* assigned to Seismic Design Category C shall comply with ACI 318, ACI 332 or PCA 100 (see Section R404.1.3).

**R404.1.4 Seismic Design Category $D_0$, $D_1$ or $D_2$.** Deleted.

**R404.1.5 Foundation wall thickness based on walls supported.** The thickness of masonry or concrete foundation walls shall be not less than that required by Section R404.1.5.1 or R404.1.5.2, respectively.

**R404.1.5.1 Masonry wall thickness.** Masonry foundation walls shall be not less than the thickness of the wall supported, except that masonry foundation walls of ~~at least~~ not less than 8-inch (203 mm) nominal thickness shall be permitted under brick veneered frame walls and under 10-inch-wide (254 mm) cavity walls where the total height of the wall supported, including gables, is not more than 20 feet (6096 mm), provided that the requirements of Section R404.1.1 are met.

**R404.1.5.2 Concrete wall thickness.** The thickness of concrete foundation walls shall be equal to or greater than the thickness of the wall in the story above. Concrete foundation walls with corbels, brackets or other projections built into the wall for support of masonry veneer or other purposes are not within the scope of the tables in this section.

Where a concrete foundation wall is reduced in thickness to provide a shelf for the support of masonry veneer, the reduced thickness shall be equal to or greater than the thickness of the wall in the story above. Vertical reinforcement for the foundation wall shall be based on Table R404.1.2(8) and located in the wall as required by Section R404.1.3.3.7.2 where that table is used. Vertical reinforcement shall be based on the thickness of the thinner portion of the wall.

**Exception:** Where the height of the reduced thickness portion measured to the underside of the floor assembly or sill plate above is less than or equal to 24 inches (610 mm) and the reduction in thickness does not exceed 4 inches (102 mm), the vertical reinforcement is permitted to be based on the thicker portion of the wall.

**R404.1.5.3 Pier and curtain wall foundations.** Use of pier and curtain wall foundations shall be permitted to support *light-frame construction* not more than two *stories* in height, provided that the following requirements are met:

1. Curtain walls shall be bonded into piers and supported on concrete footings poured integrally with pier footings.
2. The minimum actual thickness of a load-bearing masonry wall shall be not less than 4 inches (102 mm) nominal or $3^3/_8$ inches (92 mm) actual thickness, and shall be bonded integrally with piers spaced in accordance with Section R606.6.4.
3. Piers shall be constructed in accordance with Sections R606.7 and R606.7.1, and shall be bonded into the load-bearing masonry wall in accordance with Section R606.13.1 or R606.13.1.1.
4. The maximum height of a pier and curtain wall foundations shall be not more than 6 feet (1829 mm).
5. Anchorage shall be in accordance with Section R403.1.6, Figure R404.1.5 (1), or as specified by engineered design accepted by the *building official*.
6. The unbalanced fill for 4-inch (102 mm) foundation walls shall not exceed 24 inches (610 mm) for *solid masonry* or 16 inches (406 mm) for *hollow masonry*.
7. Pier size shall be based on Table R403.1(2).
8. See Chapter 45 for special anchorage and reinforcement in high wind zones.

**R404.1.5.4 Piers.** The unsupported height of masonry piers shall not exceed 10 times their least dimension. When structural clay tile or hollow concrete masonry units are used for isolated piers to support beams and girders, the cellular spaces shall be filled solidly with concrete or Type M or S mortar, except that unfilled hollow piers may be used if their unsupported height is not more than four times their least dimension. When hollow masonry units are solidly filled with concrete or Type M or S mortar, the allowable compressive stress may be increased as provided in Table R606.9.

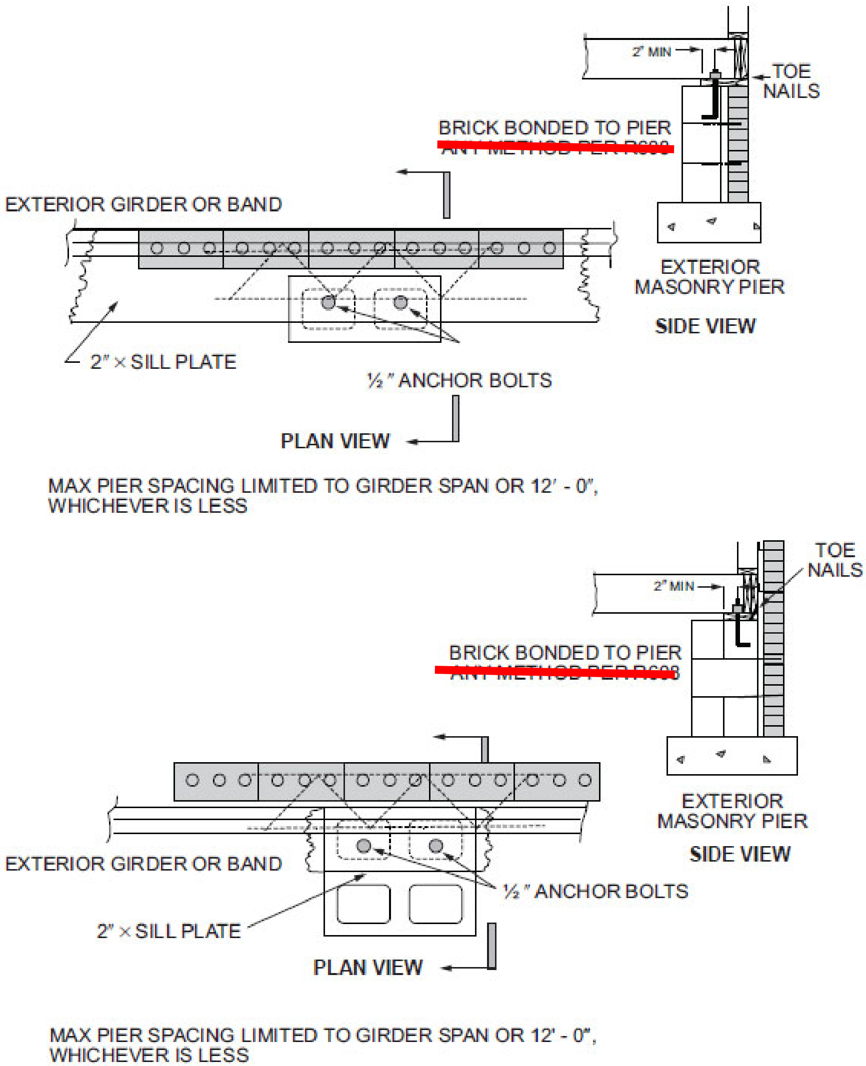



**FIGURE R404.1.5(1)**

**ALTERNATIVE ANCHORAGE FOR MASONRY CURTAIN WALL WITH CONCRETE MASONRY PIERS**

**R404.1.6 Height above finished grade.** Concrete and masonry foundation walls shall extend above the finished *grade* adjacent to the foundation at all points ~~a minimum of~~ not less than 4 inches (102 mm) where masonry veneer is used and ~~a minimum of~~ not less than 6 inches (152 mm) elsewhere.

**R404.1.7 Backfill placement.** Backfill shall not be placed against the wall until the wall has sufficient strength and has been anchored to the floor above, or has been sufficiently braced to prevent damage by the backfill.

**Exception:** Bracing is not required for walls supporting less than 4 feet (1219 mm) of unbalanced backfill.

**R404.1.8 Rubble stone masonry.** Rubble stone masonry foundation walls shall have a minimum thickness of 16 inches (406 mm), shall not support an unbalanced backfill exceeding 8 feet (2438 mm) in height, shall not support a soil pressure greater than 30 pounds per square foot per foot (4.71 kPa/m), and shall not be constructed in *Seismic Design Categories* $D_0$, $D_1$, $D_2$ or *townhouses* in Seismic Design Category C, as established in Table R301.2(7).

**R404.1.9 Isolated masonry piers.** ~~Deleted.~~ Isolated masonry piers shall be constructed in accordance with this section and the general masonry construction requirements of Section R606. *Hollow masonry* piers shall have a minimum nominal thickness of 8 inches (203 mm), with a nominal height not exceeding four times the nominal thickness and a nominal length not exceeding three times the nominal thickness. Where *hollow masonry units* are solidly filled with concrete~~, or~~ grout or Type M or S mortar, piers shall be permitted to have a nominal height not exceeding ten times the nominal thickness. Footings for isolated masonry piers shall be sized in accordance with Section R403.1.1.

**R404.1.9.1 Pier cap.** *Hollow masonry* piers shall be capped with 4 inches (102 mm) of *solid masonry* or concrete for one story and 8 inches (203 mm) of solid masonry or concrete for two stories and two and one-half stories or shall have cavities of the top course filled with concrete or grout or Type M or S mortar. Where required, termite protection for the pier cap shall be provided in accordance with Section R318.

**R404.1.9.2 Masonry piers supporting floor girders.** Masonry piers supporting wood girders sized in accordance with Tables R602.7(1) and R602.7(2) shall be permitted in accordance with this section. Piers supporting girders for interior bearing walls shall have a minimum nominal dimension of 12 inches (305 mm) and a maximum height of 10 feet (3048 mm) from top of footing to bottom of sill plate or girder. Piers supporting girders for exterior bearing walls shall have a minimum nominal dimension of 12 inches (305 mm) and a maximum height of 4 feet (1220 mm) from top of footing to bottom of sill plate or girder. Girders and sill plates shall be anchored to the pier or footing in accordance with Section R403.1.6 or Figure R404.1.5.3. Floor girder bearing shall be in accordance with Section R502.6.

**R404.1.9.3 Masonry piers supporting braced wall panels.** Masonry piers supporting *braced wall panels* shall be designed in accordance with accepted engineering practice.

**R404.1.9.4 Seismic design of masonry piers.** Masonry piers in *townhouses* in Seismic Design Category C, shall be designed in accordance with accepted engineering practice.

**R404.1.9.5 Masonry piers in flood hazard areas.** Masonry piers for *dwellings* in flood hazard areas shall be designed in accordance with Section R322.

**R404.2 Wood foundation walls.** Wood foundation walls shall be constructed in accordance with the provisions of Sections R404.2.1 through R404.2.6 and with the details shown in Figures R403.1(2) and R403.1(3).

**R404.2.1 Identification.** Load-bearing lumber shall be identified by the grade *mark* of a lumber grading or inspection agency ~~which~~ that has been *approved* by an accreditation body that complies with DOC PS 20. In lieu of a grade *mark*, a certificate of inspection issued by a lumber grading or inspection agency meeting the requirements of this section shall be accepted. *Wood structural panels* shall conform to DOC PS 1 or DOC PS 2 and shall be identified by a grade *mark* or certificate of inspection issued by an *approved agency*.

**R404.2.2 Stud size.** The studs used in foundation walls shall be 2-inch by 6-inch (51 mm by 152 mm) members. ~~When~~ Where spaced 16 inches (406 mm) on center, a wood species with an $F_b$ value of not less than 1,250 pounds per square inch (8619 kPa) as *listed* in ANSI AWC NDS shall be used. ~~When~~ Where spaced 12 inches (305 mm) on center, an $F_b$ of not less than 875 psi (6033 kPa) shall be required.

**R404.2.3 Height of backfill.** For wood foundations that are not designed and installed in accordance with AWC PWF, the height of backfill against a foundation wall shall not exceed 4 feet (1219 mm). ~~When~~ Where the height of fill is more than 12 inches (305 mm) above the interior grade of a *crawl space* or floor of a *basement*, the thickness of the plywood sheathing shall meet the requirements of Table R404.2.3.

**TABLE R404.2.3**

**PLYWOOD GRADE AND THICKNESS FOR WOOD FOUNDATION CONSTRUCTION (30 pcf equivalent-fluid weight soil pressure)**

| HEIGHT OF FILL | STUD SPACING | FACE GRAIN ACROSS STUDS | FACE GRAIN PARALLEL TO STUDS |
|---|---|---|---|

| (inches) | (inches) | Grade[a] | Minimum thickness (inches) | Span rating | Grade[a] | Minimum thickness (inches)[b, c] | Span rating |
|---|---|---|---|---|---|---|---|
| 24 | 12 | B | 15/32 | 32/16 | A | 15/32 | 32/16 |
| | | | | | B | 15/32[c] | 32/16 |
| | 16 | B | 15/32 | 32/16 | A | 15/32[c] | 32/16 |
| | | | | | B | 19/32[c] (4, 5 ply) | 40/20 |
| 36 | 12 | B | 15/32 | 32/16 | A | 15/32 | 32/16 |
| | | | | | B | 15/32[c] (4, 5 ply) | 32/16 |
| | | | | | B | 19/32 (4, 5 ply) | 40/20 |
| | 16 | B | 15/32[c] | 32/16 | A | 19/32 | 40/20 |
| | | | | | B | 23/32 | 48/24 |
| 48 | 12 | B | 15/32 | 32/16 | A | 15/32[c] | 32/16 |
| | | | | | B | 19/32[c] (4, 5 ply) | 40/20 |
| | 16 | B | 19/32 | 40/20 | A | 19/32[c] | 40/20 |
| | | | | | A | 23/32 | 48/24 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Plywood shall be of the following minimum grades in accordance with DOC PS 1 or DOC PS 2:
   1. DOC PS 1 Plywood grades marked:
      1.1. Structural I C-D (Exposure 1).
      1.2. C-D (Exposure 1).
   2. DOC PS 2 Plywood grades marked:
      2.1. Structural I Sheathing (Exposure 1).
      2.2. Sheathing (Exposure 1).
   3. Where a major portion of the wall is exposed above ground and a better appearance is desired, the following plywood grades marked exterior are suitable:
      3.1. Structural I A-C, Structural I B-C or Structural I C-C (Plugged) in accordance with DOC PS 1.
      3.2. A-C Group 1, B-C Group 1, C-C (Plugged) Group 1 or MDO Group 1 in accordance with DOC PS 1.
      3.3. Single Floor in accordance with DOC PS 1 or DOC PS 2.

b. Minimum thickness 15/32 inch, except crawl space sheathing shall have not less than 3/8 inch for face grain across studs 16 inches on center and maximum 2-foot depth of unequal fill.

c. For this fill height, thickness and grade combination, panels that are continuous over less than three spans (across less than three stud spacings) require blocking 16 inches above the bottom plate. Offset adjacent blocks and fasten through studs with two 16d corrosion-resistant nails at each end.

**R404.2.4 Backfilling.** Wood foundation walls shall not be backfilled until the *basement* floor and first floor have been constructed or the walls have been braced. For *crawl space* construction, backfill or bracing shall be installed on the interior of the walls prior to placing backfill on the exterior.

**R404.2.5 Drainage and dampproofing.** Wood foundation *basements* shall be drained and dampproofed in accordance with Sections R405 and R406, respectively.

**R404.2.6 Fastening.** *Wood structural panel* foundation wall sheathing shall be attached to framing in accordance with Table R602.3(1) and Section R402.1.1.

**R404.3 Wood sill plates.** Wood sill plates shall be ~~a minimum of~~ not less than 2-inch by 4-inch (51 mm by 102 mm) nominal lumber. Sill plate anchorage shall be in accordance with Sections R403.1.6 and R602.11.

**R404.4 Retaining walls.** ~~Retaining walls that are not laterally supported at the top and that retain in excess of 48 inches (1219 mm) of unbalanced fill shall be designed to ensure stability against overturning, sliding, excessive foundation pressure and water uplift. In addition, any retaining wall that meets the following shall be designed.~~
~~1. Any retaining wall systems on a residential site that cross over adjacent property lines regardless of vertical height, and~~
~~2. Retaining walls that support buildings and their accessory structures.~~

Retaining walls that meet the following shall be designed by a registered design professional.

1. Any retaining walls on a residential site that cross over adjacent property lines regardless of vertical height, or

2. Retaining walls that support buildings and their accessory structures, undercutting footings 10' or less per R403.1.9 and Figure 403.1.9, or

3. Individual retaining walls supporting unbalanced backfill exceeding 5 feet (1524 mm) in height within a horizontal distance of 15 feet (4572 mm) or less, or

4. Multiple retaining walls providing a cumulative vertical relief of unbalanced backfill heights greater than 5 Feet (1524 mm) within a horizontal distance of 15 feet (4572 mm) or less.

Retaining walls shall be designed for a safety factor of 1.5 against lateral sliding and overturning.

**R404.5 Precast concrete foundation walls.**

**R404.5.1 Design.** *Precast concrete* foundation walls shall be designed in accordance with accepted engineering practice. The design and manufacture of *precast concrete* foundation wall panels shall comply with the materials requirements of Section R402.3 or ACI 318. The panel design drawings shall be prepared by a *registered design professional* where required by the statutes of the *jurisdiction* in which the project is to be constructed in accordance with Section R106.1.

**R404.5.2 Precast concrete foundation design drawings.** *Precast concrete* foundation wall design drawings shall be submitted to the *building official* and *approved* prior to installation. Drawings shall include, at a minimum, the following information:

1. Design loading as applicable.
2. Footing design and material.
3. Concentrated loads and their points of application.
4. Soil bearing capacity.
5. Maximum allowable total uniform load.
6. Seismic design category.
7. Basic wind speed.

**R404.5.3 Identification.** *Precast concrete* foundation wall panels shall be identified by a certificate of inspection *label* issued by an *approved* third-party inspection agency.

## SECTION R405
## FOUNDATION DRAINAGE

**R405.1 Concrete or masonry foundations.** Exterior ~~Drains~~ drains shall be provided around concrete or masonry foundations that retain 12 inches or more of earth on the exterior of the foundation wall. ~~and enclose habitable or usable spaces located below *grade*~~. Drainage tiles, gravel or crushed stone drains, perforated pipe or other *approved* systems or materials shall be installed at or below ~~area to be protected~~ the top of the footing or below the bottom of the slab and shall discharge by gravity or mechanical means into an *approved* drainage system. Gravel or crushed stone drains shall extend not less than 1 foot (305 mm) beyond the outside edge of the footing and 6 inches (152 mm) above the top of the footing and be covered with an *approved* filter membrane material. The top of open joints of drain tiles shall be protected with strips of building paper. Except where otherwise recommended by the drain manufacturer, perforated drains shall be surrounded with an *approved* filter membrane or the filter membrane shall cover the washed gravel or crushed rock covering the drain. Drainage tiles or perforated pipe shall be placed on ~~a minimum of~~ not less than 2 inches (51 mm) of washed gravel or crushed rock not less than one sieve size larger than the tile joint opening or perforation and covered with not less than 6 inches (152 mm) of the same material.

**Exception:** A drainage system is not required where the foundation is installed on well-drained ground or sand-gravel mixture soils according to the Unified Soil Classification System, Group I soils, as detailed in Table R405.1.

**TABLE R405.1**
**PROPERTIES OF SOILS CLASSIFIED ACCORDING TO THE UNIFIED SOIL CLASSIFICATION SYSTEM**

| SOIL GROUP | UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL | SOIL DESCRIPTION | DRAINAGE CHARACTERISTICS[a] | FROST HEAVE POTENTIAL | VOLUME CHANGE POTENTIAL EXPANSION[b] |
|---|---|---|---|---|---|
| Group I | GW | Well-graded gravels, gravel sand mixtures, little or no fines | Good | Low | Low |
| | GP | Poorly graded gravels or gravel sand mixtures, little or no fines | Good | Low | Low |
| | SW | Well-graded sands, gravelly sands, little or no fines | Good | Low | Low |
| | SP | Poorly graded sands or gravelly sands, little or no fines | Good | Low | Low |
| | GM | Silty gravels, gravel-sand-silt mixtures | Good | Medium | Low |
| | SM | Silty sand, sand-silt mixtures | Good | Medium | Low |
| Group II | GC | Clayey gravels, gravel-sand-clay mixtures | Medium | Medium | Low |
| | SC | Clayey sands, sand-clay mixture | Medium | Medium | Low |
| | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity | Medium | High | Low |
| | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays | Medium | Medium | Medium to Low |
| Group III | CH | Inorganic clays of high plasticity, fat clays | Poor | Medium | High |
| | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts | Poor | High | High |
| Group IV | OL | Organic silts and organic silty clays of low plasticity | Poor | Medium | Medium |
| | OH | Organic clays of medium to high plasticity, organic silts | Unsatisfactory | Medium | High |
| | Pt | Peat and other highly organic soils | Unsatisfactory | Medium | High |

For SI: 1 inch = 25.4 mm.

a. The percolation rate for good drainage is over 4 inches per hour, medium drainage is 2 inches to 4 inches per hour, and poor is less than 2 inches per hour.

b. Soils with a low potential expansion typically have a plasticity index (PI) of 0 to 15, soils with a medium potential expansion have a PI of 10 to 35 and soils with a high potential expansion have a PI greater than 20.

**R405.1.1 Precast concrete foundation.** *Precast concrete* walls that retain earth and enclose habitable or useable space located below-*grade* that rest on crushed stone footings shall have a perforated drainage pipe installed below the base of the wall on either the interior or exterior side of the wall, not less than 1 foot (305 mm) beyond the edge of the wall. If the exterior drainage pipe is used, an *approved* filter membrane material shall cover the pipe. The drainage system shall discharge into an *approved* sewer system or to daylight.

**R405.2 Wood foundations.** Wood foundations enclosing habitable or usable spaces located below *grade* shall be adequately drained in accordance with Sections R405.2.1 through R405.2.3.

**R405.2.1 Base.** A porous layer of gravel, crushed stone or coarse sand shall be placed to a minimum thickness of 4 inches (102 mm) under the *basement* floor. Provision shall be made for automatic draining of this layer and the gravel or crushed stone wall footings.

**R405.2.2 Vapor retarder.** A 6-mil-thick (0.15 mm) polyethylene vapor retarder shall be applied over the porous layer with the *basement* floor constructed over the polyethylene.

**R405.2.3 Drainage system.** In other than Group I soils, a sump shall be provided to drain the porous layer and footings. The sump shall be not less than 24 inches (610 mm) in diameter or 20 inches square (0.0129 $m^2$), shall extend not less than 24 inches (610 mm) below the bottom of the *basement* floor and shall be capable of positive gravity or mechanical drainage to remove any accumulated water. The drainage system shall discharge into an *approved* sewer system or to daylight.

## SECTION R406
## FOUNDATION WATERPROOFING AND DAMPPROOFING

**R406.1 Concrete and masonry foundation dampproofing.** Foundation walls where the outside grade is higher than the inside grade shall be dampproofed from the top of the footing to the finished grade. ~~The foundation walls shall be dampproofed with a bituminous coating, 3 pounds per square yard (1.63 kg/m) of acrylic modified cement, or 1/8-inch (3.2 mm) coat of surface bonding mortar complying with ASTM C887 or any material permitted for waterproofing in Section R406.2. Concrete walls shall be dampproofed by applying any one of the above listed dampproofing materials or any one of the waterproofing materials listed in Section R406.2 to the exterior of the wall.~~ Masonry walls shall be dampproofed in accordance with one of the following:

1. Bituminous coating.
2. Three pounds per square yard (1.63 kg/$m^2$) of acrylic modified cement.
3. One-eighth-inch (3.2 mm) coat of surface-bonding cement complying with ASTM C887.
4. Any material permitted for waterproofing in Section R406.2.
5. Portland cement parging applied to the exterior of the wall no less than 3/8-inch (9.5 mm)
6. Other *approved* methods or materials.

Concrete walls shall be dampproofed by applying any one of the listed dampproofing materials or any one of the waterproofing materials listed in Section R406.2 to the exterior of the wall.

**R406.2 Concrete and masonry foundation waterproofing.** ~~In areas where a high water table or other severe soil-water conditions are known to exist, exterior~~ Exterior foundation walls that retain earth and enclose interior *occupiable spaces* ~~and floors~~ below *grade* shall be waterproofed from the finished *grade* to the higher of the top of the footing or 6 inches (152 mm) below the top of the basement floor. Walls shall be waterproofed in accordance with one of the following:

1. Two-ply hot-mopped felts.
2. Fifty-five-pound (25 kg) roll roofing.

~~3. Six-mil (0.15 mm) polyvinyl chloride.~~

~~4. Six-mil (0.15 mm) polyethylene.~~

~~5.~~3. Forty-mil (1 mm) polymer-modified asphalt.

~~6.~~4. Sixty-mil (1.5 mm) flexible polymer cement.

~~7.~~5. One-eighth-inch (3 mm) cement-based, fiber-reinforced, waterproof coating.

~~8.~~6. Sixty-mil (1.5 mm) solvent-free liquid-applied synthetic rubber.

All joints in membrane waterproofing shall be lapped and sealed with an adhesive compatible with the membrane.

**Exception:** Organic-solvent-based products such as hydrocarbons, chlorinated hydrocarbons, ketones and es-ters shall not be used for ICF walls with expanded polystyrene form material. Use of plastic roofing cements, acrylic coatings, latex coatings, mortars and pargings to seal ICF walls is permitted. Cold-setting asphalt or hot asphalt shall conform to Type C of ASTM D449. Hot asphalt shall be applied at a temperature of less than 200°F (93°C).

**R406.3 Dampproofing for wood foundations.** Wood foundations enclosing habitable or usable spaces located below *grade* shall be dampproofed in accordance with Sections R406.3.1 through R406.3.4.

**R406.3.1 Panel joint sealed.** Plywood panel joints in the foundation walls shall be sealed full length with a caulking compound capable of producing a moistureproof seal under the conditions of temperature and moisture content at which it will be applied and used.

**R406.3.2 Below-grade moisture barrier.** A 6-mil-thick (0.15 mm) polyethylene film shall be applied over the below-*grade* portion of exterior foundation walls prior to backfilling. Joints in the polyethylene film shall be lapped 6 inches (152 mm) and sealed with adhesive. The top edge of the polyethylene film shall be bonded to the sheathing to form a seal. Film areas at *grade* level shall be protected from mechanical damage and exposure by a pressure-preservative treated lumber or plywood strip attached to the wall several inches above finished *grade* level and extending approximately 9 inches (229 mm) below *grade*. The joint between the strip and the wall shall be caulked full length prior to fastening the strip to the wall. Where *approved*, other coverings appropriate to the architectural treatment shall be permitted to be used. The polyethylene film shall extend down to the bottom of the wood footing plate but shall not overlap or extend into the gravel or crushed stone footing.

**R406.3.3 Porous fill.** The space between the excavation and the foundation wall shall be backfilled with the same material used for footings, up to a height of 1 foot (305 mm) above the footing for well-drained sites, or one-half the total backfill height for poorly drained sites. The porous fill shall be covered with strips of 30-pound (13.6 kg) asphalt paper or 6-mil (0.15 mm) polyethylene to permit water seepage while avoiding infiltration of fine soils.

**R406.3.4 Backfill.** The remainder of the excavated area shall be backfilled with the same type of soil as was removed during the excavation.

**R406.4 Precast concrete foundation system dampproofing.** Except where required by Section R406.2 to be waterproofed, *precast concrete* foundation walls enclosing habitable or useable spaces located below *grade* shall be dampproofed in accordance with Section R406.1.

**R406.4.1 Panel joints sealed.** *Precast concrete* foundation panel joints shall be sealed full height with a sealant meeting ASTM C920, Type S or M, *Grade* NS, Class 25, Use NT, M or A. Joint sealant shall be installed in accordance with the manufacturer's instructions.

## SECTION R407
## COLUMNS

**R407.1 Wood column protection.** Wood columns shall be protected against decay as set forth in Section R317.

**R407.2 Steel column protection.** All surfaces (inside and outside) of steel columns shall be given a shop coat of rust-inhibitive paint, except for corrosion-resistant steel and steel treated with coatings to provide corrosion resistance.

**R407.3 Structural requirements.** The columns shall be restrained to prevent lateral displacement at the top and bottom end. Wood columns shall be not less in nominal size than 4 inches by 4 inches (102 mm by 102 mm). Steel columns shall be not less than 3-inch-diameter (76 mm) Schedule 40 pipe manufactured in accordance with ASTM A53/A53M Grade B or *approved* equivalent.

**Exception:** In *Seismic Design Categories* A, B and C, columns not more than 48 inches (1219 mm) in height on a pier or footing are exempt from the bottom end lateral displacement requirement within under-floor areas enclosed by a continuous foundation.

## SECTION R408
## WALL VENTED CRAWL SPACES

**R408.1 Space moisture vapor control.** Vented crawl space foundations shall be provided with foundation vent openings through the exterior foundation walls.

**R408.1.1 Foundation vent sizing.** The minimum net area of ventilation openings shall be not less than 1 square foot (0.0929 m2) for each 150 square feet (13.9 m2) of crawl space ground area.

**Exception:** The total area of ventilation openings may be reduced to 1/1,500 of the under-floor area where the ground surface is treated with an approved vapor retarder material in accordance with Section R408.2 and the required openings are placed to provide cross ventilation of the crawl space. The installation of operable louvers shall not be prohibited.

**R408.1.2 Foundation vent location.** One foundation vent shall be within 3 feet (914 mm) of each corner of the building. To prevent rainwater entry when the crawlspace is built on a sloped site, the uphill foundation walls may be constructed without wall vent openings. Vent dams shall be provided when the bottom of the foundation vent opening is less than 4 inches (102 mm) above the finished exterior grade.

**R408.1.3 Covering material.** To prevent rodent entry, foundation vents shall be covered with any of the following materials provided that the ventilation holes through the covering material shall not exceed 1/4 inch (6.4 mm) in any direction:

1. Perforated sheet metal plates not less than 0.070 inch (1.8 mm) thick.
2. Expanded sheet metal plates no less than 0.047 inch (1.2 mm) thick.
3. Cast iron grills or grating.
4. Extruded load-bearing brick vents.
5. Hardware cloth of 0.035 inch (0.89 mm) wire or heavier.
6. Corrosion-resistant mesh, with the least dimension being 1/8 inch (3.2 mm).

**R408.1.4 Drains and vent terminations.** Drains (including pressure relief and drain pans) shall terminate outdoors, to crawl space floor drains or interior pumps, and shall not intentionally discharge water into the crawl space. Crawl space drains shall be separate from roof gutter drain systems and foundation perimeter drains. Dryer vents shall terminate outdoors.

**R408.1.5 Space separation.** Wall vented crawl spaces shall be separated from adjoining basements, porches and garages by permanent solid wall surfaces with all utility penetrations through the separating wall sealed. Latched, weather-stripped doors or access panels shall provide access between the crawl space and such adjoining spaces.

**R408.2 Ground vapor retarder.** When required by Section R408.1.1 Exception, a minimum 6-mil (0.15 mm) polyethylene vapor retarder or equivalent shall be installed to nominally cover all exposed earth in the crawl space, with joints lapped not less than 12 inches (305 mm). Where there is no evidence that the groundwater table can rise to within 6 inches (152 mm) of the floor of the crawl space, it is acceptable to puncture the ground vapor retarder at low spots to prevent water puddles from forming on top of the vapor retarder due to condensation.

**R408.3 Wall damp proofing.** Where the outside grade is higher than the inside grade, the exterior walls shall be dampproofed from the top of the footing to the finished grade as required by Section R406.1.

**R408.4 Site grading.** Building site shall be graded to drain water away from the crawl space foundation in accordance with the requirements of Section R401.3.

**R408.5 Insulation.** The thermal insulation in a wall-vented crawl space shall be placed in the floor system. Wall insulation is not allowed as the only insulation system in a wall vented crawl space. The required insulation value can be determined from Table N1102.1.

**R408.6 Floor air leakage control.** All plumbing, electrical, duct, plenum, phone, cable, computer wiring and other penetrations through the subfloor shall be sealed with nonporous materials, caulks, or sealants. The use of rock wool or fiberglass insulation is prohibited as an air sealant.

**R408.7 Duct air leakage control.** All heating and cooling ductwork located in the crawl space shall be sealed with mastic or other industry-approved duct closure systems.

**R408.8 Access.** A minimum access opening measuring 18 inches by 24 inches (457 mm by 610 mm) shall be provided to the crawl space. See the *North Carolina Mechanical Code* for access requirements where mechanical equipment is located under floors.

**R408.9 Removal of debris.** The crawl space floor shall be cleaned of all vegetation and organic material. All wood forms used for placing shall be removed before the building is occupied or used for any purpose. All construction materials shall be removed before the building is occupied or used for any purpose.

**R408.10 Finished grade.** The finished grade of the crawl space is permitted to be located at the bottom of the footings; however, where there is evidence that the groundwater table can rise to within 6 inches (152 mm) of the finished grade of the crawl space at the perimeter or where there is evidence that the surface water does not readily drain from the building site, the grade in the crawl space shall be as high as the outside finished grade, unless an approved drainage system is provided.

**R408.11 Flood resistance.** For buildings located in flood hazard areas as established in Table R301.2(1):

1. Walls enclosing the under-floor space shall be provided with flood openings in accordance with Section R322.2.2.
2. The finished ground level of the under-floor space shall be equal to or higher than the outside finished ground level on at least one side.

**Exception:** Under-floor spaces that meet the requirements of FEMA/FIA TB 11-1.

## SECTION R409
## CLOSED CRAWL SPACES

**R409.1 Air sealed walls.** Closed crawl spaces shall be built to minimize the entry of outdoor air into the crawl space. Specifically prohibited are foundation wall vents and wall openings to ventilated porch foundations. When outdoor packaged heating and cooling equipment is used, solid blocking and sealants shall be used to seal gaps between the exterior wall opening and the smaller supply and return ducts that pass through the opening.

**R409.1.1 Caulking and sealants.** Air sealing caulk, gaskets or sealants shall be applied to the foundation wall and floor assemblies that separate the crawl space from outside and other ventilated areas such as joints around access door and frame, between foundation and sill plate, at penetrations for plumbing, mechanical, electrical and gas lines and at duct penetrations.

**R409.1.2 Access panel/door.** A minimum access opening measuring 18 inches by 24 inches (457 mm by 610 mm) shall be provided to the crawl space. See the *North Carolina Mechanical Code* for access requirements where mechanical equipment is located under floors. To minimize air entry, provide a tight fitting access panel/door with a latch mechanism. Access panels or doors shall be insulated to a minimum of R-2.

**R409.2 Groundwater vapor retarder.** Closed crawl spaces shall be protected from water entry by the evaporation of water from the ground surface.

**R409.2.1 Ground vapor retarder.** A minimum 6-mil (0.15 mm) polyethylene vapor retarder or equivalent shall be installed to nominally cover all exposed earth in the crawl space, with joints lapped not less than 12 inches (305 mm). Minor pockets or wrinkles that prevent total drainage across the surface of the vapor retarder are allowed. The floor of the crawl space shall be graded so that it drains to one or more low spots. Install a drain to daylight or sump pump at each low spot. Crawl space drains shall be kept separate from roof gutter drain systems and foundation perimeter drains.

**R409.2.2 Liner.** The ground vapor retarder is permitted to be installed as a full interior liner by sealing the edges to the walls and beam columns and sealing the seams. Single piece liner systems are approved. The top edge of the wall liner shall terminate 3 inches (76 mm) below the top edge of the masonry foundation wall. The top edge of the liner shall be brought up the interior columns a minimum of 4 inches (102 mm) above the crawl space floor. The floor of the crawl space shall be graded so that it drains to one or more low spots. Install a drain to daylight or sump pump at each low spot. Crawl space drains shall be separate from roof gutter drain systems and foundation perimeter drains.

**R409.2.2.1 Wall liner termite inspection gap.** Provide a clear and unobstructed 3 inch (76 mm) minimum, 4 inch (102 mm) maximum inspection gap between the top of the wall liner and the bottom of the wood sill. This inspection gap may be ignored with regards to energy performance and is not intended to create an energy penalty.

**R409.2.3 Concrete floor surfacing.** Deleted. ~~The ground vapor retarder may be protected against ripping and displacement by pouring an unreinforced, minimum 2 inch (51 mm) thick, concrete surface directly over the vapor barrier. A base course of gravel or other drainage material under the ground moisture barrier is not required. The floor of the crawl space shall be graded so that the concrete surface drains to one or more low spots. Install a drain to daylight or sump pump at each low spot. Crawl space drains shall be separate from roof gutter drain systems and foundation perimeter drains.~~

**R409.2.4 Drains and vent terminations.** Drains (including pressure relief and drain pans) shall terminate outdoors, to crawl space floor drains or interior pumps and shall not intentionally discharge water into the crawl space. Crawl space drains shall be separate from roof gutter drain systems and foundation perimeter drains. Dryer vents shall terminate outdoors.

**R409.3 Wall damp proofing.** Where the outside grade is higher than the inside grade, the exterior walls shall be dampproofed from the top of the footing to the finished grade as required by Section R406.1.

**R409.4 Site grading.** Building site shall be graded to drain water away from the crawl space foundation in accordance with the requirements of Section R401.3.

**R409.5 Space moisture vapor control.** Closed crawl spaces shall be provided with a mechanical drying capability to control space moisture levels. The allowed methods are listed below in Sections R409.5.1 through R409.5.5. At least one method shall be provided; however, combination systems shall be allowed.

**R409.5.1 Dehumidifier.** A permanently installed dehumidifier shall be provided in the crawl space. The minimum rated capacity per day is 15 pints (7.1 liters). Condensate discharge shall be drained to daylight or interior condensate pump. A permanently installed dehumidifier shall be provided with an electrical outlet.

**R409.5.2 Supply air.** Supply air from the dwelling air conditioning system shall be ducted into the crawl space at the rate of 1 cubic foot per minute (0.5 L/s) per 30 square feet (4.6 $m^2$) of crawl space floor area. No return air duct from the crawl space to the dwelling air conditioning system is allowed. The crawl space supply air duct shall be fitted with a backflow damper to prevent the entry of crawl space air into the supply duct system when the system fan is not operating. An air relief vent to the outdoors may be installed. Crawl spaces with moisture vapor control installed in accordance with this section are not considered plenums.

**R409.5.3 House air.** House air shall be blown into the crawl space with a fan at the rate of 1 cubic foot per minute (0.5 L/s) per 50 square feet (4.6 $m^2$) of crawl space floor area. The fan motor shall be rated for continuous duty. No return air duct from the crawl space to the dwelling air conditioning system is allowed. An air relief vent to the outdoors may be installed. Crawl spaces with moisture vapor control installed in accordance with this section are not considered plenums.

**R409.5.4 Exhaust fan.** Crawl space air shall be exhausted to outside with a fan at the rate of 1 cubic foot per minute (0.5 L/s) per 50 square feet (4.6 $m^2$) of crawl space floor area. The fan motor shall be rated for continuous duty. There is no requirement for make-up air.

**R409.5.5 Conditioned space.** The crawl space shall be designed as a heated and cooled, conditioned space with wall insulation installed in accordance with the requirements of Section R409.8. Intentionally returning air from the crawl space to space-conditioning equipment that serves the dwelling shall be allowed. Foam plastic insulation located in a crawl space plenum shall be protected against ignition by an approved thermal barrier.

**R409.6 Plenums.** Closed crawl spaces used as supply or return plenums for distribution of heated or cooled air shall comply with the requirements of the *North Carolina Mechanical Code*. Crawl space plenums shall not contain plumbing cleanouts, gas lines or other prohibited components. Foam plastic insulation located in a crawl space plenum shall be protected against ignition by an approved thermal barrier.

**R409.7 Combustion air.** The air sealing requirements of a closed crawl space may result in a foundation that cannot provide adequate combustion air for fuel-burning appliances; therefore, fuel-burning appliances located in the crawl space such as furnaces and water heaters shall obtain combustion air from outdoors as in accordance with the *North Carolina Mechanical Code*.

**R409.8 Insulation.** The thermal insulation in a crawl space may be located in the floor system or at the exterior walls. The required insulation value can be determined from Table N1102.1.

> **Exception:** Insulation shall be placed at the walls when the closed crawl space is designed to be intentionally heated or cooled, conditioned space.

**R409.8.1 Wall insulation.** Where the floor above a crawl space is not insulated, the walls shall be insulated. Wall insulation is permitted to be located on any combination of the exterior and interior surfaces and within the structural cavities or materials of the exterior crawl space walls. Wall insulation systems require that the band joist area of the floor frame be insulated. Wall insulation shall begin 3 inches (76 mm) below the top of the masonry foundation wall and shall extend down to 3 inches (76 mm) above the top of the footing or concrete floor, 3 inches (76 mm) above the interior ground surface or 24 inches (610 mm) below the outside finished ground level, whichever is less. No insulation shall be required on masonry walls of 9 inches (229 mm) height or less.

**R409.8.1.1 ~~Foam plastic~~ Inspection gap requirements for Insulation.**
For outside walls, Section R318.4 governs applications. When expanded polystyrene, polyisocyanurate, other foam plastic insulation fiberglass, rockwool, cellulose or other porous insulation is installed on the inside surface of the exterior foundation walls, ~~provisions in Sections R409.8.1.1.1 through R409.8.1.1.2 apply.~~

~~**R409.8.1.1.1 Earth floored crawl spaces.**~~ ~~Provide~~ provide a clear and unobstructed 3-inch (76 mm) minimum, 4-inch (102 mm) maximum termite inspection gap between the top of the foam plastic wall insulation and the bottom of the wood sill. ~~Because insulation ground contact is not allowed, provide a continuous 3-inch (76 mm) minimum clearance gap between the bottom edge of the foam plastic wall insulation and the earth floor surface. Refer to Section N1102.2.9 to determine maximum allowances for insulation gaps.~~

~~**R409.8.1.1.2 Concrete floor surfaced crawl spaces.** Provide a clear and unobstructed 3-inch (76 mm) minimum, 4-inch (102 mm) maximum termite inspection gap between the top of the foam plastic wall insulation and the bottom of the wood sill. Provide a continuous 3-inch (76 mm) minimum clearance gap between the bottom edge of the foam plastic wall insulation and the concrete floor surface. Refer to Section N1102.2.9 to determine maximum allowances for insulation gaps.~~

**R409.8.1.2 Porous insulation material.** ~~When fiberglass, rockwool, cellulose or other porous insulation materials are installed on the inside wall surface of a closed crawl space, provide a clear and unobstructed 3-inch (76 mm) minimum termite inspection gap between the top of the porous wall insulation and the bottom of the wood sill.~~
To reduce wicking potential, porous insulation ground contact is not allowed in earth floored or concrete surfaces crawl spaces. Provide a continuous 3- inch (76 mm) minimum wicking gap between the bottom edge of the porous wall insulation and the earth or concrete floor surface. Refer to Section N1102.1.7 to determine maximum allowances for insulation gaps.

**R409.8.2 Foam plastic fire safety.** Foam plastic insulation may be installed inside crawl spaces without a thermal cover when the insulation product has been tested in accordance with ASTM E84 to have a flame-spread rating of not more than 25 and a smoke developed rating of not more than 450. Foam plastics that have not been tested to meet these ratings shall be protected against ignition by covering them with a thermal barrier. Acceptable thermal barriers include 1/2-inch (13 mm) cement board, metal foil sheets, metal foil tape, steel or aluminum metal sheets or other approved materials installed in such a manner that the foam is not exposed.

> **Exception:** Foam plastic insulation located in closed crawl spaces used as conditioned spaces or plenums shall be protected against ignition by an approved thermal barrier.

**R409.9 Floor air leakage control.** All plumbing, electrical, duct, plenum, phone, cable, computer wiring and other penetrations through the subfloor shall be sealed with nonporous materials, caulks, or sealants. The use of rockwool or fiberglass insulation is prohibited as an air sealant.

**R409.10 Duct air leakage control.** All heating and cooling ductwork located in the crawl space shall be sealed with mastic or other industry approved duct closure systems.

**R409.11 Access.** A minimum access opening measuring 18 inches by 24 inches (457 mm by 610 mm) shall be provided to the crawl space. See the *North Carolina Mechanical Code* for access requirements where mechanical equipment is located under floors.

**R409.12 Removal of debris.** The crawl space floor shall be cleaned of all vegetation and organic material. All wood forms used for placing shall be removed before the building is occupied or used for any purpose. All construction materials shall be removed before the building is occupied or used for any purpose.

**R409.13 Finished grade.** The finished grade of the crawlspace is permitted to be located at the bottom of the footings; however, where there is evidence that the groundwater table can rise to within 6 inches (152 mm) of the finished grade of the crawl space at the perimeter or where there is evidence that the surface water does not readily drain from the building site, the grade in the crawl space shall be as high as the outside finished grade, unless an approved drainage system is provided.

# CHAPTER 5
# FLOORS

## SECTION R501
## GENERAL

**R501.1 Application.** The provisions of this chapter shall control the design and construction of the floors for buildings, including the floors of attic spaces used to house mechanical or plumbing fixtures and *equipment*.

**R501.2 Requirements.** Floor construction shall be capable of accommodating all loads in accordance with Section R301 and of transmitting the resulting loads to the supporting structural elements.

## SECTION R502
## WOOD FLOOR FRAMING

**R502.1 General.** Wood and wood-based products used for load-supporting purposes shall conform to the applicable provisions of this section.

**R502.1.1 Sawn lumber.** Sawn lumber shall be identified by a grade *mark* of an accredited lumber grading or inspection agency and have design values certified by an accreditation body that complies with DOC PS 20. In lieu of a grade *mark*, a certificate of inspection issued by a lumber grading or inspection agency meeting the requirements of this section shall be accepted.

**R502.1.1.1 Preservative-treated lumber.** Preservative treated dimension lumber shall ~~also~~ be identified as required by Section R317.2.

**R502.1.1.2 End-jointed lumber.** *Approved* end-jointed lumber identified by a grade *mark* conforming to Section R502.1.1 shall be permitted to be used interchangeably with solid-sawn members of the same species and grade. End-jointed lumber used in an assembly required elsewhere in this code to have a fire-resistance rating shall have the designation "Heat-Resistant Adhesive" or "HRA" included in its grade *mark*.

**R502.1.2 Prefabricated wood I-joists.** Structural capacities and design provisions for prefabricated wood I-joists shall be established and monitored in accordance with ASTM D5055.

**R502.1.3 Structural glued laminated timbers.** Glued laminated timbers shall be manufactured and identified as required in ANSI A190.1, ANSI 117 and ASTM D3737.

**R502.1.4 Structural log members.** Structural log members shall comply with the provisions of ICC 400.

**R502.1.5 Structural composite lumber.** Structural capacities for *structural composite lumber* shall be established and monitored in accordance with ASTM D5456.

**R502.1.6 Cross-laminated timber.** Cross-laminated timber shall be manufactured and identified as required by ANSI/APA PRG 320.

*R502.1.7 Engineered wood rim board.* Engineered wood rim boards shall conform to ANSI/APA PRR 410 or shall be evaluated in accordance with ASTM D7672. Structural capacities shall be in accordance with ANSI/APA PRR 410 or established in accordance with ASTM D7672. Rim boards conforming to ANSI/APA PRR 410 shall be marked in accordance with that standard.

**R502.2 Design and construction.** Floors shall be designed and constructed in accordance with the provisions of this chapter, Figure R502.2 and Sections R317 and R318 or in accordance with ANSI AWC NDS.

**R502.2.1 Framing at braced wall lines.** A load path for lateral forces shall be provided between floor framing and *braced wall panels* located above or below a floor, as specified in Section ~~R602.10.4~~ R602.10.8.

**R502.2.2 Blocking and subflooring.** Blocking for fastening panel edges or fixtures shall be ~~a minimum of~~ not less than utility grade lumber. Subflooring shall be ~~a minimum of~~ not less than utility grade lumber, No. 4 common grade boards or *wood structural panels* as specified in Section R503.2. Fireblocking shall be of any grade lumber.

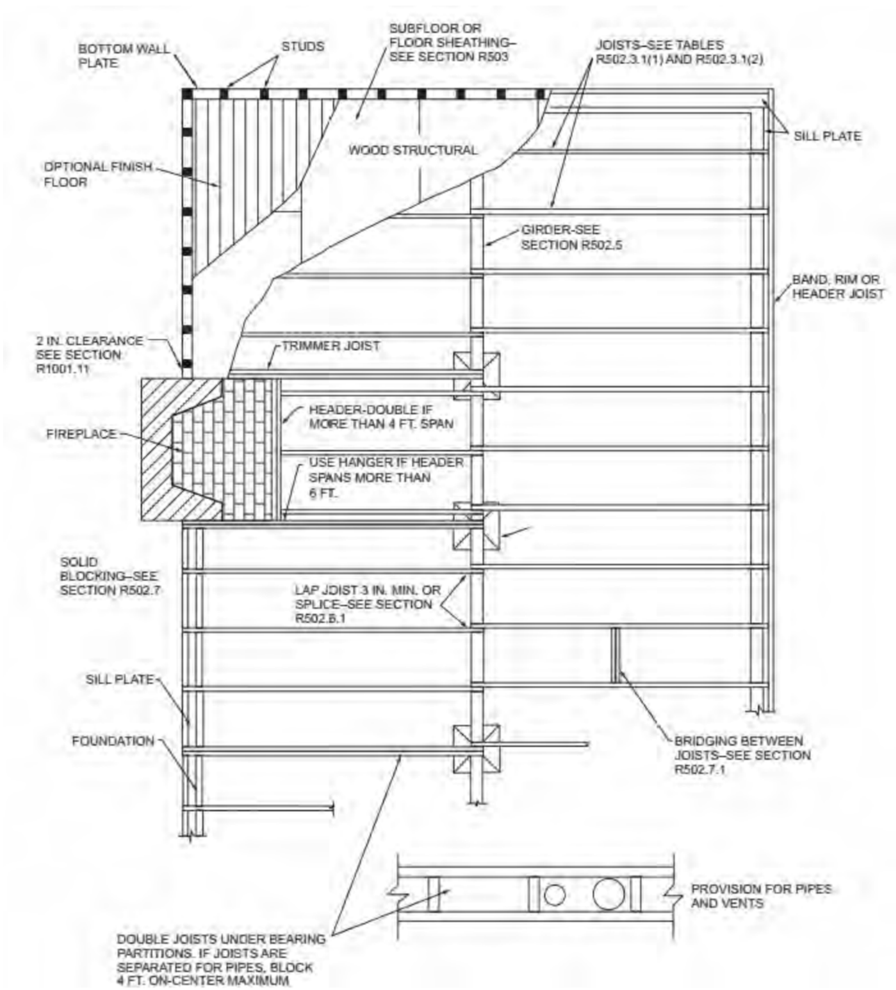



**Figure R502.2**
**FLOOR CONSTRUCTION**

**R502.3 Allowable joist spans.** Spans for floor joists shall be in accordance with Tables R502.3.1(1) and R502.3.1(2). For other grades and species and for other loading conditions, refer to the AWC STJR.

**R502.3.1 Sleeping areas and attic joists.** Table R502.3.1(1) shall be used to determine the maximum allowable span of floor joists that support sleeping areas and attics that are accessed by means of a fixed stairway in accordance with Section R311.7 provided that the design live load does not exceed 30 pounds per square foot (1.44 kPa) and the design dead load does not exceed 20 pounds per square foot (0.96 kPa). The allowable span of ceiling joists that support **attics** used for limited storage or no storage shall be determined in accordance with Section ~~R802.4~~ R802.5.

**R502.3.2 Other floor joists.** Table R502.3.1(2) shall be used to determine the maximum allowable span of floor joists that support other areas of the building, other than sleeping ~~rooms~~ areas and *attics*, provided that the design *live load* does not exceed 40 pounds per square foot (1.92 kPa) and the design dead load does not exceed 20 pounds per square foot (0.96 kPa).

**TABLE R502.3.1(1)**
**FLOOR JOIST SPANS FOR COMMON LUMBER SPECIES (Residential sleeping areas, live load = 30 psf, L/Δ = 360)[a]**

| JOIST SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | DEAD LOAD = 20 psf | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum floor joist spans | | | | | | | |
| | | | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) |
| 12 | Douglas fir-larch | SS | 12-6 | 16-6 | 21-0 | 25-7 | 12-6 | 16-6 | 21-0 | 25-7 |
| | Douglas fir-larch | #1 | 12-0 | 15-10 | 20-3 | 24-8 | 12-0 | 15-7 | 19-0 | 22-0 |
| | Douglas fir-larch | #2 | 11-10 | 15-7 | 19-10 | 23-4 | 11-8 | 14-9 | 18-0 | 20-11 |
| | Douglas fir-larch | #3 | 9-11 | 12-7 | 15-5 | 17-10 | 8-11 | 11-3 | 13-9 | 16-0 |
| | Hem-fir | SS | 11-10 | 15-7 | 19-10 | 24-2 | 11-10 | 15-7 | 19-10 | 24-2 |
| | Hem-fir | #1 | 11-7 | 15-3 | 19-5 | 23-7 | 11-7 | 15-3 | 18-9 | 21-9 |
| | Hem-fir | #2 | 11-0 | 14-6 | 18-6 | 22-6 | 11-0 | 14-4 | 17-6 | 20-4 |
| | Hem-fir | #3 | 9-8 | 12-4 | 15-0 | 17-5 | 8-8 | 11-0 | 13-5 | 15-7 |
| | Southern pine | SS | 12-3 | 16-2 | 20-8 | 25-1 | 12-3 | 16-2 | 20-8 | 25-1 |
| | Southern pine | #1 | 11-10 | 15-7 | 19-10 | 24-2 | 11-10 | 15-7 | 18-7 | 22-0 |
| | Southern pine | #2 | 11-3 | 14-11 | 18-1 | 21-4 | 10-9 | 13-8 | 16-2 | 19-1 |
| | Southern pine | #3 | 9-2 | 11-6 | 14-0 | 16-6 | 8-2 | 10-3 | 12-6 | 14-9 |
| | Spruce-pine-fir | SS | 11-7 | 15-3 | 19-5 | 23-7 | 11-7 | 15-3 | 19-5 | 23-7 |
| | Spruce-pine-fir | #1 | 11-3 | 14-11 | 19-0 | 23-0 | 11-3 | 14-7 | 17-9 | 20-7 |
| | Spruce-pine-fir | #2 | 11-3 | 14-11 | 19-0 | 23-0 | 11-3 | 14-7 | 17-9 | 20-7 |
| | Spruce-pine-fir | #3 | 9-8 | 12-4 | 15-0 | 17-5 | 8-8 | 11-0 | 13-5 | 15-7 |
| 16 | Douglas fir-larch | SS | 11-4 | 15-0 | 19-1 | 23-3 | 11-4 | 15-0 | 19-1 | 23-3 |
| | Douglas fir-larch | #1 | 10-11 | 14-5 | 18-5 | 21-4 | 10-8 | 13-6 | 16-5 | 19-1 |
| | Douglas fir-larch | #2 | 10-9 | 14-2 | 17-5 | 20-3 | 10-1 | 12-9 | 15-7 | 18-1 |
| | Douglas fir-larch | #3 | 8-7 | 10-11 | 13-4 | 15-5 | 7-8 | 9-9 | 11-11 | 13-10 |
| | Hem-fir | SS | 10-9 | 14-2 | 18-0 | 21-11 | 10-9 | 14-2 | 18-0 | 21-11 |
| | Hem-fir | #1 | 10-6 | 13-10 | 17-8 | 21-1 | 10-6 | 13-4 | 16-3 | 18-10 |
| | Hem-fir | #2 | 10-0 | 13-2 | 16-10 | 19-8 | 9-10 | 12-5 | 15-2 | 17-7 |
| | Hem-fir | #3 | 8-5 | 10-8 | 13-0 | 15-1 | 7-6 | 9-6 | 11-8 | 13-6 |
| | Southern pine | SS | 11-2 | 14-8 | 18-9 | 22-10 | 11-2 | 14-8 | 18-9 | 22-10 |
| | Southern pine | #1 | 10-9 | 14-2 | 18-0 | 21-4 | 10-9 | 13-9 | 16-1 | 19-1 |
| | Southern pine | #2 | 10-3 | 13-3 | 15-8 | 18-6 | 9-4 | 11-10 | 14-0 | 16-6 |
| | Southern pine | #3 | 7-11 | 10-0 | 11-1 | 14-4 | 7-1 | 8-11 | 10-10 | 12-10 |
| | Spruce-pine-fir | SS | 10-6 | 13-10 | 17-8 | 21-6 | 10-6 | 13-10 | 17-8 | 21-4 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Spruce-pine-fir | #1 | 10-3 | 13-6 | 17-2 | 19-11 | 9-11 | 12-7 | 15-5 | 17-10 |
| | Spruce-pine-fir | #2 | 10-3 | 13-6 | 17-2 | 19-11 | 9-11 | 12-7 | 15-5 | 17-10 |
| | Spruce-pine-fir | #3 | 8-5 | 10-8 | 13-0 | 15-1 | 7-6 | 9-6 | 11-8 | 13-6 |

*(continued)*

**TABLE R502.3.1(1)—continued**

**FLOOR JOIST SPANS FOR COMMON LUMBER SPECIES (Residential sleeping areas, live load = 30 psf, L/Δ = 360)[a]**

| JOIST SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | DEAD LOAD = 20 psf | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum floor joist spans | | | | | | | |
| | | | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) |
| 19.2 | Douglas fir-larch | SS | 10-8 | 14-1 | 18-0 | 21-10 | 10-8 | 14-1 | 18-0 | 21-4 |
| | Douglas fir-larch | #1 | 10-4 | 13-7 | 16-9 | 19-6 | 9-8 | 12-4 | 15-0 | 17-5 |
| | Douglas fir-larch | #2 | 10-1 | 13-0 | 15-11 | 18-6 | 9-3 | 11-8 | 14-3 | 16-6 |
| | Douglas fir-larch | #3 | 7-10 | 10-0 | 12-2 | 14-1 | 7-0 | 8-11 | 10-11 | 12-7 |
| | Hem-fir | SS | 10-1 | 13-4 | 17-0 | 20-8 | 10-1 | 13-4 | 17-0 | 20-7 |
| | Hem-fir | #1 | 9-10 | 13-0 | 16-7 | 19-3 | 9-7 | 12-2 | 14-10 | 17-2 |
| | Hem-fir | #2 | 9-5 | 12-5 | 15-6 | 17-1 | 8-11 | 11-4 | 13-10 | 16-1 |
| | Hem-fir | #3 | 7-8 | 9-9 | 11-10 | 13-9 | 6-10 | 8-8 | 10-7 | 12-4 |
| | Southern pine | SS | 10-6 | 13-10 | 17-8 | 21-6 | 10-6 | 13-10 | 17-8 | 21-6 |
| | Southern pine | #1 | 10-1 | 13-4 | 16-5 | 19-6 | 9-11 | 12-7 | 14-8 | 17-5 |
| | Southern pine | #2 | 9-6 | 12-1 | 14-4 | 16-10 | 8-6 | 10-10 | 12-10 | 15-1 |
| | Southern pine | #3 | 7-3 | 9-1 | 11-0 | 13-1 | 6-5 | 8-2 | 9-10 | 11-8 |
| | Spruce-pine-fir | SS | 9-10 | 13-0 | 16-7 | 20-2 | 9-10 | 13-0 | 16-7 | 19-6 |
| | Spruce-pine-fir | #1 | 9-8 | 12-9 | 15-8 | 18-3 | 9-1 | 11-6 | 14-1 | 16-3 |
| | Spruce-pine-fir | #2 | 9-8 | 12-9 | 15-8 | 18-3 | 9-1 | 11-6 | 14-1 | 16-3 |
| | Spruce-pine-fir | #3 | 7-8 | 9-9 | 11-10 | 13-9 | 6-10 | 8-8 | 10-7 | 12-4 |
| 24 | Douglas fir-larch | SS | 9-11 | 13-1 | 16-8 | 20-3 | 9-11 | 13-1 | 16-5 | 19-1 |
| | Douglas fir-larch | #1 | 9-7 | 12-4 | 15-0 | 17-5 | 8-8 | 11-0 | 13-5 | 15-7 |
| | Douglas fir-larch | #2 | 9-3 | 11-8 | 14-3 | 16-6 | 8-3 | 10-5 | 12-9 | 14-9 |
| | Douglas fir-larch | #3 | 7-0 | 8-11 | 10-11 | 12-7 | 6-3 | 8-0 | 9-9 | 11-3 |
| | Hem-fir | SS | 9-4 | 12-4 | 15-9 | 19-2 | 9-4 | 12-4 | 15-9 | 18-5 |
| | Hem-fir | #1 | 9-2 | 12-1 | 14-10 | 17-2 | 8-7 | 10-10 | 13-3 | 15-5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hem-fir | #2 | 8-9 | 11-4 | 13-10 | 16-1 | 8-0 | 10-2 | 12-5 | 14-4 |
| | Hem-fir | #3 | 6-10 | 8-8 | 10-7 | 12-4 | 6-2 | 7-9 | 9-6 | 11-0 |
| | Southern pine | SS | 9-9 | 12-10 | 16-5 | 19-11 | 9-9 | 12-10 | 16-5 | 19-8 |
| | Southern pine | #1 | 9-4 | 12-4 | 14-8 | 17-5 | 8-10 | 11-3 | 13-1 | 15-7 |
| | Southern pine | #2 | 8-6 | 10-10 | 12-10 | 15-1 | 7-7 | 9-8 | 11-5 | 13-6 |
| | Southern pine | #3 | 6-5 | 8-2 | 9-10 | 11-8 | 5-9 | 7-3 | 8-10 | 10-5 |
| | Spruce-pine-fir | SS | 9-2 | 12-1 | 15-5 | 18-9 | 9-2 | 12-1 | 15-0 | 17-5 |
| | Spruce-pine-fir | #1 | 8-11 | 11-6 | 14-1 | 16-3 | 8-1 | 10-3 | 12-7 | 14-7 |
| | Spruce-pine-fir | #2 | 8-11 | 11-6 | 14-1 | 16-3 | 8-1 | 10-3 | 12-7 | 14-7 |
| | Spruce-pine-fir | #3 | 6-10 | 8-8 | 10-7 | 12-4 | 6-2 | 7-9 | 9-6 | 11-0 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

**Note:** Check sources for availability of lumber in lengths greater than 20 feet.

a. Dead load limits for townhouses in Seismic Design Category C ~~and all structures in Seismic Design Categories $D_0$, $D_1$ and $D_2$~~ shall be determined in accordance with Section R301.2.2.2.

**TABLE R502.3.1(2)**
**FLOOR JOIST SPANS FOR COMMON LUMBER SPECIES (Residential living areas, live load = 40 psf, L/Δ = 360)[b]**

| JOIST SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | DEAD LOAD = 20 psf | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum floor joist spans | | | | | | | |
| | | | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) |
| 12 | Douglas fir-larch | SS | 11-4 | 15-0 | 19-1 | 23-3 | 11-4 | 15-0 | 19-1 | 23-3 |
| | Douglas fir-larch | #1 | 10-11 | 14-5 | 18-5 | 22-0 | 10-11 | 14-2 | 17-4 | 20-1 |
| | Douglas fir-larch | #2 | 10-9 | 14-2 | 18-0 | 20-11 | 10-8 | 13-6 | 16-5 | 19-1 |
| | Douglas fir-larch | #3 | 8-11 | 11-3 | 13-9 | 16-0 | 8-1 | 10-3 | 12-7 | 14-7 |
| | Hem-fir | SS | 10-9 | 14-2 | 18-0 | 21-11 | 10-9 | 14-2 | 18-0 | 21-11 |
| | Hem-fir | #1 | 10-6 | 13-10 | 17-8 | 21-6 | 10-6 | 13-10 | 17-1 | 19-10 |
| | Hem-fir | #2 | 10-0 | 13-2 | 16-10 | 20-4 | 10-0 | 13-1 | 16-0 | 18-6 |
| | Hem-fir | #3 | 8-8 | 11-0 | 13-5 | 15-7 | 7-11 | 10-0 | 12-3 | 14-3 |
| | Southern pine | SS | 11-2 | 14-8 | 18-9 | 22-10 | 11-2 | 14-8 | 18-9 | 22-10 |
| | Southern pine | #1 | 10-9 | 14-2 | 18-0 | 21-11 | 10-9 | 14-2 | 16-11 | 20-1 |
| | Southern pine | #2 | 10-3 | 13-6 | 16-2 | 19-1 | 9-10 | 12-6 | 14-9 | 17-5 |
| | Southern pine | #3 | 8-2 | 10-3 | 12-6 | 14-9 | 7-5 | 9-5 | 11-5 | 13-6 |
| | Spruce-pine-fir | SS | 10-6 | 13-10 | 17-8 | 21-6 | 10-6 | 13-10 | 17-8 | 21-6 |
| | Spruce-pine-fir | #1 | 10-3 | 13-6 | 17-3 | 20-7 | 10-3 | 13-3 | 16-3 | 18-10 |
| | Spruce-pine-fir | #2 | 10-3 | 13-6 | 17-3 | 20-7 | 10-3 | 13-3 | 16-3 | 18-10 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Spruce-pine-fir | #3 | 8-8 | 11-0 | 13-5 | 15-7 | 7-11 | 10-0 | 12-3 | 14-3 |
| 16 | Douglas fir-larch | SS | 10-4 | 13-7 | 17-4 | 21-1 | 10-4 | 13-7 | 17-4 | 21-1 |
| | Douglas fir-larch | #1 | 9-11 | 13-1 | 16-5 | 19-1 | 9-8 | 12-4 | 15-0 | 17-5 |
| | Douglas fir-larch | #2 | 9-9 | 12-9 | 15-7 | 18-1 | 9-3 | 11-8 | 14-3 | 16-6 |
| | Douglas fir-larch | #3 | 7-8 | 9-9 | 11-11 | 13-10 | 7-0 | 8-11 | 10-11 | 12-7 |
| | Hem-fir | SS | 9-9 | 12-10 | 16-5 | 19-11 | 9-9 | 12-10 | 16-5 | 19-11 |
| | Hem-fir | #1 | 9-6 | 12-7 | 16-0 | 18-10 | 9-6 | 12-2 | 14-10 | 17-2 |
| | Hem-fir | #2 | 9-1 | 12-0 | 15-2 | 17-7 | 8-11 | 11-4 | 13-10 | 16-1 |
| | Hem-fir | #3 | 7-6 | 9-6 | 11-8 | 13-6 | 6-10 | 8-8 | 10-7 | 12-4 |
| | Southern pine | SS | 10-2 | 13-4 | 17-0 | 20-9 | 10-2 | 13-4 | 17-0 | 20-9 |
| | Southern pine | #1 | 9-9 | 12-10 | 16-1 | 19-1 | 9-9 | 12-7 | 14-8 | 17-5 |
| | Southern pine | #2 | 9-4 | 11-10 | 14-0 | 16-6 | 8-6 | 10-10 | 12-10 | 15-1 |
| | Southern pine | #3 | 7-1 | 8-11 | 10-10 | 12-10 | 6-5 | 8-2 | 9-10 | 11-8 |
| | Spruce-pine-fir | SS | 9-6 | 12-7 | 16-0 | 19-6 | 9-6 | 12-7 | 16-0 | 19-6 |
| | Spruce-pine-fir | #1 | 9-4 | 12-3 | 15-5 | 17-10 | 9-1 | 11-6 | 14-1 | 16-3 |
| | Spruce-pine-fir | #2 | 9-4 | 12-3 | 15-5 | 17-10 | 9-1 | 11-6 | 14-1 | 16-3 |
| | Spruce-pine-fir | #3 | 7-6 | 9-6 | 11-8 | 13-6 | 6-10 | 8-8 | 10-7 | 12-4 |

*(continued)*

**TABLE R502.3.1(2)—continued**
**FLOOR JOIST SPANS FOR COMMON LUMBER SPECIES (Residential living areas, live load = 40 psf, L/Δ = 360)[b]**

| JOIST SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | DEAD LOAD = 20 psf | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum floor joist spans | | | | | | | |
| | | | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) | (ft-in) |
| 19.2 | Douglas fir-larch | SS | 9-8 | 12-10 | 16-4 | 19-10 | 9-8 | 12-10 | 16-4 | 19-6 |
| | Douglas fir-larch | #1 | 9-4 | 12-4 | 15-0 | 17-5 | 8-10 | 11-3 | 13-8 | 15-11 |
| | Douglas fir-larch | #2 | 9-2 | 11-8 | 14-3 | 16-6 | 8-5 | 10-8 | 13-0 | 15-1 |
| | Douglas fir-larch | #3 | 7-0 | 8-11 | 10-11 | 12-7 | 6-5 | 8-2 | 9-11 | 11-6 |
| | Hem-fir | SS | 9-2 | 12-1 | 15-5 | 18-9 | 9-2 | 12-1 | 15-5 | 18-9 |
| | Hem-fir | #1 | 9-0 | 11-10 | 14-10 | 17-2 | 8-9 | 11-1 | 13-6 | 15-8 |
| | Hem-fir | #2 | 8-7 | 11-3 | 13-10 | 16-1 | 8-2 | 10-4 | 12-8 | 14-8 |
| | Hem-fir | #3 | 6-10 | 8-8 | 10-7 | 12-4 | 6-3 | 7-11 | 9-8 | 11-3 |
| | Southern pine | SS | 9-6 | 12-7 | 16-0 | 19-6 | 9-6 | 12-7 | 16-0 | 19-6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Southern pine | #1 | 9-2 | 12-1 | 14-8 | 17-5 | 9-0 | 11-5 | 13-5 | 15-11 |
| | Southern pine | #2 | 8-6 | 10-10 | 12-10 | 15-1 | 7-9 | 9-10 | 11-8 | 13-9 |
| | Southern pine | #3 | 6-5 | 8-2 | 9-10 | 11-8 | 5-11 | 7-5 | 9-0 | 10-8 |
| | Spruce-pine-fir | SS | 9-0 | 11-10 | 15-1 | 18-4 | 9-0 | 11-10 | 15-1 | 17-9 |
| | Spruce-pine-fir | #1 | 8-9 | 11-6 | 14-1 | 16-3 | 8-3 | 10-6 | 12-10 | 14-10 |
| | Spruce-pine-fir | #2 | 8-9 | 11-6 | 14-1 | 16-3 | 8-3 | 10-6 | 12-10 | 14-10 |
| | Spruce-pine-fir | #3 | 6-10 | 8-8 | 10-7 | 12-4 | 6-3 | 7-11 | 9-8 | 11-3 |
| 24 | Douglas fir-larch | SS | 9-0 | 11-11 | 15-2 | 18-5 | 9-0 | 11-11 | 15-0 | 17-5 |
| | Douglas fir-larch | #1 | 8-8 | 11-0 | 13-5 | 15-7 | 7-11 | 10-0 | 12-3 | 14-3 |
| | Douglas fir-larch | #2 | 8-3 | 10-5 | 12-9 | 14-9 | 7-6 | 9-6 | 11-8 | 13-6 |
| | Douglas fir-larch | #3 | 6-3 | 8-0 | 9-9 | 11-3 | 5-9 | 7-3 | 8-11 | 10-4 |
| | Hem-fir | SS | 8-6 | 11-3 | 14-4 | 17-5 | 8-6 | 11-3 | 14-4 | 16-10[a] |
| | Hem-fir | #1 | 8-4 | 10-10 | 13-3 | 15-5 | 7-10 | 9-11 | 12-1 | 14-0 |
| | Hem-fir | #2 | 7-11 | 10-2 | 12-5 | 14-4 | 7-4 | 9-3 | 11-4 | 13-1 |
| | Hem-fir | #3 | 6-2 | 7-9 | 9-6 | 11-0 | 5-7 | 7-1 | 8-8 | 10-1 |
| | Southern pine | SS | 8-10 | 11-8 | 14-11 | 18-1 | 8-10 | 11-8 | 14-11 | 18-0 |
| | Southern pine | #1 | 8-6 | 11-3 | 13-1 | 15-7 | 8-1 | 10-3 | 12-0 | 14-3 |
| | Southern pine | #2 | 7-7 | 9-8 | 11-5 | 13-6 | 7-0 | 8-10 | 10-5 | 12-4 |
| | Southern pine | #3 | 5-9 | 7-3 | 8-10 | 10-5 | 5-3 | 6-8 | 8-1 | 9-6 |
| | Spruce-pine-fir | SS | 8-4 | 11-0 | 14-0 | 17-0 | 8-4 | 11-0 | 13-8 | 15-11 |
| | Spruce-pine-fir | #1 | 8-1 | 10-3 | 12-7 | 14-7 | 7-5 | 9-5 | 11-6 | 13-4 |
| | Spruce-pine-fir | #2 | 8-1 | 10-3 | 12-7 | 14-7 | 7-5 | 9-5 | 11-6 | 13-4 |
| | Spruce-pine-fir | #3 | 6-2 | 7-9 | 9-6 | 11-0 | 5-7 | 7-1 | 8-8 | 10-1 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

**Note:** Check sources for availability of lumber in lengths greater than 20 feet.

a. End bearing length shall be increased to 2 inches.

b. Dead load limits for townhouses in Seismic Design Category C ~~and all structures in Seismic Design Categories $D_0$, $D_1$, and $D_2$~~ shall be determined in accordance with Section R301.2.2.2.

**TABLE R502.3.1(1)**

**FLOOR JOIST SPANS FOR COMMON LUMBER SPECIES (Residential sleeping areas, live load = 30 psf, L/Δ = 360)[a]**

a. Dead load limits for townhouses in Seismic Design Category C shall be determined in accordance with ~~Section R301.2.2.1~~ R301.2.2.2.

**TABLE R502.3.1(2)**

**FLOOR JOIST SPANS FOR COMMON LUMBER SPECIES (Residential living areas, live load = 40 psf, L/Δ = 360)[b]**

a. End bearing length shall be increased to 2 inches.

b. Dead load limits for townhouses in Seismic Design Category C shall be determined in accordance with Section ~~R301.2.2.1~~ R301.2.2.2.

**TABLE R502.3.3(1)**

**CANTILEVER SPANS FOR FLOOR JOISTS SUPPORTING LIGHT-FRAME EXTERIOR BEARING WALL AND ROOF ONLY[a, b, c, f, g, h]**

**(Floor live load ≤ 40 psf, roof live load ≤ 20 psf)**

a. Tabulated values are for clear-span roof supported solely by exterior bearing walls.
b. Spans are based on No. 2 Grade lumber of Douglas fir-larch, Southern pine, hem-fir and spruce-pine-fir for repetitive (three or more) members. ~~No.1 or better shall be used for southern pine or spans shall be multiplied by 0.85 for No. 2 southern pine.~~
c. Ratio of backspan to cantilever span shall be not less than 3:1.
d. Connections capable of resisting the indicated uplift force shall be provided at the backspan support.
e. Uplift force is for a backspan to cantilever span ratio of 3:1. Tabulated uplift values are permitted to be reduced by multiplying by a factor equal to 3 divided by the actual backspan ratio provided (3/backspan ratio).
f. See Section ~~R301.2.2.5~~ R301.2.2.6, Item 1, for additional limitations on cantilevered floor joists for detached one- and two-family dwellings in Seismic Design Category $D_0$, $D_1$ or $D_2$ and townhouses in Seismic Design Category C, $D_0$, $D_1$ or $D_2$.
g. A full-depth rim joist shall be provided at the unsupported end of the cantilever joists. Solid blocking shall be provided at the supported end. Where the cantilever length is 24 inches or less and the building is assigned to Seismic Design Category A, B or C, solid blocking at the support for the cantilever shall not be required.
h. Linear interpolation shall be permitted for building widths and ground snow loads other than shown.

**TABLE R502.3.3(2)**

**CANTILEVER SPANS FOR FLOOR JOISTS SUPPORTING EXTERIOR BALCONY[a, b, e, f]**

a. Spans are based on No. 2 Grade lumber of Douglas fir-larch, Southern pine, hem-fir, and spruce-pine-fir for repetitive (three or more) members. ~~No.1 or better shall be used for southern pine or spans shall be multiplied by 0.85 for No. 2 southern pine.~~
b. Ratio of backspan to cantilever span shall be not less than 2:1.
c. Connections capable of resisting the indicated uplift force shall be provided at the backspan support.
d. Uplift force is for a backspan to cantilever span ratio of 2:1. Tabulated uplift values are permitted to be reduced by multiplying by a factor equal to 2 divided by the actual backspan ratio provided (2/backspan ratio).
e. A full-depth rim joist shall be provided at the unsupported end of the cantilever joists. Solid blocking shall be provided at the supported end. Where the cantilever length is 24 inches or less and the building is assigned to Seismic Design Category A, B or C, solid blocking at the support for the cantilever shall not be required.
f. Linear interpolation shall be permitted for ground snow loads other than shown.

**R502.3.2 Other floor joists.** Table R502.3.1(2) shall be used to determine the maximum allowable span of floor joists that support other areas of the building, other than sleeping areas and *attics*, provided that the design *live load* does not exceed 40 pounds per square foot (1.92 kPa) and the design dead load does not exceed 20 pounds per square foot (0.96 kPa).

**R502.3.3 Floor cantilevers.** Floor cantilever spans shall not exceed the nominal depth of the wood floor joist. Floor cantilevers constructed in accordance with Table R502.3.3(1) shall be permitted where supporting a light-frame bearing wall and roof only. Floor cantilevers supporting an exterior balcony are permitted to be constructed in accordance with Table R502.3.3(2).

**TABLE R502.3.3(1)**

**CANTILEVER SPANS FOR FLOOR JOISTS SUPPORTING LIGHT-FRAME EXTERIOR BEARING WALL AND ROOF ONLY[a, b, c, f, g, h]**

**(Floor live load ≤ 40 psf, roof live load ≤ 20 psf)**

| MEMBER & SPACING | MAXIMUM CANTILEVER SPAN (uplift force at backspan support in lb)[d, e] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ground Snow Load | | | | | | | | | | | |
| | ≤ 20 psf | | | 30 psf | | | 50 psf | | | 70 psf | | |
| | Roof Width | | | Roof Width | | | Roof Width | | | Roof Width | | |
| | 24 ft | 32 ft | 40 ft | 24 ft | 32 ft | 40 ft | 24 ft | 32 ft | 40 ft | 24 ft | 32 ft | 40 ft |
| 2 × 8 @ 12″ | 20″ (177) | 15″ (227) | — | 18″ (209) | — | — | — | — | — | — | — | — |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 × 10 @ 16″ | 29″ (228) | 21″ (297) | 16″ (364) | 26″ (271) | 18″ (354) | — | 20″ (375) | — | — | — | — | — |
| 2 × 10 @ 12″ | 36″ (166) | 26″ (219) | 20″ (270) | 34″ (198) | 22″ (263) | 16″ (324) | 26″ (277) | — | — | 19″ (356) | — | — |
| 2 × 12 @ 16″ | — | 32″ (287) | 25″ (356) | 36″ (263) | 29″ (345) | 21″ (428) | 29″ (367) | 20″ (484) | — | 23″ (471) | — | — |
| 2 × 12 @ 12″ | — | 42″ (209) | 31″ (263) | — | 37″ (253) | 27″ (317) | 36″ (271) | 27″ (358) | 17″ (447) | 31″ (348) | 19″ (462) | — |
| 2 × 12 @ 8″ | — | 48″ (136) | 45″ (169) | — | 48″ (164) | 38″ (206) | — | 40″ (233) | 26″ (294) | 36″ (230) | 29″ (304) | 18″ (379) |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. Tabulated values are for clear-span roof supported solely by exterior bearing walls.
b. Spans are based on No. 2 Grade lumber of Douglas fir-larch, Southern pine, hem-fir and spruce-pine-fir for repetitive (three or more) members.
c. Ratio of backspan to cantilever span shall be not less than 3:1.
d. Connections capable of resisting the indicated uplift force shall be provided at the backspan support.
e. Uplift force is for a backspan to cantilever span ratio of 3:1. Tabulated uplift values are permitted to be reduced by multiplying by a factor equal to 3 divided by the actual backspan ratio provided (3/backspan ratio).
f. See Section R301.2.2.6, Item 1, for additional limitations on cantilevered floor joists for ~~detached one- and two-family dwellings in Seismic Design Category $D_0$, $D_1$ or $D_2$ and~~ townhouses in Seismic Design Category C, ~~$D_0$, $D_1$ or $D_2$~~.
g. A full-depth rim joist shall be provided at the unsupported end of the cantilever joists. Solid blocking shall be provided at the supported end. Where the cantilever length is 24 inches or less and the building is assigned to Seismic Design Category A, B or C, solid blocking at the support for the cantilever shall not be required.
h. Linear interpolation shall be permitted for building widths and ground snow loads other than shown.

**TABLE R502.3.3(2)**
**CANTILEVER SPANS FOR FLOOR JOISTS SUPPORTING EXTERIOR BALCONY**[a, b, e, f]

| MEMBER SIZE | SPACING | MAXIMUM CANTILEVER SPAN (uplift force at backspan support in lb)[c, d] | | |
|---|---|---|---|---|
| | | Ground Snow Load | | |
| | | ≤ 30 psf | 50 psf | 70 psf |
| 2 × 8 | 12″ | 42″ (139) | 39″ (156) | 34″ (165) |
| 2 × 8 | 16″ | 36″ (151) | 34″ (171) | 29″ (180) |
| 2 × 10 | 12″ | 61″ (164) | 57″ (189) | 49″ (201) |
| 2 × 10 | 16″ | 53″ (180) | 49″ (208) | 42″ (220) |
| 2 × 10 | 24″ | 43″ (212) | 40″ (241) | 34″ (255) |
| 2 × 12 | 16″ | 72″ (228) | 67″ (260) | 57″ (268) |
| 2 × 12 | 24″ | 58″ (279) | 54″ (319) | 47″ (330) |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.

a. Spans are based on No. 2 Grade lumber of Douglas fir-larch, Southern pine, hem-fir, and spruce-pine-fir for repetitive (three or more) members.
b. Ratio of backspan to cantilever span shall be not less than 2:1.
c. Connections capable of resisting the indicated uplift force shall be provided at the backspan support.
d. Uplift force is for a backspan to cantilever span ratio of 2:1. Tabulated uplift values are permitted to be reduced by multiplying by a factor equal to 2 divided by the actual backspan ratio provided (2/backspan ratio).
e. A full-depth rim joist shall be provided at the unsupported end of the cantilever joists. Solid blocking shall be provided at the supported end. Where the cantilever length is 24 inches or less and the building is assigned to Seismic Design Category A, B or C, solid blocking at the support for the cantilever shall not be required.

f. Linear interpolation shall be permitted for ground snow loads other than shown.

**R502.4 Joists under bearing partitions.** Joists under parallel bearing partitions shall be of adequate size to support the load. Double joists, sized to adequately support the load, that are separated to permit the installation of piping or vents shall be full-depth solid blocked with lumber not less than 2 inches (51 mm) in nominal thickness spaced not more than 4 feet (1219 mm) on center. Bearing partitions perpendicular to joists shall not be offset from supporting girders, walls or partitions more than the joist depth unless such joists are of sufficient size to carry the additional load.

**R502.5 Allowable girder and header spans.** The allowable spans of girders and headers fabricated of dimension lumber shall not exceed the values set forth in Tables R602.7(1), R602.7(2) and R602.7(3).

**R502.6 Bearing.** The ends of each joist, beam or girder shall have not less than $1^1/_2$ inches (38 mm) of bearing on wood or metal, ~~and~~ have not less than 3 inches of bearing (76 mm) on masonry or concrete ~~except where~~ or be supported by *approved* joist hangers. Alternatively, the ends of joists shall be supported on a 1-inch by 4-inch (25 mm by 102 mm) ribbon strip and shall be nailed to the adjacent stud ~~or by the use of approved joist hangers~~. The bearing on masonry or concrete shall be direct, or a sill plate of 2-inch-minimum (51 mm) nominal thickness shall be provided under the joist, beam or girder. The sill plate shall provide a minimum nominal bearing area of 48 square inches (30 865 ~~square~~ $mm^2$).

**R502.6.1 Floor systems.** Joists framing from opposite sides over a bearing support shall lap not less than 3 inches (76 mm) and shall be nailed together with a minimum three 10d face nails. A wood or metal splice with strength equal to or greater than that provided by the nailed lap is permitted.

**R502.6.2 Joist framing.** Joists framing into the side of a wood girder shall be supported by *approved* framing anchors or on ledger strips not less than nominal 2 inches by 2 inches (51 mm by 51 mm).

**R502.7 Lateral restraint at supports.** Joists shall be supported laterally at the ends by full-depth solid blocking not less than 2 inches (51 mm) nominal in thickness; or by attachment to a full-depth header, band or rim joist, or to an adjoining stud or shall be otherwise provided with lateral support to prevent rotation.

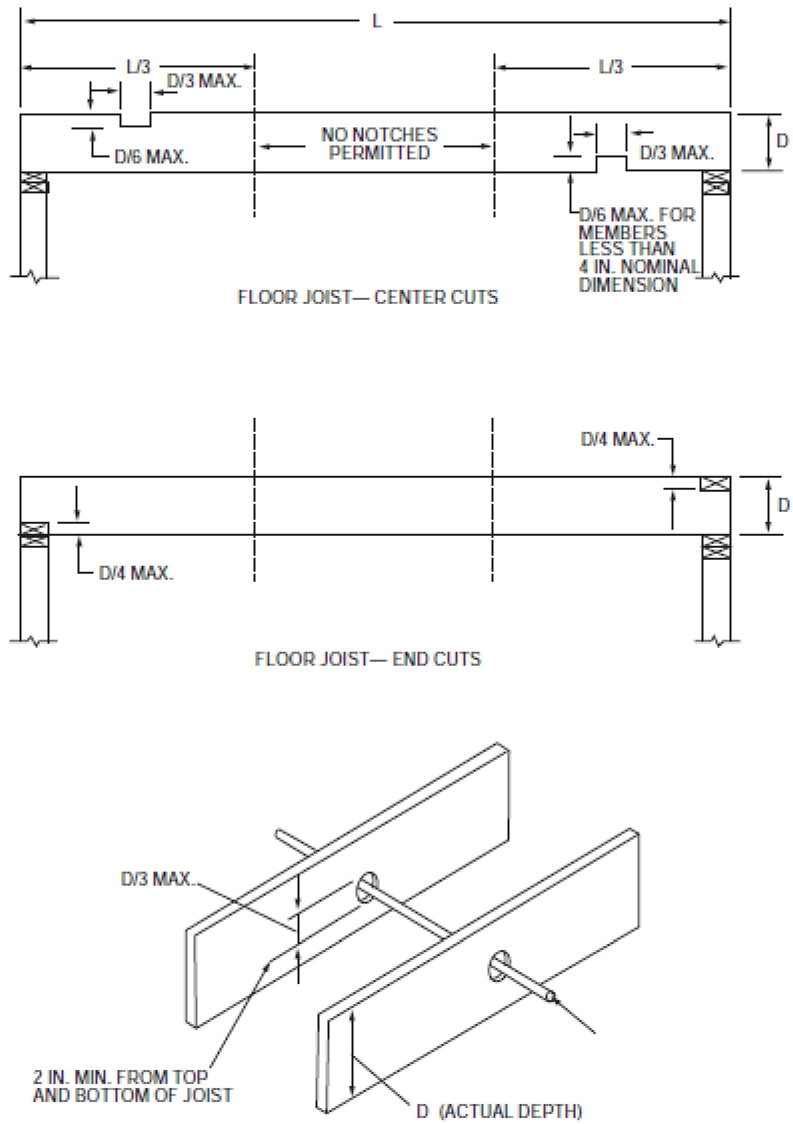
**Exceptions:**

1. Trusses, *structural composite lumber*, structural glued-laminated members and I-joists shall be supported laterally as required by the manufacturer's recommendations.
2. Deleted.

**R502.7.1 Bridging.** Joists exceeding a nominal 2 inches by 12 inches (51 mm by 305 mm) shall be supported laterally by solid blocking, diagonal bridging (wood or metal), or a continuous 1-inch by 3-inch (~~25.4~~ 25 mm by 76 mm) strip nailed across the bottom of joists perpendicular to joists at intervals not exceeding 8 feet (2438 mm).

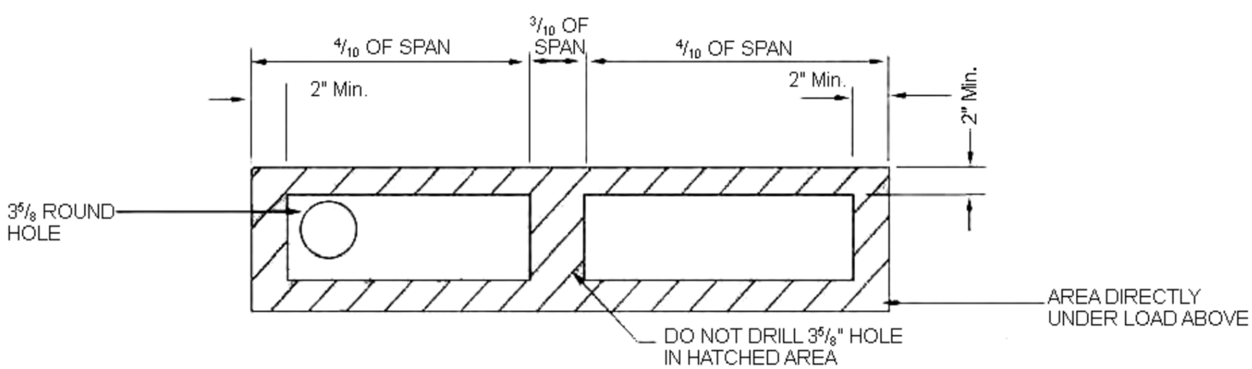
**Exception:** Trusses, *structural composite lumber*, structural glued-laminated members and I-joists shall be supported laterally as required by the manufacturer's recommendations.

**R502.8 Cutting, drilling and notching.** Structural floor members shall not be cut, bored or notched in excess of the limitations specified in this section. See Figure R502.8 (1) and R502.8(2).




For SI: 1 inch = 25.4 mm.

**FIGURE R502.8(1)**
**CUTTING, NOTCHING AND DRILLING**



For SI: 1 inch = 24.5 mm, 1 foot = 304.8 mm
1. Do not drill in center 2/10's of joist span.
2. Do not drill directly under load bearing walls at end.
3. Do not drill closer than 2 inch to top or bottom edge.
4. Apply 4 feet joist width × 1/2 inch CDX plywood with face grain running with joist to both sides using 6d nails or 11/2 inch screws 1 inch from top and bottom
4 inches o.c.
5. Holes shall not be closer than 2 inches o.c. within unhatched area only.
6. Plywood shall be attached such that 2 feet minimum of plywood is centered on each side of the hole location, except when the hole is located within 2 feet of the end of joist.

**FIGURE R502.8(2)**
**ACCEPTABLE LOCATION OF 35/8-inch DIAMETER HOLE IN 2 × 10 JOIST**

**R502.8.1 Sawn lumber.** Notches in solid lumber joists, rafters and beams shall not exceed one-sixth of the depth of the member, shall not be longer than one-third of the depth of the member and shall not be located in the middle one-third of the span. Notches at the ends of the member shall not exceed one-fourth the depth of the member. The tension side of members 4 inches (102 mm) or greater in nominal thickness shall not be notched except at the ends of the members. The diameter of holes bored or cut into members shall not exceed one-third the depth of the member. Holes shall not be closer than 2 inches (51 mm) to the top or bottom of the member, or to any other hole located in the member. Where the member is ~~also~~ notched, the hole shall not be closer than 2 inches (51 mm) to the notch.

**R502.8.2 Engineered wood products.** Cuts, notches and holes bored in trusses, *structural composite lumber*, structural glue-laminated members, cross-laminated timber members or I-joists are prohibited except where permitted by the manufacturer's recommendations or where the effects of such alterations are specifically considered in the design of the member by a *registered design professional*.

**R502.9 Fastening.** Floor framing shall be nailed in accordance with Table R602.3(1). Where posts and beam or girder construction is used to support floor framing, positive connections shall be provided to ensure against uplift and lateral displacement.

**R502.10 Framing of openings.** Openings in floor framing shall be framed with ~~a~~ header and trimmer joists. Where the header joist span does not exceed 4 feet (1219 mm), the header joist shall be a single member the same size as the floor joist. Single trimmer joists shall be used to carry a single header joist that is located within 3 feet (914 mm) of the trimmer joist bearing. Where the header joist span exceeds 4 feet (1219 mm), the trimmer joists and the header joist shall be doubled and of sufficient cross section to support the floor joists framing into the header.

**R502.11 Wood trusses.**

**R502.11.1 Design.** Wood trusses shall be designed in accordance with *approved* engineering practice. The design and manufacture of metal-plate-connected wood trusses shall comply with ANSI/TPI 1. The *truss design drawings* shall be prepared by a *registered design professional*.

**R502.11.2 Bracing.** Trusses shall be braced to prevent rotation and provide lateral stability in accordance with the requirements specified in the *construction documents* for the building and on the individual *truss design drawings*. In the absence of specific bracing requirements, trusses shall be braced in accordance with accepted industry practices, such as the SBCA *Building Component Safety Information (BCSI) Guide to Good Practice for Handling, Installing & Bracing of Metal Plate Connected Wood Trusses.*

**R502.11.3 Alterations to trusses.** Truss members and components shall not be cut, notched, spliced or otherwise altered in any way without the approval of a *registered design professional*. *Alterations* resulting in the addition of load that ~~exceed~~ exceeds the design load for the truss, shall not be permitted without verification that the truss is capable of supporting the additional loading.

**R502.11.4 Truss design drawings.** *Truss design drawings*, prepared in compliance with Section R502.11.1, shall be submitted to the *building official* ~~and *approved* prior to installation~~. *Truss design drawings* shall be provided with the shipment of trusses delivered to the job site. *Truss design drawings* shall include, at a minimum, the information specified as follows:

1. Slope or depth, span and spacing.
2. Location of all joints.
3. Required bearing widths.
4. Design loads as applicable:
   4.1. Top chord *live load*.
   4.2. Top chord dead load.
   4.3. Bottom chord *live load*.
   4.4. Bottom chord dead load.
   4.5. Concentrated loads and their points of application.
   4.6. Controlling wind and earthquake loads.
5. Adjustments to lumber and joint connector design values for conditions of use.
6. Each reaction force and direction.
7. Joint connector type and description, such as size, thickness or gage, and the dimensioned location of each joint connector except where symmetrically located relative to the joint interface.
8. Lumber size, species and grade for each member.
9. Connection requirements for:
   9.1. Truss-to-girder-truss.
   9.2. Truss ply-to-ply.
   9.3. Field splices.
10. Calculated deflection ratio ~~and/or~~, maximum description for live and total load, or both.
11. Maximum axial compression forces in the truss members to enable the building designer to design the size, connections and anchorage of the permanent continuous lateral bracing. Forces shall be shown on the truss drawing or on supplemental documents.
12. Required permanent truss member bracing location.

**R502.12 Draftstopping required.** Draftstopping shall be provided in accordance with Section R302.12.

**R502.13 Fireblocking required.** Fireblocking shall be provided in accordance with Section R302.11.

## SECTION R503
## FLOOR SHEATHING

**R503.1 Lumber sheathing.** Maximum allowable spans for lumber used as floor sheathing shall conform to Tables R503.1, R503.2.1.1(1) and R503.2.1.1(2).

**TABLE R503.1**
**MINIMUM THICKNESS OF LUMBER FLOOR SHEATHING**

| JOIST OR BEAM SPACING (inches) | MINIMUM NET THICKNESS | |
|---|---|---|
| | Perpendicular to joist | Diagonal to joist |
| 24 | $^{11}/_{16}$ | $^{3}/_{4}$ |
| 16 | $^{5}/_{8}$ | $^{5}/_{8}$ |
| 48[a] | $1^{1}/_{2}$ T & G | N/A |

| | | |
|---|---|---|
| 54[b] | | |
| 60[c] | | |

For SI: 1 inch = 25.4 mm, 1 pound per square inch = 6.895 kPa.
N/A = Not Applicable.
a. For this support spacing, lumber sheathing shall have a minimum $F_b$ of 675 and minimum E of 1,100,000 (see ANSI AWC NDS).
b. For this support spacing, lumber sheathing shall have a minimum $F_b$ of 765 and minimum E of 1,400,000 (see ANSI AWC NDS).
c. For this support spacing, lumber sheathing shall have a minimum $F_b$ of 855 and minimum E of 1,700,000 (see ANSI AWC NDS).

**R503.1.1 End joints.** End joints in lumber used as subflooring shall occur over supports unless end-matched lumber is used, in which case each piece shall bear on not less than two joists. Subflooring shall be permitted to be omitted where joist spacing does not exceed 16 inches (406 mm) and a 1-inch (25 mm) nominal tongue-and-groove wood strip flooring is applied perpendicular to the joists.

**R503.2 Wood structural panel sheathing.**

**R503.2.1 Identification and grade.** *Wood structural panel* sheathing used for structural purposes shall conform to CSA O325, CSA O437 DOC PS 1 or DOC PS 2~~, CSA O437 or CSA O325~~. Panels shall be identified for grade, bond classification and Performance Category by a grade *mark* or certificate of inspection issued by an *approved* agency. The Performance Category value shall be used as the "nominal *panel thickness*" or "*panel thickness*" wherever referenced in this code.

**R503.2.1.1 Subfloor and combined subfloor underlayment.** Where used as subflooring or combination subfloor underlayment, *wood structural panels* shall be of one of the grades specified in Table R503.2.1.1(1). Where sanded plywood is used as combination subfloor underlayment, the grade, bond classification, and Performance Category shall be as specified in Table R503.2.1.1(2).

**TABLE R503.2.1.1(1)**
**ALLOWABLE SPANS AND LOADS FOR WOOD STRUCTURAL PANELS FOR ROOF AND SUBFLOOR SHEATHING AND COMBINATION SUBFLOOR UNDERLAYMENT[a, b, c]**

| SPAN RATING | MINIMUM NOMINAL PANEL THICKNESS (inch) | ALLOWABLE LIVE LOAD (psf)[h, l] | | MAXIMUM SPAN (inches) | | LOAD (pounds per square foot, at maximum span) | | MAXIMUM SPAN (inches) |
|---|---|---|---|---|---|---|---|---|
| | | SPAN @ 16″ o.c. | SPAN @ 24″ o.c. | With edge support[d] | Without edge support | Total load | Live load | |
| Sheathing[e] | | | | Roof [f] | | | | Subfloor[j] |
| 16/0 | 3/8 | 30 | — | 16 | 16 | 40 | 30 | 0 |
| 20/0 | 3/8 | 50 | — | 20 | 20 | 40 | 30 | 0 |
| 24/0 | 3/8 | 100 | 30 | 24 | 20[g] | 40 | 30 | 0 |
| 24/16 | 7/16 | 100 | 40 | 24 | 24 | 50 | 40 | 16 |
| 32/16 | 15/32, 1/2 | 180 | 70 | 32 | 28 | 40 | 30 | 16[h] |
| 40/20 | 19/32, 5/8 | 305 | 130 | 40 | 32 | 40 | 30 | 20[h, i] |
| 48/24 | 23/32, 3/4 | — | 175 | 48 | 36 | 45 | 35 | 24 |
| 60/32 | 7/8 | — | 305 | 60 | 48 | 45 | 35 | 32 |
| Underlayment, C-C plugged, single floor[e] | | | | Roof [f] | | | | Combination subfloor underlayment[k] |
| 16 o.c. | 19/32, 5/8 | 100 | 40 | 24 | 24 | 50 | 40 | 16[i] |
| 20 o.c. | 19/32, 5/8 | 150 | 60 | 32 | 32 | 40 | 30 | 20[i, j] |
| 24 o.c. | 23/32, 3/4 | 240 | 100 | 48 | 36 | 35 | 25 | 24 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 32 o.c. | $^{7}/_{8}$ | — | 185 | 48 | 40 | 50 | 40 | 32 |
| 48 o.c. | $1^{3}/_{32}$, $1^{1}/_{8}$ | — | 290 | 60 | 48 | 50 | 40 | 48 |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.

a. The allowable total loads were determined using a dead load of 10 psf. If the dead load exceeds 10 psf, then the live load shall be reduced accordingly.

b. Panels continuous over two or more spans with long dimension (strength axis) perpendicular to supports. Spans shall be limited to values shown because of possible effect of concentrated loads.

c. Applies to panels 24 inches or wider.

d. Lumber blocking, panel edge clips (one midway between each support, except two equally spaced between supports where span is 48 inches), tongue-and-groove panel edges, or other approved type of edge support.

e. Includes Structural I panels in these grades.

f. Uniform load deflection limitation: $^{1}/_{180}$ of span under live load plus dead load, $^{1}/_{240}$ of span under live load only.

g. Maximum span 24 inches for $^{15}/_{32}$- and $^{1}/_{2}$-inch panels.

h. Maximum span 24 inches where $^{3}/_{4}$-inch wood finish flooring is installed at right angles to joists.

i. Maximum span 24 inches where 1.5 inches of lightweight concrete or approved cellular concrete is placed over the subfloor.

j. Unsupported edges shall have tongue-and-groove joints or shall be supported with blocking unless minimum nominal $^{1}/_{4}$-inch-thick wood panel-type underlayment, fiber-cement underlayment with end and edge joints offset not less than 2 inches or $1^{1}/_{2}$ inches of lightweight concrete or approved cellular concrete is placed over the subfloor, or $^{3}/_{4}$-inch wood finish flooring is installed at right angles to the supports. Fiber-cement underlayment shall comply with ASTM C1288 or ISO 8336 Category C. Allowable uniform live load at maximum span, based on deflection of $^{1}/_{360}$ of span, is 100 psf.

k. Unsupported edges shall have tongue-and-groove joints or shall be supported by blocking unless nominal $^{1}/_{4}$-inch-thick wood panel-type underlayment, fiber-cement underlayment with end and edge joints offset not less than 2 inches or $^{3}/_{4}$-inch wood finish flooring is installed at right angles to the supports. Fiber-cement underlayment shall comply with ASTM C1288 or ISO 8336 Category C. Allowable uniform live load at maximum span, based on deflection of $^{1}/_{360}$ of span, is 100 psf, except panels with a span rating of 48 on center are limited to 65 psf total uniform load at maximum span.

l. Allowable live load values at spans of 16 inches on center and 24 inches on center taken from referenced standard APA E30, *APA Engineered Wood Construction Guide*. Refer to referenced standard for allowable spans not listed in the table.

**TABLE R503.2.1.1(2)**

**ALLOWABLE SPANS FOR SANDED PLYWOOD COMBINATION SUBFLOOR UNDERLAYMENT[a]**

| IDENTIFICATION | SPACING OF JOISTS (inches) | | |
|---|---|---|---|
| | 16 | 20 | 24 |
| Species group[b] | — | — | — |
| 1 | $^{1}/_{2}$ | $^{5}/_{8}$ | $^{3}/_{4}$ |
| 2, 3 | $^{5}/_{8}$ | $^{3}/_{4}$ | $^{7}/_{8}$ |
| 4 | $^{3}/_{4}$ | $^{7}/_{8}$ | 1 |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.

a. Plywood continuous over two or more spans and face grain perpendicular to supports. Unsupported edges shall be tongue-and-groove or blocked except where nominal $^{1}/_{4}$-inch-thick wood panel-type underlayment, fiber-cement underlayment or $^{3}/_{4}$-inch wood finish floor is used. Fiber-cement underlayment shall comply with ASTM C1288 or ISO 8336 Category C. Allowable uniform live load at maximum span based on deflection of $^{1}/_{360}$ of span is 100 psf.

**b. Applicable to all grades of sanded exterior-type plywood.**

**R503.2.2 Allowable spans.** The maximum allowable span for *wood structural panels* used as subfloor or combination subfloor underlayment shall be as set forth in Table R503.2.1.1(1), or APA E30. The maximum span for sanded plywood combination subfloor underlayment shall be as set forth in Table R503.2.1.1(2).

**R503.2.3 Installation.** *Wood structural panels* used as subfloor or combination subfloor underlayment shall be attached to wood framing in accordance with Table R602.3(1) and shall be attached to cold-formed steel framing in accordance with Table R505.3.1(2).

### R503.3 Particleboard.

**R503.3.1 Identification and grade.** Particleboard shall conform to ANSI A208.1 and shall be so identified by a grade *mark* or certificate of inspection issued by an *approved agency*.

**R503.3.2 Floor underlayment.** Particleboard floor underlayment shall conform to Type PBU and shall be not less than $^{1}/_{4}$ inch (6.4 mm) in thickness.

**R503.3.3 Installation.** Particleboard underlayment shall be installed in accordance with the recommendations of the manufacturer and attached to framing in accordance with Table R602.3(1).

## SECTION R504
## PRESSURE PRESERVATIVE-TREATED WOOD FLOORS (ON GROUND)

**R504.1 General.** Pressure preservative-treated wood *basement* floors and floors on ground shall be designed to withstand axial forces and bending moments resulting from lateral soil pressures at the base of the exterior walls and floor live and dead loads. Floor framing shall be designed to meet joist deflection requirements in accordance with Section R301.

**R504.1.1 Unbalanced soil loads.** Unless special provision is made to resist sliding caused by unbalanced lateral soil loads, wood *basement* floors shall be limited to applications where the differential depth of fill on opposite exterior foundation walls is 2 feet (610 mm) or less.

**R504.1.2 Construction.** Joists in wood *basement* floors shall bear tightly against the narrow face of studs in the foundation wall or directly against a band joist that bears on the studs. Plywood subfloor shall be continuous over lapped joists or over butt joints between in-line joists. Sufficient blocking shall be provided between joists to transfer lateral forces at the base of the end walls into the floor system.

**R504.1.3 Uplift and buckling.** Where required, resistance to uplift or restraint against buckling shall be provided by interior bearing walls or properly designed stub walls anchored in the supporting soil below.

**R504.2 Site preparation.** The area within the foundation walls shall have all vegetation, topsoil and foreign material removed, and any fill material that is added shall be free of vegetation and foreign material. The fill shall be compacted to ensure uniform support of the pressure preservative-treated wood floor sleepers.

**R504.2.1 Base.** A minimum 4-inch-thick (102 mm) granular base of gravel having a maximum size of $^{3}/_{4}$ inch (19.1 mm) or crushed stone having a maximum size of $^{1}/_{2}$ inch (12.7 mm) shall be placed over the compacted earth.

**R504.2.2 Moisture barrier.** Polyethylene sheeting of minimum 6-mil (0.15 mm) thickness shall be placed over the granular base. Joints shall be lapped 6 inches (152 mm) and left unsealed. The polyethylene membrane shall be placed over the pressure preservative-treated wood sleepers and shall not extend beneath the footing plates of the exterior walls.

**R504.3 Materials.** Framing materials, including sleepers, joists, blocking and plywood subflooring, shall be pressure-preservative treated and dried after treatment in accordance with AWPA U1 (Commodity Specification A, ~~Use Category 4B and Section 5.2),~~ Special Requirement 4.2), and shall bear the *label* of an accredited agency.

## SECTION R505
## COLD-FORMED STEEL FLOOR FRAMING

**Deleted.**

## SECTION R506
## CONCRETE FLOORS (ON GROUND)

**R506.1 General.** Concrete slab-on-ground floors shall be designed and constructed in accordance with the provisions of this section or ACI 332. Floors shall be a minimum $3^{1}/_{2}$ inches (89 mm) thick (for *expansive soils*, see Section R403.1.8). The specified compressive strength of concrete shall be as set forth in Section R402.2.

**R506.2 Site preparation.** The area within the foundation walls shall have all vegetation, top soil and foreign material removed.

**R506.2.1 Fill.** Fill material shall be free of vegetation and foreign material. The fill shall be compacted to ensure uniform support of the slab, and except where *approved*, the fill depths shall not exceed 24 inches (610 mm) for clean sand or gravel and 8 inches (203 mm) for earth.

**Exception:** #57 or #67 stone may be used as fill for a maximum depth of 4 feet without consolidation.

**R506.2.2 Base.** A 4-inch-thick (102 mm) base course consisting of clean graded sand, gravel, crushed stone, crushed concrete or crushed blast-furnace slag passing a 2-inch (51 mm) sieve shall be placed on the prepared subgrade where the slab is below *grade*.

**Exception:** A base course is not required where the concrete slab is installed on well-drained or sand-gravel mixture soils classified as Group I according to the United Soil Classification System in accordance with Table R405.1.

**R506.2.3 Vapor retarder.** A minimum 6-mil (0.006 inch; 152 µm) ~~polyethylene or approved~~ vapor retarder conforming to ASTM E1745 Class A requirements with joints lapped not less than 6 inches (152 mm) shall be placed between the concrete floor slab and the base course or the prepared subgrade where ~~no~~ a base course ~~exists~~ does not exist.

**Exception:** The vapor retarder is not required for the following:

1. Garages, utility buildings and other unheated *accessory structures*.
2. For unheated storage rooms having an area of less than 70 square feet (6.5 $m^2$) and carports.
3. Driveways, walks, patios and other flatwork not likely to be enclosed and heated at a later date.
4. Where *approved* by the *building official*, based on local site conditions.

**R506.2.4 Reinforcement support.** Where provided in slabs-on-ground, reinforcement shall be supported to remain in place from the center to upper one-third of the slab for the duration of the concrete placement.

## SECTION R507
## EXTERIOR DECKS

**Deleted. See ~~Appendix M~~ Chapter 47**

# CHAPTER 6
# WALL CONSTRUCTION

## SECTION R601
## GENERAL

**R601.1 Application.** The provisions of this chapter shall control the design and construction of walls and partitions for buildings.

**R601.2 Requirements.** Wall construction shall be capable of accommodating all loads imposed in accordance with Section R301 and of transmitting the resulting loads to the supporting structural elements.

**R601.2.1 Compressible floor-covering materials.** Compressible floor-covering materials that compress more than $^1/_{32}$ inch (0.8 mm) when subjected to 50 pounds (23 kg) applied over 1 inch square (645 mm) of material and are greater than $^1/_8$ inch (3.2 mm) in thickness in the uncompressed state shall not extend beneath walls, partitions or columns, which are fastened to the floor.

## SECTION R602
## WOOD WALL FRAMING

**R602.1 General.** Wood and wood-based products used for load-supporting purposes shall conform to the applicable provisions of this section.

**R602.1.1 Sawn lumber.** Sawn lumber shall be identified by a grade *mark* of an accredited lumber grading or inspection agency and have design values certified by an accreditation body that complies with DOC PS 20. In lieu of a grade *mark*, a certification of inspection issued by a lumber grading or inspection agency meeting the requirements of this section shall be accepted.

**R602.1.2 End-jointed lumber.** *Approved* end-jointed lumber identified by a grade *mark* conforming to Section R602.1 shall be permitted to be used interchangeably with solid-sawn members of the same species and grade. End-jointed lumber used in an assembly required elsewhere in this code to have a fire-resistance rating shall have the designation "Heat Resistant Adhesive" or "HRA" included in its grade *mark*.

**R602.1.3 Structural glued-laminated timbers.** Glued-laminated timbers shall be manufactured and identified as required in ~~ANSI/AITC A190.1,~~ <u>ANSI A190.1, ANSI 117</u> and ASTM D3737.

**R602.1.4 Structural log members.** Structural log members shall comply with the provisions of ICC 400.

**R602.1.5 Structural composite lumber.** Structural capacities for *structural composite lumber* shall be established and monitored in accordance with ASTM D5456.

**R602.1.6 Cross-laminated timber.** Cross-laminated timber shall be manufactured and identified as required by ANSI/APA PRG 320.

**R602.1.7 Engineered wood rim board.** Engineered wood rim boards shall conform to ANSI/APA PRR 410 or shall be evaluated in accordance with ASTM D7672. Structural capacities shall be in accordance with either ANSI/APA PRR 410 or established in accordance with ASTM D7672. Rim boards conforming to ANSI/APA PRR 410 shall be marked in accordance with that standard.

**R602.1.8 Wood structural panels.** *Wood structural panel* sheathing shall conform to DOC PS 1, DOC PS 2 or, when manufactured in Canada, CSA O325 or CSA O437. Panels shall be identified for grade, bond classification, and performance category by a grade *mark* or certificate of inspection issued by an *approved* agency.

**R602.1.9 Particleboard.** Particleboard shall conform to ANSI A208.1. Particleboard shall be identified by the grade *mark* or certificate of inspection issued by an *approved* agency.

**R602.1.10 Fiberboard.** Fiberboard shall conform to ASTM C208. Fiberboard sheathing, where used structurally, shall be identified by an *approved* agency as conforming to ASTM C208.

**R602.1.11 Structural insulated panels.** *Structural insulated panels* shall be manufactured and identified in accordance with ANSI/APA PRS 610.1.

**R602.2 Grade.** Studs shall be a minimum No. 3, standard or stud grade lumber.

**Exception:** Bearing studs not supporting floors and nonbearing studs shall be permitted to be utility grade lumber, provided that the studs are spaced in accordance with Table R602.3(5).

**R602.3 Design and construction.** Exterior walls of wood-frame construction shall be designed and constructed in accordance with the provisions of this chapter and Figures R602.3(1) and R602.3(2), or in accordance with AWC NDS. Components of exterior walls shall be fastened in accordance with Tables R602.3(1) through R602.3(4). Wall sheathing shall be fastened directly to framing members and, where placed on the exterior side of an exterior wall, shall be capable of resisting the wind pressures listed in Table R301.2.1(1) adjusted for height and exposure using Table R301.2.1(2) and shall conform to the requirements of Table R602.3(3). Wall sheathing used only for exterior wall covering purposes shall comply with Section R703.

Studs shall be continuous from support at the sole plate to a support at the top plate to resist loads perpendicular to the wall. The support shall be a foundation or floor, ceiling or roof *diaphragm* or shall be designed in accordance with accepted engineering practice.

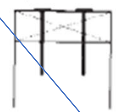
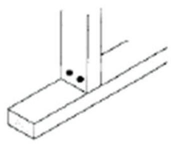
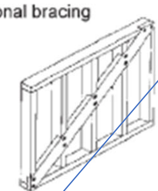
**Exception:** Jack studs, trimmer studs and cripple studs at openings in walls that comply with Tables R602.7(1) and R602.7(2).

**R602.3.1 Stud size, height and spacing.** The size, height and spacing of studs shall be in accordance with Table R602.3(5).

**Exceptions:**

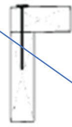
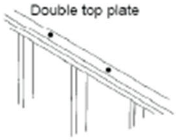
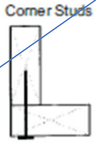
1. Utility grade studs shall not be spaced more than 16 inches (406 mm) on center, shall not support more than a roof and ceiling, and shall not exceed 8 feet (2438 mm) in height for exterior walls and *load-bearing walls* or 10 feet (3048 mm) for interior nonload-bearing walls.
2. Where ~~ground snow~~ roof loads are less than or equal to ~~25~~ 20 pounds per square foot ~~(1.2 kPa),~~ and the ultimate design wind speed is less than or equal to 130 mph (58.1 m/s), 2-inch by 6-inch (38 mm by ~~14~~ 140 mm) studs supporting a roof load with not more than 6 feet (1829 mm) of tributary length shall have a maximum height of 18 feet (5486 mm) where spaced at 16 inches (406 mm) on center, or 20 feet (6096 mm) where spaced at 12 inches (~~304.8~~ 305 mm) on center. Studs shall be No. 2 grade lumber or better.
3. Exterior load-bearing studs not exceeding 12 feet (3658 mm) in height provided in accordance with Table R602.3(6). The minimum number of full-height studs adjacent to openings shall be in accordance with Section R602.7.5. The building shall be located in Exposure B, and the roof *live load* shall not exceed 20 psf (0.96 kPa)~~,~~. Studs and plates shall be No. 2 grade lumber or better.

**TABLE R602.3(1)**
**WALL FRAMING[a, e, f]**

| CONNECTION[b] (NAIL SIZE AND POSITION EXAGGERATED FOR ILLUSTRATIVE PURPOSES) | FASTENER MINIMUM NOMINAL LENGTH IN INCHES x MINIMUM NOMINAL NAIL DIAMETER (inches) | QUANTITY PER CONNECTION OR SPACING BETWEEN FASTENERS (inches o.c.)[d] |
|---|---|---|
| Top or sole plate to stud (face nail)  | 3 1/2″ × 0.162″ (16d common)[c] | 2 |
| | 3″ × 0.148″ nail (10d common) | 3 |
| | 3 1/4″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3 1/4″ × 0.120″ nail | 4 |
| | 3″ × 0.120″ nail | |
| Stud to top or sole plate (toe nail)  | 2 1/2″ × 0.131″ nail (8d common)[c] | 4 |
| | 3 1/2″ × 0.162″ nail (16d common) | 3 |
| | 3″ × 0.148″ nail (10d common) | 4 |
| | 3 1/4″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3 1/4″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |
| | 2 1/8″ × 0.113″ nail | 5 |
| | 2″ × 0.113″ nail | |
| | 2 1/4″ × 0.105″ nail | |
| | 2 1/4″ × 0.099″ nail | |
| Cap/top plate laps and intersections  | 3 1/2″ × 0.162″ nail (16 common)[c] | 2 each side of lap |
| | 3″ × 0.148″ nail | 3 each side of lap |
| | 3 1/4″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3 1/4″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |
| Diagonal bracing  | 2 1/2″ × 0.131″ nail (8d common)[c] | 2 |
| | 3 1/2″ × 0.162″ nail (16d common) | |
| | 3″ × 0.148″ nail (10d common) | |
| | 3 1/4″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3 1/4″ × 0.120″ nail | 3 |
| | 3″ × 0.120″ nail | |
| | 2 1/8″ × 0.113″ nail | |
| | 2″ × 0.113″ nail | 4 |
| | 2 1/4″ × 0.105″ nail | |
| | 2 1/4″ × 0.099″ nail | |
| Sole plate to joist or blocking at braced panels  | 3 1/2″ × 0.135″ nail (16d box)[c] | 3 per 16″ space |
| | 3 1/2″ × 0.162″ nail (16d common) | 2 per 16″ space |
| | 3″ × 0.148″ nail (10d common) | 3 per 16″ space |
| | 3 1/4″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | 4 per 16″ space |
| | 3 1/4″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |

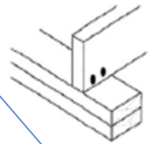
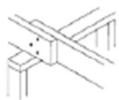
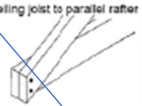
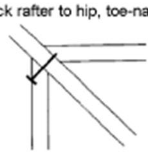
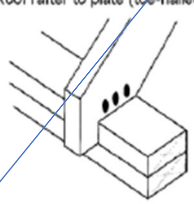
(continued)

**TABLE R602.3(1)—continued**
**WALL FRAMING[a, e, f]**

| CONNECTION[b] (NAIL SIZE AND POSITION EXAGGERATED FOR ILLUSTRATIVE PURPOSES) | FASTENER MINIMUM NOMINAL LENGTH IN INCHES × MINIMUM NOMINAL NAIL DIAMETER (Inches) | QUANTITY PER CONNECTION OR SPACING BETWEEN FASTENERS (Inches)[d] |
|---|---|---|
| Sole plate to joist or blocking  | $3^1/_2$″ × 0.162″ nail (16d common)[c] | 16″ o.c. |
| | 3″ × 0.148″ nail (10d common) | 8″ o.c. |
| | $3^1/_4$″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | $3^1/_4$″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |
| Double top plate  | 3″ × 0.148″ nail (10d common)[c] | 16″ o.c. |
| | $3^1/_2$″ × 0.162″ nail (16d common) | |
| | $3^1/_4$″ × 0.131″ nail | 12″ o.c. |
| | 3″ × 0.131″ | |
| | $3^1/_4$″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |
| Double Studs  | 3″ × 0.148″ nail (10d common)[c] | 12″ o.c. |
| | $3^1/_2$″ × 0.162″ nail (16d common) | |
| | $3^1/_4$″ × 0.131″ nail | 8″ o.c. |
| | 3″ × 0.131″ nail | |
| | $3^1/_4$″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |
| Corner Studs  | $3^1/_2$″ × 0.162″ nail (16d common)[c] | 24″ o.c. |
| | 3″ × 0.148″ nail (10d common) | 16″ o.c. |
| | $3^1/_4$″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | $3^1/_4$″ × 0.120″ nail | 12″ o.c. |
| | 3″ × 0.120″ nail | |

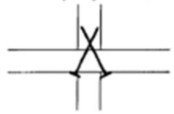
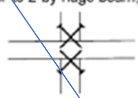
*(continued)*

**TABLE R602.3(1)—continued**
**CEILING AND ROOF FRAMING[a, e]**

| CONNECTION[b] (NAIL SIZE AND POSITION EXAGGERATED FOR ILLUSTRATIVE PURPOSES) | FASTENER MINIMUM NOMINAL LENGTH x MINIMUM NOMINAL NAIL DIAMETER (inches) | QUANTITY PER CONNECTION OR SPACING BETWEEN FASTENERS (inches)[d] |
|---|---|---|
| Ceiling joist to plate  | 3½″ × 0.162″ (16d common)[c] | 3 |
| | 3″ × 0.148″ nail (10d common) | 4 |
| | 3¼″ × 0.131″ nail | 5 |
| | 3″ × 0.131″ nail | |
| | 3¼″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |
| | 2¾″ × 0.113″ nail | 6 |
| Ceiling joists, laps over partitions  Ceiling joist to parallel rafter  | 3½″ × 0.162″ nail (16d common)[c] | 3 |
| | 3″ × 0.148″ nail (10d common) | 4 |
| | 3¼″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3¼″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |
| Collar tie to rafter  | 3″ × 0.148″ nail (10d common)[c] | 3 |
| | 3½″ × 0.162″ nail (16d common) | |
| | 3¼″ × 0.131″ nail | 4 |
| | 3″ × 0.131″ nail | |
| | 3¼″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |
| Jack rafter to hip, toe-nailed  | 3″ × 0.148″ nail (10d common)[c] | 3 |
| | 3½″ × 0.162″ nail (16d common) | |
| | 3¼″ × 0.131″ nail | 4 |
| | 3″ × 0.131″ nail | |
| | 3¼″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |
| Jack rafter to hip, face nailed  | 3½″ × 0.162″ nail (16d common)[c] | 2 |
| | 3″ × 0.148″ nail (10d common) | 3 |
| | 3¼″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3¼″ × 0.120″ nail | 4 |
| | 3″ × 0.120″ nail | |
| Roof rafter to plate (toe-nailed)  | 2½″ × 0.131″ nail (8d common)[c] | 3 |
| | 3½″ × 0.162″ nail (16d common) | |
| | 3″ × 0.148″ nail (10d common) | |
| | 3¼″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3¼″ × 0.120″ nail | 4 |
| | 3″ × 0.120″ nail | |
| | 2¾″ × 0.113″ nail | 5 |
| | 2″ × 0.113″ nail | |
| | 2¼″ × 0.105″ nail | |
| | 2¼″ × 0.099″ nail | 6 |

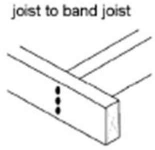
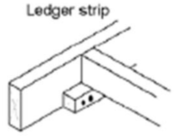
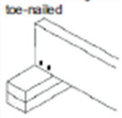
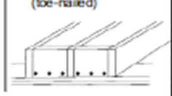
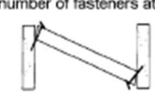
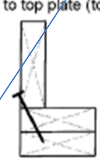
(continued)

TABLE R602.3(1)—continued
CEILING AND ROOF FRAMING[a, e]

| CONNECTION[b] (NAIL SIZE AND POSITION EXAGGERATED FOR ILLUSTRATIVE PURPOSES) | FASTENER MINIMUM NOMINAL LENGTH × MINIMUM NOMINAL NAIL DIAMETER (inches) | QUANTITY PER CONNECTION OR SPACING BETWEEN FASTENERS (inches)[d] |
|---|---|---|
| Roof rafter to 2-by ridge beam, face nailed  (only the attachment of the top rafter is illustrated) | 3 1/2″ × 0.162″ nail (16d common)[c] | 2 |
| | 3″ × 0.148″ nail (10d common) | 3 |
| | 3 1/4″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3 1/4″ × 0.120″ nail | 4 |
| | 3″ × 0.120″ nail | |
| Roof rafter to 2-by ridge beam, toe-nailed  | 3 1/2″ × 0.162″ nail (16d common)[c] | 2 |
| | 3″ × 0.148″ nail (10d common) | 3 |
| | 3 1/4″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3 1/4″ × 0.120″ nail | 4 |
| | 3″ × 0.120″ nail | |

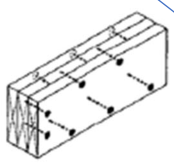
*(continued)*

TABLE R602.3(1)—continued
FLOOR FRAMING[a, e]

| CONNECTION[b] (NAIL SIZE AND POSITION EXAGGERATED FOR ILLUSTRATIVE PURPOSES) | FASTENER MINIMUM NOMINAL LENGTH × MINIMUM NOMINAL NAIL DIAMETER (inches) | QUANTITY PER CONNECTION OR SPACING BETWEEN FASTENERS[d] |
|---|---|---|
| joist to band joist  | 3 1/2″ × 0.162″ (16d common)[c] | 3 |
| | 3″ × 0.148″ nail (10d common) | 5 |
| | 3 1/4″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3 1/4″ × 0.120″ nail | 6 |
| | 3″ × 0.120″ nail | |
| Ledger strip  | 3 1/2″ × 0.162″ nail (16d common)[c] | 3 |
| | 3″ × 0.148″ nail (10d common) | 4 |
| | 3 1/4″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3 1/4″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |
| Joist to sill or girder toe-nailed  Blocking between joist or rafter to top plate (toe-nailed)  | 2 1/2″ × 0.131″ nail (8d common)[c] | 3 |
| | 3″ × 0.148″ nail (10d common) | |
| | 3 1/4″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | 4 |
| | 3 1/4″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | |
| Bridging to joist (listed number of fasteners at each end)  | 2 1/2″ × 0.131″ nail (8d common)[c] | 2 |
| | 3 1/4″ × 0.120″ nail | 3 |
| | 3″ × 0.120″ nail | |
| | 2 3/8″ × 0.113″ nail | |
| | 2″ × 0.113″ nail (6d common) | 4 |
| | 2 1/4″ × 0.105″ nail | 3 |
| | 2 1/4″ × 0.99″ nail | 4 |
| Rim joist to top plate (toe-nailed)  | 2 1/2″ × 0.113″ (3d box)[c] | 4″ o.c. |
| | 3 1/2″ × 0.162″ nail (16d common) | 8″ o.c |
| | 3″ × 0.148″ nail (10d common) | 6″ o.c. |
| | 3 1/4″ × 0.131″ nail | |
| | 3″ × 0.131″ nail | |
| | 3 1/4″ × 0.120″ nail | |
| | 3″ × 0.120″ nail | 4″ o.c. |
| | 2 3/8″ × 0.113″ nail | 4″ o.c. |
| | 2″ × 0.113″ nail (6d common) | 3″ o.c. |
| | 2 1/4″ × 0.105″ nail | |
| | 2 1/4″ × 0.099″ nail | |

*(continued)*

**TABLE R602.3(1)—continued**
**FLOOR FRAMING[a, f]**

| CONNECTION[b] (Nail size and position exaggerated for illustrative purposes) | FASTNER MINIMUM NOMINAL LENGTH × MINIMUM NOMINAL NAIL DIAMETER (inches) | SPACING OF FASTENERS ALONG THE TOP AND BOTTOM OF BEAM, STAGGERED ON EACH SIDE OF EACH LAYER | NUMBER OF FASTENERS AT EACH END AND SPLICE FOR EACH LAYER |
|---|---|---|---|
| Built-up girders and beams  | 4″ × 0.192″ nail (20d common)[c] | 32″ o.c. | 2 |
| | $3^1/_2$″ × 0.162″ nail (16d common) | 24″ o.c. | 3 |
| | 3″ × 0.148″ nail (10d common) | | |
| | $3^1/_4$″ × 0.131″ nail | | |
| | 3″ × 0.131″ nail | | |
| | $3^1/_4$″ × 0.120″ nail | 16″ o.c. | 3 |
| | 3″ × 0.120″ nail | | |
| | $2^1/_2$″ × 0.131″ nail (8d common) | 16″ o.c. | 4 |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.44 m/s, 1 foot = 304.8 mm.

a. This fastening schedule applies to framing members having an actual thickness of $1^1/_2$ inches (nominal "2-by" lumber).

b. Fastenings listed above may also be used for other connections that are not listed but that have the same configuration and the same code requirement for fastener quantity/spacing and fastener size (pennyweight and style, e.g., 8d common, "8-penny common nail").

c. This fastener, in the quantity or spacing shown in the rightmost column, comprises the most stringent fastening of the connection listed in the *International Residential Code*.

d. Fastening schedule only applies to buildings of conventional wood frame construction where wind or seismic analysis is not required by the applicable code. In areas where wind or seismic analysis is required, required fastening must be determined by structural analysis. The following are conditions for which codes require structural analysis:

   i. For nominal dimensions of nails see Table R602.3(1a)

   ii. *North Carolina Residential Code*—buildings located in areas where the design wind speed equals or exceeds 130 mph (58 m/s) or townhouses assigned to Seismic Design Category C.

e. Reprinted by permission of the ICC Evaluation Service®, LLC from Evaluation Report ESR-1539-09. Use of ESR 1539-15 is permitted.

f. Nails and staples shall conform to the requirements of ASTM F1667.

*(continued)*

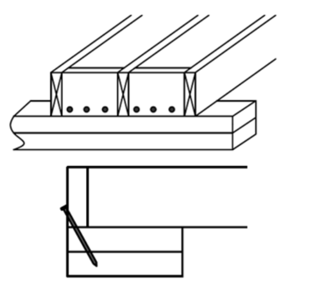
**TABLE R602.3(1)—continued**
**FASTENER SCHEDULE FOR STRUCTURAL MEMBERS[j, k]**

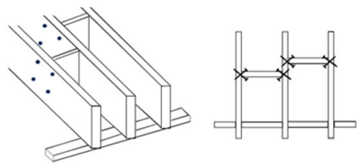
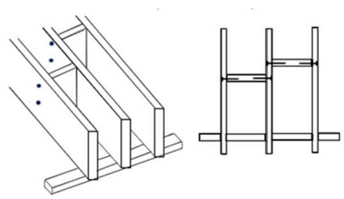
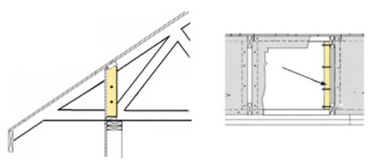
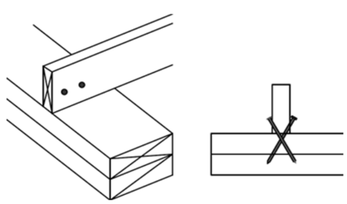
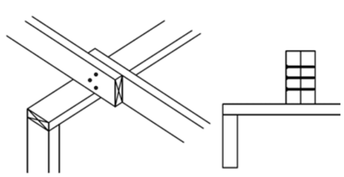
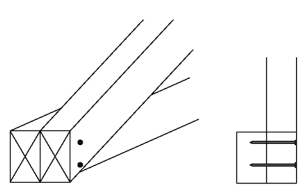
| DESCRIPTION OF BUILDING MATERIALS | DESCRIPTION OF FASTENER[b, c, e] | SPACING OF FASTENERS Edges (inches)[i] | SPACING OF FASTENERS Intermediate supports[c, e] (inches) |
|---|---|---|---|
| **Wood structural panels, subfloor, roof and interior wall sheathing to framing and particleboard wall sheathing to framing** | | | |
| 3/8″ – 1/2″ | 6d common (2″ × 0.113″) nail (subfloor wall)<br>8d common (2 1/2″ × 0.131″) nail (roof)[f] | 6 | 12[g] |
| 19/32″ – 1″ | 8d common nail (2 1/2″ × 0.131″) | 6 | 12[g] |
| 1 1/8″ – 1 1/4″ | 10d common (3″ × 0.148″) nail or<br>8d (2 1/2″ × 0.131″) deformed nail | 6 | 12 |
| **Other wall sheathing[h]** | | | |
| 1/2″ structural cellulosic fiberboard sheathing | 1 1/2″ galvanized roofing nail, 7/16″ crown or 1″ crown staple 16 ga., 1 1/4″ long | 3 | 6 |
| 25/32″ structural cellulosic fiberboard sheathing | 1 3/4″ galvanized roofing nail, 7/16″ crown or 1″ crown staple 16 ga., 1 1/2″ long | 3 | 6 |
| 1/2″ gypsum sheathing[d] | 1 1/2″ galvanized roofing nail; staple galvanized, 1 1/2″ long; 1 1/4″ screws, Type W or S | 7 | 7 |
| 5/8″ gypsum sheathing[d] | 1 3/4″ galvanized roofing nail; staple galvanized, 1 5/8″ long; 1 5/8″ screws, Type W or S | 7 | 7 |
| **Wood structural panels, combination subfloor underlayment to framing** | | | |
| 3/4″ and less | 6d deformed (2″ × 0.120″) nail or<br>8d common (2 1/2″ × 0.131″) nail | 6 | 12 |
| 7/8″ – 1″ | 8d common (2 1/2″ × 0.131″) nail or<br>8d deformed (2 1/2″ × 0.120″) nail | 6 | 12 |
| 1 1/8″ – 1 1/4″ | 10d common (3″ × 0.148″) nail or<br>8d deformed (2 1/2″ × 0.120″) nail | 6 | 12 |

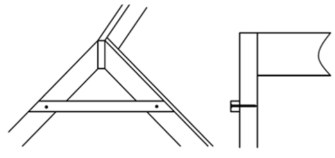
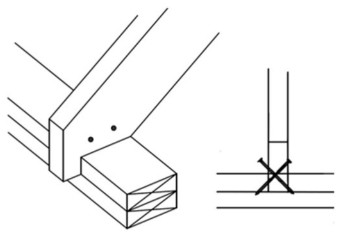
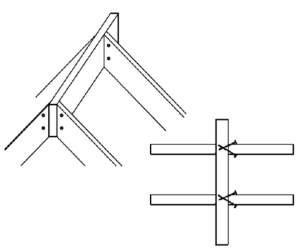
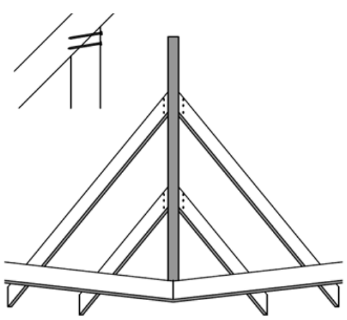
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s; 1ksi = 6.895 MPa.

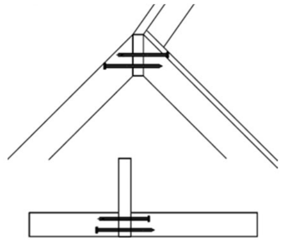
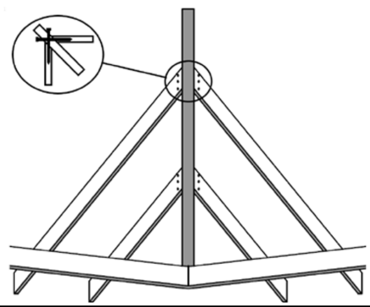
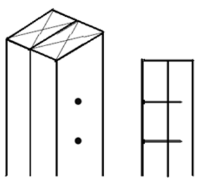
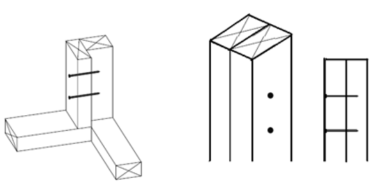
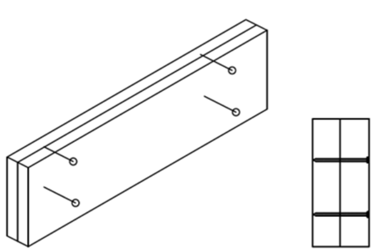
a. Deleted.
b. Staples are 16 gage wire and have a minimum 7/16-inch on diameter crown width.
c. Nails shall be spaced at not more than 6 inches on center at all supports where spans are 48 inches or greater.
d. Four-foot by 8-foot or 4-foot by 9-foot panels shall be applied vertically.
e. Spacing of fasteners not included in this table shall be based on Table R602.3(2).
f. For regions having ultimate wind speed of 130 mph or greater, 8d deformed (2 1/2″ × 0.120″) nails shall be used for attaching plywood and wood structural panel roof sheathing to framing within minimum 48-inch distance from gable end walls, if mean roof height is more than 25 feet, up to 35 feet maximum.
g. For regions having ultimate wind speed of 120 mph or less, nails for attaching wood structural panel roof sheathing to gable end wall framing shall be spaced 6 inches on center. When basic wind speed is greater than 100 mph, nails for attaching panel roof sheathing to intermediate supports shall be spaced 6 inches on center for minimum 48-inch distance from ridges, eaves and gable end walls; and 4 inches on center to gable end wall framing.
h. Gypsum sheathing shall conform to ASTM C79 and shall be installed in accordance with GA 253. Fiberboard sheathing shall conform to ASTM C208.
i. Spacing of fasteners on floor sheathing panel edges applies to panel edges supported by framing members and required blocking and at all floor perimeters only. Spacing of fasteners on roof sheathing panel edges applies to panel edges supported by framing members and required blocking. Blocking of roof or floor sheathing panel edges perpendicular to the framing members need not be provided except as required by other provisions of this code. Floor perimeter shall be supported by framing members or solid blocking. Roof sheathing 7/16-inch or greater in thickness does not require perimeter blocking.
j. For nominal dimensions of nails see Table R602.3(1a).
k. Nails and staples shall conform to the requirements of ASTM F1667.

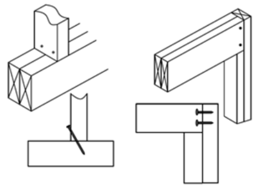
**TABLE R602.3(1)**
**FASTENING SCHEDULE [k, l,m,n]**

| ITEM | DESCRIPTION OF BUILDING ELEMENTS | NUMBER AND TYPE OF FASTENER[a, b, c] | SPACING AND LOCATION |
|---|---|---|---|
| **Roof** | | | |
| 1 | Blocking between ceiling joists, rafters or trusses to top plate or other framing below  | 4-8d box (2 1/2″ × 0.113″); or<br>3-8d common (2 1/2″ × 0.131″); or<br>3-10d box (3″ × 0.128″); or<br>3-3″ × 0.131″ nails | Toe nail |

| | | | |
|---|---|---|---|
| | Blocking between rafters or truss not at the wall top plates, to rafter or truss  | 2-8d common ($2^{1}/_{2}'' \times 0.131''$); or 2-3″ × 0.131″ nails | Each end toe nail |
| |  | 2-16d common ($3^{1}/_{2}'' \times 0.162''$); or 3-3″ × 0.131″ nails | End nail |
| | Flat blocking to truss and web filler  | 16d common ($3^{1}/_{2}'' \times 0.162''$); or 3″ × 0.131″ nails | 6″ o.c. face nail |
| 2 | Ceiling joists to top plate  | 4-8d box ($2^{1}/_{2}'' \times 0.113''$); or 3-8d common ($2^{1}/_{2}'' \times 0.131''$); or 3-10d box (3″ × 0.128″); or 3-3″ × 0.131″ nails | Per joist, toe nail |
| 3 | Ceiling joist not attached to parallel rafter, laps over partitions [see Section R802.5.2 and Table R802.5.2(1)]  | 4-10d box (3″ × 0.128″); or 3-16d common ($3^{1}/_{2}'' \times 0.162''$); or 4-3″ × 0.131″ nails | Face nail |
| 4 | Ceiling joist attached to parallel rafter (heel joint) [see Section R802.5.2 and Table R802.5.2(1)]  | Table R802.5.2(1) | Face nail |

| | | | |
|---|---|---|---|
| 5 | Collar tie to rafter, face nail<br> | 4-10d box (3″ × 0.128″); or<br>3-10d common (3″ × 0.148″); or<br>4-3″ × 0.131″ nails | Face nail each rafter |
| 6 | Rafter or roof truss to plate [o]<br> | 3-16d box ($3^{1}/_{2}$″ × 0.135″); or<br>3-10d common (3″ × 0.148″); or<br>4-10d box (3″ × 0.128″); or<br>4-3″ × 0.131″ nails | 2 toe nails on one side and 1 toe nail on opposite side of each rafter or truss[i] |
| 7 | Roof rafters to ridge, valley or hip rafters or roof rafter to minimum 2″ ridge beam<br><br> | 4-16d box ($3^{1}/_{2}$″ × 0.135″); or<br>3-10d common (3″ × 0.148″); or<br>4-10d box (3″ × 0.128″); or<br>4-3″ × 0.131″ nails | Toe nail |

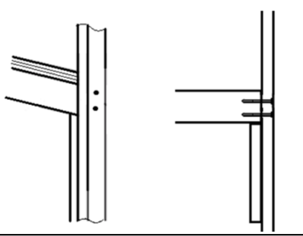
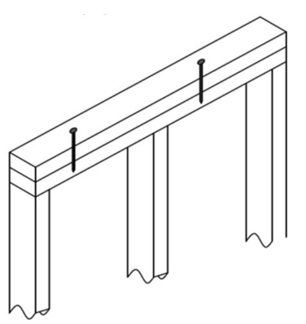
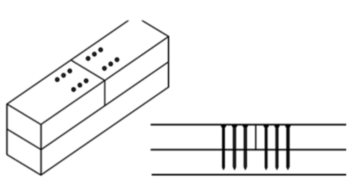
| | | | |
|---|---|---|---|
| | <br> | 3-16d box ($3^1/_2'' \times 0.135''$); or<br>2-16d common ($3^1/_2'' \times 0.162''$); or<br>3-10d box ($3'' \times 0.128''$); or<br>3-$3'' \times 0.131''$ nails | End nail |
| **Wall** | | | |
| 8 | Stud to stud<br>(not at braced wall panels)<br> | 16d common ($3^1/_2'' \times 0.162''$) | 24″ o.c. face nail |
| | | 10d box ($3'' \times 0.128''$); or<br>$3'' \times 0.131''$ nails | 16″ o.c. face nail |
| 9 | Stud to stud and abutting studs at intersecting wall corners (at braced wall panels)<br> | 16d box ($3^1/_2'' \times 0.135''$); or<br>$3'' \times 0.131''$ nails | 12″ o.c. face nail |
| | | 16d common ($3^1/_2'' \times 0.162''$) | 16″ o.c. face nail |
| 10 | Built-up header (2″ to 2″ header with $^1/_2''$ spacer)<br> | 16d common ($3^1/_2'' \times 0.162''$) | 16″ o.c. each edge face nail |
| | | 16d box ($3^1/_2'' \times 0.135''$) | 12″ o.c. each edge face nail |

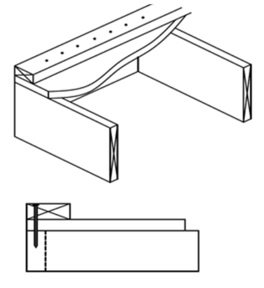
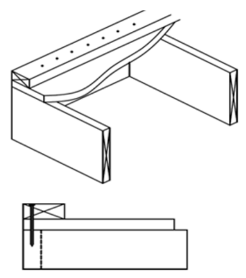
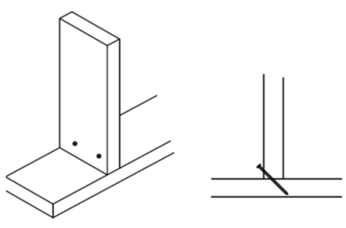
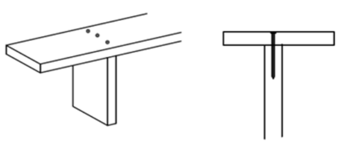
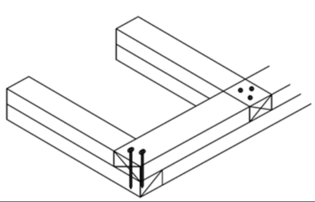
| | | | |
|---|---|---|---|
| 11 | Continuous header to stud<br> | 5-8d box ($2^1/_2''$ × 0.113″); or<br>4-8d common ($2^1/_2''$ × 0.131″); or<br>4-10d box (3″ × 0.128″) | Toe nail |

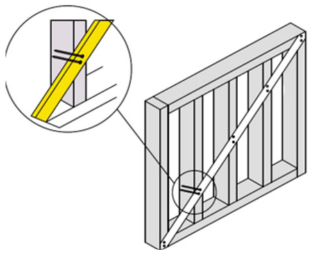
*(continued)*

**TABLE R602.3(1)—continued**

**FASTENING SCHEDULE**

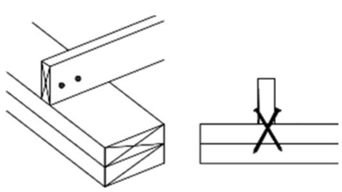
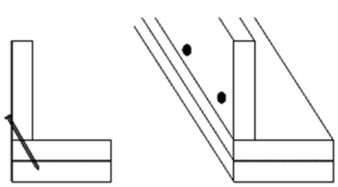
| ITEM | DESCRIPTION OF BUILDING ELEMENTS | NUMBER AND TYPE OF FASTENER[a, b, c] | SPACING AND LOCATION |
|---|---|---|---|
| | | **Wall** | |
| 12 | Adjacent full-height stud to end of header<br> | 4-16d box ($3^1/_2''$× 0.135″); or<br>3-16d common ($3^1/_2''$ × 0.162″); or<br>4-10d box (3″ × 0.128″); or<br>4-3″ × 0.131″ nails | End nail |
| 13 | Top plate to top plate<br> | 16d common ($3^1/_2''$ × 0.162″) | 16″ o.c. face nail |
| | | 10d box (3″ × 0.128″); or<br>3″ × 0.131″ nails | 12″ o.c. face nail |
| 14 | Double top plate splice<br> | 8-16d common ($3^1/_2''$ × 0.162″); or<br>12-16d box ($3^1/_2''$ × 0.135″); or<br>12-10d box (3″ × 0.128″); or<br>12-3″ × 0.131″ nails | Face nail on each side of end joint (minimum 24″ lap splice length each side of end joint) |
| 15 | Bottom plate to joist, rim joist, band joist or blocking (not at braced wall panels) | 16d common ($3^1/_2''$ × 0.162″) | 16″ o.c. face nail |
| | | 16d box ($3^1/_2''$ × 0.135″); or<br>3″ × 0.131″ nails | 12″ o.c. face nail |

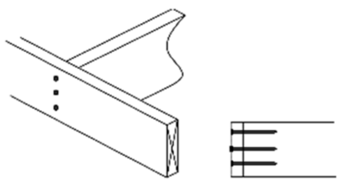
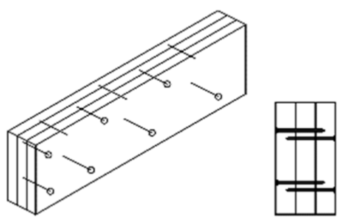
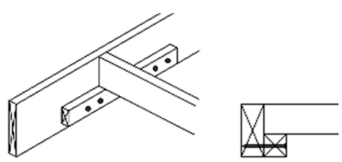
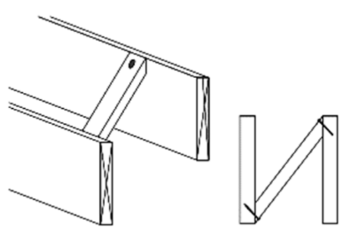
| | | | |
|---|---|---|---|
| |  | | |
| **Roof** | | | |
| 16 | Bottom plate to joist, rim joist, band joist or blocking (at braced wall panel)  | 3-16d box ($3^{1}/_{2}''$ × 0.135″); or<br>2-16d common ($3^{1}/_{2}''$ × 0.162″); or<br>4-3″ × 0.131″ nails | 16″ o.c. face nail |
| 17 | Top or bottom plate to stud [p]  | 4-8d box ($2^{1}/_{2}''$ × 0.113″); or<br>3-16d box ($3^{1}/_{2}''$ × 0.135″); or<br>4-8d common ($2^{1}/_{2}''$ × 0.131″); or<br>4-10d box (3″ × 0.128″); or<br>4-3″ × 0.131″ nails | Toe nail |
| |  | 3-16d box ($3^{1}/_{2}''$ × 0.135″); or<br>2-16d common ($3^{1}/_{2}''$ × 0.162″); or<br>3-10d box (3″ × 0.128″); or<br>3-3″ × 0.131″ nails | End nail |
| 18 | Top plates, laps at corners and intersections  | 3-10d box (3″ × 0.128″); or<br>2-16d common ($3^{1}/_{2}''$ × 0.162″); or<br>3-3″ × 0.131″ nails | Face nail |
| 19 | 1″ brace to each stud and plate | 3-8d box ($2^{1}/_{2}''$ × 0.113″); or<br>2-8d common ($2^{1}/_{2}''$ × 0.131″); or<br>2-10d box (3″ × 0.128″); or<br>2 staples $1^{3}/_{4}''$ | Face nail |

| | | | |
|---|---|---|---|
| |  | | |
| 20 | 1″ × 6″ sheathing to each bearing | 3-8d box (2$^{1}/_{2}$″ × 0.113″); or<br>2-8d common (2$^{1}/_{2}$″ × 0.131″); or<br>2-10d box (3″ × 0.128″); or<br>2 staples, 1″ crown, 16 ga., 1$^{3}/_{4}$″ long | Face nail |
| 21 | 1″ × 8″ and wider sheathing to each bearing | 3-8d box (2$^{1}/_{2}$″ × 0.113″); or<br>3-8d common (2$^{1}/_{2}$″ × 0.131″); or<br>3-10d box (3″ × 0.128″); or<br>3 staples, 1″ crown, 16 ga., 1$^{3}/_{4}$″ long | Face nail |
| | | Wider than 1″ × 8″<br>4-8d box (2$^{1}/_{2}$″ × 0.113″); or<br>3-8d common (2$^{1}/_{2}$″ × 0.131″); or<br>3-10d box (3″ × 0.128″); or<br>4 staples, 1″ crown, 16 ga., 1$^{3}/_{4}$″ long | |

*(continued)*

**TABLE R602.3(1)—continued**
**FASTENING SCHEDULE**

| ITEM | DESCRIPTION OF BUILDING ELEMENTS | NUMBER AND TYPE OF FASTENER[a, b, c] | SPACING AND LOCATION |
|---|---|---|---|
| | | **Floor** | |
| 22 | Joist to sill, top plate or girder<br> | 4-8d box (2$^{1}/_{2}$″ × 0.113″); or<br>3-8d common (2$^{1}/_{2}$″ × 0.131″); or<br>3-10d box (3″ × 0.128″); or<br>3-3″ × 0.131″ nails | Toe nail |
| 23 | Rim joist, band joist or blocking to sill or top plate (roof applications also)<br> | 8d box (2$^{1}/_{2}$″ × 0.113″) | 4″ o.c. toe nail |
| | | 8d common (2$^{1}/_{2}$″ × 0.131″); or<br>10d box (3″ × 0.128″); or<br>3″ × 0.131″ nails | 6″ o.c. toe nail |

| | | | |
|---|---|---|---|
| 24 | 1″ × 6″ subfloor or less to each joist | 3-8d box (2$^{1}/_{2}$″ × 0.113″); or<br>2-8d common (2$^{1}/_{2}$″ × 0.131″); or<br>3-10d box (3″ × 0.128″); or<br>2 staples, 1″ crown, 16 ga., 1$^{3}/_{4}$″ long | Face nail |
| 25 | 2″ subfloor to joist or girder | 3-16d box (3$^{1}/_{2}$″ × 0.135″); or<br>2-16d common (3$^{1}/_{2}$″ × 0.162″) | Blind and face nail |
| 26 | 2″ planks (plank & beam—floor & roof) | 3-16d box (3$^{1}/_{2}$″ × 0.135″); or<br>2-16d common (3$^{1}/_{2}$″ × 0.162″) | At each bearing, face nail |
| 27 | Band or rim joist to joist<br> | 3-16d common (3$^{1}/_{2}$″ × 0.162″); or<br>4-10 box (3″ × 0.128″); or<br>4-3″ × 0.131″ nails; or<br>4-3″ × 14 ga. staples, $^{7}/_{16}$″ crown | End nail |
| 28 | Built-up girders and beams, 2-inch lumber layers<br> | 20d common (4″ × 0.192″); or | Nail each layer as follows: 32″ o.c. at top and bottom and staggered. |
| | | 10d box (3″ × 0.128″); or<br>3″ × 0.131″ nails | 24″ o.c. face nail at top and bottom staggered on opposite sides |
| | | And:<br>2-20d common (4″ × 0.192″); or<br>3-10d box (3″ × 0.128″); or<br>3-3″ × 0.131″ nails | Face nail at ends and at each splice |
| 29 | Ledger strip supporting joists or rafters<br> | 4-16d box (3$^{1}/_{2}$″ × 0.135″); or<br>3-16d common (3$^{1}/_{2}$″ × 0.162″); or<br>4-10d box (3″ × 0.128″); or<br>4-3″ × 0.131″ nails | At each joist or rafter, face nail |
| 30 | Bridging or blocking to joist, rafter or truss<br> | 2-10d box (3″ × 0.128″); or<br>2-8d common (2$^{1}/_{2}$″ × 0.131″); or<br>3″ × 0.131″ nails | Each end, toe nail |

| ITEM | DESCRIPTION OF BUILDING ELEMENTS | NUMBER AND TYPE OF FASTENER[a, b, c] | SPACING OF FASTENERS | |
|---|---|---|---|---|
| | | | Edges[h] (inches) | Intermediate supports[c, e] (inches) |
| Wood structural panels, subfloor, roof and interior wall sheathing to framing and particleboard wall sheathing to framing [see Table R602.3(3) for wood structural panel exterior wall sheathing to wall framing] | | | | |

| | | | | |
|---|---|---|---|---|
| 31 | 3/8″ – 1/2″ | 6d common or deformed (2″ × 0.113″ × 0.266″ head); or 2 3/8″ × 0.113″ × 0.266″ head nail (subfloor, wall)[i] | 6[j] | 6[f,j] |
| | | 8d common (2 1/2″ × 0.131″) nail (roof); or RSRS-01 (2 3/8″ × 0.113″) nail (roof)[b] | 6[j] | 6[f,j] |
| 32 | 19/32″ – 3/4″ | 8d common (2-2 1/2″ × 0.131″) nail (subfloor, wall) | 6 | 12 |
| | | 8d common (2 1/2″ × 0.131″) nail (roof); or RSRS-01; (2 3/8″ × 0.113″) nail (roof)[b] | 6[j] | 6[f,j] |
| | | Deformed 2 3/8″ × 0.113″ × 0.266″ head (wall or subfloor) | 6 | 12 |
| 33 | 7/8″ – 1 1/4″ | 10d common (3″ × 0.148″) nail; or (2 1/2″ × 0.131 × 0.281″ head) deformed nail | 6 | 12 |

*(continued)*

**TABLE R602.3(1)—continued**

**FASTENING SCHEDULE**

| ITEM | DESCRIPTION OF BUILDING ELEMENTS | NUMBER AND TYPE OF FASTENER[a, b, c] | SPACING AND LOCATION | |
|---|---|---|---|---|
| **Other wall sheathing[g]** | | | | |
| 34 | 1/2″ structural cellulosic fiberboard sheathing | 1 1/2″ × 0.120″ galvanized roofing nail, 7/16″ head diameter; or 1 1/4″ long 16 ga. staple with 7/16″ or 1″ crown | 3 | 6 |
| 35 | 25/32″ structural cellulosic fiberboard sheathing | 1 3/4″ × 0.120″ galvanized roofing nail, 7/16″ head diameter; or 1 1/4″ long 16 ga. staple with 7/16″ or 1″ crown | 3 | 6 |

| | | | | |
|---|---|---|---|---|
| 36 | $^1/_2$″ gypsum sheathing[d] | $1^1/_2$″ × 0.120″ galvanized roofing nail, $^7/_{16}$″ head diameter, or $1^1/_4$″ long 16 ga.; staple galvanized, $1^1/_2$″ long; $^7/_{16}$″ or 1″ crown or $1^1/_4$″ screws, Type W or S | 7 | 7 |
| 37 | $^5/_8$″ gypsum sheathing[d] | $1^3/_4$″ × 0.120″ galvanized roofing nail, $^7/_{16}$″ head diameter, or $1^1/_4$″ long 16 ga.; staple galvanized, $1^1/_2$″ long; $^7/_{16}$″ or 1″ crown or $1^1/_4$″ screws, Type W or S | 7 | 7 |
| **Wood structural panels, combination subfloor underlayment to framing** | | | | |
| 38 | $^3/_4$″ and less | Deformed (2″ × 0.113″) or Deformed (2″ × 0.120″) nail; or 8d common ($2^1/_2$″ × 0.131″) nail | 6 | 12 |
| 39 | $^7/_8$″ – 1" | 8d common ($2^1/_2$″ × 0.131″) nail; or Deformed (2″ × 0.113″); or Deformed ($2^1/_2$″ × 0.120″) nail | 6 | 12 |
| 40 | $1^1/_8$″ – $1^1/_4$″ | 10d common (3″ × 0.148″) nail; or Deformed (2″ × 0.113″); or Deformed ($2^1/_2$″ × 0.120″) nail | 6 | 12 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s; 1 ksi = 6.895 MPa.

a. Nails are smooth-common, box or deformed shanks except where otherwise stated. Nails used for framing and sheathing connections are carbon steel and shall have minimum average bending yield strengths as shown: 80 ksi for shank diameter of 0.192 inch (20d common nail), 90 ksi for shank diameters larger than 0.142 inch but not larger than 0.177 inch, and 100 ksi for shank diameters of 0.142 inch or less. Connections using nails and staples of other materials, such as stainless steel, shall be designed by accepted engineering practice ~~or approved under Section R104.11.~~

b. RSRS-01 is a Roof Sheathing Ring Shank nail meeting the specifications in ASTM F1667.

c. Nails shall be spaced at not more than 6 inches on center at all supports where spans are 48 inches or greater.

d. Four-foot by 8-foot or 4-foot by 9-foot panels shall be applied vertically.

e. Spacing of fasteners not included in this table shall be based on Table R602.3(2).

f. For wood structural panel roof sheathing attached to gable end roof framing and to intermediate supports within 48 inches of roof edges and ridges, nails shall be spaced at 4 inches on center where the ultimate design wind speed is greater than 130 mph in Exposure B or greater than 115 mph in Exposure C.

g. Gypsum sheathing shall conform to ASTM C1396 and shall be installed in accordance with ASTM C1280 or GA 253. Fiberboard sheathing shall conform to ASTM C208.

h. Spacing of fasteners on floor sheathing panel edges applies to panel edges supported by framing members and required blocking and at floor perimeters only. Spacing of fasteners on roof sheathing panel edges applies to panel edges supported by framing members and required blocking. Blocking of roof or floor sheathing panel edges perpendicular to the framing members need not be provided except as required by other provisions of this code. Floor perimeter shall be supported by framing members or solid blocking. Roof sheathing 7/16-inch or greater in thickness does not require perimeter blocking.

i. Where a rafter is fastened to an adjacent parallel ceiling joist in accordance with this schedule, provide two toe nails on one side of the rafter and toe nails from the ceiling joist to top plate in accordance with this schedule. The toe nail on the opposite side of the rafter shall not be required.

j. ~~For regions having ultimate wind speed of less than 130 mph, nails for attaching wood structural panel roof sheathing to gable end wall framing shall be spaced 6 inches on center. For regions having ultimate wind speed of 130 mph or greater, nails for attaching panel roof sheathing to edge and intermediate supports shall be spaced 4 inches on center for minimum 48-inch distance from ridges, eaves, and gable end walls; and 4 inches on center to gable end wall framing.~~ For wood structural panel roof sheathing attached to gable end roof framing and to intermediate supports within 48 inches of roof edges and ridges, nails shall be spaced at 4 inches on center where the ultimate design wind speed is greater than 130 mph in Exposure C. Roof sheathing 19/32-inch or greater in thickness shall be attached to roof framing members spaced at 24-inches on center or shall be designed by accepted engineering practice where the ultimate design wind speed is greater than 130 mph in Exposure C.

~~k. This fastening schedule applies to framing members having an actual thickness of 1 1/2 inches (nominal "2-by" lumber).~~

k. Fastenings listed above may also be used for other connections that are not listed but that have the same configuration and the same code requirement for fastener quantity/spacing and fastener size (pennyweight and style, e.g., 8d common, "8-penny common nail").

~~l. This fastener, in the quantity or spacing shown in the rightmost column, comprises the most stringent fastening of the connection listed in the International Residential Code.~~

~~m. Fastening schedule only applies to buildings of conventional wood frame construction where wind or seismic analysis is not required by the applicable code. In areas where wind or seismic analysis is required, required fastening must be determined by structural analysis. The following are conditions for which codes require structural analysis:~~

i. ~~For nominal dimensions of nails see Table R602.3(1a)~~

ii. ~~North Carolina Residential Code – buildings located in areas where the design wind speed equals or exceeds 130 mph (58 m/s) or townhouses assigned to Seismic Design Category C.~~

l. For nominal dimensions of nails see Table R602.3(1a)

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n. Nails and staples shall conform to the requirements of ASTM F1667.

o. See Table 4508.3 in the 130, 140 and 150 mph (58 m/s, 63 m/s, 67 m/s)

p. See Table 4508.4 in the 130, 140 and 150 mph (58 m/s, 63 m/s, 67 m/s)

**R602.3.2 Top plate for bearing and braced wall lines.** Wood stud walls shall be capped with a double top plate installed to provide overlapping at corners and intersections with bearing partitions. End joints in top plates shall be offset not less than 24 inches (610 mm). Joints in plates need not occur over studs. Plates shall be not less than 2-inches (51 mm) nominal thickness and have a width not less than the width of the studs.

**Exception:** A single top plate used as an alternative to a double top plate shall comply with the following:

1. The single top plate shall be tied at corners, intersecting walls, and at in-line splices in straight wall lines in accordance with Table R602.3.2.
2. The rafters or joists shall be centered over the studs with a tolerance of not more than 1 inch (25 mm).
3. Omission of the top plate is permitted over headers where the headers are adequately tied to adjacent wall sections in accordance with Table R602.3.2.

TABLE R602.3(1a)
NOMINAL DIMENSIONS OF NAILS LISTED IN TABLE R602.3(1)

| NAILS DESCRIBED BY PENNYWEIGHT SYSTEM | | |
|---|---|---|
| Pennyweight | Length (inches) | Shank diameter (inches) |
| Box | | |
| 6d | 2 | 0.099 |
| 8d | 2 1/2 | 0.113 |
| 10d | 3 | 0.128 |
| Casing | | |
| 6d | 2 1/4 | 0.099 |
| 8d | 2 1/2 | 0.113 |
| 10d | 3 | 0.128 |
| Common | | |
| 6d | 2 | 0.113 |
| 8d | 2 1/2 | 0.131 |
| 10d | 3 | 0.148 |
| 16d | 3 1/2 | 0.162 |
| 20d | 4 | 0.192 |
| Cooler | | |
| 5d | 1 5/8 | 0.086 |
| 6d | 1 7/8 | 0.092 |
| 8d | 2 3/8 | 0.113 |
| Deformed[a] | | |
| 3d | 1 1/4 | 0.099 |
| 4d | 1 1/2 | 0.099 |
| 6d | 2 | 0.120 |
| 8d | 2 1/2 | 0.120 |
| Finish | | |
| 8d | 2 1/2 | 0.099 |
| 10d | 3 | 0.113 |
| Siding | | |
| 6d | 1 7/8 | 0.106 |
| 8d | 2 3/8 | 0.128 |
| Additional Recognized Nails | | |
| Smooth shank nails | 2 1/4 | 0.092 |
| | 2 1/4 | 0.105 |
| | 3 | 0.120 |
| | 3 1/4 | |
| | 1 1/2 | 0.131 |
| | 3 | |
| | 3 1/4 | |
| | 1 1/2 | 0.148 |
| | 2 1/2 | 0.162 |
| Deformed shank nails[a] | 2 1/4 | 0.099 |
| | 2 | 0.113 |
| | 2 3/8 | |
| | 2 1/2 | 0.131 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s; 1ksi = 6.895 MPa.

a. A deformed shank nail must have either a helical (screw) shank or an annular (ring) shank.

**TABLE R602.3(2)**

**ALTERNATE ATTACHMENTS TO TABLE R602.3(1)**

| | | SPACING[c] OF FASTENERS |
|---|---|---|

| NOMINAL MATERIAL THICKNESS (inches) | DESCRIPTION[a, b] OF FASTENER AND LENGTH (inches) | Edges (inches) | Intermediate supports (inches) |
|---|---|---|---|
| Wood structural panels subfloor, roof[g] and wall sheathing to framing and particleboard wall sheathing to framing[f] | | | |
| Up to $^{1}/_{2}$ | Staple 15 ga. $1^{3}/_{4}$ | 4 | 8 |
| | 0.097–0.099 Nail $2^{1}/_{4}$ | 3 | 6 |
| | Staple 16 ga. $1^{3}/_{4}$ | 3 | 6 |
| $^{19}/_{32}$ and $^{5}/_{8}$ | 0.113 Nail 2 | 3 | 6 |
| | Staple 15 and 16 ga. 2 | 4 | 8 |
| | 0.097–0.099 Nail $2^{1}/_{4}$ | 4 | 8 |
| $^{23}/_{32}$ and $^{3}/_{4}$ | Staple 14 ga. 2 | 4 | 8 |
| | Staple 15 ga. $1^{3}/_{4}$ | 3 | 6 |
| | 0.097–0.099 Nail $2^{1}/_{4}$ | 4 | 8 |
| | Staple 16 ga. 2 | 4 | 8 |
| 1 | Staple 14 ga. $2^{1}/_{4}$ | 4 | 8 |
| | 0.113 Nail $2^{1}/_{4}$ | 3 | 6 |
| | Staple 15 ga. $2^{1}/_{4}$ | 4 | 8 |
| | 0.097–0.099 Nail $2^{1}/_{2}$ | 4 | 8 |

| NOMINAL MATERIAL THICKNESS (inches) | DESCRIPTION[a, b] OF FASTENER AND LENGTH (inches) | SPACING[c] OF FASTENERS | |
|---|---|---|---|
| | | Edges (inches) | Body of panel[d] (inches) |
| Floor underlayment; plywood-hardboard-particleboard[f]-fiber-cement[h] | | | |
| Fiber-cement | | | |
| $^{1}/_{4}$ | $1^{1}/_{4}$ long × 0.099″ corrosion-resistant, ring shank nails (finished flooring other than tile) | 3 | 6 |
| | Staple 18 ga., $^{7}/_{8}$ long, $^{1}/_{4}$ crown (finished flooring other than tile) | 3 | 6 |
| | $1^{1}/_{4}$ long × .121 shank × .375 head diameter corrosion-resistant (galvanized or stainless steel) roofing nails (for tile finish) | 8 | 8 |
| | $1^{1}/_{4}$ long, No. 8 × .375 head diameter, ribbed wafer-head screws (for tile finish) | 8 | 8 |
| Plywood | | | |
| $^{1}/_{4}$ and $^{5}/_{16}$ | $1^{1}/_{4}$ ring or screw shank nail-minimum $12^{1}/_{2}$ ga. (0.099″) shank diameter | 3 | 6 |
| | Staple 18 ga., $^{7}/_{8}$, $^{3}/_{16}$ crown width | 2 | 5 |
| $^{11}/_{32}$, $^{3}/_{8}$, $^{15}/_{32}$ and $^{1}/_{2}$ | $1^{1}/_{4}$ ring or screw shank nail-minimum $12^{1}/_{2}$ ga. (0.099″) shank diameter | 6 | 8[e] |
| $^{19}/_{32}$, $^{5}/_{8}$, $^{23}/_{32}$ and $^{3}/_{4}$ | $1^{1}/_{2}$ ring or screw shank nail-minimum $12^{1}/_{2}$ ga. (0.099″) shank diameter | 6 | 8 |
| | Staple 16 ga. $1^{1}/_{2}$ | 6 | 8 |
| Hardboard[f] | | | |
| 0.200 | $1^{1}/_{2}$ long × 0.080″ ring-grooved shank underlayment nail | 6 | 6 |
| | $1^{3}/_{8}$ long × 0.080″ polymer cement-coated sinker nail | 6 | 6 |

| | | | |
|---|---|---|---|
| | Staple 18 ga., $^{7}/_{8}$ long (plastic coated) | 3 | 6 |
| **Particleboard** | | | |
| $^{1}/_{4}$ | $1^{1}/_{2}$ long × 0.099″ ring-grooved shank underlayment nail | 3 | 6 |
| | Staple 18 ga., $^{7}/_{8}$ long, $^{3}/_{16}$ crown | 3 | 6 |
| $^{3}/_{8}$ | 2 long × 0.120″ ring-grooved shank underlayment nail | 6 | 10 |
| | Staple 16 ga., $1^{1}/_{8}$ long, $^{3}/_{8}$ crown | 3 | 6 |
| $^{1}/_{2}$, $^{5}/_{8}$ | 2 long × 0.120″ ring-grooved shank underlayment nail | 6 | 10 |
| | Staple 16 ga., $1^{5}/_{8}$ long, $^{3}/_{8}$ crown | 3 | 6 |

*(continued)*

**TABLE R602.3(2)—continued**

**ALTERNATE ATTACHMENTS TO TABLE R602.3(1)**

For SI: 1 inch = 25.4 mm.

a. Nail is a general description and shall be permitted to be T-head, modified round head or round head.
b. Staples shall have a minimum crown width of $^{7}/_{16}$-inch except as noted.
c. Nails or staples shall be spaced at not more than 6 inches on center at all supports where spans are 48 inches or greater. Nails or staples shall be spaced at not more than 12 inches on center at intermediate supports for floors.
d. Fasteners shall be placed in a grid pattern throughout the body of the panel.
e. For 5-ply panels, intermediate nails shall be spaced not more than 12 inches on center each way.
f. Hardboard underlayment shall conform to CPA/ANSI A135.4.
g. Alternate fastening is only permitted for roof sheathing where the ultimate design wind speed is less than or equal to 110 mph, and where fasteners are installed 3 inches on center at all supports.
h. Fiber-cement underlayment shall conform to ASTM C1288 or ISO 8336, Category C.

**TABLE R602.3(3)**

**REQUIREMENTS FOR WOOD STRUCTURAL PANEL WALL SHEATHING USED TO RESIST WIND PRESSURES[a, b, c]**

| MINIMUM NAIL | | MINIMUM WOOD STRUCTURAL PANEL SPAN RATING | ~~MINIMUM NOMINAL~~ PANEL THICKNESS (inches) | MAXIMUM WALL STUD SPACING (inches) | PANEL NAIL SPACING | | ULTIMATE DESIGN WIND SPEED $V_{ult}$ (mph) | | |
|---|---|---|---|---|---|---|---|---|---|
| Size | Penetration (inches) | | | | Edges (inches o.c.) | Field (inches o.c.) | Wind exposure category | | |
| | | | | | | | B | C | D |
| 6d Common (2.0″ × 0.113″) | 1.5 | 24/0 | $^{3}/_{8}$ | 16 | 6 | 12 | 140 | 115 | 110 |
| 8d Common (2.5″ × 0.131″) | 1.75 | 24/16 | $^{7}/_{16}$ | 16 | 6 | 12 | 170 | 140 | 135 |
| | | | | 24 | 6 | 12 | 140 | 115 | 110 |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. Panel strength axis parallel or perpendicular to supports. Three-ply plywood sheathing with studs spaced more than 16 inches on center shall be applied with panel strength axis perpendicular to supports.
b. Table is based on wind pressures acting toward and away from building surfaces in accordance with Section R301.2. Lateral bracing requirements shall be in accordance with Section R602.10.
c. Wood structural panels with span ratings of Wall-16 or Wall-24 shall be permitted as an alternate to panels with a 24/0 span rating. Plywood siding rated 16 o.c. or 24 o.c. shall be permitted as an alternate to panels with a 24/16 span rating. Wall-16 and Plywood siding 16 o.c. shall be used with studs spaced not more than 16 inches on center.

**TABLE R602.3(4)**
**ALLOWABLE SPANS FOR PARTICLEBOARD WALL SHEATHING[a]**

| THICKNESS (inch) | GRADE | STUD SPACING (inches) | |
|---|---|---|---|
| | | Where siding is nailed to studs | Where siding is nailed to sheathing |
| $^3/_8$ | M-1 Exterior glue | 16 | — |
| $^1/_2$ | M-2 Exterior glue | 16 | 16 |

For SI: 1 inch = 25.4 mm.
a. Wall sheathing not exposed to the weather. If the panels are applied horizontally, the end joints of the panel shall be offset so that four panel corners will not meet. Panel edges must be supported. Leave a $^1/_{16}$-inch gap between panels and nail not less than $^3/_8$ inch from panel edges.

**TABLE R602.3(5)**
**SIZE, HEIGHT AND SPACING OF WOOD STUDS[a]**

| STUD SIZE (inches) | BEARING WALLS | | | | | NONBEARING WALLS | |
|---|---|---|---|---|---|---|---|
| | Laterally unsupported stud height[a] (feet) | Maximum spacing where supporting a roof-ceiling assembly or a habitable attic assembly, only (inches) | Maximum spacing where supporting one floor, plus a roof-ceiling assembly or a habitable attic assembly (inches) | Maximum spacing where supporting two floors, plus a roof-ceiling assembly or a habitable attic assembly (inches) | Maximum spacing where supporting one floor height[a] (inches) | Laterally unsupported stud height[a] (feet) | Maximum spacing (inches) |
| | | | | | | | |
| 2 × 3[b] | — | — | — | — | — | 10 | 16 |
| 2 × 4 | 10 | 24[c] | 16[c] | — | 24 | 14 | 24 |
| 3 × 4 | 10 | 24 | 24 | 16 | 24 | 14 | 24 |
| 2 × 5 | 10 | 24 | 24 | — | 24 | 16 | 24 |
| 2 × 6 | 10 | 24 | 24 | 16 | 24 | 20 | 24 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. Listed heights are distances between points of lateral support placed perpendicular to the plane of the wall. Bearing walls shall be sheathed on not less than one side or bridging shall be installed not greater than 4 feet apart measured vertically from either end of the stud. Increases in unsupported height are permitted where in compliance with Exception 2 of Section R602.3.1 or designed in accordance with accepted engineering practice.
b. Shall not be used in exterior walls.
c. A habitable attic assembly supported by 2 × 4 studs is limited to a roof span of 32 feet. Where the roof span exceeds 32 feet, the wall studs shall be increased to 2 × 6 or the studs shall be designed in accordance with accepted engineering practice.

**TABLE R602.3(6)**
**ALTERNATE WOOD BEARING WALL STUD SIZE, HEIGHT AND SPACING**

| STUD HEIGHT | SUPPORTING | STUD SPACING[a] | ULTIMATE DESIGN WIND SPEED | | |
|---|---|---|---|---|---|
| | | | 115 mph | 130 mph[b] | 140 mph[b] |
| | | | Maximum roof/floor span[c] | Maximum roof/floor span[c] | Maximum roof/floor span[c] |

| | | | 12 ft | 24 ft | 12 ft | 24 ft | 12 ft | 24 ft |
|---|---|---|---|---|---|---|---|---|
| 11 ft | Roof only | 12 in | 2 × 4 | 2 × 4 | 2 × 4 | 2 × 4 | 2 × 4 | 2 × 4 |
| | | 16 in | 2 × 4 | 2 × 4 | 2 × 4 | 2 × 6 | 2 × 4 | 2 × 6 |
| | | 24 in | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 |
| | Roof and one floor | 12 in | 2 × 4 | 2 × 6 | 2 × 4 | 2 × 6 | 2 × 4 | 2 × 6 |
| | | 16 in | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 |
| | | 24 in | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 |
| 12 ft | Roof only | 12 in | 2 × 4 | 2 × 4 | 2 × 4 | 2 × 6 | 2 × 4 | 2 × 6 |
| | | 16 in | 2 × 4 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 |
| | | 24 in | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 |
| | Roof and one floor | 12 in | 2 × 4 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 |
| | | 16 in | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 |
| | | 24 in | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | 2 × 6 | DR |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mph = 0.447 m/s, 1 pound = 4.448 N.

DR = Design Required.

a. Wall studs not exceeding 16 inches on center shall be sheathed with minimum $^1/_2$-inch gypsum board on the interior and $^3/_8$-inch wood structural panel sheathing on the exterior. Wood structural panel sheathing shall be attached with 8d (2.5″ · 0.131″) nails not greater than 6 inches on center along panel edges and 12 inches on center at intermediate supports, and all panel joints shall occur over studs or blocking.

b. Where the ultimate design wind speed exceeds 115 mph, studs shall be attached to top and bottom plates with connectors having a minimum 300-pound lateral capacity.

c. The maximum span is applicable to both single- and multiple-span roof and floor conditions. The *roof assembly* shall not contain a habitable attic.

**TABLE R602.3.2**
**SINGLE TOP-PLATE SPLICE CONNECTION DETAILS**
**FOR BEARING WALLS AND BRACED WALL LINES**

| ~~CONDITION~~ | TOP-PLATE SPLICE LOCATION | | | |
|---|---|---|---|---|
| | Corners and intersecting walls | | Butt joints in straight walls | |
| | Splice plate size | Minimum nails each side of joint | Splice plate size | Minimum nails each side of joint |
| Structures in SDC A-C | 3″ × 6″ × 0.036″ galvanized steel plate or equivalent | (6) 8d box ($2^1/_2$″ × 0.113″) nails | ~~3~~ 3″× 12″ × 0.036″ galvanized steel plate or equivalent | (12) 8d box ($2^1/_2$″ × 0.113″) nails |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

**R602.3.3 Bearing studs.** Where joists, trusses or rafters are spaced more than 16 inches (406 mm) on center and the bearing studs below are spaced 24 inches (610 mm) on center, such members shall bear within 5 inches (127 mm) of the studs beneath.

**Exceptions:**

1. The top plates are two 2-inch by 6-inch (38 mm by 140 mm) or two 3-inch by 4-inch (64 mm by 89 mm) members.
2. A third top plate is installed.
3. Solid blocking equal in size to the studs is installed to reinforce the double top plate.

**R602.3.4 Bottom (sole) plate.** Studs shall have full bearing on a nominal 2-by (51 mm) or larger plate or sill having a width not less than to the width of the studs.

**R602.3.5 Braced wall panel uplift load path.** Braced wall panels located at exterior walls that support roof rafters or trusses (including stories below top story) shall have the framing members connected in accordance with one of the following:

1. Fastening in accordance with Table R602.3(1) where:
   1.1. The ultimate design wind speed does not exceed 115 mph (51 m/s), the wind exposure category is B, the roof pitch is 5:12 or greater, and the roof span is 32 feet (9754 mm) or less.
   1.2. The net uplift value at the top of a wall does not exceed 100 plf (146 N/mm). The net uplift value shall be determined in accordance with Section R802.11 and shall be permitted to be reduced by 60 plf (86 N/mm) for each full wall above.
2. Where the net uplift value at the top of a wall exceeds 100 plf (146 N/mm), installing *approved* uplift framing connectors to provide a continuous load path from the top of the wall to the foundation or to a point where the uplift force is 100 plf (146 N/mm) or less. The net uplift value shall be as determined in Item 1.2.
3. Wall sheathing and fasteners designed to resist combined uplift and shear forces in accordance with accepted engineering practice.

**R602.4 Interior load-bearing walls.** Interior *load-bearing walls* shall be constructed, framed and fireblocked as specified for exterior walls.

**R602.5 Interior nonbearing walls.** Interior *nonbearing walls* shall be permitted to be constructed with 2-inch by 3-inch (51 mm by 76 mm) studs spaced 24 inches (610 mm) on center or, where not part of a *braced wall line*, 2-inch by 4- inch (51 mm by 102 mm) flat studs spaced at 16 inches (406 mm) on center. Interior *nonbearing walls* shall be capped with not less than a single top plate. Interior *nonbearing walls* shall be fireblocked in accordance with Section R602.8.

**R602.6 Drilling and notching of studs.** Drilling and notching of studs shall be in accordance with the following:

1. Notching. ~~Any~~ A stud in an exterior wall or bearing partition shall ~~be permitted to~~ not be cut or notched to a depth exceeding 25 percent of its ~~width~~ depth. Studs in nonbearing partitions shall not be notched to a depth ~~not to exceed~~ exceeding 40 percent of a single stud ~~width~~ depth. Notching of bearing studs shall be on one edge only and not to exceed one-fourth the height of the stud. Notching shall not occur in the bottom or top 6 inches (152 mm) of bearing studs.
2. ~~Drilling. Any stud shall be permitted to be bored or drilled, provided that the diameter of the resulting hole is not more than~~ Boring. The diameter of bored holes in studs shall not exceed 60 percent of the stud ~~width~~ depth, the edge of the hole ~~is~~ shall not ~~more~~ be less than $^{5}/_{8}$ inch (16 mm) ~~to~~ from the edge of the stud, and the hole shall not be closer than 6 inches (152 mm) from an adjacent hole or notch. Holes not exceeding 3/4 inch (19 mm) diameter can be as close as 11/2 inches (38 mm) on center spacing. Studs located in exterior walls or bearing partitions ~~drilled~~ is over 40 percent, ~~and up to 60 percent~~ such stud shall be doubled ~~with~~ and not more than two successive doubled studs shall be so bored. See Figures R602.6(1) and R602.6(2).

   **Exception:** ~~Use of~~ Where approved, stud shoes are installed in accordance with the manufacturer's ~~recommendation~~ instructions.

**R602.6.1 Drilling and notching of top plate.** ~~When~~ Where piping or ductwork is placed in or partly in an exterior wall or interior *load-bearing wall*, necessitating cutting, drilling or notching of the top plate by more than 50 percent of its width, a galvanized metal tie not less than 0.054 inch thick (1.37 mm) (16 ga) and $1^{1}/_{2}$ inches (38 mm) wide shall be fastened across and to the plate at each side of the opening with not less than eight 10d (0.148 inch diameter) nails having a minimum length of $1^{1}/_{2}$ inches (38 mm) at each side or equivalent. The metal tie must extend ~~a minimum of~~ not less than 6 inches past the opening. See Figure R602.6.1.

**Exception:** ~~When~~ Where the entire side of the wall with the notch or cut is covered by wood structural panel sheathing.

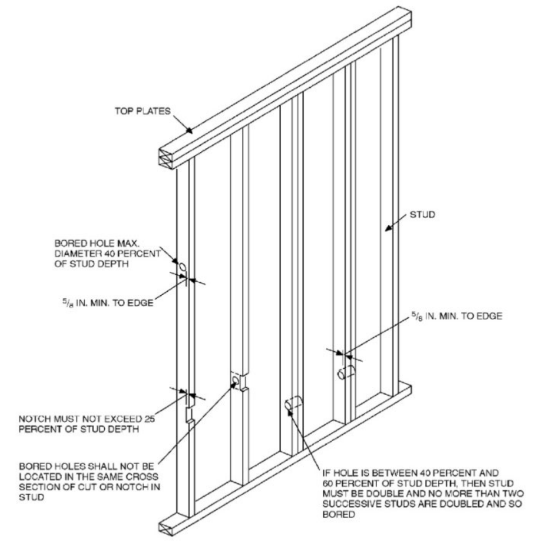



FIGURE R602.6(1)NOTCHING AND BORED HOLE LIMITATIONS FOR EXTERIOR WALLS AND BEARING WALLS

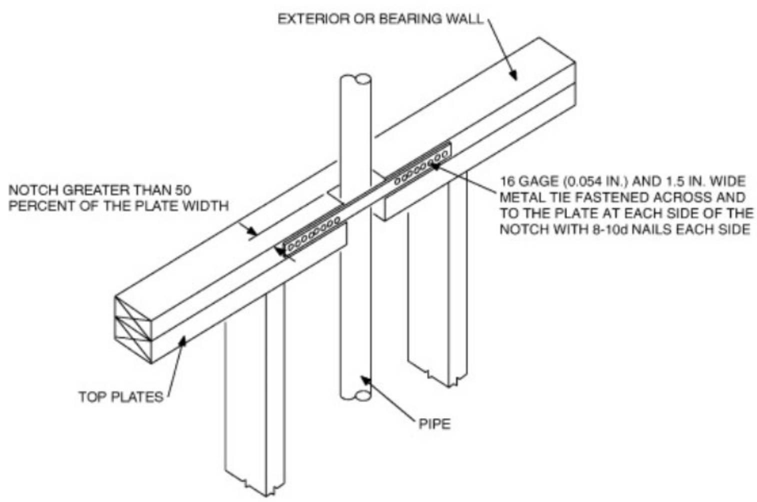



FIGURE R602.6.1TOP PLATE FRAMING TO ACCOMMODATE PIPING

**R602.7 Headers.** For header spans, see Tables R602.7(1), and R602.7(2) ~~R602.7(3).~~

## TABLE R602.7(1)
## GIRDER SPANS[a] AND HEADER SPANS[a] FOR EXTERIOR BEARING WALLS
**(Maximum spans for Douglas fir-larch, hem-fir, southern pine and spruce-pine-fir[b] and required number of jack studs)**

| GIRDERS AND HEADERS SUPPORTING | SIZE | GROUND SNOW LOAD (psf)[e] | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 30 | | | | | | 50 | | | | | | 70 | | | | | |
| | | Building width[c] (feet) | | | | | | | | | | | | | | | | | |
| | | 20 | | 28 | | 36 | | 20 | | 28 | | 36 | | 20 | | 28 | | 36 | |
| | | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] |
| Roof and ceiling | 1-2 × 8 | 4-6 | 1 | 3-10 | 1 | 3-5 | 1 | 3-9 | 1 | 3-2 | 1 | 2-10 | 2 | — | — | — | — | — | — |
| | 1-2 × 10 | 5-8 | 1 | 4-11 | 1 | 4-4 | 1 | 4-9 | 1 | 4-1 | 1 | 3-7 | 2 | — | — | — | — | — | — |
| | 1-2 × 12 | 6-11 | 1 | 5-11 | 2 | 5-3 | 2 | 5-9 | 2 | 4-8 | 2 | 3-8 | 2 | — | — | — | — | — | — |
| | 2-2 × 4 | 3-6 | 1 | 3-2 | 1 | 2-10 | 1 | 3-2 | 1 | 2-9 | 1 | 2-6 | 1 | 2-10 | 1 | 2-6 | 1 | 2-3 | 1 |
| | 2-2 × 6 | 5-5 | 1 | 4-8 | 1 | 4-2 | 1 | 4-8 | 1 | 4-1 | 1 | 3-8 | 2 | 4-2 | 1 | 3-8 | 2 | 3-3 | 2 |
| | 2-2 × 8 | 6-10 | 1 | 5-11 | 2 | 5-4 | 2 | 5-11 | 2 | 5-2 | 2 | 4-7 | 2 | 5-4 | 2 | 4-7 | 2 | 4-1 | 2 |
| | 2-2 × 10 | 8-5 | 2 | 7-3 | 2 | 6-6 | 2 | 7-3 | 2 | 6-3 | 2 | 5-7 | 2 | 6-6 | 2 | 5-7 | 2 | 5-0 | 2 |
| | 2-2 × 12 | 9-9 | 2 | 8-5 | 2 | 7-6 | 2 | 8-5 | 2 | 7-3 | 2 | 6-6 | 2 | 7-6 | 2 | 6-6 | 2 | 5-10 | 3 |
| | 3-2 × 8 | 8-4 | 1 | 7-5 | 1 | 6-8 | 1 | 7-5 | 1 | 6-5 | 2 | 5-9 | 2 | 6-8 | 1 | 5-9 | 2 | 5-2 | 2 |
| | 3-2 × 10 | 10-6 | 1 | 9-1 | 2 | 8-2 | 2 | 9-1 | 2 | 7-10 | 2 | 7-0 | 2 | 8-2 | 2 | 7-0 | 2 | 6-4 | 2 |
| | 3-2 × 12 | 12-2 | 2 | 10-7 | 2 | 9-5 | 2 | 10-7 | 2 | 9-2 | 2 | 8-2 | 2 | 9-5 | 2 | 8-2 | 2 | 7-4 | 2 |
| | 4-2 × 8 | 9-2 | 1 | 8-4 | 1 | 7-8 | 1 | 8-4 | 1 | 7-5 | 1 | 6-8 | 1 | 7-8 | 1 | 6-8 | 1 | 5-11 | 2 |
| | 4-2 × 10 | 11-8 | 1 | 10-6 | 1 | 9-5 | 2 | 10-6 | 1 | 9-1 | 2 | 8-2 | 2 | 9-5 | 2 | 8-2 | 2 | 7-3 | 2 |
| | 4-2 × 12 | 14-1 | 1 | 12-2 | 2 | 10-11 | 2 | 12-2 | 2 | 10-7 | 2 | 9-5 | 2 | 10-11 | 2 | 9-5 | 2 | 8-5 | 2 |
| Roof, ceiling and one center-bearing floor | 1-2 × 8 | 3-11 | 1 | 3-5 | 1 | 3-0 | 1 | 3-7 | 1 | 3-0 | 2 | 2-8 | 2 | — | — | — | — | — | — |
| | 1-2 × 10 | 5-0 | 2 | 4-4 | 2 | 3-10 | 2 | 4-6 | 2 | 3-11 | 2 | 3-4 | 2 | — | — | — | — | — | — |
| | 1-2 × 12 | 5-10 | 2 | 4-9 | 2 | 4-2 | 2 | 5-5 | 2 | 4-2 | 2 | 3-4 | 2 | — | — | — | — | — | — |
| | 2-2 × 4 | 3-1 | 1 | 2-9 | 1 | 2-5 | 1 | 2-9 | 1 | 2-5 | 1 | 2-2 | 1 | 2-7 | 1 | 2-3 | 1 | 2-0 | 1 |
| | 2-2 × 6 | 4-6 | 1 | 4-0 | 1 | 3-7 | 2 | 4-1 | 1 | 3-7 | 2 | 3-3 | 2 | 3-9 | 2 | 3-3 | 2 | 2-11 | 2 |
| | 2-2 × 8 | 5-9 | 2 | 5-0 | 2 | 4-6 | 2 | 5-2 | 2 | 4-6 | 2 | 4-1 | 2 | 4-9 | 2 | 4-2 | 2 | 3-9 | 2 |
| | 2-2 × 10 | 7-0 | 2 | 6-2 | 2 | 5-6 | 2 | 6-4 | 2 | 5-6 | 2 | 5-0 | 2 | 5-9 | 2 | 5-1 | 2 | 4-7 | 3 |
| | 2-2 × 12 | 8-1 | 2 | 7-1 | 2 | 6-5 | 2 | 7-4 | 2 | 6-5 | 2 | 5-9 | 3 | 6-8 | 2 | 5-10 | 3 | 5-3 | 3 |
| | 3-2 × 8 | 7-2 | 1 | 6-3 | 2 | 5-8 | 2 | 6-5 | 2 | 5-8 | 2 | 5-1 | 2 | 5-11 | 2 | 5-2 | 2 | 4-8 | 2 |
| | 3-2 × 10 | 8-9 | 2 | 7-8 | 2 | 6-11 | 2 | 7-11 | 2 | 6-11 | 2 | 6-3 | 2 | 7-3 | 2 | 6-4 | 2 | 5-8 | 2 |
| | 3-2 × 12 | 10-2 | 2 | 8-11 | 2 | 8-0 | 2 | 9-2 | 2 | 8-0 | 2 | 7-3 | 2 | 8-5 | 2 | 7-4 | 2 | 6-7 | 2 |
| | 4-2 × 8 | 8-1 | 1 | 7-3 | 1 | 6-7 | 1 | 7-5 | 1 | 6-6 | 1 | 5-11 | 2 | 6-10 | 1 | 6-0 | 2 | 5-5 | 2 |
| | 4-2 × 10 | 10-1 | 1 | 8-10 | 2 | 8-0 | 2 | 9-1 | 2 | 8-0 | 2 | 7-2 | 2 | 8-4 | 2 | 7-4 | 2 | 6-7 | 2 |
| | 4-2 × 12 | 11-9 | 2 | 10-3 | 2 | 9-3 | 2 | 10-7 | 2 | 9-3 | 2 | 8-4 | 2 | 9-8 | 2 | 8-6 | 2 | 7-7 | 2 |
| Roof, ceiling and one clear span floor | 1-2 × 8 | 3-6 | 1 | 3-0 | 1 | 2-8 | 1 | 3-5 | 1 | 2-11 | 1 | 2-7 | 2 | — | — | — | — | — | — |
| | 1-2 × 10 | 4-6 | 1 | 3-10 | 1 | 3-3 | 1 | 4-4 | 1 | 3-9 | 1 | 3-1 | 2 | — | — | — | — | — | — |
| | 1-2 × 12 | 5-6 | 1 | 4-2 | 2 | 3-3 | 2 | 5-4 | 2 | 3-11 | 2 | 3-1 | 2 | — | — | — | — | — | — |
| | 2-2 × 4 | 2-8 | 1 | 2-4 | 1 | 2-1 | 1 | 2-7 | 1 | 2-3 | 1 | 2-0 | 1 | 2-5 | 1 | 2-1 | 1 | 1-10 | 1 |
| | 2-2 × 6 | 3-11 | 1 | 3-5 | 2 | 3-0 | 2 | 3-10 | 2 | 3-4 | 2 | 3-0 | 2 | 3-6 | 2 | 3-1 | 2 | 2-9 | 2 |
| | 2-2 × 8 | 5-0 | 2 | 4-4 | 2 | 3-10 | 2 | 4-10 | 2 | 4-2 | 2 | 3-9 | 2 | 4-6 | 2 | 3-11 | 2 | 3-6 | 2 |
| | 2-2 × 10 | 6-1 | 2 | 5-3 | 2 | 4-8 | 2 | 5-11 | 2 | 5-1 | 2 | 4-7 | 3 | 5-6 | 2 | 4-9 | 2 | 4-3 | 3 |
| | 2-2 × 12 | 7-1 | 2 | 6-1 | 3 | 5-5 | 3 | 6-10 | 2 | 5-11 | 3 | 5-4 | 3 | 6-4 | 2 | 5-6 | 3 | 5-0 | 3 |
| | 3-2 × 8 | 6-3 | 2 | 5-5 | 2 | 4-10 | 2 | 6-1 | 2 | 5-3 | 2 | 4-8 | 2 | 5-7 | 2 | 4-11 | 2 | 4-5 | 2 |
| | 3-2 × 10 | 7-7 | 2 | 6-7 | 2 | 5-11 | 2 | 7-5 | 2 | 6-5 | 2 | 5-9 | 2 | 6-10 | 2 | 6-0 | 2 | 5-4 | 2 |
| | 3-2 × 12 | 8-10 | 2 | 7-8 | 2 | 6-10 | 2 | 8-7 | 2 | 7-5 | 2 | 6-8 | 2 | 7-11 | 2 | 6-11 | 2 | 6-3 | 2 |
| | 4-2 × 8 | 7-2 | 1 | 6-3 | 2 | 5-7 | 2 | 7-0 | 1 | 6-1 | 2 | 5-5 | 2 | 6-6 | 1 | 5-8 | 2 | 5-1 | 2 |
| | 4-2 × 10 | 8-9 | 2 | 7-7 | 2 | 6-10 | 2 | 8-7 | 2 | 7-5 | 2 | 6-7 | 2 | 7-11 | 2 | 6-11 | 2 | 6-2 | 2 |
| | 4-2 × 12 | 10-2 | 2 | 8-10 | 2 | 7-11 | 2 | 9-11 | 2 | 8-7 | 2 | 7-8 | 2 | 9-2 | 2 | 8-0 | 2 | 7-2 | 2 |

*(continued)*

**TABLE R602.7(1)—continued**
**GIRDER SPANS[a] AND HEADER SPANS[a] FOR EXTERIOR BEARING WALLS**
**(Maximum spans for Douglas fir-larch, hem-fir, southern pine and spruce-pine-fir[b] and required number of jack studs)**

| GIRDERS AND HEADERS SUPPORTING | SIZE | GROUND SNOW LOAD (psf)[e] | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 30 | | | | | | 50 | | | | | | 70 | | | | | |
| | | Building width[c] (feet) | | | | | | | | | | | | | | | | | |
| | | 20 | | 28 | | 36 | | 20 | | 28 | | 36 | | 20 | | 28 | | 36 | |
| | | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] |
| Roof, ceiling and two center-bearing floors | 2-2 × 4 | 2-7 | 1 | 2-3 | 1 | 2-0 | 1 | 2-6 | 1 | 2-2 | 1 | 1-11 | 1 | 2-4 | 1 | 2-0 | 1 | 1-9 | 1 |
| | 2-2 × 6 | 3-9 | 2 | 3-3 | 2 | 2-11 | 2 | 3-8 | 2 | 3-2 | 2 | 2-10 | 2 | 3-5 | 2 | 3-0 | 2 | 2-8 | 2 |
| | 2-2 × 8 | 4-9 | 2 | 4-2 | 2 | 3-9 | 2 | 4-7 | 2 | 4-0 | 2 | 3-8 | 2 | 4-4 | 2 | 3-9 | 2 | 3-5 | 2 |
| | 2-2 × 10 | 5-9 | 2 | 5-1 | 2 | 4-7 | 3 | 5-8 | 2 | 4-11 | 2 | 4-5 | 3 | 5-3 | 2 | 4-7 | 3 | 4-2 | 3 |
| | 2-2 × 12 | 6-8 | 2 | 5-10 | 3 | 5-3 | 3 | 6-6 | 2 | 5-9 | 3 | 5-2 | 3 | 6-1 | 3 | 5-4 | 3 | 4-10 | 3 |
| | 3-2 × 8 | 5-11 | 2 | 5-2 | 2 | 4-8 | 2 | 5-9 | 2 | 5-1 | 2 | 4-7 | 2 | 5-5 | 2 | 4-9 | 2 | 4-3 | 2 |
| | 3-2 × 10 | 7-3 | 2 | 6-4 | 2 | 5-8 | 2 | 7-1 | 2 | 6-2 | 2 | 5-7 | 2 | 6-7 | 2 | 5-9 | 2 | 5-3 | 2 |
| | 3-2 × 12 | 8-5 | 2 | 7-4 | 2 | 6-7 | 2 | 8-2 | 2 | 7-2 | 2 | 6-5 | 3 | 7-8 | 2 | 6-9 | 2 | 6-1 | 3 |
| | 4-2 × 8 | 6-10 | 1 | 6-0 | 2 | 5-5 | 2 | 6-8 | 1 | 5-10 | 2 | 5-3 | 2 | 6-3 | 2 | 5-6 | 2 | 4-11 | 2 |
| | 4-2 × 10 | 8-4 | 2 | 7-4 | 2 | 6-7 | 2 | 8-2 | 2 | 7-2 | 2 | 6-5 | 2 | 7-7 | 2 | 6-8 | 2 | 6-0 | 2 |
| | 4-2 × 12 | 9-8 | 2 | 8-6 | 2 | 7-8 | 2 | 9-5 | 2 | 8-3 | 2 | 7-5 | 2 | 8-10 | 2 | 7-9 | 2 | 7-0 | 2 |
| Roof, ceiling, and two clear-span floors | 2-2 × 4 | 2-1 | 1 | 1-8 | 1 | 1-6 | 2 | 2-0 | 1 | 1-8 | 1 | 1-5 | 2 | 2-0 | 1 | 1-8 | 1 | 1-5 | 2 |
| | 2-2 × 6 | 3-1 | 2 | 2-8 | 2 | 2-4 | 2 | 3-0 | 2 | 2-7 | 2 | 2-3 | 2 | 2-11 | 2 | 2-7 | 2 | 2-3 | 2 |
| | 2-2 × 8 | 3-10 | 2 | 3-4 | 2 | 3-0 | 3 | 3-10 | 2 | 3-4 | 2 | 2-11 | 3 | 3-9 | 2 | 3-3 | 2 | 2-11 | 3 |
| | 2-2 × 10 | 4-9 | 2 | 4-1 | 3 | 3-8 | 3 | 4-8 | 2 | 4-0 | 3 | 3-7 | 3 | 4-7 | 3 | 4-0 | 3 | 3-6 | 3 |
| | 2-2 × 12 | 5-6 | 3 | 4-9 | 3 | 4-3 | 3 | 5-5 | 3 | 4-8 | 3 | 4-2 | 3 | 5-4 | 3 | 4-7 | 3 | 4-1 | 4 |
| | 3-2 × 8 | 4-10 | 2 | 4-2 | 2 | 3-9 | 2 | 4-9 | 2 | 4-1 | 2 | 3-8 | 2 | 4-8 | 2 | 4-1 | 2 | 3-8 | 2 |
| | 3-2 × 10 | 5-11 | 2 | 5-1 | 2 | 4-7 | 3 | 5-10 | 2 | 5-0 | 2 | 4-6 | 3 | 5-9 | 2 | 4-11 | 2 | 4-5 | 3 |
| | 3-2 × 12 | 6-10 | 2 | 5-11 | 3 | 5-4 | 3 | 6-9 | 2 | 5-10 | 3 | 5-3 | 3 | 6-8 | 2 | 5-9 | 3 | 5-2 | 3 |
| | 4-2 × 8 | 5-7 | 2 | 4-10 | 2 | 4-4 | 2 | 5-6 | 2 | 4-9 | 2 | 4-3 | 2 | 5-5 | 2 | 4-8 | 2 | 4-2 | 2 |
| | 4-2 × 10 | 6-10 | 2 | 5-11 | 2 | 5-3 | 2 | 6-9 | 2 | 5-10 | 2 | 5-2 | 2 | 6-7 | 2 | 5-9 | 2 | 5-1 | 2 |
| | 4-2 × 12 | 7-11 | 2 | 6-10 | 2 | 6-2 | 3 | 7-9 | 2 | 6-9 | 2 | 6-0 | 3 | 7-8 | 2 | 6-8 | 2 | 5-11 | 3 |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.

a. Spans are given in feet and inches.
b. No. 1 or better grade lumber shall be used for southern pine. Other tabulated values assume #2 grade lumber.
c. Building width is measured perpendicular to the ridge. For widths between those shown, spans are permitted to be interpolated.
d. NJ = Number of jack studs required to support each end. Where the number of required jack studs equals one, the header is permitted to be supported by an approved framing anchor attached to the full-height wall stud and to the header.
e. Use 30 psf ground snow load for cases in which ground snow load is less than 30 psf and the roof live load is equal to or less than 20 psf.

**TABLE R602.7(2)**
**GIRDER SPANS[a] AND HEADER SPANS[a] FOR INTERIOR BEARING WALLS**
**(Maximum spans for Douglas fir-larch, hem-fir, southern pine and spruce-pine-fir[b] and required number of jack studs)**

| HEADERS AND GIRDERS SUPPORTING | SIZE | BUILDING Width[c] (feet) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 20 | | 28 | | 36 | |
| | | Span | NJ[d] | Span | NJ[d] | Span | NJ[d] |
| One floor only | 2-2 × 4 | 3-1 | 1 | 2-8 | 1 | 2-5 | 1 |
| | 2-2 × 6 | 4-6 | 1 | 3-11 | 1 | 3-6 | 1 |
| | 2-2 × 8 | 5-9 | 1 | 5-0 | 2 | 4-5 | 2 |
| | 2-2 × 10 | 7-0 | 2 | 6-1 | 2 | 5-5 | 2 |
| | 2-2 × 12 | 8-1 | 2 | 7-0 | 2 | 6-3 | 2 |
| | 3-2 × 8 | 7-2 | 1 | 6-3 | 1 | 5-7 | 2 |
| | 3-2 × 10 | 8-9 | 1 | 7-7 | 2 | 6-9 | 2 |
| | 3-2 × 12 | 10-2 | 2 | 8-10 | 2 | 7-10 | 2 |
| | 4-2 × 8 | 9-0 | 1 | 7-8 | 1 | 6-9 | 1 |
| | 4-2 × 10 | 10-1 | 1 | 8-9 | 1 | 7-10 | 2 |
| | 4-2 × 12 | 11-9 | 1 | 10-2 | 2 | 9-1 | 2 |
| Two floors | 2-2 × 4 | 2-2 | 1 | 1-10 | 1 | 1-7 | 1 |
| | 2-2 × 6 | 3-2 | 2 | 2-9 | 2 | 2-5 | 2 |
| | 2-2 × 8 | 4-1 | 2 | 3-6 | 2 | 3-2 | 2 |
| | 2-2 × 10 | 4-11 | 2 | 4-3 | 2 | 3-10 | 3 |
| | 2-2 × 12 | 5-9 | 2 | 5-0 | 3 | 4-5 | 3 |
| | 3-2 × 8 | 5-1 | 2 | 4-5 | 2 | 3-11 | 2 |
| | 3-2 × 10 | 6-2 | 2 | 5-4 | 2 | 4-10 | 2 |
| | 3-2 × 12 | 7-2 | 2 | 6-3 | 2 | 5-7 | 3 |
| | 4-2 × 8 | 6-1 | 1 | 5-3 | 2 | 4-8 | 2 |
| | 4-2 × 10 | 7-2 | 2 | 6-2 | 2 | 5-6 | 2 |
| | 4-2 × 12 | 8-4 | 2 | 7-2 | 2 | 6-5 | 2 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Spans are given in feet and inches.

b. No. 1 or better grade lumber shall be used for southern pine. Other tabulated values assume #2 grade lumber.

c. Building width is measured perpendicular to the ridge. For widths between those shown, spans are permitted to be interpolated.

d. NJ = Number of jack studs required to support each end. Where the number of required jack studs equals one, the header is permitted to be supported by an approved framing anchor attached to the full-height wall stud and to the header.

**TABLE R602.7(3)**
**GIRDER AND HEADER SPANS[a] FOR OPEN PORCHES**
**(Maximum span for Douglas fir-larch, hem-fir, southern pine and spruce-pine-fir[b])**

| SIZE | SUPPORTING ROOF | | | | | | SUPPORTING FLOOR | |
|---|---|---|---|---|---|---|---|---|
| | GROUND SNOW LOAD (psf) | | | | | | | |
| | 30 | | 50 | | 70 | | | |
| | DEPTH OF PORCH[c] (feet) | | | | | | | |
| | 8 | 14 | 8 | 14 | 8 | 14 | 8 | 14 |
| 2-2 × 6 | 7-6 | 5-8 | 6-2 | 4-8 | 5-4 | 4-0 | 6-4 | 4-9 |
| 2-2 × 8 | 10-1 | 7-7 | 8-3 | 6-2 | 7-1 | 5-4 | 8-5 | 6-4 |
| 2-2 × 10 | 12-4 | 9-4 | 10-1 | 7-7 | 8-9 | 6-7 | 10-4 | 7-9 |
| 2-2 × 12 | 14-4 | 10-10 | 11-8 | 8-10 | 10-1 | 7-8 | 11-11 | 9-0 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. Spans are given in feet and inches.

b. Tabulated values assume #2 grade lumber, wet service and incising for refractory species. Use 30 psf ground snow load for cases in which ground snow load is less than 30 psf and the roof live load is equal to or less than 20 psf.

c. Porch depth is measured horizontally from building face to centerline of the header. For depths between those shown, spans are permitted to be interpolated.

**TABLE R602.7(1)**

**GIRDER SPANS[a] AND HEADER SPANS[a] FOR EXTERIOR BEARING WALLS**
**(Maximum spans for Douglas fir-larch, hem-fir, Southern pine and spruce-pine-fir[b] and required number of jack studs)**

| GIRDERS AND HEADERS SUPPORTING | SIZE | GROUND SNOW LOAD (psf)[e] | | |
|---|---|---|---|---|
| | | 30 | 50 | 70 |
| | | Building width[c] (feet) | | |

| | | 12 | | 24 | | 36 | | 12 | | 24 | | 36 | | 12 | | 24 | | 36 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] |
| Roof and ceiling | 1-2 × 6 | 4-0 | 1 | 3-1 | 2 | 2-7 | 2 | 3-5 | 1 | 2-8 | 2 | 2-3 | 2 | 3-0 | 2 | 2-4 | 2 | 2-0 | 2 |
| | 1-2 × 8 | 5-1 | 2 | 3-11 | 2 | 3-3 | 2 | 4-4 | 2 | 3-4 | 2 | 2-10 | 2 | 3-10 | 2 | 3-0 | 2 | 2-6 | 3 |
| | 1-2 × 10 | 6-0 | 2 | 4-8 | 2 | 3-11 | 2 | 5-2 | 2 | 4-0 | 2 | 3-4 | 3 | 4-7 | 2 | 3-6 | 3 | 3-0 | 3 |
| | 1-2 × 12 | 7-1 | 2 | 5-5 | 2 | 4-7 | 3 | 6-1 | 2 | 4-8 | 3 | 3-11 | 3 | 5-5 | 2 | 4-2 | 3 | 3-6 | 3 |
| | 2-2 × 4 | 4-0 | 1 | 3-1 | 1 | 2-7 | 1 | 3-5 | 1 | 2-7 | 1 | 2-2 | 1 | 3-0 | 1 | 2-4 | 1 | 2-0 | 1 |
| | 2-2 × 6 | 6-0 | 1 | 4-7 | 1 | 3-10 | 1 | 5-1 | 1 | 3-11 | 1 | 3-3 | 2 | 4-6 | 1 | 3-6 | 2 | 2-11 | 2 |
| | 2-2 × 8 | 7-7 | 1 | 5-9 | 1 | 4-10 | 2 | 6-5 | 1 | 5-0 | 2 | 4-2 | 2 | 5-9 | 1 | 4-5 | 2 | 3-9 | 2 |
| | 2-2 × 10 | 9-0 | 1 | 6-10 | 2 | 5-9 | 2 | 7-8 | 2 | 5-11 | 2 | 4-11 | 2 | 6-9 | 2 | 5-3 | 2 | 4-5 | 2 |
| | 2-2 × 12 | 10-7 | 2 | 8-1 | 2 | 6-10 | 2 | 9-0 | 2 | 6-11 | 2 | 5-10 | 2 | 8-0 | 2 | 6-2 | 2 | 5-2 | 3 |
| | 3-2 × 8 | 9-5 | 1 | 7-3 | 1 | 6-1 | 1 | 8-1 | 1 | 6-3 | 1 | 5-3 | 2 | 7-2 | 1 | 5-6 | 2 | 4-8 | 2 |
| | 3-2 × 10 | 11-3 | 1 | 8-7 | 1 | 7-3 | 2 | 9-7 | 1 | 7-4 | 2 | 6-2 | 2 | 8-6 | 1 | 6-7 | 2 | 5-6 | 2 |
| | 3-2 × 12 | 13-2 | 1 | 10-1 | 2 | 8-6 | 2 | 11-3 | 2 | 8-8 | 2 | 7-4 | 2 | 10-0 | 2 | 7-9 | 2 | 6-6 | 2 |
| | 4-2 × 8 | 10-11 | 1 | 8-4 | 1 | 7-0 | 1 | 9-4 | 1 | 7-2 | 1 | 6-0 | 1 | 8-3 | 1 | 6-4 | 1 | 5-4 | 2 |
| | 4-2 × 10 | 12-11 | 1 | 9-11 | 1 | 8-4 | 1 | 11-1 | 1 | 8-6 | 1 | 7-2 | 2 | 9-10 | 1 | 7-7 | 2 | 6-4 | 2 |
| | 4-2 × 12 | 15-3 | 1 | 11-8 | 1 | 9-10 | 2 | 13-0 | 1 | 10-0 | 2 | 8-5 | 2 | 11-7 | 1 | 8-11 | 2 | 7-6 | 2 |
| Roof, ceiling and one center-bearing floor | 1-2 × 6 | 3-3 | 1 | 2-7 | 2 | 2-2 | 2 | 3-0 | 2 | 2-4 | 2 | 2-0 | 2 | 2-9 | 2 | 2-2 | 2 | 1-10 | 2 |
| | 1-2 × 8 | 4-1 | 2 | 3-3 | 2 | 2-9 | 2 | 3-9 | 2 | 3-0 | 2 | 2-6 | 3 | 3-6 | 2 | 2-9 | 2 | 2-4 | 3 |
| | 1-2 × 10 | 4-11 | 2 | 3-10 | 2 | 3-3 | 3 | 4-6 | 2 | 3-6 | 3 | 3-0 | 3 | 4-1 | 2 | 3-3 | 3 | 2-9 | 3 |
| | 1-2 × 12 | 5-9 | 2 | 4-6 | 3 | 3-10 | 3 | 5-3 | 2 | 4-2 | 3 | 3-6 | 3 | 4-10 | 3 | 3-10 | 3 | 3-3 | 4 |
| | 2-2 × 4 | 3-3 | 1 | 2-6 | 1 | 2-2 | 1 | 3-0 | 1 | 2-4 | 1 | 2-0 | 1 | 2-8 | 1 | 2-2 | 1 | 1-10 | 1 |
| | 2-2 × 6 | 4-10 | 1 | 3-9 | 1 | 3-3 | 2 | 4-5 | 1 | 3-6 | 2 | 3-0 | 2 | 4-1 | 1 | 3-3 | 2 | 2-9 | 2 |
| | 2-2 × 8 | 6-1 | 1 | 4-10 | 2 | 4-1 | 2 | 5-7 | 2 | 4-5 | 2 | 3-9 | 2 | 5-2 | 2 | 4-1 | 2 | 3-6 | 2 |
| | 2-2 × 10 | 7-3 | 2 | 5-8 | 2 | 4-10 | 2 | 6-8 | 2 | 5-3 | 2 | 4-5 | 2 | 6-1 | 2 | 4-10 | 2 | 4-1 | 2 |
| | 2-2 × 12 | 8-6 | 2 | 6-8 | 2 | 5-8 | 2 | 7-10 | 2 | 6-2 | 2 | 5-3 | 3 | 7-2 | 2 | 5-8 | 2 | 4-10 | 3 |
| | 3-2 × 8 | 7-8 | 1 | 6-0 | 1 | 5-1 | 2 | 7-0 | 1 | 5-6 | 2 | 4-8 | 2 | 6-5 | 1 | 5-1 | 2 | 4-4 | 2 |
| | 3-2 × 10 | 9-1 | 1 | 7-2 | 2 | 6-1 | 2 | 8-4 | 1 | 6-7 | 2 | 5-7 | 2 | 7-8 | 2 | 6-1 | 2 | 5-2 | 2 |
| | 3-2 × 12 | 10-8 | 2 | 8-5 | 2 | 7-2 | 2 | 9-10 | 2 | 7-8 | 2 | 6-7 | 2 | 9-0 | 2 | 7-1 | 2 | 6-1 | 2 |
| | 4-2 × 8 | 8-10 | 1 | 6-11 | 1 | 5-11 | 1 | 8-1 | 1 | 6-4 | 1 | 5-5 | 2 | 7-5 | 1 | 5-11 | 1 | 5-0 | 2 |
| | 4-2 × 10 | 10-6 | 1 | 8-3 | 2 | 7-0 | 2 | 9-8 | 1 | 7-7 | 2 | 6-5 | 2 | 8-10 | 1 | 7-0 | 2 | 6-0 | 2 |
| | 4-2 × 12 | 12-4 | 1 | 9-8 | 2 | 8-3 | 2 | 11-4 | 2 | 8-11 | 2 | 7-7 | 2 | 10-4 | 2 | 8-3 | 2 | 7-0 | 2 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Roof, ceiling and one clear-span floor | 1-2 × 6 | 2-11 | 2 | 2-3 | 2 | 1-11 | 2 | 2-9 | 2 | 2-1 | 2 | 1-9 | 2 | 2-7 | 2 | 2-0 | 2 | 1-8 | 2 |
| | 1-2 × 8 | 3-9 | 2 | 2-10 | 2 | 2-5 | 3 | 3-6 | 2 | 2-8 | 2 | 2-3 | 3 | 3-3 | 2 | 2-6 | 3 | 2 -2 | 3 |
| | 1-2 × 10 | 4-5 | 2 | 3-5 | 3 | 2-10 | 3 | 4-2 | 2 | 3-2 | 3 | 2-8 | 3 | 3-11 | 2 | 3-0 | 3 | 2-6 | 3 |
| | 1-2 × 12 | 5-2 | 2 | 4-0 | 3 | 3-4 | 3 | 4-10 | 3 | 3-9 | 3 | 3-2 | 4 | 4-7 | 3 | 3-6 | 3 | 3-0 | 4 |
| | 2-2 × 4 | 2-11 | 1 | 2-3 | 1 | 1-10 | 1 | 2-9 | 1 | 2-1 | 1 | 1-9 | 1 | 2-7 | 1 | 2-0 | 1 | 1-8 | 1 |
| | 2-2 × 6 | 4-4 | 1 | 3-4 | 2 | 2-10 | 2 | 4-1 | 1 | 3-2 | 2 | 2-8 | 2 | 3-10 | 1 | 3-0 | 2 | 2-6 | 2 |
| | 2-2 × 8 | 5-6 | 2 | 4-3 | 2 | 3-7 | 2 | 5-2 | 2 | 4-0 | 2 | 3-4 | 2 | 4-10 | 2 | 3-9 | 2 | 3-2 | 2 |
| | 2-2 × 10 | 6-7 | 2 | 5-0 | 2 | 4-2 | 2 | 6-1 | 2 | 4-9 | 2 | 4-0 | 2 | 5-9 | 2 | 4-5 | 2 | 3-9 | 3 |
| | 2-2 × 12 | 7-9 | 2 | 5-11 | 2 | 4-11 | 3 | 7-2 | 2 | 5-7 | 2 | 4-8 | 3 | 6-9 | 2 | 5-3 | 3 | 4-5 | 3 |
| | 3-2 × 8 | 6-11 | 1 | 5-3 | 2 | 4-5 | 2 | 6-5 | 1 | 5-0 | 2 | 4-2 | 2 | 6-1 | 1 | 4-8 | 2 | 4-0 | 2 |
| | 3-2 × 10 | 8-3 | 2 | 6-3 | 2 | 5-3 | 2 | 7-8 | 2 | 5-11 | 2 | 5-0 | 2 | 7-3 | 2 | 5-7 | 2 | 4-8 | 2 |
| | 3-2 × 12 | 9-8 | 2 | 7-5 | 2 | 6-2 | 2 | 9-0 | 2 | 7-0 | 2 | 5-10 | 2 | 8-6 | 2 | 6-7 | 2 | 5-6 | 3 |
| | 4-2 × 8 | 8-0 | 1 | 6-1 | 1 | 5-1 | 2 | 7-5 | 1 | 5-9 | 2 | 4-10 | 2 | 7-0 | 1 | 5-5 | 2 | 4-7 | 2 |
| | 4-2 × 10 | 9-6 | 1 | 7-3 | 2 | 6-1 | 2 | 8-10 | 1 | 6-10 | 2 | 5-9 | 2 | 8-4 | 1 | 6-5 | 2 | 5-5 | 2 |
| | 4-2 × 12 | 11-2 | 2 | 8-6 | 2 | 7-2 | 2 | 10-5 | 2 | 8-0 | 2 | 6-9 | 2 | 9-10 | 2 | 7-7 | 2 | 6-5 | 2 |

*(continued)*

**TABLE R602.7(1)—continued**

**GIRDER SPANS[a] AND HEADER SPANS[a] FOR EXTERIOR BEARING WALLS**

**(Maximum spans for Douglas fir-larch, hem-fir, Southern pine and spruce-pine-fir[b] and required number of jack studs)**

| GIRDERS AND HEADERS SUPPORTING | SIZE | GROUND SNOW LOAD (psf)[e] | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 30 | | | | | | 50 | | | | | | 70 | | | | | |
| | | Building width[c] (feet) | | | | | | | | | | | | | | | | | |
| | | 12 | | 24 | | 36 | | 12 | | 24 | | 36 | | 12 | | 24 | | 36 | |
| | | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] | Span[f] | NJ[d] |
| Roof, ceiling and two center-bearing floors | 1-2 × 6 | 2-8 | 2 | 2-1 | 2 | 1-10 | 2 | 2-7 | 2 | 2-0 | 2 | 1-9 | 2 | 2-5 | 2 | 1-11 | 2 | 1-8 | 2 |
| | 1-2 × 8 | 3-5 | 2 | 2-8 | 2 | 2-4 | 3 | 3-3 | 2 | 2-7 | 2 | 2-2 | 3 | 3-1 | 2 | 2-5 | 3 | 2-1 | 3 |
| | 1-2 × 10 | 4-0 | 2 | 3-2 | 3 | 2-9 | 3 | 3-10 | 2 | 3-1 | 3 | 2-7 | 3 | 3-8 | 2 | 2-11 | 3 | 2-5 | 3 |
| | 1-2 × 12 | 4-9 | 3 | 3-9 | 3 | 3-2 | 4 | 4-6 | 3 | 3-7 | 3 | 3-1 | 4 | 4-3 | 3 | 3-5 | 3 | 2-11 | 4 |
| | 2-2 × 4 | 2-8 | 1 | 2-1 | 1 | 1-9 | 1 | 2-6 | 1 | 2-0 | 1 | 1-8 | 1 | 2-5 | 1 | 1-11 | 1 | 1-7 | 1 |
| | 2-2 × 6 | 4-0 | 1 | 3-2 | 2 | 2-8 | 2 | 3-9 | 1 | 3-0 | 2 | 2-7 | 2 | 3-7 | 1 | 2-10 | 2 | 2-5 | 2 |
| | 2-2 × 8 | 5-0 | 2 | 4-0 | 2 | 3-5 | 2 | 4-10 | 2 | 3-10 | 2 | 3-3 | 2 | 4-7 | 2 | 3-7 | 2 | 3-1 | 2 |
| | 2-2 × 10 | 6-0 | 2 | 4-9 | 2 | 4-0 | 2 | 5-8 | 2 | 4-6 | 2 | 3-10 | 3 | 5-5 | 2 | 4-3 | 2 | 3-8 | 3 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2-2 × 12 | 7-0 | 2 | 5-7 | 2 | 4-9 | 3 | 6-8 | 2 | 5-4 | 3 | 4-6 | 3 | 6-4 | 2 | 5-0 | 3 | 4-3 | 3 |
| | 3-2 × 8 | 6-4 | 1 | 5-0 | 2 | 4-3 | 2 | 6-0 | 1 | 4-9 | 2 | 4-1 | 2 | 5-8 | 2 | 4-6 | 2 | 3-10 | 2 |
| | 3-2 × 10 | 7-6 | 2 | 5-11 | 2 | 5-1 | 2 | 7-1 | 2 | 5-8 | 2 | 4-10 | 2 | 6-9 | 2 | 5-4 | 2 | 4-7 | 2 |
| | 3-2 × 12 | 8-10 | 2 | 7-0 | 2 | 5-11 | 2 | 8-5 | 2 | 6-8 | 2 | 5-8 | 3 | 8-0 | 2 | 6-4 | 2 | 5-4 | 3 |
| | 4-2 × 8 | 7-3 | 1 | 5-9 | 1 | 4-11 | 2 | 6-11 | 1 | 5-6 | 2 | 4-8 | 2 | 6-7 | 1 | 5-2 | 2 | 4-5 | 2 |
| | 4-2 × 10 | 8-8 | 1 | 6-10 | 2 | 5-10 | 2 | 8-3 | 2 | 6-6 | 2 | 5-7 | 2 | 7-10 | 2 | 6-2 | 2 | 5-3 | 2 |
| | 4-2 × 12 | 10-2 | 2 | 8-1 | 2 | 6-10 | 2 | 9-8 | 2 | 7-8 | 2 | 6-7 | 2 | 9-2 | 2 | 7-3 | 2 | 6-2 | 2 |
| Roof, ceiling, and two clear-span floors | 1-2 × 6 | 2-3 | 2 | 1-9 | 2 | 1-5 | 2 | 2-3 | 2 | 1-9 | 2 | 1-5 | 3 | 2-2 | 2 | 1-8 | 2 | 1-5 | 3 |
| | 1-2 × 8 | 2-10 | 2 | 2-2 | 3 | 1-10 | 3 | 2-10 | 2 | 2-2 | 3 | 1-10 | 3 | 2-9 | 2 | 2-1 | 3 | 1-10 | 3 |
| | 1-2 × 10 | 3-4 | 2 | 2-7 | 3 | 2-2 | 3 | 3-4 | 3 | 2-7 | 3 | 2-2 | 4 | 3-3 | 3 | 2-6 | 3 | 2-2 | 4 |
| | 1-2 × 12 | 4-0 | 3 | 3-0 | 3 | 2-7 | 4 | 4-0 | 3 | 3-0 | 4 | 2-7 | 4 | 3-10 | 3 | 3-0 | 4 | 2-6 | 4 |
| | 2-2 × 4 | 2-3 | 1 | 1-8 | 1 | 1-4 | 1 | 2-3 | 1 | 1-8 | 1 | 1-4 | 1 | 2-2 | 1 | 1-8 | 1 | 1-4 | 2 |
| | 2-2 × 6 | 3-4 | 1 | 2-6 | 2 | 2-2 | 2 | 3-4 | 2 | 2-6 | 2 | 2-2 | 2 | 3-3 | 2 | 2-6 | 2 | 2-1 | 2 |
| | 2-2 × 8 | 4-3 | 2 | 3-3 | 2 | 2-8 | 2 | 4-3 | 2 | 3-3 | 2 | 2-8 | 2 | 4-1 | 2 | 3-2 | 2 | 2-8 | 3 |
| | 2-2 × 10 | 5-0 | 2 | 3-10 | 2 | 3-2 | 3 | 5-0 | 2 | 3-10 | 2 | 3-2 | 3 | 4-10 | 2 | 3-9 | 3 | 3-2 | 3 |
| | 2-2 × 12 | 5-11 | 2 | 4-6 | 3 | 3-9 | 3 | 5-11 | 2 | 4-6 | 3 | 3-9 | 3 | 5-8 | 2 | 4-5 | 3 | 3-9 | 3 |
| | 3-2 × 8 | 5-3 | 1 | 4-0 | 2 | 3-5 | 2 | 5-3 | 2 | 4-0 | 2 | 3-5 | 2 | 5-1 | 2 | 3-11 | 2 | 3-4 | 2 |
| | 3-2 × 10 | 6-3 | 2 | 4-9 | 2 | 4-0 | 2 | 6-3 | 2 | 4-9 | 2 | 4-0 | 2 | 6-1 | 2 | 4-8 | 2 | 4-0 | 3 |
| | 3-2 × 12 | 7-5 | 2 | 5-8 | 2 | 4-9 | 3 | 7-5 | 2 | 5-8 | 2 | 4-9 | 3 | 7-2 | 2 | 5-6 | 3 | 4-8 | 3 |
| | 4-2 × 8 | 6-1 | 1 | 4-8 | 2 | 3-11 | 2 | 6-1 | 1 | 4-8 | 2 | 3-11 | 2 | 5-11 | 1 | 4-7 | 2 | 3-10 | 2 |
| | 4-2 × 10 | 7-3 | 2 | 5-6 | 2 | 4-8 | 2 | 7-3 | 2 | 5-6 | 2 | 4-8 | 2 | 7-0 | 2 | 5-5 | 2 | 4-7 | 2 |
| | 4-2 × 12 | 8-6 | 2 | 6-6 | 2 | 5-6 | 2 | 8-6 | 2 | 6-6 | 2 | 5-6 | 2 | 8-3 | 2 | 6-4 | 2 | 5-4 | 3 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. Spans are given in feet and inches.

b. Spans are based on minimum design properties for No. 2 grade lumber of Douglas fir-larch, hem-fir, Southern pine, and spruce-pine-fir.

c. Building width is measured perpendicular to the ridge. For widths between those shown, spans are permitted to be interpolated.

d. NJ = Number of jack studs required to support each end. Where the number of required jack studs equals one, the header is permitted to be supported by an approved framing anchor attached to the full-height wall stud and to the header.

e. Use 30 psf ground snow load for cases in which ground snow load is less than 30 psf and the roof live load is equal to or less than 20 psf.

## TABLE R602.7(2)

## GIRDER SPANS[a] AND HEADER SPANS[a] FOR INTERIOR BEARING WALLS
## (Maximum spans for Douglas fir-larch, hem-fir, southern pine and spruce-pine-fir[b] and required number of jack studs)

| HEADERS AND GIRDERS SUPPORTING | SIZE | BUILDING Width[c] (feet) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 12 | | 24 | | 36 | |
| | | Span[e] | NJ[d] | Span[e] | NJ[d] | Span[e] | NJ[d] |
| One floor only | 2-2 × 4 | 4-1 | 1 | 2-10 | 1 | 2-4 | 1 |
| | 2-2 × 6 | 6-1 | 1 | 4-4 | 1 | 3-6 | 1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2-2 × 8 | 7-9 | 1 | 5-5 | 1 | 4-5 | 2 |
| | 2-2 × 10 | 9-2 | 1 | 6-6 | 2 | 5-3 | 2 |
| | 2-2 × 12 | 10-9 | 1 | 7-7 | 2 | 6-3 | 2 |
| | 3-2 × 8 | 9-8 | 1 | 6-10 | 1 | 5-7 | 1 |
| | 3-2 × 10 | 11-5 | 1 | 8-1 | 1 | 6-7 | 2 |
| | 3-2 × 12 | 13-6 | 1 | 9-6 | 2 | 7-9 | 2 |
| | 4-2 × 8 | 11-2 | 1 | 7-11 | 1 | 6-5 | 1 |
| | 4-2 × 10 | 13-3 | 1 | 9-4 | 1 | 7-8 | 1 |
| | 4-2 × 12 | 15-7 | 1 | 11-0 | 1 | 9-0 | 2 |
| Two floors | 2-2 × 4 | 2-7 | 1 | 1-11 | 1 | 1-7 | 1 |
| | 2-2 × 6 | 3-11 | 1 | 2-11 | 2 | 2-5 | 2 |
| | 2-2 × 8 | 5-0 | 1 | 3-8 | 2 | 3-1 | 2 |
| | 2-2 × 10 | 5-11 | 2 | 4-4 | 2 | 3-7 | 2 |
| | 2-2 × 12 | 6-11 | 2 | 5-2 | 2 | 4-3 | 3 |
| | 3-2 × 8 | 6-3 | 1 | 4-7 | 2 | 3-10 | 2 |
| | 3-2 × 10 | 7-5 | 1 | 5-6 | 2 | 4-6 | 2 |
| | 3-2 × 12 | 8-8 | 2 | 6-5 | 2 | 5-4 | 2 |
| | 4-2 × 8 | 7-2 | 1 | 5-4 | 1 | 4-5 | 2 |
| | 4-2 × 10 | 8-6 | 1 | 6-4 | 2 | 5-3 | 2 |
| | 4-2 × 12 | 10-1 | 1 | 7-5 | 2 | 6-2 | 2 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Spans are given in feet and inches.

b. Spans are based on minimum design properties for No. 2 grade lumber of Douglas fir-larch, hem-fir, Southern pine, and spruce-pine-fir.

c. Building width is measured perpendicular to the ridge. For widths between those shown, spans are permitted to be interpolated.

d. NJ = Number of jack studs required to support each end. Where the number of required jack studs equals one, the header is permitted to be supported by an approved framing anchor attached to the full-height wall stud and to the header.

**R602.7.1 Single member headers.** Single headers shall be framed with a single flat 2-inch-nominal (51 mm) member or wall plate not less in width than the wall studs on the top and bottom of the header in accordance with Figures R602.7.1(1) and R602.7.1(2) and face nailed to the top and bottom of the header with 10d box nails (3 inches × 0.128 inches) spaced 12 inches on center.

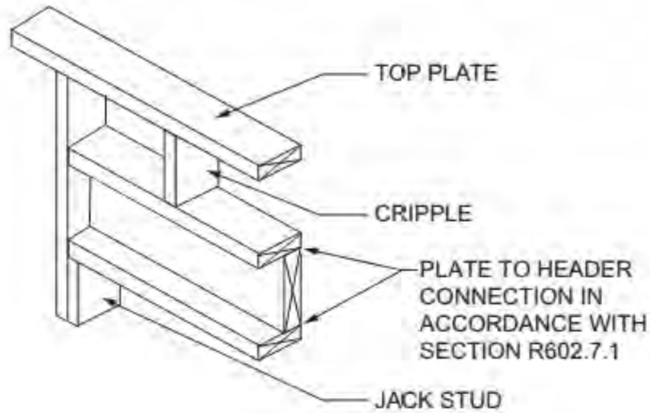



**FIGURE R602.7.1(1)**

**SINGLE-MEMBER HEADER IN EXTERIOR BEARING WALL**

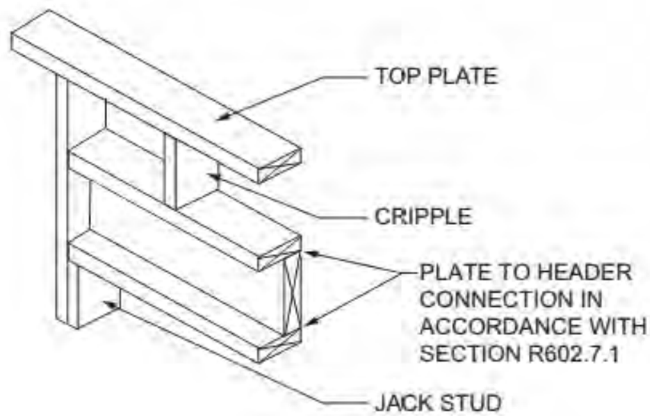



**FIGURE R602.7.1(2)**

**ALTERNATIVE SINGLE-MEMBER HEADER WITHOUT CRIPPLE**

**R602.7.2 Rim board headers.** Rim board header size, material and span shall be in accordance with Table R602.7(1). Rim board headers shall be constructed in accordance with Figure R602.7.2 and shall be supported at each end by full-height studs. The number of full-height studs at each end shall be not less than the number of studs displaced by half of the header span based on the maximum stud spacing in accordance with Table R602.3(5). Rim board headers supporting concentrated loads shall be designed in accordance with accepted engineering practice.

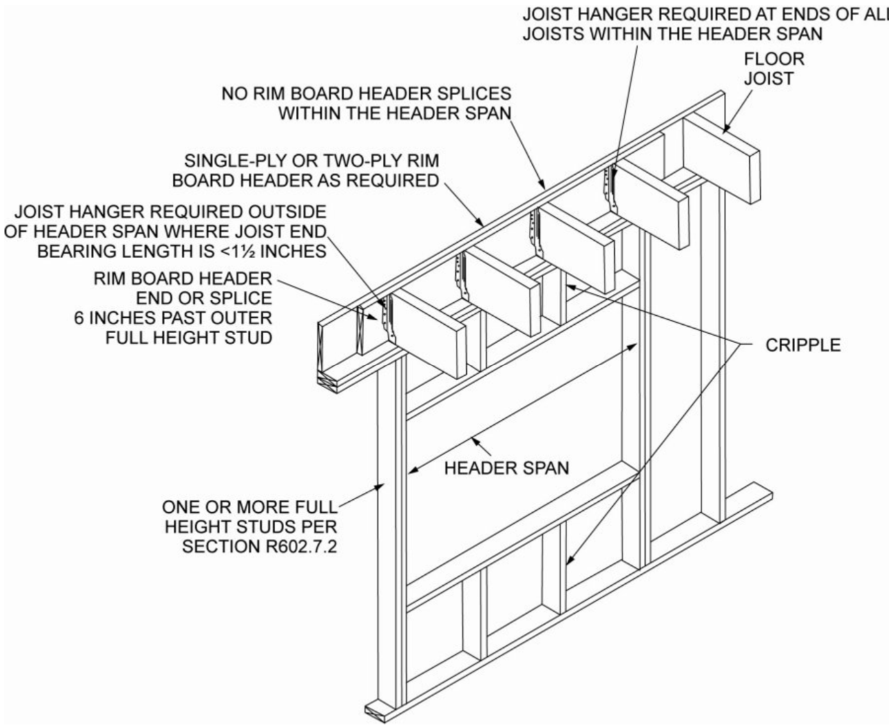
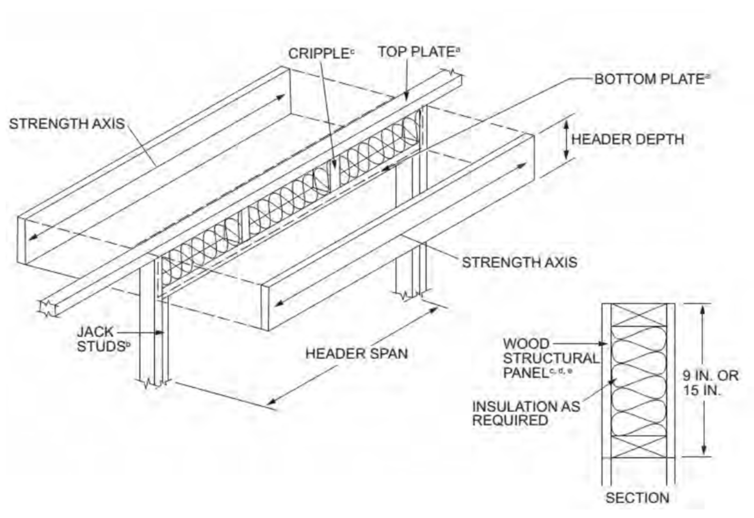



**FIGURE R602.7.2**

**RIM BOARD HEADER CONSTRUCTION**

**R602.7.3 Wood structural panel box headers.** Wood structural panel box headers shall be constructed in accordance with Figure R602.7.3 and Table R602.7.3.




**Notes:**

a. The top and bottom plates shall be continuous at header location.
b. Jack studs shall be used for spans over 4 feet.
c. Cripple spacing shall be the same as for studs.
d. Wood structural panel faces shall be single pieces of 15/32-inch-thick Exposure 1 (exterior glue) or thicker, installed on the interior or exterior or both sides of the header.
e. Wood structural panel faces shall be nailed to framing and cripples with 8d common or galvanized box nails spaced 3 inches on center, staggering alternate nails 1/2 inch. Galvanized nails shall be hot-dipped or tumbled.

**FIGURE R602.7.3**

**TYPICAL WOOD STRUCTURAL PANEL BOX HEADER CONSTRUCTION**

TABLE R602.7.3
MAXIMUM SPANS FOR WOOD STRUCTURAL PANEL BOX HEADERS[a]

| HEADER CONSTRUCTION[b] | | HEADER DEPTH (inches) | HOUSE DEPTH (feet) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 24 | 26 | 28 | 30 | 32 |
| Wood structural panel—one side | | 9<br>15 | 4<br>5 | 4<br>5 | 3<br>4 | 3<br>3 | —<br>3 |
| Wood structural panel—both sides | | 9<br>15 | 7<br>8 | 5<br>8 | 5<br>7 | 4<br>7 | 3<br>6 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. Spans are based on single story with clear-span trussed roof or two story with floor and roof supported by interior-bearing walls.
b. See Figure R602.7.3 for construction details.

**R602.7.4 Nonbearing walls.** Load-bearing headers are not required in interior or exterior *nonbearing walls*. A single flat 2-inch by 4-inch (51 mm by 102 mm) member shall be permitted to be used as a header in interior or exterior *nonbearing walls* for openings up to 8 feet (2438 mm) in width if the vertical distance to the parallel nailing surface above is not more than 24 inches (610 mm). For such nonbearing headers, cripples or blocking are not required above the header.

**R602.7.5 Supports for headers.** Headers shall be supported on each end with one or more jack studs or with *approved* framing anchors in accordance with Table R602.7(1) or R602.7(2). The full-height stud adjacent to each end of the header shall be end nailed to each end of the header ~~with four-16d nails (3.5 inches × 0.135 inches)~~ in accordance with Table R602.3(1). The minimum number of full-height studs at each end of a header shall be in accordance with Table R602.7.5.

~~TABLE R602.7.5~~
~~MINIMUM NUMBER OF FULL HEIGHT STUDS AT EACH END OF HEADERS IN EXTERIOR WALLS~~

| HEADER SPAN (feet) | MAXIMUM STUD SPACING (inches) [per Table R602.3(5)] | |
|---|---|---|
| | 16 | 24 |
| ≤ 3′ | 1 | 1 |
| 4′ | 2 | 1 |
| 8′ | 3 | 2 |
| 12′ | 5 | 3 |
| 16′ | 6 | 4 |

TABLE R602.7.5
MINIMUM NUMBER OF FULL-HEIGHT STUDS AT EACH END OF HEADERS IN EXTERIOR WALLS[a]

| MAXIMUM HEADER SPAN (feet) | ULTIMATE DESIGN WIND SPEED AND EXPOSURE CATEGORY | |
|---|---|---|
| | < 140 mph, Exposure B or < 130 mph, Exposure C | ≤ 115 mph, Exposure B[b] |
| 4 | 1 | 1 |
| 6 | 2 | 1 |
| 8 | 2 | 1 |
| 10 | 3 | 2 |

| | | |
|---|---|---|
| 12 | 3 | 2 |
| 14 | 3 | 2 |
| 16 | 4 | 2 |
| 18 | 4 | 2 |

For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

a. For header spans between those given, use the minimum number of full-height studs associated with the larger header span.

b. The tabulated minimum number of full-height studs is applicable where jack studs are provided to support the header at each end in accordance with Table R602.7(1). Where a framing anchor is used to support the header in lieu of a jack stud in accordance with Note d of Table R602.7(1), the minimum number of full-height studs at each end of a header shall be in accordance with requirements for wind speed < 140 mph, Exposure B.

**R602.8 Fireblocking required.** Fireblocking shall be provided in accordance with Section R302.11.

**R602.9 Cripple walls.** Foundation cripple walls shall be framed of studs not smaller than the studding above. ~~When~~ Where exceeding 4 feet (1219 mm) in height, such walls shall be framed of studs having the size required for an additional story.

Exterior cripple walls with a stud height less than 14 inches (356 mm) shall be continuously sheathed on one side with wood structural panels fastened to both the top and bottom plates in accordance with Table R602.3(1), or the cripple walls shall be constructed of solid blocking.

Cripple walls shall be supported on continuous foundations.

~~**R602.10 Wall bracing.** Buildings, and portions thereof, shall be braced in accordance with one or more of the following sections using bracing materials and methods complying with Section R602.10.1 and load path detailing in accordance with Section R602.10.4:~~

~~1. Isolated panel bracing in accordance with Section R602.10.2;~~

~~2. Continuous sheathing in accordance with Section R602.10.3;~~

~~3. Engineered design in accordance with Section R602.10.5;~~

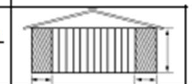
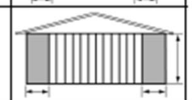
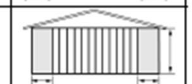
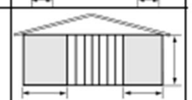
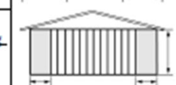
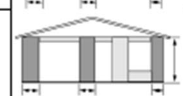
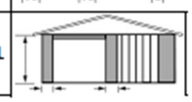
~~4. 2015 *International Residential Code* (IRC), Section R602.10; or~~

~~5. SR-102 as published by APA, The Engineered Wood Association with limitations indicated in this document.~~

~~Where a building, or portion thereof, does not comply with Section R602.10.2, R602.10.3, or R602.10.4, those portions shall be designed and constructed in accordance with Section R602.10.5.~~

~~**R602.10.1 Bracing materials and methods.** Wall bracing materials and methods shall comply with Table R602.10.1.~~

**TABLE R602.10.1**
**BRACING METHODS[a, b]**

| METHOD | MINIMUM BRACE MATERIAL THICKNESS OR SIZE | MINIMUM BRACE PANEL LENGTH OR BRACE ANGLE | CONNECTION CRITERIA | | FIGURE OF BRACING METHOD, NOT NECESSARILY LOCATION |
|---|---|---|---|---|---|
| | | | Fasteners | Spacing | |
| **LIB** Let-in-bracing | 1 × 4 wood brace (or approved metal brace installed per manufacturer instructions) | 45° angle for maximum 16" o.c. stud spacing[c] | 2-8d common nails or 3-8d ($2^1/_2$" long × 0.113" dia.) nails | Per stud and top and bottom plates |  |
| **DWB** Diagonal wood boards | $^3/_4$" (1" nominal) | 48" | 2-8d ($2^1/_2$" long × 0.113" diameter) or 2 - $1^3/_4$" long staples | Per stud and top and bottom plates |  |
| **WSP** Wood structural panel | $^3/_8$" | 48"[d] | 6d common nail or 8d ($2^1/_2$" long × 0.113" diameter) nail [See Table R602.3(3)] | 6" edges 12" field |  |
| **SFB** Structural fiberboard sheathing | $^1/_2$" | 48"[d] | $1^1/_2$" long × 0.120" diameter galvanized roofing nails | 3" edges 6" field |  |
| **GB** Gypsum board installed on both sides of wall | $^1/_2$" | 96" for use with R602.10.2 48" for use with R602.10.3 | Minimum 5d cooler nails or #6 screws | 7" edges 7" field |  |
| **PCP** Portland cement plaster | $^3/_4$" (maximum 16" o.c. stud spacing) | 48" | $1^1/_2$" long, 11 gage, $^7/_{16}$" diameter head nails or $^7/_8$" long, 6 gage staples | 6" o.c. on all framing members |  |
| CS-WSP[e, i] Continuously sheathed WSP | $^3/_8$" | 24" adjacent to window not more than 67% of wall height; 30" adjacent to door or window greater than 67% and less than 85% of wall height. 48" for taller openings. | Same as WSP | Same as WSP |  |
| CS-SFB[e, i] Continuously sheathed SFB | $^1/_2$" | | Same as SFB | Same as SFB |  |
| PF Portal Frame[f, g, h] | $^7/_{16}$" | See Figure R602.10.1 | See Figure R602.10.1 | See Figure R602.10.1 |  |

**Notes:**

a. Alternative bracing materials and methods shall comply with Section 105 of the *North Carolina Administrative Code and Policies*, and shall be permitted to be used as a substitute for any of the bracing materials listed in Table R602.10.1 provided at least equivalent performance is demonstrated. Where the tested bracing strength or stiffness differs from tabulated materials, the bracing amount required for the alternative material shall be permitted to be factored to achieve equivalence.

b. All edges of panel-type wall bracing required from Tables R602.10.1 and R602.10.3 shall be attached to framing or blocking, except GB bracing horizontal joints shall not be required to be blocked when joints are finished.

c. Two LIB braces installed at a 60° angle shall be permitted to be substituted for each 45° angle LIB brace.

d. For 8-foot (2483 mm) or 9-foot (2743 mm) wall height, brace panel minimum length shall be permitted to be reduced to 36-inch (914 mm) or 42-inch length (1067 mm), respectively, where not located adjacent to a door opening. A braced wall panel shall be permitted to be reduced to a 32-inch (813 mm) length when studs at each end of the braced wall panel are anchored to foundation or framing below using hold-down device with minimum 2,800 pounds design tension capacity. For detached single story garages and attached garages supporting roof only, a minimum 24-inch (610 mm) brace panel length shall be permitted on one wall containing one or more garage door openings.

e. Bracing methods designated CS-WSP and CS-SFB shall have sheathing installed on all sheathable surfaces above, below, and between wall openings.

f. For purposes of bracing in accordance with Section R602.10.2, two portal frame brace panels with wood structural panel sheathing applied to the exterior face of each brace panel as shown in Figure R602.10.1 shall be considered equivalent to one braced wall panel.

g. Structural fiberboard (SFB) shall not be used in portal frame construction.

h. No more than three portal frames shall be used in a single building elevation.

i. CS-WSP and CS-SFB cannot be mixed on the same story. Gable ends shall match the panel type of the wall below.

~~**R602.10.2 Isolated panel bracing.**~~

~~**R602.10.2.1 Limitations.** The conventional bracing requirements of Section R602.10.2.2 shall be limited to the following conditions of use:~~

~~1. Ultimate design wind speed shall not exceed 120 mph (53 m/s), Exposure Category B.~~

~~2. Bracing methods shall be LIB, DWB, WSP, SFB, GB, PCP, and PF in accordance with Table R602.10.1.~~

~~3. Length of the house is limited to 75 feet (22.9 m). Overall plan length shall not exceed 3 times the overall plan width. The multiple circumscribed rectangle method from Section R602.10.3.2 may~~

~~be applied to the method set forth in this section.~~
~~4. Wall height at each story level shall not exceed 10 feet (3048 mm).~~
~~5. Roof eave-to-ridge height shall not exceed 10 feet (3048 mm) unless the roof is considered as an additional story for the purpose of determining bracing amounts required.~~
~~6. Except when used for bracing method GB, the interior side of exterior walls and both sides of interior walls shall be sheathed continuously with minimum 1/2-inch (12.7 mm) thick gypsum wall board interior finish fastened in accordance with Table R702.3.5, or approved interior finish of equivalent or greater shear resistance.~~
~~7. Floors shall not cantilever more than 24 inches (610 mm) beyond the foundation or bearing wall below.~~
~~8. Townhouses shall be stabilized independently of adjacent units unless a design is provided to permit lateral load transfer between adjacent units.~~
~~9. Townhouses in Seismic Design Category C shall be designed in accordance with Section R602.10.5 or the 2015 *International Residential Code*.~~
**R602.10.2.2 Requirements.** ~~Braced wall panels shall be constructed of bracing methods, materials, and minimum braced panel lengths complying with Table R602.10.1. The number of braced wall panels required for each side of a building (elevation view) at each story level of the building shall comply with Table R602.10.2. The following additional requirements shall apply:~~
~~1. In no case shall the amount of bracing be less than two braced wall panels on exterior walls comprising each side of the floor plan (or plan elevation) for each story level of the building.~~
~~2. A braced wall panel shall be located within 12 feet (3658 mm) of both ends of each elevation view of the house. Braced wall panels on exterior walls shall be installed such that the edge-to-edge distance between braced wall panels does not exceed 21 feet (6401 mm). See Figures R602.10.2.2(1) and R602.10.2.2(2).~~

~~3. No more than one-half of bracing on parallel exterior walls shall be permitted to be relocated to interior walls oriented in the same plan direction and within one-half the floor plan dimension perpendicular to the exterior wall. See Figure R602.10.2.2(3).~~
~~4. Use of multiple bracing methods and materials complying with Table R602.10.1 shall be permitted.~~
~~5. Detached garages or storage buildings connected to the house with a covered walk-way shall be considered separate buildings. Houses with skewed wings shall be designed in accordance~~

~~with Section R602.10.3, Section R602.10.5, or the 2015 *International Residential Code* (Section R602.10).~~

~~6. Garage door openings supporting a floor load above shall be braced using the portal frame method (PF) unless the building plan level containing the garage opening wall complies with all the bracing requirements of this section.~~

~~**R602.10.3 Continuous sheathing.**~~

~~**R602.10.3.1 Limitations.** The continuous sheathing requirements of Section R602.10.3 shall be limited to bracing methods CS-WSP and CS-SFB in accordance with Table R602.10.1 with the following conditions of use:~~

~~1. Ultimate design wind speed shall not exceed 130 mph (58 m/s).~~

~~2. Wall height at each story level shall not exceed 12 feet (3658 mm).~~

~~3. Eave-to-ridge height shall not exceed 20 feet (6096 mm).~~

~~4. Exterior walls shall be sheathed on all sheathable surfaces including infill areas between braced wall panels, above and below wall openings, and on gable end walls.~~

~~5. Except when used for bracing method GB, the interior side of exterior walls and both sides of interior walls shall be sheathed continuously with minimum 1/2-inch (12.7 mm) thick gypsum wall board interior finish fastened in accordance with Table R702.3.5, or approved interior finish of equivalent or greater shear resistance. Unless required for fire separation by Section R302.6, gypsum board shall be permitted to be omitted where the required length of bracing, as determined in Table R602.10.3, is multiplied by 1.40.~~

~~6. Floors shall not cantilever more than 24 inches (610 mm) beyond the foundation or bearing wall below.~~

~~7. Townhouses in Seismic Design Category C shall be designed in accordance with Section R602.10.5 or the 2015 *International Residential Code*.~~

~~8. Townhouses shall be stabilized independently of adjacent units, unless a design is provided to permit lateral load transfer between adjacent units~~

~~9. CS-WSP and CS-SFB cannot be mixed on the same story. Gable ends shall match the panel type of the wall below.~~

~~**R602.10.3.2 Requirements.** The required length of bracing for each side of a rectangle circumscribed around the plan or a portion of the plan at each story level shall be determined using Table R602.10.3 and Figure R602.10.3(1). The cumulative contributing length of braced wall panels assigned to a rectangle~~

~~side shall be greater than or equal to the required length of bracing specified in Table R602.10.3. The following additional requirements shall apply.~~

~~1. Braced wall panels on exterior or interior walls shall be assigned to the nearest rectangle side as shown in Figure R602.10.3(2) for each story level floor plan.~~

~~2. Braced wall panels shall be distributed and installed in accordance with Figures R602.10.3(3), R602.10.3(4) and R602.10.3(5).~~

~~3. A minimum of one-half the required bracing amount for each rectangle side should be located on exterior walls within 8 feet (2438 mm) of the location of the rectangle side.~~

~~4. Interior braced wall panels using method GB shall be assigned to the closest parallel rectangle side and shall contribute 0.5 times their actual length.~~

~~5. The bracing amount provided on an upper story building side shall be deemed to comply where it equals or exceeds the amount of bracing required for the story immediately below.~~

~~6. Where the bracing amount provided on an upper story equals or exceeds the amount of bracing required for the story below, an analysis of bracing shall not be required for the upper story.~~

~~**R602.10.4 Load path details.** Construction shall comply with applicable detailing requirements of this section to ensure an adequate continuous load path for transfer of bracing loads and uplift loads from the roof to the foundation.~~

~~**R602.10.4.1 Wind uplift load path.** Framing connections to transfer roof uplift forces shall comply with Section R602.3.5 and Section R802.11. In the 130 mph (58 m/s) wind zone, provide uplift anchorage in accordance with Sections R4508 and R4504.1.~~

~~**R602.10.4.2 Foundation anchorage.** Braced wall panels shall be connected to the foundation in accordance with Section R403.1.6, Section R602.11 and as required in Figure R602.10.1 for portal frames.~~

~~**R602.10.4.3 Masonry or concrete pedestals.** Masonry or concrete stem walls with a length of 48 inches (1219 mm) or less supporting braced wall panels shall be reinforced in accordance with Figure R602.10.4.3. Concrete stem walls shall be 6 inches (152 mm) nominal minimum thickness. Continuous concrete stem walls shall be reinforced in accordance with Section R404.1.3.2.~~

~~**R602.10.4.4 Blocking of floor framing.** When perpendicular to floor framing, braced wall panels shall be connected to full-height solid blocking between floor framing in accordance with Figure R602.10.4.4(1). When parallel to floor framing, braced wall panels shall be connected to a band, rim or header joist, floor framing~~

~~or perpendicular full-height solid blocking between floor framing at 16 inches (406 mm) on center in accordance with Figure R602.10.4.4(2). Attachments shall be in accordance with Table R602.3(1). Manufactured lumber or truss blocking panels shall be permitted to substitute for full-height solid blocking.~~

~~**R602.10.4.5 Blocking of roof framing.** When parallel to roof framing, braced wall panels shall be connected to a band, rim or header joist, or roof truss. When perpendicular to roof framing, the top plates of exterior braced wall panels shall be connected to the rafters or roof trusses above in accordance with Table R602.10.4.5 and fastened in accordance with Table R602.3(1).~~

~~**R602.10.4.6 Cripple walls and framed walls of walkout basements.** The required length of bracing for cripple walls with a maximum height of 48 inches (1219 mm) or less along its entire length shall be equal to the bracing provided for the wall above. The required length of bracing for cripple walls with a height greater than 48 inches (1219 mm) at any location along its length and for framed walls of a walk-out basement shall be determined in accordance with Section R602.10.2 or R602.10.3, considering the cripple wall or walk-out basement as an additional story. As an alternative, the required length of bracing shall be permitted to equal to the bracing provided for the wall above multiplied by a factor of 1.15.~~

~~**R602.10.4.7 Open elevated foundations.** Open elevated foundations, such as pile foundations, shall be constructed to transfer all lateral loads from the wall bracing system to the piles or open pier system, including shears, overturning, and uplift loads. Piles or open pier systems along with their foundations shall be sized and embedded to transfer all lateral loads imposed by the wall bracing system to the ground.~~

~~**R602.10.4.8 Balloon frame wall bracing.** Balloon frame walls shall have a maximum height of two stories and a maximum length of 20 feet (6096 mm) unless constructed in accordance with an approved design. Wall framing shall be continuous from lowest floor to the wall top plate at the roof. Braced wall panels shall extend to the full-height of the balloon frame wall. All edges of sheathing shall be supported on and fastened to blocking or framing. The required brace wall panel length assigned to the balloon frame wall shall be based on the bracing required for the lowest floor level supporting the balloon frame wall as determined in accordance with Section R602.10.2 or R602.10.3. For balloon framed walls having a maximum height of two stories and a maximum length of 20 feet (6096 mm), braced wall panels shall be permitted to be placed both parallel and perpendicular to the balloon framed wall on each side and at each story adjacent to the balloon~~

~~framed wall, and no bracing shall be required for the balloon frame wall portion. Bracing in the direction perpendicular to the balloon framed wall may be omitted when the opening dimension in the second floor perpendicular to the balloon framed wall created by the two story space is less than one half the least overall dimension of the house. See Figure R602.10.4.8.~~

~~**R602.10.5 Wall bracing by engineered design.** Design using bracing materials and methods listed in Table R602.10.1 or approved alternative materials and methods shall be permitted and shall comply with accepted engineering practice. Accepted engineering practice shall include the following:~~

~~1. Design in accordance with Section R301,~~

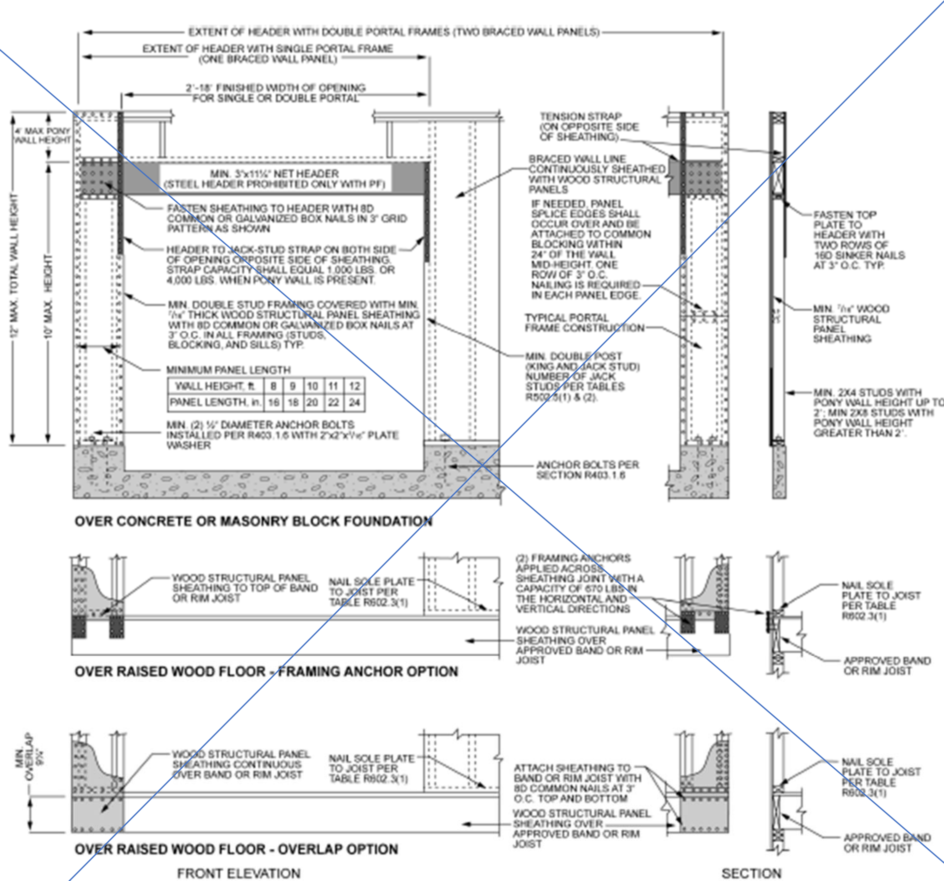
~~2. Design equivalent to the analysis basis of the provisions in Sections R602.10.2, R602.10.3, and R602.10.4, including determination of design loads, design unit shear values, and bracing amounts.~~

~~**R602.11 Wall anchorage.** *Braced wall line* sills shall be anchored to concrete or masonry foundations in accordance with Sections R403.1.6 and R602.11.1.~~

~~**R602.11.1 Wall anchorage for townhouses in Seismic Design Category C.** Plate washers, not less than 0.229 inch by 3 inches by 3 inches (5.8 mm by 76 mm by 76 mm) in size, shall be provided between the foundation sill plate and the nut except where *approved* anchor straps are used. The hole in the plate washer is permitted to be diagonally slotted with a width of up to 3/16 inch (5 mm) larger than the bolt diameter and a slot length not to exceed 1 3/4 inches (44 mm), provided a standard cut washer is placed between the plate washer and the nut.~~

~~**R602.11.2 Stepped foundations in Seismic Design Categories $D_0$, $D_1$ and $D_2$.** Deleted.~~

~~**R602.12 Simplified wall bracing.** Deleted.~~




For SI: 1 inch = 25.4 mm, 1 foot = 305 mm, 1 lb = 4.45 N.

**FIGURE R602.10.1**
**METHOD PF—PORTAL FRAME CONSTRUCTION**

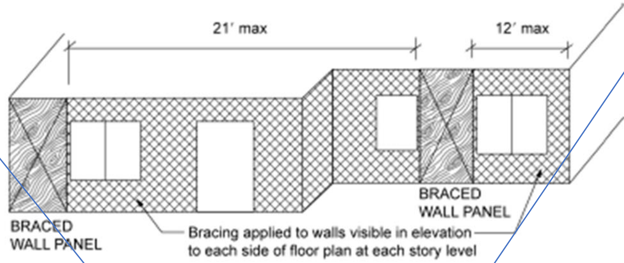



FIGURE R602.10.2.2(1)
LOCATION OF BRACED WALL PANELS

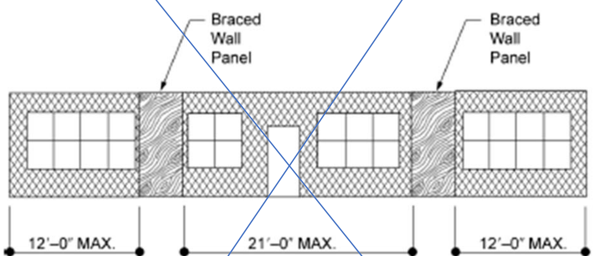
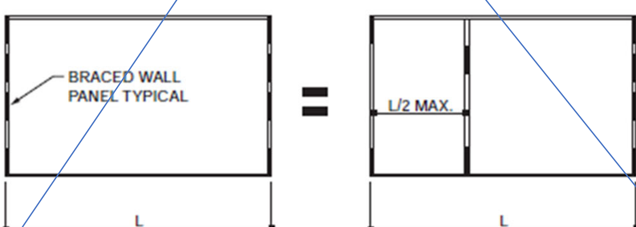



FIGURE R602.10.2.2(2)
PANELS INSET 12′-0″ FROM BOTH ENDS OF WALL ELEVATION



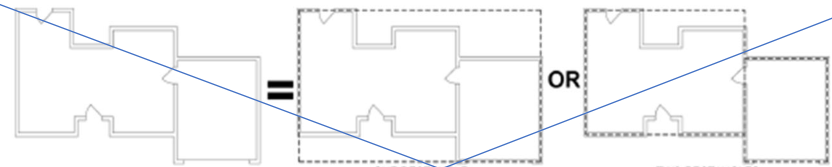

Note: Bracing shown in one direction only for clarity. Braced panel locations may be shifted along the walls to any location meeting the distribution rules in Figure R602.10.2.2(3). desired by the permit holder.

FIGURE R602.10.2.2(3)
PANELS SHIFTED TO INTERIOR WALLS

TABLE R602.10.2
NUMBER OF BRACED WALL PANELS REQUIRED
FOR EACH HOUSE ELEVATION (BUILDING SIDE) AT EACH STORY LEVEL[a]

| WIND SPEED | STORY LEVEL SUPPORTING | LONGEST OVERALL DIMENSION OF FLOOR PLAN FOR A GIVEN STORY LEVEL | | |
|---|---|---|---|---|
| | | 25′ | 50′ | 75′ |
| 115 mph | Roof Only | 1 | 2 | 3 |
| | Roof + 1 Story | 2 | 4 | 6 |
| | Roof + 2 Stories | 3 | 6 | 9 |
| 120 mph | Roof Only | 2 | 3 | 4 |
| | Roof + 1 Story | 3 | 5 | 8 |
| | Roof + 2 Stories | 4 | 8 | 11 |


a. Interpolation between dimensions is permitted. Extrapolation is prohibited. Fractions of panels shall be rounded to the nearest whole panel.

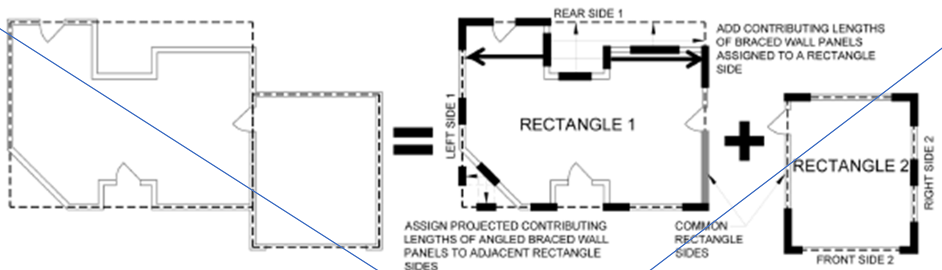



a. Each floor plan level shall be circumscribed with one or more rectangles around the floor plan or portions of the plan at the floor level under consideration as shown in Figure R602.10.3(1).

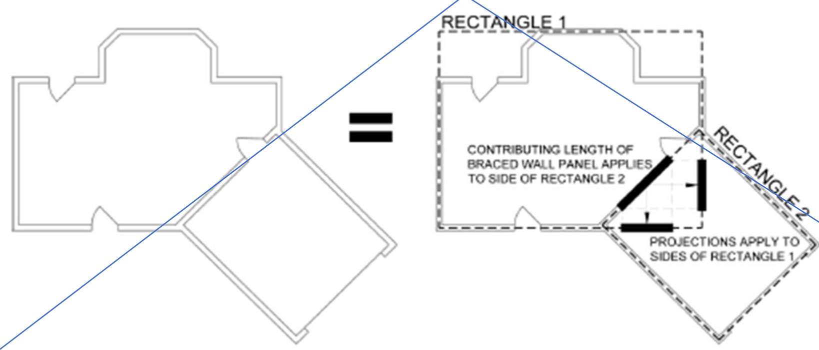
b. Rectangles shall surround all enclosed offsets and projections such as sunrooms and attached garages for a given story level floor plan. Chimneys, partial height projections, and open structures, such as carports and decks, shall be excluded from the rectangle.

c. Each rectangle shall have no side greater than 80 feet (24.4 m) with a maximum rectangle length-to-width ratio of 3:1. Rectangles shall be permitted to be skewed to accommodate diagonal walls.

**FIGURE R602.10.3(1)**
**CIRCUMSCRIBED RECTANGLES**~~[a, b, c]~~

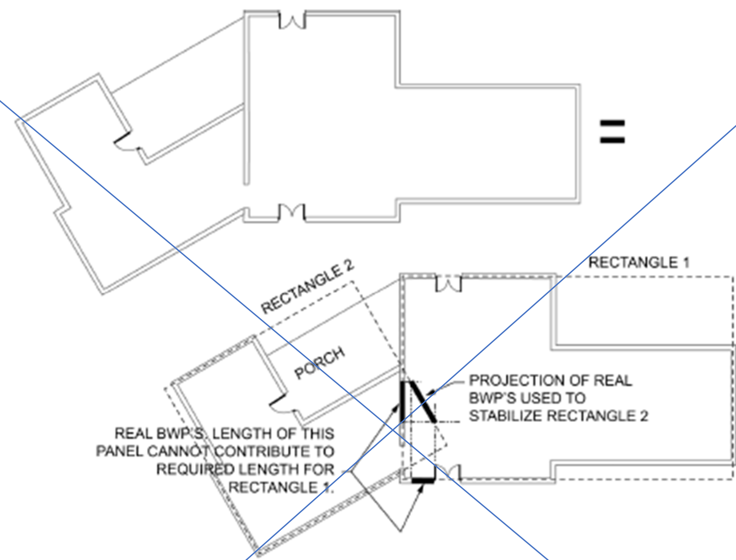



(a) Regular Floor Plan




(b) Skewed Floor Plan

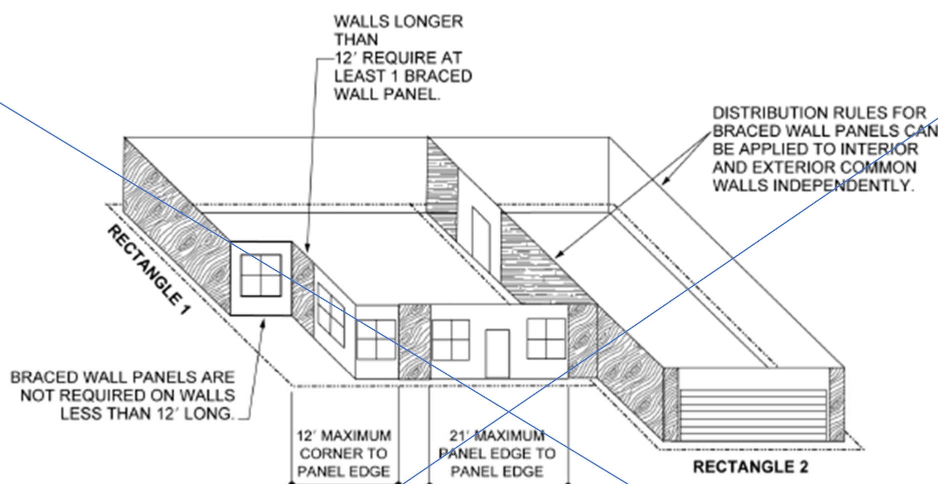
*(continued)*




(c) Skewed Floor Plan
Case 2.

a. Exterior braced wall panels shall be assigned to the closest parallel rectangle side and shall contribute their actual length.
b. Interior braced wall panels using method GB shall be assigned to the closest parallel rectangle side and shall contribute 0.5 times their actual length.
c. Projected contributing lengths of angled braced wall panels shall be assigned to the closest rectangle sides.
d. Portal frame braced wall panels shall contribute 1.5 times their actual length to their assigned rectangle side.
e. Where multiple rectangles share a common side or sides, as shown in Figure R602.10.3(2) plan a, the required length of bracing shall equal the sum of the required lengths from each of the shared rectangle sides.
f. Braced wall panels located on a common wall where skewed rectangles intersect, as shown in Figure R602.10.3(2) plan b, shall have their contributing length applied towards the required length of bracing for the parallel rectangle side and its projected contributing lengths towards the adjacent skewed rectangle sides. Where the common side of rectangle 2 as shown in Figure R602.10.3(2) plan c, has no physical wall, the wall bracing required to stabilize this side of Rectangle 2 shall be determined from Table 602.10.3. This length of bracing shall be resolved into orthogonal projections, and the orthogonal projections shall be added to the length of bracing required for the walls of Rectangle 1 which connect to Rectangle 2 in the directions parallel to the projections.

**FIGURE R602.10.3(2)**
**ASSIGNMENT OF BRACED WALL PANELS TO CIRCUMSCRIBED RECTANGLE SIDES[a, b, c, d, e, f]**




For SI: 1 feet = 304.8 mm.
a. A braced wall panel shall be located on each elevation view within 12 feet (3658 mm) of the corners of circumscribed rectangles. Detached garages or storage buildings connected to the house with a covered walk-way shall be considered separate buildings.
b. The distance between adjacent edges of braced wall panels shall be no more than 21 feet (6401 mm).
c. Segments of exterior walls greater than 12 feet (3658 mm) in length shall have a minimum of one braced wall panel.
d. Segments of exterior wall 12 feet (3658 mm) or less in length shall be permitted to have no bracing provided a braced wall panel is located within 12 feet (3658 mm) from the rectangle corner.
e. Interior and exterior wall segments which contribute to the common sides of multiple rectangles shall be permitted to apply the distribution requirements given above to each wall segment independently.
f. See Figures R602.10.3(4) and R602.10.3(5) for end conditions for braced walls with continuous sheathing.

**FIGURE R602.10.3(3)**
**DISTRIBUTION OF BRACED WALL PANELS[a, b, c, d, e, f]**

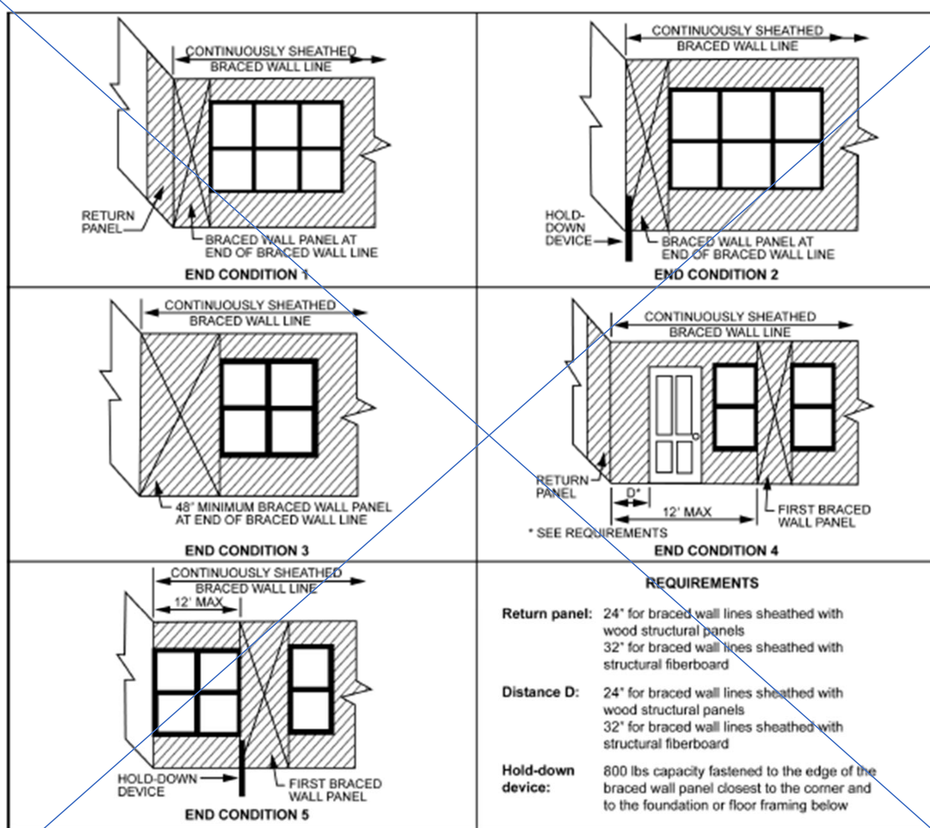
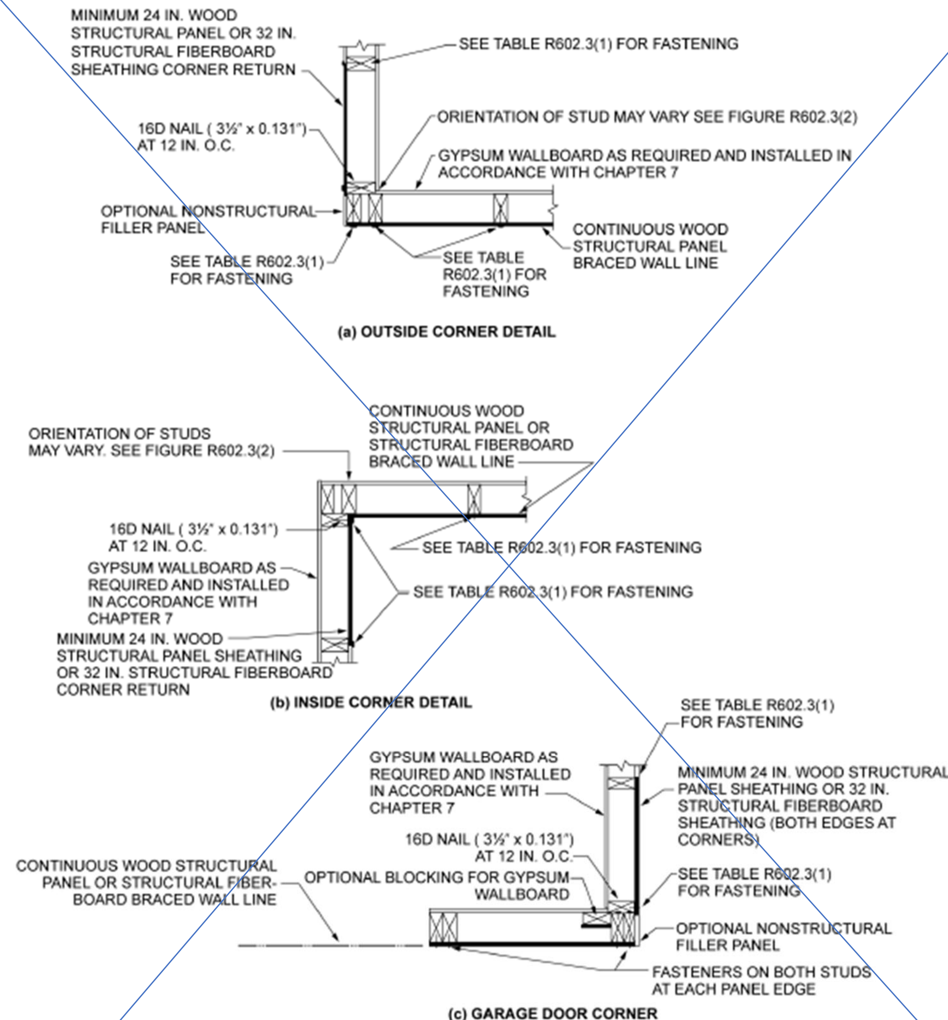
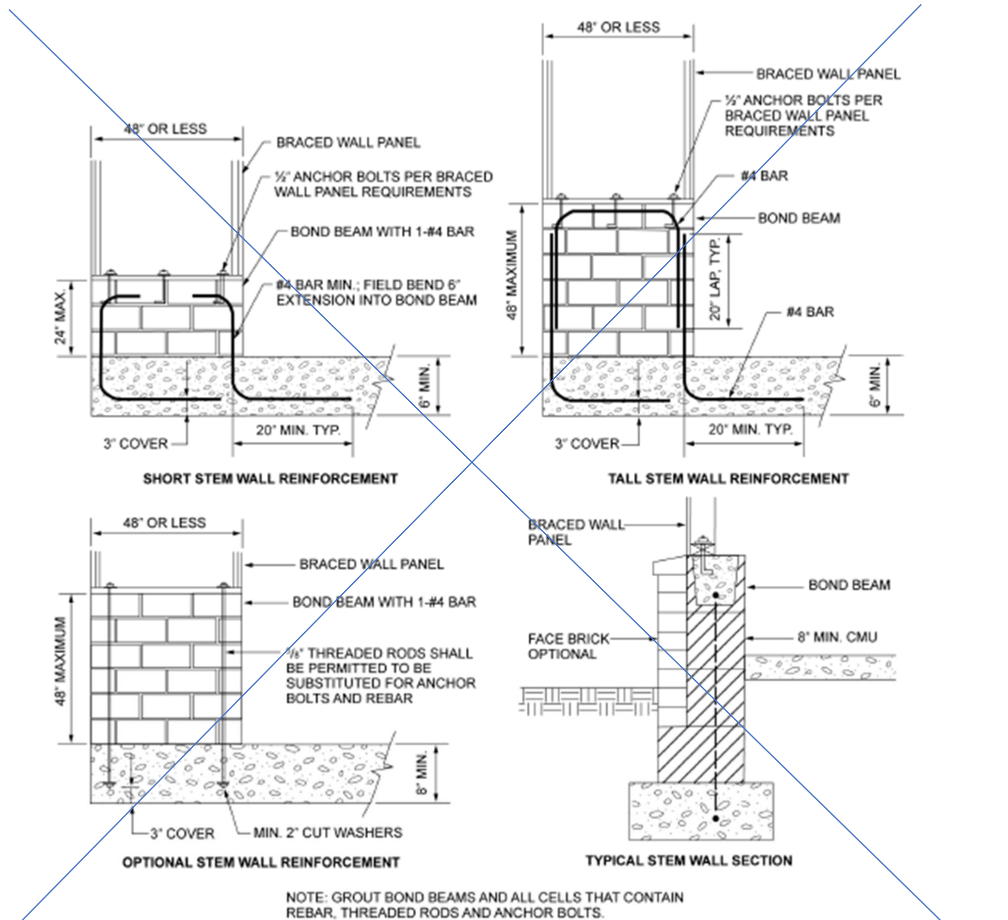



**FIGURE R602.10.3(4)**
**END CONDITIONS FOR BRACED WALLS WITH CONTINUOUS SHEATHING**



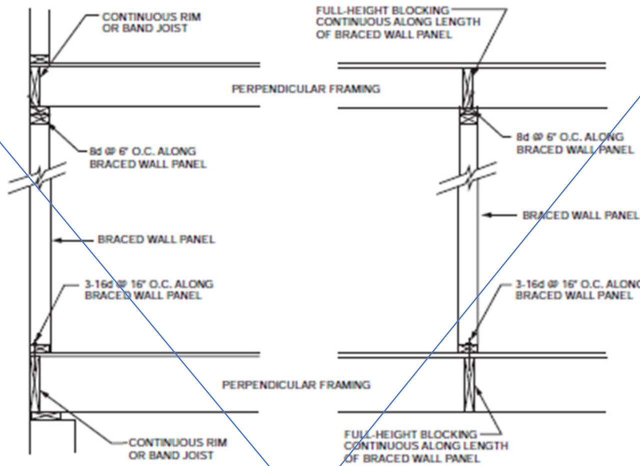

For SI: 1 inch = 25.4 mm, 1 foot = 305 mm.

**FIGURE R602.10.3(5)**
**TYPICAL EXTERIOR CORNER FRAMING FOR CONTINUOUS SHEATHING**



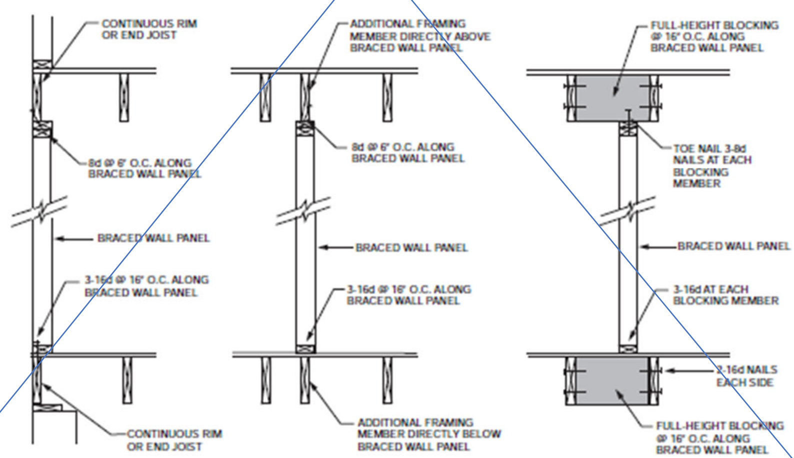

For SI: 1 inch = 25.4 mm.

**FIGURE R602.10.4.3**
**MASONRY STEM WALLS SUPPORTING BRACED WALL PANELS**




r SI: 1 inch = 25.4 mm.

**FIGURE R602.10.4.4(1)**
**BRACED WALL PANEL CONNECTION WHEN PERPENDICULAR TO FLOOR/CEILING FRAMING**




r SI: 1 inch = 25.4 mm.

**FIGURE R602.10.4.4(2)**
**BRACED WALL PANEL CONNECTION WHEN PARALLEL TO FLOOR/CEILING FRAMING**

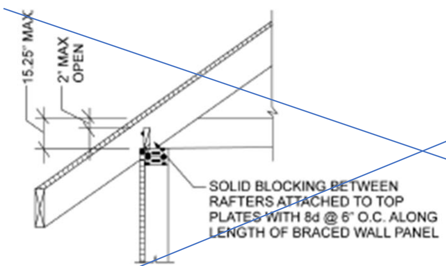



**FIGURE R602.10.4.5(1)**
**BRACED WALL PANEL CONNECTION TO PERPENDICULAR RAFTERS OR ROOF TRUSSES**

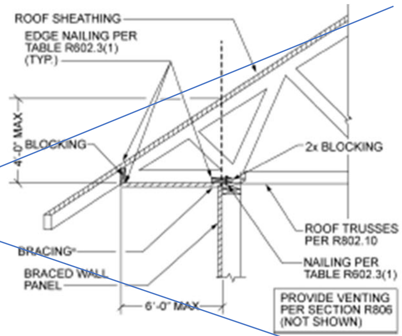
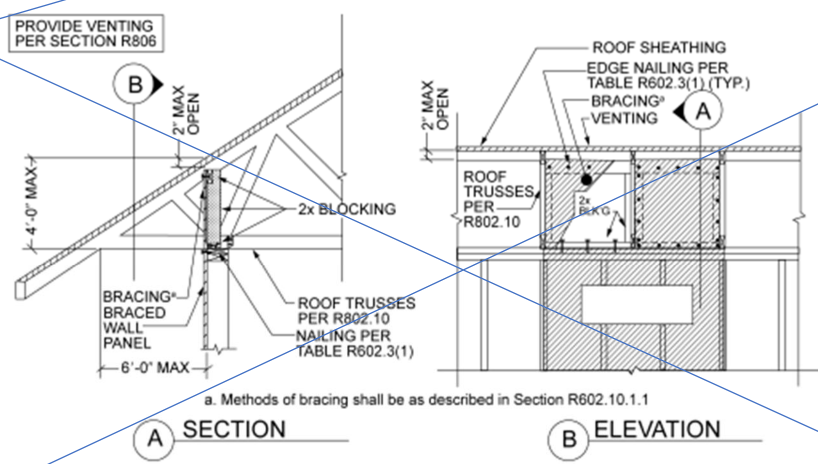



**FIGURE R602.10.4.5(2)**
**ALTERNATE TO FIGURE R602.10.4.5(1) OR FIGURE R602.10.4.5(3)**

**TABLE R602.10.4.5**
**BRACED WALL PANEL CONNECTIONS TO PERPENDICULAR ROOF FRAMING**

| DISTANCE FROM TOP OF BRACED WALL PANEL TO TOP OF RAFTER OR ROOF TRUSS (inches) | REQUIREMENT | REFERENCED FIGURE |
|---|---|---|
| ≤ 9.25 | No blocking required | NA |
| 9.26 – 15.25 | Solid 2× blocking between rafters or trusses | R602.10.4.5(1) or (2) |
| 15.26 – 48 | Vertical blocking panels | R602.10.4.5(2) or (3) |
| > 48 | Designed in accordance with accepted engineering practice | NA |

For SI: 1 inch = 25.4 mm




a. Methods of bracing shall be as described in Section R602.10.1.1

**FIGURE R602.10.4.5(3)**
**BRACED WALL PANEL CONNECTION TO PERPENDICULAR RAFTERS OR TRUSSES**

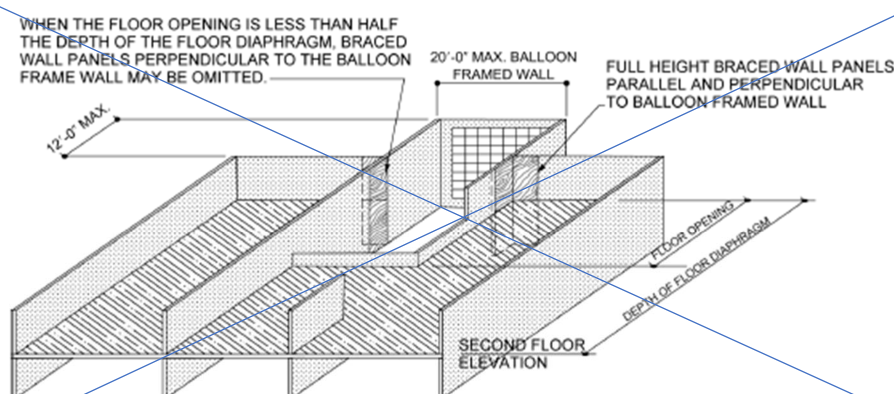



**FIGURE R602.10.4.8**
**BALLOON FRAMED WALL**

**R602.10 Wall bracing.** Buildings shall be braced in accordance with this section or, when applicable, Section R602.12. Where a building, or portion thereof, does not comply with one or more of the bracing requirements in this section, those portions shall be designed and constructed in accordance with Section R301.1.

**R602.10.1 Braced wall lines.** For the purpose of determining the amount and location of bracing required in each story level of a building, *braced wall lines* shall be designated as straight lines in the building plan placed in accordance with this section.

**R602.10.1.1 Length of a braced wall line.** The length of a *braced wall line* shall be the distance between its ends. The end of a *braced wall line* shall be the intersection with a perpendicular *braced wall line*, an angled *braced wall line* as permitted in Section R602.10.1.4 or an exterior wall as shown in Figure R602.10.1.1.

**R602.10.1.2** Location of **braced wall** lines and permitted offsets**.** Each *braced wall line* shall be located such that no more than two-thirds of the required *braced wall panel* length is located to one side of the *braced wall line*. Braced wall panels shall be permitted to be offset up to 4 feet (1219 mm) from the designated *braced wall line*. Braced wall panels parallel to a *braced wall line* shall be offset not more than 4 feet (1219 mm) from the designated *braced wall line* location as shown in Figure R602.10.1.1.

Exterior walls parallel to a *braced wall line* shall be offset not more than 4 feet (1219 mm) from the designated *braced wall line* location as shown in Figure R602.10.1.1.

Interior walls used as bracing shall be offset not more than 4 feet (1219 mm) from a *braced wall line* through the interior of the building as shown in Figure R602.10.1.1.

**R602.10.1.3 Spacing of braced wall lines.** The spacing between parallel *braced wall lines* shall be in accordance with Table R602.10.1.3. Intermediate *braced wall lines* through the interior of the building shall be permitted.

**R602.10.1.4 Angled walls.** Any portion of a wall along a *braced wall line* shall be permitted to angle out of plane for a maximum diagonal length of 8 feet (2438 mm). Where the angled wall occurs at a corner, the length of the *braced wall line* shall be measured from the projected corner as shown in Figure R602.10.1.4. Where the diagonal length is greater than 8 feet (2438 mm), it shall be considered to be a separate *braced wall line* and shall be braced in accordance with Section R602.10.1.

**R602.10.2 Braced wall panels.** *Braced wall panel*s shall be full-height sections of wall that shall not have vertical or horizontal offsets. *Braced wall panel*s shall be constructed and placed along a *braced wall line* in accordance with this section and the bracing methods specified in Section R602.10.4.

**R602.10.2.1 Braced wall panel uplift load path.** The bracing lengths in Table R602.10.3(1) apply only when uplift loads are resisted in accordance with Section R602.3.5.

**R602.10.2.2 Locations of braced wall panels.** A *braced wall panel* shall begin within 10 feet (3810 mm) from each end of a *braced wall line* as determined in Section R602.10.1.1. The distance between adjacent edges of braced wall panels along a *braced wall line* shall be not greater than 20 feet (6096 mm) as shown in Figure R602.10.2.2.

**Exceptions:**

1. Deleted.
2. *Braced wall panels* with continuous sheathing in *Seismic Design Categories* A, B and C shall comply with Section R602.10.7.

**R602.10.2.2.1 Location of braced wall panels in Seismic Design Categories $D_0$, $D_1$ and $D_2$.** Deleted.

**R602.10.2.3 Minimum number of braced wall panels.** *Braced wall lines* with a length of 16 feet (4877 mm) or less shall have not less than two *braced wall panel*s of any length or one *braced wall panel* equal to 48 inches (1219 mm) or more. *Braced wall lines* greater than 16 feet (4877 mm) shall have not less than two *braced wall panel*s.

**R602.10.3 Required length of bracing.** The required length of bracing along each *braced wall line* shall be determined as follows:

1. All buildings in *Seismic Design Categories* A and B shall use Table R602.10.3(1) and the applicable adjustment factors in Table R602.10.3(2).

2. Detached buildings in *Seismic Design Category* C shall use Table R602.10.3(1) and the applicable adjustment factors in Table R602.10.3(2).

3. Townhouses in *Seismic Design Category* C shall use the greater value determined from Table R602.10.3(1) or R602.10.3(3) and the applicable adjustment factors in Table R602.10.3(2) or R602.10.3(4), respectively.

4. Deleted.

Only *braced wall panel*s parallel to the *braced wall line* shall contribute toward the required length of bracing of that *braced wall line*. *Braced wall panel*s along an angled wall meeting the minimum length requirements of Tables R602.10.5 and R602.10.5.2 shall be permitted to contribute its projected length toward the minimum required length of bracing for the *braced wall line* as shown in Figure R602.10.1.4. Any *braced wall panel* on an angled wall at the end of a *braced wall line* shall contribute its projected length for only one of the *braced wall lines* at the projected corner.

**Exception:** Deleted.

**R602.10.4 Construction methods for braced wall panels.** Intermittent and continuously sheathed *braced wall panel*s shall be constructed in accordance with this section and the methods listed in Table R602.10.4.

**R602.10.4.1 Mixing methods.** Mixing of bracing methods shall be permitted as follows:

1. Mixing intermittent bracing and continuous sheathing methods from story to story shall be permitted.
2. Mixing intermittent bracing methods from *braced wall line* to *braced wall line* within a story shall be permitted. In regions within *Seismic Design Categories* A, B and C where the ultimate design wind speed is less than or equal to 130 mph (58m/s), mixing of intermittent bracing and continuous sheathing methods from *braced wall line* to *braced wall line* within a story shall be permitted.
3. Mixing intermittent bracing methods along a *braced wall line* shall be permitted in *Seismic Design Categories* A and B, and detached dwellings in *Seismic Design Category* C, provided that the length of required bracing in accordance with Table R602.10.3(1) or R602.10.3(3) is the highest value of all intermittent bracing methods used.
4. Mixing of continuous sheathing methods CS-WSP, CS-G and CS-PF along a *braced wall line* shall be permitted. Intermittent methods ABW, PFH and PFG shall be permitted to be used along a *braced wall line* with continuous sheathed methods, provided that the length of required bracing for that *braced wall line* is determined in accordance with Table R602.10.3(1) or R602.10.3(3) using the highest value of the bracing methods used.
5. In *Seismic Design Categories* A and B, and for detached one- and two-family dwellings in *Seismic Design Category* C, mixing of intermittent bracing methods along the interior portion of a *braced wall line* with continuous sheathing methods CS-WSP, CS-G and CS-PF along the exterior portion of the same *braced wall line* shall be permitted. The length of required bracing shall be the highest value of all intermittent bracing methods used in accordance with Table R602.10.3(1) or R602.10.3(3) as adjusted by Tables R602.10.3(2) and R602.10.3(4), respectively. The requirements of Section R602.10.7 shall apply to each end of the continuously sheathed portion of the *braced wall line*.

**R602.10.4.2 Continuous sheathing methods.** Continuous sheathing methods require structural panel sheathing to be used on all sheathable surfaces on one side of a *braced wall line* including areas above and below openings and gable end walls and shall meet the requirements of Section R602.10.7.

**R602.10.4.3 Braced wall panel interior finish material.** *Braced wall panel*s shall have gypsum wall board installed on the side of the wall opposite the bracing material. Gypsum wall board shall be not less than $^1/_2$ inch (12.7 mm) in thickness and be fastened with nails or screws in accordance with Table R602.3(1) for exterior sheathing or Table R702.3.5 for interior gypsum wall board. Spacing of fasteners at panel edges for gypsum wall board opposite Method LIB bracing shall not exceed 8 inches (203 mm).

**Exceptions:**

1. Interior finish material is not required opposite wall panels that are braced in accordance with Methods GB, BV-WSP, ABW, PFH, PFG and CS-PF, unless otherwise required by Section R302.6.
2. An *approved* interior finish material with an in-plane shear resistance equivalent to gypsum board shall be permitted to be substituted, unless otherwise required by Section R302.6.
3. Except for Method LIB, gypsum wall board is permitted to be omitted provided that the required length of bracing in Tables R602.10.3(1) and R602.10.3(3) is multiplied by the appropriate

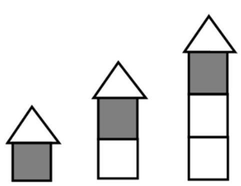
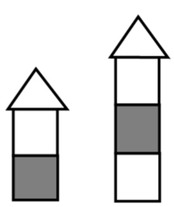
adjustment factor in Tables R602.10.3(2) and R602.10.3(4), respectively, unless otherwise required by Section R302.6.

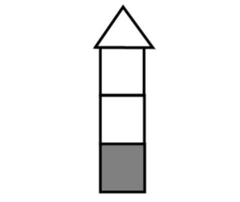
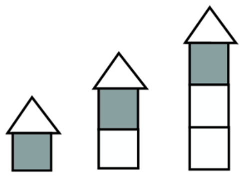
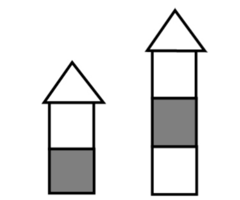
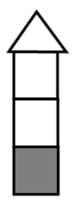
**TABLE R602.10.1.3**
**BRACED WALL LINE SPACING**

| APPLICATION | CONDITION | BUILDING TYPE | BRACED WALL LINE SPACING CRITERIA | |
|---|---|---|---|---|
| | | | Maximum Spacing | Exception to Maximum Spacing |
| Wind bracing | Ultimate design wind speed < 140 mph | Detached, townhouse | 60 feet | None |
| Seismic bracing | SDC A – C | Detached | Use wind bracing | |
| | SDC A – B | Townhouse | Use wind bracing | |
| | SDC C | Townhouse | 35 feet | Up to 50 feet when length of required bracing per Table R602.10.3(3) is adjusted in accordance with Table R602.10.3(4). |

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 $m^2$, 1 mile per hour = 0.447 m/s.

**TABLE R602.10.3(1)**
**BRACING REQUIREMENTS BASED ON WIND SPEED**

| • EXPOSURE CATEGORY B<br>• 30-FOOT MEAN ROOF HEIGHT<br>• 10-FOOT WALL HEIGHT<br>• 2 BRACED WALL LINES | | | MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE[a] | | | |
|---|---|---|---|---|---|---|
| Ultimate Design Wind Speed (mph) | Story Location | Braced Wall Line Spacing[c] (feet) | Method LIB[b] | Method GB | Methods DWB, WSP, SFB, PBS, PCP, HPS, BV-WSP, ABW, PFH, PFC, CS-SFB | Methods CS-WSP, CS-G, CS-PF |
| ≤ 115 |  | 10 | 3.5 | 3.5 | 2.0 | 2.0 |
| | | 20 | 6.5 | 6.5 | 3.5 | 3.5 |
| | | 30 | 9.5 | 9.5 | 5.5 | 4.5 |
| | | 40 | 12.5 | 12.5 | 7.0 | 6.0 |
| | | 50 | 15.0 | 15.0 | 9.0 | 7.5 |
| | | 60 | 18.0 | 18.0 | 10.5 | 9.0 |
| |  | 10 | 7.0 | 7.0 | 4.0 | 3.5 |
| | | 20 | 12.5 | 12.5 | 7.5 | 6.5 |
| | | 30 | 18.0 | 18.0 | 10.5 | 9.0 |
| | | 40 | 23.5 | 23.5 | 13.5 | 11.5 |
| | | 50 | 29.0 | 29.0 | 16.5 | 14.0 |
| | | 60 | 34.5 | 34.5 | 20.0 | 17.0 |
| | | 10 | NP | 10.0 | 6.0 | 5.0 |

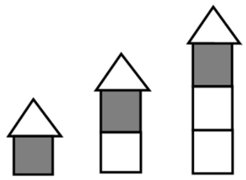
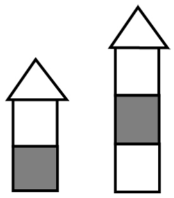
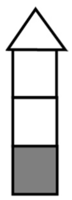
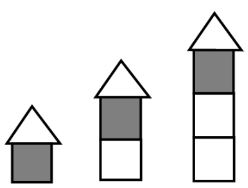
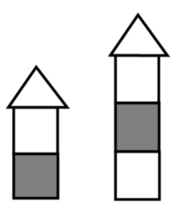
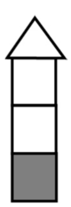
| | | | | | | |
|---|---|---|---|---|---|---|
| |  | 20 | NP | 18.5 | 11.0 | 9.0 |
| | | 30 | NP | 27.0 | 15.5 | 13.0 |
| | | 40 | NP | 35.0 | 20.0 | 17.0 |
| | | 50 | NP | 43.0 | 24.5 | 21.0 |
| | | 60 | NP | 51.0 | 29.0 | 25.0 |
| ≤ 120 |  | 10 | 4.0 | 4.0 | 2.5 | 2.0 |
| | | 20 | 7.0 | 7.0 | 4.0 | 3.5 |
| | | 30 | 10.5 | 10.5 | 6.0 | 5.0 |
| | | 40 | 13.5 | 13.5 | 8.0 | 6.5 |
| | | 50 | 16.5 | 16.5 | 9.5 | 8.0 |
| | | 60 | 19.5 | 19.5 | 11.5 | 9.5 |
| |  | 10 | 7.5 | 7.5 | 4.5 | 3.5 |
| | | 20 | 14.0 | 14.0 | 8.0 | 7.0 |
| | | 30 | 20.0 | 20.0 | 11.5 | 9.5 |
| | | 40 | 25.5 | 25.5 | 15.0 | 12.5 |
| | | 50 | 31.5 | 31.5 | 18.0 | 15.5 |
| | | 60 | 37.5 | 37.5 | 21.5 | 18.5 |
| |  | 10 | NP | 11.0 | 6.5 | 5.5 |
| | | 20 | NP | 20.5 | 11.5 | 10.0 |
| | | 30 | NP | 29.0 | 17.0 | 14.5 |
| | | 40 | NP | 38.0 | 22.0 | 18.5 |
| | | 50 | NP | 47.0 | 27.0 | 23.0 |
| | | 60 | NP | 55.5 | 32.0 | 27.0 |

*(continued)*

**TABLE R602.10.3(1)—continued**

**BRACING REQUIREMENTS BASED ON WIND SPEED**

| • EXPOSURE CATEGORY B<br>• 30-FOOT MEAN ROOF HEIGHT<br>• 10-FOOT WALL HEIGHT<br>• 2 BRACED WALL LINES | | | MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE[a] | | | |
|---|---|---|---|---|---|---|
| **Ultimate Design Wind Speed (mph)** | **Story Location** | **Braced Wall Line Spacing[c] (feet)** | **Method LIB[b]** | **Method GB** | **Methods DWB, WSP, SFB, PBS, PCP, HPS, BV-WSP, ABW, PFH, PFC, CS-SFB** | **Methods CS-WSP, CS-G, CS-PF** |
| ≤ 130 | | 10 | 4.5 | 4.5 | 2.5 | 2.5 |
| | | 20 | 8.5 | 8.5 | 5.0 | 4.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| |  | 30 | 12.0 | 12.0 | 7.0 | 6.0 |
| | | 40 | 15.5 | 15.5 | 9.0 | 7.5 |
| | | 50 | 19.5 | 19.5 | 11.0 | 9.5 |
| | | 60 | 23.0 | 23.0 | 13.0 | 11.0 |
| |  | 10 | 8.5 | 8.5 | 5.0 | 4.5 |
| | | 20 | 16.0 | 16.0 | 9.5 | 8.0 |
| | | 30 | 23.0 | 23.0 | 13.5 | 11.5 |
| | | 40 | 30.0 | 30.0 | 17.5 | 15.0 |
| | | 50 | 37.0 | 37.0 | 21.5 | 18.0 |
| | | 60 | 44.0 | 44.0 | 25.0 | 21.5 |
| |  | 10 | NP | 13.0 | 7.5 | 6.5 |
| | | 20 | NP | 24.0 | 13.5 | 11.5 |
| | | 30 | NP | 34.5 | 19.5 | 17.0 |
| | | 40 | NP | 44.5 | 25.5 | 22.0 |
| | | 50 | NP | 55.0 | 31.5 | 26.5 |
| | | 60 | NP | 65.0 | 37.5 | 31.5 |
| < 140 |  | 10 | 5.5 | 5.5 | 3.0 | 2.5 |
| | | 20 | 10.0 | 10.0 | 5.5 | 5.0 |
| | | 30 | 14.0 | 14.0 | 8.0 | 7.0 |
| | | 40 | 18.0 | 18.0 | 10.5 | 9.0 |
| | | 50 | 22.5 | 22.5 | 13.0 | 11.0 |
| | | 60 | 26.5 | 26.5 | 15.0 | 13.0 |
| |  | 10 | 10.0 | 10.0 | 6.0 | 5.0 |
| | | 20 | 18.5 | 18.5 | 11.0 | 9.0 |
| | | 30 | 27.0 | 27.0 | 15.5 | 13.0 |
| | | 40 | 35.0 | 35.0 | 20.0 | 17.0 |
| | | 50 | 43.0 | 43.0 | 24.5 | 21.0 |
| | | 60 | 51.0 | 51.0 | 29.0 | 25.0 |
| |  | 10 | NP | 15.0 | 8.5 | 7.5 |
| | | 20 | NP | 27.5 | 16.0 | 13.5 |
| | | 30 | NP | 39.5 | 23.0 | 19.5 |
| | | 40 | NP | 51.5 | 29.5 | 25.0 |
| | | 50 | NP | 63.5 | 36.5 | 31.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | 60 | NP | 75.5 | 43.0 | 36.5 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.
NP = Not Permitted.
a. Linear interpolation shall be permitted.
b. Method LIB shall have gypsum board fastened to not less than one side with nails or screws in accordance with Table R602.3(1) for exterior sheathing or Table R702.3.5 for interior gypsum board. Spacing of fasteners at panel edges shall not exceed 8 inches.
c. Where three or more parallel braced wall lines are present and the distances between adjacent braced wall lines are different, the average dimension shall be permitted to be used for braced wall line spacing.

**TABLE R602.10.3(2)**
**WIND ADJUSTMENT FACTORS TO THE REQUIRED LENGTH OF WALL BRACING**

| ITEM NUMBER | ADJUSTMENT BASED ON | STORY/SUPPORTING | CONDITION | ADJUSTMENT FACTOR[a, b] [multiply length from Table R602.10.3(1) by this factor] | APPLICABLE METHODS |
|---|---|---|---|---|---|
| 1 | Exposure category[d] | One-story structure | B | 1.00 | All methods |
| | | | C | 1.20 | |
| | | | D | 1.50 | |
| | | Two-story structure | B | 1.00 | |
| | | | C | 1.30 | |
| | | | D | 1.60 | |
| | | Three-story structure | B | 1.00 | |
| | | | C | 1.40 | |
| | | | D | 1.70 | |
| 2 | Roof eave-to-ridge height | Roof only | ≤ 5 feet | 0.70 | |
| | | | 10 feet | 1.00 | |
| | | | 15 feet | 1.30 | |
| | | | 20 feet | 1.60 | |
| | | Roof + 1 floor | ≤ 5 feet | 0.85 | |
| | | | 10 feet | 1.00 | |
| | | | 15 feet | 1.15 | |
| | | | 20 feet | 1.30 | |
| | | Roof + 2 floors | ≤ 5 feet | 0.90 | |
| | | | 10 feet | 1.00 | |
| | | | 15 feet | 1.10 | |
| | | | 20 feet | Not permitted | |
| 3 | Story height (Section R301.3) | Any story | 8 feet | 0.90 | |
| | | | 9 feet | 0.95 | |
| | | | 10 feet | 1.00 | |
| | | | 11 feet | 1.05 | |
| | | | 12 feet | 1.10 | |

| | | | | | |
|---|---|---|---|---|---|
| 4 | Number of braced wall lines (per plan direction)[c] | Any story | 2 | 1.00 | |
| | | | 3 | 1.30 | |
| | | | 4 | 1.45 | |
| | | | ≥ 5 | 1.60 | |
| 5 | Additional 800-pound hold-down device | Top story only | Fastened to the end studs of each braced wall panel and to the foundation or framing below | 0.80 | DWB, WSP, SFB, PBS, PCP, HPS |
| 6 | Interior gypsum board finish (or equivalent) | Any story | Omitted from inside face of braced wall panels | 1.40 | DWB, WSP, SFB, PBS, PCP, HPS, CS-WSP, CS-G, CS-SFB |
| 7 | Gypsum board fastening | Any story | 4 inches o.c. at panel edges, including top and bottom plates, and all horizontal joints blocked | 0.7 | GB |
| 8 | Horizontal blocking | Any story | Horizontal block is omitted | 2.0 | WSP, PBS, CS-WSP |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 4.48 N.

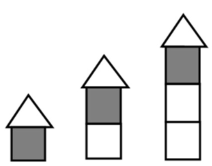
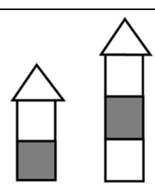
a. Linear interpolation shall be permitted.

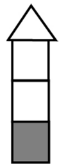
b. The total adjustment factor is the product of all applicable adjustment factors.

c. The adjustment factor is permitted to be 1.0 when determining bracing amounts for intermediate braced wall lines provided the bracing amounts on adjacent braced wall lines are based on a spacing and number that neglects the intermediate braced wall line.

d. The same adjustment factor shall be applied to all braced wall lines on all floors of the structure, based on the worst-case exposure category.

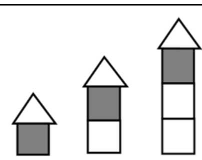
**TABLE R602.10.3(3)**
**BRACING REQUIREMENTS BASED ON SEISMIC DESIGN CATEGORY**

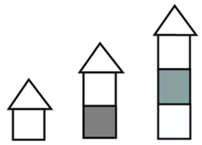
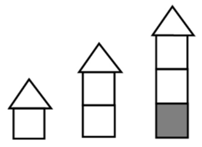
| • WALL HEIGHT = 10 FEET<br>• 10 PSF FLOOR DEAD LOAD<br>• 15 PSF ROOF/CEILING DEAD LOAD<br>• BRACED WALL LINE SPACING ≤ 25 FEET | | | MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE[a, g] | | | | |
|---|---|---|---|---|---|---|---|
| **Seismic Design Category[b]** | **Story Location** | **Braced Wall Line Length (feet)[c]** | **Method LIB[d]** | **Method GB** | **Methods DWB, SFB, PBS, PCP, HPS, CS-SFB[e]** | Methods WSP, ABW[f], PFH[f] and PFG[e, f] | **Methods CS-WSP, CS-G, CS-PF** |
| C (townhouses only) |  | 10 | 2.5 | 2.5 | 2.5 | 1.6 | 1.4 |
| | | 20 | 5.0 | 5.0 | 5.0 | 3.2 | 2.7 |
| | | 30 | 7.5 | 7.5 | 7.5 | 4.8 | 4.1 |
| | | 40 | 10.0 | 10.0 | 10.0 | 6.4 | 5.4 |
| | | 50 | 12.5 | 12.5 | 12.5 | 8.0 | 6.8 |
| |  | 10 | NP | 4.5 | 4.5 | 3.0 | 2.6 |
| | | 20 | NP | 9.0 | 9.0 | 6.0 | 5.1 |
| | | 30 | NP | 13.5 | 13.5 | 9.0 | 7.7 |
| | | 40 | NP | 18.0 | 18.0 | 12.0 | 10.2 |
| | | 50 | NP | 22.5 | 22.5 | 15.0 | 12.8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| |  | 10 | NP | 6.0 | 6.0 | 4.5 | 3.8 |
| | | 20 | NP | 12.0 | 12.0 | 9.0 | 7.7 |
| | | 30 | NP | 18.0 | 18.0 | 13.5 | 11.5 |
| | | 40 | NP | 24.0 | 24.0 | 18.0 | 15.3 |
| | | 50 | NP | 30.0 | 30.0 | 22.5 | 19.1 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
NP = Not Permitted.
a. Linear interpolation shall be permitted.
b. Interpolation of bracing length between the $S_{ds}$ values associated with the seismic design categories shall be permitted when a site-specific $S_{ds}$ value is determined in accordance with Section 1613.2 of the *International Building Code*.
c. Where the braced wall line length is greater than 50 feet, braced wall lines shall be permitted to be divided into shorter segments having lengths of 50 feet or less, and the amount of bracing within each segment shall be in accordance with this table.
d. Method LIB shall have gypsum board fastened to not less than one side with nails or screws in accordance with Table R602.3(1) for exterior sheathing or Table R702.3.5 for interior gypsum board. Spacing of fasteners at panel edges shall not exceed 8 inches.
e. Deleted.
f. Methods PFH, PFG and ABW are only permitted on a single story or a first of two stories.
g. Where more than one bracing method is used, mixing methods shall be in accordance with Section R602.10.4.1.
h. Deleted.

**TABLE R602.10.3(4)**
**SEISMIC ADJUSTMENT FACTORS TO THE REQUIRED LENGTH OF WALL BRACING**

| ITEM NUMBER | ADJUSTMENT BASED ON | STORY[g] | CONDITION | ADJUSTMENT FACTOR[a, b] [Multiply length from Table R602.10.3(3) by this factor] | APPLICABLE METHODS |
|---|---|---|---|---|---|
| 1 | Story height (Section 301.3) | Any story | ≤ 10 feet | 1.0 | All methods |
| | | | > 10 feet and ≤ 12 feet | 1.2 | |
| 2 | Braced wall line spacing, townhouses in SDC C | Any story | ≤ 35 feet | 1.0 | |
| | | | > 35 feet and ≤ 50 feet | 1.43 | |
| ~~3~~ | ~~Braced wall line spacing, in SDC $D_0$, $D_1$, $D_2$~~[e] | ~~Any story~~ | ~~> 25 feet and ≤ 30 feet~~ | ~~1.2~~ | |
| | | | ~~> 30 feet and ≤ 35 feet~~ | ~~1.4~~ | |
| 4 | Wall dead load | Any story | > 8 psf and < 15 psf | 1.0 | |
| | | | < 8psf | 0.85 | |
| 5 | Roof/ceiling dead load for wall supporting | 1-, 2- or 3-story building | ≤15 psf | 1.0 | |
| | | 2- or 3-story building | > 15 psf and ≤ 25 psf | 1.1 | |
| | | 1-story building or top story | > 15 psf and ≤ 25 psf | 1.2 | |
| 6 | Walls with stone or masonry veneer, townhouses in SDC C[d, e] |  | 1.0 | | All methods |

| | | | | | |
|---|---|---|---|---|---|
| | |  | 1.5 | | |
| | |  | 1.5 | | |
| ~~7~~ | ~~Walls with stone or masonry veneer, detached one- and two-family dwellings in SDC $D_0$ – $D_2$~~[d, f] | ~~Any story~~ | ~~See Section R602.10.6.5.4~~ | | ~~BV-WSP~~ |
| ~~8~~ | ~~Walls with stone or masonry veneer, detached one- and two-family dwellings in SDC $D_0$ – $D_2$~~[d, f] | ~~First and second story of two-story dwelling~~ | ~~Limited brick veneer on second story. See Section R602.10.6.5.3.~~ | ~~1.2~~ | ~~WSP, CS-WSP~~ |
| 9 | Interior gypsum board finish (or equivalent) | Any story | Omitted from inside face of braced wall panels | 1.5 | DWB, WSP, SFB, PBS, PCP, HPS, CS-WSP, CS-G, CS-SFB |
| 10 | Horizontal blocking | Any story | Horizontal blocking omitted | 2.0 | WSP, PBS, CS-WSP |

For SI: 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
a. Linear interpolation shall be permitted.
b. The total length of bracing required for a given wall line is the product of all applicable adjustment factors.
c. The length-to-width ratio for the floor/roof diaphragm shall not exceed 3:1.
d. Applies to stone or masonry veneer exceeding the first story height.
e. The adjustment factor for stone or masonry veneer shall be applied to all exterior braced wall lines and all braced wall lines on the interior of the building, backing or perpendicular to and laterally supporting veneered walls.
f. See Section R602.10.6.5 for requirements where stone or masonry veneer does not exceed the first-story height.
g. Deleted.

**R602.10.4.4 Panel joints.** Vertical joints of panel sheathing shall occur over and be fastened to common studs. Horizontal joints of panel sheathing in *braced wall panels* shall occur over and be fastened to common blocking of a thickness of $1^1/_2$ inches (38 mm) or greater.

**Exceptions:**

1. For methods WSP and CS-WSP, blocking of horizontal joints is permitted to be omitted when adjustment factor No. 8 of Table R602.10.3(2) or No. 9 of Table R602.10.3(4) is applied.
2. Vertical joints of panel sheathing shall be permitted to occur over double studs, where adjoining panel edges are attached to separate studs with the required panel edge fastening schedule, and the adjacent studs are attached together with two rows of 10d box nails [3 inches by 0.128 inch (76.2 mm by 3.25 mm)] at 10 inches o.c. (254 mm).
3. Blocking at horizontal joints shall not be required in wall segments that are not counted as *braced wall panels.*
4. Where Method GB panels are installed horizontally, blocking of horizontal joints is not required.

**R602.10.5 Minimum length of a braced wall panel.** The minimum length of a *braced wall panel* shall comply with Table R602.10.5. For Methods CS-WSP and CS-SFB, the minimum panel length shall be based on the adjacent clear opening height in accordance with Table R602.10.5 and Figure R602.10.5. Where a panel has an opening on either side of differing heights, the taller opening height shall be used to determine the panel length.

**R602.10.5.1 Contributing length.** For purposes of computing the required length of bracing in Tables R602.10.3(1) and R602.10.3(3), the contributing length of each *braced wall panel* shall be as specified in Table R602.10.5.

**R602.10.5.2 Partial credit.** For Methods DWB, WSP, SFB, PBS, PCP and HPS in *Seismic Design Categories* A, B and C, panels between 36 inches and 48 inches (914 mm and 1219 mm) in length shall be considered a *braced wall panel* and shall be permitted to partially contribute toward the required length of bracing in Tables R602.10.3(1) and R602.10.3(3), and the contributing length shall be determined from Table R602.10.5.2.

**R602.10.6 Construction of Methods ABW, PFH, PFG, CS-PF and BV-WSP.** Methods ABW, PFH, PFG, CS-PF and BV-WSP shall be constructed as specified in Sections R602.10.6.1 through R602.10.6.5.

**R602.10.6.1 Method ABW: Alternate braced wall panels.** Method ABW *braced wall panel*s shall be constructed in accordance with Figure R602.10.6.1. The hold-down force shall be in accordance with Table R602.10.6.1.

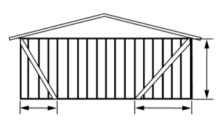
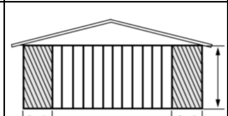
**R602.10.6.2 Method PFH: Portal frame with hold-downs.** Method PFH *braced wall panels* shall be constructed in accordance with Figure R602.10.6.2.

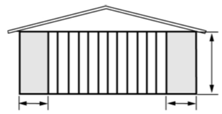
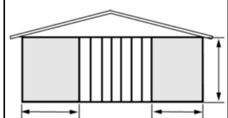
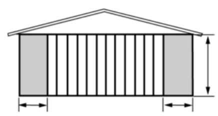
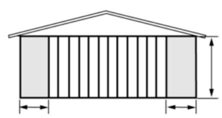
**R602.10.6.3 Method PFG: Portal frame at garage door openings in Seismic Design Categories A, B and C.** Where supporting a roof or one story and a roof, a Method PFG *braced wall panel* constructed in accordance with Figure R602.10.6.3 shall be permitted on either side of garage door openings.

**R602.10.6.4 Method CS-PF: Continuously sheathed portal frame.** Continuously sheathed portal frame *braced wall panel*s shall be constructed in accordance with Figure R602.10.6.4 and Table R602.10.6.4.

**R602.10.6.5 Wall bracing for dwellings with stone and masonry veneer in Seismic Design Categories $D_0$, $D_1$ and $D_2$.** Deleted.

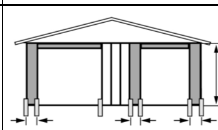
**TABLE R602.10.4**
**BRACING METHODS**

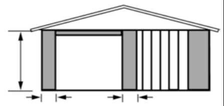
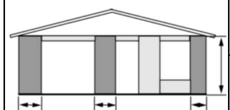
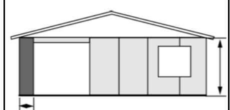
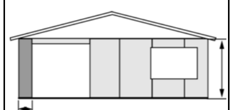
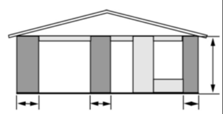
| METHODS, MATERIAL | | MINIMUM THICKNESS | FIGURE | CONNECTION CRITERIA[a] | |
|---|---|---|---|---|---|
| | | | | Fasteners | Spacing |
| Intermittent Bracing Methods | **LIB** Let-in-bracing | 1 × 4 wood or approved metal straps at 45° to 60° angles for maximum 16″ stud spacing |  | Wood: 2-8d common nails or 3-8d (2 1/2″ long × 0.113″ dia.) nails | Wood: per stud and top and bottom plates |
| | | | | Metal strap: per manufacturer | Metal: per manufacturer |
| | **DWB** Diagonal wood boards | 3/4″ (1″ nominal) for maximum 24″ stud spacing |  | 2-8d (2 1/2″ long × 0.113″ dia.) nails or 2-1 3/4″ long staples | Per stud |
| | **WSP** Wood structural panel (See Section R604) | 3/8″ |  | Exterior sheathing per Table R602.3(3) | 6″ edges 12″ field |
| | | | | Interior sheathing per Table R602.3(1) or R602.3(2) | Varies by fastener |

| | | | | | |
|---|---|---|---|---|---|
| | **BV-WSP**[e] Wood structural panels with stone or masonry veneer (See Section R602.10.6.5) | $^{7}/_{16}$″ | See Figure R602.10.6.5.2 | 8d common ($2^{1}/_{2}$″ × 0.131) nails | 4″ at panel edges 12″ at intermediate supports 4″ at braced wall panel end posts |
| | **SFB** Structural fiberboard sheathing | $^{1}/_{2}$″ or $^{25}/_{32}$″ for maximum 16″ stud spacing |  | $1^{1}/_{2}$″ long × 0.12″ dia. (for $^{1}/_{2}$″ thick sheathing) $1^{3}/_{4}$″ long × 0.12″ dia. (for $^{25}/_{32}$″ thick sheathing) galvanized roofing nails | 3″ edges 6″ field |
| | **GB** Gypsum board | $^{1}/_{2}$″ |  | Nails or screws per Table R602.3(1) for exterior locations<br>Nails or screws per Table R702.3.5 for interior locations | For all braced wall panel locations: 7″edges (including top and bottom plates) 7″ field |
| | **PBS** Particleboard sheathing (See Section R605) | $^{3}/_{8}$″ or $^{1}/_{2}$″ for maximum 16″stud spacing |  | For $^{3}/_{8}$″, 6d common (2″ long × 0.113″ dia.) nails; For $^{1}/_{2}$″, 8d common ($2^{1}/_{2}$″ long × 0.131″ dia.) nails | 3″ edges 6″ field |
| | **PCP** Portland cement plaster | See Section R703.6 for maximum 16″ stud spacing |  | $1^{1}/_{2}$″ long, 11 gage, 0.120" dia., $^{7}/_{16}$″ dia. head nails or $^{7}/_{8}$″ long, 16 gage staples | 6″ o.c. on all framing members |
| | **HPS** Hardboard panel siding | $^{7}/_{16}$″ for maximum 16″ stud spacing |  | 0.092″ dia., 0.225″ dia. head nails with length to accommodate $1^{1}/_{2}$″ penetration into studs | 4″ edges 8″ field |
| | **ABW** Alternate braced wall | $^{3}/_{8}$″ |  | See Section R602.10.6.1 | See Section R602.10.6.1 |

*(continued)*

**TABLE R602.10.4—continued**
**BRACING METHODS**

| METHODS, MATERIAL | | MINIMUM THICKNESS | FIGURE | CONNECTION CRITERIA[a] | |
|---|---|---|---|---|---|
| | | | | Fasteners | Spacing |
| Intermittent Bracing | **PFH** Portal frame with hold-downs | $^{3}/_{8}$″ |  | See Section R602.10.6.2 | See Section R602.10.6.2 |

| | | | | | |
|---|---|---|---|---|---|
| | **PFG**<br>Portal frame at garage | ${}^{7}/_{16}$″ |  | See Section R602.10.6.3 | See Section R602.10.6.3 |
| Continuous Sheathing Methods | **CS-WSP**<br>Continuously sheathed wood structural panel | ${}^{3}/_{8}$″ |  | Exterior sheathing per Table R602.3(3) | 6″ edges 12″ field |
| | | | | Interior sheathing per Table R602.3(1) or R602.3(2) | Varies by fastener |
| | **CS-G**[b, c]<br>Continuously sheathed wood structural panel adjacent to garage openings | ${}^{3}/_{8}$″ |  | See Method CS-WSP | See Method CS-WSP |
| | **CS-PF**<br>Continuously sheathed portal frame | ${}^{7}/_{16}$″ |  | See Section R602.10.6.4 | See Section R602.10.6.4 |
| | **CS-SFB**[d]<br>Continuously sheathed structural fiberboard | ${}^{1}/_{2}$″ or ${}^{25}/_{32}$″ for maximum 16″ stud spacing |  | $1^{1}/_{2}$″ long × 0.12″ dia. (for ${}^{1}/_{2}$″ thick sheathing) $1^{3}/_{4}$″ long × 0.12″ dia. (for ${}^{25}/_{32}$″ thick sheathing) galvanized roofing nails | 3″ edges 6″ field |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad, 1 pound per square foot = 47.8 N/m$^2$, 1 mile per hour = 0.447 m/s.

a. Adhesive attachment of wall sheathing, including Method GB, shall not be permitted in Seismic Design Categories C, $D_0$, $D_1$ and $D_2$.

b. Applies to panels next to garage door opening where supporting gable end wall or roof load only. Shall only be used on one wall of the garage.

c. Garage openings adjacent to a Method CS-G panel shall be provided with a header in accordance with Table R602.7(1). A full-height clear opening shall not be permitted adjacent to a Method CS-G panel.

d. Deleted.

e. Deleted.

**TABLE R602.10.5**
**MINIMUM LENGTH OF BRACED WALL PANELS**

| METHOD (See Table R602.10.4) | | MINIMUM LENGTH[a] (inches) | | | | | CONTRIBUTING LENGTH (inches) |
|---|---|---|---|---|---|---|---|
| | | Wall Height | | | | | |
| | | 8 feet | 9 feet | 10 feet | 11 feet | 12 feet | |
| DWB, WSP, SFB, PBS, PCP, HPS, BV-WSP | | 48 | 48 | 48 | 53 | 58 | Actual[b] |
| GB | | 48 | 48 | 48 | 53 | 58 | Double sided = Actual<br>Single sided = 0.5 × Actual |
| LIB | | 55 | 62 | 69 | NP | NP | Actual[b] |
| ABW | SDC A, B and C, ultimate design wind speed < 140 mph | 28 | 32 | 34 | 38 | 42 | 48 |
| | ~~SDC $D_0$, $D_1$ and $D_2$, ultimate design wind speed < 140 mph~~ | ~~32~~ | ~~32~~ | ~~34~~ | ~~NP~~ | ~~NP~~ | |
| CS-G | | 24 | 27 | 30 | 33 | 36 | Actual[b] |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Adjacent clear opening height (inches) | | | | | | |
| CS-WSP, CS-SFB | ≤ 64 | 24 | 27 | 30 | 33 | 36 | Actual[b] |
| | 68 | 26 | 27 | 30 | 33 | 36 | |
| | 72 | 27 | 27 | 30 | 33 | 36 | |
| | 76 | 30 | 29 | 30 | 33 | 36 | |
| | 80 | 32 | 30 | 30 | 33 | 36 | |
| | 84 | 35 | 32 | 32 | 33 | 36 | |
| | 88 | 38 | 35 | 33 | 33 | 36 | |
| | 92 | 43 | 37 | 35 | 35 | 36 | |
| | 96 | 48 | 41 | 38 | 36 | 36 | |
| | 100 | — | 44 | 40 | 38 | 38 | |
| | 104 | — | 49 | 43 | 40 | 39 | |
| | 108 | — | 54 | 46 | 43 | 41 | |
| | 112 | — | — | 50 | 45 | 43 | |
| | 116 | — | — | 55 | 48 | 45 | |
| | 120 | — | — | 60 | 52 | 48 | |
| | 124 | — | — | — | 56 | 51 | |
| | 128 | — | — | — | 61 | 54 | |
| | 132 | — | — | — | 66 | 58 | |
| | 136 | — | — | — | — | 62 | |
| | 140 | — | — | — | — | 66 | |
| | 144 | — | — | — | — | 72 | |
| **METHOD (See Table R602.10.4)** | | **Portal header height** | | | | | |
| | | **8 feet** | **9 feet** | **10 feet** | **11 feet** | **12 feet** | |
| PFH | Supporting roof only | 16 | 16 | 16 | Note c | Note c | 48 |
| | Supporting one story and roof | 24 | 24 | 24 | Note c | Note c | |
| PFG | | 24 | 27 | 30 | Note d | Note d | 1.5 × Actual[b] |
| CS-PF | SDC A, B and C | 16 | 18 | 20 | Note e | Note e | 1.5 × Actual[b] |
| | ~~SDC $D_0$, $D_1$ and $D_2$~~ | ~~16~~ | ~~18~~ | ~~20~~ | ~~Note e~~ | ~~Note e~~ | ~~Actual[b]~~ |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

NP = Not Permitted.

a. Linear interpolation shall be permitted.

b. Use the actual length where it is greater than or equal to the minimum length.

c. Maximum header height for PFH is 10 feet in accordance with Figure R602.10.6.2, but wall height shall be permitted to be increased to 12 feet with pony wall.

d. Maximum header height for PFG is 10 feet in accordance with Figure R602.10.6.3, but wall height shall be permitted to be increased to 12 feet with pony wall.

e. Maximum header height for CS-PF is 10 feet in accordance with Figure R602.10.6.4, but wall height shall be permitted to be increased to 12 feet with pony wall.

**TABLE R602.10.5.2**

**PARTIAL CREDIT FOR BRACED WALL PANELS LESS THAN 48 INCHES IN ACTUAL LENGTH**

| ACTUAL LENGTH OF BRACED WALL PANEL (inches) | CONTRIBUTING LENGTH OF BRACED WALL PANEL (inches)[a] | |
|---|---|---|
| | 8-foot Wall Height | 9-foot Wall Height |
| 48 | 48 | 48 |
| 42 | 36 | 36 |
| 36 | 27 | NA |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

NA = Not Applicable.

a. Linear interpolation shall be permitted.

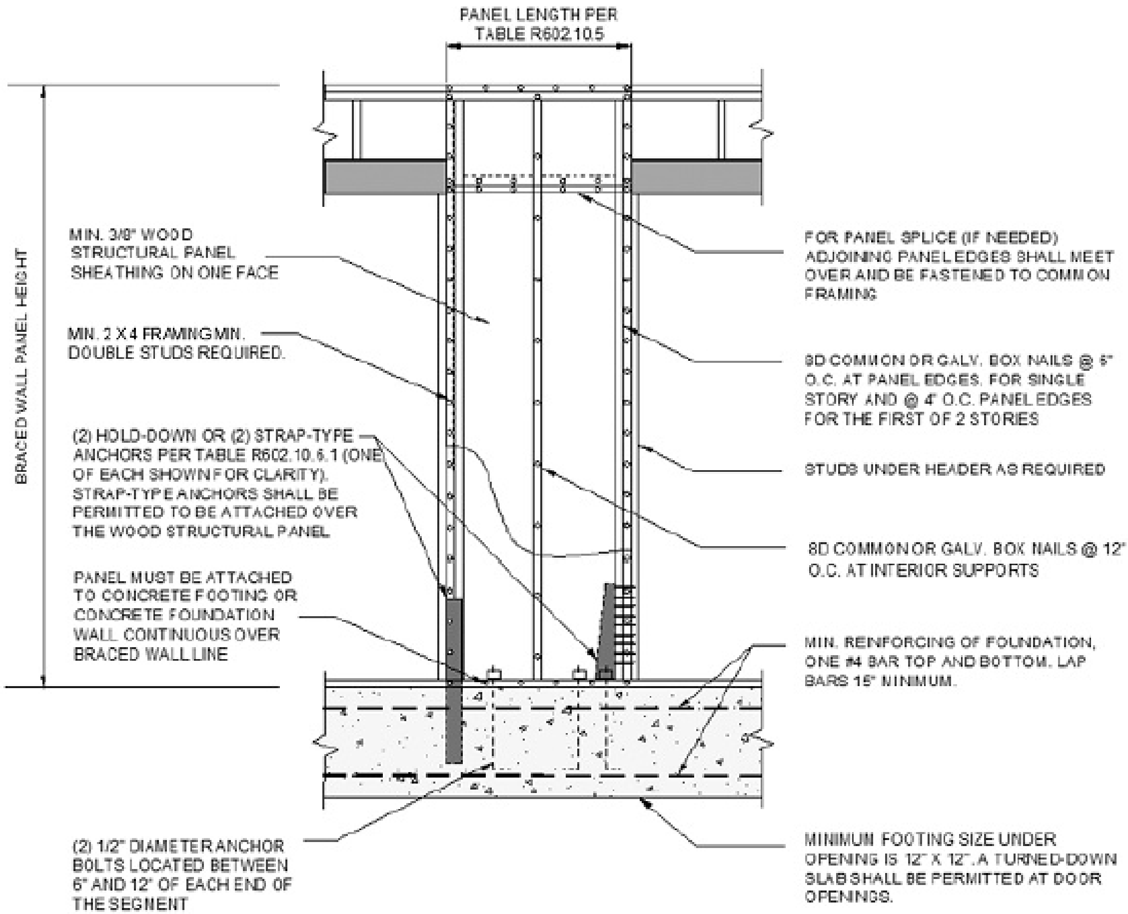
**TABLE R602.10.6.1**

**MINIMUM HOLD-DOWN FORCES FOR METHOD ABW BRACED WALL PANELS**

| SEISMIC DESIGN CATEGORY AND WIND SPEED | SUPPORTING/STORY | HOLD-DOWN FORCE (pounds) | | | | |
|---|---|---|---|---|---|---|
| | | Height of Braced Wall Panel | | | | |
| | | 8 feet | 9 feet | 10 feet | 11 feet | 12 feet |
| SDC A, B and C<br>Ultimate design wind speed < 140 mph | One story | 1,800 | 1,800 | 1,800 | 2,000 | 2,200 |
| | First of two stories | 3,000 | 3,000 | 3,000 | 3,300 | 3,600 |

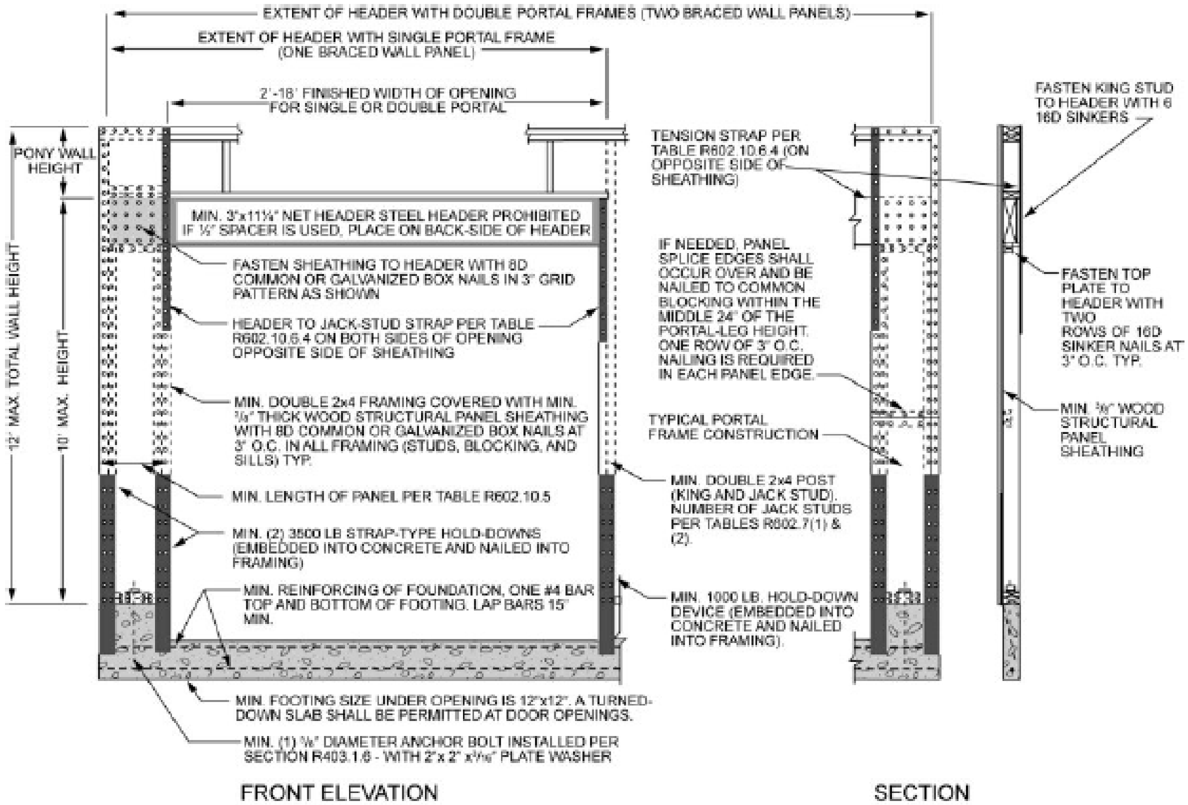
For SI: 1 foot = 304.8 mm, 1 pound = 4.45 N, 1 mile per hour = 0.447 m/s.

NP = Not Permitted.



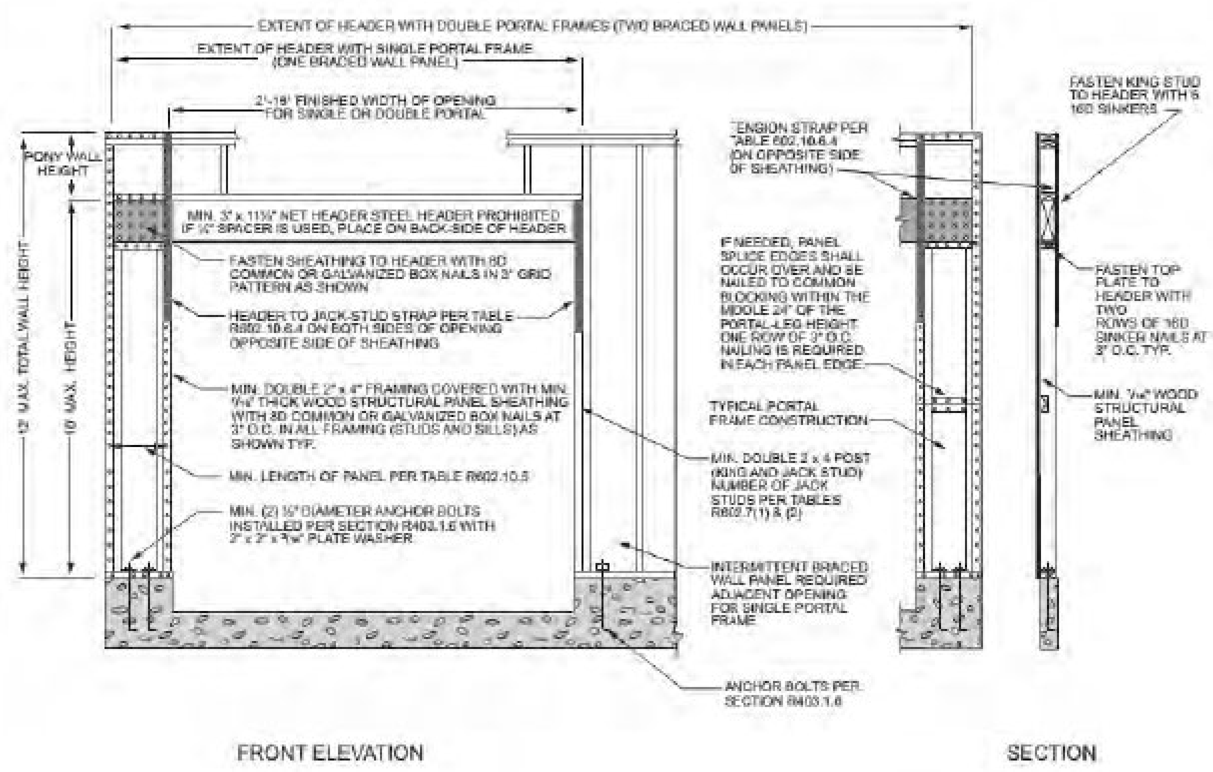

For SI: 1 inch = 25.4 mm.

**FIGURE R602.10.6.1**
**METHOD ABW—ALTERNATE BRACED WALL PANEL**




For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

**FIGURE R602.10.6.2**
**METHOD PFH—PORTAL FRAME WITH HOLD-DOWNS**




For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

**FIGURE R602.10.6.3**
**METHOD PFG—PORTAL FRAME AT GARAGE DOOR OPENINGS IN SEISMIC DESIGN CATEGORIES A, B AND C**

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**TABLE R602.10.6.4**

**TENSION STRAP CAPACITY FOR RESISTING WIND PRESSURES PERPENDICULAR TO METHODS PFH, PFG AND CS-PF BRACED WALL PANELS[a]**

| MINIMUM WALL STUD FRAMING NOMINAL SIZE AND GRADE | MAXIMUM PONY WALL HEIGHT (feet) | MAXIMUM TOTAL WALL HEIGHT (feet) | MAXIMUM OPENING WIDTH (feet) | TENSION STRAP CAPACITY REQUIRED (pounds)[a] | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Ultimate Design Wind Speed $V_{ult}$ (mph) | | | | | |
| | | | | ≤ 110 | 115 | 130 | ≤ 110 | 115 | 130 |
| | | | | Exposure B | | | Exposure C | | |
| 2 × 4 No. 2 Grade | 0 | 10 | 18 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,050 |
| | 1 | 10 | 9 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,750 |
| | | | 16 | 1,000 | 1,025 | 2,050 | 2,075 | 2,500 | 3,950 |
| | | | 18 | 1,000 | 1,275 | 2,375 | 2,400 | 2,850 | DR |
| | 2 | 10 | 9 | 1,000 | 1,000 | 1,475 | 1,500 | 1,875 | 3,125 |
| | | | 16 | 1,775 | 2,175 | 3,525 | 3,550 | 4,125 | DR |

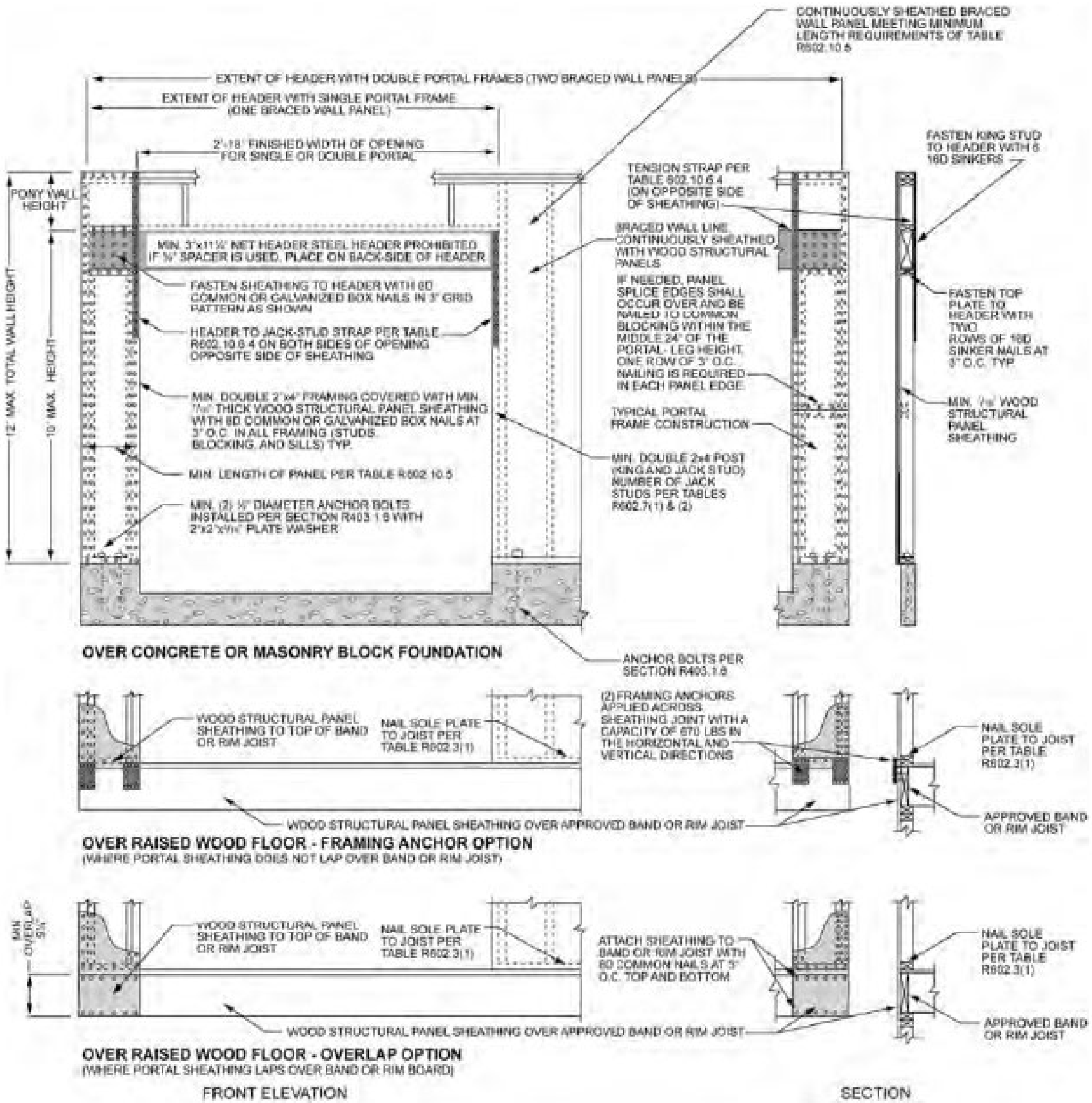
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 18 | 2,075 | 2,500 | 3,950 | 3,975 | DR | DR |
| | 2 | 12 | 9 | 1,150 | 1,500 | 2,650 | 2,675 | 3,175 | DR |
| | | | 16 | 2,875 | 3,375 | DR | DR | DR | DR |
| | | | 18 | 3,425 | 3,975 | DR | DR | DR | DR |
| | 4 | 12 | 9 | 2,275 | 2,750 | DR | DR | DR | DR |
| | | | 12 | 3,225 | 3,775 | DR | DR | DR | DR |
| 2 × 6 Stud Grade | 2 | 12 | 9 | 1,000 | 1,000 | 1,700 | 1,700 | 2,025 | 3,050 |
| | | | 16 | 1,825 | 2,150 | 3,225 | 3,225 | 3,675 | DR |
| | | | 18 | 2,200 | 2,550 | 3,725 | 3,750 | DR | DR |
| | 4 | 12 | 9 | 1,450 | 1,750 | 2,700 | 2,725 | 3,125 | DR |
| | | | 16 | 2,050 | 2,400 | DR | DR | DR | DR |
| | | | 18 | 3,350 | 3,800 | DR | DR | DR | DR |

For SI: 1 foot = 304.8 mm, 1 pound = 4.45 N, 1 mile per hour = 0.447 m/s.
DR = Design Required.
a. Straps shall be installed in accordance with manufacturer's recommendations.

TABLE R602.10.6.5.4

**METHOD BV-WSP WALL BRACING REQUIREMENTS[d]**

Deleted.




For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

**FIGURE R602.10.6.4**
**METHOD CS-PF—CONTINUOUSLY SHEATHED PORTAL FRAME PANEL CONSTRUCTION**

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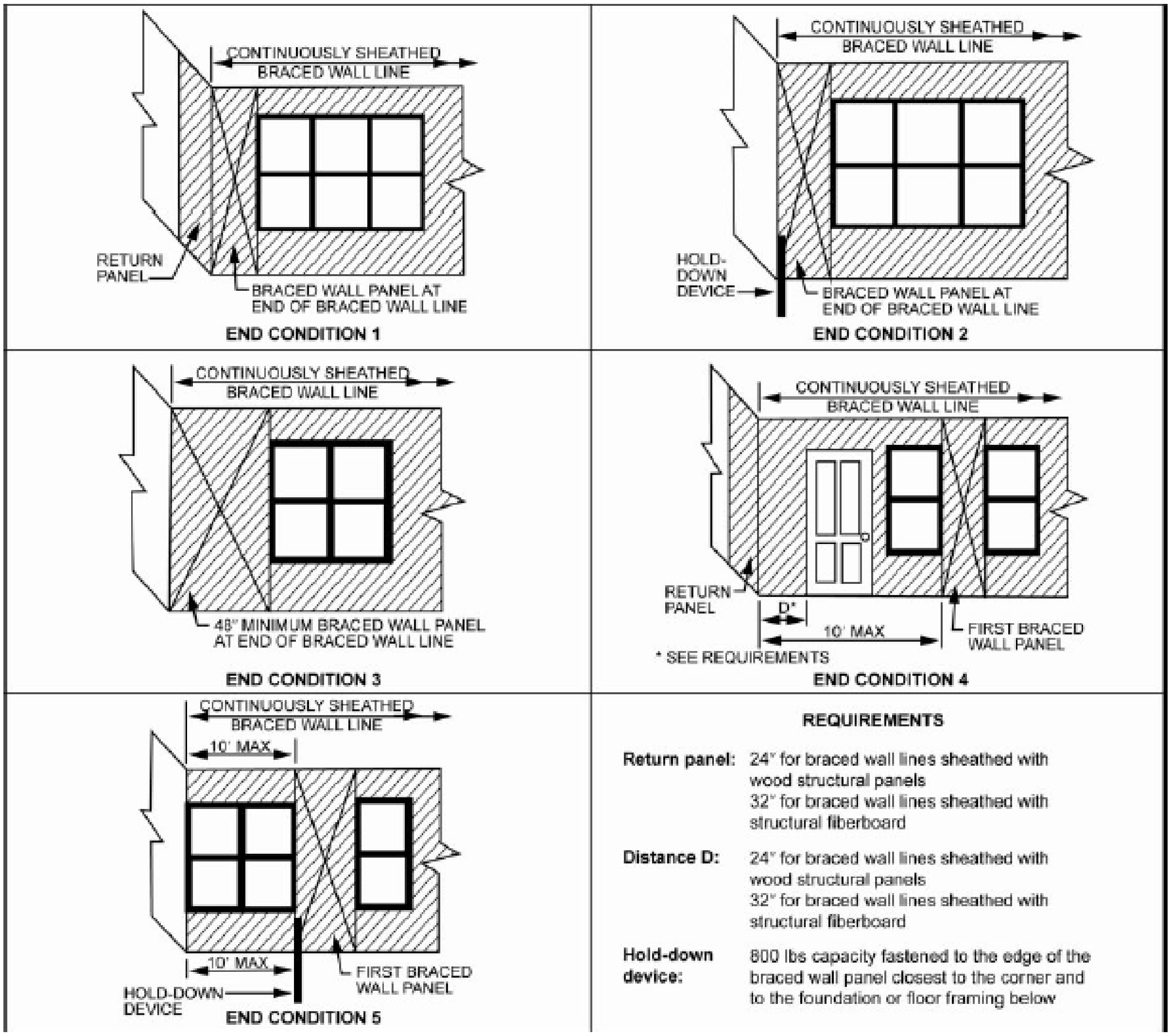
**R602.10.7 Ends of braced wall lines with continuous sheathing.** Each end of a *braced wall line* with continuous sheathing shall have one of the conditions shown in Figure R602.10.7.




For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 4.45 N.

**FIGURE R602.10.7**
**END CONDITIONS FOR BRACED WALL LINES WITH CONTINUOUS SHEATHING**

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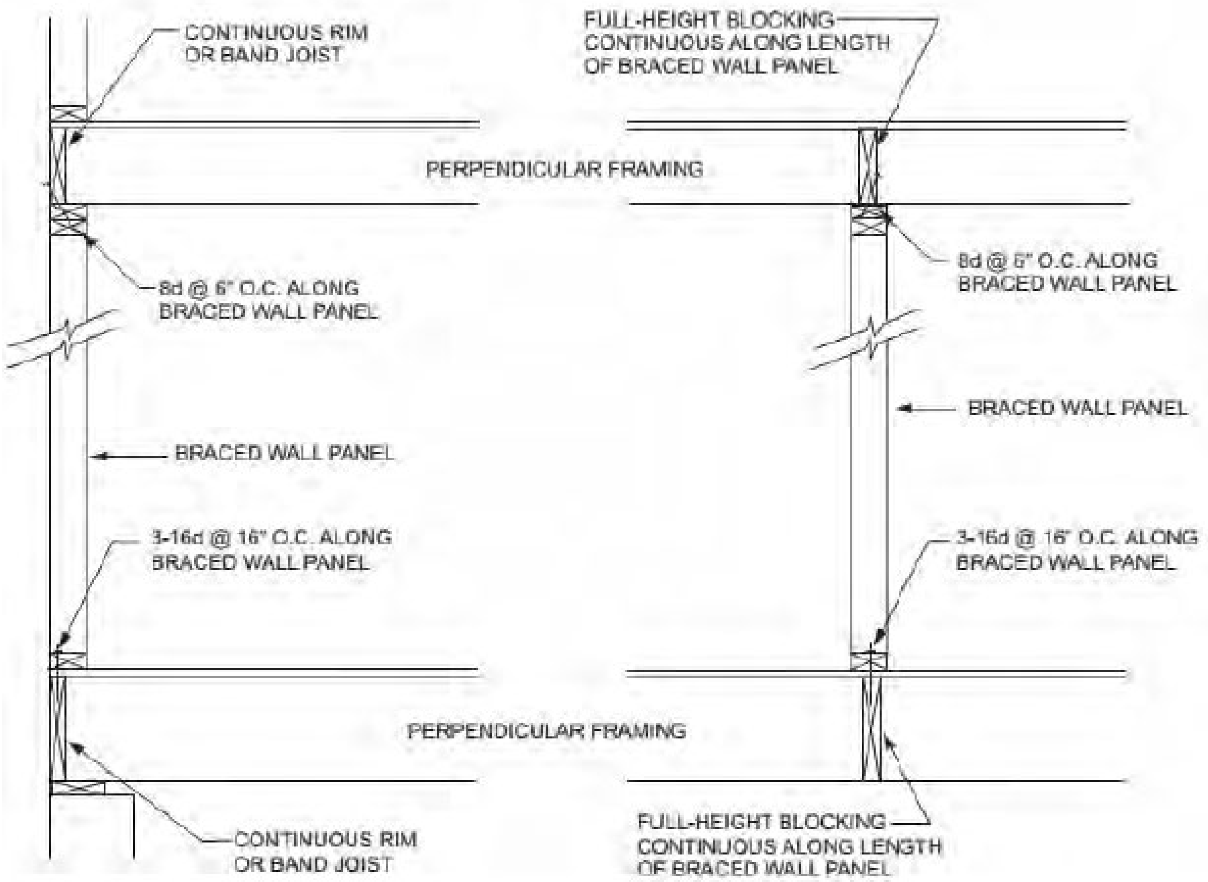
**R602.10.8 Braced wall panel connections.** *Braced wall panel*s shall be connected to floor framing or foundations as follows:

1. Where joists are perpendicular to a *braced wall panel* above or below, a rim joist, band joist or blocking shall be provided along the entire length of the *braced wall panel* in accordance with Figure R602.10.8(1). Fastening of top and bottom wall plates to framing, rim joist, band joist or blocking shall be in accordance with Table R602.3(1).
2. Where joists are parallel to a *braced wall panel* above or below, a rim joist, end joist or other parallel framing member shall be provided directly above and below the *braced wall panel* in accordance with Figure R602.10.8(2). Where a parallel framing member cannot be located directly above and below the panel, full-depth blocking at 16-inch (406 mm) spacing shall be provided between the parallel framing members to each side of the *braced wall panel* in accordance with Figure R602.10.8(2). Fastening of blocking and wall plates shall be in accordance with Table R602.3(1) and Figure R602.10.8(2).
3. Connections of *braced wall panel*s to concrete or masonry shall be in accordance with Section R403.1.6.




For SI: 1 inch = 25.4 mm.

**FIGURE R602.10.8(1)**
**BRACED WALL PANEL CONNECTION WHEN PERPENDICULAR TO FLOOR/CEILING FRAMING**

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**R602.10.8.1 Braced wall panel connections for Seismic Design Categories $D_0$, $D_1$ and $D_2$~~.~~** Deleted.

**R602.10.8.2 Connections to roof framing.** Top plates of exterior *braced wall panels* shall be attached to rafters or roof trusses above in accordance with Table R602.3(1) and this section. Where required by this section, blocking between rafters or roof trusses shall be attached to top plates of *braced wall panels* and to rafters and roof trusses in accordance with Table R602.3(1). A continuous band, rim or header joist or roof truss parallel to the *braced wall panels* shall be permitted to replace the blocking required by this section. Blocking shall not be required over openings in continuously sheathed *braced wall lines*. In addition to the requirements of this section, lateral support shall be provided for rafters and ceiling joists in accordance with Section R802.8 and for trusses in accordance with Section R802.10.3. Roof *ventilation* shall be provided in accordance with Section R806.1.

1. For *Seismic Design Categories* A, B and C where the distance from the top of the *braced wall panel* to the top of the rafters or roof trusses above is $9^{1}/_{4}$ inches (235 mm) or less, blocking between rafters or roof trusses shall not be required. Where the distance from the top of the *braced wall panel* to the top of the rafters or roof trusses above is between $9^{1}/_{4}$ inches (235 mm) and $15^{1}/_{4}$ inches (387 mm), blocking between rafters or roof trusses shall be provided above the *braced wall panel* in accordance with Figure R602.10.8.2(1).

   **Exception:** Where the outside edge of truss vertical web members aligns with the outside face of the wall studs below, wood structural panel sheathing extending above the top plate as shown in Figure R602.10.8.2(3) shall be permitted to be fastened to each truss web with three-8d nails ($2^{1}/_{2}$ inches ×

0.131 inch) and blocking between the trusses shall not be required.

2. Deleted.

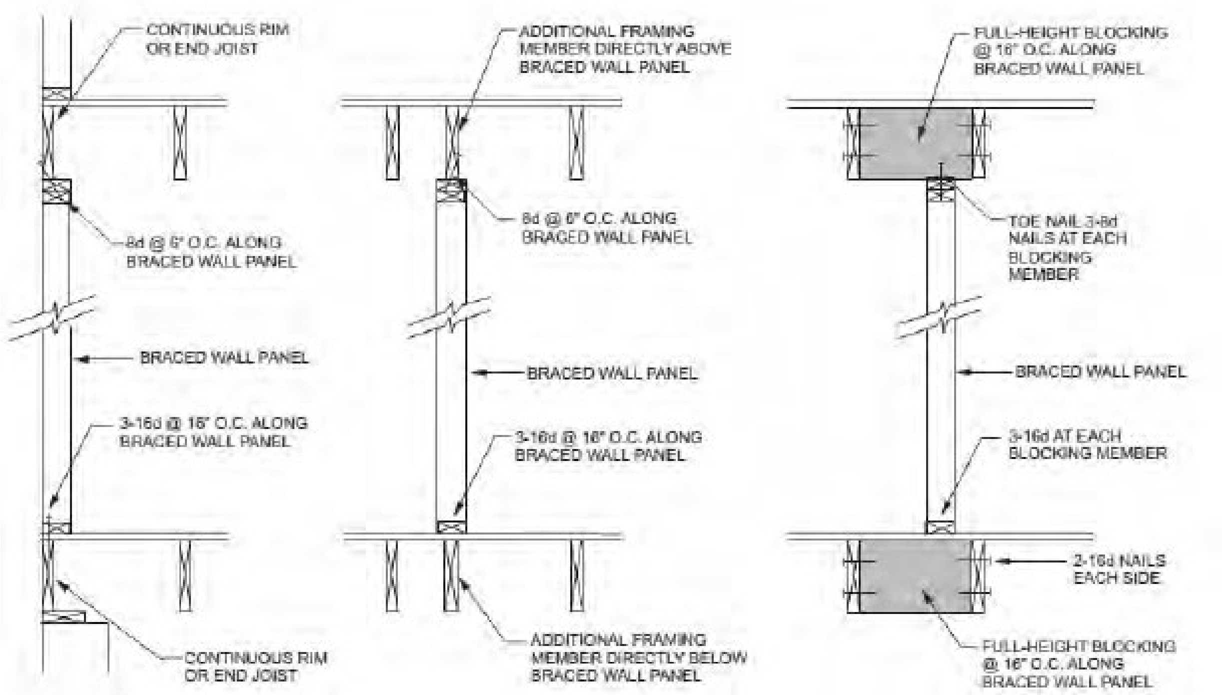
3. Where the distance from the top of the *braced wall panel* to the top of rafters or roof trusses exceeds $15^{1}/_{4}$ inches (387 mm), the top plates of the *braced wall panel* shall be connected to perpendicular rafters or roof trusses above in accordance with one or more of the following methods:

   3.1. Soffit blocking panels constructed in accordance with Figure R602.10.8.2(2).

   3.2. Vertical blocking panels constructed in accordance with Figure R602.10.8.2(3).

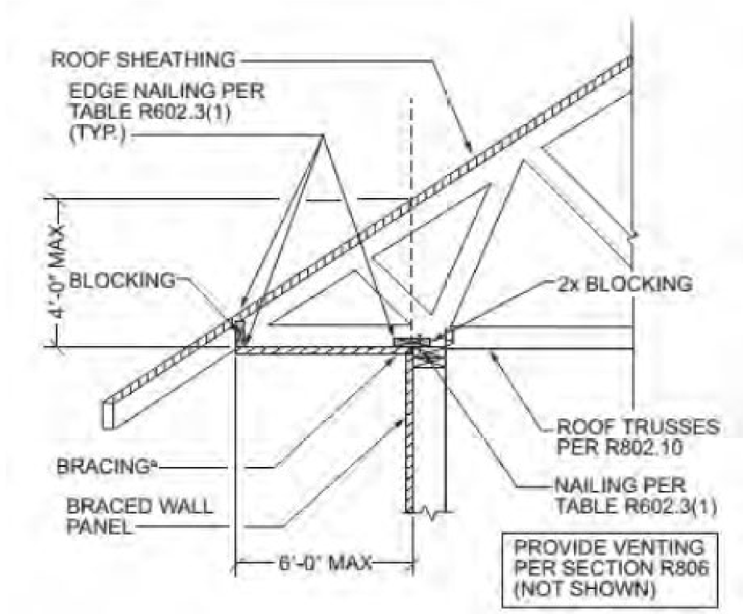
   3.3. Blocking panels provided by the roof truss manufacturer and designed in accordance with Section R802.

   3.4. Blocking, blocking panels or other methods of lateral load transfer designed in accordance with the AWC WFCM or accepted engineering practice.




For SI: 1 inch = 25.4 mm.

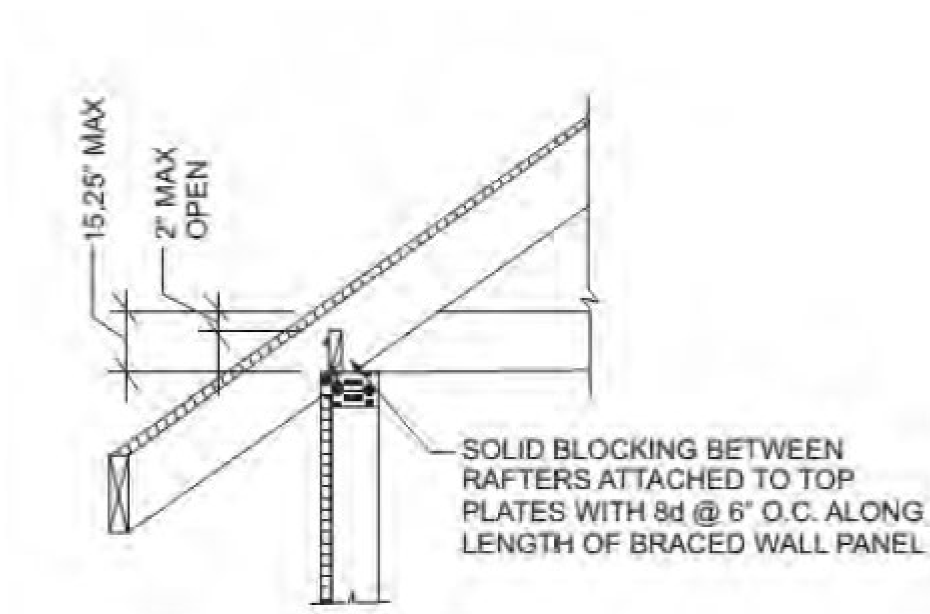
**FIGURE R602.10.8(2)**
**BRACED WALL PANEL CONNECTION WHEN PARALLEL TO FLOOR/CEILING FRAMING**




For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

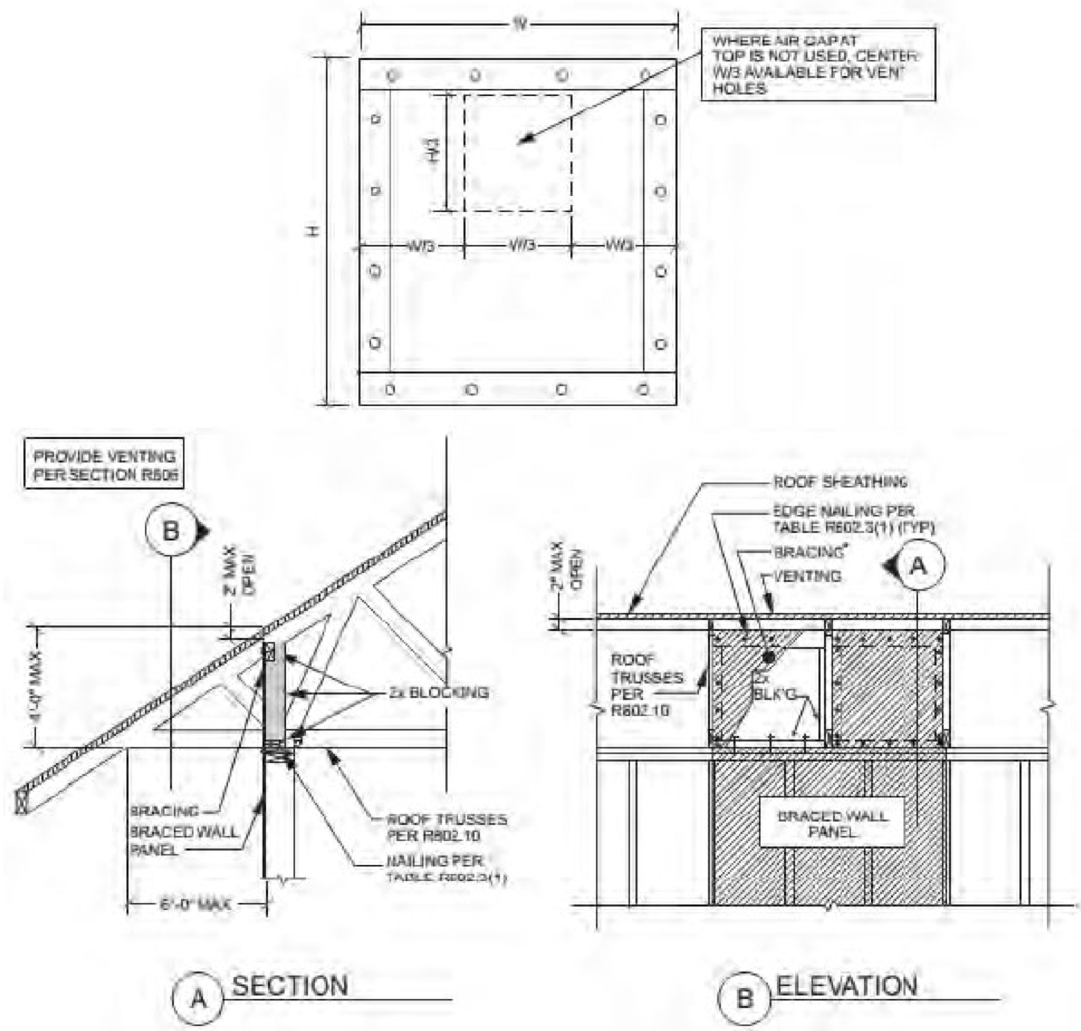
a. Methods of bracing shall be as described in **Section R602.10.4**.

**FIGURE R602.10.8.2(2)**
**BRACED WALL PANEL CONNECTION OPTION TO PERPENDICULAR RAFTERS OR ROOF TRUSSES**




For SI: 1 inch = 25.4 mm.

**FIGURE R602.10.8.2(1)**
**BRACED WALL PANEL CONNECTION TO PERPENDICULAR RAFTERS**




For SI: 1 inch = 25.4 mm, 1 foot =304.8 mm

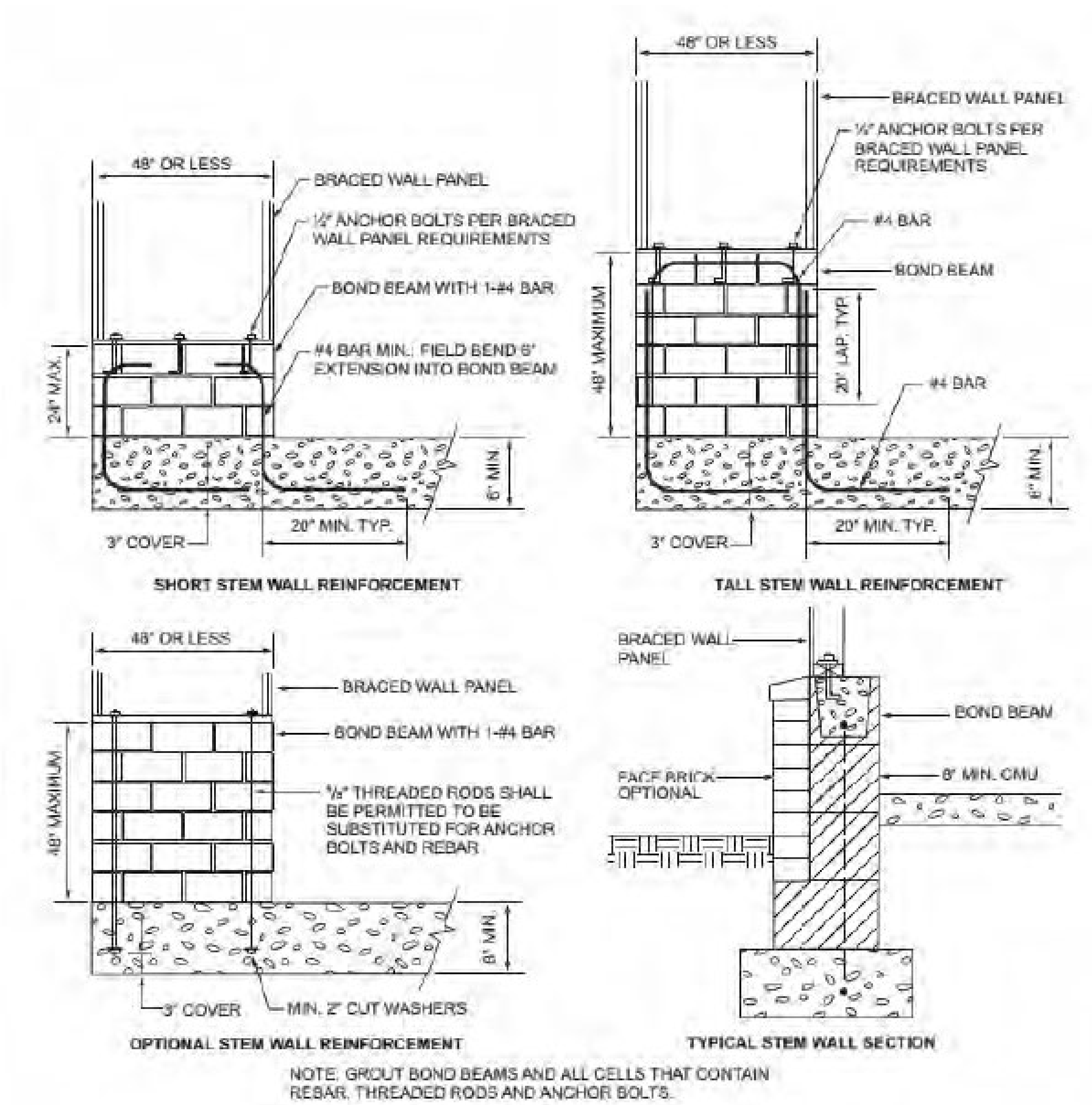
a. Methods of bracing shall be as described in **Section R602.10.4**.

**FIGURE R602.10.8.2(3)**
**BRACED WALL PANEL CONNECTION OPTION TO PERPENDICULAR RAFTERS OR ROOF TRUSSES**

**R602.10.9 Braced wall panel support.** *Braced wall panel* support shall be provided as follows:

1. Cantilevered floor joists complying with Section R502.3.3 shall be permitted to support *braced wall panel*s.
2. Raised floor system post or pier foundations supporting *braced wall panel*s shall be designed in accordance with accepted engineering practice.
3. Masonry stem walls with a length of 48 inches (1219 mm) or less supporting *braced wall panel*s shall be reinforced in accordance with Figure R602.10.9. Masonry stem walls with a length greater than 48 inches (1219 mm) supporting *braced wall panel*s shall be constructed in accordance with Section R403.1 Methods ABW and PFH shall not be permitted to attach to masonry stem walls.
4. Concrete stem walls with a length of 48 inches (1219 mm) or less, greater than 12 inches (305 mm) tall and less than 6 inches (152 mm) thick shall have reinforcement sized and located in accordance with Figure R602.10.9.

**R602.10.9.1 Braced wall panel support for Seismic Design Categories $D_0$, $D_1$ and $D_2$.**-Deleted.




For SI: 1 inch = 25.4 mm.

**FIGURE R602.10.9**
**MASONRY STEM WALLS SUPPORTING BRACED WALL PANELS**

**R602.10.10 Cripple wall bracing.** Cripple walls shall be constructed in accordance with Section R602.9 and braced in accordance with this section. Cripple walls shall be braced with the length and method of bracing used for the wall above in accordance with Tables R602.10.3(1) and R602.10.3(3), and the applicable adjustment factors in Table R602.10.3(2) or R602.10.3(4), respectively, except that the length of cripple wall bracing shall be multiplied by a factor of 1.15. Where gypsum wall board is not used on the inside of the cripple wall bracing, the length adjustments for the elimination of the gypsum wallboard, or equivalent, shall be applied as directed in Tables R602.10.3(2) and R602.10.3(4) to the length of cripple wall bracing required. This adjustment shall be taken in addition to the 1.15 increase.

**R602.10.10.1 Cripple wall bracing for townhouses in Seismic Design Category C.** In addition to the requirements in Section R602.10.10, cripple wall bracing shall be limited to methods WSP and CS-WSP, and the distance between adjacent edges of *braced wall panel*s for cripple walls along a *braced wall line* shall be 14 feet (4267 mm) maximum.

Where *braced wall lines* at interior walls are not supported on a continuous foundation below, the adjacent parallel cripple walls, where provided, shall be braced with Method WSP or Method CS-WSP in accordance with Section R602.10.4. The length of bracing required in accordance with Table R602.10.3(3) for the cripple walls shall be multiplied by 1.5. Where the cripple walls do not have sufficient length to provide the required bracing, the spacing of panel edge fasteners shall be reduced to 4 inches (102 mm) on center and the required bracing length adjusted by 0.7. If the required length can still not be provided, the cripple wall shall be designed in accordance with accepted engineering practice.

**R602.10.10.2 Cripple wall bracing for Seismic Design Category $D_2$.** Deleted.~~.~~

**R602.10.10.3 Redesignation of cripple walls.** Where all cripple wall segments along a *braced wall line* do not exceed 48 inches (1219 mm) in height, the cripple walls shall be permitted to be redesignated as a first-*story* wall for purposes of determining wall bracing requirements. Where any cripple wall segment in a *braced wall line* exceeds 48 inches (1219 mm) in height, the entire cripple wall shall be counted as an additional *story*. If the cripple walls are redesignated, the stories above the redesignated *story* shall be counted as the second and third stories, respectively.

**R602.11 Wall anchorage.** *Braced wall line* sills shall be anchored to concrete or masonry foundations in accordance with Sections R403.1.6 and R602.11.1.

**R602.11.1 Wall anchorage for townhouses in Seismic Design Category C.** Plate washers, not less than 0.229 inch by 3 inches by 3 inches (5.8 mm by 76 mm by 76 mm) in size, shall be provided between the foundation sill plate and the nut except where *approved* anchor straps are used. The hole in the plate washer is permitted to be diagonally slotted with a width of up to $^{3}/_{16}$ inch (5 mm) larger than the bolt diameter and a slot length not to exceed $1^{3}/_{4}$ inches (44 mm), provided a standard cut washer is placed between the plate washer and the nut.

**R602.11.2 Stepped foundations in Seismic Design Categories $D_0$, $D_1$ and $D_2$.** Deleted.

**R602.12 Simplified wall bracing.** Buildings meeting all of the following conditions shall be permitted to be braced in accordance with this section as an alternative to the requirements of Section R602.10. The entire building shall be braced in accordance with this section; the use of other bracing provisions of Section R602.10, except as specified herein, shall not be permitted.

1. There shall be not more than three stories above the top of a concrete or masonry foundation or basement wall. Permanent wood foundations shall not be permitted.
2. Floors shall not cantilever more than 24 inches (607 mm) beyond the foundation or bearing wall below.
3. Wall height shall not be greater than 10 feet (3048 mm).
4. The building shall have a roof eave-to-ridge height of 15 feet (4572 mm) or less.
5. Exterior walls shall have gypsum board with a minimum thickness of $^{1}/_{2}$ inch (12.7 mm) installed on the interior side fastened in accordance with Table R702.3.5.
6. The structure shall be located where the ultimate design wind speed is less than or equal to 130 mph (58 m/s), and the exposure category is B or C.
7. The structure shall be located in *Seismic Design Category* A, B or C for detached one- and two-family dwellings or *Seismic Design Category* A or B for townhouses.
8. Cripple walls shall not be permitted in three-story buildings.

**R602.12.1 Circumscribed rectangle.** The bracing required for each building shall be determined by circumscribing a rectangle around the entire building on each floor as shown in Figure R602.12.1. The rectangle shall surround all enclosed offsets and projections such as *sunrooms* and attached garages. Open structures, such as carports and decks, shall be permitted to be excluded. The rectangle shall not have a side greater than 60 feet (18 288 mm), and the ratio between the long side and short side shall be not greater than 3:1.

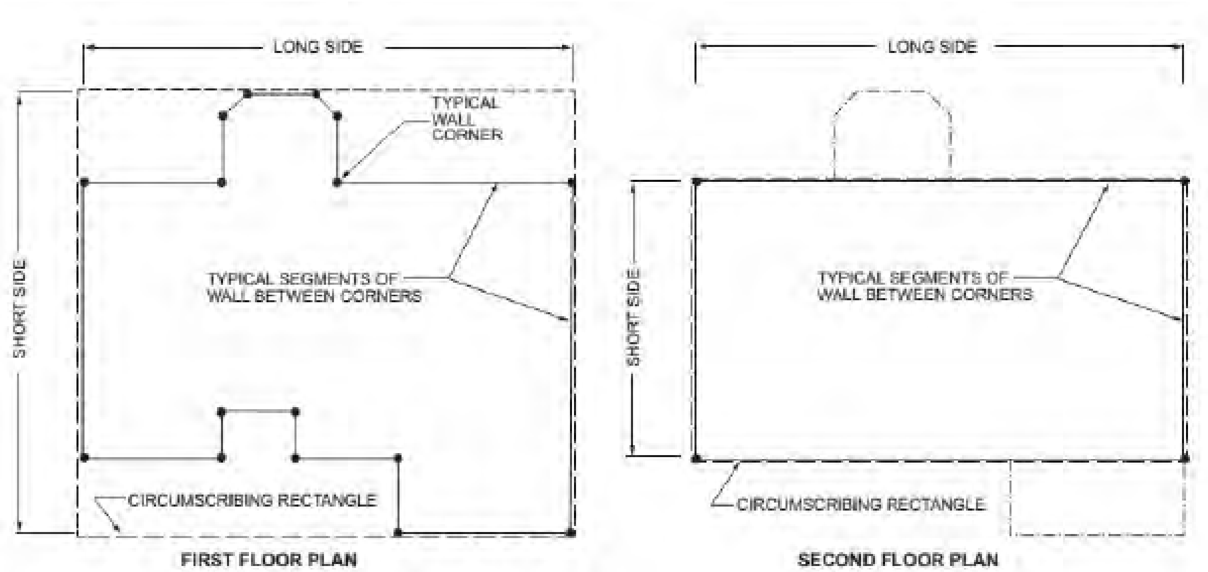



**FIGURE R602.12.1**
**RECTANGLE CIRCUMSCRIBING AN ENCLOSED BUILDING**

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**R602.12.2 Sheathing materials.** The following sheathing materials installed on the exterior side of exterior walls shall be used to construct a bracing unit as defined in Section R602.12.3. Mixing materials is prohibited.

1. Wood structural panels with a minimum thickness of $^3/_8$ inch (9.5 mm) fastened in accordance with Table R602.3(3).
2. Structural fiberboard sheathing with a minimum thickness of $^1/_2$ inch (12.7 mm) fastened in accordance with Table R602.3(1).

**R602.12.3 Bracing unit.** A bracing unit shall be a full-height sheathed segment of the exterior wall without openings or vertical or horizontal offsets and a minimum length as specified herein. Interior walls shall not contribute toward the amount of required bracing. Mixing of Items 1 and 2 is prohibited on the same story.

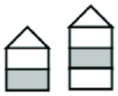
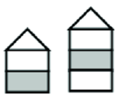
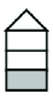
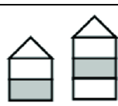
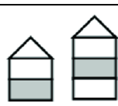
1. Where all framed portions of all exterior walls are sheathed in accordance with Section R602.12.2, including wall areas between bracing units, above and below openings and on gable end walls, the minimum length of a bracing unit shall be 3 feet (914 mm).
2. Where the exterior walls are braced with sheathing panels in accordance with Section R602.12.2 and areas between bracing units are covered with other materials, the minimum length of a bracing unit shall be 4 feet (1219 mm).

**R602.12.3.1 Multiple bracing units.** Segments of wall compliant with Section R602.12.3 and longer than the minimum bracing unit length shall be considered as multiple bracing units. The number of bracing units shall be determined by dividing the wall segment length by the minimum bracing unit length. Full-height sheathed segments of wall narrower than the minimum bracing unit length shall not contribute toward a bracing unit except as specified in Section R602.12.6.

**R602.12.4 Number of bracing units.** Each side of the circumscribed rectangle, as shown in Figure R602.12.1, shall have, at a minimum, the number of bracing units in accordance with Table R602.12.4 placed on the parallel exterior walls facing the side of the rectangle. Bracing units shall then be placed using the distribution requirements specified in Section R602.12.5.

**TABLE R602.12.4**
**MINIMUM NUMBER OF BRACING UNITS ON EACH SIDE OF THE CIRCUMSCRIBED RECTANGLE**

| | STORY LEVEL | | MINIMUM NUMBER OF BRACING UNITS ON EACH LONG SIDE[a, b, d] | MINIMUM NUMBER OF BRACING UNITS ON EACH SHORT SIDE[a, b, d] |
|---|---|---|---|---|

| ULTIMATE DESIGN WIND SPEED (mph) | | EAVE-TO-RIDGE HEIGHT (feet) | Length of short side (feet)[c] | | | | | | Length of long side (feet)[c] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 10 | 20 | 30 | 40 | 50 | 60 | 10 | 20 | 30 | 40 | 50 | 60 |
| 115 |  | 10 | 1 | 2 | 2 | 2 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 |
| |  | | 2 | 3 | 3 | 4 | 5 | 6 | 2 | 3 | 3 | 4 | 5 | 6 |
| |  | | 2 | 3 | 4 | 6 | 7 | 8 | 2 | 3 | 4 | 6 | 7 | 8 |
| |  | 15 | 1 | 2 | 3 | 3 | 4 | 4 | 1 | 2 | 3 | 3 | 4 | 4 |
| |  | | 2 | 3 | 4 | 5 | 6 | 7 | 2 | 3 | 4 | 5 | 6 | 7 |
| |  | | 2 | 4 | 5 | 6 | 7 | 9 | 2 | 4 | 5 | 6 | 7 | 9 |
| 130 |  | 10 | 1 | 2 | 2 | 3 | 3 | 4 | 1 | 2 | 2 | 3 | 3 | 4 |
| |  | | 2 | 3 | 4 | 5 | 6 | 7 | 2 | 3 | 4 | 5 | 6 | 7 |
| |  | | 2 | 4 | 5 | 7 | 8 | 10 | 2 | 4 | 5 | 7 | 8 | 10 |
| |  | 15 | 2 | 3 | 3 | 4 | 4 | 6 | 2 | 3 | 3 | 4 | 4 | 6 |
| |  | | 3 | 4 | 6 | 7 | 8 | 10 | 3 | 4 | 6 | 7 | 8 | 10 |
| |  | | 3 | 6 | 7 | 10 | 11 | 13 | 3 | 6 | 7 | 10 | 11 | 13 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447m/s.

a. Interpolation shall not be permitted.

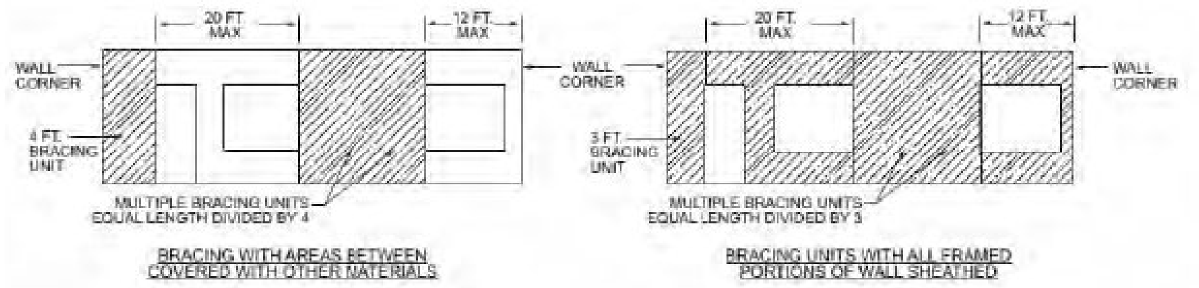
b. Cripple walls or wood-framed *basement walls* in a walk-out condition shall be designated as the first story and the stories above shall be redesignated as the second and third stories, respectively, and shall be prohibited in a three-story structure.

c. Actual lengths of the sides of the circumscribed rectangle shall be rounded to the next highest unit of 10 when using this table.

d. For Exposure Category C, multiply bracing units by a factor of 1.20 for a one-story building, 1.30 for a two-story building and 1.40 for a three-story building.

**R602.12.5 Distribution of bracing units.** The placement of bracing units on exterior walls shall meet all of the following requirements as shown in Figure R602.12.5.

1. A bracing unit shall begin not more than 12 feet (3658 mm) from any wall corner.
2. The distance between adjacent edges of bracing units shall be not greater than 20 feet (6096 mm).
3. Segments of wall greater than 8 feet (2438 mm) in length shall have not less than one bracing unit.




For SI: 1 foot = 304.8 mm.

**FIGURE R602.12.5**
**BRACING UNIT DISTRIBUTION**

**R602.12.6 Narrow panels.** The bracing methods referenced in Section R602.10 and specified in Sections R602.12.6.1 through R602.12.6.3 shall be permitted where using simplified wall bracing.

**R602.12.6.1 Method CS-G.** *Braced wall panels* constructed as Method CS-G in accordance with Tables R602.10.4 and R602.10.5 shall be permitted for one-story garages where all framed portions of all exterior walls are sheathed with *wood structural panels*. Each CS-G panel shall be equivalent to 0.5 of a bracing unit. Segments of wall that include a Method CS-G panel shall meet the requirements of Section R602.10.4.2.

**R602.12.6.2 Method CS-PF.** *Braced wall panels* constructed as Method CS-PF in accordance with Section R602.10.6.4 shall be permitted where all framed portions of all exterior walls are sheathed with *wood structural panels*. Each CS-PF panel shall equal 0.75 bracing units. Segments of wall that include a Method CS-PF panel shall meet the requirements of Section R602.10.4.2.

**R602.12.6.3 Methods ABW, PFH and PFG.** *Braced wall panels* constructed as Method ABW, PFH and PFG shall be permitted where bracing units are constructed using *wood structural panels* applied either continuously or intermittently. Each ABW and PFH panel shall equal one bracing unit and each PFG panel shall be equal to 0.75 bracing unit.

**R602.12.7 Lateral support.** For bracing units located along the eaves, the vertical distance from the outside edge of the top wall plate to the roof sheathing above shall not exceed 9.25 inches (235 mm) at the location of a bracing unit unless lateral support is provided in accordance with Section R602.10.8.2.

**R602.12.8 Stem walls.** Masonry stem walls with a height and length of 48 inches (1219 mm) or less supporting a bracing unit or a Method CS-G, CS-PF or PFG *braced wall panel* shall be constructed in accordance with Figure R602.10.9. Concrete stem walls with a length of 48 inches (1219 mm) or less, greater than 12 inches (305 mm) tall and less than 6 inches (152 mm) thick shall be reinforced sized and located in accordance with Figure R602.10.9.

## SECTION R603
## COLD-FORMED STEEL WALL FRAMING

**(Deleted)**

## SECTION R604
## WOOD STRUCTURAL PANELS

**R604.1 Identification and grade.** *Wood structural panels* shall conform to DOC PS 1, DOC PS 2, ANSI/APA PRP 210, CSA O325 or CSA O437. Panels shall be identified by a grade *mark* or certificate of inspection issued by an *approved* agency.

**R604.2 Allowable spans.** The maximum allowable spans for wood structural panel wall sheathing shall not exceed the values set forth in Table R602.3(3).

**R604.3 Installation.** Wood structural panel wall sheathing shall be attached to framing in accordance with Table R602.3(1) or R602.3(3).

## SECTION R605
## PARTICLEBOARD

**R605.1 Identification and grade.** Particleboard shall conform to ANSI A208.1 and shall be so identified by a grade *mark* or certificate of inspection issued by an *approved* agency. Particleboard shall comply with the grades specified in Table R602.3(4).

## SECTION R606
## GENERAL MASONRY CONSTRUCTION

**R606.1 General.** Masonry construction shall be designed and constructed in accordance with the provisions of this section, ~~TMS 403 or in accordance with the provisions of TMS 402/ACI 530/ASCE 5~~ TMS 402, TMS 403 or TMS 404.

**R606.1.1 Professional registration not required.** ~~When~~ Where the empirical design provisions of Appendix A of TMS ~~402/ACI 530/ASCE 5,~~ 402, the provisions of TMS 403, or the provisions of this section are used to design masonry, project drawings, typical details and specifications are not required to bear the seal of the *registered design professional* responsible for design, unless otherwise required by the state law of the *jurisdiction* having authority.

**R606.2 Masonry construction materials.**

**R606.2.1 Concrete masonry units.** *Concrete masonry units* shall conform to the following standards: ASTM C55 for concrete brick; ASTM C73 for calcium silicate face brick; ASTM C90 for load-bearing *concrete masonry units*; ASTM C744 for prefaced concrete and calcium silicate *masonry units*; or ASTM C1634 for concrete facing brick.

**R606.2.2 Clay or shale masonry units.** Clay or shale *masonry units* shall conform to the following standards: ASTM C34 for structural clay *load-bearing wall* tile; ASTM C56 for structural clay non load-bearing wall tile; ASTM C62 for building brick (*solid masonry* units made from clay or shale); ASTM C126 for ~~solid units of thin veneer brick; ASTM C 126 for~~ ceramic-glazed structural clay facing tile, facing brick and *solid masonry* units; ASTM C212 for structural clay facing tile; ASTM C216 for facing brick (*solid masonry* units made from clay or shale); ASTM C652 for hollow brick (*hollow masonry units* made from clay or shale); ASTM C1088 for solid units of thin veneer brick; or ASTM C1405 for glazed brick (single-fired solid brick units).

**Exception:** Structural clay tile for nonstructural use in fireproofing of structural members and in wall furring shall not be required to meet the compressive strength specifications. The fire-resistance rating shall be determined in accordance with ASTM E119 or UL 263 and shall comply with the requirements of Section R302.

**R606.2.3 AAC masonry.** AAC *masonry units* shall conform to ASTM C1691 and ASTM C1693 for the strength class specified.

**R606.2.4 Stone masonry units.** Stone *masonry units* shall conform to the following standards: ASTM C503 for marble building stone (exterior); ASTM C568 for limestone building stone; ASTM C615 for granite building stone; ASTM C616 for sandstone building stone; or ASTM C629 for slate building stone.

**R606.2.5 Architectural cast stone.** Architectural cast stone shall conform to ASTM C1364.

**R606.2.6 Adhered manufactured stone masonry veneer units.** Adhered manufactured stone masonry veneer units shall conform to ASTM C1670.

~~R606.2.6~~ **R606.2.7 Second-hand units.** Second-hand *masonry units* shall not be reused unless they conform to the requirements of new units. The units shall be of whole, sound materials and free from cracks and other defects that will interfere with proper laying or use. Old mortar shall be cleaned from the unit before reuse.

**Exception:** Second hand units are permitted to be used for interior nonbearing conditions.

~~R606.2.7~~ **R606.2.8 Mortar.** Except for mortars listed in Sections R606.2.9, R606.2.10 and R606.2.11, mortar for use in masonry construction shall meet the proportion specifications of Table R606.2.8 or the property specifications of ASTM C270. The type of mortar shall be in accordance with Sections R606.2.8.1, R606.2.8.2 and R606.2.8.3.

~~R606.2.7.1~~ **R606.2.8.1 Foundation walls.** Mortar for masonry foundation walls constructed as set forth in Tables R404.1.1(1) through R404.1.1(4) shall be Type M or S mortar.

~~R606.2.7.2~~ **R606.2.8.2 Masonry in Seismic Design Categories A, B and C.** Mortar for masonry serving as the lateral force-resisting system in *Seismic Design Categories* A, B and C shall be Type M, S or N mortar.

~~R606.2.7.3~~ **R606.2.8.3 Masonry in Seismic Design Categories $D_0$, $D_1$ and $D_2$.** Deleted.

**TABLE ~~R606.2.7~~ R606.2.8**
**MORTAR PROPORTIONS[a, b]**

| MORTAR | TYPE | PROPORTIONS BY VOLUME (cementitious materials) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Portland cement or blended cement | Mortar cement M | Mortar cement S | Mortar cement N | Masonry cement M | Masonry cement S | Masonry cement N | Hydrated lime[c] or lime putty | Aggregate ratio (measured in damp, loose conditions) |
| Cement-lime | M | 1 | — | — | — | — | — | — | $^1/_4$ | Not less than $2^1/_4$ and not more than 3 times the sum of separate volumes of lime, if used, and cement |
| | S | 1 | — | — | — | — | — | — | over $^1/_4$ to $^1/_2$ | |
| | N | 1 | — | — | — | — | — | — | over $^1/_2$ to $1^1/_4$ | |
| | O | 1 | — | — | — | — | — | — | over $1^1/_4$ to $2^1/_2$ | |
| Mortar cement | M | 1 | — | — | 1 | — | — | — | — | |
| | M | — | 1 | — | — | — | — | — | | |
| | S | $^1/_2$ | — | — | 1 | — | — | — | | |
| | S | — | — | 1 | — | — | — | — | | |
| | N | — | — | — | 1 | — | — | — | | |
| | O | — | — | — | 1 | — | — | — | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Masonry cement | M | 1 | — | — | — | — | — | 1 | | |
| | M | — | — | — | — | 1 | — | — | | |
| | S | 1/2 | — | — | — | — | — | 1 | — | |
| | S | — | — | — | — | — | 1 | — | | |
| | N | — | — | — | — | — | — | 1 | | |
| | O | — | — | — | — | — | — | 1 | | |

For SI: 1 cubic foot = 0.0283 $m^3$, 1 pound = 0.454 kg.

a. For the purpose of these specifications, the weight of 1 cubic foot of the respective materials shall be considered to be as follows:
   Hydrated lime = 40 pounds
   Lime putty (Quicklime) = 80 pounds
   Masonry cement = Weight printed on bag
   Mortar cement = Weight printed on bag
   Portland cement = 94 pounds
   Sand, damp and loose = 80 pounds of dry sand

b. Two air-entraining materials shall not be combined in mortar.

c. Hydrated lime conforming to the requirements of ASTM C207.

**~~R606.2.8~~ <u>R606.2.9</u> Surface-bonding mortar.** Surface-bonding mortar shall comply with ASTM C887. Surface bonding of *concrete masonry units* shall comply with ASTM C946.

**~~R606.2.9~~ <u>R606.2.10</u> Mortar for AAC masonry.** Thin-bed mortar for AAC masonry shall comply with Article 2.1 C.1 of TMS 602~~/ACI530.1/ASCE 6~~. Mortar used for the leveling courses of AAC masonry shall comply with Article 2.1 C.2 of TMS 602~~/ACI530.1/ASCE 6~~.

**~~R606.2.10~~ <u>R606.2.11</u> Mortar for adhered masonry veneer.** Mortar for use with adhered masonry veneer shall conform to ASTM C270 Type S or Type N or shall comply with ANSI A118.4 for latex-modified ~~portland~~ <u>Portland</u> cement mortar.

**~~R606.2.11~~ <u>R606.2.12</u> Grout.** Grout shall consist of cementitious material and aggregate in accordance with ASTM C476 or the proportion specifications of Table ~~R606.2.11~~ <u>R606.2.12</u>. Type M or Type S mortar to which sufficient water has been added to produce pouring consistency shall be permitted to be used as grout.

**TABLE ~~R606.2.11~~ <u>R606.2.12</u>**
**GROUT PROPORTIONS BY VOLUME FOR MASONRY CONSTRUCTION**

| TYPE | PORTLAND CEMENT OR BLENDED CEMENT SLAG CEMENT | HYDRATED LIME OR LIME PUTTY | AGGREGATE MEASURED IN A DAMP, LOOSE CONDITION | |
|---|---|---|---|---|
| | | | Fine | Coarse |
| Fine | 1 | 0 to 1/10 | $2^1/_4$ to 3 times the sum of the volumes of the cementitious materials | — |
| Coarse | 1 | 0 to 1/10 | $2^1/_4$ to 3 times the sum of the volumes of the cementitious materials | 1 to 2 times the sum of the volumes of the cementitious materials |

**R606.2.13 Metal reinforcement and accessories.** Metal reinforcement and accessories shall conform to Article 2.4 of TMS 602~~/ACI530.1/ASCE 6~~.

## R606.3 Construction requirements.

**R606.3.1 Bed and head joints.** Unless otherwise required or indicated on the project drawings, head and bed joints shall be $^{3}/_{8}$ inch (9.5 mm) thick, except that the thickness of the bed joint of the starting course placed over foundations shall be not less than $^{1}/_{4}$ inch (6.4 mm) and not more than $^{3}/_{4}$ inch (19.1 mm). Mortar joint thickness for load-bearing masonry shall be within the following tolerances from the specified dimensions:

1. Bed joint: + $^{1}/_{8}$ inch (3.2 mm).
2. Head joint: - $^{1}/_{4}$ inch (6.4 mm), + $^{3}/_{8}$ inch (9.5 mm).
3. Collar joints: - $^{1}/_{4}$ inch (6.4 mm), + $^{3}/_{8}$ inch (9.5 mm).

**R606.3.2 Masonry unit placement.** The mortar shall be sufficiently plastic and units shall be placed with sufficient pressure to extrude mortar from the joint and produce a tight joint. Deep furrowing of bed joints that produces voids shall not be permitted. Any units disturbed to the extent that initial bond is broken after initial placement shall be removed and relaid in fresh mortar. Surfaces to be in contact with mortar shall be clean and free of deleterious materials.

**R606.3.2.1 Solid masonry.** *Solid masonry* units shall be laid with full head and bed joints and all interior vertical joints that are designed to receive mortar shall be filled.

**R606.3.2.2 Hollow masonry.** For *hollow masonry units*, head and bed joints shall be filled solidly with mortar for a distance in from the face of the unit not less than the thickness of the face shell.

**R606.3.3 Installation of wall ties.** The installation of wall ties shall be as follows:

1. The ends of wall ties shall be embedded in mortar joints. Wall ties shall have not less than $^{5}/_{8}$-inch (15.9 mm) mortar coverage from the exposed face.
2. Wall ties shall not be bent after being embedded in grout or mortar.
3. For *solid masonry* units, solid grouted hollow units, or hollow units in anchored masonry veneer, wall ties shall be embedded in mortar bed not less than $1^{1}/_{2}$ inches (38 mm).
4. For *hollow masonry units* in other than anchored masonry veneer, wall ties shall engage outer face shells by not less than $^{1}/_{2}$ inch (13 mm).

**R606.3.4 Protection for reinforcement.** Bars shall be completely embedded in mortar or grout. Joint reinforcement embedded in horizontal mortar joints shall not have less than $^{5}/_{8}$-inch (15.9 mm) mortar coverage from the exposed face. Other reinforcement shall have a minimum coverage of one bar diameter over all bars, but not less than $^{3}/_{4}$ inch (19 mm), except where exposed to weather or soil, in which case the minimum coverage shall be 2 inches (51 mm).

**R606.3.4.1 Corrosion protection.** Minimum corrosion protection of joint reinforcement, anchor ties and wire fabric for use in masonry wall construction shall conform to Table R606.3.4.1.

**TABLE R606.3.4.1**
**MINIMUM CORROSION PROTECTION**

| MASONRY METAL ACCESSORY | STANDARD |
|---|---|
| Joint reinforcement, interior walls | ASTM A641, Class 1 |
| Wire ties or anchors in exterior walls completely embedded in mortar or grout | ASTM A641, Class 3 |
| Wire ties or anchors in exterior walls not completely embedded in mortar or grout | ASTM A153, Class B-2 |
| Joint reinforcement in exterior walls or interior walls exposed to moist environment | ASTM A153, Class B-2 |
| Sheet metal ties or anchors exposed to weather | ASTM A153, Class B-2 |
| Sheet metal ties or anchors completely embedded in mortar or grout | ASTM A653, Coating Designation G60 |
| Stainless steel hardware for any exposure | ASTM A167, Type 304 |

**R606.3.5 Grouting requirements.**

**R606.3.5.1 Grout placement.** Grout shall be a plastic mix suitable for pumping without segregation of the constituents and shall be mixed thoroughly. Grout shall be placed by pumping or by an *approved* alternate method and shall be placed before any initial set occurs and not more than $1^{1}/_{2}$ hours after water has been added. Grout shall be consolidated by puddling or mechanical vibrating during placing and reconsolidated after excess moisture has been absorbed but before plasticity is lost. Grout shall not be pumped through aluminum pipes.

Maximum pour heights and the minimum dimensions of spaces provided for grout placement shall conform to Table R606.3.5.1. Grout shall be poured in lifts ~~of 8-foot (2438 mm) maximum height~~ with a maximum height of 8 feet (2438 mm). Where a total grout pour exceeds 8 feet (2438 mm) in height, the grout shall be placed in lifts not exceeding 64 inches (1626 mm). ~~and special inspection during grouting shall be required.~~ If the work is stopped for 1 hour or longer, the horizontal construction joints shall be formed by stopping all tiers at the same elevation and with the grout 1 inch (25 mm) below the top.

**R606.3.5.2 Cleanouts.** Provisions shall be made for cleaning the space to be grouted. Mortar that projects more than $^{1}/_{2}$ inch (12.7 mm) into the grout space and any other foreign matter shall be removed from the grout space prior to inspection and grouting. Where required by the building official, cleanouts shall be provided in the bottom course of masonry for each grout pour where the grout pour height exceeds 64 inches (1626 mm). In solid grouted masonry, cleanouts shall be spaced horizontally not more than 32 inches (813 mm) on center. The cleanouts shall be sealed before grouting and after inspection.

**R606.3.5.3 Construction.** Requirements for grouted masonry construction shall be as follows:

1. Masonry shall be built to preserve the unobstructed vertical continuity of the cells or spaces to be filled. In partially grouted construction, cross webs forming cells to be filled shall be full-bedded in mortar to prevent leakage of grout. Head and end joints shall be solidly filled with mortar for a distance in from the face of the wall or unit not less than the thickness of the longitudinal face shells.
2. Vertical reinforcement shall be held in position at top and bottom and at intervals not exceeding 200 diameters of the reinforcement.
3. Cells containing reinforcement shall be filled solidly with grout.
4. The thickness of grout or mortar between *masonry units* and reinforcement shall be not less than $^{1}/_{4}$ inch (6.4 mm), except that $^{1}/_{4}$-inch (6.4 mm) bars shall be permitted to be laid in horizontal mortar joints not less than $^{1}/_{2}$ inch (12.7 mm) thick, and steel wire reinforcement shall be permitted to be laid in horizontal mortar joints not less than twice the thickness of the wire diameter.

**TABLE R606.3.5.1**
**GROUT SPACE DIMENSIONS AND POUR HEIGHTS**

| GROUT TYPE | GROUT POUR MAXIMUM HEIGHT (feet) | MINIMUM WIDTH OF GROUT SPACES[a, b] (inches) | MINIMUM GROUT[b, c] SPACE DIMENSIONS FOR GROUTING CELLS OF HOLLOW UNITS (inches × inches) |
|---|---|---|---|
| Fine | 1 | 0.75 | 1.5 × 2 |
| | 5 | 2 | 2 × 3 |
| | 12 | 2.5 | 2.5 × 3 |
| | 24 | 3 | 3 × 3 |
| Coarse | 1 | 1.5 | 1.5 × 3 |
| | 5 | 2 | 2.5 × 3 |
| | 12 | 2.5 | 3 × 3 |
| | 24 | 3 | 3 × 4 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. For grouting between masonry wythes.

b. Grout space dimension is the clear dimension between any masonry protrusion and shall be increased by the horizontal projection of the diameters of the horizontal bars within the cross section of the grout space.

c. Area of vertical reinforcement shall not exceed 6 percent of the area of the grout space.

**R606.3.6 Grouted multiple-wythe masonry.** Grouted multiple-wythe masonry shall conform to all the requirements specified in Section R606.3.5 and the requirements of this section.

**R606.3.6.1 Bonding of backup wythe.** Where all interior vertical spaces are filled with grout in multiple-wythe construction, masonry headers shall not be permitted. Metal wall ties shall be used in accordance with Section R606.13.2 to prevent spreading of the wythes and to maintain the vertical alignment of the wall. Wall ties shall be installed in accordance with Section R606.13.2 where the backup wythe in multiple-wythe construction is fully grouted.

**R606.3.6.2 Grout barriers.** Vertical grout barriers or dams shall be built of *solid masonry* across the grout space the entire height of the wall to control the flow of the grout horizontally. Grout barriers shall be not more than 25 feet (7620 mm) apart. The grouting of any section of a wall between control barriers shall be completed in one day without interruptions greater than 1 hour.

**R606.3.7 Masonry bonding pattern.** Masonry laid in running and *stack bond* shall conform to Sections R606.3.7.1 and R606.3.7.2.

**R606.3.7.1 Masonry laid in running bond.** In each wythe of masonry laid in *running bond*, head joints in successive courses shall be offset by not less than one-fourth the unit length, or the masonry walls shall be reinforced longitudinally as required in Section R606.3.7.2.

**R606.3.7.2 Masonry laid in stack bond.** In unreinforced masonry where masonry units are laid in stack bond, longitudinal reinforcement consisting of not less than two continuous wires each with a minimum aggregate cross-sectional area of 0.017 square inch (11 $mm^2$) shall be provided in horizontal bed joints spaced not more than 16 inches (406 mm) on center vertically.

**R606.4 Thickness of masonry.** The nominal thickness of masonry walls shall conform to the requirements of Sections R606.4.1 through R606.4.4.

**R606.4.1 Minimum thickness.** The minimum thickness of masonry bearing walls more than one story high shall be 8 inches (203 mm). *Solid masonry* walls of one-story dwellings and garages shall be not less than 6 inches (152 mm) in thickness where not greater than 9 feet (2743 mm) in height, provided that where gable construction is used, an additional 6 feet (1829 mm) is permitted to the peak of the gable. Masonry walls shall be laterally supported in either the horizontal or vertical direction at intervals as required by Section R606.6.4.

**R606.4.2 Rubble stone masonry wall.** The minimum thickness of rough, random or coursed rubble stone masonry walls shall be 16 inches (406 mm).

**R606.4.3 Change in thickness.** Where walls of masonry of hollow units or masonry-bonded hollow walls are decreased in thickness, a course of *solid masonry* or *masonry units* filled with mortar or grout shall be constructed between the wall below and the thinner wall above, or special units or construction shall be used to transmit the loads from face shells or wythes above to those below.

**R606.4.4 Parapet walls.** Unreinforced *solid masonry* parapet walls shall be not less than 8 inches (203 mm) thick and their height shall not exceed four times their thickness. Unreinforced hollow unit masonry parapet walls shall be not less than 8 inches (203 mm) thick, and their height shall not exceed three times their thickness. Masonry parapet walls in areas subject to wind loads of 30 pounds per square foot (1.44 kPa) located on townhouses in *Seismic Design Category* C shall be reinforced in accordance with Section R606.12.

**R606.5 Corbeled masonry.** Corbeled masonry shall be in accordance with Sections R606.5.1 through R606.5.3.

**R606.5.1 Units.** *Solid masonry* units or masonry units filled with mortar or grout shall be used for corbeling.

**R606.5.2 Corbel projection.** The maximum projection of one unit shall not exceed one-half the height of the unit or one-third the thickness at right angles to the wall. The maximum corbeled projection beyond the face of the wall shall not exceed:

1. One-half of the wall thickness for ~~multi~~ multiple-wythe walls bonded by mortar or grout and wall ties or masonry headers.

2. One-half the wythe thickness for single wythe walls, masonry-bonded hollow walls, ~~multi~~ multiple-wythe walls with open collar joints and veneer walls.

**R606.5.3 Corbeled masonry supporting floor or roof-framing members.** Where corbeled masonry is used to support floor or roof-framing members, the top course of the corbel shall be a header course or the top course bed joint shall have ties to the vertical wall.

**R606.6 Support conditions.** Bearing and support conditions shall be in accordance with Sections R606.6.1 through R606.6.4.

**R606.6.1 Bearing on support.** Each masonry wythe shall be supported by not less than two-thirds of the wythe thickness.

**R606.6.2 Support at foundation.** Cavity wall or masonry veneer construction shall be permitted to be supported on an 8-inch (203 mm) foundation wall, provided the 8-inch (203 mm) wall is corbeled to the width of the wall system above with masonry constructed of *solid masonry* units or masonry units filled with mortar or grout. The total horizontal projection of the corbel shall not exceed 2 inches (51 mm) with individual corbels projecting not more than one-third the thickness of the unit or one-half the height of the unit. The hollow space behind the corbeled masonry shall be filled with mortar or grout.

**R606.6.3 Beam supports.** Beams, girders or other concentrated loads supported by a wall or column shall have a bearing of not less than 3 inches (76 mm) in length measured parallel to the beam on *solid masonry* not less than 4 inches (102 mm) in thickness, or on a metal bearing plate of adequate design and dimensions to distribute the load safely, or on a continuous reinforced masonry member projecting not less than 4 inches (102 mm) from the face of the wall.

**R606.6.3.1 Joist bearing.** Joists shall have a bearing of not less than $1^1/_2$ inches (38 mm), except as provided in Section R606.6.3, and shall be supported in accordance with Figure R606.11(1).

**R606.6.4 Lateral support.** Masonry walls shall be laterally supported in either the horizontal or the vertical direction. The maximum spacing between lateral supports shall not exceed the distances in Table R606.6.4. Lateral support shall be provided by cross walls, pilasters, buttresses or structural frame members where the limiting distance is taken horizontally, or by floors or roofs where the limiting distance is taken vertically.

**TABLE R606.6.4**
**SPACING OF LATERAL SUPPORT FOR MASONRY WALLS**

| CONSTRUCTION | MAXIMUM WALL LENGTH TO THICKNESS OR WALL HEIGHT TO THICKNESS[a, b] |
|---|---|
| Bearing walls: | |
| Solid or solid grouted | 20 |
| All other | 18 |
| Nonbearing walls: | |
| Exterior | 18 |
| Interior | 36 |

For SI: 1 foot = 304.8 mm.

a. Except for cavity walls and cantilevered walls, the thickness of a wall shall be its nominal thickness measured perpendicular to the face of the wall. For cavity walls, the thickness shall be determined as the sum of the nominal thicknesses of the individual wythes. For cantilever walls, except for parapets, the ratio of height to nominal thickness shall not exceed 6 for solid masonry, or 4 for hollow masonry. For parapets, see Section R606.4.4.

b. An additional unsupported height of 6 feet is permitted for gable end walls.

**R606.6.4.1 Horizontal lateral support.** Lateral support in the horizontal direction provided by intersecting masonry walls shall be provided by one of the methods in Section R606.6.4.1.1 or R606.6.4.1.2.

**R606.6.4.1.1 Bonding pattern.** Fifty percent of the units at the intersection shall be laid in an overlapping masonry bonding pattern, with alternate units having a bearing of not less than 3 inches (76 mm) on the unit below.

**R606.6.4.1.2 Metal reinforcement.** Interior nonload-bearing walls shall be anchored at their intersections, at vertical intervals of not more than 16 inches (406 mm) with joint reinforcement of not less than 9 gage [0.148 inch (4 mm)], or $^{1}/_{4}$-inch (6 mm) galvanized mesh hardware cloth. Intersecting masonry walls, other than interior nonload-bearing walls, shall be anchored at vertical intervals of not more than 8 inches (203 mm) with joint reinforcement of not less than 9 gage (4 mm) and shall extend not less than 30 inches (762 mm) in each direction at the intersection. Other metal ties, joint reinforcement or anchors, if used, shall be spaced to provide equivalent area of anchorage to that required by this section.

**R606.6.4.2 Vertical lateral support.** Vertical lateral support of masonry walls in *Seismic Design Category* A, B or C shall be provided in accordance with one of the methods in Section R606.6.4.2.1 or R606.6.4.2.2.

**R606.6.4.2.1 Roof structures.** Masonry walls shall be anchored to roof structures with metal strap anchors spaced in accordance with the manufacturer's instructions, $^{1}/_{2}$-inch (13 mm) bolts spaced not more than 6 feet (1829 mm) on center, or other *approved* anchors. Anchors shall be embedded not less than 16 inches (406 mm) into the masonry, or be hooked or welded to bond beam reinforcement placed not less than 6 inches (152 mm) from the top of the wall.

**R606.6.4.2.2 Floor diaphragms.** Masonry walls shall be anchored to floor *diaphragm* framing by metal strap anchors spaced in accordance with the manufacturer's instructions, $^{1}/_{2}$-inch-diameter (13 mm) bolts spaced at intervals not to exceed 6 feet (1829 mm) and installed as shown in Figure R606.11(1), or by other *approved* methods.

**R606.7 Piers.** The unsupported height of masonry piers shall not exceed 10 times their least dimension. Where structural clay tile or hollow *concrete masonry units* are used for isolated piers to support beams and girders, the cellular spaces shall be filled solidly with grout or Type M or S mortar, except that unfilled hollow piers shall be permitted to be used if their unsupported height is not more than four times their least dimension. Where *hollow masonry units* are solidly filled with grout or Type M, S or N mortar, the allowable compressive stress shall be permitted to be increased as provided in Table R606.9.

**R606.7.1 Pier cap.** Hollow piers shall be capped with 4 inches (102 mm) of solid masonry or concrete for one story and 8 inches (203 mm) of solid masonry or concrete for two stories and two and one-half stories or shall have cavities of the top course filled with concrete or grout or other approved methods.

**R606.8 Chases.** Chases and recesses in masonry walls shall not be deeper than one-third the wall ~~thickness, and the~~ thickness. The maximum length of a horizontal chase or horizontal projection shall not exceed 4 feet (1219 mm) and shall have not less than 8 inches (203 mm) of masonry in back of the chases and recesses and between adjacent chases or recesses and the jambs of openings. Chases and recesses in masonry walls shall be designed and constructed so as not to reduce the required strength or required fire resistance of the wall and ~~in no case~~ shall ~~a chase or recess~~ not be permitted within the required area of a pier. Masonry directly above chases or recesses wider than 12 inches (305 mm) shall be supported on noncombustible lintels.

**R606.9 Allowable stresses.** Allowable compressive stresses in masonry shall not exceed the values prescribed in Table R606.9. In determining the stresses in masonry, the effects of all loads and conditions of loading and the influence of all forces affecting the design and strength of the several parts shall be taken into account.

**R606.9.1 Combined units.** In walls or other structural members composed of different kinds or grades of units, materials or mortars, the maximum stress shall not exceed the allowable stress for the weakest of the combination of units, materials and mortars of which the member is composed. The net thickness of any facing unit that is used to resist stress shall be not less than $1^{1}/_{2}$ inches (38 mm).

**TABLE R606.9**

**ALLOWABLE COMPRESSIVE STRESSES FOR EMPIRICAL DESIGN OF MASONRY**

| | ALLOWABLE COMPRESSIVE STRESSES[a] GROSS CROSS-SECTIONAL AREA[b] |
|---|---|

| CONSTRUCTION; COMPRESSIVE STRENGTH OF UNIT, GROSS AREA | Type M or S mortar | Type N mortar |
|---|---|---|
| Solid masonry of brick and other solid units of clay or shale; sand-lime or concrete brick: | | |
| 8,000 + psi | 350 | 300 |
| 4,500 psi | 225 | 200 |
| 2,500 psi | 160 | 140 |
| 1,500 psi | 115 | 100 |
| Grouted[c] masonry, of clay or shale; sand-lime or concrete: | | |
| 4,500 + psi | 225 | 200 |
| 2,500 psi | 160 | 140 |
| 1,500 psi | 115 | 100 |
| Solid masonry of solid concrete masonry units: | | |
| 3,000 + psi | 225 | 200 |
| 2,000 psi | 160 | 140 |
| 1,200 psi | 115 | 100 |
| Masonry of hollow load-bearing units: | | |
| 2,000 + psi | 140 | 120 |
| 1,500 psi | 115 | 100 |
| 1,000 psi | 75 | 70 |
| 700 psi | 60 | 55 |
| Hollow walls (cavity or masonry bonded[d]) solid units: | | |
| 2,500 + psi | 160 | 140 |
| 1,500 psi | 115 | 100 |
| Hollow units | 75 | 70 |
| Stone ashlar masonry: | | |
| Granite | 720 | 640 |
| Limestone or marble | 450 | 400 |
| Sandstone or cast stone | 360 | 320 |
| Rubble stone masonry: | | |

| | | |
|---|---|---|
| Coarse, rough or random | 120 | 100 |

For SI: 1 pound per square inch = 6.895 kPa.

a. Linear interpolation shall be used for determining allowable stresses for masonry units having compressive strengths that are intermediate between those given in the table.

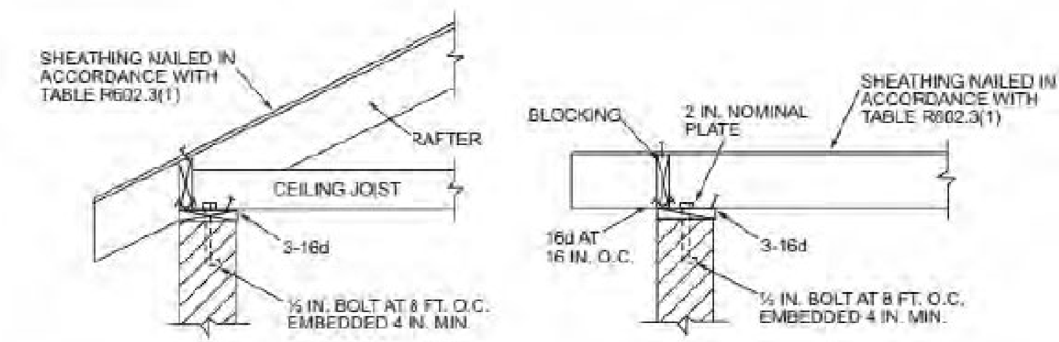
b. Gross cross-sectional area shall be calculated on the actual rather than nominal dimensions.

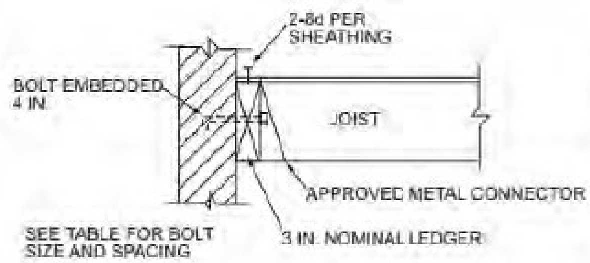
c. See Section R606.13.

d. Where floor and roof loads are carried ~~upon~~ on one wythe, the gross cross-sectional area is that of the wythe under load; if both wythes are loaded, the gross cross-sectional area is that of the wall minus the area of the cavity between the wythes. Walls bonded with metal ties shall be considered as cavity walls unless the collar joints are filled with mortar or grout.

**R606.10 Lintels.** Masonry over openings shall be supported by steel lintels, reinforced concrete or masonry lintels or masonry arches, designed to support load imposed.

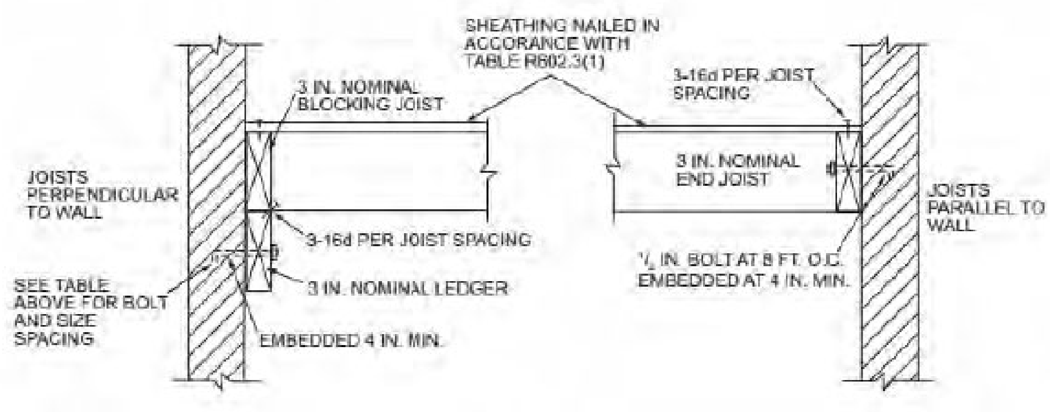
**R606.11 Anchorage.** Masonry walls shall be anchored to floor and roof systems in accordance with the details shown in Figure R606.11(1)~~,~~ or R606.11(2) ~~or R606.11(3)~~. Footings shall be permitted to be considered as points of lateral support.




**LEDGER BOLT SIZE AND SPACING**

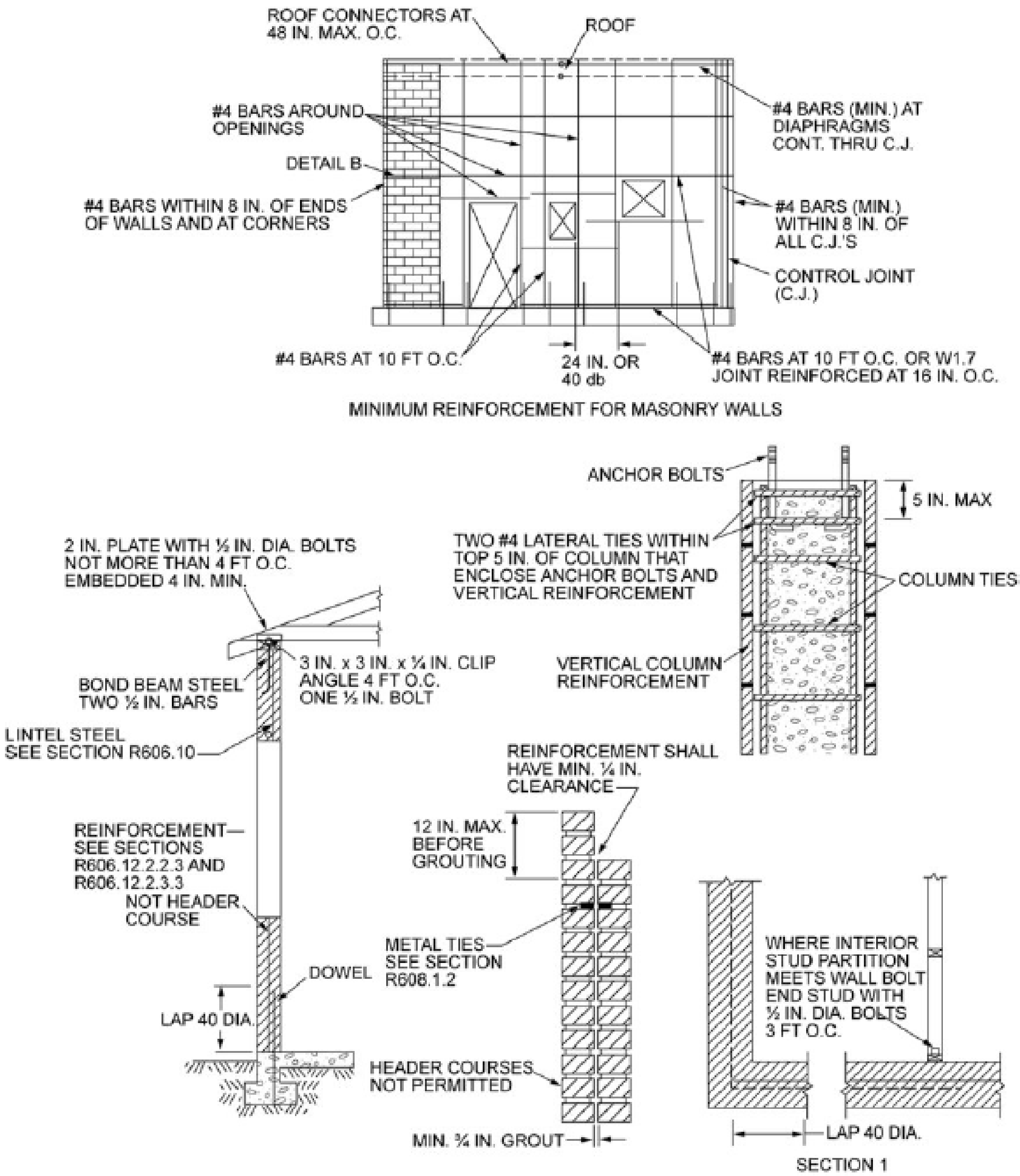
| JOIST SPAN | BOLT SIZE AND SPACING | |
|---|---|---|
| | ROOF | FLOOR |
| 10 FT. | 1/2 AT 2 FT. 6 IN.<br>7/8 AT 3 FT. 6 IN. | 1/2 AT 2 FT. 0 IN.<br>7/8 AT 2 FT. 9 IN. |
| 10—15 FT. | 1/2 AT 1 FT. 9 IN.<br>7/8 AT 2 FT. 6 IN. | 1/2 AT 1 FT. 4 IN.<br>7/8 AT 2 FT. 0 IN. |
| 15—20 FT. | 1/2 AT 1 FT. 3 IN.<br>7/8 AT 2 FT. 0 IN. | 1/2 AT 1 FT. 0 IN.<br>7/8 AT 1 FT. 6 IN. |




For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

**Note:** Where bolts are located in hollow masonry, the cells in the courses receiving the bolt shall be grouted solid.

**FIGURE R606.11(1)**
**ANCHORAGE REQUIREMENTS FOR MASONRY WALLS LOCATED IN SEISMIC DESIGN CATEGORY A, B OR C AND WHERE WIND LOADS ARE LESS THAN 30 PSF**




For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

**FIGURE R606.11(2)**
**REQUIREMENTS FOR REINFORCED GROUTED MASONRY CONSTRUCTION IN SEISMIC DESIGN CATEGORY C**

**R606.12 Seismic requirements.** Townhouses in *Seismic Design Category* C shall comply with the requirements of Section R606.12.2. These requirements shall not apply to glass unit masonry conforming to Section R610, anchored masonry veneer conforming to Section R703.8 or adhered masonry veneer conforming to Section R703.12.

**R606.12.1 General.** Masonry structures and masonry elements shall comply with the requirements of Sections R606.12.2 based on the seismic design category established in Table R301.2.1(1). Masonry structures and masonry elements shall comply with the requirements of Section R606.12 and Figures R606.11(1), and R606.11(2) or shall be designed in accordance with TMS ~~402/ACI 530/ASCE 5~~ 402 or TMS 403.

**R606.12.1.1 Floor and roof diaphragm construction.** Floor and roof *diaphragms* shall be constructed of *wood structural panels* attached to wood framing in accordance with Table R602.3(1) Additionally, sheathing panel edges perpendicular to framing members shall be backed by blocking, and sheathing shall be connected to the blocking with fasteners at the edge spacing. For *Seismic Design Categories* C, , where the width-to-thickness dimension of the *diaphragm* exceeds 2-to-1, edge spacing of fasteners shall be 4 inches (102 mm) on center.

**R606.12.2 Seismic Design Category C.** Townhouses located in *Seismic Design Category* C shall comply with the requirements of this section.

**R606.12.2.1 Minimum length of wall without openings.** Table R606.12.2.1 shall be used to determine the minimum required solid wall length without openings at each masonry exterior wall. The provided percentage of solid wall length shall include only those wall segments that are 3 feet (914 mm) or longer. The maximum clear distance between wall segments included in determining the solid wall length shall not exceed 18 feet (5486 mm). *Shear wall* segments required to meet the minimum wall length shall be in accordance with Section R606.12.2.2.3.

**TABLE R606.12.2.1**
**MINIMUM SOLID WALL LENGTH ALONG EXTERIOR WALL LINES**

| SESIMIC DESIGN CATEGORY | MINIMUM SOLID WALL LENGTH (percent)[a] | | |
|---|---|---|---|
| | One story or top story of two story | Wall supporting light-frame second story and roof | Wall supporting masonry second story and roof |
| Townhouses in C | 20 | 25 | 35 |

NP = Not Permitted, except with design in accordance with the *International Building Code*.

a. For all walls, the minimum required length of solid walls shall be based on the table percent multiplied by the dimension, parallel to the wall direction under consideration, of a rectangle inscribing the overall building plan.

**R606.12.2.2 Design of elements not part of the lateral force-resisting system.**

**R606.12.2.2.1 Load-bearing frames or columns.** Elements not part of the lateral force-resisting system shall be analyzed to determine their effect on the response of the system. The frames or columns shall be adequate for vertical load-carrying capacity and induced moment caused by the design *story* drift.

**R606.12.2.2.2 Masonry partition walls.** Masonry partition walls, masonry screen walls and other masonry elements that are not designed to resist vertical or lateral loads, other than those induced by their own weight, shall be isolated from the structure so that vertical and lateral forces are not imparted to these elements. Isolation joints and connectors between these elements and the structure shall be designed to accommodate the design *story* drift.

**R606.12.2.2.3 Reinforcement requirements for masonry elements.** Masonry elements listed in Section R606.12.2.2.2 shall be reinforced in either the horizontal or vertical direction as shown in Figure R606.11(2) and in accordance with the following:

1. Horizontal reinforcement. Horizontal joint reinforcement shall consist of not less than two longitudinal W1.7 wires spaced not more than 16 inches (406 mm) for walls greater than 4 inches (102 mm) in width and not less than one longitudinal W1.7 wire spaced not more than 16 inches (406 mm) for walls not exceeding 4 inches (102 mm) in width; or not less than one No. 4 bar spaced not more than 48 inches (1219 mm). Where two longitudinal wires of joint reinforcement are used, the space between these wires shall be the widest that the mortar joint will accommodate. Horizontal reinforcement shall be provided within 16 inches (406 mm) of the top and bottom of these masonry elements.

2. Vertical reinforcement. Vertical reinforcement shall consist of not less than one No. 4 bar spaced not more than 48 inches (1219 mm). Vertical reinforcement shall be located within 16 inches (406 mm) of the ends of masonry walls.

**R606.12.2.3 Design of elements part of the lateral force-resisting system.**

**R606.12.2.3.1 Connections to masonry shear walls.** Connectors shall be provided to transfer forces between masonry walls and horizontal elements in accordance with the requirements of Section 4.1.4 of TMS ~~402/ACI 530/ASCE 5~~ 402. Connectors shall be designed to transfer horizontal design forces acting either perpendicular or parallel to the wall, but not less than 200 pounds per linear foot (2919 N/m) of wall. The maximum spacing between connectors shall be 4 feet (1219 mm). Such anchorage mechanisms shall not induce tension stresses perpendicular to grain in ledgers or nailers.

**R606.12.2.3.2 Connections to masonry columns.** Connectors shall be provided to transfer forces between masonry columns and horizontal elements in accordance with the requirements of Section 4.1.4 of TMS ~~402/ACI 530/ASCE 5~~ 402. Where anchor bolts are used to connect horizontal elements to the tops of columns, the bolts shall be placed within lateral ties. Lateral ties shall enclose both the vertical bars in the column and the anchor bolts. There shall be not less than two No. 4 lateral ties provided in the top 5 inches (127 mm) of the column.

**R606.12.2.3.3 Minimum reinforcement requirements for masonry shear walls.** Vertical reinforcement of not less than one No. 4 bar shall be provided at corners, within 16 inches (406 mm) of each side of openings, within 8 inches (203 mm) of each side of movement joints, within 8 inches (203 mm) of the ends of walls, and at a maximum spacing of 10 feet (3048 mm).

Horizontal joint reinforcement shall consist of not less than two wires of W1.7 spaced not more than 16 inches (406 mm); or bond beam reinforcement of not less than one No. 4 bar spaced not more than 10 feet (3048 mm) shall be provided. Horizontal reinforcement shall be provided at the bottom and top of wall openings and shall extend not less than 24 inches (610 mm) nor less than 40 bar diameters past the opening; continuously at structurally connected roof and floor levels; and within 16 inches (406 mm) of the top of walls.

**R606.12.3 Seismic Design Category $D_0$ or $D_1$.** Deleted.

**R606.13 Multiple-wythe masonry.** The facing and backing of multiple-wythe masonry walls shall be bonded in accordance with Section R606.13.1, R606.13.2 or R606.13.3. In cavity walls, neither the facing nor the backing shall be less than 3 inches (76 mm) nominal in thickness and the cavity shall be not more than 4 inches (102 mm) nominal in width. The backing shall ~~be~~ not be less than ~~as thick as~~ the thickness of the facing.

**Exception:** Cavities shall be permitted to exceed the 4-inch (102 mm) nominal dimension provided that tie size and tie spacing have been established by calculation.

**R606.13.1 Bonding with masonry headers.** Bonding with solid or *hollow masonry* headers shall comply with Sections R606.13.1.1 and R606.13.1.2.

**R606.13.1.1 Solid units.** Where the facing and backing (adjacent wythes) of *solid masonry* construction are bonded by means of masonry headers, not less than 4 percent of the wall surface of each face shall be composed of headers extending not less than 3 inches (76 mm) into the backing. The distance between adjacent full-length headers shall not exceed 24 inches (610 mm) either vertically or horizontally. In walls in which a single header does not extend through the wall, headers from the opposite sides shall overlap not less than 3 inches (76 mm), or headers from opposite sides shall be covered with another header course overlapping the header below not less than 3 inches (76 mm).

**R606.13.1.2 Hollow units.** Where two or more hollow units are used to make up the thickness of a wall, the stretcher courses shall be bonded at vertical intervals not exceeding 34 inches (864 mm) by lapping not less than 3 inches (76 mm) over the unit below, or by lapping at vertical intervals not exceeding 17 inches (432 mm) with units that are not less than 50 percent thicker than the units below.

**R606.13.2 Bonding with wall ties or joint reinforcement.** Bonding with wall ties or joint reinforcement shall comply with Section R606.13.2.3.

**R606.13.2.1 Bonding with wall ties.** Bonding with wall ties, except as required by Section R607, where the facing and backing (adjacent wythes) of masonry walls are bonded with $^{3}/_{16}$-inch-diameter (5 mm) wall ties embedded in the horizontal mortar joints, there shall be not less than one metal tie for each $4^{1}/_{2}$ square feet (0.418 m$^2$) of wall area. Ties in alternate courses shall be staggered. The maximum vertical distance between ties shall not exceed 24 inches (610 mm), and the maximum horizontal distance shall not exceed 36 inches (914 mm). Rods or ties bent to rectangular shape shall be used with *hollow masonry units* laid with the cells vertical. In other walls, the ends of ties shall be bent to 90-degree (0.79 rad) angles to provide hooks not less than 2 inches (51 mm) long. Additional bonding ties shall be provided at all openings, spaced not more than 3 feet (914 mm) apart around the perimeter and within 12 inches (305 mm) of the opening.

**R606.13.2.2 Bonding with adjustable wall ties.** Where the facing and backing (adjacent wythes) of masonry are bonded with adjustable wall ties, there shall be not less than one tie for each 2.67 square feet (0.248 m$^2$) of wall area. Neither the vertical nor the horizontal spacing of the adjustable wall ties shall exceed 24 inches (610 mm). The maximum vertical offset of bed joints from one wythe to the other shall be 1.25 inches (32 mm). The maximum clearance between connecting parts of the ties shall be $^{1}/_{16}$ inch (2 mm). Where pintle legs are used, ties shall have not less than two $^{3}/_{16}$-inch-diameter (5 mm) legs.

**R606.13.2.3 Bonding with prefabricated joint reinforcement.** Where the facing and backing (adjacent wythes) of masonry are bonded with prefabricated joint reinforcement, there shall be not less than one cross wire serving as a tie for each 2.67 square feet (0.248 m$^2$) of wall area. The vertical spacing of the joint reinforcement shall not exceed 16 inches (406 mm). Cross wires on prefabricated joint reinforcement shall not be smaller than No. 9 gage. The longitudinal wires shall be embedded in the mortar.

**R606.13.3 Bonding with natural or cast stone.** Bonding with natural and cast stone shall conform to Sections R606.13.3.1 and R606.13.3.2.

**R606.13.3.1 Ashlar masonry.** In ashlar masonry, bonder units, uniformly distributed, shall be provided to the extent of not less than 10 percent of the wall area. Such bonder units shall extend not less than 4 inches (102 mm) into the backing wall.

**R606.13.3.2 Rubble stone masonry.** Rubble stone masonry 24 inches (610 mm) or less in thickness shall have bonder units with a maximum spacing of 3 feet (914 mm) vertically and 3 feet (914 mm) horizontally, and if the masonry is of greater thickness than 24 inches (610 mm), shall have one bonder unit for each 6 square feet (0.557 m$^2$) of wall surface on both sides.

**R606.14 Anchored and adhered masonry veneer.**

**R606.14.1 Anchored veneer.** Anchored masonry veneer installed over a backing of wood or cold-formed steel shall meet the requirements of Section R703.8.

**R606.14.2 Adhered veneer.** Adhered masonry veneer shall be installed in accordance with the requirements of Section R703.12.

## SECTION R607
## GLASS UNIT MASONRY

**R607.1 General.** Panels of glass unit masonry located in load-bearing and non load-bearing exterior and interior walls shall be constructed in accordance with this section.

**R607.2 Materials.** Hollow glass units shall be partially evacuated and have a minimum average glass face thickness of $^{3}/_{16}$ inch (5 mm). The surface of units in contact with mortar shall be treated with a polyvinyl butyral coating or latex-based paint. The use of reclaimed units is prohibited.

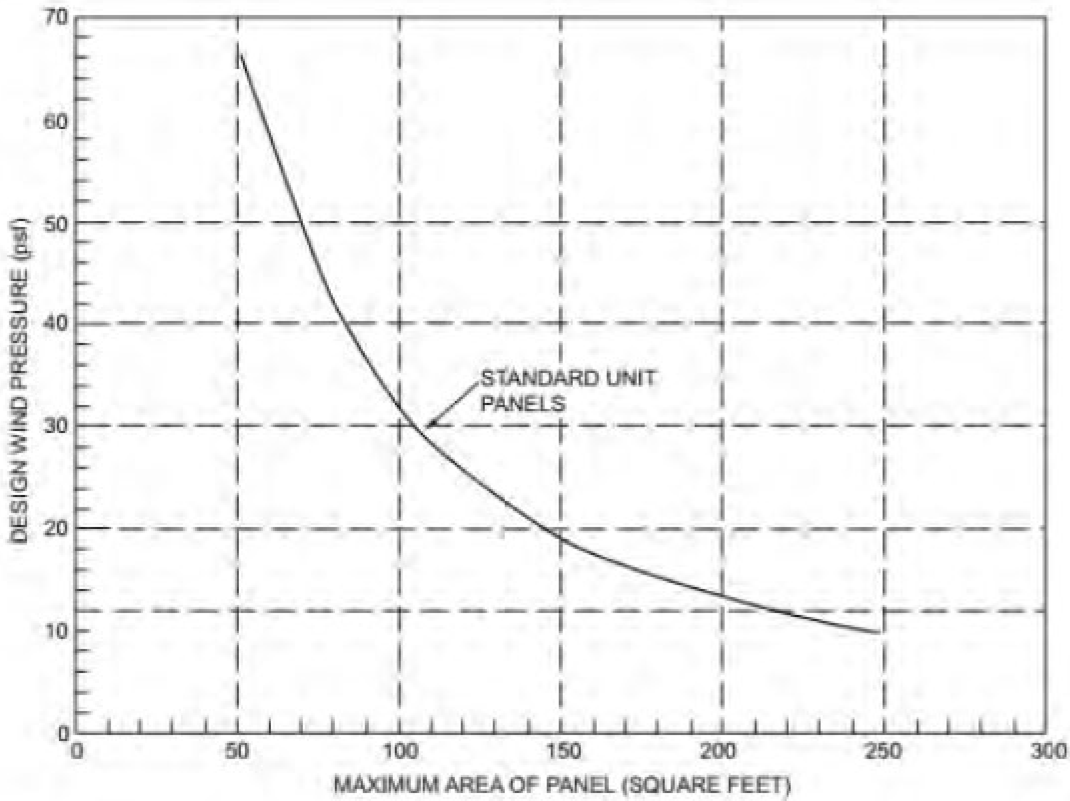
**R607.3 Units.** Hollow or solid glass block units shall be standard or thin units.

**R607.3.1 Standard units.** The specified thickness of standard units shall be not less than $3^{7}/_{8}$ inches (98 mm).

**R607.3.2 Thin units.** The specified thickness of thin units shall be not less than $3^{1}/_{8}$ inches (79 mm) for hollow units and not less than 3 inches (76 mm) for solid units.

**R607.4 Isolated panels.** Isolated panels of glass unit masonry shall conform to the requirements of this section.

**R607.4.1 Exterior standard-unit panels.** The maximum area of each individual standard-unit panel shall be 144 square feet (13.4 $m^2$) where the design wind pressure is 20 pounds per square foot (958 Pa). The maximum area of such panels subjected to design wind pressures other than 20 pounds per square foot (958 Pa) shall be in accordance with Figure R607.4.1. The maximum panel dimension between structural supports shall be 25 feet (7620 mm) in width or 20 feet (6096 mm) in height.




For SI: 1 square foot = 0.0929 $m^2$, 1 pound per square foot = 0.0479 kPa.

**FIGURE R607.4.1**
**GLASS UNIT MASONRY DESIGN WIND LOAD RESISTANCE**

**R607.4.2 Exterior thin-unit panels.** The maximum area of each individual thin-unit panel shall be 85 square feet (7.9 $m^2$). The maximum dimension between structural supports shall be 15 feet (4572 mm) in width or 10 feet (3048 mm) in height. Thin units shall not be used in applications where the design wind pressure as stated in Table R301.2.1(1) exceeds 20 pounds per square foot (958 Pa).

**R607.4.3 Interior panels.** The maximum area of each individual standard-unit panel shall be 250 square feet (23.2 $m^2$). The maximum area of each thin-unit panel shall be 150 square feet (13.9 $m^2$). The maximum dimension between structural supports shall be 25 feet (7620 mm) in width or 20 feet (6096 mm) in height.

**R607.4.4 Curved panels.** The width of curved panels shall conform to the requirements of Sections R607.4.1, R607.4.2 and R607.4.3, except additional structural supports shall be provided at locations where a curved section joins a straight section, and at inflection points in multiple-curve walls.

**R607.5 Panel support.** Glass unit masonry panels shall conform to the support requirements of this section.

**R607.5.1 Deflection.** The maximum total deflection of structural members that support glass unit masonry shall not exceed $^1/_{600}$.

**R607.5.2 Lateral support.** Glass unit masonry panels shall be laterally supported along the top and sides of the panel. Lateral supports for glass unit masonry panels shall be designed to resist not less than 200 pounds per lineal feet (2918 N/m) of panel, or the actual applied loads, whichever is greater. Except for single-unit panels, lateral support shall be provided by panel anchors along the top and sides spaced not greater than 16 inches (406 mm) on center or by channel-type restraints. Single-unit panels shall be supported by channel-type restraints.

**Exceptions:**

1. Lateral support is not required at the top of panels that are one unit wide.
2. Lateral support is not required at the sides of panels that are one unit high.

**R607.5.2.1 Panel anchor restraints.** Panel anchors shall be spaced not greater than 16 inches (406 mm) on center in both jambs and across the head. Panel anchors shall be embedded not less than 12 inches (305 mm) and shall be provided with two fasteners so as to resist the loads specified in Section R607.5.2.

**R607.5.2.2 Channel-type restraints.** Glass unit masonry panels shall be recessed not less than 1 inch (25 mm) within channels and chases. Channel-type restraints shall be oversized to accommodate expansion material in the opening, packing and sealant between the framing restraints, and the glass unit masonry perimeter units.

**R607.6 Sills.** Before the bedding of glass units, the sill area shall be covered with a ~~water base~~ water-base asphaltic emulsion coating. The coating shall be not less than $^1/_8$ inch (3 mm) thick.

**R607.7 Expansion joints.** Glass unit masonry panels shall be provided with expansion joints along the top and sides at all structural supports. Expansion joints shall be not less than $^3/_8$ inch (10 mm) in thickness and shall have sufficient thickness to accommodate displacements of the supporting structure. Expansion joints shall be entirely free of mortar and other debris and shall be filled with resilient material.

**R607.8 Mortar.** Glass unit masonry shall be laid with Type S or N mortar. Mortar shall not be retempered after initial set. Mortar unused within $1^1/_2$ hours after initial mixing shall be discarded.

**R607.9 Reinforcement.** Glass unit masonry panels shall have horizontal joint reinforcement spaced not greater than 16 inches (406 mm) on center located in the mortar bed joint. Horizontal joint reinforcement shall extend the entire length of the panel but shall not extend across expansion joints. Longitudinal wires shall be lapped not less than 6 inches (152 mm) at splices. Joint reinforcement shall be placed in the bed joint immediately below and above openings in the panel. The reinforcement shall have not less than two parallel longitudinal wires of size W1.7 or greater, and have welded cross wires of size W1.7 or greater.

**R607.10 Placement.** Glass units shall be placed so head and bed joints are filled solidly. Mortar shall not be furrowed. Head and bed joints of glass unit masonry shall be $^1/_4$ inch (6.4 mm) thick, except that vertical joint thickness of radial panels shall be not less than $^1/_8$ inch (3 mm) or greater than $^5/_8$ inch (16 mm). The bed joint thickness tolerance shall be minus $^1/_{16}$ inch (1.6 mm) and plus $^1/_8$ inch (3 mm). The head joint thickness tolerance shall be plus or minus $^1/_8$ inch (3 mm).

## SECTION R608
## EXTERIOR CONCRETE WALL CONSTRUCTION

**R608.1 General.** Exterior concrete walls shall be designed and constructed in accordance with the provisions of this section or in accordance with the provisions of PCA 100, ACI 318 or ACI 332. Where PCA 100, ACI 318, ACI 332 or the provisions of this section are used to design concrete walls, project drawings, typical details and specifications are not required to bear the seal of the *registered design professional* responsible for design, unless otherwise required by the state law of the *jurisdiction* having authority.

**R608.1.1 Interior construction.** These provisions are based on the assumption that interior walls and partitions, both load-bearing and nonload-bearing, floors and roof/ceiling assemblies are constructed of *light-frame construction* complying with the limitations of this code and the additional limitations of Section R608.2. Design and construction of light-frame assemblies shall be in accordance with the applicable provisions of this code. Where second-story exterior walls are of *light-frame construction*, they shall be designed and constructed as required by this code.

Aspects of concrete construction not specifically addressed by this code, including interior concrete walls, shall comply with ACI 318.

**R608.1.2 Other concrete walls.** Exterior concrete walls constructed in accordance with this code shall comply with the shapes and minimum concrete cross-sectional dimensions of Table R608.3. Other types of forming systems resulting in concrete walls not in compliance with this section shall be designed in accordance with ACI 318.

**R608.2 Applicability limits.** The provisions of this section shall apply to the construction of exterior concrete walls for buildings not greater than 60 feet (18 288 mm) in plan dimensions, floors with clear spans not greater than 32 feet (9754 mm) and roofs with clear spans not greater than 40 feet (12 192 mm). Buildings shall not exceed 35 feet (10 668 mm) in mean roof height or two stories in height above grade. Floor/ceiling dead loads shall not exceed 10 pounds per square foot (479 Pa), roof/ceiling dead loads shall not exceed 15 pounds per square foot (718 Pa) and attic live loads shall not exceed 20 pounds per square foot (958 Pa). Roof overhangs shall not exceed 2 feet (610 mm) of horizontal projection beyond the exterior wall and the dead load of the overhangs shall not exceed 8 pounds per square foot (383 Pa).

Walls constructed in accordance with the provisions of this section shall be limited to buildings subjected to a maximum design wind speed of 160 mph (72 m/s) Exposure B, 136 mph (61 m/s) Exposure C and 125 mph (56 m/s) Exposure D. Walls constructed in accordance with the provisions of this section shall be limited to detached one- and two-family *dwellings* and townhouses assigned to *Seismic Design Category* A or B, and detached one- and two-family *dwellings* assigned to *Seismic Design Category* C.

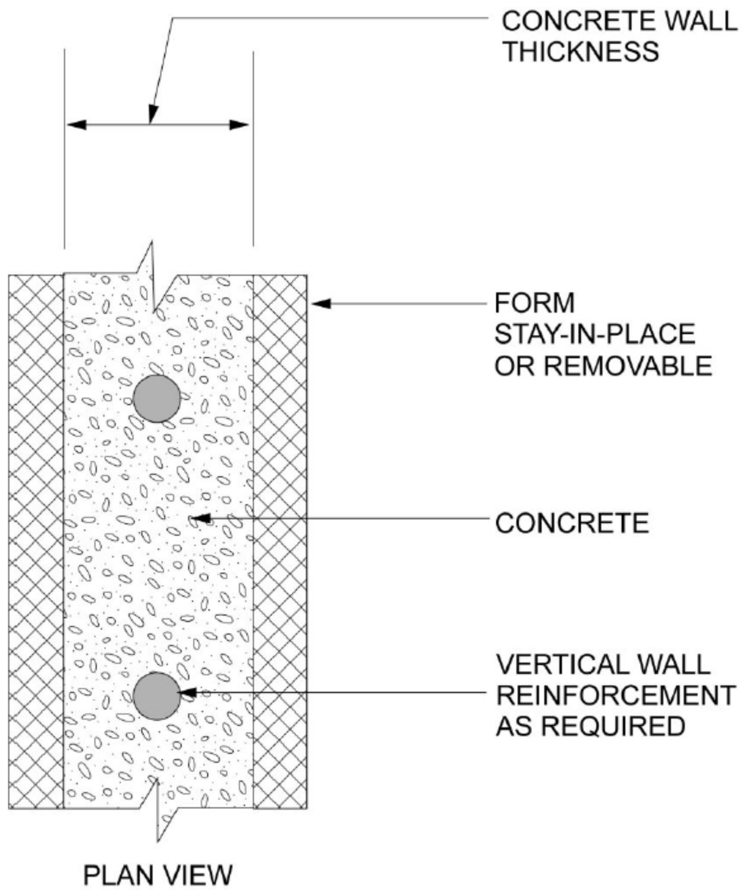
Buildings that are not within the scope of this section shall be designed in accordance with PCA 100 or ACI 318.

**R608.3 Concrete wall systems.** Concrete walls constructed in accordance with these provisions shall comply with the shapes and minimum concrete cross-sectional dimensions of Table R608.3.

**R608.3.1 Flat wall systems.** Flat concrete wall systems shall comply with Table R608.3 and Figure R608.3(1) and have a minimum nominal thickness of 4 inches (102 mm).

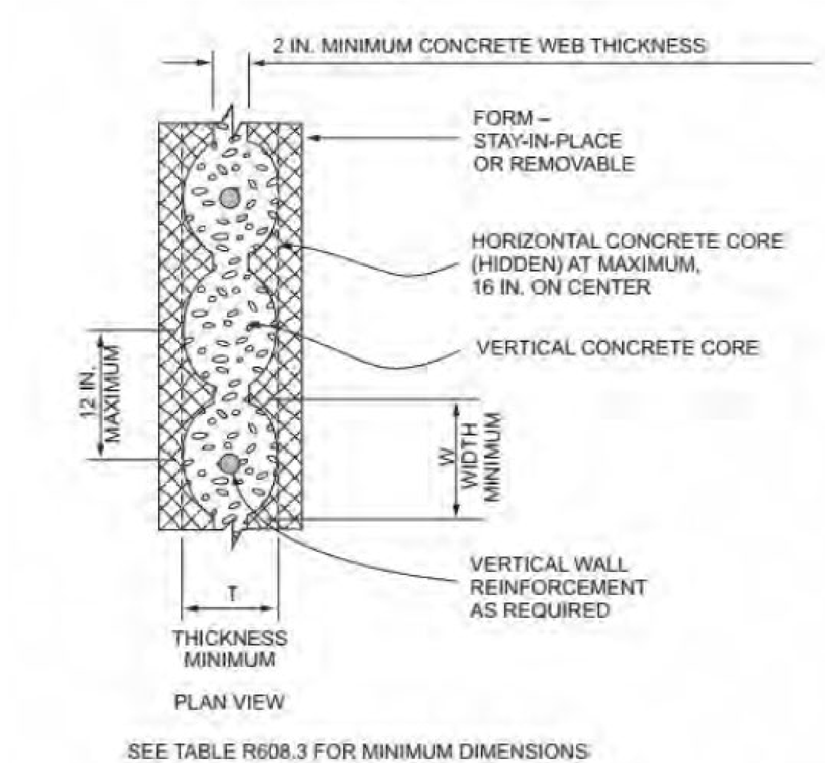
**R608.3.2 Waffle-grid wall systems.** Waffle-grid wall systems shall comply with Table R608.3 and Figure R608.3(2) and shall have a minimum nominal thickness of 6 inches (152 mm) for the horizontal and vertical concrete members (cores). The core and web dimensions shall comply with Table R608.3. The maximum weight of waffle-grid walls shall comply with Table R608.3.

**R608.3.3 Screen-grid wall systems.** Screen-grid wall systems shall comply with Table R608.3 and Figure R608.3(3) and shall have a minimum nominal thickness of 6 inches (152 mm) for the horizontal and vertical concrete members (cores). The core dimensions shall comply with Table R608.3. The maximum weight of screen-grid walls shall comply with Table R608.3.



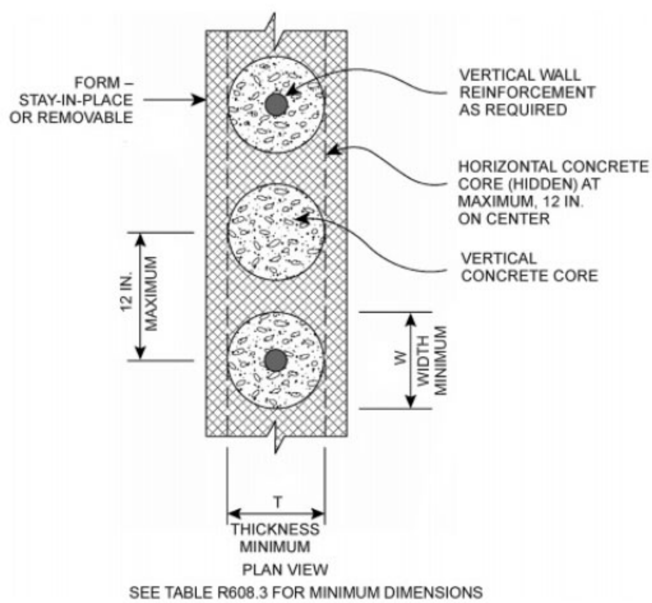

SEE TABLE R608.3 FOR MINIMUM DIMENSIONS

**FIGURE R608.3(1)**
**FLAT WALL SYSTEM**




For SI: 1 inch = 25.4 mm.

**FIGURE R608.3(2)**
**WAFFLE-GRID WALL SYSTEM**




For SI: 1 inch = 25.4 mm.

**FIGURE R608.3(3)**
**SCREEN-GRID WALL SYSTEM**

**TABLE R608.3**
**DIMENSIONAL REQUIREMENTS FOR WALLS[a]**

| WALL TYPE AND NOMINAL THICKNESS | MAXIMUM WALL WEIGHT[b] (psf) | MINIMUM WIDTH, W, OF VERTICAL CORES (inches) | MINIMUM THICKNESS, T, OF VERTICAL CORES (inches) | MAXIMUM SPACING OF VERTICAL CORES (inches) | MAXIMUM SPACING OF HORIZONTAL CORES (inches) | MINIMUM WEB THICKNESS (inches) |
|---|---|---|---|---|---|---|
| 4″ Flat[c] | 50 | NA | NA | NA | NA | NA |
| 6″ Flat[c] | 75 | NA | NA | NA | NA | NA |
| 8″ Flat[c] | 100 | NA | NA | NA | NA | NA |
| 10″ Flat[c] | 125 | NA | NA | NA | NA | NA |
| 6″ Waffle-grid | 56 | 8[d] | 5.5[d] | 12 | 16 | 2 |
| 8″ Waffle-grid | 76 | 8[e] | 8[e] | 12 | 16 | 2 |
| 6″ Screen-grid | 53 | 6.25[f] | 6.25[f] | 12 | 12 | NA |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per cubic foot = 2402.77 kg/m$^3$, 1 square inch = 645.16 mm$^2$, 1 inch$^4$ = 42 cm$^4$.

NA = Not Applicable.

a. Width "W," thickness "T," spacing and web thickness, refer to Figures R608.3(2) and R608.3(3).

~~c.~~ b. Wall weight is based on a unit weight of concrete of 150 pcf. For flat walls the weight is based on the nominal thickness. The tabulated values do not include any allowance for interior and exterior finishes.

~~d.~~ c. Nominal wall thickness. The actual as-built thickness of a flat wall shall not be more than $^1/_2$ inch less or more than $^1/_4$ inch more than the nominal dimension indicated.

~~e.~~ d. Vertical core is assumed to be elliptical-shaped. Another shape of core is permitted provided the minimum thickness is 5 inches, the moment of inertia, *I*, about the centerline of the wall (ignoring the web) is not less than 65 inch$^4$, and the area, *A*, is not less than 31.25 square inches. The width used to calculate *A* and *I* shall not exceed 8 inches.

~~f.~~ e. Vertical core is assumed to be circular. Another shape of core is permitted provided the minimum thickness is 7 inches, the moment of inertia, *I*, about the centerline of the wall (ignoring the web) is not less than 200 inch$^4$, and the area, *A*, is not less than 49 square inches. The width used to calculate *A* and *I* shall not exceed 8 inches.

~~g.~~ f. Vertical core is assumed to be circular. Another shape of core is permitted provided the minimum thickness is 5.5 inches, the moment of inertia, *I*, about the centerline of the wall is not less than 76 inch$^4$, and the area, *A*, is not less than 30.25 square inches. The width used to calculate *A* and *I* shall not exceed 6.25 inches.

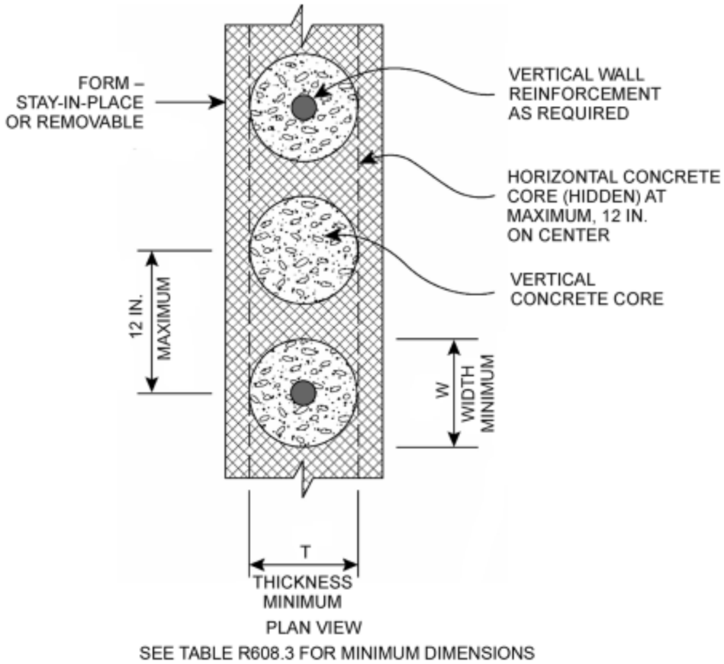



**FIGURE ~~R6083(2)~~R608.3(2)**
**WAFFLE-GRID WALL SYSTEM**

**R608.4 Stay-in-place forms.** Stay-in-place concrete forms shall comply with this section.

**R608.4.1 Surface burning characteristics.** The flame spread index and *smoke-developed index* of forming material, other than foam plastic, left exposed on the interior shall comply with Section R302.9. The surface burning characteristics of foam plastic used in *insulating concrete forms* shall comply with Section R316.3.

**R608.4.2 Interior covering.** Stay-in-place forms constructed of rigid foam plastic shall be protected on the interior of the building as required by Sections R316.4 and R702.3.4. Where gypsum board is used to protect the foam plastic, it shall be installed with a mechanical fastening system. Use of adhesives is permitted in addition to mechanical fasteners.

**R608.4.3 Exterior wall covering.** Stay-in-place forms constructed of rigid foam plastics shall be protected from sunlight and physical damage by the application of an *approved* exterior wall covering complying with this code. Exterior surfaces of other stay-in-place forming systems shall be protected in accordance with this code.

Requirements for installation of masonry veneer, stucco and other finishes on the exterior of concrete walls and other construction details not covered in this section shall comply with the requirements of this code.

**R608.4.4 Flat ICF wall systems.** Flat ICF wall system forms shall conform to ASTM E2634.

**R608.5 Materials.** Materials used in the construction of concrete walls shall comply with this section.

**R608.5.1 Concrete and materials for concrete.** Materials used in concrete, and the concrete itself, shall conform to requirements of this section, PCA 100, ACI 318 or ACI 332.

**R608.5.1.1 Cements.** The following standards as referenced in Chapter 44 shall be permitted to be used:

1. ASTM C150
2. ASTM C595
3. ASTM C1157

**R608.5.1.2 Concrete mixing and delivery.** Mixing and delivery of concrete shall comply with ASTM C94 or ASTM C685.

**R608.5.1.3 Maximum aggregate size.** The nominal maximum size of coarse aggregate shall not exceed one-fifth the narrowest distance between sides of forms, or three-fourths the clear spacing between reinforcing bars or between a bar and the side of the form.

**Exception:** When *approved*, these limitations shall not apply where removable forms are used and workability and methods of consolidation permit concrete to be placed without honeycombs or voids.

**R608.5.1.4 Proportioning and slump of concrete.** Proportions of materials for concrete shall be established to provide workability and consistency to permit concrete to be worked readily into forms and around reinforcement under conditions of placement to be employed, without segregation or excessive bleeding. Slump of concrete placed in removable forms shall not exceed 6 inches (152 mm).

**Exception:** When *approved*, the slump is permitted to exceed 6 inches (152 mm) for concrete mixtures that are resistant to segregation, and are in accordance with the form manufacturer's recommendations.

Slump of concrete placed in stay-in-place forms shall exceed 6 inches (152 mm). Slump of concrete shall be determined in accordance with ASTM C143.

**R608.5.1.5 Compressive strength.** The minimum specified compressive strength of concrete, $f'_c$, shall comply with Section R402.2 and shall be not less than 2,500 pounds per square inch (17.2 MPa) at 28 days.

**R608.5.1.6 Consolidation of concrete.** Concrete shall be consolidated by suitable means during placement and shall be worked around embedded items and reinforcement and into corners of forms. Where stay-in-place forms are used, concrete shall be consolidated by internal vibration.

**Exception:** When *approved*, self-consolidating concrete mixtures with slumps equal to or greater than 8 inches (203 mm) that are specifically designed for placement without internal vibration need not be internally vibrated.

**R608.5.2 Steel reinforcement and anchor bolts.**

**R608.5.2.1 Steel reinforcement.** Steel reinforcement shall comply with ASTM A615, ASTM A706, or ASTM A996. ASTM A996 bars produced from rail steel shall be Type R.

**R608.5.2.2 Anchor bolts.** Anchor bolts for use with connection details in accordance with Figures R608.9(1) through R608.9(~~12~~ 4) and R608.9(9) through R608.9(10) shall be bolts with heads complying with ASTM A307 or ASTM F1554. ASTM A307 bolts shall be Grade A with heads. ASTM F1554 bolts shall be Grade 36 minimum. Instead of bolts with heads, it is permissible to use rods with threads on both ends fabricated from steel complying with ASTM A36. The threaded end of the rod to be embedded in the concrete shall be provided with a hex or square nut.

**R608.5.2.3 Sheet steel angles and tension tie straps.** Angles and tension tie straps for use with connection details in accordance with Figures R608.9(1) through R608.9(~~12~~ 4) and R608.9(9) through R608.9(10) shall be fabricated from sheet steel complying with ASTM A653 SS, ASTM A792 SS, or ASTM A875 SS. The steel shall be minimum Grade 33 unless a higher grade is required by the applicable figure.

**TABLE R608.5.4(1)**
**LAP SPLICE AND TENSION DEVELOPMENT LENGTHS**

| | BAR SIZE NO. | YIELD STRENGTH OF STEEL, $f_y$ psi (MPa) | |
|---|---|---|---|
| | | 40,000 (280) | 60,000 (420) |
| | | Splice length or tension development length (inches) | |
| Lap splice length-tension | 4 | 20 | 30 |
| | 5 | 25 | 38 |
| | 6 | 30 | 45 |
| Tension development length for straight bar | 4 | 15 | 23 |
| | 5 | 19 | 28 |

| | | | |
|---|---|---|---|
| | 6 | 23 | 34 |
| Tension development length for:<br>a. 90-degree and 180-degree standard hooks with not less than $2^1/_2$ inches of side cover perpendicular to plane of hook.<br>b. 90-degree standard hooks with not less than 2 inches of cover on the bar extension beyond the hook. | 4 | 6 | 9 |
| | 5 | 7 | 11 |
| | 6 | 8 | 13 |
| Tension development length for bar with 90-degree or 180-degree standard hook having less cover than required in Items a and b. | 4 | 8 | 12 |
| | 5 | 10 | 15 |
| | 6 | 12 | 18 |

For SI: 1 inch = 25.4 mm, 1 degree = 0.0175 rad, 1 pound per square inch = 6.895 kPa.

**TABLE R608.5.4(2)**

**MAXIMUM SPACING FOR ALTERNATIVE BAR SIZE AND~~/OR~~ ALTERNATIVE GRADE OF STEEL[a, b, c]**

| BAR SPACING FROM APPLICABLE TABLE IN SECTION R608.6 (inches) | BAR SIZE FROM APPLICABLE TABLE IN SECTION R608.6 | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #4 | | | | | #5 | | | | | #6 | | | | |
| | Alternative bar size and~~/or~~ alternative grade of steel desired | | | | | | | | | | | | | | |
| | Grade 60 | | Grade 40 | | | Grade 60 | | Grade 40 | | | Grade 60 | | Grade 40 | | |
| | #5 | #6 | #4 | #5 | #6 | #4 | #6 | #4 | #5 | #6 | #4 | #5 | #4 | #5 | #6 |
| | Maximum spacing for alternative bar size and~~/or~~ alternative grade of steel (inches) | | | | | | | | | | | | | | |
| 8 | 12 | 18 | 5 | 8 | 12 | 5 | 11 | 3 | 5 | 8 | 4 | 6 | 2 | 4 | 5 |
| 9 | 14 | 20 | 6 | 9 | 13 | 6 | 13 | 4 | 6 | 9 | 4 | 6 | 3 | 4 | 6 |
| 10 | 16 | 22 | 7 | 10 | 15 | 6 | 14 | 4 | 7 | 9 | 5 | 7 | 3 | 5 | 7 |
| 11 | 17 | 24 | 7 | 11 | 16 | 7 | 16 | 5 | 7 | 10 | 5 | 8 | 3 | 5 | 7 |
| 12 | 19 | 26 | 8 | 12 | 18 | 8 | 17 | 5 | 8 | 11 | 5 | 8 | 4 | 6 | 8 |
| 13 | 20 | 29 | 9 | 13 | 19 | 8 | 18 | 6 | 9 | 12 | 6 | 9 | 4 | 6 | 9 |
| 14 | 22 | 31 | 9 | 14 | 21 | 9 | 20 | 6 | 9 | 13 | 6 | 10 | 4 | 7 | 9 |
| 15 | 23 | 33 | 10 | 16 | 22 | 10 | 21 | 6 | 10 | 14 | 7 | 11 | 5 | 7 | 10 |
| 16 | 25 | 35 | 11 | 17 | 23 | 10 | 23 | 7 | 11 | 15 | 7 | 11 | 5 | 8 | 11 |
| 17 | 26 | 37 | 11 | 18 | 25 | 11 | 24 | 7 | 11 | 16 | 8 | 12 | 5 | 8 | 11 |
| 18 | 28 | 40 | 12 | 19 | 26 | 12 | 26 | 8 | 12 | 17 | 8 | 13 | 5 | 8 | 12 |
| 19 | 29 | 42 | 13 | 20 | 28 | 12 | 27 | 8 | 13 | 18 | 9 | 13 | 6 | 9 | 13 |
| 20 | 31 | 44 | 13 | 21 | 29 | 13 | 28 | 9 | 13 | 19 | 9 | 14 | 6 | 9 | 13 |
| 21 | 33 | 46 | 14 | 22 | 31 | 14 | 30 | 9 | 14 | 20 | 10 | 15 | 6 | 10 | 14 |
| 22 | 34 | 48 | 15 | 23 | 32 | 14 | 31 | 9 | 15 | 21 | 10 | 16 | 7 | 10 | 15 |
| 23 | 36 | 48 | 15 | 24 | 34 | 15 | 33 | 10 | 15 | 22 | 10 | 16 | 7 | 11 | 15 |
| 24 | 37 | 48 | 16 | 25 | 35 | 15 | 34 | 10 | 16 | 23 | 11 | 17 | 7 | 11 | 16 |
| 25 | 39 | 48 | 17 | 26 | 37 | 16 | 35 | 11 | 17 | 24 | 11 | 18 | 8 | 12 | 17 |
| 26 | 40 | 48 | 17 | 27 | 38 | 17 | 37 | 11 | 17 | 25 | 12 | 18 | 8 | 12 | 17 |
| 27 | 42 | 48 | 18 | 28 | 40 | 17 | 38 | 12 | 18 | 26 | 12 | 19 | 8 | 13 | 18 |
| 28 | 43 | 48 | 19 | 29 | 41 | 18 | 40 | 12 | 19 | 26 | 13 | 20 | 8 | 13 | 19 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 45 | 48 | 19 | 30 | 43 | 19 | 41 | 12 | 19 | 27 | 13 | 20 | 9 | 14 | 19 |
| 30 | 47 | 48 | 20 | 31 | 44 | 19 | 43 | 13 | 20 | 28 | 14 | 21 | 9 | 14 | 20 |
| 31 | 48 | 48 | 21 | 32 | 45 | 20 | 44 | 13 | 21 | 29 | 14 | 22 | 9 | 15 | 21 |
| 32 | 48 | 48 | 21 | 33 | 47 | 21 | 45 | 14 | 21 | 30 | 15 | 23 | 10 | 15 | 21 |
| 33 | 48 | 48 | 22 | 34 | 48 | 21 | 47 | 14 | 22 | 31 | 15 | 23 | 10 | 16 | 22 |
| 34 | 48 | 48 | 23 | 35 | 48 | 22 | 48 | 15 | 23 | 32 | 15 | 24 | 10 | 16 | 23 |
| 35 | 48 | 48 | 23 | 36 | 48 | 23 | 48 | 15 | 23 | 33 | 16 | 25 | 11 | 16 | 23 |
| 36 | 48 | 48 | 24 | 37 | 48 | 23 | 48 | 15 | 24 | 34 | 16 | 25 | 11 | 17 | 24 |
| 37 | 48 | 48 | 25 | 38 | 48 | 24 | 48 | 16 | 25 | 35 | 17 | 26 | 11 | 17 | 25 |
| 38 | 48 | 48 | 25 | 39 | 48 | 25 | 48 | 16 | 25 | 36 | 17 | 27 | 12 | 18 | 25 |
| 39 | 48 | 48 | 26 | 40 | 48 | 25 | 48 | 17 | 26 | 37 | 18 | 27 | 12 | 18 | 26 |
| 40 | 48 | 48 | 27 | 41 | 48 | 26 | 48 | 17 | 27 | 38 | 18 | 28 | 12 | 19 | 27 |
| 41 | 48 | 48 | 27 | 42 | 48 | 26 | 48 | 18 | 27 | 39 | 19 | 29 | 12 | 19 | 27 |
| 42 | 48 | 48 | 28 | 43 | 48 | 27 | 48 | 18 | 28 | 40 | 19 | 30 | 13 | 20 | 28 |
| 43 | 48 | 48 | 29 | 44 | 48 | 28 | 48 | 18 | 29 | 41 | 20 | 30 | 13 | 20 | 29 |
| 44 | 48 | 48 | 29 | 45 | 48 | 28 | 48 | 19 | 29 | 42 | 20 | 31 | 13 | 21 | 29 |
| 45 | 48 | 48 | 30 | 47 | 48 | 29 | 48 | 19 | 30 | 43 | 20 | 32 | 14 | 21 | 30 |
| 46 | 48 | 48 | 31 | 48 | 48 | 30 | 48 | 20 | 31 | 44 | 21 | 32 | 14 | 22 | 31 |
| 47 | 48 | 48 | 31 | 48 | 48 | 30 | 48 | 20 | 31 | 44 | 21 | 33 | 14 | 22 | 31 |
| 48 | 48 | 48 | 32 | 48 | 48 | 31 | 48 | 21 | 32 | 45 | 22 | 34 | 15 | 23 | 32 |

For SI: 1 inch = 25.4 mm.

a. This table is for use with tables in Section R608.6 that specify the minimum bar size and maximum spacing of vertical wall reinforcement for foundation walls and above-grade walls. Reinforcement specified in tables in Section R608.6 is based on Grade 60 (420 MPa) steel reinforcement.

b. Bar spacing shall not exceed 48 inches on center and shall be not less than one-half the nominal wall thickness.

c. For Grade 50 (350 MPa) steel bars (ASTM A996, Type R), use spacing for Grade 40 (280 MPa) bars or interpolate between Grade 40 (280 MPa) and Grade 60 (420 MPa).

**R608.5.3 Form materials and form ties.** Forms shall be made of wood, steel, aluminum, plastic, a composite of cement and foam insulation, a composite of cement and wood chips, or other *approved* material suitable for supporting and containing concrete. Forms shall provide sufficient strength to contain concrete during the concrete placement operation.

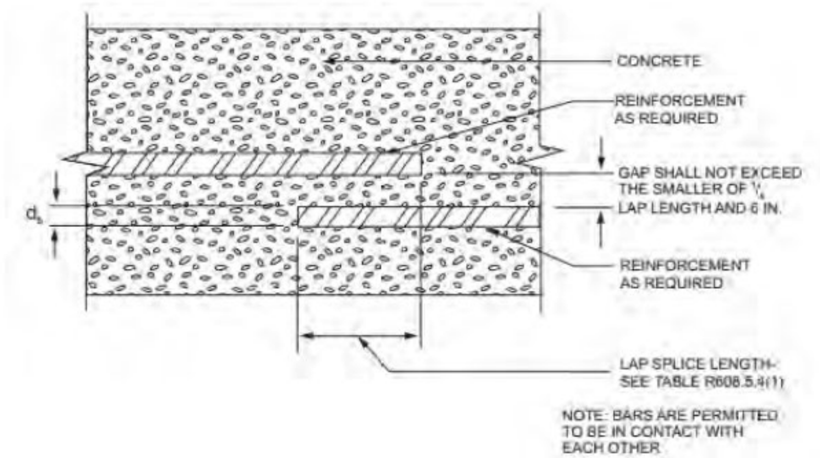
Form ties shall be steel, solid plastic, foam plastic, a composite of cement and wood chips, a composite of cement and foam plastic, or other suitable material capable of resisting the forces created by fluid pressure of fresh concrete.

**R608.5.4 Reinforcement installation details.**

**R608.5.4.1 Support and cover.** Reinforcement shall be secured in the proper location in the forms with tie wire or other bar support system such that displacement will not occur during the concrete placement operation. Steel reinforcement in concrete cast against the earth shall have a minimum cover of 3 inches (76 mm). Minimum cover for reinforcement in concrete cast in removable forms that will be exposed to the earth or weather shall be $1^1/_2$ inches (38 mm) for No. 5 bars and smaller, and 2 inches (50 mm) for No. 6 bars and larger. For concrete cast in removable forms that will not be exposed to the earth or weather, and for concrete cast in stay-in-place forms, minimum cover shall be $^3/_4$ inch (19 mm). The minus tolerance for cover shall not exceed the smaller of one-third the required cover and $^3/_8$ inch (10 mm). See Section R608.5.4.4 for cover requirements for hooks of bars developed in tension.

**R608.5.4.2 Location of reinforcement in walls.** For location of reinforcement in foundation walls and above-grade walls, see Sections R404.1.3.3.7.2 and R608.6.5, respectively.

**R608.5.4.3 Lap splices.** Vertical and horizontal wall reinforcement required by Sections R608.6 and R608.7 shall be the longest lengths practical. Where splices are necessary in reinforcement, the length of lap splices shall be in accordance with Table R608.5.4(1) and Figure R608.5.4(1). The maximum gap between noncontact parallel bars at a lap splice shall not exceed the smaller of one-fifth the required lap length and 6 inches (152 mm). See Figure R608.5.4(1).



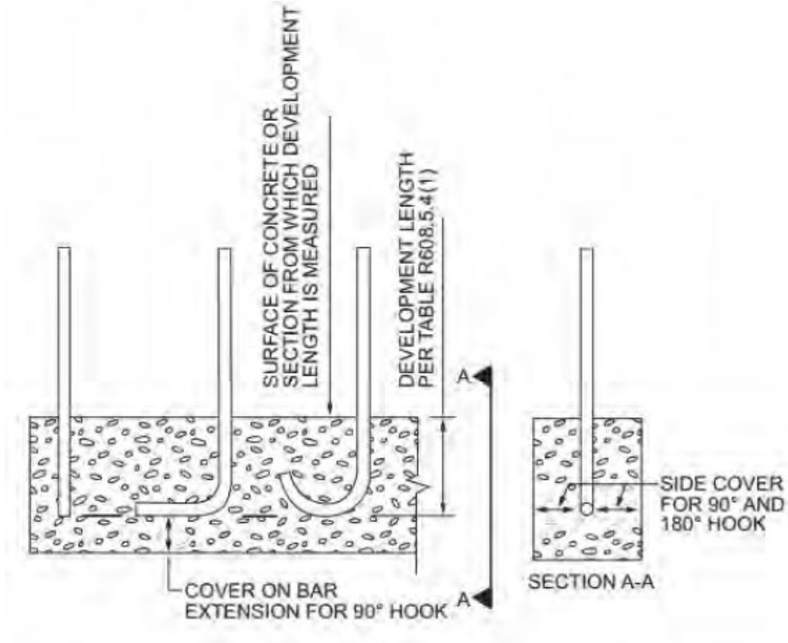

For SI: 1 inch = 25.4 mm.

**FIGURE R608.5.4(1)**
**LAP SPLICES**

**R608.5.4.4 Development of bars in tension.** Where bars are required to be developed in tension by other provisions of this code, development lengths and cover for hooks and bar extensions shall comply with Table R608.5.4(1) and Figure R608.5.4(2). The development lengths shown in Table R608.5.4(1) shall apply to bundled bars in lintels installed in accordance with Section R608.8.2.2.

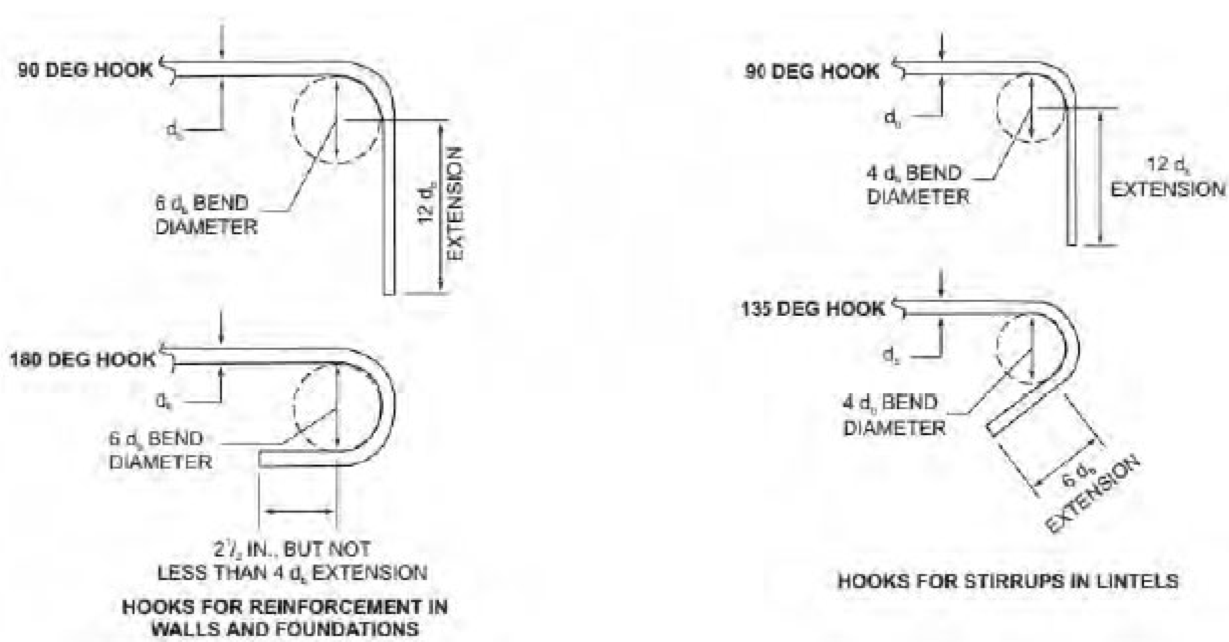
**R608.5.4.5 Standard hooks.** Where reinforcement is required by this code to terminate with a standard hook, the hook shall comply with Figure R608.5.4(3).

**R608.5.4.6 Webs of waffle-grid walls.** Reinforcement, including stirrups, shall not be placed in webs of waffle-grid walls, including lintels. Webs are permitted to have form ties.




For SI: 1 degree = 0.0175 rad.

**FIGURE R608.5.4(2)**
**DEVELOPMENT LENGTH AND COVER FOR HOOKS AND BAR EXTENSION**




For SI: 1 inch = 25.4 mm, 1 degree = 0.0175 rad.

**FIGURE R608.5.4(3)**
**STANDARD HOOKS**

**R608.5.4.7 Alternate grade of reinforcement and spacing.** Where tables in Sections R404.1.3 and R608.6 specify vertical wall reinforcement based on minimum bar size and maximum spacing, which are based on Grade 60 (420 MPa) steel reinforcement, different size bars or bars made from a different grade of steel are permitted provided an equivalent area of steel per linear foot of wall is provided. Use of Table R608.5.4(2) is permitted to determine the maximum bar spacing for different bar sizes than specified in the tables and~~/or~~ bars made from a different grade of steel. Bars shall not be spaced less than one-half the wall thickness, or more than 48 inches (1219 mm) on center.

**R608.5.5 Construction joints in walls.** Construction joints shall be made and located to not impair the strength of the wall. Construction joints in plain concrete walls, including walls required to have not less than No. 4 bars at 48 inches (1219 mm) on center by Section R608.6, shall be located at points of lateral support, and not less than one No. 4 bar shall extend across the construction joint at a spacing not to exceed 24 inches (610 mm) on center. Construction joint reinforcement shall have not less than 12 inches (305 mm) of embedment on both sides of the joint. Construction joints in reinforced concrete walls shall be located in the middle third of the span between lateral supports, or located and constructed as required for joints in plain concrete walls.

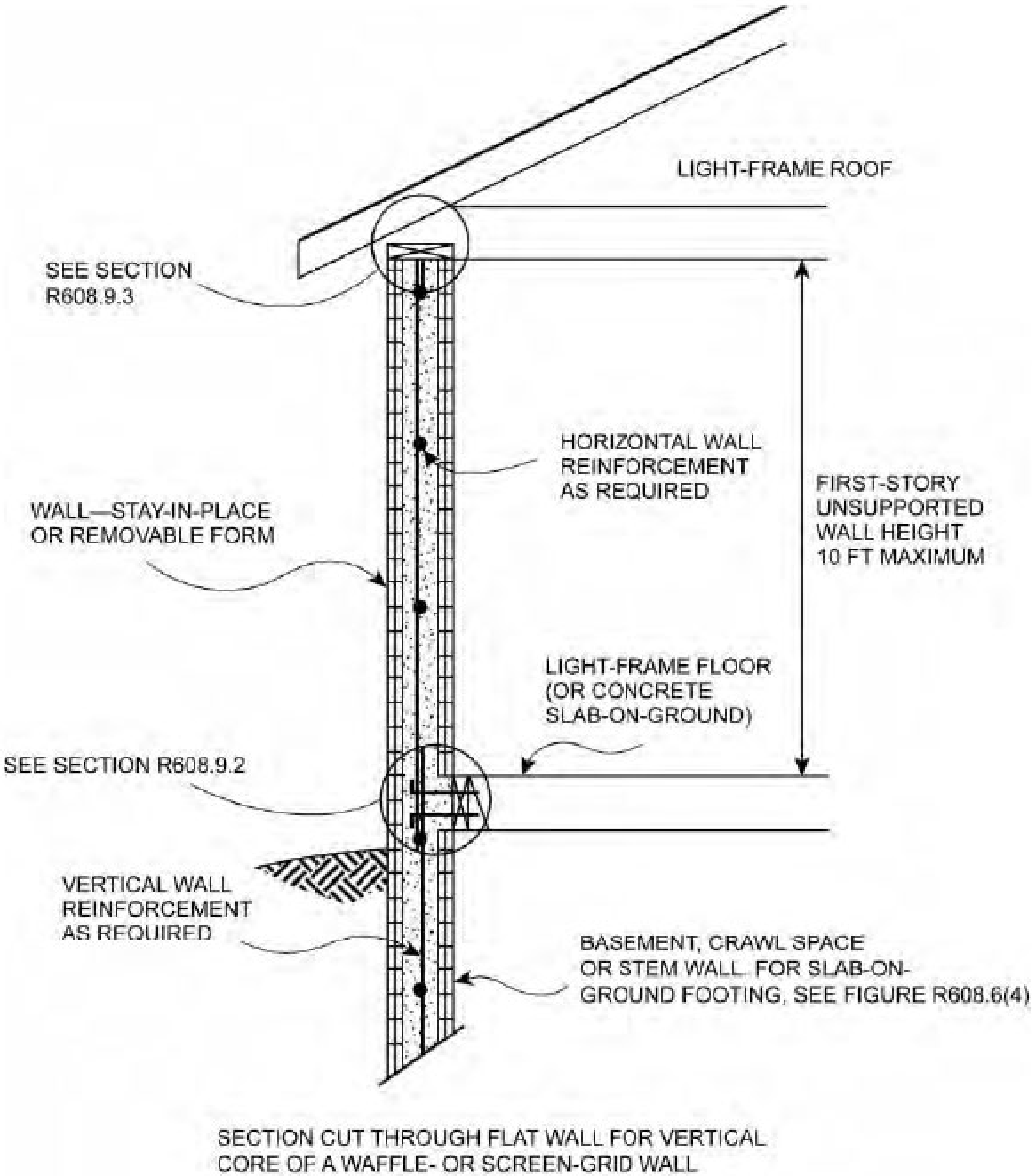
**Exception:** Vertical wall reinforcement required by this code is permitted to be used in lieu of construction joint reinforcement, provided the spacing does not exceed 24 inches (610 mm), or the combination of wall reinforcement and No. 4 bars described in Section R608.5.5 does not exceed 24 inches (610 mm).

**R608.6 Above-grade wall requirements.**

**R608.6.1 General.** The minimum thickness of load-bearing and nonload-bearing above-grade walls and reinforcement shall be as set forth in the appropriate table in this section based on the type of wall form to be used. The wall shall be designed in accordance with ACI 318 where the wall or building is not within the limitations of Section R608.2, where design is required by the tables in this section or where the wall is not within the scope of the tables in this section.

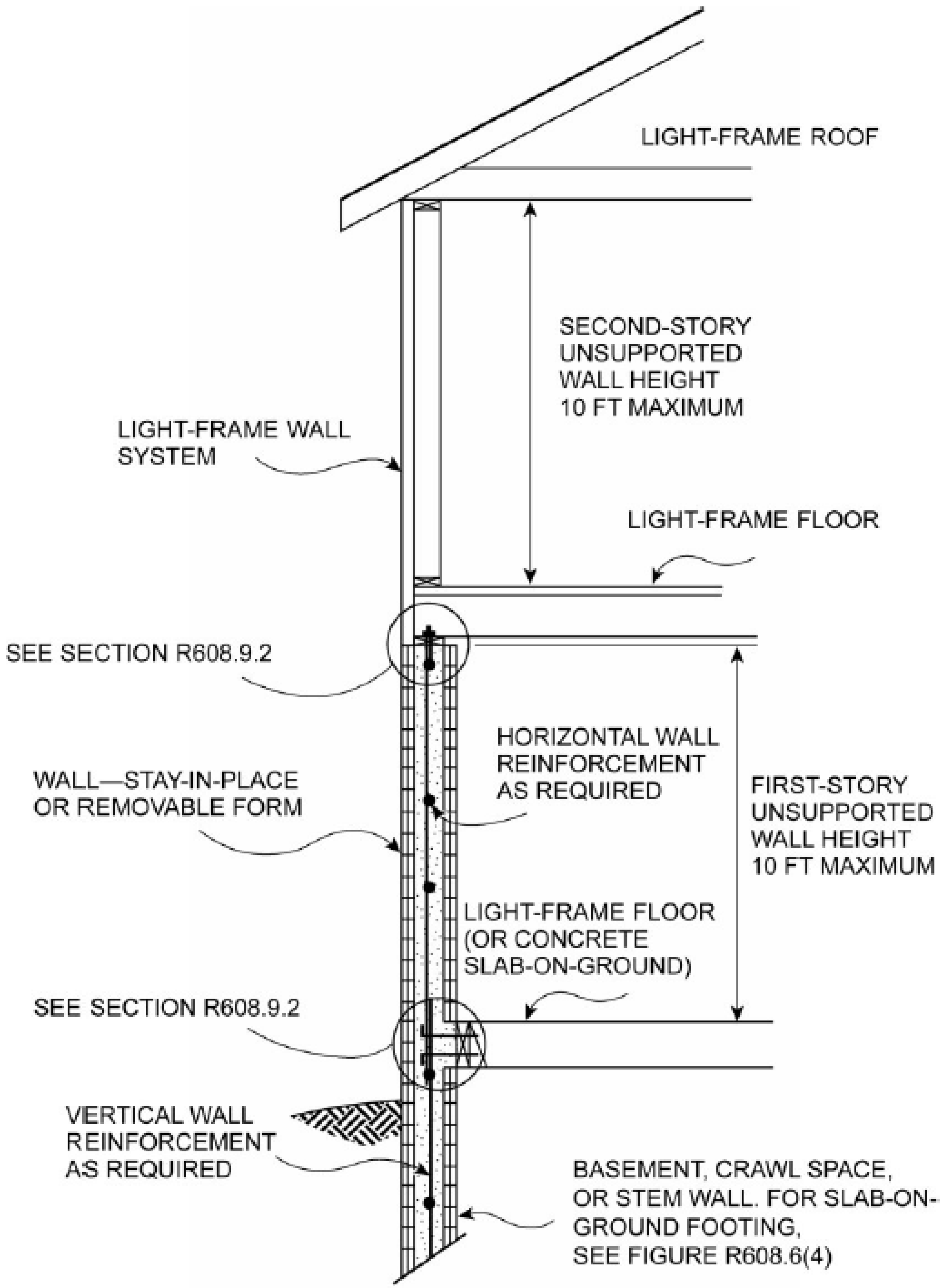
Above-grade concrete walls shall be constructed in accordance with this section and Figure R608.6(1), R608.6(2), R608.6(3) or R608.6(4). Above-grade concrete walls that are continuous with stem walls and not laterally supported by the slab-on-ground shall be designed and constructed in accordance with this section. Concrete walls shall be supported on continuous foundation walls or slabs-on-ground that are monolithic with the footing in accordance with Section R403. The minimum length of solid wall without openings shall be in accordance with Section R608.7. Reinforcement around openings, including lintels, shall be in accordance with Section R608.8. Lateral support for above-grade walls in the out-of-plane direction shall be provided by connections to the floor framing system, if applicable, and to ceiling and roof framing systems in accordance with Section R608.9. The wall thickness shall be equal to or greater than the thickness of the wall in the *story* above.

**R608.6.2 Wall reinforcement for wind.** Vertical wall reinforcement for resistance to out-of-plane wind forces shall be determined from Table R608.6(1), R608.6(2), R608.6(3) or R608.6(4). For the design of nonload-bearing walls, in Tables R608.6(1), R608.6(2) and R608.6(3) use the appropriate column labeled “Top.” (see Sections R608.7.2.2.2 and R608.7.2.2.3). There shall be a vertical bar at corners of exterior walls. Unless more horizontal reinforcement is required by Section R608.7.2.2.1, the minimum horizontal reinforcement shall be four No. 4 bars [Grade 40 (280 MPa)] placed as follows: top bar within 12 inches (305 mm) of the top of the wall, bottom bar within 12 inches (305 mm) of the finish floor and one bar each at approximately one-third and two-thirds of the wall height.




For SI: 1 foot = 304.8 mm.

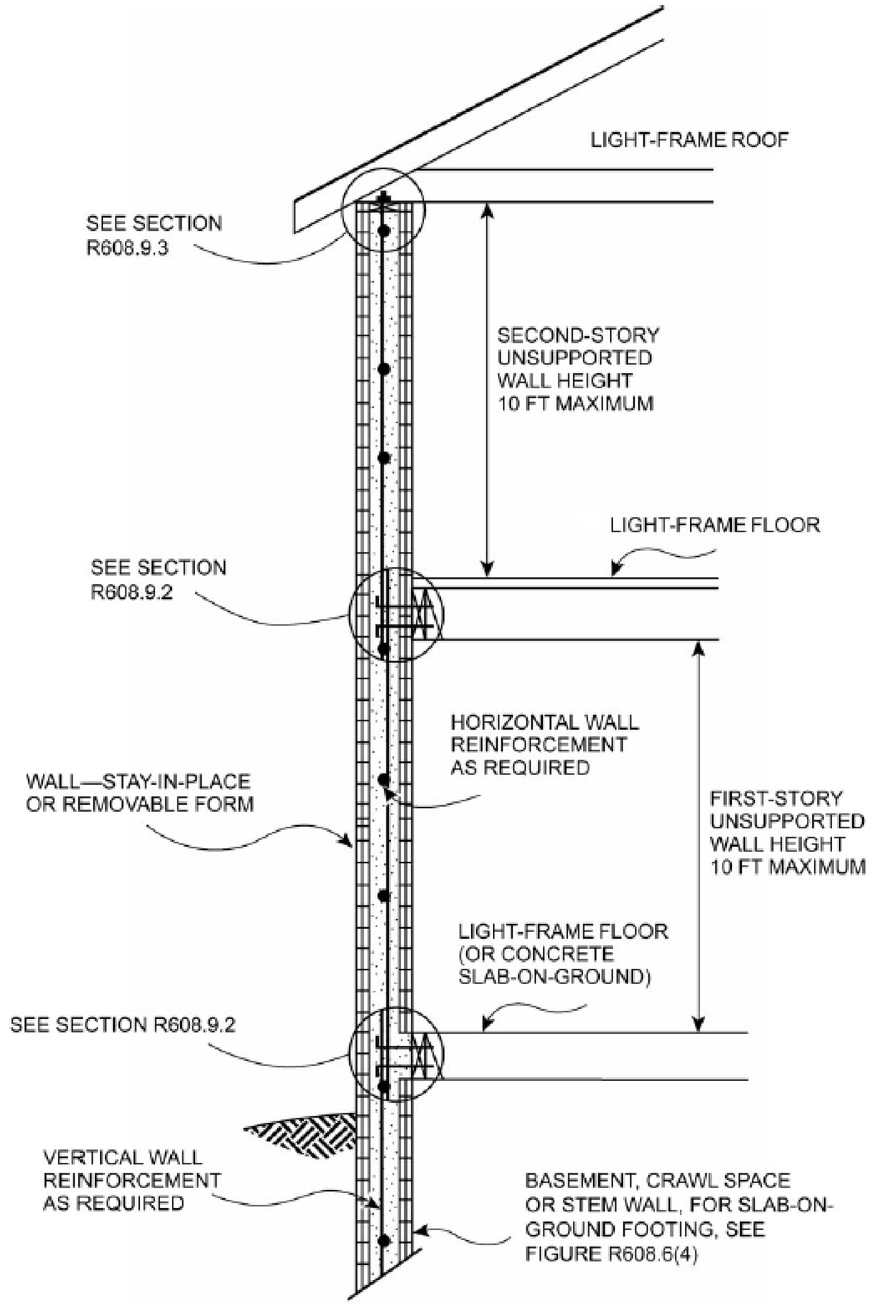
**FIGURE R608.6(1)**
**ABOVE-GRADE CONCRETE WALL CONSTRUCTION ONE STORY**




SECTION CUT THROUGH FLAT WALL OR VERTICAL CORE OF WAFFLE- OR SCREEN-GRID WALL

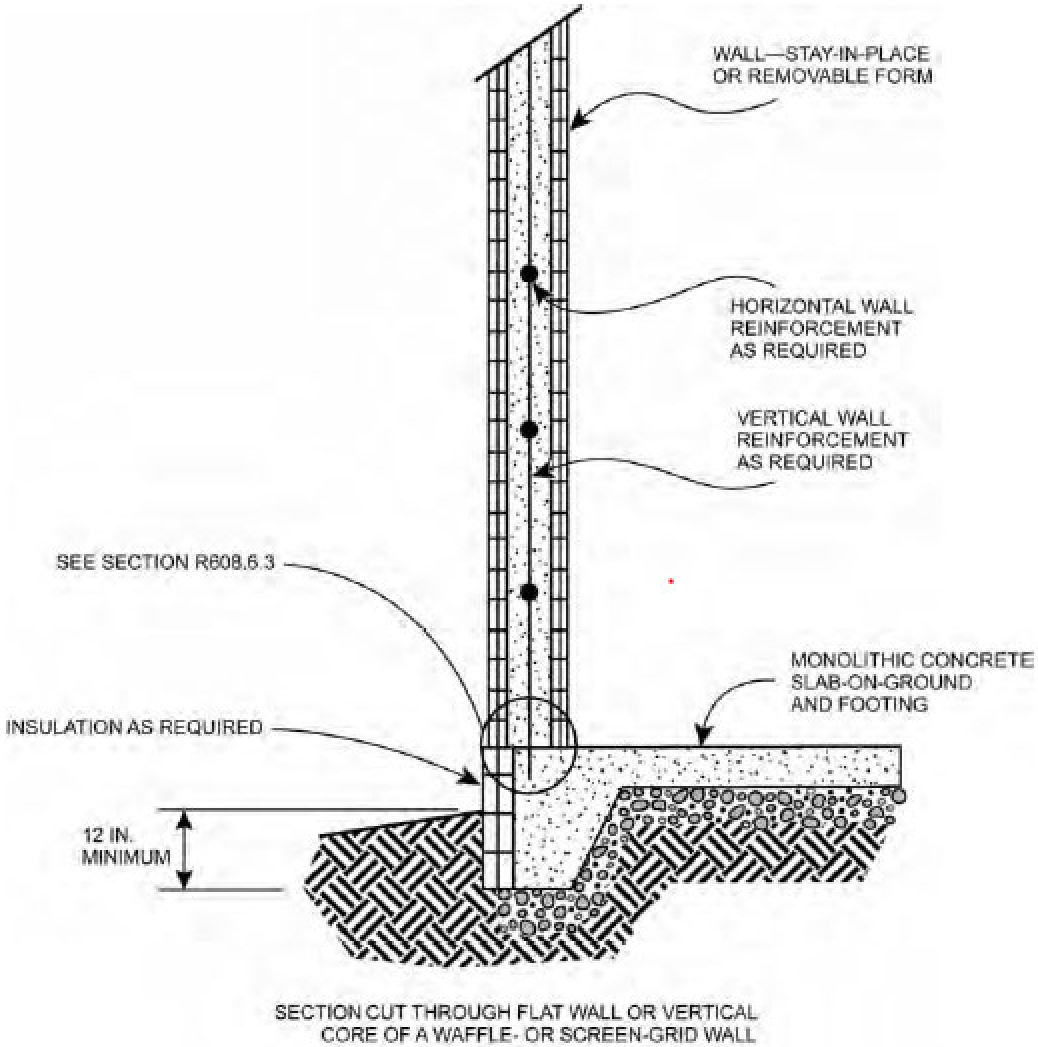
For SI: 1 foot = 304.8 mm.

**FIGURE R608.6(2)**
**ABOVE-GRADE CONCRETE WALL CONSTRUCTION CONCRETE FIRST STORY AND LIGHT-FRAME SECOND STORY**




For SI: 1 foot = 304.8 mm.

**FIGURE R608.6(3)**
**ABOVE-GRADE CONCRETE WALL CONSTRUCTION TWO-STORY**




For SI: 1 inch = 25.4 mm.

**FIGURE R608.6(4)**
**ABOVE-GRADE CONCRETE WALL SUPPORTED ON MONOLITHIC SLAB-ON-GROUND FOOTING**

**TABLE R608.6(1)**
**MINIMUM VERTICAL REINFORCEMENT FOR FLAT ABOVE-GRADE WALLS[a, b, c, d, e]**

| MAXIMUM WIND SPEED (mph) | | | MAXIMUM UNSUPPORTED WALL HEIGHT PER STORY (feet) | MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)[f, g] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Nominal[h] wall thickness (inches) | | | | | | | |
| Exposure Category | | | | 4 | | 6 | | 8 | | 10 | |
| B | C | D | | Top[i] | Side[i] | Top[i] | Side[i] | Top[i] | Side[i] | Top[i] | Side[i] |
| 115 | — | — | 8 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 9 | 4@48 | 4@39 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 10 | 4@41 | 4@34 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| 120 | — | — | 8 | 4@48 | 4@43 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 9 | 4@48 | 4@36 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 10 | 4@37 | 4@34 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| 130 | 110 | — | 8 | 4@48 | 4@38 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 9 | 4@39 | 4@34 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 10 | 4@34 | 4@34 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| 140 | 119 | 110 | 8 | 4@43 | 4@34 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 9 | 4@34 | 4@34 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 10 | 4@34 | 4@31 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| 150 | 127 | 117 | 8 | 4@37 | 4@34 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 9 | 4@34 | 4@33 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 10 | 4@31 | 4@27 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| 160 | 136 | 125 | 8 | 4@34 | 4@34 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 9 | 4@34 | 4@29 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 10 | 4@27 | 4@24 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 | 4@48 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound per square inch = 1.895 kPa, 1 square foot = 0.0929 m$^2$.

a. Table is based on ASCE 7 components and cladding wind pressures for an enclosed building using a mean roof height of 35 feet, interior wall area 4, an effective wind area of 10 square feet, topographic factor, $K_{zt}$, equal to 1.0, and Risk Category II.

b. Table is based on concrete with a minimum specified compressive strength of 2,500 psi.

c. See Section R608.6.5 for location of reinforcement in wall.

d. Deflection criterion is $L/240$, where $L$ is the unsupported height of the wall in inches.

e. Interpolation is not permitted.

f. Where No. 4 reinforcing bars at a spacing of 48 inches are specified in the table as indicated by shaded cells, use of bars with a minimum yield strength of 40,000 psi or 60,000 psi is permitted.

g. Other than for No. 4 bars spaced at 48 inches on center, table values are based on reinforcing bars with a minimum yield strength of 60,000 psi. Vertical reinforcement with a yield strength of less than 60,000 psi or bars of a different size than specified in the table are permitted in accordance with Section R608.5.4.7 and Table R608.5.4(2).

h. See Table R608.3 for tolerances on nominal thicknesses.

i. "Top" means gravity load from roof or floor construction bears on top of wall. "Side" means gravity load from floor construction is transferred to wall from a wood ledger or cold-formed steel track bolted to side of wall. For nonload-bearing walls where floor framing members span parallel to the wall, use of the "Top" bearing condition is permitted.

**TABLE R608.6(2)**

**MINIMUM VERTICAL REINFORCEMENT FOR WAFFLE-GRID ABOVE-GRADE WALLS[a, b, c, d, e]**

| MAXIMUM WIND SPEED (mph) | | MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)[f, g] |
|---|---|---|

| Exposure Category | | | MAXIMUM UNSUPPORTED WALL HEIGHT PER STORY (feet) | Nominal[h] wall thickness (inches) | | | |
|---|---|---|---|---|---|---|---|
| | | | | 6 | | 8 | |
| B | C | D | | Top[i] | Side[i] | Top[i] | Side[i] |
| 115 | — | — | 8 | 4@48 | 4@48 | 4@48 | 4@48 |
| | | | 9 | 4@48 | 5@43 | 4@48 | 4@48 |
| | | | 10 | 5@47 | 5@37 | 4@48 | 4@48 |
| 120 | — | — | 8 | 4@48 | 5@48 | 4@48 | 4@48 |
| | | | 9 | 4@48 | 5@40 | 4@48 | 4@48 |
| | | | 10 | 5@43 | 5@37 | 4@48 | 4@48 |
| 130 | 110 | — | 8 | 4@48 | 5@42 | 4@48 | 4@48 |
| | | | 9 | 5@45 | 5@37 | 4@48 | 4@48 |
| | | | 10 | 5@37 | 5@37 | 4@48 | 4@48 |
| 140 | 119 | 110 | 8 | 4@48 | 5@38 | 4@48 | 4@48 |
| | | | 9 | 5@39 | 5@37 | 4@48 | 4@48 |
| | | | 10 | 5@37 | 5@35 | 4@48 | 4@48 |
| 150 | 127 | 117 | 8 | 5@43 | 5@37 | 4@48 | 4@48 |
| | | | 9 | 5@37 | 5@37 | 4@48 | 4@48 |
| | | | 10 | 5@36 | 6@44 | 4@48 | 4@48 |
| 160 | 136 | 125 | 8 | 5@38 | 5@37 | 4@48 | 4@48 |
| | | | 9 | 5@37 | 6@47 | 4@48 | 4@48 |
| | | | 10 | 6@45 | 6@39 | 4@48 | 6@46 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound per square inch = 6.895 kPa, 1 square foot = 0.0929 m$^2$.

a. Table is based on ASCE 7 components and cladding wind pressures for an enclosed building using a mean roof height of 35 feet, interior wall area 4, an effective wind area of 10 square feet, topographic factor, $K_{zt}$, equal to 1.0, and Risk Category II.

b. Table is based on concrete with a minimum specified compressive strength of 2,500 psi.

c. See Section R608.6.5 for location of reinforcement in wall.

d. Deflection criterion is *L*/240, where *L* is the unsupported height of the wall in inches.

e. Interpolation is not permitted.

f. Where No. 4 reinforcing bars at a spacing of 48 inches are specified in the table as indicated by shaded cells, use of bars with a minimum yield strength of 40,000 psi or 60,000 psi is permitted.

g. Other than for No. 4 bars spaced at 48 inches on center, table values are based on reinforcing bars with a minimum yield strength of 60,000 psi. Maximum spacings shown are the values calculated for the specified bar size. Where the bar used is Grade 60 and the size specified in the table, the actual spacing in the wall shall not exceed a whole-number multiple of 12 inches such as, 12, 24, 36 and 48, that is less than or equal to the tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi or bars of a different size than specified in the table are permitted in accordance with Section R608.5.4.7 and Table R608.5.4(2).

h. See Table R608.3 for minimum core dimensions and maximum spacing of horizontal and vertical cores.
i. “Top” means gravity load from roof or floor construction bears on top of wall. “Side” means gravity load from floor construction is transferred to wall from a wood ledger or cold-formed steel track bolted to side of wall. For nonload-bearing walls and where floor framing members span parallel to the wall, the “top” bearing condition is permitted to be used.

**TABLE R608.6(3)**
**MINIMUM VERTICAL REINFORCEMENT FOR 6-INCH SCREEN-GRID ABOVE-GRADE WALLS[a, b, c, d, e]**

| MAXIMUM WIND SPEED (mph) | | | MAXIMUM UNSUPPORTED WALL HEIGHT PER STORY (feet) | MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)[f, g] | |
|---|---|---|---|---|---|
| | | | | Nominal[h] wall thickness (inches) | |
| Exposure Category | | | | 6 | |
| B | C | D | | Top[i] | Side[i] |
| 115 | — | — | 8 | 4@48 | 4@48 |
| | | | 9 | 4@48 | 5@41 |
| | | | 10 | 4@48 | 6@48 |
| 120 | — | — | 8 | 4@48 | 4@48 |
| | | | 9 | 4@48 | 5@38 |
| | | | 10 | 5@42 | 6@48 |
| 130 | 110 | — | 8 | 4@48 | 5@41 |
| | | | 9 | 5@44 | 6@48 |
| | | | 10 | 5@35 | 6@48 |
| 140 | 119 | 110 | 8 | 4@48 | 5@36 |
| | | | 9 | 5@38 | 6@48 |
| | | | 10 | 6@48 | 6@48 |
| 150 | 127 | 117 | 8 | 5@42 | 6@48 |
| | | | 9 | 6@48 | 6@48 |
| | | | 10 | 6@48 | 6@42 |
| 160 | 136 | 125 | 8 | 5@37 | 6@48 |
| | | | 9 | 6@48 | 6@45 |
| | | | 10 | 6@44 | 6@38 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound per square inch = 6.895 kPa, 1 square foot = 0.0929 m$^2$.

a. Table is based on ASCE 7 components and cladding wind pressures for an enclosed building using a mean roof height of 35 feet, interior wall area 4, an effective wind area of 10 square feet, topographic factor, $K_{zt}$, equal to 1.0, and Risk Category II.
b. Table is based on concrete with a minimum specified compressive strength of 2,500 psi.
c. See Section R608.6.5 for location of reinforcement in wall.
d. Deflection criterion is $L/240$, where $L$ is the unsupported height of the wall in inches.
e. Interpolation is not permitted.
f. Where No. 4 reinforcing bars at a spacing of 48 inches are specified in the table as indicated by shaded cells, use of bars with a minimum yield strength of 40,000 psi or 60,000 psi is permitted.
g. Other than for No. 4 bars spaced at 48 inches on center, table values are based on reinforcing bars with a minimum yield strength of 60,000 psi. Maximum spacings shown are the values calculated for the specified bar size. Where the bar used is Grade 60 and the size specified in the table, the actual spacing in the wall shall not exceed a whole-number multiple of 12 inches such as, 12, 24, 36 and 48, that is less than or equal to the tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi or bars of a different size than specified in the table are permitted in accordance with Section R608.5.4.7 and Table R608.5.4(2).
h. See Table R608.3 for minimum core dimensions and maximum spacing of horizontal and vertical cores.
i. "Top" means gravity load from roof or floor construction bears on top of wall. "Side" means gravity load from floor construction is transferred to wall from a wood ledger or cold-formed steel track bolted to side of wall. For nonload-bearing wall and where floor framing members span parallel to the wall, use of the "Top" bearing condition is permitted.

**TABLE R608.6(4)**
**MINIMUM VERTICAL REINFORCEMENT FOR FLAT, WAFFLE- AND SCREEN-GRID ABOVE-GRADE WALLS DESIGNED CONTINUOUS WITH FOUNDATION STEM WALLS[a, b, c, d, e, k]**

| MAXIMUM WIND SPEED (mph) | | | HEIGHT OFSTEM WALL[h, i] (feet) | MAXIMUM DESIGN LATERAL SOIL LOAD (psf/ft) | MAXIMUM UNSUPPORTED HEIGHT OF ABOVE-GRADE WALL (feet) | MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)[f, g] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Wall type and nominal thickness[j] (inches) | | | | | | |
| Exposure Category | | | | | | Flat | | | | Waffle | | Screen |
| B | C | D | | | | 4 | 6 | 8 | 10 | 6 | 8 | 6 |
| 115 | — | — | 3 | 30 | 8 | 4@30 | 4@48 | 4@48 | 4@48 | 4@22 | 4@26 | 4@21 |
| | | | | | 10 | 4@23 | 5@43 | 4@48 | 4@48 | 4@17 | 4@20 | 4@16 |
| | | | | 60 | 10 | 4@19 | 5@37 | 4@48 | 4@48 | 4@14 | 4@17 | 4@14 |
| | | | 6 | 30 | 10 | DR | 5@21 | 6@35 | 4@48 | DR | 4@10 | DR |
| | | | | 60 | 10 | DR | 5@12 | 6@25 | 6@28 | DR | DR | DR |
| 120 | — | — | 3 | 30 | 8 | 4@28 | 4@48 | 4@48 | 4@48 | 4@21 | 4@48 | 4@20 |
| | | | | | 10 | 4@22 | 5@41 | 4@48 | 4@48 | 4@16 | 4@19 | 4@15 |
| | | | | 60 | 10 | 4@18 | 5@35 | 4@48 | 4@48 | 4@14 | 4@17 | 4@13 |
| | | | 6 | 30 | 10 | DR | 5@21 | 6@35 | 4@48 | DR | 4@10 | DR |
| | | | | 60 | 10 | DR | 5@12 | 6@25 | 6@28 | DR | DR | DR |
| 130 | 110 | — | 3 | 30 | 8 | 4@25 | 4@48 | 4@48 | 4@48 | 4@18 | 4@22 | 4@18 |
| | | | | | 10 | 4@19 | 5@36 | 4@48 | 4@48 | 4@14 | 4@17 | 4@13 |
| | | | 6 | 60 | 10 | 4@16 | 5@34 | 4@48 | 4@48 | 4@12 | 4@17 | 4@12 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 30 | 10 | DR | 5@19 | 6@35 | 4@48 | DR | 4@9 | DR |
| | | | | 60 | 10 | DR | 5@12 | 6@24 | 6@28 | DR | DR | DR |
| 140 | 119 | 110 | 3 | 30 | 8 | 4@22 | 5@42 | 4@48 | 4@48 | 4@16 | 4@20 | 4@16 |
| | | | | | 10 | 4@17 | 5@34 | 4@48 | 4@48 | 4@21 | 4@17 | 4@12 |
| | | | | 60 | 10 | 4@15 | 5@34 | 4@48 | 4@48 | 4@11 | 4@17 | 4@10 |
| | | | 6 | 30 | 10 | DR | 5@18 | 6@35 | 6@35 | DR | 4@48 | DR |
| | | | | 60 | 10 | DR | 5@11 | 6@23 | 6@28 | DR | DR | DR |
| 150 | 127 | 117 | 3 | 30 | 8 | 4@20 | 5@37 | 4@48 | 4@48 | 4@15 | 4@18 | 4@14 |
| | | | | | 10 | 4@15 | 5@34 | 4@48 | 4@48 | 4@11 | 4@17 | 4@11 |
| | | | | 60 | 10 | 4@13 | 5@34 | 4@48 | 4@48 | 4@10 | 4@16 | 4@9 |
| | | | 6 | 30 | 10 | DR | 5@17 | 6@33 | 6@32 | DR | 4@8 | DR |
| | | | | 60 | 10 | DR | DR | 6@22 | 6@28 | DR | DR | DR |
| 160 | 136 | 125 | 3 | 30 | 8 | 4@18 | 5@34 | 4@48 | 4@48 | 4@13 | 4@17 | 4@13 |
| | | | | | 10 | 4@13 | 5@34 | 4@48 | 4@48 | 4@10 | 4@16 | 4@9 |
| | | | | 60 | 10 | 4@11 | 5@31 | 6@45 | 4@48 | 4@9 | 4@14 | 4@8 |
| | | | 6 | 30 | 10 | DR | 5@15 | 6@31 | 6@30 | DR | 4@7 | DR |
| | | | | 60 | 10 | DR | DR | 6@21 | 6@27 | DR | DR | DR |

*(continued)*

**TABLE R608.6(4)—continued**

**MINIMUM VERTICAL REINFORCEMENT FOR FLAT, WAFFLE- AND SCREEN-GRID ABOVE-GRADE WALLS DESIGNED CONTINUOUS WITH FOUNDATION STEM WALLS[a, b, c, d, e, k]**

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound per square inch = 6.895 kPa, 1 square foot = 0.0929 $m^2$.

DR = Design Required.

a. Table is based on ASCE 7 components and cladding wind pressures for an enclosed building using a mean roof height of 35 feet, interior wall area 4, an effective wind area of 10 square feet, topographic factor, $K_{zt}$, equal to 1.0, and Risk Category II.

b. Table is based on concrete with a minimum specified compressive strength of 2,500 psi.

c. See Section R608.6.5 for location of reinforcement in wall.

d. Deflection criterion is $L$/240, where $L$ is the height of the wall in inches from the exterior finish ground level to the top of the above-grade wall.

e. Interpolation is not permitted. For intermediate values of basic wind speed, heights of stem wall and above-grade wall, and design lateral soil load, use next higher value.

f. Where No. 4 reinforcing bars at a spacing of 48 inches are specified in the table as indicated by shaded cells, use of bars with a minimum yield strength of 40,000 psi or 60,000 psi is permitted.

g. Other than for No. 4 bars spaced at 48 inches on center, table values are based on reinforcing bars with a minimum yield strength of 60,000 psi. Maximum spacings shown are the values calculated for the specified bar size. In waffle and screen-grid walls where the bar used is Grade 60 and the size specified in the table, the actual spacing in the wall shall not exceed a whole-number multiple of 12 inches such as, 12, 24, 36 and 48, that is less than or equal to the tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi and~~/or~~ bars of a different size than specified in the table are permitted in accordance with Section R608.5.4.7 and Table R608.5.4(2).

h. Height of stem wall is the distance from the exterior finish ground level to the top of the slab-on-ground.

i. Where the distance from the exterior finish ground level to the top of the slab-on-ground is equal to or greater than 4 feet, the stem wall shall be laterally supported at the top and bottom before backfilling. Where the wall is designed and constructed to be continuous with the above-grade wall, temporary supports bracing the top of the stem wall shall remain in place until the above-grade wall is laterally supported at the top by floor or roof construction.

j. See Table R608.3 for tolerances on nominal thicknesses, and minimum core dimensions and maximum spacing of horizontal and vertical cores for waffle-and screen-grid walls.

k. Tabulated values are applicable to construction where gravity loads bear on top of wall, and conditions where gravity loads from floor construction are transferred to wall from a wood ledger or cold-formed steel track bolted to side of wall. See Tables R608.6(1), R608.6(2) and R608.6(3).

~~l. DR=Design Required~~

**R608.6.3 Continuity of wall reinforcement between stories.** Vertical reinforcement required by this section shall be continuous between elements providing lateral support for the wall. Reinforcement in the wall of the *story* above shall be continuous with the reinforcement in the wall of the *story* below, or the foundation wall, if applicable. Lap splices, where required, shall comply with Section R608.5.4.3 and Figure R608.5.4(1). Where the above-grade wall is supported by a monolithic slab-on-ground and footing, dowel bars with a size and spacing to match the vertical above-grade concrete wall reinforcement shall be embedded in the monolithic slab-on-ground and footing the distance required to develop the dowel bar in tension in accordance with Section R608.5.4.4 and Figure R608.5.4(2) and lap-spliced with the above-grade wall reinforcement in accordance with Section R608.5.4.3 and Figure R608.5.4(1).

Where a construction joint in the wall is located below the level of the floor and less than the distance required to develop the bar in tension, the distance required to develop the bar in tension shall be measured from the top of the concrete below the joint. See Section R608.5.5.

**Exception:** Where reinforcement in the wall above cannot be made continuous with the reinforcement in the wall below, the bottom of the reinforcement in the wall above shall be terminated in accordance with one of the following:

1. Extend below the top of the floor the distance required to develop the bar in tension in accordance with Section R608.5.4.4 and Figure R608.5.4(2).
2. Lap-spliced in accordance with Section R608.5.4.3 and Figure R608.5.4(1) with a dowel bar that extends into the wall below the distance required to develop the bar in tension in accordance with Section R608.5.4.4 and Figure R608.5.4(2).

**R608.6.4 Termination of reinforcement.** Where indicated in Items 1 through 3, vertical wall reinforcement in the top-most *story* with concrete walls shall be terminated with a 90-degree (1.57 rad) standard hook complying with Section R608.5.4.5 and Figure R608.5.4(3).

1. Vertical bars adjacent to door and window openings required by Section R608.8.1.2.
2. Vertical bars at the ends of required solid wall segments (see Section R608.7.2.2.2).
3. Vertical bars (other than end bars, see Item 2) used as shear reinforcement in required solid wall segments where the reduction factor for design strength, $R_3$, used is based on the wall having horizontal and vertical shear reinforcement (see Section R608.7.2.2.3).

The bar extension of the hook shall be oriented parallel to the horizontal wall reinforcement and be within 4 inches (102 mm) of the top of the wall.

Horizontal reinforcement shall be continuous around the building corners by bending one of the bars and lap-splicing it with the bar in the other wall in accordance with Section R608.5.4.3 and Figure R608.5.4(1).

In required solid wall segments where the reduction factor for design strength, $R_3$, is based on the wall having horizontal and vertical shear reinforcement in accordance with Section R608.7.2.2.1, horizontal wall reinforcement shall be terminated with a standard hook complying with Section R608.5.4.5 and Figure R608.5.4(3) or in a lap-splice, except at corners where the reinforcement shall be continuous as required.

**Exception:** In lieu of bending horizontal reinforcement at corners, separate bent reinforcing bars shall be permitted provided that the bent bar is lap-spliced with the horizontal reinforcement in both walls in accordance with Section R608.5.4.3 and Figure R608.5.4(1).

**R608.6.5 Location of reinforcement in wall.** Except for vertical reinforcement at the ends of required solid wall segments, which shall be located as required by Section R608.7.2.2.2, the location of the vertical reinforcement shall not vary from the center of the wall by more than the greater of 10 percent of the wall thickness and $^3/_8$-inch

(10 mm). Horizontal and vertical reinforcement shall be located to provide not less than the minimum cover required by Section R608.5.4.1.

**R608.7 Solid walls for resistance to lateral forces.**

**R608.7.1 Length of solid wall.** Each exterior wall line in each *story* shall have a total length of solid wall required by Section R608.7.1.1. A solid wall is a section of flat, waffle-grid or screen-grid wall, extending the full *story height* without openings or penetrations, except those permitted by Section R608.7.2. Solid wall segments that contribute to the total length of solid wall shall comply with Section R608.7.2.

**R608.7.1.1 Length of solid wall for wind.** Buildings shall have solid walls in each exterior endwall line (the side of a building that is parallel to the span of the roof or floor framing) and sidewall line (the side of a building that is perpendicular to the span of the roof or floor framing) to resist lateral in-plane wind forces. The site-appropriate basic wind speed and exposure category shall be used in Tables R608.7.1.1(1) through (3) to determine the unreduced total length, *UR*, of solid wall required in each exterior endwall line and sidewall line. For buildings with a mean roof height of less than 35 feet (10 668 mm), the unreduced values determined from Tables R608.7.1.1(1) through (3) are permitted to be reduced by multiplying by the applicable factor, $R_1$, from Table R608.7.1.1(4); however, reduced values shall be not less than the minimum values in Tables R608.7.1.1(1) through (3). Where the floor-to-ceiling height of a *story* is less than 10 feet (3048 mm), the unreduced values determined from Tables R608.7.1.1(1) through (3), including minimum values, are permitted to be reduced by multiplying by the applicable factor, $R_2$, from Table R608.7.1.1(5). To account for different design strengths than assumed in determining the values in Tables R608.7.1.1(1) through (3), the unreduced lengths determined from Tables R608.7.1.1(1) through (3), including minimum values, are permitted to be reduced by multiplying by the applicable factor, $R_3$, from Table R608.7.1.1(6). The reductions permitted by Tables R608.7.1.1(4), R608.7.1.1(5) and R608.7.1.1(6) are cumulative.

The total length of solid wall segments, *TL*, in a wall line that comply with the minimum length requirements of Section R608.7.2.1 [see Figure R608.7.1.1(1)] shall be equal to or greater than the product of the unreduced length of solid wall from Tables R608.7.1.1(1) through (3), *UR* and the applicable reduction factors, if any, from Tables R608.7.1.1(4), R608.7.1.1(5) and R608.7.1.1(6) as indicated by Equation R6-1.

$$TL \geq R_1 \cdot R_2 \cdot R_3 \cdot UR \qquad \textbf{(Equation R6-1)}$$

where:

*TL* = Total length of solid wall segments in a wall line that comply with Section R608.7.2.1 [see Figure R608.7.1.1(1)].

$R_1$ = 1.0 or reduction factor for mean roof height from Table R608.7.1.1(4).

$R_2$ = 1.0 or reduction factor for floor-to-ceiling wall height from Table R608.7.1.1(5).

$R_3$ = 1.0 or reduction factor for design strength from Table R608.7.1.1(6).

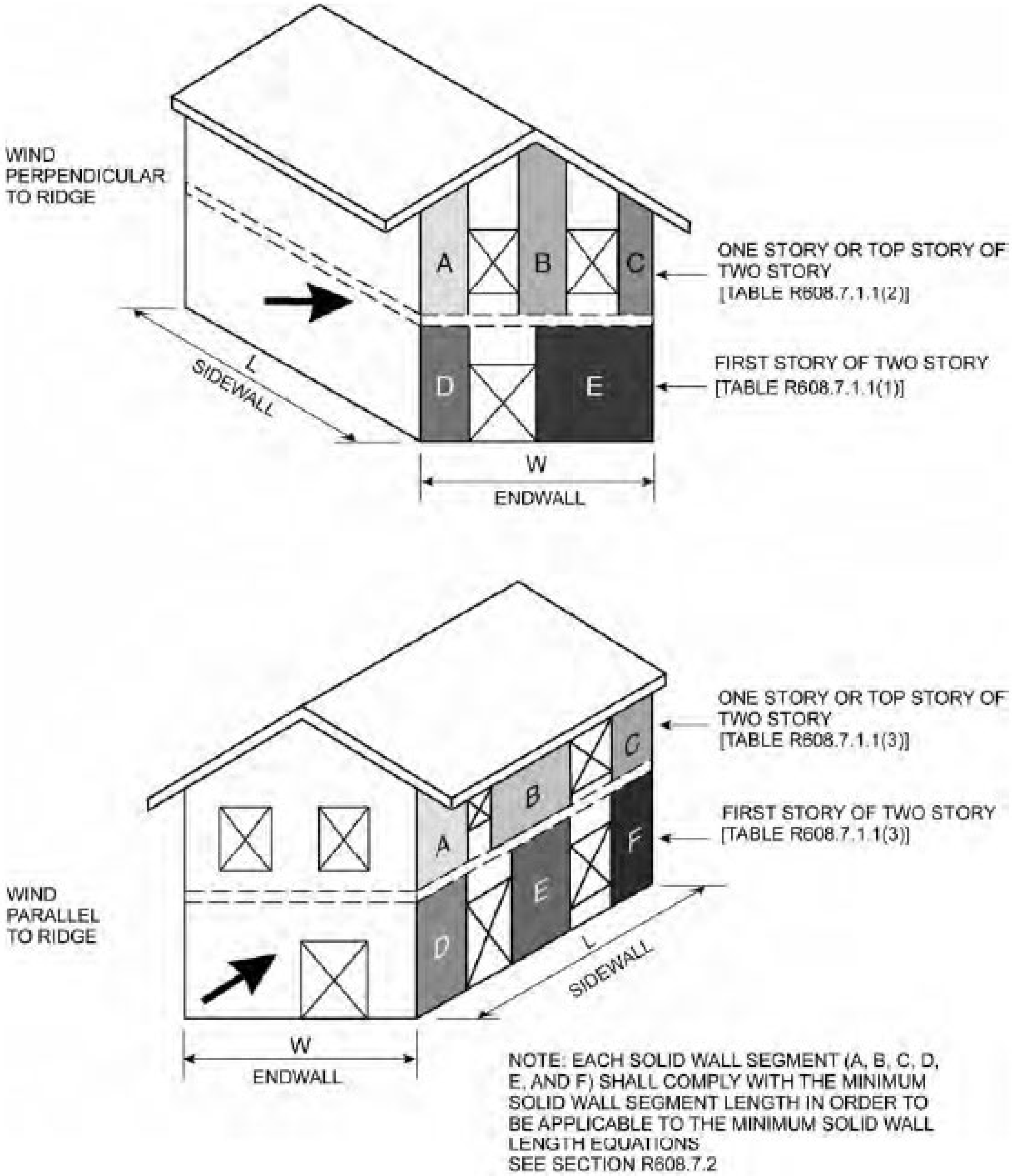
*UR* = Unreduced length of solid wall from Tables R608.7.1.1(1) through (3).

The total length of solid wall in a wall line, *TL*, shall be not less than that provided by two solid wall segments complying with the minimum length requirements of Section R608.7.2.1.

To facilitate determining the required wall thickness, wall type, number and *grade* of vertical bars at each end of each solid wall segment, and whether shear reinforcement is required, use of Equation R6-2 is permitted.

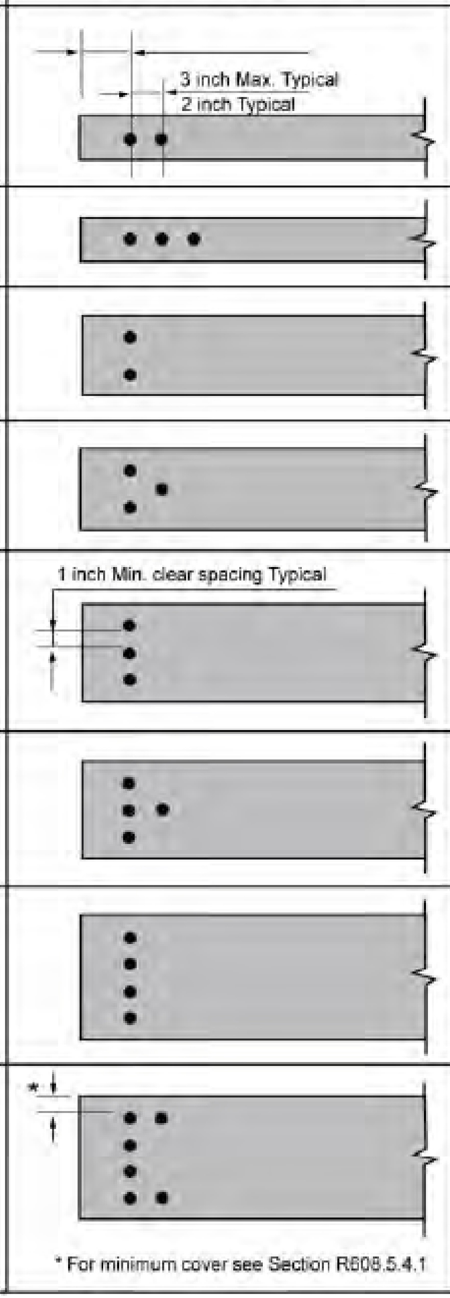
$$R_3 \leq \frac{TL}{R_1 \times R_2 \times UR} \qquad \textbf{(Equation R6-2)}$$

After determining the maximum permitted value of the reduction factor for design strength, $R_3$, in accordance with Equation R6-2, select a wall type from Table R608.7.1.1(6) with $R_3$ less than or equal to the value calculated.




**~~FIGURE R608.7(1)~~FIGURE R608.7.1.1(1)**
**MINIMUM SOLID WALL LENGTH**

| DETAIL NO. | NOM. WALL THICKNESS, IN. | REINFORCEMENT LAYOUT AT ENDS OF SOLID WALL SEGMENTS |
|---|---|---|
| 1 | 4 | see layout drawing |
| 2 | 4 | |
| 3 | 6<br>8<br>10 | |
| 4 | 6 | |
| 5 | 8 | |
| 6 | 8 | |
| 7 | 10 | |
| 8 | 10 | |

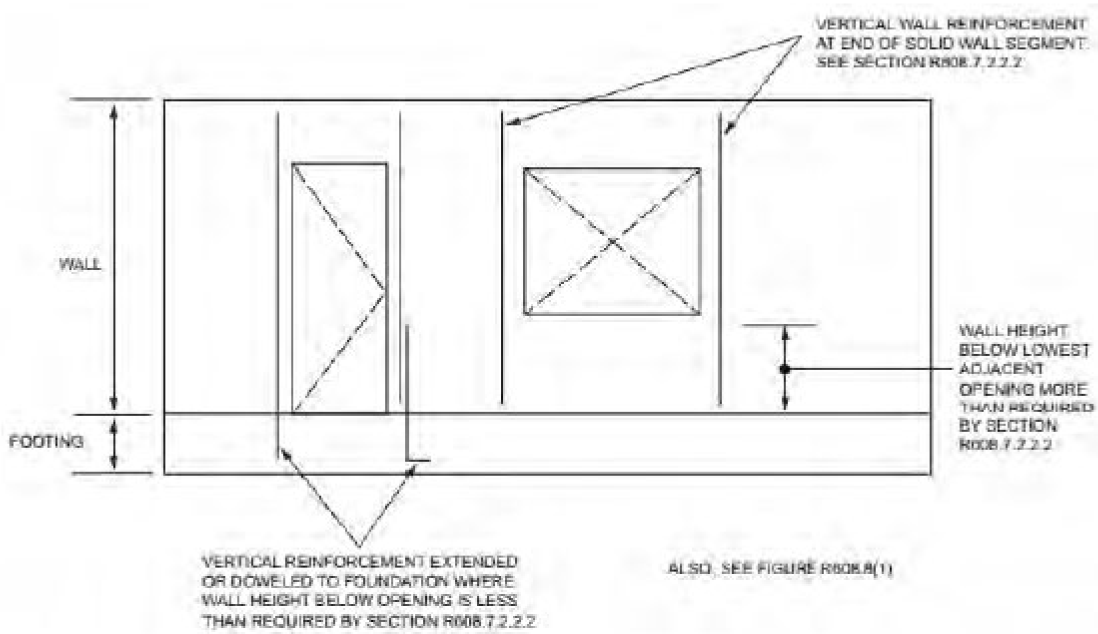



**NOTES**

For SI: 1 inch = 25.4 mm.

1. See Table R608.7(4) for use of details.
2. Minimum length of solid wall segment and size and grade of reinforcement in each end of each solid wall segment shall be determined from Table R608.7.1.1(6).
3. For minimum cover requirements, see Section R608.5.4.1.
4. For details 3 - 8 where two or more bars are in the same row parallel to the end of the segment, place bars so that corner bars are as close to the sides of the wall segments as minimum cover requirements of Section R608.5.4.1 will permit.
5. For waffle- and screen-grid walls, each end of each solid wall segment shall have rectangular flanges. In the through-the-wall dimension, the flange shall be not less than 5½ inches for 6-inch nominal waffle- and screen-grid forms, and not less than 7½ inches for 8-inch nominal waffle-grid forms. In the in-plane dimension, flanges shall be long enough to accommodate the vertical reinforcement required by the layout detail selected and provide the cover required by Section R608.5.4.1. If necessary to achieve the required dimensions, form material shall be removed or flat wall forms are permitted. See Table R608.7.1.1(6), Note e.

~~FIGURE R608.7(2)~~FIGURE R608.7.1.1(2)
**VERTICAL REINFORCEMENT LAYOUT DETAIL**




**~~FIGURE R608.7(3)~~FIGURE R608.7.1.1(3)**
**VERTICAL WALL REINFORCEMENT ADJACENT TO WALL OPENINGS**

**TABLE R608.7.1.1(1)**
**UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN EACH EXTERIOR ENDWALL FOR WIND PERPENDICULAR TO RIDGE ONE STORY OR TOP STORY OF TWO STORY[a, c, d, e, f, g]**

| SIDEWALL LENGTH (feet) | ENDWALL LENGTH (feet) | ROOF SLOPE | UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN ENDWALLS FOR WIND PERPENDICULAR TO RIDGE (feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Basic Wind Speed (mph) Exposure | | | | | | |
| | | | 115B | 120B | 130B | 140B | 150B | 160B | Minimum[b] |
| | | | — | — | 110C | 119C | 127C | 136C | |
| | | | — | — | — | 110D | 117D | 125D | |
| 15 | 15 | < 1:12 | 1.03 | 1.12 | 1.32 | 1.53 | 1.76 | 2.00 | 0.92 |
| | | 5:12 | 1.43 | 1.56 | 1.83 | 2.12 | 2.43 | 2.77 | 1.15 |
| | | 7:12 | 2.00 | 2.18 | 2.56 | 2.97 | 3.41 | 3.88 | 1.25 |
| | | 12:12 | 3.20 | 3.48 | 4.09 | 4.74 | 5.44 | 6.19 | 1.54 |
| | 30 | < 1:12 | 1.03 | 1.12 | 1.32 | 1.53 | 1.76 | 2.00 | 0.98 |
| | | 5:12 | 1.43 | 1.56 | 1.83 | 2.12 | 2.43 | 2.77 | 1.43 |
| | | 7:12 | 2.78 | 3.03 | 3.56 | 4.13 | 4.74 | 5.39 | 1.64 |
| | | 12:12 | 5.17 | 5.63 | 6.61 | 7.67 | 8.80 | 10.01 | 2.21 |
| | 45 | < 1:12 | 1.03 | 1.12 | 1.32 | 1.53 | 1.76 | 2.00 | 1.04 |
| | | 5:12 | 1.43 | 1.56 | 1.83 | 2.12 | 2.43 | 2.77 | 1.72 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 7:12 | 3.57 | 3.88 | 4.56 | 5.28 | 6.07 | 6.90 | 2.03 |
| | | 12:12 | 7.15 | 7.78 | 9.13 | 10.59 | 12.16 | 13.84 | 2.89 |
| | 60 | < 1:12 | 1.03 | 1.12 | 1.32 | 1.53 | 1.76 | 2.00 | 1.09 |
| | | 5:12 | 1.43 | 1.56 | 1.83 | 2.12 | 2.43 | 2.77 | 2.01 |
| | | 7:12 | 4.35 | 4.73 | 5.55 | 6.44 | 7.39 | 8.41 | 2.42 |
| | | 12:12 | 9.12 | 9.93 | 11.66 | 13.52 | 15.52 | 17.66 | 3.57 |
| 30 | 15 | < 1:12 | 1.84 | 2.01 | 2.35 | 2.73 | 3.13 | 3.57 | 1.82 |
| | | 5:12 | 2.56 | 2.78 | 3.27 | 3.79 | 4.35 | 4.95 | 2.23 |
| | | 7:12 | 3.61 | 3.93 | 4.61 | 5.34 | 6.13 | 6.98 | 2.42 |
| | | 12:12 | 5.61 | 6.10 | 7.16 | 8.31 | 9.54 | 10.85 | 2.93 |
| | 30 | < 1:12 | 1.84 | 2.01 | 2.35 | 2.73 | 3.13 | 3.57 | 1.93 |
| | | 5:12 | 2.56 | 2.78 | 3.27 | 3.79 | 4.35 | 4.95 | 2.75 |
| | | 7:12 | 4.92 | 5.35 | 6.28 | 7.29 | 8.37 | 9.52 | 3.12 |
| | | 12:12 | 8.92 | 9.71 | 11.39 | 13.22 | 15.17 | 17.26 | 4.14 |
| | 45 | < 1:12 | 1.84 | 2.01 | 2.35 | 2.73 | 3.13 | 3.57 | 2.03 |
| | | 5:12 | 2.56 | 2.78 | 3.27 | 3.79 | 4.35 | 4.95 | 3.26 |
| | | 7:12 | 6.23 | 6.78 | 7.96 | 9.23 | 10.60 | 12.06 | 3.82 |
| | | 12:12 | 12.23 | 13.31 | 15.63 | 18.12 | 20.80 | 23.67 | 5.36 |
| | 60 | < 1:12 | 1.84 | 2.01 | 2.35 | 2.73 | 3.13 | 3.57 | 2.14 |
| | | 5:12 | 2.56 | 2.78 | 3.27 | 3.79 | 4.35 | 4.95 | 3.78 |
| | | 7:12 | 7.54 | 8.21 | 9.64 | 11.17 | 12.83 | 14.60 | 4.52 |
| | | 12:12 | 15.54 | 16.92 | 19.86 | 23.03 | 26.44 | 30.08 | 6.57 |

*(continued)*

**TABLE R608.7.1.1(1)—continued**

**UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN EACH EXTERIOR ENDWALL FOR WIND PERPENDICULAR TO RIDGE ONE STORY OR TOP STORY OF TWO STORY[a, c, d, e, f, g]**

| SIDEWALL LENGTH (feet) | ENDWALL LENGTH (feet) | ROOF SLOPE | UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN ENDWALLS FOR WIND PERPENDICULAR TO RIDGE (feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Basic Wind Speed (mph) Exposure | | | | | | |
| | | | 115B | 120B | 130B | 140B | 150B | 160B | Minimum[b] |
| | | | — | — | 110C | 119C | 127C | 136C | |
| | | | — | — | — | 110D | 117D | 125D | |
| 60 | 15 | < 1:12 | 3.42 | 3.72 | 4.36 | 5.06 | 5.81 | 6.61 | 3.63 |
| | | 5:12 | 4.75 | 5.17 | 6.06 | 7.03 | 8.07 | 9.19 | 4.40 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 7:12 | 6.76 | 7.36 | 8.64 | 10.02 | 11.51 | 13.09 | 4.75 |
| | | 12:12 | 10.35 | 11.27 | 13.23 | 15.34 | 17.61 | 20.04 | 5.71 |
| | 30 | < 1:12 | 3.42 | 3.72 | 4.36 | 5.06 | 5.81 | 6.61 | 3.83 |
| | | 5:12 | 4.75 | 5.17 | 6.06 | 7.03 | 8.07 | 9.19 | 5.37 |
| | | 7:12 | 9.12 | 9.93 | 11.66 | 13.52 | 15.52 | 17.66 | 6.07 |
| | | 12:12 | 16.30 | 17.75 | 20.83 | 24.16 | 27.73 | 31.55 | 8.00 |
| | 45 | < 1:12 | 3.55 | 3.87 | 4.54 | 5.27 | 6.05 | 6.88 | 4.03 |
| | | 5:12 | 4.94 | 5.37 | 6.31 | 7.31 | 8.40 | 9.55 | 6.34 |
| | | 7:12 | 11.71 | 12.75 | 14.97 | 17.36 | 19.93 | 22.67 | 7.39 |
| | | 12:12 | 22.70 | 24.71 | 29.00 | 33.64 | 38.62 | 43.94 | 10.29 |
| | 60 | < 1:12 | 3.68 | 4.01 | 4.71 | 5.46 | 6.27 | 7.13 | 4.23 |
| | | 5:12 | 5.11 | 5.57 | 6.54 | 7.58 | 8.70 | 9.90 | 7.31 |
| | | 7:12 | 14.38 | 15.66 | 18.37 | 21.31 | 24.46 | 27.83 | 8.71 |
| | | 12:12 | 29.30 | 31.90 | 37.44 | 43.42 | 49.85 | 56.72 | 12.57 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound-force per linear foot = 0.146 kN/m, 1 pound per square foot = 47.88 Pa.

a. Tabulated lengths were derived by calculating design wind pressures in accordance with Figure 28.4-1 of ASCE 7 for a building with a mean roof height of 35 feet, topographic factor, $K_{zt}$, equal to 1.0, and Risk Category II. For wind perpendicular to the ridge, the effects of a 2-foot overhang on each endwall are included. The design pressures were used to calculate forces to be resisted by solid wall segments in each. The forces to be resisted by each wall line were then divided by the default design strength of 840 pounds per linear foot of length to determine the unreduced length, *UR*, of solid wall length required in each endwall. The actual mean roof height of the building shall not exceed the least horizontal dimension of the building.

b. Tabulated lengths in the "minimum" column are based on the requirement of Section 28.4.4 of ASCE 7 that the main windforce-resisting system be designed for a minimum pressure of 16 psf multiplied by the wall area of the building and 8 psf multiplied by the roof area of the building projected onto a vertical plane normal to the assumed wind direction. Tabulated lengths in shaded cells are less than the "minimum" value. Where the minimum controls, it is permitted to be reduced in accordance with Notes c, d and e. See Section R608.7.1.1.

c. For buildings with a mean roof height of less than 35 feet, tabulated lengths are permitted to be reduced by multiplying by the appropriate factor, $R_1$, from Table R608.7.1.1(4). The reduced length shall be not less than the "minimum" value shown in the table.

d. Tabulated lengths for "one story or top story of two story" are based on a floor-to-ceiling height of 10 feet. Tabulated lengths for "first story of two story" are based on floor-to-ceiling heights of 10 feet each for the first and second story. For floor-to-ceiling heights less than assumed, use the lengths in this table or Table R608.1.1(2) or (3), or multiply the value in the table by the reduction factor, $R_2$, from Table R608.7.1.1(5).

e. Tabulated lengths are based on the default design shear strength of 840 pounds per linear foot of solid wall segment. The tabulated lengths are permitted to be reduced by multiplying by the applicable reduction factor for design strength, $R_3$, from Table R608.7.1.1(6).

f. The reduction factors, $R_1$, $R_2$ and $R_3$, in Tables R608.7.1.1(4), R608.7.1.1(5), and R608.7.1.1(6), respectively, are permitted to be compounded, subject to the limitations of Note b. However, the minimum number and minimum length of solid wall segments in each wall line shall comply with Sections R608.7.1 and R608.7.2.1, respectively.

g. For intermediate values of sidewall length, endwall length, roof slope and basic wind speed, use the next higher value, or determine by interpolation.

**TABLE R608.7.1.1(2)**

**UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN EACH EXTERIOR ENDWALL FOR WIND PERPENDICULAR TO RIDGE FIRST STORY OF TWO STORY[a, c, d, e, f, g]**

| SIDEWALL LENGTH (feet) | ENDWALL LENGTH (feet) | ROOF SLOPE | UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN ENDWALLS FOR WIND PERPENDICULAR TO RIDGE (feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Basic Wind Speed (mph) Exposure | | | | | | |
| | | | 115B | 120B | 130B | 140B | 150B | 160B | Minimum[b] |
| | | | — | — | 110C | 119C | 127C | 136C | |

| | | | — | — | — | 110D | 117D | 125D | |
|---|---|---|---|---|---|---|---|---|---|
| 15 | 15 | < 1:12 | 2.98 | 3.25 | 3.81 | 4.42 | 5.07 | 5.77 | 2.54 |
| | | 5:12 | 4.13 | 4.50 | 5.28 | 6.12 | 7.03 | 8.00 | 2.76 |
| | | 7:12 | 4.31 | 4.70 | 5.51 | 6.39 | 7.34 | 8.35 | 2.87 |
| | | 12:12 | 5.51 | 6.00 | 7.04 | 8.16 | 9.37 | 10.66 | 3.15 |
| | 30 | < 1:12 | 2.98 | 3.25 | 3.81 | 4.42 | 5.07 | 5.77 | 2.59 |
| | | 5:12 | 4.13 | 4.50 | 5.28 | 6.12 | 7.03 | 8.00 | 3.05 |
| | | 7:12 | 5.09 | 5.55 | 6.51 | 7.55 | 8.67 | 9.86 | 3.26 |
| | | 12:12 | 7.48 | 8.15 | 9.56 | 11.09 | 12.73 | 14.49 | 3.83 |
| | 45 | < 1:12 | 2.98 | 3.25 | 3.81 | 4.42 | 5.07 | 5.77 | 2.65 |
| | | 5:12 | 4.13 | 4.50 | 5.28 | 6.12 | 7.03 | 8.00 | 3.34 |
| | | 7:12 | 5.88 | 6.40 | 7.51 | 8.71 | 10.00 | 11.37 | 3.65 |
| | | 12:12 | 9.46 | 10.30 | 12.09 | 14.02 | 16.09 | 18.31 | 4.51 |
| | 60 | < 1:12 | 2.98 | 3.25 | 3.81 | 4.42 | 5.07 | 5.77 | 2.71 |
| | | 5:12 | 4.13 | 4.50 | 5.28 | 6.12 | 7.03 | 8.00 | 3.63 |
| | | 7:12 | 6.66 | 7.25 | 8.51 | 9.87 | 11.32 | 12.89 | 4.04 |
| | | 12:12 | 11.43 | 12.45 | 14.61 | 16.94 | 19.45 | 22.13 | 5.19 |
| 30 | 15 | < 1:12 | 5.32 | 5.79 | 6.80 | 7.89 | 9.05 | 10.30 | 5.06 |
| | | 5:12 | 7.39 | 8.04 | 9.44 | 10.95 | 12.57 | 14.30 | 5.47 |
| | | 7:12 | 7.94 | 8.65 | 10.15 | 11.77 | 13.51 | 15.37 | 5.65 |
| | | 12:12 | 9.94 | 10.82 | 12.70 | 14.73 | 16.91 | 19.24 | 6.17 |
| | 30 | < 1:12 | 5.32 | 5.79 | 6.80 | 7.89 | 9.05 | 10.30 | 5.16 |
| | | 5:12 | 7.39 | 8.04 | 9.44 | 10.95 | 12.57 | 14.30 | 5.98 |
| | | 7:12 | 9.25 | 10.07 | 11.82 | 13.71 | 15.74 | 17.91 | 6.35 |
| | | 12:12 | 13.25 | 14.43 | 16.93 | 19.64 | 22.54 | 25.65 | 7.38 |
| | 45 | < 1:12 | 5.32 | 5.79 | 6.80 | 7.89 | 9.05 | 10.30 | 5.27 |
| | | 5:12 | 7.39 | 8.04 | 9.44 | 10.95 | 12.57 | 14.30 | 6.50 |
| | | 7:12 | 10.56 | 11.50 | 13.50 | 15.65 | 17.97 | 20.45 | 7.06 |
| | | 12:12 | 16.56 | 18.03 | 21.16 | 24.55 | 28.18 | 32.06 | 8.60 |
| | 60 | < 1:12 | 5.32 | 5.79 | 6.80 | 7.89 | 9.05 | 10.30 | 5.38 |
| | | 5:12 | 7.39 | 8.04 | 9.44 | 10.95 | 12.57 | 14.30 | 7.01 |
| | | 7:12 | 11.87 | 12.93 | 15.17 | 17.60 | 20.20 | 22.98 | 7.76 |
| | | 12:12 | 19.87 | 21.64 | 25.40 | 29.45 | 33.81 | 38.47 | 9.81 |

**TABLE R608.7.1.1(2)—continued**

**UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN EACH EXTERIOR ENDWALL FOR WIND PERPENDICULAR TO RIDGE FIRST STORY OF TWO STORY[a, c, d, e, f, g]**

| SIDEWALL LENGTH (feet) | ENDWALL LENGTH (feet) | ROOF SLOPE | UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN ENDWALLS FOR WIND PERPENDICULAR TO RIDGE (feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Basic Wind Speed (mph) Exposure | | | | | | |
| | | | 115B | 120B | 130B | 140B | 150B | 160B | Minimum[b] |
| | | | — | — | 110C | 119C | 127C | 136C | |
| | | | — | — | — | 110D | 117D | 125D | |
| 60 | 15 | < 1:12 | 9.87 | 10.74 | 12.61 | 14.62 | 16.79 | 19.10 | 10.10 |
| | | 5:12 | 13.71 | 14.93 | 17.52 | 20.32 | 23.33 | 26.54 | 10.87 |
| | | 7:12 | 15.08 | 16.42 | 19.27 | 22.35 | 25.66 | 29.20 | 11.22 |
| | | 12:12 | 18.67 | 20.33 | 23.86 | 27.67 | 31.77 | 36.14 | 12.19 |
| | 30 | < 1:12 | 9.87 | 10.74 | 12.61 | 14.62 | 16.79 | 19.10 | 10.30 |
| | | 5:12 | 13.71 | 14.93 | 17.52 | 20.32 | 23.33 | 26.54 | 11.85 |
| | | 7:12 | 17.44 | 18.99 | 22.29 | 25.85 | 29.67 | 33.76 | 12.54 |
| | | 12:12 | 24.62 | 26.81 | 31.46 | 36.49 | 41.89 | 47.66 | 14.48 |
| | 45 | < 1:12 | 10.27 | 11.18 | 13.12 | 15.21 | 17.47 | 19.87 | 10.50 |
| | | 5:12 | 14.26 | 15.52 | 18.22 | 21.13 | 24.26 | 27.60 | 12.82 |
| | | 7:12 | 20.21 | 22.01 | 25.83 | 29.95 | 34.39 | 39.12 | 13.86 |
| | | 12:12 | 31.20 | 33.97 | 39.87 | 46.23 | 53.07 | 60.39 | 16.76 |
| | 60 | < 1:12 | 10.64 | 11.59 | 13.60 | 15.77 | 18.11 | 20.60 | 10.70 |
| | | 5:12 | 14.77 | 16.09 | 18.88 | 21.90 | 25.14 | 28.60 | 13.79 |
| | | 7:12 | 23.05 | 25.09 | 29.45 | 34.15 | 39.21 | 44.61 | 15.18 |
| | | 12:12 | 37.97 | 41.34 | 48.52 | 56.27 | 64.60 | 73.49 | 19.05 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound force per linear foot = 0.146 kN/m, 1 pound per square foot = 47.88 Pa.

a. Tabulated lengths were derived by calculating design wind pressures in accordance with Figure 28.4-1 of ASCE 7 for a building with a mean roof height of 35 feet, topographic factor, $K_{zt}$, equal to 1.0, and Risk Category II. For wind perpendicular to the ridge, the effects of a 2-foot overhang on each endwall are included. The design pressures were used to calculate forces to be resisted by solid wall segments in each endwall. The forces to be resisted by each wall line were then divided by the default design strength of 840 pounds per linear foot of length to determine the unreduced length, *UR*, of solid wall length required in each endwall. The actual mean roof height of the building shall not exceed the least horizontal dimension of the building.

b. Tabulated lengths in the "minimum" column are based on the requirement of Section 28.4.4 of ASCE 7 that the main windforce-resisting system be designed for a minimum pressure of 1016 psf multiplied by the wall area of the building and 8 psf multiplied by the roof area of the building projected onto a vertical plane normal to the assumed wind direction. Tabulated lengths in shaded cells are less than the "minimum" value. Where the minimum controls, it is permitted to be reduced in accordance with Notes c, d and e. See Section R608.7.1.1.

c. For buildings with a mean roof height of less than 35 feet, tabulated lengths are permitted to be reduced by multiplying by the appropriate factor, $R_1$, from Table R608.7.1.1(4). The reduced length shall be not less than the "minimum" value shown in the table.

d. Tabulated lengths for "one story or top story of two story" are based on a floor-to-ceiling height of 10 feet. Tabulated lengths for "first story of two story" are based on floor-to-ceiling heights of 10 feet each for the first and second story. For floor-to-ceiling heights less than assumed, use the lengths in this table or Table R608.7.1.1(1) or R608.7.1.1(3), or multiply the value in the table by the reduction factor, $R_2$, from Table R608.7.1.1(5).

e. Tabulated lengths are based on the default design shear strength of 840 pounds per linear foot of solid wall segment. The tabulated lengths are permitted to be reduced by multiplying by the applicable reduction factor for design strength, $R_3$, from Table R608.7.1.1(6).

f. The reduction factors, $R_1$, $R_2$ and $R_3$, in Tables R608.7.1.1(4), R608.7.1.1(5), and R608.7.1.1(6), respectively, are permitted to be compounded, subject to the limitations of Note b. However, the minimum number and minimum length of solid wall segments in each wall line shall comply with Sections R608.7.1 and R608.7.2.1, respectively.

g. For intermediate values of sidewall length, endwall length, roof slope and basic wind speed, use the next higher value, or determine by interpolation.

**TABLE ~~R608.7~~ R608.7.1.1(3)**

**UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN EACH EXTERIOR SIDEWALL FOR WIND PARALLEL TO RIDGE[a, c, d, e, f, g]**

| SIDEWALL LENGTH (feet) | ENDWALL LENGTH (feet) | ROOF SLOPE | UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN SIDEWALLS FOR WIND PARALLEL TO RIDGE (feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Basic Wind Speed (mph) Exposure | | | | | | |
| | | | 115B | 120B | 130B | 140B | 150B | 160B | Minimum[b] |
| | | | — | — | 110C | 119C | 127C | 136C | |
| | | | — | — | — | 110D | 117D | 125D | |
| | | | One story or top story of two story | | | | | | |
| < 30 | 15 | < 1:12 | 1.08 | 1.18 | 1.39 | 161 | 1.84 | 2.10 | 0.90 |
| | | 5:12 | 1.29 | 1.40 | 1.65 | 1.91 | 2.19 | 2.49 | 1.08 |
| | | 7:12 | 1.38 | 1.50 | 1.76 | 2.04 | 2.35 | 2.67 | 1.17 |
| | | 12:12 | 1.63 | 1.78 | 2.09 | 2.42 | 2.78 | 3.16 | 1.39 |
| | 30 | < 1:12 | 2.02 | 2.20 | 2.59 | 3.00 | 3.44 | 3.92 | 1.90 |
| | | 5:12 | 2.73 | 2.97 | 3.48 | 4.04 | 4.64 | 5.28 | 2.62 |
| | | 7:12 | 3.05 | 3.32 | 3.89 | 4.51 | 5.18 | 5.89 | 2.95 |
| | | 12:12 | 3.93 | 4.27 | 5.02 | 5.82 | 6.68 | 7.60 | 3.86 |
| | 45 | < 1:12 | 3.03 | 3.30 | 3.87 | 4.49 | 5.15 | 5.86 | 2.99 |
| | | 5:12 | 4.55 | 4.96 | 5.82 | 6.75 | 7.74 | 8.81 | 4.62 |
| | | 7:12 | 5.24 | 5.71 | 6.70 | 7.77 | 8.92 | 10.15 | 5.36 |
| | | 12:12 | 7.16 | 7.79 | 9.14 | 10.61 | 12.17 | 13.85 | 7.39 |
| | 60 | < 1:12 | 4.11 | 4.47 | 5.25 | 6.09 | 6.99 | 7.96 | 4.18 |
| | | 5:12 | 6.78 | 7.39 | 8.67 | 10.05 | 11.54 | 13.13 | 7.07 |
| | | 7:12 | 8.00 | 8.71 | 10.22 | 11.85 | 13.61 | 15.48 | 8.38 |
| | | 12:12 | 11.35 | 12.36 | 14.51 | 16.82 | 19.31 | 21.97 | 12.00 |
| 60 | 45 | < 1:12 | 3.17 | 3.46 | 4.06 | 4.70 | 5.40 | 6.14 | 2.99 |
| | | 5:12 | 4.75 | 5.18 | 6.07 | 7.04 | 8.09 | 9.20 | 4.62 |
| | | 7:12 | 5.47 | 5.96 | 6.99 | 8.11 | 9.31 | 10.59 | 5.36 |
| | | 12:12 | 7.45 | 8.11 | 9.52 | 11.04 | 12.68 | 14.43 | 7.39 |
| | 60 | < 1:12 | 4.41 | 4.81 | 5.64 | 6.54 | 7.51 | 8.54 | 4.18 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 5:12 | 7.22 | 7.86 | 9.23 | 10.70 | 12.29 | 13.98 | 7.07 |
| | | 7:12 | 8.50 | 9.25 | 10.86 | 12.59 | 14.46 | 16.45 | 8.38 |
| | | 12:12 | 12.02 | 13.09 | 15.36 | 17.81 | 20.45 | 23.27 | 12.00 |

*(continued)*

**TABLE ~~R608.7~~ R608.7.1.1(3)—continued**

**UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN EACH EXTERIOR SIDEWALL FOR WIND PARALLEL TO RIDGE[a, c, d, e, f, g]**

| SIDEWALL LENGTH (feet) | ENDWALL LENGTH (feet) | ROOF SLOPE | UNREDUCED LENGTH, *UR*, OF SOLID WALL REQUIRED IN SIDEWALLS FOR WIND PARALLEL TO RIDGE (feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Basic Wind Speed (mph) Exposure | | | | | | |
| | | | 115B | 120B | 130B | 140B | 150B | 160B | Minimum[b] |
| | | | — | — | 110C | 119C | 127C | 136C | |
| | | | — | — | — | 110D | 117D | 125D | |
| | | | One story or top story of two story | | | | | | |
| < 30 | 15 | < 1:12 | 3.03 | 3.30 | 3.88 | 4.49 | 5.16 | 5.87 | 2.52 |
| | | 5:12 | 3.24 | 3.52 | 4.14 | 4.80 | 5.51 | 6.26 | 2.70 |
| | | 7:12 | 3.33 | 3.62 | 4.25 | 4.93 | 5.66 | 6.44 | 2.79 |
| | | 12:12 | 3.58 | 3.90 | 4.58 | 5.31 | 6.10 | 6.94 | 3.01 |
| | 30 | < 1:12 | 5.50 | 5.99 | 7.03 | 8.16 | 9.36 | 10.65 | 5.14 |
| | | 5:12 | 6.21 | 6.76 | 7.93 | 9.20 | 10.56 | 12.01 | 5.86 |
| | | 7:12 | 6.52 | 7.10 | 8.34 | 9.67 | 11.10 | 12.63 | 6.19 |
| | | 12:12 | 7.41 | 8.06 | 9.46 | 10.97 | 12.60 | 14.33 | 7.10 |
| | 45 | < 1:12 | 8.00 | 8.71 | 10.22 | 11.85 | 13.61 | 15.48 | 7.85 |
| | | 5:12 | 9.52 | 10.37 | 12.17 | 14.11 | 16.20 | 18.43 | 9.48 |
| | | 7:12 | 10.21 | 11.12 | 13.05 | 15.14 | 17.38 | 19.77 | 10.21 |
| | | 12:12 | 12.13 | 13.20 | 15.50 | 17.97 | 20.63 | 23.47 | 12.25 |
| | 60 | < 1:12 | 10.56 | 11.50 | 13.50 | 15.65 | 17.97 | 20.44 | 10.65 |
| | | 5:12 | 13.24 | 14.41 | 16.91 | 19.62 | 22.52 | 25.62 | 13.54 |
| | | 7:12 | 14.45 | 15.73 | 18.46 | 21.41 | 24.58 | 27.97 | 14.85 |
| | | 12:12 | 17.80 | 19.38 | 22.75 | 26.38 | 30.29 | 34.46 | 18.48 |
| 60 | 45 | < 1:12 | 8.39 | 9.14 | 10.72 | 12.44 | 14.28 | 16.25 | 7.85 |
| | | 5:12 | 9.97 | 10.86 | 12.74 | 14.78 | 16.97 | 19.30 | 9.48 |
| | | 7:12 | 10.69 | 11.64 | 13.66 | 15.84 | 18.19 | 20.69 | 10.21 |
| | | 12:12 | 12.67 | 13.80 | 16.19 | 18.78 | 21.56 | 24.53 | 12.25 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 60 | < 1:12 | 11.37 | 12.38 | 14.53 | 16.85 | 19.35 | 22.01 | 10.65 |
| | | 5:12 | 14.18 | 15.44 | 18.12 | 21.02 | 24.13 | 27.45 | 13.54 |
| | | 7:12 | 15.46 | 16.83 | 19.75 | 22.91 | 26.29 | 29.92 | 14.85 |
| | | 12:12 | 18.98 | 20.66 | 24.25 | 28.13 | 32.29 | 36.74 | 18.48 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound force per linear foot = 0.146 kN/m, 1 pound per square foot = 47.88 Pa.

a. Tabulated lengths were derived by calculating design wind pressures in accordance with Figure 28.4-1 of ASCE 7 for a building with a mean roof height of 35 feet, topographic factor, $K_{zt}$, equal to 1.0, and Risk Category II. The design pressures were used to calculate forces to be resisted by solid wall segments in each sidewall. The forces to be resisted by each wall line were then divided by the default design strength of 840 pounds per linear foot of length to determine the unreduced length, *UR*, of solid wall length required in each sidewall. The actual mean roof height of the building shall not exceed the least horizontal dimension of the building.

b. Tabulated lengths in the "minimum" column are based on the requirement of Section 28.4.4 of ASCE 7 that the main windforce-resisting system be designed for a minimum pressure of 16 psf multiplied by the wall area of the building and 8 psf multiplied by the roof area of the building projected onto a vertical plane normal to the assumed wind direction. Tabulated lengths in shaded cells are less than the "minimum" value. Where the minimum controls, it is permitted to be reduced in accordance with Notes c, d and e. See Section R608.7.1.1.

c. For buildings with a mean roof height of less than 35 feet, tabulated lengths are permitted to be reduced by multiplying by the appropriate factor, $R_1$, from Table R608.7.1.1(4). The reduced length shall be not less than the "minimum" value shown in the table.

d. Tabulated lengths for "one story or top story of two story" are based on a floor-to-ceiling height of 10 feet. Tabulated lengths for "first story of two story" are based on floor-to-ceiling heights of 10 feet each for the first and second story. For floor-to-ceiling heights less than assumed, use the lengths in this table or Table R608.7.1.1(1) or Table R608.7.1.1(2), or multiply the value in the table by the reduction factor, $R_2$, from Table R608.7.1.1(5).

e. Tabulated lengths are based on the default design shear strength of 840 pounds per linear foot of solid wall segment. The tabulated lengths are permitted to be reduced by multiplying by the applicable reduction factor for design strength, $R_3$, from Table R608.7.1.1(6).

f. The reduction factors, $R_1$, $R_2$ and $R_3$, in Table R608.7.1.1(4), Table R608.7.1.1(5), and Table R608.7.1.1(6), respectively, are permitted to be compounded, subject to the limitations of Note b. However, the minimum number and minimum length of solid walls segments in each wall line shall comply with Sections R608.7.1 and R608.7.2.1, respectively.

g. For intermediate values of sidewall length, endwall length, roof slope and basic wind speed, use the next higher value, or determine by interpolation.

**TABLE ~~R608.7(2)~~ R608.7.1.1(4)**

**REDUCTION FACTOR, $R_1$, FOR BUILDINGS WITH MEAN ROOF HEIGHT LESS THAN 35 FEET[a]**

| MEAN ROOF HEIGHT[b, c] (feet) | REDUCTION FACTOR $R_1$, FOR MEAN ROOF HEIGHT | | |
|---|---|---|---|
| | Exposure category | | |
| | B | C | D |
| < 15 | 0.96 | 0.84 | 0.87 |
| 20 | 0.96 | 0.89 | 0.91 |
| 25 | 0.96 | 0.93 | 0.94 |
| 30 | 0.96 | 0.97 | 0.98 |
| 35 | 1.00 | 1.00 | 1.00 |

For SI: 1 foot = 304.8 mm, 1 degree = 0.0175 rad.

a. See Section R608.7.1.1 and Note c to Table R608.7.1.1(1) for application of reduction factors in this table. This reduction is not permitted for "minimum" values.

b. For intermediate values of mean roof height, use the factor for the next greater height, or determine by interpolation.

c. Mean roof height is the average of the roof eave height and height of the highest point on the roof surface, except that for roof slopes of less than or equal to $2^1/_8$:12 (10 degrees), the mean roof height is permitted to be taken as the roof eave height.

**TABLE ~~R608.7(3)~~ R608.7.1.1(5)**

**REDUCTION FACTOR, $R_2$, FOR FLOOR-TO-CEILING WALL HEIGHTS LESS THAN 10 FEET[a, b]**

| STORY UNDER CONSIDERATION | FLOOR-TO-CEILING HEIGHT[c] (feet) | ENDWALL LENGTH (feet) | ROOF SLOPE | REDUCTION FACTOR, $R_2$ |
|---|---|---|---|---|
| **Endwalls—for wind perpendicular to ridge** | | | | |
| One story or top story of two story | 8 | 15 | < 5:12 | 0.83 |
| | | | 7:12 | 0.90 |
| | | | 12:12 | 0.94 |
| | | 60 | < 5:12 | 0.83 |
| | | | 7:12 | 0.95 |
| | | | 12:12 | 0.98 |
| First story of two story | 16 combined first and second story | 15 | < 5:12 | 0.83 |
| | | | 7:12 | 0.86 |
| | | | 12:12 | 0.89 |
| | | 60 | < 5:12 | 0.83 |
| | | | 7:12 | 0.91 |
| | | | 12:12 | 0.95 |
| **Sidewalls—for wind parallel to ridge** | | | | |
| One story or top story of two story | 8 | 15 | < 1:12 | 0.84 |
| | | | 5:12 | 0.87 |
| | | | 7:12 | 0.88 |
| | | | 12:12 | 0.89 |
| | | 60 | < 1:12 | 0.86 |
| | | | 5:12 | 0.92 |
| | | | 7:12 | 0.93 |
| | | | 12:12 | 0.95 |
| First story of two story | 16 combined first and second story | 15 | < 1:12 | 0.83 |
| | | | 5:12 | 0.84 |
| | | | 7:12 | 0.85 |
| | | | 12:12 | 0.86 |
| | | 60 | < 1:12 | 0.84 |
| | | | 5:12 | 0.87 |
| | | | 7:12 | 0.88 |
| | | | 12:12 | 0.90 |

For SI: 1 foot = 304.8 mm.

a. See Section R608.7.1.1 and Note d to Table R608.7.1.1(1) for application of reduction factors in this table.

b. For intermediate values of endwall length and roof slope, use the next higher value or determine by interpolation.

c. Tabulated values in Tables R608.7.1.1(1) and R608.7.1.1(3) for "one story or top story of two story" are based on a floor-to-ceiling height of 10 feet. Tabulated values in Tables R608.7.1.1(2) and R608.7.1.1(3) for "first story of two story" are based on floor-to-ceiling heights of 10 feet each for the first and second story. For floor to ceiling heights between those shown in this table and those assumed in Table R608.7.1.1(1), R608.7.1.1(2) or R608.7.1.1(3), use the solid wall lengths in Table R608.7.1.1(1), R608.7.1.1(2) or R608.7.1.1(3), or determine the reduction factor by interpolating between 1.0 and the factor shown in this table.

**TABLE ~~R608.7(4)~~ R608.7.1.1(6)**

**REDUCTION FACTOR FOR DESIGN STRENGTH, $R_3$, FOR FLAT, WAFFLE- AND SCREEN-GRID WALLS[a, c]**

| NOMINAL THICKNESS OF WALL (inches) | VERTICAL BARS AT EACH END OF SOLID WALL SEGMENT | | VERTICAL REINFORCEMENT LAYOUT DETAIL [see Figure R608.7.1.1(2)] | REDUCTION FACTOR, $R_3$, FOR LENGTH OF SOLID WALL | | | |
|---|---|---|---|---|---|---|---|
| | | | | Horizontal and vertical shear reinforcement provided | | | |
| | | | | No | | Yes[d] | |
| | Number of bars | Bar size | | 40,000[b] | 60,000[b] | 40,000[b] | 60,000[b] |
| Flat walls | | | | | | | |
| 4 | 2 | 4 | 1 | 0.74 | 0.61 | 0.74 | 0.50 |
| | 3 | 4 | 2 | 0.61 | 0.61 | 0.52 | 0.27 |
| | 2 | 5 | 1 | 0.61 | 0.61 | 0.48 | 0.25 |
| | 3 | 5 | 2 | 0.61 | 0.61 | 0.26 | 0.18 |
| 6 | 2 | 4 | 3 | 0.70 | 0.48 | 0.70 | 0.48 |
| | 3 | 4 | 4 | 0.49 | 0.38 | 0.49 | 0.33 |
| | 2 | 5 | 3 | 0.46 | 0.38 | 0.46 | 0.31 |
| | 3 | 5 | 4 | 0.38 | 0.38 | 0.32 | 0.16 |
| 8 | 2 | 4 | 3 | 0.70 | 0.47 | 0.70 | 0.47 |
| | 3 | 4 | 5 | 0.47 | 0.32 | 0.47 | 0.32 |
| | 2 | 5 | 3 | 0.45 | 0.31 | 0.45 | 0.31 |
| | 4 | 4 | 6 | 0.36 | 0.28 | 0.36 | 0.25 |
| | 3 | 5 | 5 | 0.31 | 0.28 | 0.31 | 0.16 |
| | 4 | 5 | 6 | 0.28 | 0.28 | 0.24 | 0.12 |
| 10 | 2 | 4 | 3 | 0.70 | 0.47 | 0.70 | 0.47 |
| | 2 | 5 | 3 | 0.45 | 0.30 | 0.45 | 0.30 |
| | 4 | 4 | 7 | 0.36 | 0.25 | 0.36 | 0.25 |
| | 6 | 4 | 8 | 0.25 | 0.22 | 0.25 | 0.13 |
| | 4 | 5 | 7 | 0.24 | 0.22 | 0.24 | 0.12 |
| | 6 | 5 | 8 | 0.22 | 0.22 | 0.12 | 0.08 |
| Waffle-grid walls[e] | | | | | | | |
| 6 | 2 | 4 | 3 | 0.78 | 0.78 | 0.70 | 0.48 |
| | 3 | 4 | 4 | 0.78 | 0.78 | 0.49 | 0.25 |
| | 2 | 5 | 3 | 0.78 | 0.78 | 0.46 | 0.23 |
| | 3 | 5 | 4 | 0.78 | 0.78 | 0.24 | 0.16 |
| 8 | 2 | 4 | 3 | 0.78 | 0.78 | 0.70 | 0.47 |
| | 3 | 4 | 5 | 0.78 | 0.78 | 0.47 | 0.24 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 | 5 | 3 | 0.78 | 0.78 | 0.45 | 0.23 |
| | 4 | 4 | 6 | 0.78 | 0.78 | 0.36 | 0.18 |
| | 3 | 5 | 5 | 0.78 | 0.78 | 0.23 | 0.16 |
| | 4 | 5 | 6 | 0.78 | 0.78 | 0.18 | 0.13 |
| **Screen-grid walls[e]** | | | | | | | |
| 6 | 2 | 4 | 3 | 0.93 | 0.93 | 0.70 | 0.48 |
| | 3 | 4 | 4 | 0.93 | 0.93 | 0.49 | 0.25 |
| | 2 | 5 | 3 | 0.93 | 0.93 | 0.46 | 0.23 |
| | 3 | 5 | 4 | 0.93 | 0.93 | 0.24 | 0.16 |

For SI: 1 inch = 25.4 mm, 1,000 pounds per square inch = 6.895 MPa.

a. See Note e to Table R608.7.1.1(1) for application of adjustment factors in this table.

b. Yield strength in pounds per square inch of vertical wall reinforcement at ends of solid wall segments.

c. Values are based on concrete with a specified compressive strength, $f'_c$, of 2,500 psi. Where concrete with $f'_c$ of not less than 3,000 psi is used, values in shaded cells are permitted to be decreased by multiplying by 0.91.

d. Horizontal and vertical shear reinforcement shall be provided in accordance with Section R608.7.2.2.

e. Each end of each solid wall segment shall have rectangular flanges. In the through-the-wall dimension, the flange shall be not less than $5^1/_2$ inches for 6-inch-nominal waffle- and screen-grid walls, and not less than $7^1/_2$ inches for 8-inch-nominal waffle-grid walls. In the in-plane dimension, flanges shall be long enough to accommodate the vertical reinforcement required by the layout detail selected from Figure R608.7.1.1(2) and provide the cover required by Section R608.5.4.1. If necessary to achieve the required dimensions, form material shall be removed or use of flat wall forms is permitted.

**R608.7.2 Solid wall segments.** Solid wall segments that contribute to the required length of solid wall shall comply with this section. Reinforcement shall be provided in accordance with Section R608.7.2.2 and Table R608.7.1.1(6). Solid wall segments shall extend the full story-height without openings, other than openings for the utilities and other building services passing through the wall. In flat walls and waffle-grid walls, such openings shall have an area of less than 30 square inches (19 355 mm$^2$) without any dimension exceeding $6^1/_4$ inches (159 mm), and shall not be located within 6 inches (152 mm) of the side edges of the solid wall segment. In screen-grid walls, such openings shall be located in the portion of the solid wall segment between horizontal and vertical cores of concrete and opening size and location are not restricted provided there is not any concrete removed.

**R608.7.2.1 Minimum length of solid wall segment and maximum spacing.** Only solid wall segments equal to or greater than 24 inches (610 mm) in length shall be included in the total length of solid wall required by Section R608.7.1. In addition, not more than two solid wall segments equal to or greater than 24 inches (610 mm) in length and less than 48 inches (1219 mm) in length shall be included in the required total length of solid wall. The maximum clear opening width shall be 18 feet (5486 mm). See Figure R608.7.1.1(1).

**R608.7.2.2 Reinforcement in solid wall segments.**

**R608.7.2.2.1 Horizontal shear reinforcement.** Where reduction factors for design strength, $R_3$, from Table R608.7.1.1(6) based on horizontal and vertical shear reinforcement being provided are used, solid wall segments shall have horizontal reinforcement consisting of minimum No. 4 bars. Horizontal shear reinforcement shall be the same grade of steel required for the vertical reinforcement at the ends of solid wall segments by Section R608.7.2.2.2.

The spacing of horizontal reinforcement shall not exceed the smaller of one-half the length of the solid wall segment, minus 2 inches (51 mm), and 18 inches (457 mm). Horizontal shear reinforcement shall terminate in accordance with Section R608.6.4.

**R608.7.2.2.2 Vertical reinforcement.** Vertical reinforcement applicable to the reduction factor(s) for design strength, $R_3$, from Table R608.7.1.1(6) that is used, shall be located at each end of each solid wall segment in accordance with the applicable detail in Figure R608.7.1.1(2). The No. 4 vertical bar required on each side of an opening by Section R608.8.1.2 is permitted to be used as reinforcement at the ends of solid wall segments where installed in accordance with the applicable detail in Figure R608.7.1.1(2). There shall be not less than two No. 4 bars at each end of solid wall segments located as required by the applicable detail in Figure R608.7.1.1(2). One of the bars at each end of solid wall segments shall be deemed to meet the requirements for vertical wall reinforcement required by Section R608.6.

The vertical wall reinforcement at each end of each solid wall segment shall be developed below the bottom of the adjacent wall opening [see Figure R608.7.1.1(3)] by one of the following methods:

1. Where the wall height below the bottom of the adjacent opening is equal to or greater than 22 inches (559 mm) for No. 4 or 28 inches (711 mm) for No. 5 vertical wall reinforcement, reinforcement around openings in accordance with Section R608.8.1 shall be sufficient.
2. Where the wall height below the bottom of the adjacent opening is less than required by Item 1 ~~above~~, the vertical wall reinforcement adjacent to the opening shall extend into the footing far enough to develop the bar in tension in accordance with Section R608.5.4.4 and Figure R608.5.4(2), or shall be lap-spliced with a dowel that is embedded in the footing far enough to develop the dowel-bar in tension.

**R608.7.2.2.3 Vertical shear reinforcement.** Where reduction factors for design strength, $R_3$, from Table R608.7.1.1(6) based on horizontal and vertical shear reinforcement being provided are used, solid wall segments shall have vertical reinforcement consisting of minimum No. 4 bars. Vertical shear reinforcement shall be the same grade of steel required by Section R608.7.2.2.2 for the vertical reinforcement at the ends of solid wall segments. The spacing of vertical reinforcement throughout the length of the segment shall not exceed the smaller of one third the length of the segment, and 18 inches (457 mm). Vertical shear reinforcement shall be continuous between stories in accordance with Section R608.6.3, and shall terminate in accordance with Section R608.6.4. Vertical shear reinforcement required by this section is permitted to be used for vertical reinforcement required by Table R608.6(1), R608.6(2), R608.6(3) or R608.6(4), whichever is applicable.

**R608.7.2.3 Solid wall segments at corners.** At all interior and exterior corners of exterior walls, a solid wall segment shall extend the full height of each wall *story*. The segment shall have the length required to develop the horizontal reinforcement above and below the adjacent opening in tension in accordance with Section R608.5.4.4. For an exterior corner, the limiting dimension is measured on the outside of the wall, and for an interior corner the limiting dimension is measured on the inside of the wall. See Section R608.8.1. The length of a segment contributing to the required length of solid wall shall comply with Section R608.7.2.1.

The end of a solid wall segment complying with the minimum length requirements of Section R608.7.2.1 shall be located not more than 6 feet (1829 mm) from each corner.

**R608.8 Requirements for lintels and reinforcement around openings.**

**R608.8.1 Reinforcement around openings.** Reinforcement shall be provided around openings in walls equal to or greater than 2 feet (610 mm) in width in accordance with this section and Figure R608.8(1), in addition to the minimum wall reinforcement required by Sections R404.1.3, R608.6 and R608.7. Vertical wall reinforcement required by this section is permitted to be used as reinforcement at the ends of solid wall segments required by Section R608.7.2.2.2 provided it is located in accordance with Section R608.8.1.2. Wall openings shall have a minimum depth of concrete over the width of the opening of 8 inches (203 mm) in flat walls and waffle-grid walls, and 12 inches (305 mm) in screen-grid walls. Wall openings in waffle-grid and screen-grid walls shall be located such that not less than one-half of a vertical core occurs along each side of the opening.

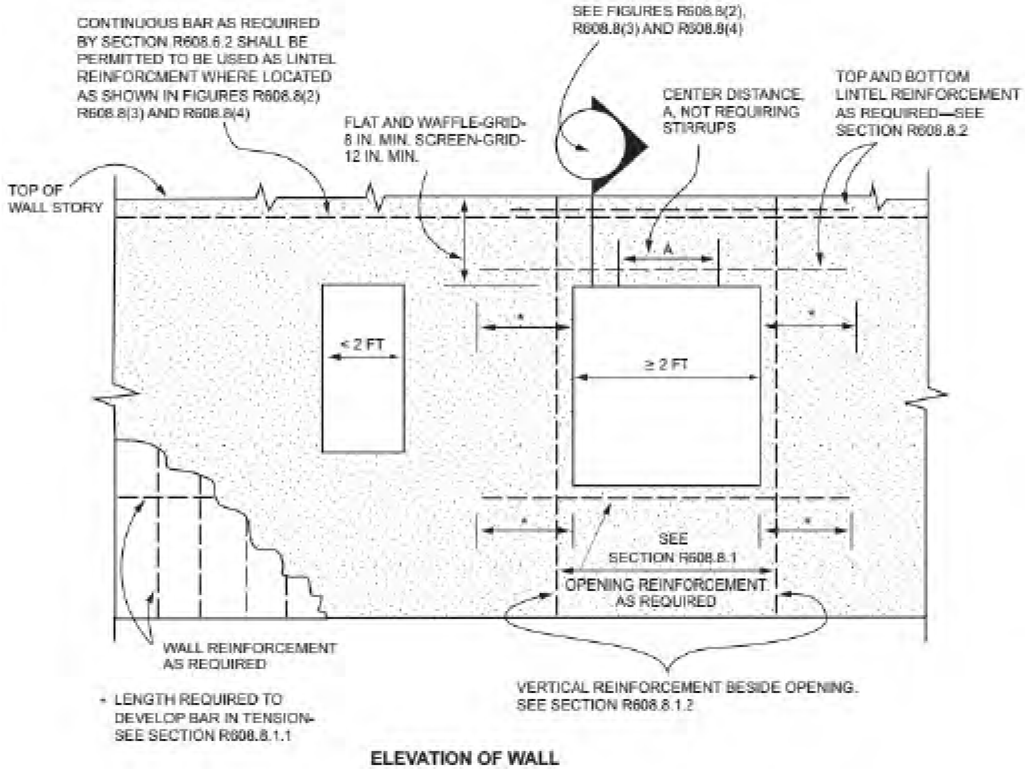
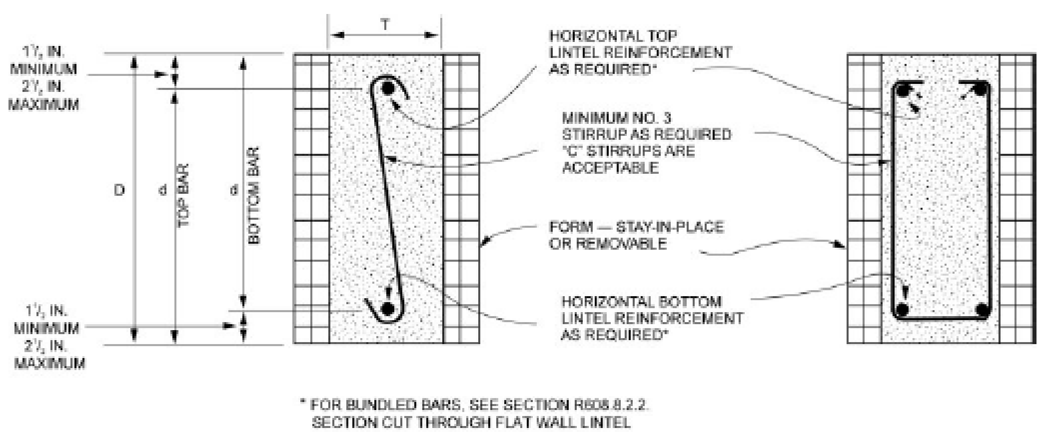
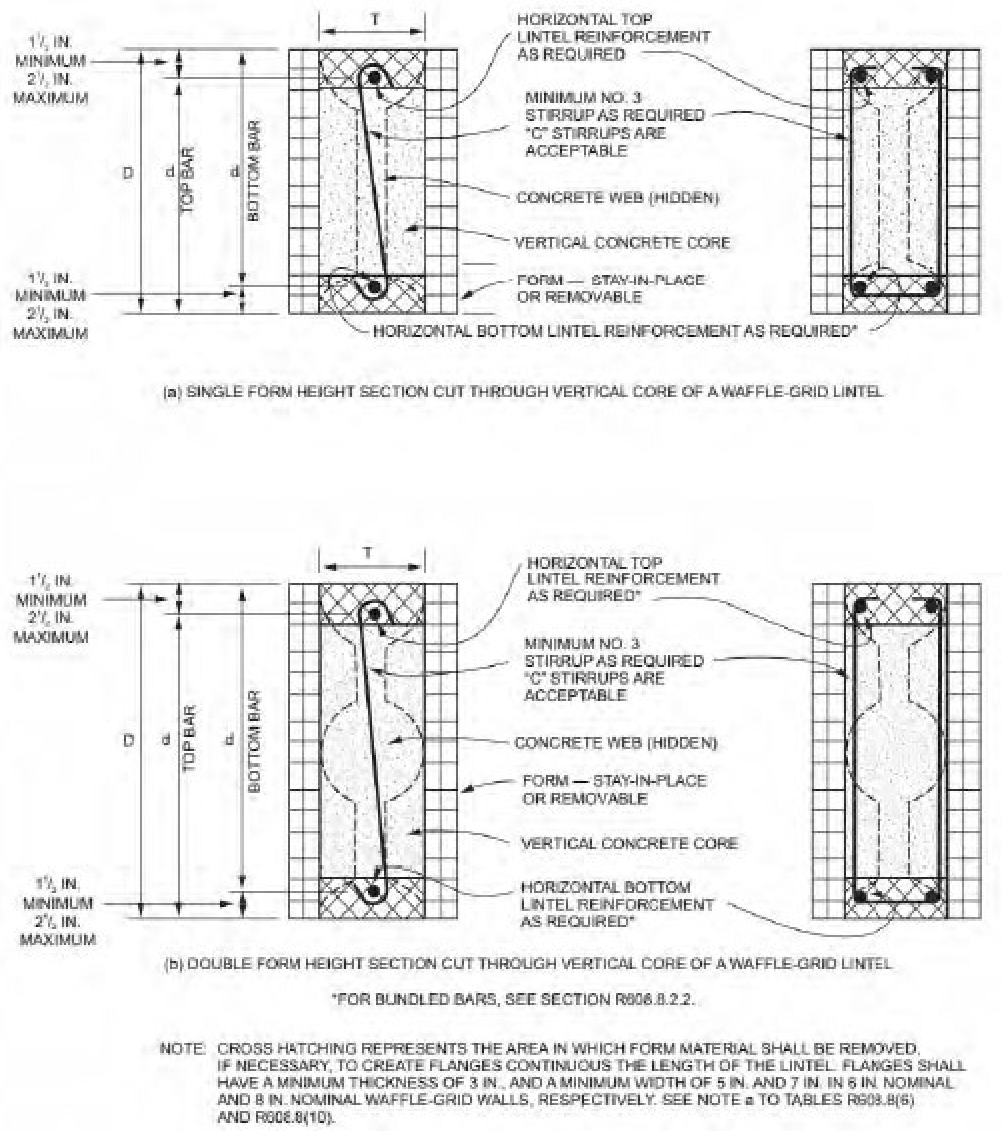



**FIGURE R608.8(1)**
**REINFORCEMENT OF OPENINGS**



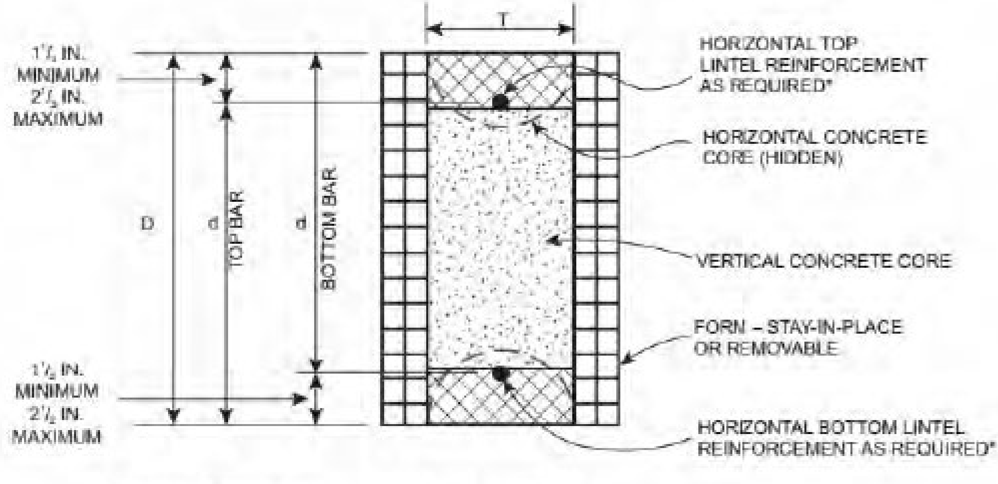

For SI: 1 inch = 25.4 mm.

**FIGURE R608.8(2)**
**LINTEL FOR FLAT WALLS**

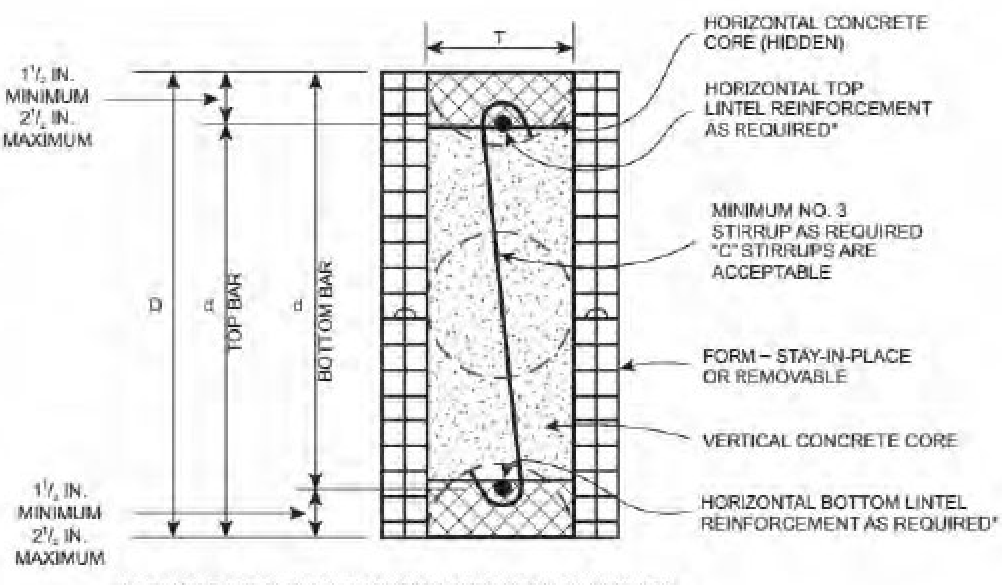



For SI: 1 inch = 25.4 mm.

**FIGURE R608.8(3)**
**LINTELS FOR WAFFLE-GRID WALLS**




(a) SINGLE FORM HEIGHT SECTION CUT THROUGH VERTICAL CORE OF A SCREEN-GRID LINTEL




(b) DOUBLE FORM HEIGHT SECTION CUT THROUGH VERTICAL CORE OF A SCREEN-GRID LINTEL

*FOR BUNDLED BARS, SEE SECTION R608.8.2.2

NOTE: CROSS HATCHING REPRESENTS THE AREA IN WHICH FORM MATERIAL SHALL BE REMOVED, IF NECESSARY, TO CREATE FLANGES CONTINUOUS THE LENGTH OF THE LINTEL. FLANGES SHALL HAVE A MINIMUM THICKNESS OF 2.5 IN. AND A MINIMUM WIDTH OF 5 IN. SEE NOTE a TO TABLES R608.8(8) AND R608.8(10).

For SI: 1 inch = 25.4 mm.

**FIGURE R608.8(4)**
**LINTELS FOR SCREEN-GRID WALLS**

**R608.8.1.1 Horizontal reinforcement.** Lintels complying with Section R608.8.2 shall be provided above wall openings equal to or greater than 2 feet (610 mm) in width.

Openings equal to or greater than 2 feet (610 mm) in width shall have not less than one No. 4 bar placed within 12 inches (305 mm) of the bottom of the opening. See Figure R608.8(1).

Horizontal reinforcement placed above and below an opening shall extend beyond the edges of the opening the dimension required to develop the bar in tension in accordance with Section R608.5.4.4.

> **Exception:** Continuous horizontal wall reinforcement placed within 12 inches (305 mm) of the top of the wall *story* as required in Sections R404.1.3.2 and R608.6.2 is permitted in lieu of top or bottom lintel reinforcement required by Section R608.8.2 provided that the continuous horizontal wall reinforcement meets the location requirements specified in Figures R608.8(2), R608.8(3), and R608.8(4) and the size requirements specified in Tables R608.8(2) through R608.8(10).

**TABLE R608.8(1)**
**LINTEL DESIGN LOADING CONDITIONS[a, b, d]**

<table>
<tr><th colspan="3">DESCRIPTION OF LOADS AND OPENINGS ABOVE INFLUENCING DESIGN OF LINTEL</th><th>DESIGN LOAD CONDITION[c]</th></tr>
<tr><td colspan="4">Opening in wall of top story of two-story building, or first story of one-story building</td></tr>
<tr><td rowspan="2">Wall supporting loads from roof, including attic floor, if applicable, and</td><td colspan="2">Top of lintel equal to or less than W/2 below top of wall</td><td>2</td></tr>
<tr><td colspan="2">Top of lintel greater than W/2 below top of wall</td><td>NLB</td></tr>
<tr><td colspan="3">Wall not supporting loads from roof or attic floor</td><td>NLB</td></tr>
<tr><td colspan="4">Opening in wall of first story of two-story building where wall immediately above is of concrete construction, or opening in basement wall of one-story building where wall immediately above is of concrete construction</td></tr>
<tr><td rowspan="3">LB ledger board mounted to side of wall with bottom of ledger less than or equal to W/2 above top of lintel, and</td><td colspan="2">Top of lintel greater than W/2 below bottom of opening in story above</td><td>1</td></tr>
<tr><td rowspan="2">Top of lintel less than or equal to W/2 below bottom of opening in story above, and</td><td>Opening is entirely within the footprint of the opening in the story above</td><td>1</td></tr>
<tr><td>Opening is partially within the footprint of the opening in the story above</td><td>4</td></tr>
<tr><td colspan="3">LB ledger board mounted to side of wall with bottom of ledger more than W/2 above top of lintel</td><td>NLB</td></tr>
<tr><td rowspan="3">NLB ledger board mounted to side of wall with bottom of ledger less than or equal to W/2 above top of lintel, or no ledger board, and</td><td colspan="2">Top of lintel greater than W/2 below bottom of opening in story above</td><td>NLB</td></tr>
<tr><td rowspan="2">Top of lintel less than or equal to W/2 below bottom of opening in story above, and</td><td>Opening is entirely within the footprint of the opening in the story above</td><td>NLB</td></tr>
<tr><td>Opening is partially within the footprint of the opening in the story above</td><td>1</td></tr>
<tr><td colspan="4">Opening in basement wall of two-story building where walls of two stories above are of concrete construction</td></tr>
<tr><td rowspan="3">LB ledger board mounted to side of wall with bottom of ledger less than or equal toW/2 above top of lintel, and</td><td colspan="2">Top of lintel greater than W/2 below bottom of opening in story above</td><td>1</td></tr>
<tr><td rowspan="2">Top of lintel less than or equal to W/2 below bottom of opening in story above, and</td><td>Opening is entirely within the footprint of the opening in the story above</td><td>1</td></tr>
<tr><td>Opening is partially within the footprint of the opening in the story above</td><td>5</td></tr>
<tr><td colspan="3">LB ledger board mounted to side of wall with bottom of ledger more than W/2 above top of lintel</td><td>NLB</td></tr>
</table>

| | | | |
|---|---|---|---|
| NLB ledger board mounted to side of wall with bottom of ledger less than or equal to W/2 above top of lintel, or no ledger board, and | Top of lintel greater than W/2 below bottom of opening in story above | | NLB |
| | Top of lintel less than or equal to W/2 below bottom of opening in story above, and | Opening is entirely within the footprint of the opening in the story above | NLB |
| | | Opening is partially within the footprint of the opening in the story above | 1 |
| **Opening in wall of first story of two-story building where wall immediately above is of light-frame construction, or opening in basement wall of one-story building where wall immediately above is of light-frame construction** | | | |
| Wall supporting loads from roof, second floor and top-story wall of light-frame construction, and | Top of lintel equal to or less than W/2 below top of wall | | 3 |
| | Top of lintel greater than W/2 below top of wall | | NLB |
| Wall not supporting loads from roof or second floor | | | NLB |

a. LB means load bearing, NLB means nonload bearing, and W means width of opening.
b. Footprint is the area of the wall below an opening in the story above, bounded by the bottom of the opening and vertical lines extending downward from the edges of the opening.
c. For design loading condition "NLB" see Tables R608.8(9) and R608.8(10). For all other design loading conditions, see Tables R608.8(2) through R608.8(8).
d. An NLB ledger board is a ledger attached to a wall that is parallel to the span of the floor, roof or ceiling framing that supports the edge of the floor, ceiling or roof.

**TABLE R608.8(2)**
**MAXIMUM ALLOWABLE CLEAR SPANS FOR 4-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, m]**
**ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET**

| LINTEL DEPTH, $D$[g] (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 8 | Span without stirrups[i, j] | | 3-2 | 3-4 | 2-4 | 2-6 | 2-2 | 2-1 | 2-0 | 2-0 | 2-0 |
| | 1-#4 | 40,000 | 5-2 | 5-5 | 4-1 | 4-3 | 3-10 | 3-7 | 3-4 | 2-9 | 2-9 |
| | | 60,000 | 6-2 | 6-5 | 4-11 | 5-1 | 4-6 | 4-2 | 3-8 | 2-11 | 2-10 |
| | 1-#5 | 40,000 | 6-3 | 6-7 | 5-0 | 5-2 | 4-6 | 4-2 | 3-8 | 2-11 | 2-10 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance $A$[k, l] | | 1-1 | 1-2 | 0-8 | 0-9 | 0-7 | 0-6 | 0-5 | 0-4 | 0-4 |
| 12 | Span without stirrups[i, j] | | 3-4 | 3-7 | 2-9 | 2-11 | 2-8 | 2-6 | 2-5 | 2-2 | 2-2 |
| | 1-#4 | 40,000 | 6-7 | 7-0 | 5-4 | 5-7 | 5-0 | 4-9 | 4-4 | 3-8 | 3-7 |
| | | 60,000 | 7-11 | 8-6 | 6-6 | 6-9 | 6-0 | 5-9 | 5-3 | 4-5 | 4-4 |
| | 1-#5 | 40,000 | 8-1 | 8-8 | 6-7 | 6-10 | 6-2 | 5-10 | 5-4 | 4-6 | 4-5 |
| | | 60,000 | 9-8 | 10-4 | 7-11 | 8-2 | 7-4 | 6-11 | 6-2 | 4-10 | 4-8 |
| | 2-#4 | 40,000 | 9-1 | 9-8 | 7-4 | 7-8 | 6-10 | 6-6 | 6-0 | 4-10 | 4-8 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-#6 | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance $A^{k, l}$ | | 1-8 | 1-11 | 1-1 | 1-3 | 1-0 | 0-11 | 0-9 | 0-6 | 0-6 |
| 16 | Span without stirrups[i, j] | | 4-7 | 5-0 | 3-11 | 4-0 | 3-8 | 3-7 | 3-4 | 3-1 | 3-0 |
| | 1-#4 | 40,000 | 6-8 | 7-3 | 5-6 | 5-9 | 5-2 | 4-11 | 4-6 | 3-10 | 3-8 |
| | | 60,000 | 9-3 | 10-1 | 7-9 | 8-0 | 7-2 | 6-10 | 6-3 | 5-4 | 5-2 |
| | 1-#4 | 40,000 | 9-6 | 10-4 | 7-10 | 8-2 | 7-4 | 6-11 | 6-5 | 5-5 | 5-3 |
| | | 60,000 | 11-5 | 12-5 | 9-6 | 9-10 | 8-10 | 8-4 | 7-9 | 6-6 | 6-4 |
| | 2-#4<br>1-#6 | 40,000 | 10-7 | 11-7 | 8-10 | 9-2 | 8-3 | 7-9 | 7-2 | 6-1 | 5-11 |
| | | 60,000 | 12-9 | 13-10 | 10-7 | 11-0 | 9-10 | 9-4 | 8-7 | 6-9 | 6-6 |
| | 2-#5 | 40,000 | 13-0 | 14-1 | 10-9 | 11-2 | 9-11 | 9-2 | 8-2 | 6-6 | 6-3 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance $A^{k, l}$ | | 2-3 | 2-8 | 1-7 | 1-8 | 1-4 | 1-3 | 1-0 | 0-9 | 0-8 |
| 20 | Span without stirrups $A^{i, j}$ | | 5-9 | 6-5 | 5-0 | 5-2 | 4-9 | 4-7 | 4-4 | 3-11 | 3-11 |
| | 1-#4 | 40,000 | 7-5 | 8-2 | 6-3 | 6-6 | 5-10 | 5-7 | 5-1 | 4-4 | 4-2 |
| | | 60,000 | 9-0 | 10-0 | 7-8 | 7-11 | 7-1 | 6-9 | 6-3 | 5-3 | 5-1 |
| | 1-#5 | 40,000 | 9-2 | 10-2 | 7-9 | 8-1 | 7-3 | 6-11 | 6-4 | 5-4 | 5-2 |
| | | 60,000 | 12-9 | 14-2 | 10-10 | 11-3 | 10-1 | 9-7 | 8-10 | 7-5 | 7-3 |
| | 2-#4<br>1-#6 | 40,000 | 11-10 | 13-2 | 10-1 | 10-5 | 9-4 | 8-11 | 8-2 | 6-11 | 6-9 |
| | | 60,000 | 14-4 | 15-10 | 12-1 | 12-7 | 11-3 | 10-9 | 9-11 | 8-4 | 8-1 |
| | 2-#5 | 40,000 | 14-7 | 16-2 | 12-4 | 12-9 | 11-4 | 10-6 | 9-5 | 7-7 | 7-3 |
| | | 60,000 | 17-5 | 19-2 | 14-9 | 15-3 | 13-5 | 12-4 | 11-0 | 8-8 | 8-4 |
| | 2-#6 | 40,000 | 16-4 | 18-11 | 12-7 | 13-3 | 11-4 | 10-6 | 9-5 | 7-7 | 7-3 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance $A^{k, l}$ | | 2-9 | 3-5 | 2-0 | 2-2 | 1-9 | 1-7 | 1-4 | 0-11 | 0-11 |

*(continued)*

**TABLE R608.8(2)—continued**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 4-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, m]**
**ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET**

| LINTEL DEPTH, $D$[g] (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 24 | Span without stirrups[i, j] | | 6-11 | 7-9 | 6-1 | 6-3 | 5-9 | 5-7 | 5-3 | 4-9 | 4-8 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-#4 | 40,000 | 8-0 | 9-0 | 6-11 | 7-2 | 6-5 | 6-2 | 5-8 | 4-9 | 4-8 |
| | | 60,000 | 9-9 | 11-0 | 8-5 | 8-9 | 7-10 | 7-6 | 6-11 | 5-10 | 5-8 |
| | 1-#5 | 40,000 | 10-0 | 11-3 | 8-7 | 8-11 | 8-0 | 7-7 | 7-0 | 5-11 | 5-9 |
| | | 60,000 | 13-11 | 15-8 | 12-0 | 12-5 | 11-2 | 10-7 | 9-10 | 8-3 | 8-0 |
| | 2-#4<br>1-#6 | 40,000 | 12-11 | 14-6 | 11-2 | 11-6 | 10-5 | 9-10 | 9-1 | 7-8 | 7-5 |
| | | 60,000 | 15-7 | 17-7 | 13-6 | 13-11 | 12-7 | 11-11 | 11-0 | 9-3 | 9-0 |
| | 2-#5 | 40,000 | 15-11 | 17-11 | 13-7 | 14-3 | 12-8 | 11-9 | 10-8 | 8-7 | 8-4 |
| | | 60,000 | 19-1 | 21-6 | 16-5 | 17-1 | 15-1 | 14-0 | 12-6 | 9-11 | 9-7 |
| | 2-#6 | 40,000 | 17-7 | 21-1 | 14-1 | 14-10 | 12-8 | 11-9 | 10-8 | 8-7 | 8-4 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance *A*[k, l] | | 3-3 | 4-1 | 2-5 | 2-7 | 2-1 | 1-11 | 1-7 | 1-2 | 1-1 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 pound per square foot = 0.0479 kPa, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

a. See Table R608.3 for tolerances permitted from nominal thickness.

b. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Note j.

c. Table values are based on uniform loading. See Section R608.8.2 for lintels supporting concentrated loads.

d. Deflection criterion is *L*/240, where *L* is the clear span of the lintel in inches, or $^1/_2$-inch, whichever is less.

e. Linear interpolation is permitted between ground snow loads and between lintel depths.

f. DR indicates design required.

g. Lintel depth, *D*, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.

i. Allowable clear span without stirrups applicable to all lintels of the same depth, *D.* Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than *d*/2.

j. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.

k. Center distance, *A*, is the center portion of the clear span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.

l. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, A, shall be permitted to be multiplied by 1.10.

m. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel clear spans in the table greater than 18 feet are shown for interpolation and information only.

**TABLE R608.8(3)**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 6-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, m]**
**ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET**

| LINTEL DEPTH, *D*[g] (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 8 | Span without stirrups[i, j] | | 4-2 | 4-8 | 3-1 | 3-3 | 2-10 | 2-6 | 2-3 | 2-0 | 2-0 |
| | 1-#4 | 40,000 | 5-1 | 5-5 | 4-2 | 4-3 | 3-10 | 3-6 | 3-3 | 2-8 | 2-7 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 60,000 | 6-2 | 6-7 | 5-0 | 5-2 | 4-8 | 4-2 | 3-11 | 3-3 | 3-2 |
| | 1-#5 | 40,000 | 6-3 | 6-8 | 5-1 | 5-3 | 4-9 | 4-3 | 4-0 | 3-3 | 3-2 |
| | | 60,000 | 7-6 | 8-0 | 6-1 | 6-4 | 5-8 | 5-1 | 4-9 | 3-8 | 3-6 |
| | 2-#4<br>1-#6 | 40,000 | 7-0 | 7-6 | 5-8 | 5-11 | 5-3 | 4-9 | 4-5 | 3-8 | 3-6 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance *A*[k, l] | | 1-7 | 1-10 | 1-1 | 1-2 | 0-11 | 0-9 | 0-8 | 0-5 | 0-5 |
| 12 | Span without stirrups[i, j] | | 4-2 | 4-8 | 3-5 | 3-6 | 3-2 | 2-11 | 2-9 | 2-5 | 2-4 |
| | 1-#4 | 40,000 | 5-7 | 6-1 | 4-8 | 4-10 | 4-4 | 3-11 | 3-8 | 3-0 | 2-11 |
| | | 60,000 | 7-9 | 8-6 | 6-6 | 6-9 | 6-1 | 5-6 | 5-1 | 4-3 | 4-1 |
| | 1-#5 | 40,000 | 7-11 | 8-8 | 6-8 | 6-11 | 6-2 | 5-7 | 5-2 | 4-4 | 4-2 |
| | | 60,000 | 9-7 | 10-6 | 8-0 | 8-4 | 7-6 | 6-9 | 6-3 | 5-2 | 5-1 |
| | 2-#4<br>1-#6 | 40,000 | 8-11 | 9-9 | 7-6 | 7-9 | 6-11 | 6-3 | 5-10 | 4-10 | 4-8 |
| | | 60,000 | 10-8 | 11-9 | 8-12 | 9-4 | 8-4 | 7-6 | 7-0 | 5-10 | 5-8 |
| | 2-#5 | 40,000 | 10-11 | 12-0 | 9-2 | 9-6 | 8-6 | 7-8 | 7-2 | 5-6 | 5-3 |
| | | 60,000 | 12-11 | 14-3 | 10-10 | 11-3 | 10-1 | 9-0 | 8-1 | 6-1 | 5-10 |
| | 2-#6 | 40,000 | 12-9 | 14-0 | 10-8 | 11-1 | 9-7 | 8-1 | 7-3 | 5-6 | 5-3 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance *A*[k, l] | | 2-6 | 3-0 | 1-9 | 1-10 | 1-6 | 1-3 | 1-1 | 0-9 | 0-8 |
| 16 | Span without stirrups[i, j] | | 5-7 | 6-5 | 4-9 | 4-11 | 4-5 | 4-0 | 3-10 | 3-4 | 3-4 |
| | 1-#4 | 40,000 | 6-5 | 7-2 | 5-6 | 5-9 | 5-2 | 4-8 | 4-4 | 3-7 | 3-6 |
| | | 60,000 | 7-10 | 8-9 | 6-9 | 7-0 | 6-3 | 5-8 | 5-3 | 4-4 | 4-3 |
| | 1-#5 | 40,000 | 7-11 | 8-11 | 6-10 | 7-1 | 6-5 | 5-9 | 5-4 | 4-5 | 4-4 |
| | | 60,000 | 11-1 | 12-6 | 9-7 | 9-11 | 8-11 | 8-0 | 7-6 | 6-2 | 6-0 |
| | 2-#4<br>1-#6 | 40,000 | 10-3 | 11-7 | 8-10 | 9-2 | 8-3 | 7-6 | 6-11 | 5-9 | 5-7 |
| | | 60,000 | 12-5 | 14-0 | 10-9 | 11-1 | 10-0 | 9-0 | 8-5 | 7-0 | 6-9 |
| | 2-#5 | 40,000 | 12-8 | 14-3 | 10-11 | 11-4 | 10-2 | 9-2 | 8-7 | 6-9 | 6-6 |
| | | 60,000 | 15-2 | 17-1 | 13-1 | 13-7 | 12-3 | 11-0 | 10-3 | 7-11 | 7-7 |
| | 2-#6 | 40,000 | 14-11 | 16-9 | 12-8 | 13-4 | 11-4 | 9-8 | 8-8 | 6-9 | 6-6 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance *A*[k, l] | | 3-3 | 4-1 | 2-5 | 2-7 | 2-1 | 1-9 | 1-6 | 1-0 | 1-0 |

*(continued)*

**TABLE R608.8(3)—continued**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 6-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, m]**
**ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET**

| LINTEL DEPTH, $D^g$ (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 20 | Span without stirrups[i, j] | | 6-11 | 8-2 | 6-1 | 6-3 | 5-8 | 5-2 | 4-11 | 4-4 | 4-3 |
| | 1-#5 | 40,000 | 8-9 | 10-1 | 7-9 | 8-0 | 7-3 | 6-6 | 6-1 | 5-1 | 4-11 |
| | | 60,000 | 10-8 | 12-3 | 9-5 | 9-9 | 8-10 | 8-0 | 7-5 | 6-2 | 6-0 |
| | 2-#4<br>1-#6 | 40,000 | 9-11 | 11-4 | 8-9 | 9-1 | 8-2 | 7-4 | 6-10 | 5-8 | 5-7 |
| | | 60,000 | 13-9 | 15-10 | 12-2 | 12-8 | 11-5 | 10-3 | 9-7 | 7-11 | 7-9 |
| | 2-#5 | 40,000 | 14-0 | 16-2 | 12-5 | 12-11 | 11-7 | 10-6 | 9-9 | 7-11 | 7-8 |
| | | 60,000 | 16-11 | 19-6 | 15-0 | 15-6 | 14-0 | 12-7 | 11-9 | 9-1 | 8-9 |
| | 2-#6 | 40,000 | 16-7 | 19-1 | 14-7 | 15-3 | 13-1 | 11-3 | 10-2 | 7-11 | 7-8 |
| | | 60,000 | 19-11 | 22-10 | 17-4 | 18-3 | 15-6 | 13-2 | 11-10 | 9-1 | 8-9 |
| | Center distance $A^{k, l}$ | | 3-11 | 5-2 | 3-1 | 3-3 | 2-8 | 2-2 | 1-11 | 1-4 | 1-3 |
| 24 | Span without stirrups[i, j] | | 8-2 | 9-10 | 7-4 | 7-8 | 6-11 | 6-4 | 5-11 | 5-3 | 5-2 |
| | 1-#5 | 40,000 | 9-5 | 11-1 | 8-7 | 8-10 | 8-0 | 7-3 | 6-9 | 5-7 | 5-5 |
| | | 60,000 | 11-6 | 13-6 | 10-5 | 10-9 | 9-9 | 8-9 | 8-2 | 6-10 | 6-8 |
| | 2-#4<br>1-#6 | 40,000 | 10-8 | 12-6 | 9-8 | 10-0 | 9-0 | 8-2 | 7-7 | 6-4 | 6-2 |
| | | 60,000 | 12-11 | 15-2 | 11-9 | 12-2 | 11-0 | 9-11 | 9-3 | 7-8 | 7-6 |
| | 2-#5 | 40,000 | 15-2 | 17-9 | 13-9 | 14-3 | 12-10 | 11-7 | 10-10 | 9-0 | 8-9 |
| | | 60,000 | 18-4 | 21-6 | 16-7 | 17-3 | 15-6 | 14-0 | 13-1 | 10-4 | 10-0 |
| | 2-#6 | 40,000 | 18-0 | 21-1 | 16-4 | 16-11 | 14-10 | 12-9 | 11-8 | 9-2 | 8-11 |
| | | 60,000 | 21-7 | 25-4 | 19-2 | 20-4 | 17-2 | 14-9 | 13-4 | 10-4 | 10-0 |
| | Center distance $A^{k, l}$ | | 4-6 | 6-2 | 3-8 | 4-0 | 3-3 | 2-8 | 2-3 | 1-7 | 1-6 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 pound per square foot = 0.0479 kPa, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

a. See Table R608.3 for tolerances permitted from nominal thickness.

b. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Note j.

c. Table values are based on uniform loading. See Section R608.8.2 for lintels supporting concentrated loads.

d. Deflection criterion is $L/240$, where $L$ is the clear span of the lintel in inches, or $^1/_2$ inch, whichever is less.

e. Linear interpolation is permitted between ground snow loads and between lintel depths.

f. DR indicates design required.

g. Lintel depth, $D$, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.

i. Allowable clear span without stirrups applicable to all lintels of the same depth, $D$. Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than $d/2$.

j. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.

k. Center distance, A, is the center portion of the clear span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.

l. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, A, shall be permitted to be multiplied by 1.10.

m. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel clear spans in the table greater than 18 feet are shown for interpolation and information only.

## TABLE R608.8(4)
## MAXIMUM ALLOWABLE CLEAR SPANS FOR 8-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, m] ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET

| LINTEL DEPTH, $D^g$ (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 8 | Span without stirrups[i, j] | | 4-4 | 4-9 | 3-7 | 3-9 | 3-4 | 2-10 | 2-7 | 2-1 | 2-0 |
| | 1-#4 | 40,000 | 4-4 | 4-9 | 3-7 | 3-9 | 3-4 | 2-11 | 2-9 | 2-3 | 2-2 |
| | | 60,000 | 6-1 | 6-7 | 5-0 | 5-3 | 4-8 | 4-0 | 3-9 | 3-1 | 3-0 |
| | 1-#5 | 40,000 | 6-2 | 6-9 | 5-2 | 5-4 | 4-9 | 4-1 | 3-10 | 3-2 | 3-1 |
| | | 60,000 | 7-5 | 8-1 | 6-2 | 6-5 | 5-9 | 4-11 | 4-7 | 3-9 | 3-8 |
| | 2-#4<br>1-#6 | 40,000 | 6-11 | 7-6 | 5-9 | 6-0 | 5-4 | 4-7 | 4-4 | 3-6 | 3-5 |
| | | 60,000 | 8-3 | 9-0 | 6-11 | 7-2 | 6-5 | 5-6 | 5-2 | 4-2 | 4-1 |
| | 2-#5 | 40,000 | 8-5 | 9-2 | 7-0 | 7-3 | 6-6 | 5-7 | 5-3 | 4-2 | 4-0 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance $A$[k, l] | | 2-1 | 2-6 | 1-5 | 1-6 | 1-3 | 0-11 | 0-10 | 0-6 | 0-6 |
| 12 | Span without stirrups[i, j] | | 4-10 | 5-8 | 4-0 | 4-2 | 3-9 | 3-2 | 3-0 | 2-7 | 2-6 |
| | 1-#4 | 40,000 | 5-5 | 6-1 | 4-8 | 4-10 | 4-4 | 3-9 | 3-6 | 2-10 | 2-10 |
| | | 60,000 | 6-7 | 7-5 | 5-8 | 5-11 | 5-4 | 4-7 | 4-3 | 3-6 | 3-5 |
| | 1-#5 | 40,000 | 6-9 | 7-7 | 5-9 | 6-0 | 5-5 | 4-8 | 4-4 | 3-7 | 3-6 |
| | | 60,000 | 9-4 | 10-6 | 8-1 | 8-4 | 7-6 | 6-6 | 6-1 | 5-0 | 4-10 |
| | 2-#4<br>1-#6 | 40,000 | 8-8 | 9-9 | 7-6 | 7-9 | 7-0 | 6-0 | 5-8 | 4-7 | 4-6 |
| | | 60,000 | 10-6 | 11-9 | 9-1 | 9-5 | 8-5 | 7-3 | 6-10 | 5-7 | 5-5 |
| | 2-#5 | 40,000 | 10-8 | 12-0 | 9-3 | 9-7 | 8-7 | 7-5 | 6-11 | 5-6 | 5-4 |
| | | 60,000 | 12-10 | 14-5 | 11-1 | 11-6 | 10-4 | 8-11 | 8-4 | 6-7 | 6-4 |
| | 2-#6 | 40,000 | 12-7 | 14-2 | 10-10 | 11-3 | 10-2 | 8-3 | 7-6 | 5-6 | 5-4 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance $A$[k, l] | | 3-2 | 4-0 | 2-4 | 2-6 | 2-0 | 1-6 | 1-4 | 0-11 | 0-10 |
| 16 | Span without stirrups[i, j] | | 6-5 | 7-9 | 5-7 | 5-10 | 5-2 | 4-5 | 4-2 | 3-7 | 3-6 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-#4 | 40,000 | 6-2 | 7-1 | 5-6 | 5-8 | 5-1 | 4-5 | 4-2 | 3-5 | 3-4 |
| | | 60,000 | 7-6 | 8-8 | 6-8 | 6-11 | 6-3 | 5-5 | 5-1 | 4-2 | 4-0 |
| | 1-#5 | 40,000 | 7-8 | 8-10 | 6-10 | 7-1 | 6-4 | 5-6 | 5-2 | 4-3 | 4-1 |
| | | 60,000 | 9-4 | 10-9 | 8-4 | 8-7 | 7-9 | 6-8 | 6-3 | 5-2 | 5-0 |
| | 2-#4<br>1-#6 | 40,000 | 8-8 | 10-0 | 7-8 | 8-0 | 7-2 | 6-2 | 5-10 | 4-9 | 4-8 |
| | | 60,000 | 12-0 | 13-11 | 10-9 | 11-2 | 10-0 | 8-8 | 8-1 | 6-8 | 6-6 |
| | 2-#5 | 40,000 | 12-3 | 14-2 | 11-0 | 11-4 | 10-3 | 8-10 | 8-3 | 6-9 | 6-7 |
| | | 60,000 | 14-10 | 17-2 | 13-3 | 13-8 | 12-4 | 10-8 | 10-0 | 7-11 | 7-8 |
| | 2-#6 | 40,000 | 14-6 | 16-10 | 13-0 | 13-5 | 12-1 | 10-1 | 9-2 | 6-11 | 6-8 |
| | | 60,000 | 17-5 | 20-2 | 15-7 | 16-1 | 14-6 | 11-10 | 10-8 | 7-11 | 7-8 |
| | Center distance $A$[k, l] | | 4-1 | 5-5 | 3-3 | 3-6 | 2-10 | 2-1 | 1-10 | 1-3 | 1-2 |

*(continued)*

**TABLE R608.8(4)—continued**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 8-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, m]**
**ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET**

| LINTEL DEPTH, $D$[g] (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 20 | Span without stirrups[i, j] | | 7-10 | 9-10 | 7-1 | 7-5 | 6-7 | 5-8 | 5-4 | 4-7 | 4-6 |
| | 1-#5 | 40,000 | 8-4 | 9-11 | 7-8 | 8-0 | 7-2 | 6-3 | 5-10 | 4-9 | 4-8 |
| | | 60,000 | 10-2 | 12-1 | 9-5 | 9-9 | 8-9 | 7-7 | 7-1 | 5-10 | 5-8 |
| | 2-#4<br>1-#6 | 40,000 | 9-5 | 11-3 | 8-8 | 9-0 | 8-1 | 7-0 | 6-7 | 5-5 | 5-3 |
| | | 60,000 | 11-6 | 13-8 | 10-7 | 11-0 | 9-11 | 8-7 | 8-0 | 6-7 | 6-5 |
| | 2-#5 | 40,000 | 11-9 | 13-11 | 10-10 | 11-2 | 10-1 | 8-9 | 8-2 | 6-8 | 6-7 |
| | | 60,000 | 16-4 | 19-5 | 15-0 | 15-7 | 14-0 | 12-2 | 11-4 | 9-3 | 9-0 |
| | 2-#6 | 40,000 | 16-0 | 19-0 | 14-9 | 15-3 | 13-9 | 11-10 | 10-10 | 8-3 | 8-0 |
| | | 60,000 | 19-3 | 22-11 | 17-9 | 18-5 | 16-7 | 13-7 | 12-4 | 9-3 | 9-0 |
| | Center distance $A$[k, l] | | 4-10 | 6-10 | 4-1 | 4-5 | 3-7 | 2-8 | 2-4 | 1-7 | 1-6 |
| 24 | Span without stirrups[i, j] | | 9-2 | 11-9 | 8-7 | 8-11 | 8-0 | 6-11 | 6-6 | 5-7 | 5-6 |
| | 1-#5 | 40,000 | 8-11 | 10-10 | 8-6 | 8-9 | 7-11 | 6-10 | 6-5 | 5-3 | 5-2 |
| | | 60,000 | 10-11 | 13-3 | 10-4 | 10-8 | 9-8 | 8-4 | 7-10 | 6-5 | 6-3 |
| | 2-#4<br>1-#6 | 40,000 | 10-1 | 12-3 | 9-7 | 9-11 | 8-11 | 7-9 | 7-3 | 6-0 | 5-10 |
| | | 60,000 | 12-3 | 15-0 | 11-8 | 12-1 | 10-11 | 9-5 | 8-10 | 7-3 | 7-1 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2-#5 | 40,000 | 12-6 | 15-3 | 11-11 | 12-4 | 11-1 | 9-7 | 9-0 | 7-5 | 7-3 |
| | | 60,000 | 17-6 | 21-3 | 16-7 | 17-2 | 15-6 | 13-5 | 12-7 | 10-4 | 10-1 |
| | 2-#6 | 40,000 | 17-2 | 20-11 | 16-3 | 16-10 | 15-3 | 13-2 | 12-4 | 9-7 | 9-4 |
| | | 60,000 | 20-9 | 25-3 | 19-8 | 20-4 | 18-5 | 15-4 | 14-0 | 10-7 | 10-3 |
| | Center distance *A*[k, l] | | 5-6 | 8-1 | 4-11 | 5-3 | 4-4 | 3-3 | 2-10 | 1-11 | 1-10 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 pound per square foot = 0.0479 kPa, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

**Note:** Top and bottom reinforcement for lintels without stirrups, as shown in shaded cells, shall be equal to or greater than that required for lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups.

a. See Table R608.3 for tolerances permitted from nominal thickness.

b. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Note j.

c. Table values are based on uniform loading. See Section R608.8.2 for lintels supporting concentrated loads.

d. Deflection criterion is *L*/240, where *L* is the clear span of the lintel in inches, or $^1/_2$ inch, whichever is less.

e. Linear interpolation is permitted between ground snow loads and between lintel depths.

f. DR indicates design required.

g. Lintel depth, *D*, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.

i. Allowable clear span without stirrups applicable to all lintels of the same depth, *D.* Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than *d*/2.

j. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.

k. Center distance, A, is the center portion of the clear span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.

l. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, *A*, shall be permitted to be multiplied by 1.10.

m. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel clear spans in the table greater than 18 feet are shown for interpolation and information only.

**TABLE R608.8(5)**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 10-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, m]**

**ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET**

| LINTEL DEPTH, *D*[g] (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 8 | Span without stirrups[i, j] | | 6-0 | 7-2 | 4-7 | 4-10 | 4-1 | 3-1 | 2-11 | 2-3 | 2-2 |
| | 1-#4 | 40,000 | 4-3 | 4-9 | 3-7 | 3-9 | 3-4 | 2-9 | 2-7 | 2-1 | 2-1 |
| | | 60,000 | 5-11 | 6-7 | 5-0 | 5-3 | 4-8 | 3-10 | 3-8 | 2-11 | 2-11 |
| | 1-#5 | 40,000 | 6-1 | 6-9 | 5-2 | 5-4 | 4-9 | 3-11 | 3-9 | 3-0 | 2-11 |
| | | 60,000 | 7-4 | 8-1 | 6-3 | 6-5 | 5-9 | 4-9 | 4-6 | 3-7 | 3-7 |
| | 2-#4<br>1-#6 | 40,000 | 6-10 | 7-6 | 5-9 | 6-0 | 5-5 | 4-5 | 4-2 | 3-4 | 3-4 |
| | | 60,000 | 8-2 | 9-1 | 6-11 | 7-2 | 6-6 | 5-4 | 5-0 | 4-1 | 4-0 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2-#5 | 40,000 | 8-4 | 9-3 | 7-1 | 7-4 | 6-7 | 5-5 | 5-1 | 4-1 | 4-0 |
| | | 60,000 | 9-11 | 11-0 | 8-5 | 8-9 | 7-10 | 6-6 | 6-1 | 4-8 | 4-6 |
| | 2-#6 | 40,000 | 9-9 | 10-10 | 8-3 | 8-7 | 7-9 | 6-4 | 5-10 | 4-1 | 4-0 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance *A*[k, l] | | 2-6 | 3-1 | 1-10 | 1-11 | 1-7 | 1-1 | 0-11 | 0-7 | 0-7 |
| 12 | Span without stirrups[i, j] | | 5-5 | 6-7 | 4-7 | 4-10 | 4-3 | 3-5 | 3-3 | 2-8 | 2-8 |
| | 1-#4 | 40,000 | 5-3 | 6-0 | 4-8 | 4-10 | 4-4 | 3-7 | 3-4 | 2-9 | 2-8 |
| | | 60,000 | 6-5 | 7-4 | 5-8 | 5-10 | 5-3 | 4-4 | 4-1 | 3-4 | 3-3 |
| | 1-#5 | 40,000 | 6-6 | 7-6 | 5-9 | 6-0 | 5-5 | 4-5 | 4-2 | 3-5 | 3-4 |
| | | 60,000 | 7-11 | 9-1 | 7-0 | 7-3 | 6-7 | 5-5 | 5-1 | 4-2 | 4-0 |
| | 2-#4<br>1-#6 | 40,000 | 7-4 | 8-5 | 6-6 | 6-9 | 6-1 | 5-0 | 4-9 | 3-10 | 3-9 |
| | | 60,000 | 10-3 | 11-9 | 9-1 | 9-5 | 8-6 | 7-0 | 6-7 | 5-4 | 5-3 |
| | 2-#5 | 40,000 | 10-5 | 12-0 | 9-3 | 9-7 | 8-8 | 7-2 | 6-9 | 5-5 | 5-4 |
| | | 60,000 | 12-7 | 14-5 | 11-2 | 11-6 | 10-5 | 8-7 | 8-1 | 6-6 | 6-4 |
| | 2-#6 | 40,000 | 12-4 | 14-2 | 10-11 | 11-4 | 10-2 | 8-5 | 7-8 | 5-7 | 5-5 |
| | | 60,000 | 14-9 | 17-0 | 13-1 | 13-6 | 12-2 | 10-0 | 9-1 | 6-6 | 6-4 |
| | Center distance *A*[k, l] | | 3-9 | 4-11 | 2-11 | 3-2 | 2-7 | 1-9 | 1-7 | 1-0 | 1-0 |
| 16 | Span without stirrups[i, j] | | 7-1 | 9-0 | 6-4 | 6-8 | 5-10 | 4-9 | 4-6 | 3-9 | 3-8 |
| | 1-#4 | 40,000 | 5-11 | 7-0 | 5-5 | 5-8 | 5-1 | 4-3 | 4-0 | 3-3 | 3-2 |
| | | 60,000 | 7-3 | 8-7 | 6-8 | 6-11 | 6-3 | 5-2 | 4-10 | 3-11 | 3-10 |
| | 1-#5 | 40,000 | 7-4 | 8-9 | 6-9 | 7-0 | 6-4 | 5-3 | 4-11 | 4-0 | 3-11 |
| | | 60,000 | 9-0 | 10-8 | 8-3 | 8-7 | 7-9 | 6-5 | 6-0 | 4-11 | 4-9 |
| | 2-#4<br>1-#6 | 40,000 | 8-4 | 9-11 | 7-8 | 7-11 | 7-2 | 5-11 | 5-7 | 4-6 | 4-5 |
| | | 60,000 | 10-2 | 12-0 | 9-4 | 9-8 | 8-9 | 7-3 | 6-10 | 5-6 | 5-5 |
| | 2-#5 | 40,000 | 10-4 | 12-3 | 9-6 | 9-10 | 8-11 | 7-4 | 6-11 | 5-8 | 5-6 |
| | | 60,000 | 14-4 | 17-1 | 13-3 | 13-8 | 12-4 | 10-3 | 9-8 | 7-10 | 7-8 |
| | 2-#6 | 40,000 | 14-1 | 16-9 | 13-0 | 13-5 | 12-2 | 10-1 | 9-6 | 7-0 | 6-10 |
| | | 60,000 | 17-0 | 20-2 | 15-8 | 16-2 | 14-7 | 12-0 | 10-11 | 8-0 | 7-9 |
| | Center distance *A*[k, l] | | 4-9 | 6-8 | 4-0 | 4-4 | 3-6 | 2-5 | 2-2 | 1-5 | 1-4 |

*(continued)*

**TABLE R608.8(5)—continued**
**MAXIMUM ALLOWABLE CLEAR SPANS FOR 10-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, m]**
**ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET**

| LINTEL DEPTH, $D$[g] (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 20 | Span without stirrups[i, j] | | 8-7 | 11-4 | 8-1 | 8-5 | 7-5 | 6-1 | 5-9 | 4-10 | 4-9 |
| | 1-#4 | 40,000 | 6-5 | 7-10 | 6-2 | 6-4 | 5-9 | 4-9 | 4-6 | 3-8 | 3-7 |
| | | 60,000 | 7-10 | 9-7 | 7-6 | 7-9 | 7-0 | 5-10 | 5-6 | 4-5 | 4-4 |
| | 1-#5 | 40,000 | 8-0 | 9-9 | 7-8 | 7-11 | 7-2 | 5-11 | 5-7 | 4-6 | 4-5 |
| | | 60,000 | 9-9 | 11-11 | 9-4 | 9-8 | 8-9 | 7-3 | 6-10 | 5-6 | 5-5 |
| | 2-#4<br>1-#6 | 40,000 | 9-0 | 11-1 | 8-8 | 8-11 | 8-1 | 6-9 | 6-4 | 5-2 | 5-0 |
| | | 60,000 | 11-0 | 13-6 | 10-6 | 10-11 | 9-10 | 8-2 | 7-9 | 6-3 | 6-2 |
| | 2-#5 | 40,000 | 11-3 | 13-9 | 10-9 | 11-1 | 10-0 | 8-4 | 7-10 | 6-5 | 6-3 |
| | | 60,000 | 15-8 | 19-2 | 15-0 | 15-6 | 14-0 | 11-8 | 11-0 | 8-11 | 8-9 |
| | 2-#6 | 40,000 | 15-5 | 18-10 | 14-8 | 15-2 | 13-9 | 11-5 | 10-9 | 8-6 | 8-3 |
| | | 60,000 | 18-7 | 22-9 | 17-9 | 18-5 | 16-7 | 13-10 | 12-9 | 9-5 | 9-2 |
| | Center distance $A$[k, l] | | 5-7 | 8-4 | 5-1 | 5-5 | 4-5 | 3-1 | 2-9 | 1-10 | 1-9 |
| 24 | Span without stirrups[i, j] | | 9-11 | 13-7 | 9-9 | 10-2 | 9-0 | 7-5 | 7-0 | 5-10 | 5-9 |
| | 1-#5 | 40,000 | 8-6 | 10-8 | 8-5 | 8-8 | 7-10 | 6-6 | 6-2 | 5-0 | 4-11 |
| | | 60,000 | 10-5 | 13-0 | 10-3 | 10-7 | 9-7 | 8-0 | 7-6 | 6-1 | 6-0 |
| | 2-#4<br>1-#6 | 40,000 | 9-7 | 12-1 | 9-6 | 9-9 | 8-10 | 7-5 | 7-0 | 5-8 | 5-6 |
| | | 60,000 | 11-9 | 14-9 | 11-7 | 11-11 | 10-10 | 9-0 | 8-6 | 6-11 | 6-9 |
| | 2-#5 | 40,000 | 12-0 | 15-0 | 11-9 | 12-2 | 11-0 | 9-2 | 8-8 | 7-1 | 6-11 |
| | | 60,000 | 14-7 | 18-3 | 14-4 | 14-10 | 13-5 | 11-2 | 10-7 | 8-7 | 8-5 |
| | 2-#6 | 40,000 | 14-3 | 17-11 | 14-1 | 14-7 | 13-2 | 11-0 | 10-4 | 8-5 | 8-3 |
| | | 60,000 | 19-11 | 25-0 | 19-7 | 20-3 | 18-4 | 15-3 | 14-5 | 10-10 | 10-7 |
| | Center distance $A$[k, l] | | 6-3 | 9-11 | 6-1 | 6-6 | 5-4 | 3-9 | 3-4 | 2-2 | 2-1 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 pound per square foot = 0.0479 kPa, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

**Note:** Top and bottom reinforcement for lintels without stirrups, as shown in shaded cells, shall be equal to or greater than that required for lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups.

a. See Table R608.3 for tolerances permitted from nominal thickness.
b. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Note j.
c. Table values are based on uniform loading. See Section R608.8.2 for lintels supporting concentrated loads.
d. Deflection criterion is $L/240$, where $L$ is the clear span of the lintel in inches, or $^1/_2$ inch, whichever is less.
e. Linear interpolation is permitted between ground snow loads and between lintel depths.
f. DR indicates design required.
g. Lintel depth, $D$, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.
h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.

i. Allowable clear span without stirrups applicable to all lintels of the same depth, *D.* Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than *d*/2.
j. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.
k. Center distance, A, is the center portion of the clear span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.
l. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, *A*, shall be permitted to be multiplied by 1.10.
m. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel clear spans in the table greater than 18 feet are shown for interpolation and information only.

**TABLE R608.8(6)**
**MAXIMUM ALLOWABLE CLEAR SPANS FOR 6-INCH-THICK WAFFLE-GRID LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, o]**
**MAXIMUM ROOF CLEAR SPAN 40 FEET AND MAXIMUM FLOOR SPAN 32 FEET**

| LINTEL DEPTH, $D$[g] (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 8[i] | Span without stirrups[k, l] | | 2-7 | 2-9 | 2-0 | 2-1 | 2-0 | 2-0 | 2-0 | 2-0 | 2-0 |
| | 1-#4 | 40,000 | 5-2 | 5-5 | 4-0 | 4-3 | 3-7 | 3-3 | 2-11 | 2-4 | 2-3 |
| | | 60,000 | 5-9 | 6-3 | 4-0 | 4-3 | 3-7 | 3-3 | 2-11 | 2-4 | 2-3 |
| | 1-#5 | 40,000 | 5-9 | 6-3 | 4-0 | 4-3 | 3-7 | 3-3 | 2-11 | 2-4 | 2-3 |
| | | 60,000 | 5-9 | 6-3 | 4-0 | 4-3 | 3-7 | 3-3 | 2-11 | 2-4 | 2-3 |
| | 2-#4<br>1-#6 | 40,000 | 5-9 | 6-3 | 4-0 | 4-3 | 3-7 | 3-3 | 2-11 | 2-4 | 2-3 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance *A*[m, n] | | 0-9 | 0-10 | 0-6 | 0-6 | 0-5 | 0-5 | 0-4 | STL | STL |
| 12[i] | Span without stirrups[k, l] | | 2-11 | 3-1 | 2-6 | 2-7 | 2-5 | 2-4 | 2-3 | 2-1 | 2-0 |
| | 1-#4 | 40,000 | 5-9 | 6-2 | 4-8 | 4-10 | 4-4 | 4-1 | 3-9 | 3-2 | 3-1 |
| | | 60,000 | 8-0 | 8-7 | 6-6 | 6-9 | 6-0 | 5-5 | 4-11 | 3-11 | 3-10 |
| | 1-#5 | 40,000 | 8-1 | 8-9 | 6-8 | 6-11 | 6-0 | 5-5 | 4-11 | 3-11 | 3-10 |
| | | 60,000 | 9-1 | 10-3 | 6-8 | 7-0 | 6-0 | 5-5 | 4-11 | 3-11 | 3-10 |
| | 2-#4<br>1-#6 | 40,000 | 9-1 | 9-9 | 6-8 | 7-0 | 6-0 | 5-5 | 4-11 | 3-11 | 3-10 |
| | Center distance *A*[m, n] | | 1-3 | 1-5 | 0-10 | 0-11 | 0-9 | 0-8 | 0-6 | STL | STL |
| | Span without stirrups[k, l] | | 4-0 | 4-4 | 3-6 | 3-7 | 3-4 | 3-3 | 3-1 | 2-10 | 2-10 |
| 16[i] | 1-#4 | 40,000 | 6-7 | 7-3 | 5-6 | 5-9 | 5-2 | 4-10 | 4-6 | 3-9 | 3-8 |
| | | 60,000 | 8-0 | 8-10 | 6-9 | 7-0 | 6-3 | 5-11 | 5-5 | 4-7 | 4-5 |
| | 1-#5 | 40,000 | 8-2 | 9-0 | 6-11 | 7-2 | 6-5 | 6-0 | 5-7 | 4-8 | 4-6 |
| | | 60,000 | 11-5 | 12-6 | 9-3 | 9-9 | 8-4 | 7-7 | 6-10 | 5-6 | 5-4 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2-#4<br>1-#6 | 40,000 | 10-7 | 11-7 | 8-11 | 9-3 | 8-3 | 7-7 | 6-10 | 5-6 | 5-4 |
| | | 60,000 | 12-2 | 14-0 | 9-3 | 9-9 | 8-4 | 7-7 | 6-10 | 5-6 | 5-4 |
| | 2-#5 | 40,000 | 12-2 | 14-2 | 9-3 | 9-9 | 8-4 | 7-7 | 6-10 | 5-6 | 5-4 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance *A*[m, n] | | 1-8 | 2-0 | 1-2 | 1-3 | 1-0 | 0-11 | 0-9 | STL | STL |
| 20[i] | Span without stirrups[k, l] | | 5-0 | 5-6 | 4-6 | 4-7 | 4-3 | 4-1 | 4-0 | 3-8 | 3-8 |
| | 1-#4 | 40,000 | 7-2 | 8-2 | 6-3 | 6-6 | 5-10 | 5-6 | 5-1 | 4-3 | 4-2 |
| | | 60,000 | 8-11 | 9-11 | 7-8 | 7-11 | 7-1 | 6-8 | 6-2 | 5-2 | 5-0 |
| | 1-#5 | 40,000 | 9-1 | 10-2 | 7-9 | 8-1 | 7-3 | 6-10 | 6-4 | 5-4 | 5-2 |
| | | 60,000 | 12-8 | 14-2 | 10-11 | 11-3 | 10-2 | 9-6 | 8-9 | 7-1 | 6-10 |
| | 2-#4<br>1-#6 | 40,000 | 10-3 | 11-5 | 8-9 | 9-1 | 8-2 | 7-8 | 7-1 | 6-0 | 5-10 |
| | | 60,000 | 14-3 | 15-11 | 11-9 | 12-5 | 10-8 | 9-9 | 8-9 | 7-1 | 6-10 |
| | 2-#5 | 40,000 | 14-6 | 16-3 | 11-6 | 12-1 | 10-4 | 9-6 | 8-6 | 6-11 | 6-8 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance *A*[m, n] | | 2-0 | 2-6 | 1-6 | 1-7 | 1-3 | 1-1 | 1-0 | STL | STL |

*(continued)*

**TABLE R608.8(6)—continued**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 6-INCH-THICK WAFFLE-GRID LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, o]**
**MAXIMUM ROOF CLEAR SPAN 40 FEET AND MAXIMUM FLOOR SPAN 32 FEET**

| LINTEL DEPTH, *D*[g] (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 24w[j] | Span without stirrups[k, l] | | 6-0 | 6-8 | 5-5 | 5-7 | 5-3 | 5-0 | 4-10 | 4-6 | 4-5 |
| | 1-#4 | 40,000 | 7-11 | 9-0 | 6-11 | 7-2 | 6-5 | 6-0 | 5-7 | 4-8 | 4-7 |
| | | 60,000 | 9-8 | 10-11 | 8-5 | 8-9 | 7-10 | 7-4 | 6-10 | 5-9 | 5-7 |
| | 1-#5 | 40,000 | 9-10 | 11-2 | 8-7 | 8-11 | 8-0 | 7-6 | 7-0 | 5-10 | 5-8 |
| | | 60,000 | 12-0 | 13-7 | 10-6 | 10-10 | 9-9 | 9-2 | 8-6 | 7-2 | 6-11 |
| | 2-#4<br>1-#6 | 40,000 | 11-1 | 12-7 | 9-8 | 10-1 | 9-1 | 8-6 | 7-10 | 6-7 | 6-5 |
| | | 60,000 | 15-6 | 17-7 | 13-6 | 14-0 | 12-8 | 11-10 | 10-8 | 8-7 | 8-4 |
| | 2-#5 | 40,000 | 15-6 | 17-11 | 12-8 | 13-4 | 11-6 | 10-7 | 9-7 | 7-10 | 7-7 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance *A*[m, n] | | 2-4 | 3-0 | 1-9 | 1-11 | 1-6 | 1-4 | 1-2 | STL | STL |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 pound per square foot = 0.0479 kPa, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

a. Where lintels are formed with waffle-grid forms, form material shall be removed, if necessary, to create top and bottom flanges of the lintel that are not less than 3 inches in depth (in the vertical direction), are not less than 5 inches in width for 6-inch-nominal waffle-grid forms and not less than 7 inches in width for 8-inch-nominal waffle-grid forms. See Figure R608.8(3). Flat form lintels shall be permitted in place of waffle-grid lintels. See Tables R608.8(2) through R608.8(5).

b. See Table R608.3 for tolerances permitted from nominal thicknesses and minimum dimensions and spacing of cores.

c. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Notes l and n. Table values are based on uniform loading. See Section R608.8.2 for lintels supporting concentrated loads.

d. Deflection criterion is $L/240$, where $L$ is the clear span of the lintel in inches, or $^1/_2$ inch, whichever is less.

e. Linear interpolation is permitted between ground snow loads.

f. DR indicates design required. STL indicates stirrups required throughout lintel.

g. Lintel depth, $D$, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.

i. Lintels less than 24 inches in depth with stirrups shall be formed from flat-wall forms [see Tables R608.8(2) through R608.8(5)], or, if necessary, form material shall be removed from waffle-grid forms so as to provide the required cover for stirrups. Allowable spans for lintels formed with flat-wall forms shall be determined from Tables R608.8(2) through R608.8(5).

j. Where stirrups are required for 24-inch-deep lintels, the spacing shall not exceed 12 inches on center.

k. Allowable clear span without stirrups applicable to all lintels of the same depth, $D$. Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than $d/2$.

l. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.

m. Center distance, $A$, is the center portion of the span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.

n. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, A, shall be permitted to be multiplied by 1.10.

o. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel spans in the table greater than 18 feet are shown for interpolation and information only.

### TABLE R608.8(7)
### MAXIMUM ALLOWABLE CLEAR SPANS FOR 8-INCH-THICK WAFFLE-GRID LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, o] MAXIMUM ROOF CLEAR SPAN 40 FEET AND MAXIMUM FLOOR CLEAR SPAN 32 FEET

| LINTEL DEPTH, $D$[g] (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 8[i] | Span ~~with~~ without stirrups[k, l] | | 2-6 | 2-9 | 2-0 | 2-1 | 2-0 | 2-0 | 2-0 | 2-0 | 2-0 |
| | 1-#4 | 40,000 | 4-5 | 4-9 | 3-7 | 3-9 | 3-4 | 3-0 | 2-10 | 2-3 | 2-2 |
| | | 60,000 | 5-6 | 6-2 | 4-0 | 4-3 | 3-7 | 3-1 | 2-10 | 2-3 | 2-2 |
| | 1-#5 | 40,000 | 5-6 | 6-2 | 4-0 | 4-3 | 3-7 | 3-1 | 2-10 | 2-3 | 2-2 |
| | Center distance $A$[m, n] | | 0-9 | 0-10 | 0-6 | 0-6 | 0-5 | 0-4 | 0-4 | STL | STL |
| 12[i] | Span without stirrups[k, l] | | 2-10 | 3-1 | 2-6 | 2-7 | 2-5 | 2-3 | 2-2 | 2-0 | 2-0 |
| | 1-#4 | 40,000 | 5-7 | 6-1 | 4-8 | 4-10 | 4-4 | 3-11 | 3-8 | 3-0 | 2-11 |
| | | 60,000 | 6-9 | 7-5 | 5-8 | 5-11 | 5-4 | 4-9 | 4-5 | 3-8 | 3-7 |
| | 1-#5 | 40,000 | 6-11 | 7-7 | 5-10 | 6-0 | 5-5 | 4-10 | 4-6 | 3-9 | 3-7 |
| | | 60,000 | 8-8 | 10-1 | 6-7 | 7-0 | 5-11 | 5-2 | 4-8 | 3-9 | 3-7 |
| | 2-#4 | 40,000 | 8-8 | 9-10 | 6-7 | 7-0 | 5-11 | 5-2 | 4-8 | 3-9 | 3-7 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-#6 | 60,000 | 8-8 | 10-1 | 6-7 | 7-0 | 5-11 | 5-2 | 4-8 | 3-9 | 3-7 |
| | Center distance *A*[m, n] | | 1-2 | 1-5 | 0-10 | 0-11 | 0-9 | 0-7 | 0-6 | STL | STL |
| 16[i] | Span without stirrups[k, l] | | 3-10 | 4-3 | 3-6 | 3-7 | 3-4 | 3-2 | 3-0 | 2-10 | 2-9 |
| | 1-#4 | 40,000 | 6-5 | 7-2 | 5-6 | 5-9 | 5-2 | 4-8 | 4-4 | 3-7 | 3-6 |
| | | 60,000 | 7-9 | 8-9 | 6-9 | 7-0 | 6-3 | 5-8 | 5-3 | 4-4 | 4-3 |
| | 1-#5 | 40,000 | 7-11 | 8-11 | 6-10 | 7-1 | 6-5 | 5-9 | 5-4 | 4-5 | 4-4 |
| | | 60,000 | 9-8 | 10-11 | 8-4 | 8-8 | 7-10 | 7-0 | 6-6 | 5-2 | 5-1 |
| | 2-#4<br>1-#6 | 40,000 | 9-0 | 10-1 | 7-9 | 8-0 | 7-3 | 6-6 | 6-1 | 5-0 | 4-11 |
| | | 60,000 | 11-5 | 13-10 | 9-2 | 9-8 | 8-3 | 7-2 | 6-6 | 5-2 | 5-1 |
| | Center distance *A*[m, n] | | 1-6 | 1-11 | 1-2 | 1-3 | 1-0 | 0-10 | 0-8 | STL | STL |
| 20[i] | Span without stirrups[k, l] | | 4-10 | 5-5 | 4-5 | 4-7 | 4-3 | 4-0 | 3-11 | 3-7 | 3-7 |
| | 1-#4 | 40,000 | 7-0 | 8-1 | 6-3 | 6-5 | 5-10 | 5-3 | 4-11 | 4-1 | 3-11 |
| | | 60,000 | 8-7 | 9-10 | 7-7 | 7-10 | 7-1 | 6-5 | 6-0 | 4-11 | 4-10 |
| | 1-#5 | 40,000 | 8-9 | 10-1 | 7-9 | 8-0 | 7-3 | 6-6 | 6-1 | 5-1 | 4-11 |
| | | 60,000 | 10-8 | 12-3 | 9-6 | 9-10 | 8-10 | 8-0 | 7-5 | 6-2 | 6-0 |
| | 2-#4<br>1-#6 | 40,000 | 9-10 | 11-4 | 8-9 | 9-1 | 8-2 | 7-4 | 6-10 | 5-8 | 5-7 |
| | | 60,000 | 12-0 | 13-10 | 10-8 | 11-0 | 9-11 | 9-0 | 8-4 | 6-8 | 6-6 |
| | 2-#5 | 40,000 | 12-3 | 14-1 | 10-10 | 11-3 | 10-2 | 8-11 | 8-1 | 6-6 | 6-4 |
| | | 60,000 | 14-0 | 17-6 | 11-8 | 12-3 | 10-6 | 9-1 | 8-4 | 6-8 | 6-6 |
| | Center distance *A*[m, n] | | 1-10 | 2-5 | 1-5 | 1-7 | 1-3 | 1-0 | 0-11 | STL | STL |

*(continued)*

**TABLE R608.8(7)—continued**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 8-INCH-THICK WAFFLE-GRID LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, o]**
**MAXIMUM ROOF CLEAR SPAN 40 FEET AND MAXIMUM FLOOR CLEAR SPAN 32 FEET**

| LINTEL DEPTH, *D*[g] (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 24[j] | Span without stirrups[k, l] | | 5-9 | 6-7 | 5-5 | 5-6 | 5-2 | 4-11 | 4-9 | 4-5 | 4-4 |
| | 1-#4 | 40,000 | 7-6 | 8-10 | 6-10 | 7-1 | 6-5 | 5-9 | 5-5 | 4-6 | 4-4 |
| | | 60,000 | 9-2 | 10-9 | 8-4 | 8-8 | 7-10 | 7-1 | 6-7 | 5-6 | 5-4 |
| | 1-#5 | 40,000 | 9-5 | 11-0 | 8-6 | 8-10 | 8-0 | 7-2 | 6-8 | 5-7 | 5-5 |
| | | 60,000 | 11-5 | 13-5 | 10-5 | 10-9 | 9-9 | 8-9 | 8-2 | 6-10 | 6-8 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2-#4<br>1-#6 | 40,000 | 10-7 | 12-5 | 9-8 | 10-0 | 9-0 | 8-1 | 7-7 | 6-3 | 6-2 |
| | | 60,000 | 12-11 | 15-2 | 11-9 | 12-2 | 11-0 | 9-11 | 9-3 | 7-8 | 7-6 |
| | 2-#5 | 40,000 | 13-2 | 15-6 | 12-0 | 12-5 | 11-2 | 9-11 | 9-2 | 7-5 | 7-3 |
| | | 60,000 | 16-3 | 21-0 | 14-1 | 14-10 | 12-9 | 11-1 | 10-1 | 8-1 | 7-11 |
| | 2-#6 | 40,000 | 14-4 | 18-5 | 12-6 | 13-2 | 11-5 | 9-11 | 9-2 | 7-5 | 7-3 |
| | Center distance *A*[m, n] | | 2-1 | 2-11 | 1-9 | 1-10 | 1-6 | 1-3 | 1-1 | STL | STL |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 pound per square foot = 0.0479 kPa, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

a. Where lintels are formed with waffle-grid forms, form material shall be removed, if necessary, to create top and bottom flanges of the lintel that are not less than 3 inches in depth (in the vertical direction), are not less than 5 inches in width for 6-inch-nominal waffle-grid forms and not less than 7 inches in width for 8-inch-nominal waffle-grid forms. See Figure R608.8(3). Flat-form lintels shall be permitted in lieu of waffle-grid lintels. See Tables R608.8(2) through R608.8(5).

b. See Table R608.3 for tolerances permitted from nominal thicknesses and minimum dimensions and spacing of cores.

c. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Notes l and n. Table values are based on uniform loading. See Section R608.8.2 for lintels supporting concentrated loads.

d. Deflection criterion is $L/240$, where $L$ is the clear span of the lintel in inches, or $^1/_2$ inch, whichever is less.

e. Linear interpolation is permitted between ground snow loads.

f. STL indicates stirrups required throughout lintel.

g. Lintel depth, *D*, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.

i. Lintels less than 24 inches in depth with stirrups shall be formed from flat-wall forms [see Tables R608.8(2) through R608.8(5)], or, if necessary, form material shall be removed from waffle-grid forms so as to provide the required cover for stirrups. Allowable spans for lintels formed with flat-wall forms shall be determined from Tables R608.8(2) through R608.8(5).

j. Where stirrups are required for 24-inch-deep lintels, the spacing shall not exceed 12 inches on center.

k. Allowable clear span without stirrups applicable to all lintels of the same depth, *D.* Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than $d/2$.

l. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.

m. Center distance, A, is the center portion of the span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.

n. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, A, shall be permitted to be multiplied by 1.10.

o. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel spans in the table greater than 18 feet are shown for interpolation and information only.

**TABLE R608.8(8)**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 6-INCH-THICK SCREEN-GRID LINTELS IN LOAD-BEARING WALLS[a, b, c, d, e, f, p]**
**ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET**

| LINTEL DEPTH, *D*[g] (inches) | NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL | STEEL YIELD STRENGTH[h], $f_y$ (psi) | DESIGN LOADING CONDITION DETERMINED FROM Table R608.8(1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | 3 | | 4 | | 5 | |
| | | | Maximum ground snow load (psf) | | | | | | | | |
| | | | — | 30 | 70 | 30 | 70 | 30 | 70 | 30 | 70 |
| | | | Maximum clear span of lintel (feet-inches) | | | | | | | | |
| 12[i, j] | Span without stirrups | | 2-9 | 2-11 | 2-4 | 2-5 | 2-3 | 2-3 | 2-2 | 2-0 | 2-0 |
| 16[i, j] | Span without stirrups | | 3-9 | 4-0 | 3-4 | 3-5 | 3-2 | 3-1 | 3-0 | 2-9 | 2-9 |
| 20[i, j] | Span without stirrups | | 4-9 | 5-1 | 4-3 | 4-4 | 4-1 | 4-0 | 3-10 | 3-7 | 3-7 |
| 24[k] | Span without stirrups[l, m] | | 5-8 | 6-3 | 5-2 | 5-3 | 5-0 | 4-10 | 4-8 | 4-4 | 4-4 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-#4 | 40,000 | 7-11 | 9-0 | 6-11 | 7-2 | 6-5 | 6-1 | 5-8 | 4-9 | 4-7 |
| | | 60,000 | 9-9 | 11-0 | 8-5 | 8-9 | 7-10 | 7-5 | 6-10 | 5-9 | 5-7 |
| | 1-#5 | 40,000 | 9-11 | 11-2 | 8-7 | 8-11 | 8-0 | 7-7 | 7-0 | 5-11 | 5-9 |
| | | 60,000 | 12-1 | 13-8 | 10-6 | 10-10 | 9-9 | 9-3 | 8-6 | 7-2 | 7-0 |
| | 2-#4<br>1-#6 | 40,000 | 11-2 | 12-8 | 9-9 | 10-1 | 9-1 | 8-7 | 7-11 | 6-8 | 6-6 |
| | | 60,000 | 15-7 | 17-7 | 12-8 | 13-4 | 11-6 | 10-8 | 9-8 | 7-11 | 7-8 |
| | 2-#5 | 40,000 | 14-11 | 18-0 | 12-2 | 12-10 | 11-1 | 10-3 | 9-4 | 7-8 | 7-5 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | Center distance *A*[n, o] | | 2-0 | 2-6 | 1-6 | 1-7 | 1-4 | 1-2 | 1-0 | STL | STL |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 pound per square foot = 0.0479 kPa, Grade 40 = 280 MPa,
Grade 60 = 420 MPa.

a. Where lintels are formed with screen-grid forms, form material shall be removed if necessary to create top and bottom flanges of the lintel that are not less than 5 inches in width and not less than 2.5 inches in depth (in the vertical direction). See Figure R608.8(4). Flat-form lintels shall be permitted in lieu of screen-grid lintels. See Tables R608.8(2) through R608.8(5).

b. See Table R608.3 for tolerances permitted from nominal thickness and minimum dimensions and spacings of cores.

c. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Notes m and o. Table values are based on uniform loading. See Section R608.7.2.1 for lintels supporting concentrated loads.

d. Deflection criterion is $L/240$, where $L$ is the clear span of the lintel in inches, or $^1/_2$ inch, whichever is less.

e. Linear interpolation is permitted between ground snow loads.

f. DR indicates design required. STL indicates stirrups required throughout lintel.

g. Lintel depth, *D*, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.

i. Stirrups are not required for lintels less than 24 inches in depth fabricated from screen-grid forms. Top and bottom reinforcement shall consist of a No. 4 bar having a yield strength of 40,000 psi or 60,000 psi.

j. Lintels between 12 and 24 inches in depth with stirrups shall be formed from flat-wall forms [see Tables R608.8(2) through R608.8(5)], or form material shall be removed from screen-grid forms to provide a concrete section comparable to that required for a flat wall. Allowable spans for flat lintels with stirrups shall be determined from Tables R608.8(2) through R608.8(5).

k. Where stirrups are required for 24-inch-deep lintels, the spacing shall not exceed 12 inches on center.

l. Allowable clear span without stirrups applicable to all lintels of the same depth, *D*. Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than 12 inches.

m. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.

n. Center distance, A, is the center portion of the span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.

o. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, A, shall be permitted to be multiplied by 1.10.

p. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel spans in the table greater than 18 feet are shown for interpolation and information only.

**TABLE R608.8(9)**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR FLAT LINTELS WITHOUT STIRRUPS IN NONLOAD-BEARING WALLS[a, b, c, d, e, g]**

| LINTEL DEPTH, *D*[f] (inches) | NUMBER OF BARS AND BAR SIZE | STEEL YIELD STRENGTH, $f_y$ (psi) | NOMINAL WALL THICKNESS (inches) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 4 | | 6 | | 8 | | 10 | |
| | | | Lintel Supporting | | | | | | | |
| | | | Concrete Wall | Light-frame Gable | Concrete Wall | Light-frame Gable | Concrete Wall | Light-frame Gable | Concrete Wall | Light-frame Gable |
| | | | Maximum Clear Span of Lintel (feet-inches) | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 1-#4 | 40,000 | 10-11 | 11-5 | 9-7 | 11-2 | 7-10 | 9-5 | 7-3 | 9-2 |
| | | 60,000 | 12-5 | 11-7 | 10-11 | 13-5 | 9-11 | 13-2 | 9-3 | 12-10 |
| | 1-#5 | 40,000 | 12-7 | 11-7 | 11-1 | 13-8 | 10-1 | 13-5 | 9-4 | 13-1 |
| | | 60,000 | DR | DR | 12-7 | 16-4 | 11-6 | 14-7 | 10-9 | 14-6 |
| | 2-#4<br>1-#6 | 40,000 | DR | DR | 12-0 | 15-3 | 10-11 | 15-0 | 10-2 | 14-8 |
| | | 60,000 | DR | DR | DR | DR | 12-2 | 15-3 | 11-7 | 15-3 |
| | 2-#5 | 40,000 | DR | DR | DR | DR | 12-7 | 16-7 | 11-9 | 16-7 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | 13-3 | 16-7 |
| | 2-#6 | 40,000 | DR | DR | DR | DR | DR | DR | 13-2 | 17-8 |
| | | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR |
| 12 | 1-#4 | 40,000 | 11-5 | 9-10 | 10-6 | 12-0 | 9-6 | 11-6 | 8-9 | 11-1 |
| | | 60,000 | 11-5 | 9-10 | 11-8 | 13-3 | 10-11 | 14-0 | 10-1 | 13-6 |
| | 1-#5 | 40,000 | 11-5 | 9-10 | 11-8 | 13-3 | 11-1 | 14-4 | 10-3 | 13-9 |
| | | 60,000 | 11-5 | 9-10 | 11-8 | 13-3 | 11-10 | 16-0 | 11-9 | 16-9 |
| | 2-#4<br>1-#6 | 40,000 | DR | DR | 11-8 | 13-3 | 11-10 | 16-0 | 11-2 | 15-6 |
| | | 60,000 | DR | DR | 11-8 | 13-3 | 11-10 | 16-0 | 11-11 | 18-4 |
| | 2-#5 | 40,000 | DR | DR | 11-8 | 13-3 | 11-10 | 16-0 | 11-11 | 18-4 |
| | | 60,000 | DR | DR | 11-8 | 13-3 | 11-10 | 16-0 | 11-11 | 18-4 |
| 16 | 1-#4 | 40,000 | 13-6 | 13-0 | 11-10 | 13-8 | 10-7 | 12-11 | 9-11 | 12-4 |
| | | 60,000 | 13-6 | 13-0 | 13-8 | 16-7 | 12-4 | 15-9 | 11-5 | 15-0 |
| | 1-#5 | 40,000 | 13-6 | 13-0 | 13-10 | 17-0 | 12-6 | 16-1 | 11-7 | 15-4 |
| | | 60,000 | 13-6 | 13-0 | 13-10 | 17-1 | 14-0 | 19-7 | 13-4 | 18-8 |
| | 2-#4<br>1-#6 | 40,000 | 13-6 | 13-0 | 13-10 | 17-1 | 13-8 | 18-2 | 12-8 | 17-4 |
| | | 60,000 | 13-6 | 13-0 | 13-10 | 17-1 | 14-0 | 20-3 | 14-1 | — |
| | 2-#5 | 40,000 | 13-6 | 13-0 | 13-10 | 17-1 | 14-0 | 20-3 | 14-1 | — |
| | | 60,000 | DR | DR | 13-10 | 17-1 | 14-0 | 20-3 | 14-1 | — |
| 20 | 1-#4 | 40,000 | 14-11 | 15-10 | 13-0 | 14-10 | 11-9 | 13-11 | 10-10 | 13-2 |
| | | 60,000 | 15-3 | 15-10 | 14-11 | 18-1 | 13-6 | 17-0 | 12-6 | 16-2 |
| | 1-#5 | 40,000 | 15-3 | 15-10 | 15-2 | 18-6 | 13-9 | 17-5 | 12-8 | 16-6 |
| | | 60,000 | 15-3 | 15-10 | 15-8 | 20-5 | 15-9 | — | 14-7 | 20-1 |
| | 2-#4<br>1-#6 | 40,000 | 15-3 | 15-10 | 15-8 | 20-5 | 14-11 | — | 13-10 | — |
| | | 60,000 | 15-3 | 15-10 | 15-8 | 20-5 | 15-10 | — | 15-11 | — |
| | 2-#5 | 40,000 | 15-3 | 15-10 | 15-8 | 20-5 | 15-10 | — | 15-11 | — |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 60,000 | 15-3 | 15-10 | 15-8 | 20-5 | 15-10 | — | 15-11 | — |

*(continued)*

**TABLE R608.8(9)—continued**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR FLAT LINTELS WITHOUT STIRRUPS IN NONLOAD-BEARING WALLS[a, b, c, d, e, g]**

| LINTEL DEPTH, $D^f$ (inches) | NUMBER OF BARS AND BAR SIZE | STEEL YIELD STRENGTH, $f_y$ (psi) | NOMINAL WALL THICKNESS (inches) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 4 | | 6 | | 8 | | 10 | |
| | | | Lintel Supporting | | | | | | | |
| | | | Concrete Wall | Light-frame Gable | Concrete Wall | Light-frame Gable | Concrete Wall | Light-frame Gable | Concrete Wall | Light-frame Gable |
| | | | Maximum Clear Span of Lintel (feet-inches) | | | | | | | |
| 24 | 1-#4 | 40,000 | 16-1 | 17-1 | 13-11 | 15-10 | 12-7 | 14-9 | 11-8 | 13-10 |
| | | 60,000 | 16-11 | 18-5 | 16-1 | 19-3 | 14-6 | 18-0 | 13-5 | 17-0 |
| | 1-#5 | 40,000 | 16-11 | 18-5 | 16-3 | 19-8 | 14-9 | 18-5 | 13-8 | 17-4 |
| | | 60,000 | 16-11 | 18-5 | 17-4 | — | 17-0 | — | 15-8 | — |
| | 2-#4<br>1-#6 | 40,000 | 16-11 | 18-5 | 17-4 | — | 16-1 | — | 14-10 | — |
| | | 60,000 | 16-11 | 18-5 | 17-4 | — | 17-6 | — | 17-1 | — |
| | 2-#5 | 40,000 | 16-11 | 18-5 | 17-4 | — | 17-6 | — | 17-4 | — |
| | | 60,000 | 16-11 | 18-5 | 17-4 | — | 17-6 | — | 17-8 | — |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

DR = Design Required.

a. See Table R608.3 for tolerances permitted from nominal thickness.

b. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Note e.

c. Deflection criterion is $L/240$, where $L$ is the clear span of the lintel in inches, or $^1/_2$ inch, whichever is less.

d. Linear interpolation between lintels depths, $D$, is permitted provided the two cells being used to interpolate are shaded.

e. Where concrete with a minimum specified compressive strength of 3,000 psi is used, spans in cells that are shaded shall be permitted to be multiplied by 1.05.

f. Lintel depth, $D$, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

~~g. DR indicates design required~~

~~h.~~ g. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel spans in the table greater than 18 feet are shown for interpolation and information purposes only.

**TABLE R608.8(10)**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR WAFFLE-GRID AND SCREEN-GRID LINTELS WITHOUT STIRRUPS IN NONLOAD-BEARING WALLS[c, d, e, f, g]**

| LINTEL DEPTH[h], $D$ (inches) | FORM TYPE AND NOMINAL WALL THICKNESS (inches) | | | | | |
|---|---|---|---|---|---|---|
| | 6-inch Waffle-grid[a] | | 8-inch Waffle-grid[a] | | 6-inch Screen-grid[b] | |
| | Lintel supporting | | | | | |
| | Concrete Wall | Light-frame Gable | Concrete Wall | Light-frame Gable | Concrete Wall | Light-frame Gable |
| | Maximum Clear Span of Lintel (feet-inches) | | | | | |
| 8 | 10-3 | 8-8 | 8-8 | 8-3 | — | — |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12 | 9-2 | 7-6 | 7-10 | 7-1 | 8-8 | 6-9 |
| 16 | 10-11 | 10-0 | 9-4 | 9-3 | — | — |
| 20 | 12-5 | 12-2 | 10-7 | 11-2 | — | — |
| 24 | 13-9 | 14-2 | 11-10 | 12-11 | 13-0 | 12-9 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

a. Where lintels are formed with waffle-grid forms, form material shall be removed, if necessary, to create top and bottom flanges of the lintel that are not less than 3 inches in depth (in the vertical direction), are not less than 5 inches in width for 6-inch waffle-grid forms and not less than 7 inches in width for 8-inch waffle-grid forms. See Figure R608.8(3). Flat-form lintels shall be permitted in lieu of waffle-grid lintels. See Tables R608.8(2) through R608.8(5).

b. Where lintels are formed with screen-grid forms, form material shall be removed if necessary to create top and bottom flanges of the lintel that are not less than 5 inches in width and not less than 2.5 inches in depth (in the vertical direction). See Figure R608.8(4). Flat-form lintels shall be permitted in lieu of screen-grid lintels. See Tables R608.8(2) through R608.8(5).

c. See Table R608.3 for tolerances permitted from nominal thickness and minimum dimensions and spacing of cores.

d. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Note g.

e. Deflection criterion is *L*/240, where *L* is the clear span of the lintel in inches, or $^{1}/_{2}$ inch, whichever is less.

f. Top and bottom reinforcement shall consist of a No. 4 bar having a minimum yield strength of 40,000 psi.

g. Where concrete with a minimum specified compressive strength of 3,000 psi is used, spans in shaded cells shall be permitted to be multiplied by 1.05.

h. Lintel depth, *D*, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

**R608.8.1.2 Vertical reinforcement.** Not less than one No. 4 bar [Grade 40 (280 MPa)] shall be provided on each side of openings equal to or greater than 2 feet (610 mm) in width. The vertical reinforcement required by this section shall extend the full height of the wall story and shall be located within 12 inches (305 mm) of each side of the opening. The vertical reinforcement required on each side of an opening by this section is permitted to serve as reinforcement at the ends of solid wall segments in accordance with Section R608.7.2.2.2, provided it is located as required by the applicable detail in Figure R608.7.1.1(2). Where the vertical reinforcement required by this section is used to satisfy the requirements of Section R608.7.2.2.2 in waffle- and screen-grid walls, a concrete flange shall be created at the ends of the solid wall segments in accordance with Table R608.7.1.1(6), Note e. In the top-most story, the reinforcement shall terminate in accordance with Section R608.6.4.

**R608.8.2 Lintels.** Lintels shall be provided over all openings equal to or greater than 2 feet (610 mm) in width. Lintels with uniform loading shall conform to Sections R608.8.2.1 and R608.8.2.2, or Section R608.8.2.3. Lintels supporting concentrated loads, such as from roof or floor beams or girders, shall be designed in accordance with ACI 318.

**R608.8.2.1 Lintels designed for gravity load-bearing conditions.** Where a lintel will be subjected to gravity load conditions 1 through 5 of Table R608.8(1), the clear span of the lintel shall not exceed that permitted by Tables R608.8(2) through R608.8(8). The maximum clear span of lintels with and without stirrups in flat walls shall be determined in accordance with Tables R608.8(2) through R608.8(5), and constructed in accordance with Figure R608.8(2). The maximum clear span of lintels with and without stirrups in waffle-grid walls shall be determined in accordance with Tables R608.8(6) and R608.8(7), and constructed in accordance with Figure R608.8(3). The maximum clear span of lintels with and without stirrups in screen-grid walls shall be determined in accordance with Table R608.8(8), and constructed in accordance with Figure R608.8(4).

Where required by the applicable table, No. 3 stirrups shall be installed in lintels at a maximum spacing of *d/2* where *d* equals the depth of the lintel, *D*, less the cover of the concrete as shown in Figures R608.8(2) through R608.8(4). The smaller value of *d* computed for the top and bottom bar shall be used to determine the maximum stirrup spacing. Where stirrups are required in a lintel with a single bar or two bundled bars in the top and bottom, they shall be fabricated like the letter “c” or “s” with 135-degree (2.36 rad) standard hooks at each end that comply with Section R608.5.4.5 and Figure R608.5.4(3) and installed as shown in Figures R608.8(2) through R608.8(4). Where two bars are required in the top and bottom of the lintel and the bars are not bundled, the bars shall be separated by not less than 1 inch (25 mm). The free end of the stirrups shall be fabricated with 90- or 135-degree (1.57 or 2.36 rad) standard hooks that comply with Section R608.5.4.5 and Figure R608.5.4(3) and installed as shown in Figures R608.8(2) and R608.8(3). For flat, waffle-grid and screen-grid lintels, stirrups are not required in the center distance, *A*, portion of spans in accordance with Figure R608.8(1) and Tables

R608.8(2) through R608.8(8). See Section R608.8.2.2, Item 5, for requirement for stirrups through out lintels with bundled bars.

**R608.8.2.2 Bundled bars in lintels.** It is permitted to bundle two bars in contact with each other in lintels if all of the following are observed:

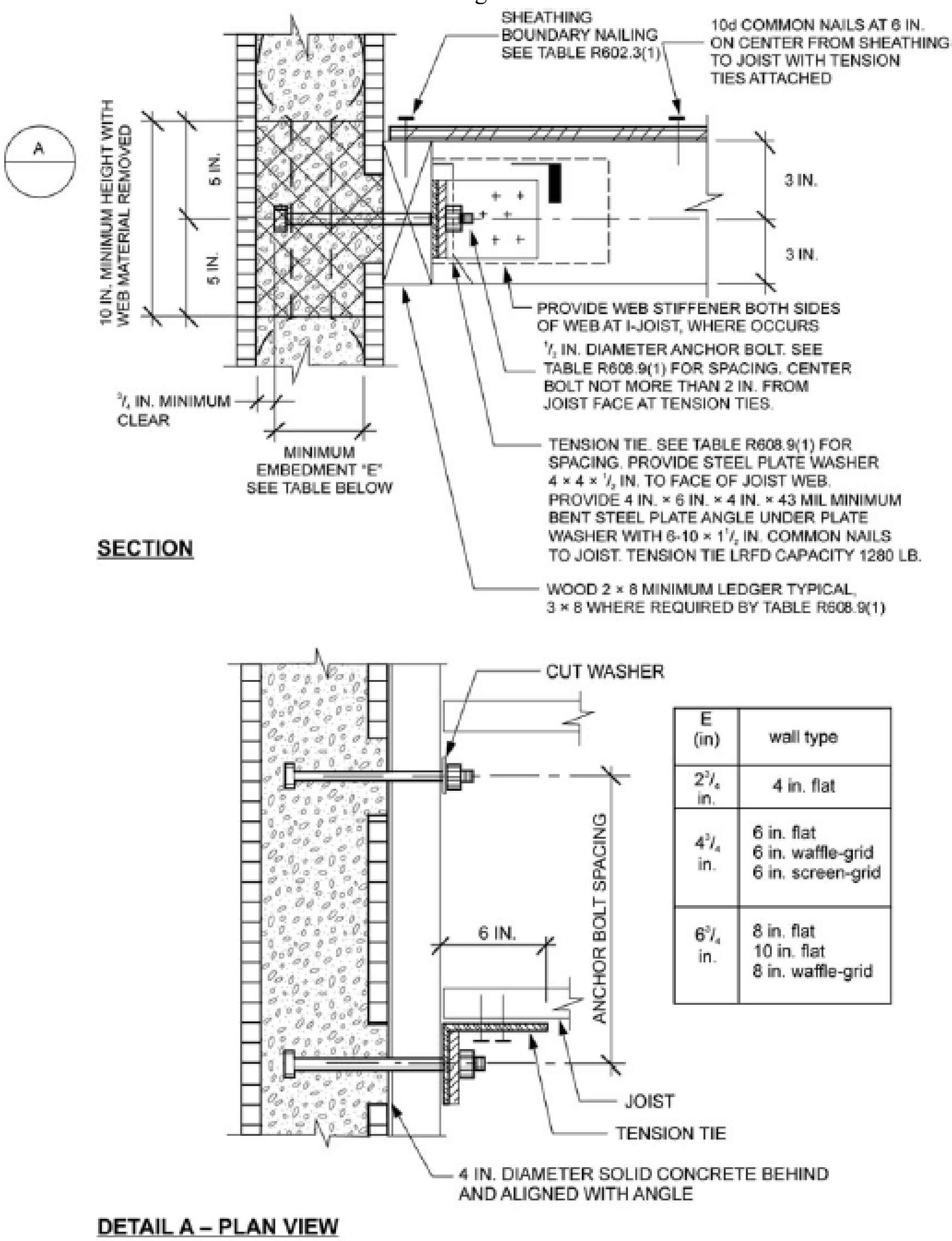
1. Bars equal to or less than No. 6 are bundled.
2. Where the wall thickness is not sufficient to provide not less than 3 inches (76 mm) of clear space beside bars (total on both sides) oriented horizontally in a bundle, the bundled bars shall be oriented in a vertical plane.
3. Where vertically oriented bundled bars terminate with standard hooks to develop the bars in tension beyond the support (see Section R608.5.4.4), the hook extensions shall be staggered to provide not less than 1 inch (25 mm) clear spacing between the extensions.
4. Bundled bars shall not be lap spliced within the lintel span and the length on each end of the lintel that is required to develop the bars in tension.
5. Bundled bars shall be enclosed within stirrups throughout the length of the lintel. Stirrups and the installation thereof shall comply with Section R608.8.2.1.

**R608.8.2.3 Lintels without stirrups designed for nonload-bearing conditions.** The maximum clear span of lintels without stirrups designed for nonload-bearing conditions of Table R608.8(1) shall be determined in accordance with this section. The maximum clear span of lintels without stirrups in flat walls shall be determined in accordance with Table R608.8(9), and the maximum clear span of lintels without stirrups in walls of waffle-grid or screen-grid construction shall be determined in accordance with Table R608.8(10).

**R608.9 Requirements for connections—general.** Concrete walls shall be connected to footings, floors, ceilings and roofs in accordance with this section.

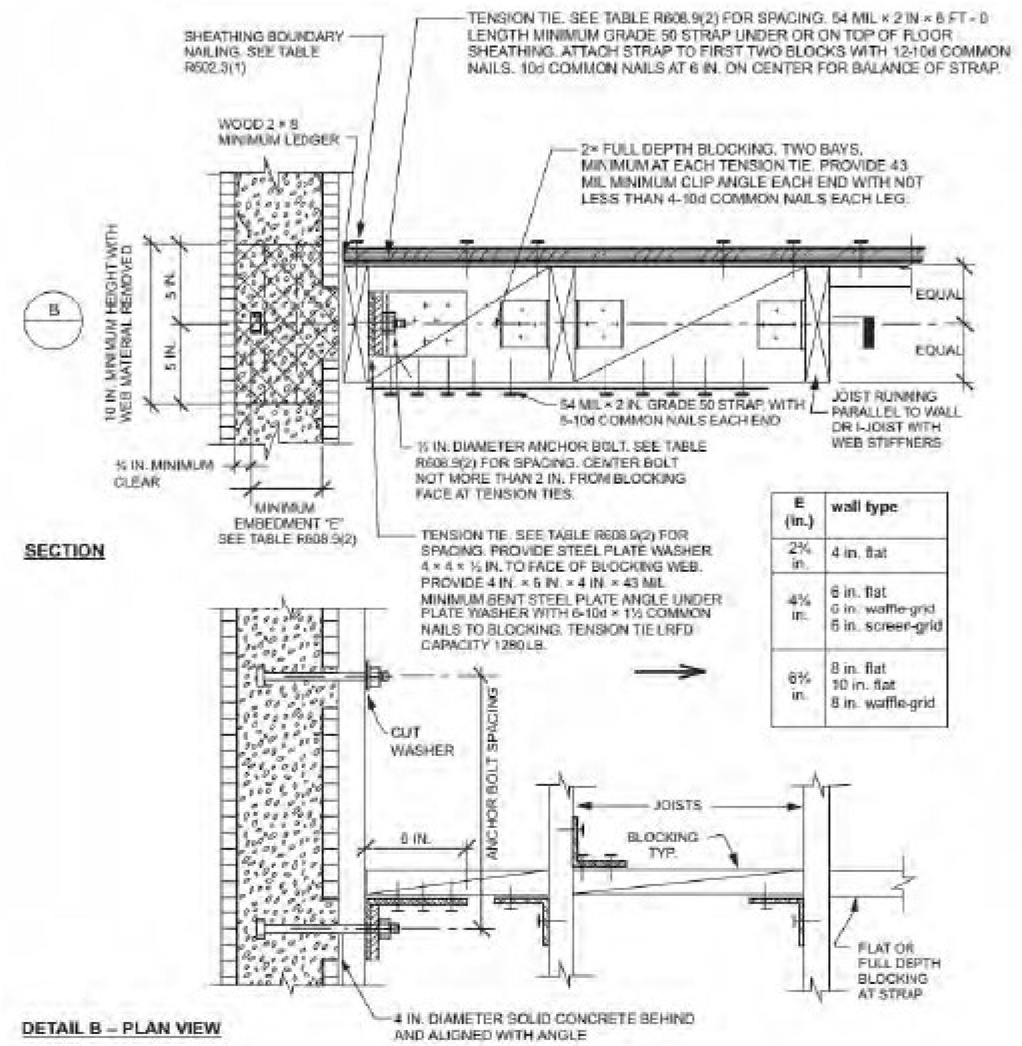
**R608.9.1 Connections between concrete walls and light-frame floor, ceiling and roof systems.** Connections between concrete walls and light-frame floor, ceiling and roof systems using the prescriptive details of Figures R608.9(1) through R608.9(~~12~~ 4) and R608.9(9) through R608.9(10) shall comply with this section and Sections R608.9.2 and R608.9.3.

**R608.9.1.1 Anchor bolts.** Anchor bolts used to connect light-frame floor, ceiling and roof systems to concrete walls in accordance with Figures R608.9(1) through R608.9(~~12~~ 4) and R608.9(9) through R608.9(10) shall have heads, or shall be rods with threads on both ends with a hex or square nut on the end embedded in the concrete. Bolts and threaded rods shall comply with Section R608.5.2.2. Anchor bolts with J- or L-hooks shall not be used where the connection details in these figures are used.



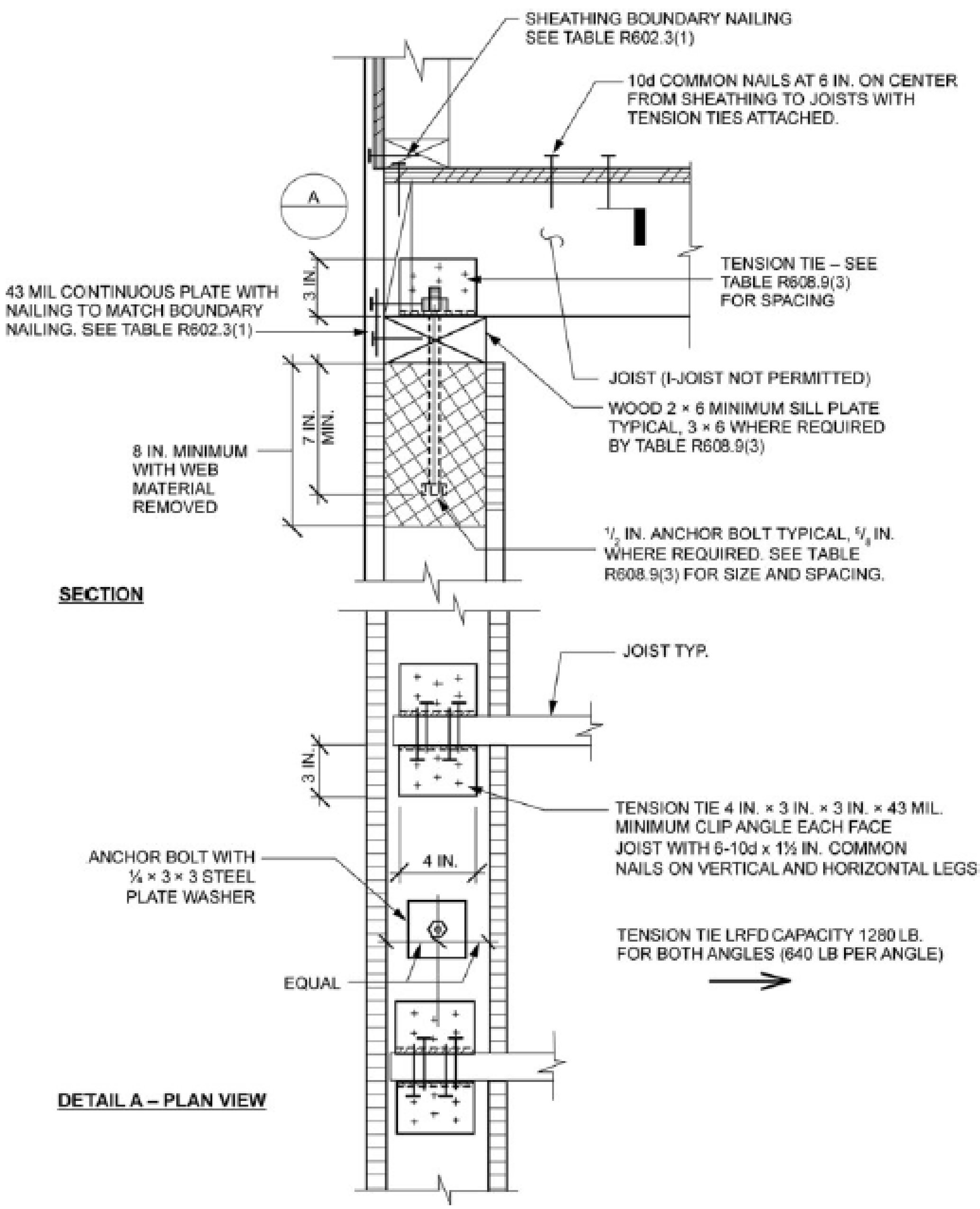

For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 pound-force = 4.448 N.

**FIGURE R608.9(1)**



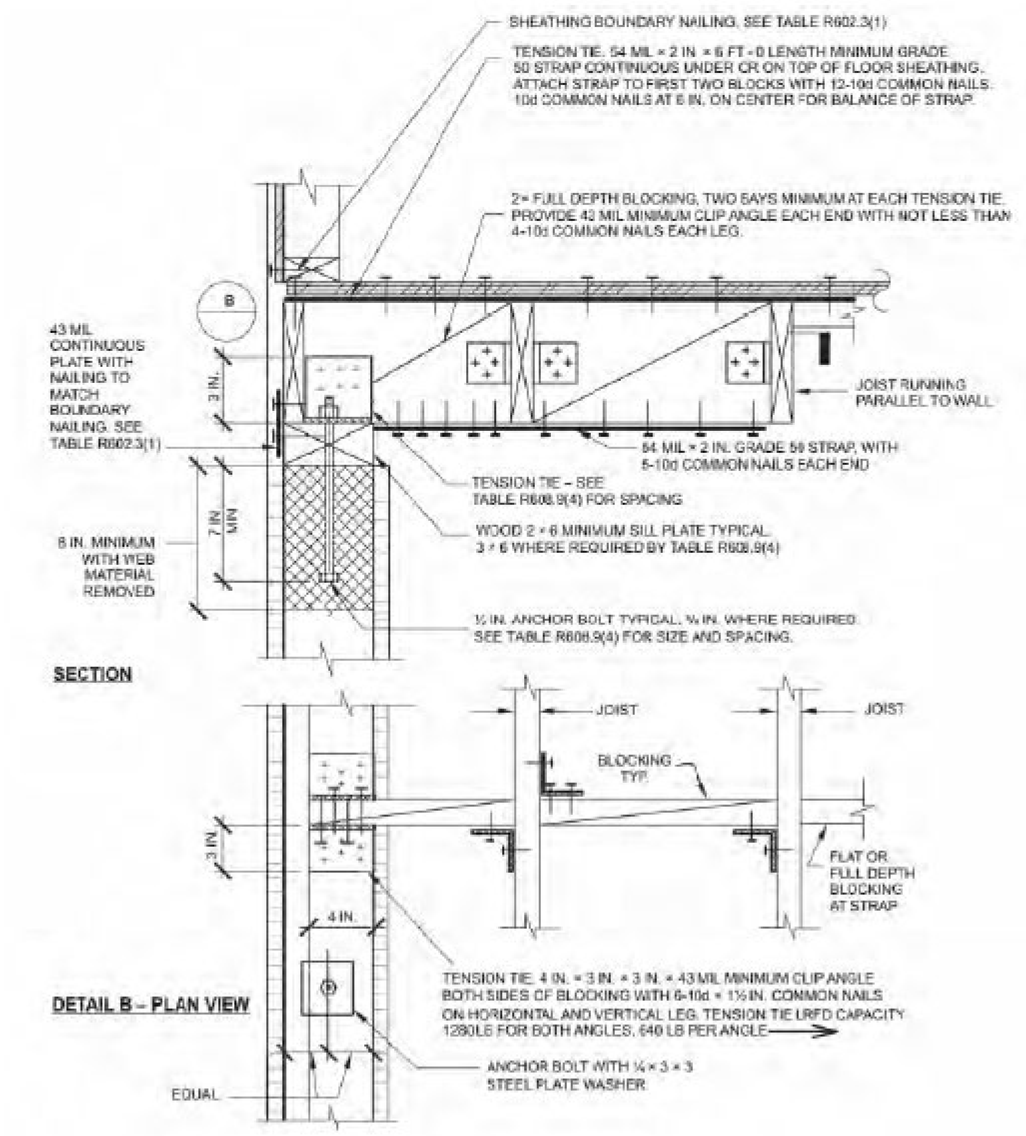

For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound-force = 4.448 N.

**FIGURE R608.9(2)**
**WOOD-FRAMED FLOOR TO SIDE OF CONCRETE WALL, FRAMING PARALLEL**



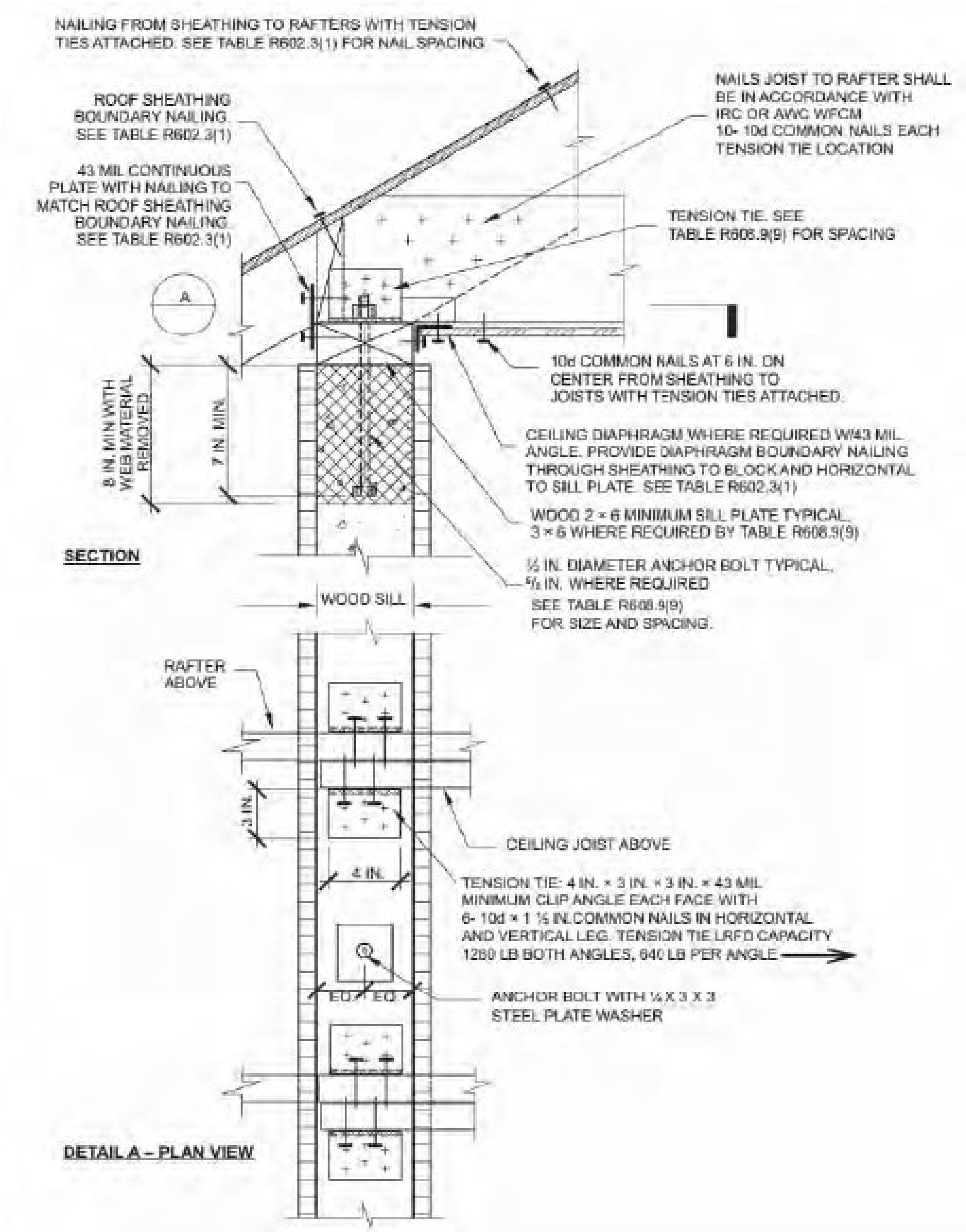

For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 pound-force = 4.448 N.

**FIGURE R608.9(3)**
**WOOD-FRAMED FLOOR TO TOP OF CONCRETE WALL, FRAMING PERPENDICULAR**



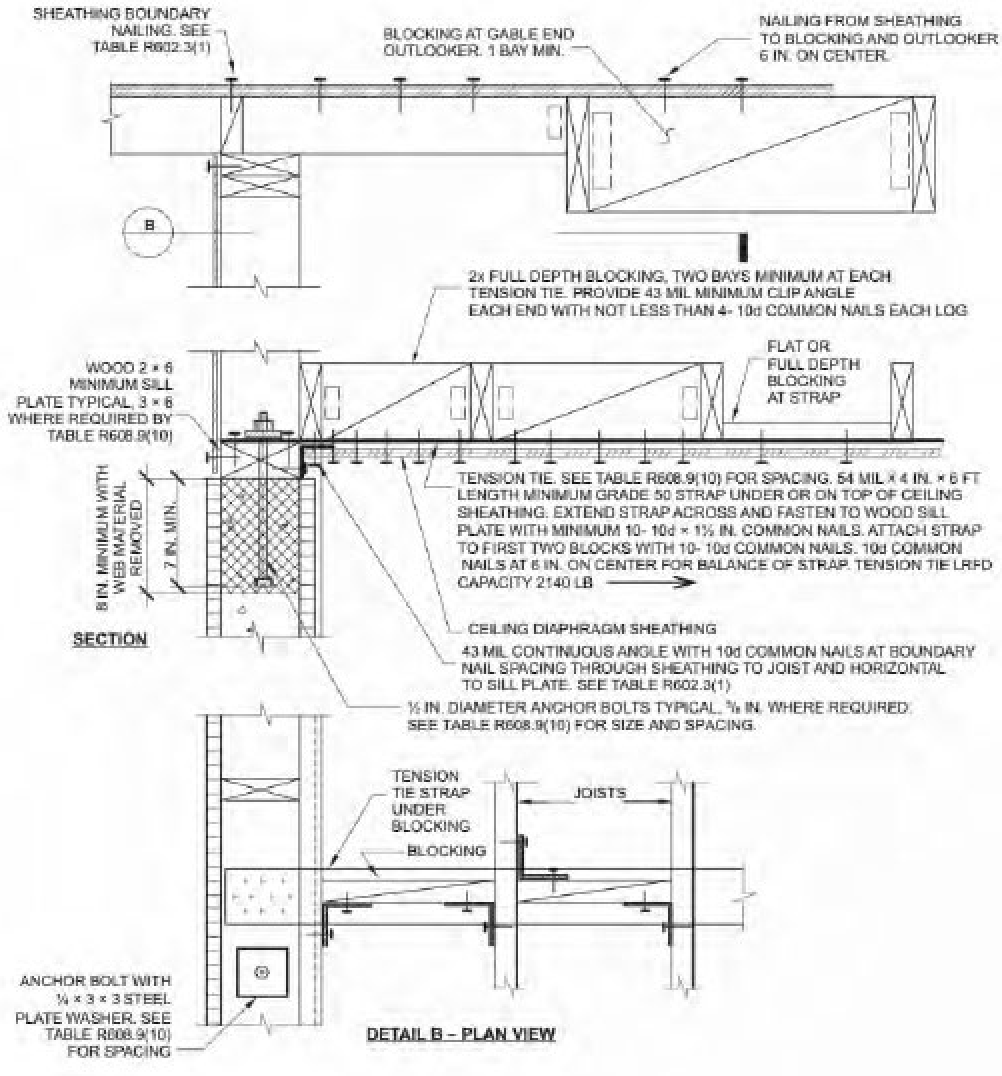

For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound-force = 4.448 N.

**FIGURE R608.9(4)**
**WOOD-FRAMED FLOOR TO TOP OF CONCRETE WALL, FRAMING PARALLEL**




For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 pound-force = 4.448 N.

**FIGURE R608.9(9)**
**WOOD-FRAMED ROOF TO TOP OF CONCRETE WALL, FRAMING PERPENDICULAR**




For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 pound-force = 4.448 N.

**FIGURE R608.9(10)**
**WOOD-FRAMED ROOF TO TOP OF CONCRETE WALL, FRAMING PARALLEL**

**TABLE R608.9(1)**
**WOOD-FRAMED FLOOR TO SIDE OF CONCRETE WALL, FRAMING PERPENDICULAR[a, b]**

| ANCHOR BOLT SPACING (inches) | TENSION TIE SPACING (inches) | BASIC WIND SPEED (mph) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 115B | 120B | 130B | 140B | 150B | 160B |
| | | — | — | 110C | 119C | 127C | 136C |
| | | — | — | — | 110D | 117D | 125D |
| 12 | 12 | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12 | 24 | | | | | | |
| 12 | 36 | | | | | | |
| 12 | 48 | | | | | | |
| 16 | 16 | | | | | | |
| 16 | 32 | | | | | | |
| 16 | 48 | | | | | | |
| 19.2 | 19.2 | | | | | | |
| 19.2 | 38.4 | | | | | | |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(1). Use of this detail is permitted where a cell is not shaded and prohibited where shaded.

b. Wall design per other provisions of Section R608 is required.

**TABLE R608.9(2)**

**WOOD-FRAMED FLOOR TO SIDE OF CONCRETE WALL, FRAMING PARALLEL[a, b]**

| ANCHOR BOLT SPACING (inches) | TENSION TIE SPACING (inches) | BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY | | | | | |
|---|---|---|---|---|---|---|---|
| | | 115B | 120B | 130B | 140B | 150B | 160B |
| | | — | — | 110C | 119C | 127C | 136C |
| | | — | — | — | 110D | 117D | 125D |
| 12 | 12 | | | | | | |
| 12 | 24 | | | | | | |
| 12 | 36 | | | | | | |
| 12 | 48 | | | | | | |
| 16 | 16 | | | | | | |
| 16 | 32 | | | | | | |
| 16 | 48 | | | | | | |
| 19.2 | 19.2 | | | | | | |
| 19.2 | 38.4 | | | | | | |
| 24 | 24 | | | | | | |
| 24 | 48 | | | | | | |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(2). Use of this detail is permitted where a cell is not shaded and prohibited where shaded.

b. Wall design per other provisions of Section R608 is required.

**TABLE R608.9(3)**

**WOOD-FRAMED FLOOR TO TOP OF CONCRETE WALL, FRAMING PERPENDICULAR[a, b, c, d, e]**

| ANCHOR BOLT SPACING (inches) | TENSION TIE SPACING (inches) | BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY | | | | | |
|---|---|---|---|---|---|---|---|
| | | 115B | 120B | 130B | 140B | 150B | 160B |
| | | — | — | 110C | 119C | 127C | 136C |

| | | — | — | — | 110D | 117D | 125D |
|---|---|---|---|---|---|---|---|
| 12 | 12 | | | | | | 6 |
| 12 | 24 | | | | | 6 | 6 |
| 12 | 36 | | | | | 6 | 6 |
| 12 | 48 | | | | 6 | 6 | 6 |
| 16 | 16 | | | | | 6 | 6A |
| 16 | 32 | | | | 6 | 6 | 6A |
| 16 | 48 | | | 6 | 6 | 6 | 6A |
| 19.2 | 19.2 | | | | 6A | 6A | 6B |
| 19.2 | 38.4 | | | 6 | 6A | 6A | 6B |
| 24 | 24 | | | 6A | 6B | 6B | 6B |
| 24 | 48 | | 6 | 6A | 6B | 6B | 8B |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(3). Use of this detail is permitted where cell is not shaded.

b. Wall design per other provisions in Section R608 is required.

c. For wind design, minimum 4-inch-nominal wall is permitted in unshaded cells that do not contain a number.

d. Numbers 6 and 8 indicate minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross hatching in Figure R608.9(3). For the remainder of the wall, see Note b.

e. Letter "A" indicates that a minimum nominal 3 × 6 sill plate is required. Letter "B" indicates that a $^5/_8$-inch-diameter anchor bolt and a minimum nominal 3 × 6 sill plate are required.

**TABLE R608.9(4)**

**WOOD-FRAMED FLOOR TO TOP OF CONCRETE WALL, FRAMING PARALLEL[a, b, c, d, e]**

| ANCHOR BOLT SPACING (inches) | TENSION TIE SPACING (inches) | BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY | | | | | |
|---|---|---|---|---|---|---|---|
| | | 115B | 120B | 130B | 140B | 150B | 160B |
| | | — | — | 110C | 119C | 127C | 136C |
| | | — | — | — | 110D | 117D | 125D |
| 12 | 12 | | | | | | 6 |
| 12 | 24 | | | | | 6 | 6 |
| 12 | 36 | | | | | 6 | 6 |
| 12 | 48 | | | | 6 | 6 | 6 |
| 16 | 16 | | | | | 6 | 6A |
| 16 | 32 | | | | 6 | 6 | 6A |
| 16 | 48 | | | 6 | 6 | 6 | 6A |
| 19.2 | 19.2 | | | | 6A | 6A | 6B |
| 19.2 | 38.4 | | | 6 | 6A | 6A | 6B |
| 24 | 24 | | | 6A | 6B | 6B | 6B |
| 24 | 48 | | 6 | 6A | 6B | 6B | 8B |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(4). Use of this detail is permitted where a cell is not shaded.

b. Wall design per other provisions of Section R608 is required.

c. For wind design, minimum 4-inch-nominal wall is permitted in unshaded cells that do not contain a number.

d. Numbers 6 and 8 indicate minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross hatching in Figure R608.9(4). For the remainder of the wall, see Note b.

e. Letter “A” indicates that a minimum nominal 3 × 6 sill plate is required. Letter “B” indicates that a $^5/_8$-inch-diameter anchor bolt and a minimum nominal 3 × 6 sill plate are required.

**~~TABLE R608.9(5)~~**

**~~COLD-FORMED STEEL-FRAMED FLOOR TO SIDE OF CONCRETE WALL, FRAMING PERPENDICULAR~~[a, b, c]**

| ~~ANCHOR BOLT SPACING (inches)~~ | ~~TENSION TIE SPACING (inches)~~ | ~~BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY~~ | | | | | |
|---|---|---|---|---|---|---|---|
| | | ~~115B~~ | ~~120B~~ | ~~130B~~ | ~~140B~~ | ~~150B~~ | ~~160B~~ |
| | | — | — | ~~110C~~ | ~~119C~~ | ~~127C~~ | ~~136C~~ |
| | | — | — | — | ~~110D~~ | ~~117D~~ | ~~125D~~ |
| ~~12~~ | ~~12~~ | | | | | | |
| ~~12~~ | ~~24~~ | | | | | | |
| ~~12~~ | ~~36~~ | | | | | | |
| ~~12~~ | ~~48~~ | | | | | | |
| ~~16~~ | ~~16~~ | | | | | | |
| ~~16~~ | ~~32~~ | | | | | | |
| ~~16~~ | ~~48~~ | | | | | | |
| ~~19.2~~ | ~~19.2~~ | | | | | | |
| ~~19.2~~ | ~~38.4~~ | | | | | | |
| ~~24~~ | ~~24~~ | | | | | | |
| ~~24~~ | ~~48~~ | | | | | | |

~~For SI:1 inch = 25.4 mm, 1 mile per hour = 0.4470 m/s.~~

~~a. This table is for use with the detail in Figure R608.9(5). Use of this detail is permitted where a cell is not shaded.~~

~~b. Wall design per other provisions of Section R608 is required.~~

~~c. For wind design, minimum 4-inch-nominal wall is permitted in unshaded cells that do not contain a number.~~

**~~TABLE R608.9(6)~~**

**~~COLD-FORMED STEEL-FRAMED FLOOR TO SIDE OF CONCRETE WALL, FRAMING PARALLEL~~[a, b, c]**

| ~~ANCHOR BOLT SPACING (inches)~~ | ~~TENSION TIE SPACING (inches)~~ | ~~BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY~~ | | | | | |
|---|---|---|---|---|---|---|---|
| | | ~~115B~~ | ~~120B~~ | ~~130B~~ | ~~140B~~ | ~~150B~~ | ~~160B~~ |
| | | — | — | ~~110C~~ | ~~119C~~ | ~~127C~~ | ~~136C~~ |
| | | — | — | — | ~~110D~~ | ~~117D~~ | ~~125D~~ |
| ~~12~~ | ~~12~~ | | | | | | |
| ~~12~~ | ~~24~~ | | | | | | |
| ~~12~~ | ~~36~~ | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ~~12~~ | ~~48~~ | | | | | | |
| ~~16~~ | ~~16~~ | | | | | | |
| ~~16~~ | ~~32~~ | | | | | | |
| ~~16~~ | ~~48~~ | | | | | | |
| ~~19.2~~ | ~~19.2~~ | | | | | | |
| ~~19.2~~ | ~~38.4~~ | | | | | | |
| ~~24~~ | ~~24~~ | | | | | | |
| ~~24~~ | ~~48~~ | | | | | | |

~~For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.~~

~~a. This table is for use with the detail in Figure R608.9(6). Use of this detail is permitted where a cell is not shaded.~~

~~b. Wall design per other provisions of Section R608 is required.~~

~~c. For wind design, minimum 4-inch nominal wall is permitted in unshaded cells that do not contain a number.~~

**~~TABLE R608.9(7)~~**

**~~COLD-FORMED STEEL-FRAMED FLOOR TO TOP OF CONCRETE WALL, FRAMING PERPENDICULAR~~[a, b, c, d, e]**

| ~~ANCHOR BOLT SPACING (inches)~~ | ~~TENSION TIE SPACING (inches)~~ | ~~BASIC WIND SPEED AND WIND EXPOSURE CATEGORY (mph)~~ | | | | | |
|---|---|---|---|---|---|---|---|
| | | ~~115B~~ | ~~120B~~ | ~~130B~~ | ~~140B~~ | ~~150B~~ | ~~160B~~ |
| | | — | — | ~~110C~~ | ~~119C~~ | ~~127C~~ | ~~136C~~ |
| | | — | — | — | ~~110D~~ | ~~117D~~ | ~~125D~~ |
| ~~12~~ | ~~12~~ | | | | | | ~~6~~ |
| ~~12~~ | ~~24~~ | | | | | ~~6~~ | ~~6~~ |
| ~~16~~ | ~~16~~ | | | | | ~~6~~ | ~~6A~~ |
| ~~16~~ | ~~32~~ | | | | ~~6~~ | ~~6~~ | ~~6A~~ |
| ~~19.2~~ | ~~19.2~~ | | | | ~~6A~~ | ~~6A~~ | ~~6B~~ |
| ~~19.2~~ | ~~38.4~~ | | | ~~6~~ | ~~6A~~ | ~~6A~~ | ~~6B~~ |
| ~~24~~ | ~~24~~ | | | ~~6A~~ | ~~6B~~ | ~~6B~~ | ~~6B~~ |

~~For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.~~

~~a. This table is for use with the detail in Figure R608.9(7). Use of this detail is permitted where a cell is not shaded.~~

~~b. Wall design per other provisions of Section R608 is required.~~

~~c. For wind design, minimum 4-inch nominal wall is permitted in unshaded cells that do not contain a number.~~

~~d. Number 6 indicates minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross hatching in Figure R608.9(7). For the remainder of the wall, see Note b.~~

~~e. Letter "A" indicates that a minimum nominal 3 × 6 sill plate is required. Letter "B" indicates that a $^5/_8$-inch-diameter anchor bolt and a minimum nominal 3 × 6 sill plate are required.~~

**~~TABLE R608.9(8)~~**

**~~COLD-FORMED STEEL-FRAMED FLOOR TO TOP OF CONCRETE WALL, FRAMING PARALLEL~~[a, b, c, d, e]**

| ~~ANCHOR BOLT SPACING (inches)~~ | ~~TENSION TIE SPACING (inches)~~ | ~~BASIC WIND SPEED AND WIND EXPOSURE CATEGORY (mph)~~ | | | | | |
|---|---|---|---|---|---|---|---|
| | | ~~115B~~ | ~~120B~~ | ~~130B~~ | ~~140B~~ | ~~150B~~ | ~~160B~~ |
| | | — | — | ~~110C~~ | ~~119C~~ | ~~127C~~ | ~~136C~~ |
| | | — | — | — | ~~110D~~ | ~~117D~~ | ~~125D~~ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ~~12~~ | ~~12~~ | | | | | | ~~6~~ |
| ~~12~~ | ~~24~~ | | | | | ~~6~~ | ~~6~~ |
| ~~16~~ | ~~16~~ | | | | | ~~6~~ | ~~6A~~ |
| ~~16~~ | ~~32~~ | | | | ~~6~~ | ~~6~~ | ~~6A~~ |
| ~~19.2~~ | ~~19.2~~ | | | | ~~6A~~ | ~~6A~~ | ~~6B~~ |
| ~~19.2~~ | ~~38.4~~ | | | ~~6~~ | ~~6A~~ | ~~6A~~ | ~~6B~~ |
| ~~24~~ | ~~24~~ | | | ~~6A~~ | ~~6B~~ | ~~6B~~ | ~~6B~~ |

~~For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.~~

~~a. This table is for use with the detail in Figure R608.9(8). Use of this detail is permitted where a cell is not shaded.~~

~~b. Wall design per other provisions of Section R608 is required.~~

~~c. For wind design, minimum 4-inch-nominal wall is permitted in unshaded cells that do not contain a number.~~

~~d. Number 6 indicates minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross hatching in Figure R608.9(8). For the remainder of the wall, see Note b.~~

~~e. Letter "A" indicates that a minimum nominal 3 × 6 sill plate is required. Letter "B" indicates that a $^5/_8$-inch diameter anchor bolt and a minimum nominal 3 × 6 sill plate are required.~~

**TABLE R608.9(9)**

**WOOD-FRAMED ROOF TO TOP OF CONCRETE WALL, FRAMING PERPENDICULAR[a, b, c, d, e]**

| ANCHOR BOLT SPACING (inches) | TENSION TIE SPACING (inches) | BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY | | | | | |
|---|---|---|---|---|---|---|---|
| | | 115B | 120B | 130B | 140B | 150B | 160B |
| | | — | — | 110C | 119C | 127C | 136C |
| | | — | — | — | 110D | 117D | 125D |
| 12 | 12 | | | | | | 6 |
| 12 | 24 | | | | | | 6 |
| 12 | 36 | | | | | 6 | 6 |
| 12 | 48 | | | | 6 | 6 | 6 |
| 16 | 16 | | | | | 6 | 6 |
| 16 | 32 | | | | | 6 | 6 |
| 16 | 48 | | | | 6 | 6 | 6 |
| 19.2 | 19.2 | | | | | 6 | 6 |
| 19.2 | 38.4 | | | | 6 | 6 | |
| 24 | 24 | | | | 6 | | |
| 24 | 48 | | | 6 | 8B | | |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(9). Use of this detail is permitted where a cell is not shaded, and prohibited where shaded.

b. Wall design per other provisions of Section R608 is required.

c. For wind design, minimum 4-inch-nominal wall is permitted in unshaded cells that do not contain a number.

d. Numbers 6 and 8 indicate minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross hatching in Figure R608.9(9). For the remainder of the wall, see Note b.

e. Letter "B" indicates that a $^5/_8$-inch-diameter anchor bolt and a minimum nominal 3 × 6 sill plate are required.

**TABLE R608.9(10)**
**WOOD-FRAMED ROOF TO TOP OF CONCRETE WALL, FRAMING PARALLEL[a, b, c, d, e]**

| ANCHOR BOLT SPACING (inches) | TENSION TIE SPACING (inches) | BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY | | | | | |
|---|---|---|---|---|---|---|---|
| | | 115B | 120B | 130B | 140B | 150B | 160B |
| | | — | — | 110C | 119C | 127C | 136C |
| | | — | — | — | 110D | 117D | 125D |
| 12 | 12 | | | | | | 6 |
| 12 | 24 | | | | | | 6 |
| 12 | 36 | | | | | 6 | 6 |
| 12 | 48 | | | | 6 | 6 | 6 |
| 16 | 16 | | | | | 6 | 6 |
| 16 | 32 | | | | | 6 | 6 |
| 16 | 48 | | | | 6 | 6 | 6 |
| 19.2 | 19.2 | | | | | 6 | 6 |
| 19.2 | 38.4 | | | | 6 | 6 | |
| 24 | 24 | | | | 6 | | |
| 24 | 48 | | | 6 | 8B | | |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(10). Use of this detail is permitted where a cell is not shaded, and prohibited where shaded.
b. Wall design per other provisions of Section R608 is required.
c. For wind design, minimum 4-inch-nominal wall is permitted in cells that do not contain a number.
d. Numbers 6 and 8 indicate minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross hatching in Figure R608.9(10). For the remainder of the wall, see Note b.
e. Letter "B" indicates that a $^5/_8$-inch-diameter anchor bolt and a minimum nominal 3 × 6 sill plate are required.

**TABLE R608.9(11)**
COLD-FORMED STEEL ROOF **TO TOP OF CONCRETE WALL, FRAMING PERPENDICULAR[a, b, c, d, e]**

| ANCHOR BOLT SPACING (inches) | TENSION TIE SPACING (inches) | BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY | | | | | |
|---|---|---|---|---|---|---|---|
| | | 115B | 120B | 130B | 140B | 150B | 160B |
| | | — | — | 110C | 119C | 127C | 136C |
| | | — | — | — | 110D | 117D | 125D |
| 12 | 12 | | | | | | 6 |
| 12 | 24 | | | | | | 6 |
| 16 | 16 | | | | | 6 | 6 |
| 16 | 32 | | | | | 6 | 6 |
| 19.2 | 19.2 | | | | | 6 | 6 |
| 19.2 | 38.4 | | | | 6 | 6 | 6 |
| 24 | 24 | | | | 6 | 6A | 6B |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(11). Use of this detail is permitted where a cell is not shaded.

b. Wall design per other provisions of Section R608 is required.

c. For wind design, minimum 4-inch-nominal wall is permitted in unshaded cells that do not contain a number.

d. Number 6 indicates minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross hatching in Figure R608.9(11). For the remainder of the wall, see Note b.

e. Letter "A" indicates that a minimum nominal 3 × 6 sill plate is required. Letter "B" indicates that a $^5/_8$-inch-diameter anchor bolt and a minimum nominal 3 × 6 sill plate are required.

**TABLE R608.9(12)**
**COLD-FORMED STEEL ROOF TO TOP OF CONCRETE WALL, FRAMING PARALLEL[a, b, c, d, e]**

| ANCHOR BOLT SPACING (inches) | TENSION TIE SPACING (inches) | BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY | | | | | |
|---|---|---|---|---|---|---|---|
| | | 115B | 120B | 130B | 140B | 150B | 160B |
| | | — | — | 110C | 119C | 127C | 136C |
| | | — | — | — | 110D | 117D | 125D |
| 12 | 12 | | | | | | 6 |
| 12 | 24 | | | | | | 6 |
| 16 | 16 | | | | | 6 | 6 |
| 16 | 32 | | | | | 6 | 6 |
| 19.2 | 19.2 | | | | | 6 | 6 |
| 19.2 | 38.4 | | | | 6 | 6 | 6 |
| 24 | 24 | | | | 6 | 6 | 6B |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(12). Use of this detail is permitted where a cell is not shaded.

b. Wall design per other provisions of Section R608 is required.

c. For wind design, minimum 4-inch-nominal wall is permitted in cells that do not contain a number.

d. Number 6 indicates minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross hatching in Figure R608.9(12). For the remainder of the wall, see Note b.

e. Letter "B" indicates that a $^5/_8$-inch-diameter anchor bolt is required.

**R608.9.1.2 Removal of stay-in-place form material at bolts.** Holes in stay-in-place forms for installing bolts for attaching face-mounted wood ledger boards to the wall shall be not less than 4 inches (102 mm) in diameter for forms not greater than $1^1/_2$ inches (38 mm) in thickness, and increased 1 inch (25 mm) in diameter for each $^1/_2$-inch (12.7 mm) increase in form thickness. Holes in stay-in-place forms for installing bolts for attaching face-mounted cold-formed steel tracks to the wall shall be not less than 4 inches (102 mm) square. The wood ledger board or steel track shall be in direct contact with the concrete at each bolt location.

**Exception:** A vapor retarder or other material less than or equal to $^1/_{16}$ inch (1.6 mm) in thickness is permitted to be installed between the wood ledger or cold-formed track and the concrete.

**R608.9.2 Connections between concrete walls and light-frame floor systems.** Connections between concrete walls and light-frame floor systems shall be in accordance with one of the following:

1. For floor systems of wood-framed construction, the provisions of Section R608.9.1 and the prescriptive details of Figures R608.9(1) through R608.9(4), where permitted by the tables accompanying those figures. Portions of connections of wood-framed floor systems not noted in the figures shall be in accordance with Section R502, or AWC WFCM, if applicable. Wood framing members shall be of a species having a specific gravity equal to or greater than 0.42.
2. Deleted. ~~For floor systems of cold-formed steel construction, the provisions of Section R608.9.1 and the prescriptive details of Figures R608.9(5) through R608.9(8), where permitted by the tables accompanying~~

~~those figures. Portions of connections of cold-formed steel-framed floor systems not noted in the figures shall be in accordance with Section R505, or AISI S230, if applicable.~~

3. Proprietary connectors selected to resist loads and load combinations in accordance with Appendix A (ASD) or Appendix B (LRFD) of PCA 100.
4. An engineered design using loads and load combinations in accordance with Appendix A (ASD) or Appendix B (LRFD) of PCA 100.
5. An engineered design using loads and material design provisions in accordance with this code, or in accordance with ASCE 7, ACI 318, and AWC NDS for wood-framed construction.

**R608.9.3 Connections between concrete walls and light-frame ceiling and roof systems.** Connections between concrete walls and light-frame ceiling and roof systems shall be in accordance with one of the following:

1. For ceiling and roof systems of wood-framed construction, the provisions of Section R608.9.1 and the prescriptive details of Figures R608.9(9) and R608.9(10), where permitted by the tables accompanying those figures. Portions of connections of wood-framed ceiling and roof systems not noted in the figures shall be in accordance with Section R802, or AWC WFCM, if applicable. Wood framing members shall be of a species having a specific gravity equal to or greater than 0.42.
2. Deleted.
3. Proprietary connectors selected to resist loads and load combinations in accordance with Appendix A (ASD) or Appendix B (LRFD) of PCA 100.
4. An engineered design using loads and load combinations in accordance with Appendix A (ASD) or Appendix B (LRFD) of PCA 100.
5. An engineered design using loads and material design provisions in accordance with this code, or in accordance with ASCE 7, ACI 318, and AWC NDS for wood-framed construction. ~~or AISI S100 for cold-formed steel-framed construction.~~

**R608.10 Floor, roof and ceiling diaphragms.** Floors and roofs in buildings with exterior walls of concrete shall be designed and constructed as diaphragms. Where gable-end walls occur, ceilings shall be designed and constructed as diaphragms. The design and construction of floors, roofs and ceilings of wood framing or cold-formed-steel framing serving as diaphragms shall comply with the applicable requirements of this code, or AWC WFCM ~~or AISI S230~~, if applicable. Wood framing members shall be of a species having a specific gravity equal to or greater than 0.42.

## SECTION R609
## EXTERIOR WINDOWS AND DOORS

**R609.1 General.** This section prescribes performance and construction requirements for exterior windows and doors installed in walls. Windows and doors shall be installed in accordance with the fenestration manufacturer's written instructions. Window and door openings shall be flashed in accordance with Section R703.4. Written installation instructions shall be provided by the fenestration manufacturer for each window or door.

**R609.2 Performance.** Exterior windows and doors shall be capable of resisting the design wind loads specified in Table R301.2.1(1) adjusted for height and exposure in accordance with Table R301.2.1(2) or determined in accordance with ASCE 7 using the allowable stress design load combinations of ASCE 7. For exterior windows and doors tested in accordance with Sections R609.3 and R609.5, required design wind pressures determined from ASCE 7 using the ultimate strength design (USD) are permitted to be multiplied by 0.6. Design wind loads for exterior glazing not part of a labeled assembly shall be permitted to be determined in accordance with Chapter 24 of the *International Building Code*. Design wind loads for exterior glazing not part of a labeled assembly shall be permitted to be determined in accordance with Chapter 24 of the *International Building Code*.

> **Exception:** Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall not be required to be protected provided the spaces are separated from the building interior by a wall and all openings in the wall separating the unit from the balcony, deck or porch are protected in accordance with this section. Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state "Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s)." Decals shall be placed such that the decal is visible when the panel is installed.

**R609.3 Testing and labeling.** Exterior windows and sliding doors shall be tested by an *approved* independent laboratory, and bear a *label* identifying manufacturer, performance characteristics and *approved* inspection agency to indicate compliance with AAMA/WDMA/CSA 101/I.S.2/A440. Exterior side-hinged doors shall be tested and *labeled* as conforming to AAMA/WDMA/CSA 101/I.S.2/A440 or AMD 100, or comply with Section R609.5.

**Exception:** Decorative glazed openings.

**R609.3.1 Comparative analysis.** Structural wind load design pressures for window and door units different than the size tested in accordance with Section R609.3 shall be permitted to be different than the design value of the tested unit where determined in accordance with one of the following comparative analysis methods:

1. Structural wind load design pressures for window and door units smaller than the size tested in accordance with Section R609.3 shall be permitted to be higher than the design value of the tested unit provided such higher pressures are determined by accepted engineering analysis. Components of the smaller unit shall be the same as those of the tested unit. Where such calculated design pressures are used, they shall be validated by an additional test of the window or door unit having the highest allowable design pressure.
2. In accordance with WDMA I.S.11.

**R609.4 Garage doors.** Garage doors shall be tested in accordance with either ASTM E330 or ANSI/DASMA 108, and shall meet the pass/fail criteria of ANSI/DASMA 108.

**R609.4.1 Garage door labeling.** Garage doors shall be *labeled* with a permanent *label* provided by the garage door manufacturer. The *label* shall identify the garage door manufacturer, the garage door model/series number, the positive and negative design wind pressure rating, the installation instruction drawing reference number, and the applicable test standard.

**R609.5 Other exterior window and door assemblies.** Exterior windows and door assemblies not included within the scope of Section R609.3 or R609.4 shall be tested in accordance with ASTM E330. Glass in assemblies covered by this section shall comply with Section R308.5.

**R609.6 Windborne debris protection.** Protection of exterior windows, glass doors and doors with glass in buildings located in *windborne debris regions* shall be in accordance with Section R301.2.1.2.

**R609.6.1 Fenestration testing and labeling.** *Fenestration* shall be tested by an *approved* independent laboratory, *listed* by an *approved* entity, and bear a *label* identifying the manufacturer, performance characteristics and an *approved* inspection agency to indicate compliance with the requirements of the following specification(s):

1. ASTM E1886 and ASTM E1996; or
2. AAMA 506.

**R609.6.2 Impact protective systems testing and labeling.** *Impact protective systems* shall be tested for impact resistance by an *approved* independent laboratory for compliance with ASTM E1886 and ASTM E1996. *Impact protective systems* shall be tested for design wind pressure by an *approved* independent laboratory for compliance with ASTM E330. Required design wind pressures shall be determined in accordance with Table R301.2.1(1), adjusted for height and exposure in accordance with Table R301.2.1(2) or determined in accordance with ASCE 7. For the purposes of this section, design wind pressures determined in accordance with ASCE 7 are permitted to be multiplied by 0.6.

*Impact protective systems* bear a *label* identifying the manufacturer, performance characteristics and an *approved* inspection agency. *Impact protective systems* shall have a permanent *label* providing traceability to the manufacturer, product designation and performance characteristics. The permanent *label* shall be acid etched, sand blasted, ceramic fired, laser etched, embossed or of a type that, once applied, cannot be removed without being destroyed.

**R609.7 Anchorage methods.** The methods cited in this section apply only to anchorage of window and glass door assemblies to the main force-resisting system.

**R609.7.1 Anchoring requirements.** Window and glass door assemblies shall be anchored in accordance with the published manufacturer's recommendations to achieve the design pressure specified. Substitute anchoring systems used for substrates not specified by the fenestration manufacturer shall provide equal or greater anchoring performance as demonstrated by accepted engineering practice.

**R609.7.2 Anchorage details.** Products shall be anchored in accordance with the minimum requirements illustrated in Figures R609.7.2(1), R609.7.2(2), R609.7.2(3), R609.7.2(4), R609.7.2(5), R609.7.2(6), R609.7.2(7) and R609.7.2(8).


**FIGURE R609.7.2(1)**
**THROUGH THE FRAME**

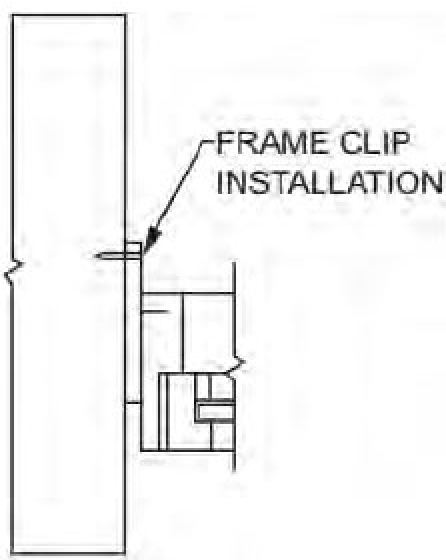


**FIGURE R609.7.2(2)**
**FRAME CLIP**

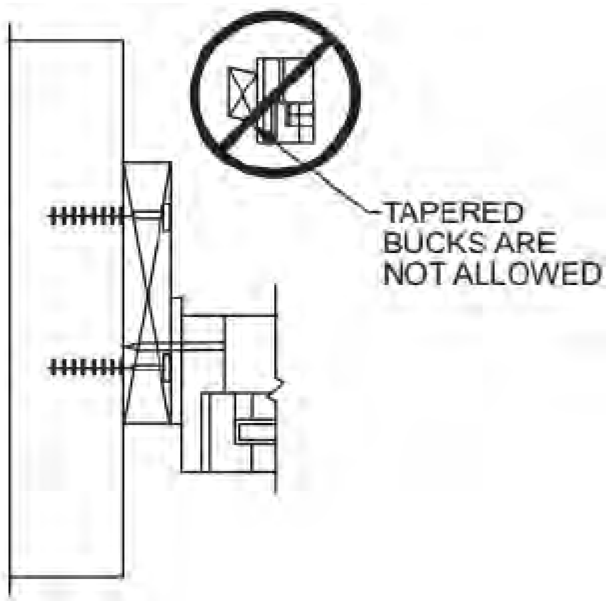



**FIGURE R609.7.2(3)**
**THROUGH THE FRAME**

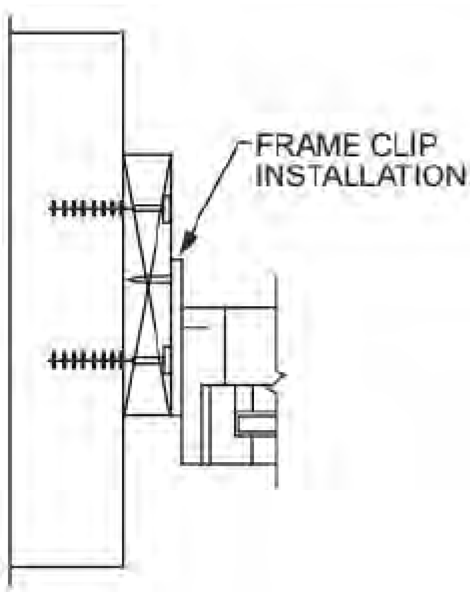



**FIGURE R609.7.2(4)**
**FRAME CLIP**

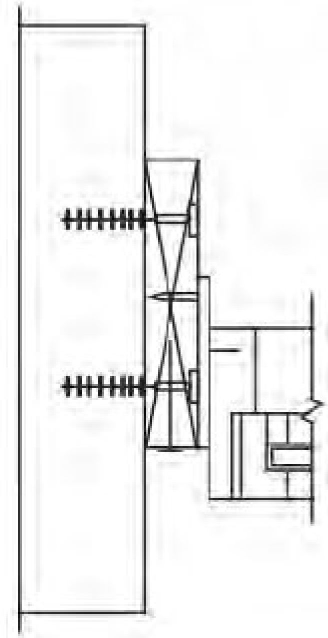


**FIGURE R609.7.2(5)**
**THROUGH THE FLANGE**

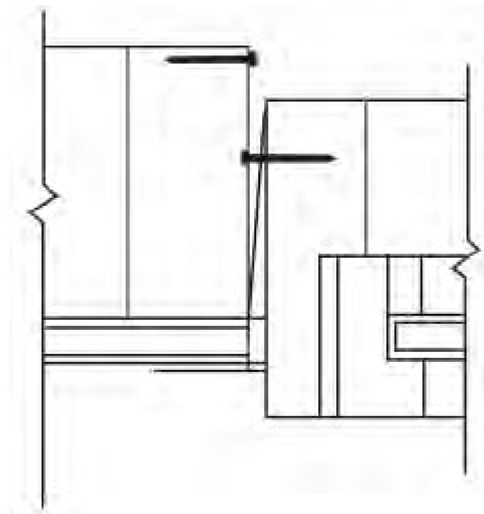


**FIGURE R609.7.2(7)**
**FRAME CLIP**

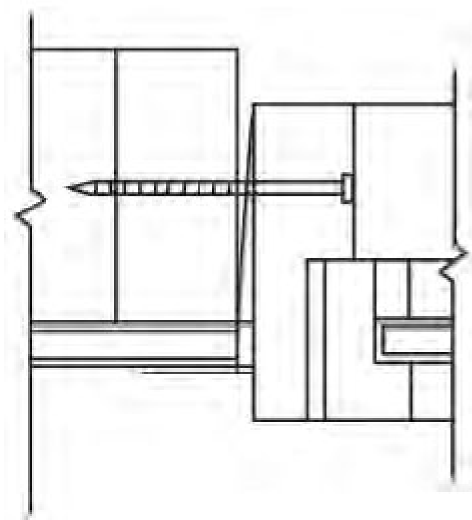


**FIGURE R609.7.2(6)**
**THROUGH THE FLANGE**

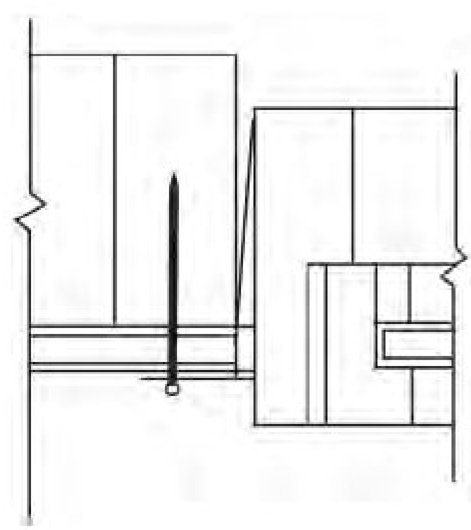


**FIGURE R609.7.2(8)**
**THROUGH THE FLANGE**

**R609.7.2.1 Masonry, concrete or other structural substrate.** Where the wood shim or buck thickness is less than $1^{1}/_{2}$ inches (38 mm), window and glass door assemblies shall be anchored through the jamb, or by jamb clip and anchors shall be embedded directly into the masonry, concrete or other substantial substrate material. Anchors shall adequately transfer load from the window or door frame into the rough opening substrate [see Figures R609.7.2(1) and R609.7.2(2)].

Where the wood shim or buck thickness is $1^{1}/_{2}$ inches (38 mm) or more, the buck is securely fastened to the masonry, concrete or other substantial substrate, and the buck extends beyond the interior face of the window or door frame, window and glass door assemblies shall be anchored through the jamb, or by jamb clip, or through the flange to the secured wood buck. Anchors shall be embedded into the secured wood buck to adequately transfer load from the window or door frame assembly [see Figures R609.7.2(3), R609.7.2(4) and R609.7.2(5)].

**R609.7.2.2 Wood or other approved framing material.** Where the framing material is wood or other *approved* framing material, window and glass door assemblies shall be anchored through the frame, or by frame clip, or through the flange. Anchors shall be embedded into the frame construction to adequately transfer load [see Figures R609.7.2(6), R609.7.2(7) and R609.7.2(8)].

**R609.8 Mullions.** Mullions shall be tested by an *approved* testing laboratory in accordance with AAMA 450, or be engineered in accordance with accepted engineering practice. Mullions tested as stand-alone units or qualified by engineering shall use performance criteria cited in Sections R609.8.1, R609.8.2 and R609.8.3. Mullions qualified by an actual test of an entire assembly shall comply with Sections R609.8.1 and R609.8.3.

**R609.8.1 Load transfer.** Mullions shall be designed to transfer the design pressure loads applied by the window and door assemblies to the rough opening substrate.

**R609.8.2 Deflection.** Mullions shall be capable of resisting the design pressure loads applied by the window and door assemblies to be supported without deflecting more than $L/175$, where $L$ is the span of the mullion in inches.

**R609.8.3 Structural safety factor.** Mullions shall be capable of resisting a load of 1.5 times the design pressure loads applied by the window and door assemblies to be supported without exceeding the appropriate material stress levels. If tested by an *approved* laboratory, the 1.5 times the design pressure load shall be sustained for 10 seconds, and the permanent deformation shall not exceed 0.4 percent of the mullion span after the 1.5 times design pressure load is removed.

## SECTION R610 STRUCTURAL INSULATED PANEL WALL CONSTRUCTION

**R610.1 General.** Structural insulated panel (SIP) walls shall be designed in accordance with the provisions of this section. Where the provisions of this section are used to design *structural insulated panel* walls, project drawings, typical details and specifications are not required to bear the seal of the architect or engineer responsible for design, unless otherwise required by the state law of the *jurisdiction* having authority.

**R610.2 Applicability limits.** The provisions of this section shall control the construction of exterior *structural insulated panel* walls and interior load-bearing *structural insulated panel* walls for buildings not greater than 60 feet (18 288 mm) in length perpendicular to the joist or truss span, not greater than 40 feet (12 192 mm) in width parallel to the joist or truss span and not greater than two stories in height with each wall not greater than 10 feet (3048 mm) high. Exterior walls installed in accordance with the provisions of this section shall be considered as *load-bearing walls*. *Structural insulated panel* walls constructed in accordance with the provisions of this section shall be limited to sites where the ultimate design wind speed ($V_{ult}$) is not greater than 155 miles per hour (69 m/s) in Exposure B or 140 miles per hour (63 m/s) in Exposure C, the ground snow load is not greater than 70 pounds per square foot (3.35 kPa), and the seismic design category is A, B or C.

**R610.3 Materials.** SIPs shall comply with the requirements of ANSI/APA PRS 610.1.

**R610.3.1 Lumber.** The minimum lumber framing material used for SIPs prescribed in this document is NLGA graded No. 2 Spruce-pine-fir. Substitution of other wood species/grades that meet or exceed the mechanical properties and specific gravity of No. 2 Spruce-pine-fir shall be permitted.

**R610.3.2 SIP screws.** Screws used for the erection of SIPs as specified in Section R610.5 shall be fabricated from steel, shall be provided by the SIP manufacturer and shall be sized to penetrate the wood member to which the assembly is being attached by not less than 1 inch (25 mm). The screws shall be corrosion resistant and have a minimum shank diameter of 0.188 inch (4.7 mm) and a minimum head diameter of 0.620 inch (15.5 mm).

**R610.3.3 Nails.** Nails specified in Section R610 shall be common or galvanized box unless otherwise stated.

**R610.4 SIP wall panels.** SIPs shall comply with Figure R610.4 and shall have minimum *panel thickness* in accordance with Tables R610.5(1) and R610.5(2) for above-grade walls. SIPs shall be identified by grade *mark* or certificate of inspection issued by an *approved* agency in accordance with ANSI/APA PRS 610.1.

**R610.5 Wall construction.** Exterior walls of SIP construction shall be designed and constructed in accordance with the provisions of this section and Tables R610.5(1) and R610.5(2) and Figures R610.5(1) through R610.5(5). SIP walls shall be fastened to other wood building components in accordance with Tables R602.3(1) through R602.3(4).

Framing shall be attached in accordance with Table R602.3(1) unless otherwise provided for in Section R610.

**R610.5.1 Top plate connection.** SIP walls shall be capped with a double top plate installed to provide overlapping at corner, intersections and *splines* in accordance with Figure R610.5.1. The double top plates shall be made up of a single 2-by (nominal 2-inch) top plate having a width equal to the width of the panel core, and shall be recessed into the SIP below. Over this top plate a cap plate shall be placed. The cap plate width shall match the SIP thickness and overlap the facers on both sides of the panel. End joints in top plates shall be offset not less than 24 inches (610 mm).

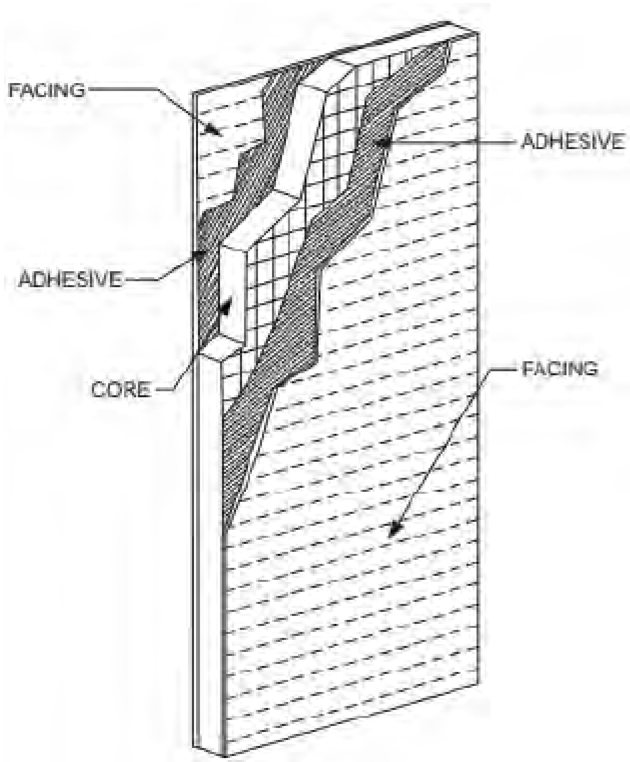
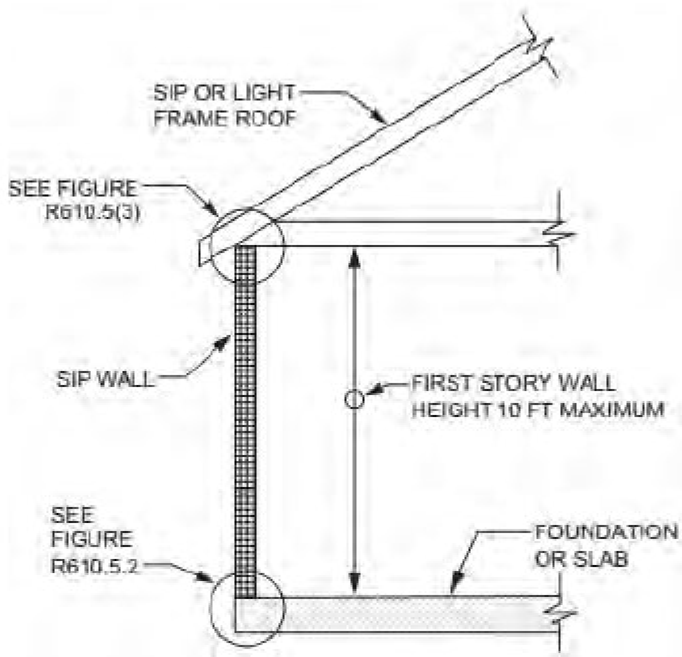


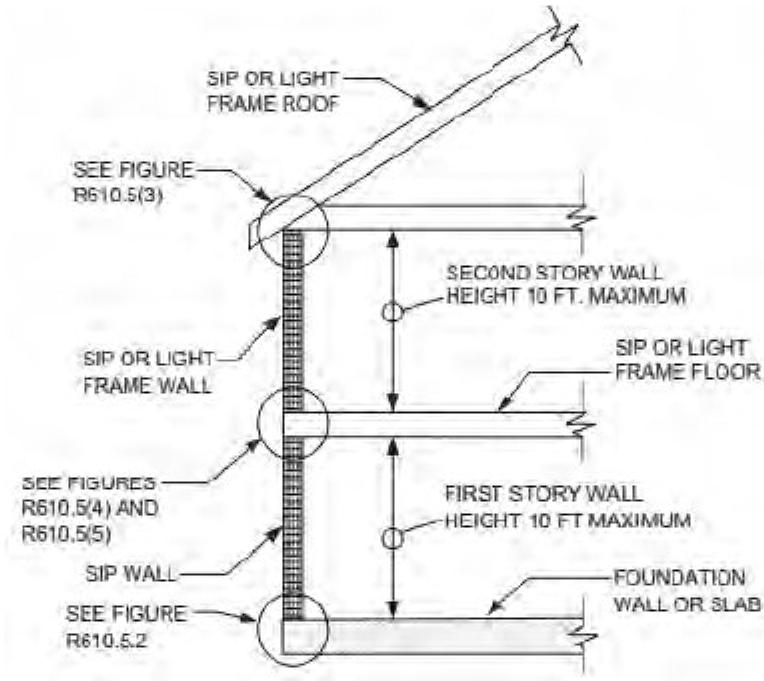

**FIGURE R610.4**
**SIP WALL PANEL**




For SI: 1 foot = 304.8 mm.

**Note:** Figure illustrates SIP-specific attachment requirements. Other connections shall be made in accordance with **Tables R602.3(1)** and **R602.3(2)**, as appropriate.

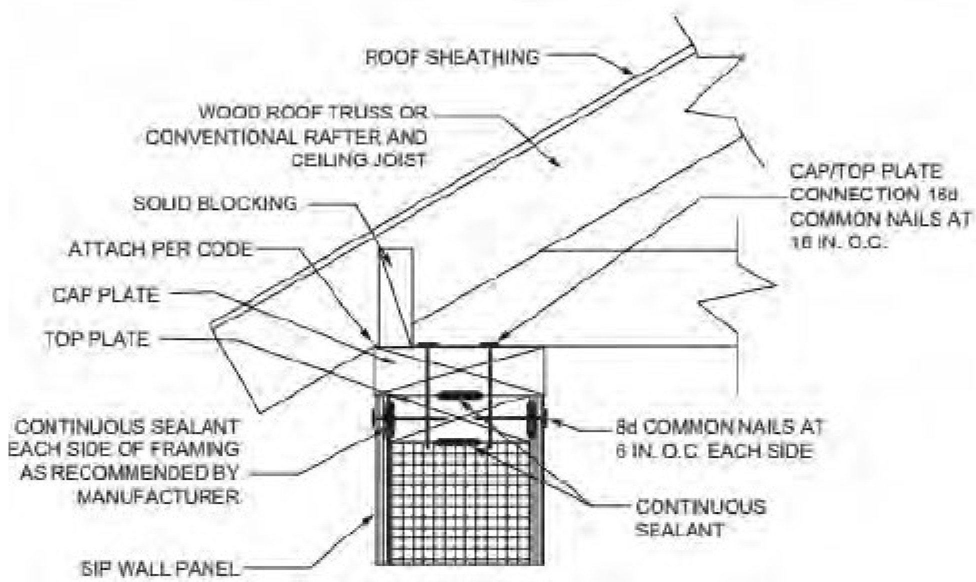
**FIGURE R610.5(1)**
**MAXIMUM ALLOWABLE HEIGHT OF SIP WALLS**




For SI: 1 foot = 304.8 mm.

**Note:** Figure illustrates SIP-specific attachment requirements. Other connections shall be made in accordance with **Tables R602.3(1)** and **R602.3(2)**, as appropriate.

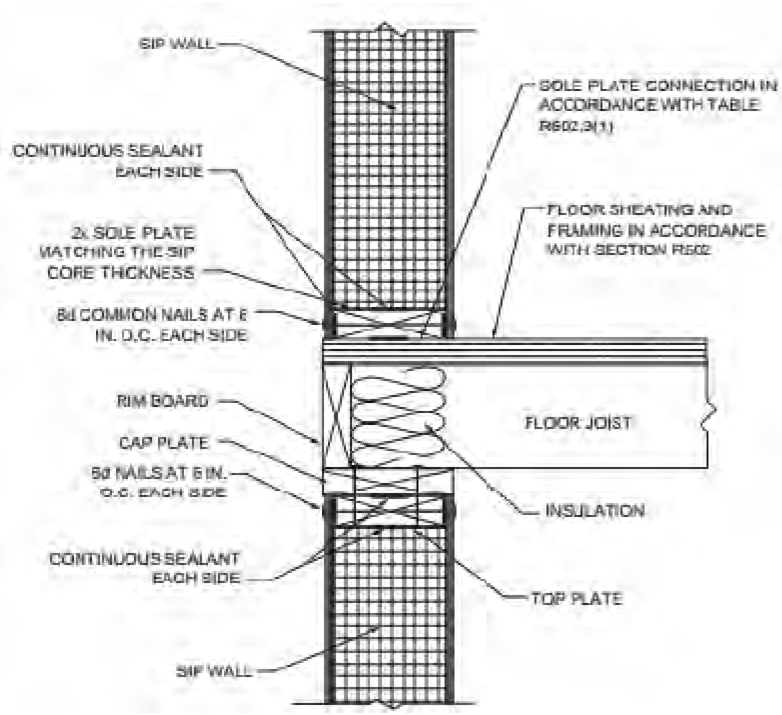
**FIGURE R610.5(2)**
**MAXIMUM ALLOWABLE HEIGHT OF SIP WALLS**




For SI: 1 inch = 25.4 mm.

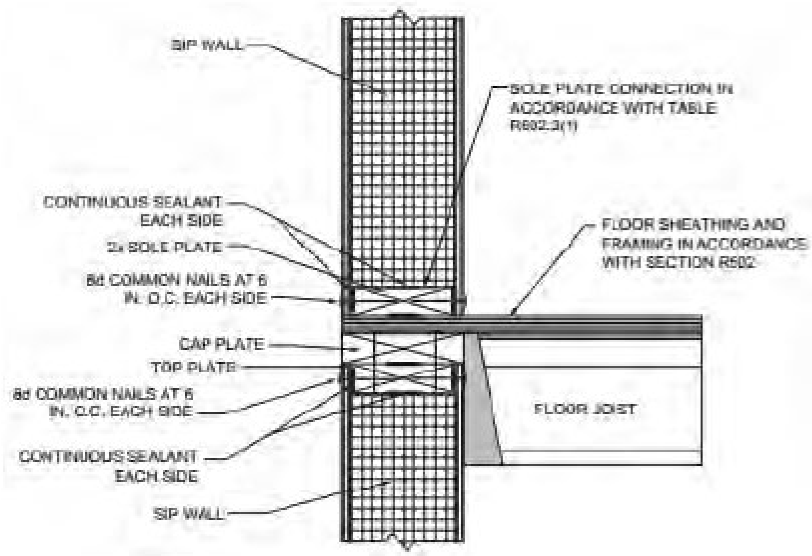
**Note:** Figure illustrates SIP-specific attachment requirements. Other connections

**FIGURE R610.5(3)**
**TRUSSED ROOF TO TOP PLATE CONNECTION**




For SI: 1 inch = 25.4 mm.
**Note:** Figure illustrates SIP-specific attachment requirements. Other connections shall be made in accordance with **Tables R602.3(1)** and **R602.3(2)**, as appropriate.

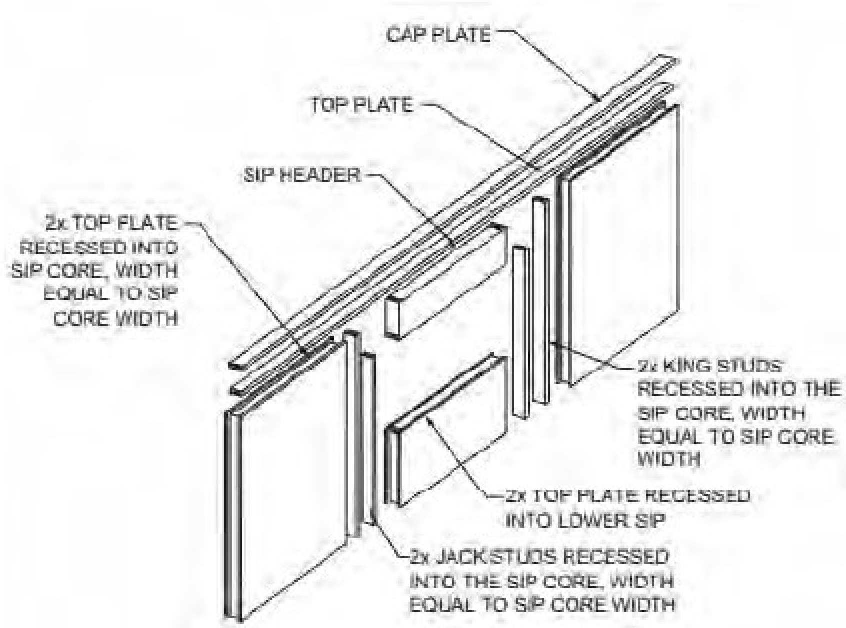
**FIGURE R610.5(4)**
**SIP WALL-TO-WALL PLATFORM FRAME CONNECTION**




For SI: 1 inch = 25.4 mm.

**Note:** Figure illustrates SIP-specific attachment requirements. Other connections shall be made in accordance with **Tables R602.3(1)** and **R602.3(2)**, as appropriate.

**FIGURE R610.5(5)**
**SIP WALL-TO-WALL HANGING FLOOR FRAME CONNECTION (I-Joist floor shown for Illustration only)**

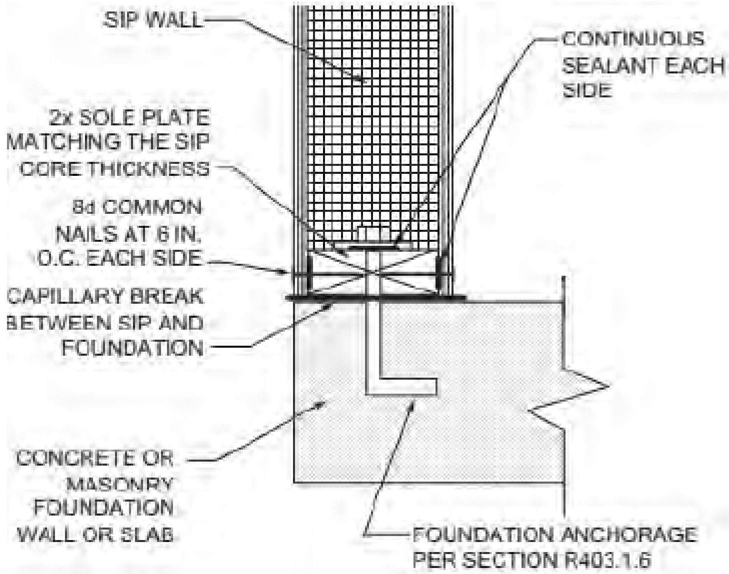



For SI: 1 inch = 25.4 mm.

**Notes:**

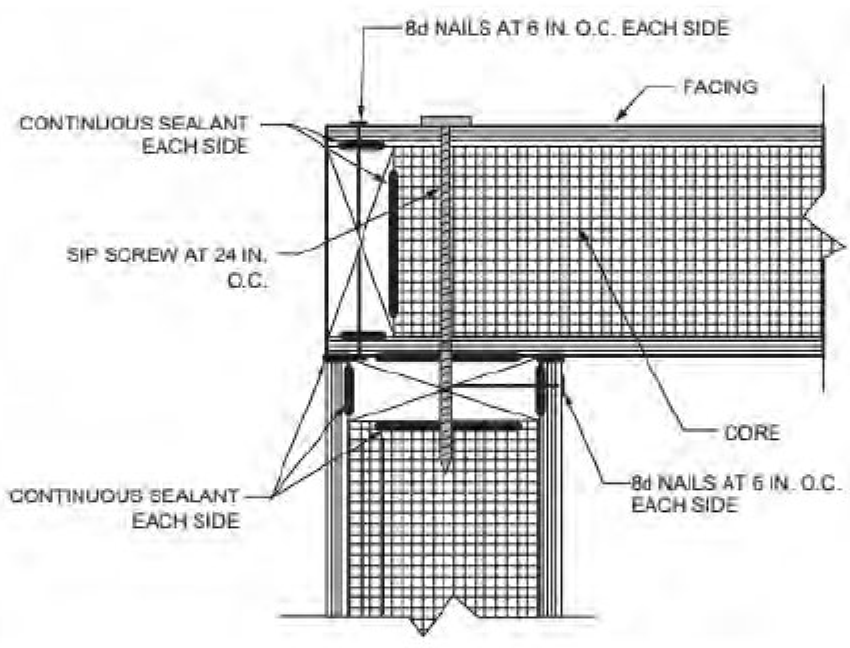
1. Top plates shall be continuous over header.
2. Lower 2x top plate shall have a width equal to the SIP core width and shall be recessed into the top edge of the panel. Cap plate shall be placed over the recessed top plate and shall have a width equal to the SIP's width.
3. SIP facing surfaces shall be nailed to framing and cripples with 8d common or galvanized box nails spaced 6 inches on center.

**FIGURE R610.5.1**
**SIP WALL FRAMING CONFIGURATION**




For SI: 1 inch = 25.4 mm.

**FIGURE R610.5.2**
**SIP WALL TO CONCRETE SLAB FOR FOUNDATION WALL ATTACHMENT**




For SI: 1 inch = 25.4 mm.

**FIGURE R610.5.4**
**SIP CORNER FRAMING DETAIL**

**TABLE R610.5(1)**
**MINIMUM THICKNESS FOR SIP WALL SUPPORTING SIP OR LIGHT-FRAME ROOF ONLY (inches)[a]**

| BUILDING WIDTH (ft) |
|---|

| ULTIMATE DESIGN WIND SPEED $V_{ult}$ (mph) | | GROUND SNOW LOAD (psf) | 24 | | | 28 | | | 32 | | | 36 | | | 40 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Wall Height (feet) | | | Wall Height (feet) | | | Wall Height (feet) | | | Wall Height (feet) | | | Wall Height (feet) | | |
| Exp. B | Exp. C | | 8 | 9 | 10 | 8 | 9 | 10 | 8 | 9 | 10 | 8 | 9 | 10 | 8 | 9 | 10 |
| 110 | — | 20 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| | | 30 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| | | 50 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| | | 70 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | 6.5 |
| 115 | — | 20 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| | | 30 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| | | 50 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 6.5 |
| | | 70 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | DR | 4.5 | 4.5 | DR |
| 130 | 110 | 20 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | DR | 4.5 | 4.5 | DR |
| | | 30 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | DR | 4.5 | 4.5 | DR | 4.5 | 4.5 | DR |
| | | 50 | 4.5 | 4.5 | DR | 4.5 | 4.5 | DR | 4.5 | 4.5 | DR | 4.5 | 6.5 | DR | 4.5 | DR | DR |
| | | 70 | 4.5 | 4.5 | DR | 4.5 | DR | DR | 4.5 | DR | DR | 4.5 | DR | DR | DR | DR | DR |
| 140 | 120 | 20 | 4.5 | 6.5 | DR | 4.5 | 6.5 | DR | 4.5 | DR | DR | 4.5 | DR | DR | 4.5 | DR | DR |
| | | 30 | 4.5 | 6.5 | DR | 4.5 | DR | DR | 4.5 | DR | DR | 4.5 | DR | DR | 4.5 | DR | DR |
| | | 50 | 4.5 | DR | DR | 4.5 | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | | 70 | 4.5 | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 mile per hour = 0.447 m/s.
DR = Design Required.

a. Design assumptions:
Maximum deflection criteria: L/240.
Maximum roof dead load: 10 psf.
Maximum roof live load: 70 psf.
Maximum ceiling dead load: 5 psf.
Maximum ceiling live load: 20 psf.
Wind loads based on Table R301.2.1(1).
Strength axis of facing material applied vertically.

**R610.5.2 Bottom (sole) plate connection.** SIP walls shall have full bearing on a sole plate having a width equal to the nominal width of the foam core. Where SIP walls are supported directly on continuous foundations, the wall wood sill plate shall be anchored to the foundation in accordance with Figure R610.5.2 and Section R403.1.

**TABLE R610.5(2)**
**MINIMUM THICKNESS FOR SIP WALL SUPPORTING SIP OR LIGHT-FRAME ONE STORY AND ROOF ONLY (inches)[a]**

| BUILDING WIDTH (ft) | | | | | | |
|---|---|---|---|---|---|---|
| ULTIMATE DESIGN WIND SPEED $V_{ult}$ (mph) | GROUND SNOW LOAD (psf) | 24 | 28 | 32 | 36 | 40 |

| Exp. B | Exp. C | | Wall Height (feet) | | | Wall Height (feet) | | | Wall Height (feet) | | | Wall Height (feet) | | | Wall Height (feet) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 8 | 9 | 10 | 8 | 9 | 10 | 8 | 9 | 10 | 8 | 9 | 10 | 8 | 9 | 10 |
| 110 | — | 20 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | DR | 4.5 | 4.5 | DR |
| | | 30 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | DR | 4.5 | 6.5 | DR |
| | | 50 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | DR | 4.5 | DR | DR | DR | DR | DR |
| | | 70 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | DR | 4.5 | DR | DR | DR | DR | DR | DR | DR | DR |
| 115 | — | 20 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | DR | 4.5 | 4.5 | DR | 4.5 | DR | DR |
| | | 30 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | DR | 4.5 | 6.5 | DR | 4.5 | DR | DR |
| | | 50 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | DR | 4.5 | DR | DR | 4.5 | DR | DR | DR | DR | DR |
| | | 70 | 4.5 | 4.5 | DR | 4.5 | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| 120 | — | 20 | 4.5 | 4.5 | 6.5 | 4.5 | 4.5 | DR | 4.5 | 4.5 | DR | 4.5 | DR | DR | 4.5 | DR | DR |
| | | 30 | 4.5 | 4.5 | DR | 4.5 | 4.5 | DR | 4.5 | 6.5 | DR | 4.5 | DR | DR | DR | DR | DR |
| | | 50 | 4.5 | 4.5 | DR | 4.5 | DR | DR | 4.5 | DR | DR | DR | DR | DR | DR | DR | DR |
| | | 70 | 4.5 | DR | DR | 4.5 | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| 130 | 110 | 20 | 4.5 | 6.5 | DR | 4.5 | DR | DR | 4.5 | DR | DR | DR | DR | DR | DR | DR | DR |
| | | 30 | 4.5 | DR | DR | 4.5 | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | | 50 | 4.5 | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR |
| | | 70 | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR | DR |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 mile per hour = 0.447 m/s.
DR = Design Required.

a. Design assumptions:
Maximum deflection criteria: L/240.
Maximum roof dead load: 10 psf.
Maximum roof live load: 70 psf.
Maximum ceiling dead load: 5 psf.
Maximum ceiling live load: 20 psf.
Maximum second-floor dead load: 10 psf.
Maximum second-floor live load: 30 psf.
Maximum second-floor dead load from walls: 10 psf.
Maximum first-floor dead load: 10 psf.
Maximum first-floor live load: 40 psf.
Wind loads based on Table R301.2.1(1).
Strength axis of facing material applied vertically.

**R610.5.3 Panel-to-panel connection.** SIPs shall be connected at vertical in-plane joints in accordance with Figure R610.8 or by other *approved* methods.

**R610.5.4 Corner framing.** Corner framing of SIP walls shall be constructed in accordance with Figure R610.5.4.

**R610.5.5 Wall bracing.** SIP walls shall be braced in accordance with Section R602.10. SIP walls shall be considered continuous wood structural panel sheathing (bracing Method CS-WSP) for purposes of computing required bracing. SIP walls shall meet the requirements of Section R602.10.4.2 except that SIP corners shall be fabricated as shown in Figure R610.8. Where SIP walls are used for wall bracing, the SIP bottom plate shall be attached to wood framing below in accordance with Table R602.3(1).

**R610.5.6 Thermal barrier.** SIP walls shall be separated from the interior of a building by an *approved* thermal barrier in accordance with Section R316.4.

**R610.6 Interior load-bearing walls.** Interior *load-bearing walls* shall be constructed as specified for exterior walls.

**R610.7 Drilling and notching.** The maximum vertical chase penetration in SIPs shall have a maximum side dimension of 2 inches (51 mm) centered in the panel. Vertical chases shall have a minimum spacing of 24 inches (610 mm) on center. Not more than two horizontal chases shall be permitted in each wall panel, one at 14 inches (360 mm) plus or minus 2 inches (51 mm) from the bottom of the panel and one at 48 inches (1220 mm) plus or minus 2 inches (51 mm) from the bottom edge of the SIP's panel. Additional penetrations are permitted where justified by analysis.

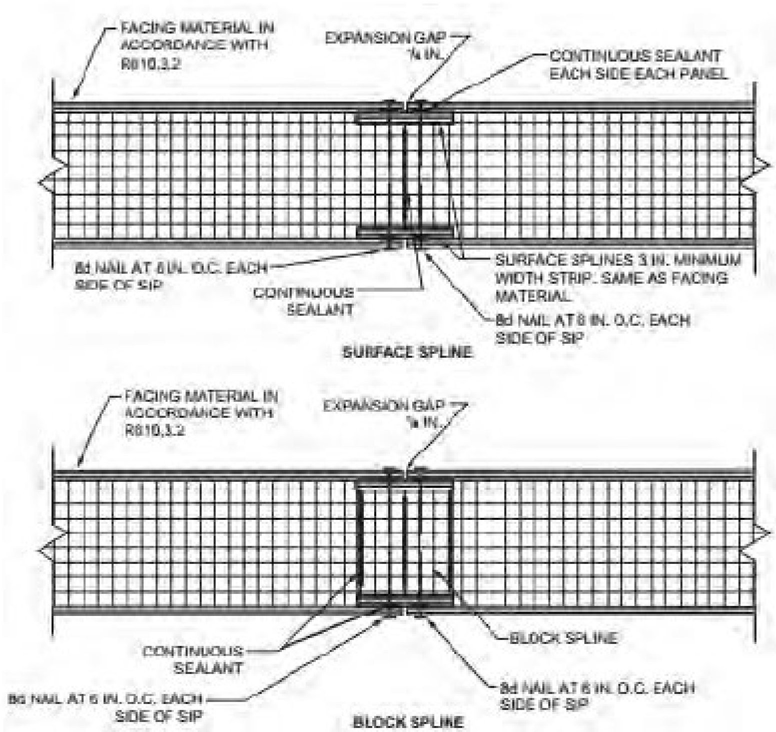
**R610.8 Headers.** SIP headers shall be designed and constructed in accordance with Table R610.8 and Figure R610.5.1. SIP headers shall be continuous sections without *splines*. Headers shall be not less than $11^{7}/_{8}$ inches (302 mm) deep. Headers longer than 4 feet (1219 mm) shall be constructed in accordance with Section R602.7. The strength axis of the factors on the header shall be oriented horizontally.

**R610.8.1 Wood structural panel box headers.** Wood structural panel box headers shall be allowed where SIP headers are not applicable. Wood structural panel box headers shall be constructed in accordance with Figure R602.7.3 and Table R602.7.3.

**TABLE R610.8**
**MAXIMUM SPANS FOR $11^{7}/_{8}$-INCH OR DEEPER SIP HEADERS (feet)[a, c, d]**

| LOAD CONDITION | GROUND SNOW LOAD (psf) | BUILDING[b] width (feet) | | | | |
|---|---|---|---|---|---|---|
| | | 24 | 28 | 32 | 36 | 40 |
| Supporting roof only | 20 | 4 | 4 | 4 | 4 | 2 |
| | 30 | 4 | 4 | 4 | 2 | 2 |
| | 50 | 2 | 2 | 2 | 2 | 2 |
| | 70 | 2 | 2 | 2 | DR | DR |
| Supporting roof and one-story | 20 | 2 | 2 | DR | DR | DR |
| | 30 | 2 | 2 | DR | DR | DR |
| | 50 | 2 | DR | DR | DR | DR |
| | 70 | DR | DR | DR | DR | DR |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
DR = Design Required.
a. Design assumptions:
Maximum deflection criterion: L/240.
Maximum roof dead load: 10 psf.
Maximum ceiling load: 5 psf.
Maximum ceiling live load: 20 psf
Maximum second-floor live load: 30 psf.
Maximum second-floor dead load: 10 psf.
Maximum second-floor dead load from walls: 10 psf.
Maximum first floor dead load: 10 psf.
Wind loads based on Table R301.2.1(1).
Strength axis of facing material applied horizontally.
b. Building width is in the direction of horizontal framing members supported by the header.
c. The table provides for roof slopes between 3:12 and 12:12.
d. The maximum roof overhang is 24 inches (610 mm).




For SI: 1 inch = 25.4 mm.

**FIGURE R610.8**
**TYPICAL SIP WALL PANEL-TO-PANEL CONNECTION DETAILS**

# CHAPTER 7
# WALL COVERING

## SECTION R701
## GENERAL

**R701.1 Application.** The provisions of this chapter shall control the design and construction of the interior and exterior wall covering for buildings.

**R701.2 Installation.** Products sensitive to adverse weather shall not be installed until adequate weather protection for the installation is provided. Exterior sheathing shall be dry before applying exterior cover.

## SECTION R702
## INTERIOR COVERING

**R702.1 General.** Interior coverings or wall finishes shall be installed in accordance with this chapter and Tables R702.1(1), R702.1(2), R702.1(3) and R702.3.5. Interior masonry veneer shall comply with the requirements of Section R703.8.1 for support and Section R703.8.4 for anchorage, except an airspace is not required. Interior finishes and materials shall conform to the flame spread and smoke-development requirements of Section R302.9.

**TABLE R702.1(1)**
**THICKNESS OF PLASTER**

| PLASTER BASE | FINISHED THICKNESS OF PLASTER FROM FACE OF LATH, MASONRY, CONCRETE (inches) | |
|---|---|---|
| | Gypsum Plaster | Cement Plaster |
| Expanded metal lath | $^{5}/_{8}$, minimum[a] | $^{5}/_{8}$, minimum[a] |
| Wire lath | $^{5}/_{8}$, minimum[a] | $^{3}/_{4}$, minimum (interior)[b] |
| | | $^{7}/_{8}$, minimum (exterior)[b] |
| Gypsum lath[g] | $^{1}/_{2}$, minimum | $^{3}/_{4}$, minimum (interior)[b] |
| Masonry walls[c] | $^{1}/_{2}$, minimum | $^{1}/_{2}$, minimum |
| Monolithic concrete walls[c, d] | $^{5}/_{8}$, maximum | $^{7}/_{8}$, maximum |
| Monolithic concrete ceilings[c, d] | $^{3}/_{8}$, maximum[e] | $^{1}/_{2}$, maximum |
| Gypsum veneer base[f, g] | $^{1}/_{16}$, minimum | $^{3}/_{4}$, minimum (interior)[b] |
| Gypsum sheathing[g] | — | $^{3}/_{4}$, minimum (interior)[b] |
| | | $^{7}/_{8}$, minimum (exterior)[b] |

For SI: 1 inch = 25.4 mm.
a. Where measured from back plane of expanded metal lath, exclusive of ribs, or self-furring lath, plaster thickness shall be $^{3}/_{4}$ inch minimum.
b. Where measured from face of support or backing.
c. Because masonry and concrete surfaces vary in plane, thickness of plaster need not be uniform.
d. Where applied over a liquid bonding agent, finish coat shall be permitted to be applied directly to concrete surface.
e. *Approved* acoustical plaster shall be permitted to be applied directly to concrete or over base coat plaster, beyond the maximum plaster thickness shown.
f. Attachment shall be in accordance with Table R702.3.5.
g. Where gypsum board is used as a base for cement plaster, a water-resistive barrier complying with Section R703.2 shall be provided.

## TABLE R702.1(2)
## GYPSUM PLASTER PROPORTIONS[a]

| NUMBER | COAT | PLASTER BASE OR LATH | MAXIMUM VOLUME AGGREGATE PER 100 POUNDS NEAT PLASTER[b] (cubic feet) | |
|---|---|---|---|---|
| | | | Damp Loose Sand[a] | Perlite or Vermiculite[c] |
| Two-coat work | Base coat | Gypsum lath | 2.5 | 2 |
| | Base coat | Masonry | 3 | 3 |
| Three-coat work | First coat | Lath | 2[d] | 2 |
| | Second coat | Lath | 3[d] | 2[e] |
| | First and second coats | Masonry | 3 | 3 |

For SI: 1 inch = 25.4 mm, 1 cubic foot = 0.0283 $m^3$, 1 pound = 0.454 kg.

a. Wood-fibered gypsum plaster shall be mixed in the proportions of 100 pounds of gypsum to not more than 1 cubic foot of sand where applied on masonry or concrete.

b. Where determining the amount of aggregate in set plaster, a tolerance of 10 percent shall be allowed.

c. Combinations of sand and lightweight aggregate shall be permitted to be used, provided the volume and weight relationship of the combined aggregate to gypsum plaster is maintained.

d. If used for both first and second coats, the volume of aggregate shall be permitted to be 2.5 cubic feet.

e. Where plaster is 1 inch or more in total thickness, the proportions for the second coat may be increased to 3 cubic feet.

## TABLE R702.1(3)
## CEMENT PLASTER PROPORTIONS, PARTS BY VOLUME

| COAT | CEMENT PLASTER TYPE | CEMENTITIOUS MATERIALS | | | | VOLUME OF AGGREGATE PER SUM OF SEPARATE VOLUMES OF CEMENTITIOUS MATERIALS[b] |
|---|---|---|---|---|---|---|
| | | Portland Cement Type I, II or III; Blended Hydraulic Cement Type IP, I (~~PM~~ S < 70),~~IS or I(SM)~~ IL, or IT (S < 70); or Hydraulic Cement Type GU, HE, MS, HS or MH | Plastic Cement | Masonry Cement Type M, S or N | Lime | |
| First | Portland or blended | 1 | — | — | $^3/_4$–$1^1/_2$[a] | $2^1/_2$–4 |
| | Masonry | — | — | 1 | — | $2^1/_2$–4 |
| | Plastic | — | 1 | — | — | $2^1/_2$–4 |
| Second | Portland or blended | 1 | — | — | $^3/_4$–$1^1/_2$ | 3–5 |
| | Masonry | — | — | 1 | — | 3–5 |
| | Plastic | — | 1 | — | — | 3–5 |
| Finish | Portland or blended | 1 | — | — | $1^1/_2$–2 | $1^1/_2$–3 |
| | Masonry | — | — | 1 | — | $1^1/_2$–3 |
| | Plastic | — | 1 | — | — | $1^1/_2$–3 |

a. Lime by volume of 0 to $^3/_4$ shall be used where the plaster will be placed over low-absorption surfaces such as dense clay tile or brick.

b. The same or greater sand proportion shall be used in the second coat than used in the first coat.

**R702.2 Interior plaster.**

**R702.2.1 Gypsum plaster.** Gypsum plaster materials shall conform to ASTM C5, C22, C28, C35, C59, C61, C587, C631, C847, C933, C1032 and C1047, and shall be installed or applied in compliance with ASTM C841, C842 and C843. Gypsum lath or gypsum base for veneer plaster shall conform to ASTM C1396 and shall be installed in compliance with ASTM C844. Plaster shall be not less than three coats where applied over metal lath and not less than two coats where applied over other bases permitted by this section, except that veneer plaster shall be applied in one coat not to exceed $^3/_{16}$ inch (4.76 mm) thickness, provided the total thickness is in accordance with Table R702.1(1).

**R702.2.2 Cement plaster.** Cement plaster materials shall conform to ASTM C91 (Type M, S or N), C150 (~~Type~~ Types I, II and III), C595 [~~Type~~ Types IP, I (PM), IS and I (SM)], C847, C897, C933, C1032, C1047 and C1328, and shall be installed or applied in compliance with ASTM C926 and C1063. Gypsum lath shall conform to ASTM C1396. Plaster shall be not less than three coats where applied over metal lath and not less than two coats where applied over other bases permitted by this section. ~~except that veneer plaster shall be applied in one coat not to exceed 3/16 inch (4.76 mm) thickness, provided the total thickness is in accordance with Table R702.1(1).~~

**R702.2.2.1 Application.** Each coat shall be kept in a moist condition for not less than 24 hours prior to application of the next coat.

**Exception:** Applications installed in accordance with ASTM C926.

**R702.2.2.2 Curing.** The finish coat for two-coat cement plaster shall not be applied sooner than 48 hours after application of the first coat. For three-coat cement plaster, the second coat shall not be applied sooner than 24 hours after application of the first coat. The finish coat for three-coat cement plaster shall not be applied sooner than 48 hours after application of the second coat.

**R702.2.3 Support.** Support spacing for gypsum or metal lath on walls or ceilings shall not exceed 16 inches (406 mm) for $^3/_8$-inch-thick (9.5 mm) or 24 inches (610 mm) for $^1/_2$-inch-thick (12.7 mm) plain gypsum lath. Gypsum lath shall be installed at right angles to support framing with end joints in adjacent courses staggered by not less than one framing space.

**R702.3 Gypsum board and gypsum panel products.**

**R702.3.1 Materials.** Gypsum board and gypsum panel product materials and accessories shall conform to ASTM C22, C475, C514, C1002, C1047, C1177, C1178, C1278, C1396, C1658 or C1766 and shall be installed in accordance with the provisions of this section. Adhesives for the installation of gypsum board and gypsum panel products shall conform to ASTM C557.

**R702.3.1.1 Adhesives.** Expandable foam adhesives for the installation of gypsum board and gypsum panel products shall conform to ASTM D6464. Other adhesives for the installation of gypsum board and gypsum panel products shall conform to ASTM C557. Supports and fasteners used to attach gypsum board and gypsum panel products shall comply with Table R702.3.5 or other *approved* method.

**R702.3.2 Wood framing.** Wood framing supporting gypsum board and gypsum panel products shall be not less than 2 inches (51 mm) nominal thickness in the least dimension except that wood furring strips not less than 1-inch by 2-inch (25 mm by 51 mm) nominal dimension shall be permitted to be used over solid backing or framing spaced not more than 24 inches (610 mm) on center.

**R702.3.3 Cold-formed steel framing.** Deleted.

**R702.3.4 Insulating concrete form walls.** Foam plastics for insulating concrete form walls constructed in accordance with Sections R404.1.2 and R608 on the interior of *habitable spaces* shall be protected in accordance with Section R316.4. Use of adhesives in conjunction with mechanical fasteners is permitted. Adhesives used for interior and exterior finishes shall be compatible with the insulating form materials.

**R702.3.5 Application.** Supports and fasteners used to attach gypsum board and gypsum panel products shall comply with Table R702.3.5. Gypsum sheathing shall be attached to exterior walls in accordance with Table R602.3(1). Gypsum board and gypsum panel products shall be applied at right angles or parallel to framing members. All edges and ends of gypsum board and gypsum panel products shall occur on the framing members, except those edges and ends that are perpendicular to the framing members. Interior gypsum board shall not be installed where it is directly exposed to the weather or to water.

**TABLE R702.3.5**

**MINIMUM THICKNESS AND APPLICATION OF GYPSUM BOARD AND GYPSUM PANEL PRODUCTS**

| THICKNESS OF GYPSUM BOARD OR GYPSUM PANEL PRODUCTS (inches) | APPLICATION | ORIENTATION OF GYPSUM BOARD OR GYPSUM PANEL PRODUCTS TO FRAMING | MAXIMUM SPACING OF FRAMING MEMBERS (inches o.c.) | MAXIMUM SPACING OF FASTENERS (inches) | | SIZE OF NAILS FOR APPLICATION TO WOOD FRAMING[c] |
|---|---|---|---|---|---|---|
| | | | | Nails[a] | Screws[b] | |
| **Application without adhesive** | | | | | | |
| $^3/_8$ | Ceiling[d] | Perpendicular | 16 | 7 | 12 | 13 gage, $1^1/_4$″ long, $^{19}/_{64}$″ head; 0.098″ diameter, $1^1/_4$″ long, ~~annular-ringed~~ ring shank; or 4d cooler nail, 0.080″ diameter, $1^3/_8$″ long, $^7/_{32}$″ head. |
| | Wall | Either direction | 16 | 8 | 16 | |
| $^1/_2$ | Ceiling | Either direction | 16 | 7 | 12 | 13 gage, $1^3/_8$″ long, $^{19}/_{64}$″ head; 0.098″ diameter, $1^1/_4$″ long, ~~annular-ringed~~ ring shank; 5d cooler nail, 0.086″ diameter, $1^5/_8$″ long, $^{15}/_{64}$″ head; or gypsum board nail, 0.086″ diameter, 1 $^5/_8$″ long, $^9/_{32}$″ head. |
| | Ceiling[d] | Perpendicular | 24 | 7 | 12 | |
| | Wall | Either direction | 24 | 8 | 12 | |
| | Wall | Either direction | 16 | 8 | 16 | |
| $^5/_8$ | Ceiling | Either direction | 16 | 7 | 12 | 13 gage, $1^5/_8$″ long, $^{19}/_{64}$″ head; 0.098″ diameter, $1^3/_8$″ long, ~~annular-ringed~~ ring shank; 6d cooler nail, 0.092″ diameter, $1^7/_8$″ long, $^1/_4$″ head; or gypsum board nail, 0.0915″ diameter, $1^7/_8$″ long, $^{19}/_{64}$″ head. |
| | Ceiling | Perpendicular | 24 | 7 | 12 | |
| | Type X at garage ceiling beneath habitable rooms | Perpendicular | 24 | 6 | 6 | $1^7/_8$″ long ~~6d coated~~ 0.099″ diameter galvanized nails or equivalent drywall screws. Screws shall comply with Section R702.3.5.1. |
| | Wall | Either direction | 24 | 8 | 12 | 13 gage, $1^5/_8$″ long, $^{19}/_{64}$″ head; 0.098″ diameter, $1^3/_8$″ long, ~~annular-ringed~~ ring shank; 6d cooler nail, 0.092″ diameter, $1^7/_8$″ long, $^1/_4$″ head; or gypsum board nail, 0.0915″ diameter, $1^7/_8$″ long, $^{19}/_{64}$″ head. |
| | Wall | Either direction | 16 | 8 | 16 | |
| **Application with adhesive** | | | | | | |
| $^3/_8$ | Ceiling[d] | Perpendicular | 16 | 16 | 16 | Same as above for $^3/_8$″ gypsum board and gypsum panel products. |
| | Wall | Either direction | 16 | 16 | 24 | |
| $^1/_2$ or $^5/_8$ | Ceiling | Either direction | 16 | 16 | 16 | Same as above for $^1/_2$″ and $^5/_8$″ gypsum board and gypsum panel products, respectively. |
| | Ceiling[d] | Perpendicular | 24 | 12 | 16 | |
| | Wall | Either direction | 24 | 16 | 24 | |
| Two $^3/_8$ layers | Ceiling | Perpendicular | 16 | 16 | 16 | Base ply nailed as above for $^1/_2$″ gypsum board and gypsum panel products; face ply installed with adhesive. |
| | Wall | Either direction | 24 | 24 | 24 | |

For SI: 1 inch = 25.4 mm.

a. For application without adhesive, a pair of nails spaced not less than 2 inches apart or more than $2^1/_2$ inches apart shall be permitted to be used with the pair of nails spaced 12 inches on center.

b. Screws shall be in accordance with Section ~~R702.3.6~~ R702.3.5.1. Screws for attaching gypsum board or gypsum panel products to structural insulated panels shall penetrate the wood structural panel facing not less than $^7/_{16}$ inch.

c. Deleted.

d. Three-eighths-inch-thick single-ply gypsum board or gypsum panel product shall not be used on a ceiling where a water-based textured finish is to be applied, or where it will be required to support insulation above a ceiling. On ceiling applications to receive a water-based texture material, either hand or spray applied, the gypsum board or gypsum panel product shall be applied perpendicular to framing. Where applying a water-based texture material, the minimum gypsum board thickness shall be increased from $^3/_8$ inch to $^1/_2$ inch for 16-inch on center framing, and from $^1/_2$ inch to $^5/_8$ inch for 24-inch on center framing or $^1/_2$-inch sag-resistant gypsum ceiling board shall be used.

**R702.3.5.1 Screw fastening.** Screws for attaching gypsum board and gypsum panel products to wood framing shall be Type W or Type S in accordance with ASTM C1002 and shall penetrate the wood not less than $^5/_8$ inch (15.9 mm). Gypsum board and gypsum panel products shall be attached to cold-formed steel framing with minimum No. 6 screws. Screws for attaching gypsum board and gypsum panel products to cold-formed steel framing less than 0.033 inch (1 mm) thick shall be Type S in accordance with ASTM C1002 or bugle head style in accordance with ASTM C1513 and shall penetrate the steel not less than $^3/_8$ inch (9.5 mm). Screws for attaching gypsum board and gypsum panel products to cold-formed steel framing 0.033 inch to 0.112 inch (1 mm to 3 mm) thick shall be in accordance with ASTM C954 or bugle head style in accordance with ASTM C1513. Screws for attaching gypsum board and gypsum panel products to structural insulated panels shall penetrate the wood structural panel facing not less than $^7/_{16}$ inch (11.1 mm).

**R702.3.6 Horizontal gypsum board diaphragm ceilings.** Gypsum board and gypsum panel products shall be permitted on wood joists to create a horizontal *diaphragm* in accordance with Table R702.3.6. Gypsum board and gypsum panel products shall be installed perpendicular to ceiling framing members. End joints of adjacent courses of board and panels shall not occur on the same joist. The maximum allowable *diaphragm* proportions shall be $1^1/_2$:1 between shear resisting elements. Rotation or cantilever conditions shall not be permitted. Gypsum board or gypsum panel products shall not be used in *diaphragm* ceilings to resist lateral forces imposed by masonry or concrete construction. Perimeter edges shall be blocked using wood members not less than 2-inch by 6-inch (51 mm by 152 mm) nominal dimension. Blocking material shall be installed flat over the top plate of the wall to provide a nailing surface not less than 2 inches (51 mm) in width for the attachment of the gypsum board or gypsum panel product.

**TABLE R702.3.6**

**SHEAR CAPACITY FOR HORIZONTAL WOOD-FRAMED GYPSUM BOARD DIAPHRAGM CEILING ASSEMBLIES**

| MATERIAL | THICKNESS OF MATERIAL (min.) (inch) | SPACING OF FRAMING MEMBERS (max.) (inch) | SHEAR VALUE[a, b] (plf of ceiling) | MINIMUM FASTENER SIZE[c, d] |
|---|---|---|---|---|
| Gypsum board or gypsum panel product | $^1/_2$ | 16 o.c. | 90 | 5d cooler or wallboard nail; $1^5/_8$-inch long; 0.086-inch shank; $^{15}/_{64}$-inch head |
| Gypsum board or gypsum panel product | $^1/_2$ | 24 o.c. | 70 | 5d cooler or wallboard nail; $1^5/_8$-inch long; 0.086-inch shank; $^{15}/_{64}$-inch head |

For SI: 1 inch = 25.4 mm, 1 pound per linear foot = 1.488 kg/m.

a. Values are not cumulative with other horizontal diaphragm values and are for short-term loading caused by wind or seismic loading. Values shall be reduced 25 percent for normal loading.

b. Deleted.

c. $1^1/_4$-inch, No. 6 Type S or W screws shall be permitted to be substituted for the listed nails.

d. Fasteners shall be spaced not more than 7 inches on center at all supports, including perimeter blocking, and not less than $^3/_8$ inch from the edges and ends of the gypsum board.

**R702.3.7 Water-resistant gypsum backing board.** Gypsum board used as the base or backer for adhesive application of ceramic tile or other required nonabsorbent finish material shall conform to ASTM C1178, C1278 or C1396. Use of water-resistant gypsum backing board shall be permitted on ceilings. Use of water-resistant gypsum backing board shall be permitted on ceilings where framing spacing does not exceed 12 inches (305 mm) on center for 1/2-inch (12.7 mm) thick or 16 inches (406 mm) for 5/8-inch (16 mm) thick gypsum board. Water-resistant gypsum board shall not be installed over a Class I or II vapor retarder in a shower or tub compartment. Cut or exposed edges, including those at wall intersections, shall be sealed as recommended by the manufacturer.

**R702.3.7.1 Limitations.** Water-resistant gypsum backing board shall not be used where there will be direct exposure to water, or in areas subject to continuous high humidity.

**R702.4 Ceramic tile.**

**R702.4.1 General.** Ceramic tile surfaces shall be installed in accordance with ANSI A108.1, A108.4, A108.5, A108.6, A108.11, A118.1, A118.3, A136.1 and A137.1.

**R702.4.2 Backer boards.** Materials used as backers for wall tile in tub and shower areas and wall panels in shower areas shall be of materials listed in Table R702.4.2, and installed in accordance with the manufacturer's recommendations.

**TABLE R702.4.2**
**BACKER BOARD MATERIALS**

| MATERIAL | STANDARD |
|---|---|
| Glass mat gypsum backing panel | ASTM C1178 |
| Fiber-reinforced gypsum panels | ASTM C1278 |
| Nonasbestos fiber-cement backer board | ASTM C1288 or ISO 8336, Category C |
| Nonasbestos fiber mat-reinforced cementitious backer units | ASTM C1325 |

**R702.5 Other finishes.** Wood veneer paneling and hardboard paneling shall be placed on wood or cold-formed steel framing spaced not more than 16 inches (406 mm) on center. Wood veneer and hard board paneling less than $^{1}/_{4}$-inch (6 mm) nominal thickness shall not have less than a $^{3}/_{8}$-inch (10 mm) gypsum board or gypsum panel product backer. Wood veneer paneling not less than $^{1}/_{4}$-inch (6 mm) nominal thickness shall conform to ANSI/HPVA HP-1. Hardboard paneling shall conform to CPA/ANSI A135.5.

**R702.6 Wood shakes and shingles.** Wood shakes and shingles shall conform to CSSB *Grading Rules for Wood Shakes and Shingles* and shall be permitted to be installed directly to the studs with maximum 24 inches (610 mm) on-center spacing.

**R702.6.1 Attachment.** Nails, staples or glue are permitted for attaching shakes or shingles to the wall, and attachment of the shakes or shingles directly to the surface shall be permitted provided the fasteners are appropriate for the type of wall surface material. Where nails or staples are used, two fasteners shall be provided and shall be placed so that they are covered by the course above.

**R702.6.2 Furring strips.** Where furring strips are used, they shall be 1 inch by 2 inches or 1 inch by 3 inches (25 mm by 51 mm or 25 mm by 76 mm), spaced a distance on center equal to the desired exposure, and shall be attached to the wall by nailing through other wall material into the studs.

**R702.7 Vapor retarders.** ~~Class I or II vapor retarders are required on the interior side of frame walls in Climate Zones 5, 6, 7, 8 and Marine 4.~~Vapor retarder materials shall be classified in accordance with Table R702.7(1). A vapor retarder shall be provided on the interior side of frame walls of the class indicated in Table R702.7(2), including compliance with Table R702.7(3) or R702.7(4) where applicable. An *approved* design using accepted engineering practice for hygrothermal analysis shall be permitted as an alternative. The climate zone shall be determined in accordance with Section N1101.7.

**Exceptions:**

1. *Basement walls*.
2. Below-grade portion of any wall.

3. Construction where accumulation, condensation ~~moisture~~ or ~~its~~ freezing of moisture will not damage the materials.
4. A vapor retarder shall not be required in Climate Zones 1, 2 and 3.

**R702.7.1 Spray foam plastic insulation for moisture** control with Class II and III vapor retarders. For purposes of compliance with Tables R702.7(3) and R702.7(4), spray foam with a maximum permeance of 1.5 perms at the installed thickness applied to the interior side of wood structural panels, fiberboard, *insulating sheathing* or gypsum shall be deemed to meet the continuous insulation moisture control requirement in accordance with one of the following conditions:

1. The spray foam *R*-value is equal to or greater than the specified continuous insulation *R*-value.
2. The combined *R*-value of the spray foam and continuous insulation is equal to or greater than the specified continuous insulation *R*-value.

**TABLE R702.7(1)**
**VAPOR RETARDER MATERIALS AND CLASSES**

| CLASS | ACCEPTABLE MATERIALS |
|---|---|
| I | Sheet polyethylene, nonperforated aluminum foil or other approved materials with a perm rating less than or equal to 0.1. |
| II | Kraft-faced fiberglass batts, vapor retarder paint or other approved materials applied in accordance with the manufacturer's installation instructions for a perm rating greater than 0.1 and less than or equal to 1.0. |
| III | Latex paint, enamel paint or other approved materials applied in accordance with the manufacturer's installation instructions for a perm rating greater than 1.0 and less than or equal to 10.0. |

**TABLE R702.7(2)**
**VAPOR RETARDER OPTIONS**

| CLIMATE ZONE | VAPOR RETARDER CLASS | | |
|---|---|---|---|
| | CLASS I[a] | CLASS II[a] | CLASS III |
| 3, 4 (except Marine 4) | Not Permitted | Permitted[c] | Permitted |
| Marine 4, 5, | Permitted[b] | Permitted[c] | See Table R702.7(3) |

a. Class I and II vapor retarders with vapor permeance greater than 1 perm when measured by ASTM E96 water method (Procedure B) shall be allowed on the interior side of any frame wall in all climate zones.
b. Use of a Class I interior vapor retarder in frame walls with a Class I vapor retarder on the exterior side shall require an approved design.
c. Where a Class II vapor retarder is used in combination with foam plastic insulating sheathing installed as continuous insulation on the exterior side of frame walls, the continuous insulation shall comply with Table R702.7(4) and the Class II vapor retarder shall have a vapor permeance greater than 1 perm when measured by ASTM E96 water method (Procedure B).

**TABLE ~~R702.7.1~~ R702.7(3)**
**CLASS III VAPOR RETARDERS**

| CLIMATE ZONE | CLASS III VAPOR RETARDERS PERMITTED FOR:[a, b] |
|---|---|
| ~~Marine 4~~ | ~~Vented cladding over wood structural panels.~~ |

| | |
|---|---|
| | ~~Vented cladding over fiberboard.~~ |
| | ~~Vented cladding over gypsum.~~ |
| | ~~Continuous insulation with *R*-value ≥ 2.5 over 2 × 4 wall.~~ |
| | ~~Continuous insulation with *R*-value ≥ 3.75 over 2 × 6 wall.~~ |
| 5 | Vented cladding over wood structural panels. |
| | Vented cladding over fiberboard. |
| | Vented cladding over gypsum. |
| | Continuous insulation with *R*-value ≥ 5 over 2 × 4 wall. |
| | Continuous insulation with *R*-value ≥ 7.5 over 2 × 6 wall. |
| ~~6~~ | ~~Vented cladding over fiberboard.~~ |
| | ~~Vented cladding over gypsum.~~ |
| | ~~Continuous insulation with *R*-value ≥ 7.5 over 2 × 4 wall.~~ |
| | ~~Continuous insulation with *R*-value ≥ 11.25 over 2 × 6 wall.~~ |
| ~~7and 8~~ | ~~Continuous insulation with *R*-value ≥ 10 over 2 × 4 wall.~~ |
| | ~~Continuous insulation with *R*-value ≥ 15 over 2 × 6 wall.~~ |

a. ~~Spray foam with a maximum permeance of 1.5 perms at the installed thickness, applied to the interior cavity side of wood structural panels, fiberboard, insulating sheathing or gypsum is deemed to meet the continuous insulation requirement where the spray foam R-value meets or exceeds the specified continuous insulation R-value.~~ Vented cladding shall include vinyl, polypropylene, or horizontal aluminum siding, brick veneer with a clear airspace as specified in Table R703.8.4(1), and other approved vented claddings.

b. The requirements in this table apply only to insulation used to control moisture in order to permit the use of Class III vapor retarders. The insulation materials used to satisfy this option also contribute to but do not supersede the thermal envelope requirements of Chapter 11.

**TABLE R702.7(4)**

**CONTINUOUS INSULATION WITH CLASS II VAPOR RETARDER**

| CLIMATE ZONE | CLASS II VAPOR RETARDERS PERMITTED FOR:[a] |
|---|---|
| 3 | Continuous insulation with *R*-value ≥ 2. |
| 4, 5 | Continuous insulation with *R*-value ≥ 3 over 2 × 4 wall.<br>Continuous insulation with *R*-value ≥ 5 over 2 × 6 wall. |

a. The requirements in this table apply only to insulation used to control moisture in order to permit the use of Class II vapor retarders. The insulation materials used to satisfy this option also contribute to but do not supersede the thermal envelope requirements of Chapter 11.

**~~R702.7.1 Class III vapor retarders.~~**

~~Class III vapor retarders shall be permitted where any one of the conditions in Table R702.7.1 is met.~~

**R702.7.1 Spray foam plastic insulation for moisture** control with Class II and III vapor retarders. For purposes of compliance with Tables R702.7(3) and R702.7(4), spray foam with a maximum permeance of 1.5 perms at the installed thickness applied to the interior side of wood structural panels, fiberboard, *insulating sheathing* or gypsum shall be deemed to meet the continuous insulation moisture control requirement in accordance with one of the following conditions:

1. The spray foam *R*-value is equal to or greater than the specified continuous insulation *R*-value.
2. The combined *R*-value of the spray foam and continuous insulation is equal to or greater than the specified continuous insulation *R*-value.

~~**R702.7.2 Material vapor retarder class.**~~

~~The vapor retarder class shall be based on the manufacturer's certified testing or a tested assembly.~~

~~The following shall be deemed to meet the class specified:~~

~~1. Class I: Sheet polyethylene, unperforated aluminum foil.~~

~~2. Class II: Kraft-faced fiberglass batts.~~

~~3. Class III: Latex or enamel paint.~~

~~**R702.7.3 Minimum clear airspaces and vented openings for vented cladding.**~~

~~For the purposes of this section, vented cladding shall include the following minimum clear airspaces. Other openings with the equivalent vent area shall be permitted.~~

~~1. Vinyl lap or horizontal aluminum siding applied over a weather-resistive barrier as specified in Table R703.3(1).~~

~~2. Brick veneer with a clear airspace as specified in Table R703.8.4. 3. Other approved vented claddings.~~

## SECTION R703
## EXTERIOR COVERING

**R703.1 General.** Exterior walls shall provide the building with a weather-resistant exterior wall envelope. The exterior wall envelope shall include flashing as described in Section R703.4.

**Exception:** Log walls designed and constructed in accordance with the provisions of ICC 400.

**R703.1.1 Water resistance.** The exterior wall envelope shall be designed and constructed in a manner that prevents the accumulation of water within the wall assembly by providing a water-resistant barrier behind the exterior ~~veneer~~ cladding as required by Section R703.2 and a means of draining to the exterior water that ~~enters~~ penetrates the ~~assembly~~ exterior cladding. ~~Protection against condensation in the exterior wall assembly shall be provided in accordance with Section R702.7 of this code.~~

**Exceptions:**

1. A weather-resistant exterior wall envelope shall not be required over concrete or masonry walls designed in accordance with Chapter 6 and flashed in accordance with Section R703.4 or R703.8.
2. Compliance with the requirements for a means of drainage, and the requirements of Sections R703.2 and R703.4, shall not be required for an exterior wall envelope that has been demonstrated to resist wind-driven rain through testing of the exterior wall envelope, including joints, penetrations and intersections with dissimilar materials, in accordance with ASTM E331 under the following conditions:
   2.1. Exterior wall envelope test assemblies shall include at least one opening, one control joint, one wall/eave interface and one wall sill. All tested openings and penetrations shall be representative of the intended end-use configuration.
   2.2. Exterior wall envelope test assemblies shall be at least 4 feet by 8 feet (1219 mm by 2438 mm) in size.

2.3. Exterior wall assemblies shall be tested at a minimum differential pressure of 6.24 pounds per square foot (299 Pa).

2.4. Exterior wall envelope assemblies shall be subjected to the minimum test exposure for a minimum of 2 hours.

The exterior wall envelope design shall be considered to resist wind-driven rain where the results of testing indicate that water did not penetrate control joints in the exterior wall envelope, joints at the perimeter of openings penetration or intersections of terminations with dissimilar materials.

**R703.1.2 Wind resistance.** Wall coverings, backing materials and their attachments shall be capable of resisting wind loads in accordance with Tables R301.2.1(1) and R301.2.1(2). Wind-pressure resistance of the siding, soffit and backing materials shall be determined by ASTM E330 or other applicable standard test methods. Where wind-pressure resistance is determined by design analysis, data from *approved* design standards and analysis conforming to generally accepted engineering practice shall be used to evaluate the siding, soffit and backing material and its fastening. All applicable failure modes including bending rupture of siding, fastener withdrawal and fastener head pull-through shall be considered in the testing or design analysis. Where the wall covering, soffit and ~~the~~ backing material resist wind load as an assembly, use of the design capacity of the assembly shall be permitted.

**R703.2 Water-resistive barrier.** ~~One layer of No. 15 asphalt felt, free from holes and breaks, complying with ASTM D226 for Type 1 felt or other approved water-resistive barrier shall be applied over studs or sheathing of all exterior walls. No.15 asphalt felt shall be applied horizontally, with the upper layer lapped over the lower layer not less than 2 inches (51 mm). Where joints occur, felt shall be lapped not less than 6 inches (152 mm). Other approved materials shall be installed in accordance with the water-resistive barrier manufacturer's installation instructions. The No. 15 asphalt felt or other approved water-resistive barrier material shall be continuous to the top of walls and terminated at penetrations and building appendages in a manner to meet the requirements of the exterior wall envelope as described in Section R703.1.~~ A minimum one layer of *water-resistive barrier* shall be applied over studs or sheathing of all exterior walls with flashing as indicated in Section R703.4, in such a manner as to provide a continuous water-resistive barrier behind the exterior wall veneer. The water-resistive barrier material shall be continuous to the top of walls and terminated at penetrations and building appendages in a manner to meet the requirements of the exterior wall envelope as described in Section R703.1. Water-resistive barrier materials shall comply with one of the following:

1. No. 15 felt complying with ASTM D226, Type 1.
2. ASTM E2568, Type 1 or 2.
3. ASTM E331 in accordance with Section R703.1.1.
4. Other ~~approved~~*approved* materials in accordance with the manufacturer's installation instructions.

No.15 asphalt felt and *water-resistive barriers* complying with ASTM E2556 shall be applied horizontally, with the upper layer lapped over the lower layer not less than 2 inches (51 mm), and where joints occur, shall be lapped not less than 6 inches (152 mm).

**R703.3 ~~Nominal~~ Wall covering nominal thickness and attachments.** The nominal thickness and attachment of exterior wall coverings shall be in accordance with Table R703.3(1), the wall covering material requirements of this section, and the wall covering manufacturer's installation instructions. Cladding attachment over foam sheathing shall comply with the additional requirements and limitations of Sections R703.15 and R703.17. Nominal material thicknesses in Table R703.3(1) are based on a maximum stud spacing of 16 inches (406 mm) on center. Where specified by the siding manufacturer's instructions and supported by a test report or other documentation, attachment to studs with greater spacing is permitted. Fasteners for exterior wall coverings attached to wood framing shall be in accordance with Section ~~R703.3.2~~ R703.3.3 and Table R703.3(1).

**TABLE R703.3(1)**

**SIDING MINIMUM ATTACHMENT AND MINIMUM THICKNESS**

| SIDING MATERIAL | | | TYPE OF SUPPORTS FOR THE SIDING MATERIAL AND FASTENERS |
|---|---|---|---|

| | | NOMINAL THICKNESS (inches) | JOINT TREATMENT | Wood or wood structural panel sheathing into stud | Fiberboard sheathing into stud | Gypsum sheathing into stud | Foam plastic sheathing into stud[i] | Direct to studs | Number or spacing of fasteners |
|---|---|---|---|---|---|---|---|---|---|
| Anchored veneer: brick, concrete, masonry or stone (see Section R703.8) | | 2 | Section R703.8 | Section R703.8 | | | | | |
| Adhered veneer: concrete, stone or masonry (see Section R703.12) | | — | Section R703.12 | Section R703.12 | | | | | |
| Fiber cement siding | Panel siding (see Section R703.10.1) | $^{5}/_{16}$ | Section R703.10.1 | 6d common (2″ × 0.113″) | 6d common (2″ × 0.113″) | 6d common (2″ × 0.113″) | 6d common (2″ × 0.113″) | 4d common ($1^{1}/_{2}$″ × 0.099″) | 6″ panel edges 12″ inter. sup. |
| | Lap siding (see Section R703.10.2) | $^{5}/_{16}$ | Section R703.10.2 | 6d common (2″ × 0.113″) | 6d common (2″ × 0.113″) | 6d common (2″ × 0.113″) | 6d common (2″ × 0.113″) | 6d common (2″ × 0.113″) or 11 gage roofing nail | Note f |
| Hardboard panel siding (see Section R703.5) | | $^{7}/_{16}$ | — | 0.120″ nail (shank) with 0.225″ head | 0.120″ nail (shank) with 0.225″ head | 0.120″ nail (shank) with 0.225″ head | 0.120″ nail (shank) with 0.225″ head | 0.120″ nail (shank) with 0.225″ head | 6″ panel edges 12″ inter. sup.[d] |
| Hardboard lap siding (see Section R703.5) | | $^{7}/_{16}$ | Note e | 0.099″ nail (shank) with 0.240″ head | 0.099″ nail (shank) with 0.240″ head | 0.099″ nail (shank) with 0.240″ head | 0.099″ nail (shank) with 0.240″ head | 0.099″ nail (shank) with 0.240″ head | Same as stud spacing 2 per bearing |
| Horizontal aluminum[a] | Without insulation | 0.019[b] | Lap | Siding nail $1^{1}/_{2}$″ × 0.120″ | Siding nail 2″ × 0.120″ | Siding nail 2″ × 0.120″ | Siding nail[h] $1^{1}/_{2}$″ × 0.120″ | Not allowed | Same as stud spacing |
| | | 0.024 | Lap | Siding nail $1^{1}/_{2}$″ × 0.120″ | Siding nail 2″ × 0.120″ | Siding nail 2″ × 0.120″ | Siding nail[h] $1^{1}/_{2}$″ × 0.120″ | Not allowed | |
| | With insulation | 0.019 | Lap | Siding nail $1^{1}/_{2}$″ × 0.120″ | Siding nail $2^{1}/_{2}$″ × 0.120″ | Siding nail $2^{1}/_{2}$″ × 0.120″ | Siding nail[h] $1^{1}/_{2}$″ × 0.120″ | Siding nail $1^{1}/_{2}$″ × 0.120″ | |
| Insulated vinyl siding[j] | | 0.035 (vinyl siding layer only) | Lap | 0.120 nail (shank) with a 0.313 head or 16-gage crown[h, i] | 0.120 nail (shank) with a 0.313 head or 16-gage crown[h] | 0.120 nail (shank) with a 0.313 head or 16-gage crown[h] | 0.120 nail (shank) with a 0.313 head Section R703.11.2 | Not allowed | 16 inches on center or specified by manufacturer instructions, test report or other sections of this code |
| Particleboard panels | | $^{3}/_{8}$ | — | 6d box nail (2″ × 0.099″) | 6d box nail (2″ × 0.099″) | 6d box nail (2″ × 0.099″) | 6d box nail (2″ × 0.099″) | Not allowed | 6″ panel edges 12″ inter. sup. |
| | | $^{1}/_{2}$ | — | 6d box nail (2″ × 0.099″) | 6d box nail (2″ × 0.099″) | 6d box nail (2″ × 0.099″) | 6d box nail (2″ × 0.099″) | 6d box nail (2″ × 0.099″) | |
| | | $^{5}/_{8}$ | — | 6d box nail (2″ × 0.099″) | 8d box nail ($2^{1}/_{2}$″ × 0.113″) | 8d box nail ($2^{1}/_{2}$″ × 0.113″) | 6d box nail (2″ × 0.099″) | 6d box nail (2″ × 0.099″) | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Polypropylene siding[k] | | Not applicable | Lap | Section 703.14.1 | Section 703.14.1 | Section 703.14.1 | Section 703.14.1 | Not allowed | As specified by the manufacturer instructions, test report or other sections of this code |

*(continued)*

**TABLE R703.3(1)—continued**

**SIDING MINIMUM ATTACHMENT AND MINIMUM THICKNESS**

| SIDING MATERIAL | | NOMINAL THICKNESS (inches) | JOINT TREATMENT | TYPE OF SUPPORTS FOR THE SIDING MATERIAL AND FASTENERS | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Wood or wood structural panel sheathing into stud | Fiberboard sheathing into stud | Gypsum sheathing into stud | Foam plastic sheathing into stud[l] | Direct to studs | Number or spacing of fasteners |
| Steel[c] | | 29 ga. | Lap | Siding nail ($1^{3}/_{4}''$ × 0.113″) Staple–$1^{3}/_{4}$ | Siding nail ($2^{3}/_{4}''$ × 0.113″) Staple–$2^{1}/_{2}$ | Siding nail ($2^{1}/_{2}''$ × 0.113″) Staple–$2^{1}/_{4}$ | Siding nail ($1^{3}/_{4}''$ × 0.113″) Staple–$1^{3}/_{4}$ | Not allowed | Same as stud spacing |
| Vinyl siding (see Section R703.11) | | 0.035 | Lap | 0.120″ nail (shank) with a 0.313″ head or 16-gage staple with $^{3}/_{8}$- to $^{1}/_{2}$-inch crown[h, i] | 0.120″ nail (shank) with a 0.313″ head or 16-gage staple with $^{3}/_{8}$- to $^{1}/_{2}$-inch crown[h] | 0.120″ nail (shank) with a 0.313″ head or 16-gage staple with $^{3}/_{8}$- to $^{1}/_{2}$-inch crown[h] | 0.120″ nail (shank) with a 0.313 head Section R703.11.2 | Not allowed | 16 inches on center or as specified by the manufacturer instructions or test report |
| Wood siding (see Section R703.5) | Wood rustic, drop | $^{3}/_{8}$ min. | Lap | 6d box or siding nail (2″ × 0.099″) | 6d box or siding nail (2″ ×0.099″) | 6d box or siding nail (2″ × 0.099″) | 6d box or siding nail (2″ × 0.099″) | 8d box or siding nail ($2^{1}/_{2}''$ × 0.113″) Staple–2″ | Face nailing up to 6″ widths, 1 nail per bearing; 8″ width sand over, 2 nails per bearing |
| | Shiplap | $^{19}/_{32}$ average | Lap | | | | | | |
| | Bevel | $^{7}/_{16}$ | | | | | | | |
| | Butt tip | $^{3}/_{16}$ | Lap | | | | | | |
| Wood structural panel ANSI/APA PRP-210 siding (exterior grade) (see Section R703.5) | | $^{3}/_{8}$ – $^{1}/_{2}$ | Note e | 2″ × 0.099″ siding nail | $2^{1}/_{2}''$ × 0.113″ siding nail | $2^{1}/_{2}''$ × 0.113″ siding nail | $2^{1}/_{2}''$ × 0.113″ siding nail | 2″ × 0.099″ siding nail | 6″ panel edges 12″ inter. sup. |
| Wood structural panel lap siding (see Section R703.5) | | $^{3}/_{8}$ – $^{1}/_{2}$ | Note e Note g | 2″ × 0.099″ siding nail | $2^{1}/_{2}''$ × 0.113″ siding nail | $2^{1}/_{2}''$ × 0.113″ siding nail | $2^{1}/_{2}''$ × 0.113″ siding nail | 2″ × 0.099″ siding nail | 8″ along bottom edge |

For SI: 1 inch = 25.4 mm.

a. Aluminum nails shall be used to attach aluminum siding.

b. Aluminum (0.019 inch) shall be unbacked only where the maximum panel width is 10 inches and the maximum flat area is 8 inches. The tolerance for aluminum siding shall be +0.002 inch of the nominal dimension.

c. Shall be of approved type.

d. Where used to resist shear forces, the spacing must be 4 inches at panel edges and 8 inches on interior supports.

e. Vertical end joints shall occur at studs and shall be covered with a joint cover or shall be caulked.

f. Face nailing: one 6d common nail through the overlapping planks at each stud. Concealed nailing: one 11-gage $1^{1}/_{2}$-inch-long galv. roofing nail through the top edge of each plank at each stud in accordance with the manufacturer's installation instructions.

g. Vertical joints, if staggered, shall be permitted to be away from studs if applied over wood structural panel sheathing.

h. Minimum fastener length must be sufficient to penetrate sheathing other nailable substrate and framing a total of a minimum of $1^{1}/_{4}$ inches or in accordance with the manufacturer's installation instructions.
i. Where specified by the manufacturer's instructions and supported by a test report, fasteners are permitted to penetrate into or fully through nailable sheathing or other nailable substrate of minimum thickness specified by the instructions or test report, without penetrating into framing.
j. Insulated vinyl siding shall comply with ASTM D7793.
k. Polypropylene siding shall comply with ASTM D7254.
l. Cladding attachment over foam sheathing shall comply with the additional requirements and limitations of Sections R703.15, R703.16 and R703.17.

**R703.3.1 Soffit installation.** Soffits shall comply with Section R704.

~~R703.3.1~~ R703.3.2 **Wind limitations.** Deleted.

~~R703.3.2~~ R703.3.3 **Fasteners.** Exterior wall coverings and roof overhang soffits shall be securely fastened with aluminum, galvanized, stainless steel or rust-preventative coated nails or staples in accordance with Table R703.3(1) or with other *approved* corrosion-resistant fasteners in accordance with the wall covering manufacturer's installation instructions. Nails and staples shall comply with ASTM F1667. Nails shall be T-head, modified round head, or round head with smooth or deformed shanks. Staples shall have a minimum crown width of $^{7}/_{16}$ inch (11.1 mm) outside diameter and be manufactured of minimum 16-gage wire. Where fiberboard, gypsum, or foam plastic sheathing backing is used, nails or staples shall be driven into the studs. Where wood or wood structural panel sheathing is used, fasteners shall be driven into studs unless otherwise permitted to be driven into sheathing in accordance with either the siding manufacturer's installation instructions or Table R703.3.3.

**TABLE ~~R703.3.2~~ R703.3.3**
**OPTIONAL SIDING ATTACHMENT SCHEDULE FOR FASTENERS WHERE NO STUD PENETRATION NECESSARY**

| APPLICATION | NUMBER AND TYPE OF FASTENER | SPACING OF FASTENERS[b] |
|---|---|---|
| Exterior wall covering (weighing 3 psf or less) attachment to wood structural panel sheathing, either direct or over foam sheathing a maximum of 2 inches thick.[a] Note: Does not apply to vertical siding. | Ring shank roofing nail (0.120″ min. dia.) | 12″ o.c. |
| | Ring shank nail (0.148″ min. dia.) | 15″ o.c. |
| | No. 6 screw (0.138″ min. dia.) | 12″ o.c. |
| | No. 8 screw (0.164″ min. dia.) | 16″ o.c. |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.479 kPa.
a. Fastener length shall be sufficient to penetrate the back side of the wood structural panel sheathing by at least $^{1}/_{4}$ inch. The wood structural panel sheathing shall be not less than $^{7}/_{16}$ inch in thickness.
b. Spacing of fasteners is per 12 inches of siding width. For other siding widths, multiply "Spacing of Fasteners" above by a factor of 12/s, where "s" is the siding width in inches. Fastener spacing shall never be greater than the manufacturer's minimum recommendations.

~~R703.3.3~~ R703.3.4 **Minimum fastener length and penetration.** Fasteners shall have the greater of the minimum length specified in Table R703.3(1) or as required to provide a minimum penetration into framing as follows:

1. Fasteners for horizontal aluminum siding, steel siding, particleboard panel siding, wood structural panel siding in accordance with ANSI/APA-PRP 210, fiber-cement panel siding and fiber-cement lap siding installed over foam plastic sheathing shall penetrate not less than $1^{1}/_{2}$ inches (38 mm) into framing or shall be in accordance with the manufacturer's installation instructions.
2. Fasteners for hardboard panel and lap siding shall penetrate not less than $1^{1}/_{2}$ inches (38 mm) into framing.
3. Fasteners for vinyl siding and insulated vinyl siding installed over wood or wood structural panel sheathing shall penetrate not less than $1^{1}/_{4}$ inches (32 mm) into sheathing and framing combined. Vinyl siding and insulated vinyl siding shall be permitted to be installed with fasteners penetrating into or through wood or wood structural sheathing of minimum thickness as specified by the manufacturer's instructions or test report, with or without penetration into the framing. Where the fastener penetrates fully through the sheathing, the end of the fastener shall extend not less than $^{1}/_{4}$ inch (6.4 mm) beyond the opposite face of the sheathing. Fasteners for vinyl siding and insulated vinyl siding installed over foam plastic sheathing

shall be in accordance with Section R703.11.2. Fasteners for vinyl siding and insulated vinyl siding installed over fiberboard or gypsum sheathing shall penetrate not less than $1^1/_4$ inches (32 mm) into framing.

4. Fasteners for vertical or horizontal wood siding shall penetrate not less than $1^1/_2$ inches (38 mm) into studs, studs and wood sheathing combined, or blocking.
5. Fasteners for siding material installed over foam plastic sheathing shall have sufficient length to accommodate foam plastic sheathing thickness and to penetrate framing or sheathing and framing combined, as specified in Items 1 through 4.

**TABLE R703.3(2)**

**SCREW FASTENER SUBSTITUTION FOR SIDING ATTACHMENT TO COLD-FORMED STEEL LIGHT FRAME CONSTRUCTION[a, b, c, d, e]**

| NAIL DIAMETER PER TABLE R703.3(1) | MINIMUM SCREW FASTENER SIZE |
|---|---|
| 0.099″ | No. 6 |
| 0.113″ | No. 7 |
| 0.120″ | No. 8 |

For SI: 1 inch = 25.4 mm.

a. Screws shall comply with ASTM C1513 and shall penetrate a minimum of three threads through minimum 33 mil (20 gage) cold-formed steel frame construction.

b. Screw head diameter shall be not less than the nail head diameter required by Table R703.3(1).

c. Number and spacing of screw fasteners shall comply with Table R703.3(1).

d. Pan head, hex washer head, modified truss head or other screw head types with a flat attachment surface under the head shall be used for vinyl siding attachment.

e. Aluminum siding shall not be fastened directly to cold-formed steel light frame construction.

**TABLE R703.3.2**

**LIMITS FOR ATTACHMENT PER Table R703.3(1)**

| MAXIMUM MEAN ROOF HEIGHT | | | |
|---|---|---|---|
| Ultimate Wind Speed (mph 3-second gust) | Exposure | | |
| | B | C | D |
| 95 | NL | NL | NL |
| 100 | NL | NL | NL |
| 105 | NL | NL | NL |
| 110 | NL | NL | 40′ |
| 115 | NL | 50′ | 20′ |
| 120 | NL | 30′ | DR |
| 130 | 60′ | 15′ | DR |
| 140 | 35′ | DR | DR |

For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

NL = Not Limited by Table R703.3.2, DR = Design Required.

**R703.4 Flashing.** *Approved* corrosion-resistant flashing shall be applied *shingle-fashion* in a manner to prevent entry of water into the wall cavity or penetration of water to the building structural framing components. Self-adhered membranes used as flashing shall comply with AAMA 711. Fluid-applied membranes used as flashing in exterior walls shall comply with AAMA 714. The flashing shall extend to the surface of the exterior wall finish. Aluminum flashing shall not be used in contact with cementitious material, except at counter flashing. *Approved* corrosion-resistant flashings shall be installed at the following locations:

1. Exterior window and door openings. Flashing at exterior window and door openings shall be installed in accordance with Section R703.4.1. ~~extend to the surface of the exterior wall finish or to the water-resistive barrier complying with Section 703.2 for subsequent drainage. Mechanically attached flexible flashings shall comply with AAMA 712. Flashing at exterior window and door openings shall be installed in accordance with one or more of the following:~~

   ~~1.1. The fenestration manufacturer's installation and flashing instructions, or for applications not addressed in the fenestration manufacturer's instructions, in accordance with the flashing manufacturer's instructions. Where flashing instructions or details are not provided, pan flashing shall be installed at the sill of exterior window and door openings. Pan flashing shall be sealed or sloped in such a manner as to direct water to the surface of the exterior wall finish or to the water-resistive barrier for subsequent drainage. Openings using pan flashing shall incorporate flashing or protection at the head and sides.~~

   ~~1.2. In accordance with the flashing design or method of a registered design professional.~~

   ~~1.3. In accordance with other approved methods.~~
2. At the intersection of chimneys or other masonry construction with frame or stucco walls, with projecting lips on both sides under stucco copings.
3. Under and at the ends of masonry, wood or metal copings and sills.
4. Continuously above all projecting wood *trim*.
5. Where exterior porches, decks or stairs attach to a wall or floor assembly of wood-frame construction.
6. At wall and roof intersections.
7. At built-in gutters.

**R703.4.1** Flashing installation at exterior window and door openings. Flashing at exterior window and door openings shall extend to the surface of the exterior wall finish or to a *water-resistive barrier* complying with Section 703.2 for subsequent drainage. Air sealing shall be installed around all window and door openings on the interior side of the rough opening gap. Mechanically attached flexible flashings shall comply with AAMA 712. Flashing at exterior window and door openings shall be installed in accordance with one or more of the following:

1. The fenestration manufacturer's installation and flashing instructions, or for applications not addressed in the fenestration manufacturer's instructions, in accordance with the flashing manufacturer's instructions. Where flashing instructions or details are not provided, *pan flashing* shall be installed at the sill of exterior window and door openings. *Pan flashing* shall be sealed or sloped in such a manner as to direct water to the surface of the exterior wall finish or to the water-resistive barrier for subsequent drainage. Openings using *pan flashing* shall incorporate flashing or protection at the head and sides.
2. In accordance with the flashing design or method of a *registered design professional.*
3. In accordance with other *approved* methods.

**R703.5 Wood, hardboard and wood structural panel siding.** Wood, hardboard and wood structural panel siding shall be installed in accordance with this section and Table R703.3(1). Hardboard siding shall comply with ANSI A135.5. ~~Hardboard siding used as architectural trim shall comply with CPA/ANSI A 135.7.~~

**R703.5.1 Vertical wood siding.** Wood siding applied vertically shall be nailed to horizontal nailing strips or blocking set not more than 24 inches (610 mm) on center.

**R703.5.2 Panel siding.** ~~3/8 inch~~ Three-eighths-inch (9.5 mm) wood structural panel siding shall not be applied directly to studs spaced more than 16 inches (406 mm) on center where long dimension is parallel to studs. Wood structural panel siding $^{7}/_{16}$ inch (11.1 mm) or thinner shall not be applied directly to studs spaced more than 24 inches (610 mm) on center. The stud spacing shall not exceed the panel span rating provided by the manufacturer unless the panels are installed with the face grain perpendicular to the studs or over sheathing *approved* for that stud spacing.

Joints in wood, hardboard or wood structural panel siding shall be made as follows unless otherwise *approved*. Vertical joints in panel siding shall occur over framing members, unless wood or wood structural panel sheathing is used, and shall be shiplapped or covered with a batten. Horizontal joints in panel siding shall be lapped not less than 1 inch (25 mm) or shall be shiplapped or flashed with Z-flashing and occur over solid blocking, wood or wood structural panel sheathing.

**R703.5.3 Horizontal wood siding.** Horizontal lap siding shall be installed in accordance with the manufacturer's recommendations. Where there are no recommendations the siding shall be lapped not less than 1 inch (25 mm), or $^{1}/_{2}$ inch (12.7 mm) if rabbeted, and shall have the ends caulked, covered with a batten or sealed and installed over a strip of flashing.

**R703.6 Wood shakes and shingles.** Wood shakes and shingles shall conform to CSSB. ~~Grading Rules for Wood Shakes and Shingles.~~

**R703.6.1 Application.** Wood shakes or shingles shall be applied either single course or double course over nominal $^{1}/_{2}$-inch (12.7 mm) wood-based sheathing or to furring strips over $^{1}/_{2}$-inch (12.7 mm) nominal nonwood sheathing. A *water-resistive barrier* shall be provided over all sheathing, with horizontal overlaps in the membrane of not less than 2 inches (51 mm) and vertical overlaps of not less than 6 inches (152 mm). Where horizontal furring strips are used, they shall be 1 inch by 3 inches or 1 inch by 4 inches (25 mm by 76 mm or 25 mm by 102 mm) and shall be fastened to the studs with minimum 7d or 8d box nails and shall be spaced a distance on center equal to the actual weather exposure of the shakes or shingles, not to exceed the maximum exposure specified in Table R703.6.1. When installing shakes or shingles over a nonpermeable *water-resistive barrier*, furring strips shall be placed first vertically over the barrier and in addition, horizontal furring strips shall be fastened to the vertical furring strips prior to attaching the shakes or shingles to the horizontal furring strips. The spacing between adjacent shingles to allow for expansion shall be $^{1}/_{8}$ inch (3.2 mm) to $^{1}/_{4}$ inch (6.4 mm) apart, and between adjacent shakes shall be $^{3}/_{8}$ inch (9.5 mm) to $^{1}/_{2}$ inch (12.7 mm) apart. The offset spacing between joints in adjacent courses shall be not less than $1^{1}/_{2}$ inches (38 mm).

**TABLE R703.6.1**

**MAXIMUM WEATHER EXPOSURE FOR WOOD SHAKES AND SHINGLES ON EXTERIOR WALLS[a, b, c]**
**(Dimensions are in inches)**

| LENGTH | EXPOSURE FOR SINGLE COURSE | EXPOSURE FOR DOUBLE COURSE |
|---|---|---|
| **Shingles[a]** | | |
| 16 | 7 | 12[b] |
| 18 | 8 | 14[c] |
| 24 | $10^{1}/_{2}$ | 16[d] |
| **Shakes[a]** | | |
| 18 | 8 | 14 |
| 24 | $10^{1}/_{2}$ | 18 |

For SI: 1 inch = 25.4 mm.
a. Dimensions given are for No. 1 grade.
b. A maximum 9-inch exposure is permitted for No. 2 grade.
c. A maximum 10-inch exposure is permitted for No. 2 grade.
d. A maximum 14-inch exposure is permitted for No. 2 grade.

**R703.6.2 Weather exposure.** The maximum weather exposure for shakes and shingles shall not exceed that specified in Table R703.6.1.

**R703.6.3 Attachment.** Wood shakes or shingles shall be installed according to this chapter and the manufacturer's instructions. Each shake or shingle shall be held in place by two stainless steel Type 304, Type 316 or hot-dipped zinc-coated galvanized corrosion-resistant box nails in accordance with Table R703.6.3(1) or R703.6.3(2). The hot-dipped zinc-coated galvanizing shall ~~conform to minimum standard~~ be in compliance with ASTM ~~A153D~~ A153, 1.0 ounce per square foot. Alternatively, 16-gage stainless steel Type 304 or Type 316 staples with crown widths $^{7}/_{16}$ inch (11 mm) minimum, $^{3}/_{4}$ inch (19 mm) maximum, shall be used and the crown of the staple shall be placed parallel with the butt of the shake or the shingle. In single-course application, the fasteners shall be concealed by the course above and shall be driven approximately 1 inch (25 mm) above the butt line of the succeeding course and $^{3}/_{4}$ inch (19 mm) from the edge. In double-course applications, the exposed shake or shingle shall be face-nailed with two fasteners, driven approximately 2 inches (51 mm) above the butt line and $^{3}/_{4}$ inch (19 mm) from each edge. Fasteners installed within 15 miles (24 km) of saltwater coastal areas shall be stainless steel Type 316. Fasteners for fire-retardant-treated shakes or shingles in accordance with Section R902 or pressure-impregnated-preservative-treated shakes or shingles in accordance with AWPA U1 shall be stainless steel Type 316. The fasteners shall penetrate the sheathing or furring strips by not less than $^{1}/_{2}$ inch (13 mm) and shall not be overdriven. Fasteners for untreated (natural) and treated products shall comply with ASTM F1667.

**TABLE R703.6.3(1)**
**SINGLE COURSE SIDEWALL FASTENERS**

| SINGLE COURSE SIDEWALL FASTENERS | | | |
|---|---|---|---|
| **Product type** | **Nail type and minimum length (inches)** | **Minimum head diameter (inches)** | **Minimum shank thickness (inches)** |
| **R & R and sanded shingles** | **Type** | | |
| 16″ and 18″ shingles | 3d box $1^{1}/_{4}$ | 0.19 | 0.08 |
| 24″ shingles | 4d box $1^{1}/_{2}$ | 0.19 | 0.08 |
| **Grooved shingles** | **Type** | | |
| 16″ and 18″ shingles | 3d box $1^{1}/_{4}$ | 0.19 | 0.08 |
| 24″ shingles | 4d box $1^{1}/_{2}$ | 0.19 | 0.08 |
| **Split and sawn shakes** | **Type** | | |
| 18″ straight-split shakes | 5d box $1^{3}/_{4}$ | 0.19 | 0.08 |
| 18″ and 24″ handsplit shakes | 6d box 2 | 0.19 | 0.0915 |
| 24″ tapersplit shakes | 5d box $1^{3}/_{4}$ | 0.19 | 0.08 |
| 18″ and 24″ tapersawn shakes | 6d box 2 | 0.19 | 0.0915 |

For SI: 1 inch = 25.4 mm.

**TABLE R703.6.3(1)**
**SINGLE-COURSE SIDEWALL FASTENERS**

| **PRODUCT TYPE** | **NAIL TYPE, MINIMUM LENGTH AND SHANK DIAMETER (inches)** |
|---|---|
| **R & R and sanded shingles** | |
| 16″ and 18″ shingles | 3d box 1 $^{1}/_{4}$ × 0.076 |
| 24″ shingles | 4d box $1^{1}/_{2}$ × 0.076 |
| **Grooved shingles** | |
| 16″ and 18″ shingles | 3d box $1^{1}/_{4}$ × 0.076 |

| | |
|---|---|
| 24″ shingles | 4d box $1^1/_2 \times 0.076$ |
| **Split and sawn shakes** | |
| 18″ straight-split shakes | 5d box $1^3/_4 \times 0.080$ |
| 18″ and 24″ handsplit shakes | 6d box $2 \times 0.099$ |
| 24″ tapersplit shakes | 5d box $1^3/_4 \times 0.080$ |
| 18″ and 24″ tapersawn shakes | 6d box $2 \times 0.099$ |

For SI: 1 inch = 25.4 mm.

**TABLE R703.6.3(2)**
**DOUBLE COURSE SIDEWALL FASTENERS**

| DOUBLE COURSE SIDEWALL FASTENERS | | | |
|---|---|---|---|
| **Product type** | **Nail type and minimum length** | **Minimum head diameter (inches)** | **Minimum shank thickness (inches)** |
| **R & R and sanded shingles** | | | |
| 16,″ 8″ and 24″ shingles | 5d box $1^3/_4$ or same size casing nails | 0.19 | 0.08 |
| **Grooved shingles** | | | |
| 16,″ 18″ and 24″shingles | 5d box $1^3/_4$ | 0.19 | 0.08 |
| **Split and sawn shakes** | | | |
| 18″ straight-split shakes | 7d box $2^1/_4$ or 8d $2^1/_2$ | 0.19 | 0.099 |
| 18″ and 24″ handsplit shakes | 7d box $2^1/_4$ or 8d $2^1/_2$ | 0.19 | 0.099 |
| 24″ tapersplit shakes | 7d box $2^1/_4$ or 8d $2^1/_2$ | 0.19 | 0.099 |
| 18″ and 24″ tapersawn shakes | 7d box $2^1/_4$ or 8d $2^1/_2$ | 0.19 | 0.099 |

For SI: 1 inch = 25.4 mm.

**TABLE R703.6.3(2)**
**DOUBLE-COURSE SIDEWALL FASTENERS**

| PRODUCT TYPE | NAIL TYPE, MINIMUM LENGTH AND SHANK DIAMETER (inches) |
|---|---|
| **R & R and sanded shingles** | |
| 16″, 8″ and 24″ shingles | 5d box $1^3/_4 \times 0.08$ or 5d casing nails $1^3/_4 \times 0.080$ |
| **Grooved shingles** | |
| 16″, 18″ and 24″shingles | 5d box $1^3/_4 \times 0.080$ |
| **Split and sawn shakes** | |
| 18″ straight-split shakes | 7d box $2^1/_4 \times 0.099$ or 8d box $2^1/_2 \times 0.113$ |
| 18″ and 24″ handsplit shakes | 7d box $2^1/_4 \times 0.099$ or 8d box $2^1/_2 \times 0.113$ |
| 24″ tapersplit shakes | 7d box $2^1/_4 \times 0.099$ or 8d box $2^1/_2 \times 0.113$ |
| 18″ and 24″ tapersawn shakes | 7d box $2^1/_4 \times 0.099$ or 8d box $2^1/_2 \times 0.113$ |

For SI: 1 inch = 25.4 mm.

**R703.6.4 Bottom courses.** The bottom courses shall be doubled.

**R703.7 Exterior plaster.** Installation of ~~these materials~~ exterior plaster shall be in compliance with ASTM C926, ASTM C1063 and the provisions of this code.

**R703.7.1 Lath.** Lath and lath attachments shall be of corrosion-resistant materials in accordance with ASTM C1063. Expanded metal, welded wire, or woven wire lath shall be attached to wood framing members or furring. Where the exterior plaster is serving as wall bracing in accordance with Table R602.10.4, the lath shall be attached directly to framing. The lath shall be attached with $1\frac{1}{2}$-inch-long (38 mm), 11-gage nails having a $\frac{7}{16}$-inch (11.1 mm) head, or $\frac{7}{8}$-inch-long (22.2 mm), 16-gage staples, spaced not more than ~~6~~ 7 inches (~~152~~ 178 mm) on center along framing members or furring and not more than 24 inches (610 mm) on center between framing members or furring, or as otherwise *approved*. Additional fastening between wood framing members shall not be prohibited. Lath attachments to cold-formed steel framing or to masonry, stone, or concrete substrates shall be in accordance with ASTM C1063. Where lath is installed directly over foam sheathing, lath connections shall also be in accordance with Section R703.15, R703.16 or R703.17. Where lath is attached to furring installed over foam sheathing, the furring connections shall be in accordance with Section R703.15, R703.16 or R703.17.

**Exception:** Lath is not required over masonry, cast-in-place concrete, *precast concrete* or stone substrates prepared in accordance with ASTM C1063.

**703.7.1.1 Furring.** Where provided, furring shall consist of wood furring strips not less than 1 inch by 2 inches (25 mm by 51 mm), minimum $\frac{3}{4}$-inch (19 mm) metal channels, or self-furring lath, and shall be installed in accordance with ASTM C1063. Furring shall be spaced not greater than 24 inches (600 mm) on center and, where installed over wood or cold-formed steel framing, shall be fastened into framing members.

**R703.7.2 Plaster.** Plastering with ~~portland~~ cement plaster shall be ~~not less than three coats where applied over metal lath or wire lath and shall be not less than two coats where applied over masonry, concrete, pressure-preservative-treated wood or decay-resistant wood as specified in Section R317.1 or gypsum backing. If the plaster surface is completely covered by veneer or other facing material or is completely concealed, plaster application need be only two coats, provided the total thickness is as set forth in Table R702.1(1)~~in accordance with ASTM C926. Cement materials shall be in accordance with one of the following:

1. Masonry cement conforming to ASTM C91, Type M, S or N.
2. Portland cement conforming to ASTM C150, Type I, II or III.
3. Blended hydraulic cement conforming to ASTM C595, Type IP, IS (< 70), IL, or IT (S < 70).
4. Hydraulic cement conforming to ASTM C1157, Type GU, HE, MS, HS or MH.
5. Plastic cement conforming to ASTM C1328.

Plaster shall be not less than three coats where applied over metal lath or wire lath and shall be not less than two coats where applied over masonry, concrete, pressure-preservative-treated wood or decay-resistant wood as specified in Section R317.1 or gypsum backing. If the plaster surface is completely covered by veneer or other facing material or is completely concealed, plaster application need be only two coats, provided the total thickness is as set forth in Table R702.1(1).

On wood-frame construction with an on-grade floor slab system, exterior plaster shall be applied to cover, but not extend below, lath, paper and screed.

The proportion of aggregate to cementitious materials shall be as set forth in Table R702.1(3).

**R703.7.2.1 Weep screeds.** A minimum 0.019-inch (0.5 mm) (No. 26 galvanized sheet gage), corrosion-resistant weep screed or plastic weep screed, with a minimum vertical attachment flange of $3\frac{1}{2}$ inches (89 mm), shall be provided at or below the foundation plate line on exterior stud walls in accordance with ASTM C926. The weep screed shall be placed not less than 4 inches (102 mm) above the earth or 2 inches (51 mm) above paved areas and shall be of a type that will allow trapped water to drain to the exterior of the building. The weather-resistant barrier shall lap the attachment flange. The exterior lath shall cover and terminate on the attachment flange of the weep screed.

**R703.7.3 Water-resistive barriers.** Water-resistive barriers shall be installed as required in Section R703.2 and, where applied over wood-based sheathing, shall comply with Section R703.7.3.1 or R703.7.3.2. ~~include a water-resistive, vaporpermeable barrier with a performance at least equivalent to two layers of Grade D paper.The individual layers shall be installed independently such that each layer provides a separate continuous plane and any~~

~~flashing, installed in accordance with Section R703.4 and intended to drain to the water-resistive barrier , is directed between the layers.~~

~~**Exception:** Where the water-resistive barrier that is applied over wood-based sheathing has a water resistance equal to or greater than that of 60 minute Grade D paper and is separated from the stucco by an intervening, substantially nonwaterabsorbing layer or designed drainage space.~~

**R703.7.3.1 Dry climates.** In Dry (B) climate zones indicated in Figure N1101.7, *water-resistive barriers* shall comply with one of the following:

1. The *water-resistive barrier* shall be two layers of 10-minute Grade D paper or have a water resistance equal to or greater than two layers of a *water-resistive barrier* complying with ASTM E2556, Type I. The individual layers shall be installed independently such that each layer provides a separate continuous plane. Flashing installed in accordance with Section R703.4 and intended to drain to the *water-resistive barrier* shall be directed between the layers.
2. The *water-resistive barrier* shall be 60-minute Grade D paper or have a water resistance equal to or greater than one layer of a water-resistive barrier complying with ASTM E2556, Type II. The *water-resistive barrier* shall be separated from the stucco by a layer of foam plastic *insulating sheathing* or other non-water-absorbing layer, or a designed drainage space.

**R703.7.3.2 Moist or marine climates.** In the Moist (A) or Marine (C) climate zones indicated in Figure N1101.7, *water-resistive barriers* shall comply with one of the following:

1. In addition to complying with Section R703.7.3.1, a space or drainage material not less than $^3/_{16}$ inch (5 mm) in depth shall be added to the exterior side of the *water-resistive barrier.*
2. In addition to complying with Section R703.7.3.1, Item 2, drainage on the exterior of the *water-resistive barrier* shall have a drainage efficiency of not less than 90 percent, as measured in accordance with ASTM E2273 or Annex A2 of ASTM E2925.

**R703.7.4 Application.** Each coat shall be kept in a moist condition for at least 48 hours prior to application of the next coat.

**Exception:** Applications installed in accordance with ASTM C926.

**R703.7.5 Curing.** The finish coat for two-coat cement plaster shall not be applied sooner than seven days after application of the first coat. For three-coat cement plaster, the second coat shall not be applied sooner than 48 hours after application of the first coat. The finish coat for three-coat cement plaster shall not be applied sooner than seven days after application of the second coat.

**R703.8 Anchored stone and masonry veneer, general.** Anchored stone and masonry veneer shall be installed in accordance with this chapter, Table R703.3(1) and Figures R703.8(1) and R703.8(2). These veneers installed over a backing of wood or cold-formed steel shall be limited to the first *story above grade plane* and shall not exceed 5 inches (127 mm) in thickness. See Section R602.10 for wall bracing requirements for masonry veneer for wood-framed construction and Section R603.9.5 for wall bracing requirements for masonry veneer for cold-formed steel construction.

**Exceptions:**

1. Exterior stone or masonry veneer, as specified in Table R703.8(1), with a backing of wood or steel framing shall be permitted to the height specified in Table R703.8(1) above a noncombustible foundation.
2. Deleted.

**TABLE R703.8(1)**

**STONE OR MASONRY VENEER LIMITATIONS AND REQUIREMENTS, WOOD OR STEEL FRAMING, SEISMIC DESIGN CATEGORIES A, B AND C**

| SEISMIC DESIGN CATEGORY | NUMBER OF WOOD- OR STEEL-FRAMED STORIES | MAXIMUM HEIGHT OF VENEER ABOVE NONCOMBUSTIBLE FOUNDATION[a] (feet) | MAXIMUM NOMINAL THICKNESS OF VENEER (inches) | MAXIMUM WEIGHT OF VENEER (psf)[b] | WOOD- OR STEEL-FRAMED STORY |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| A or B | Steel: 1 or 2<br>Wood: 1, 2 or 3 | 30 | 5 | 50 | all |
| C | 1 | 30 | 5 | 50 | 1 only |
| | 2 | 30 | 5 | 50 | top |
| | | | | | bottom |
| | Wood only: 3 | 30 | 5 | 50 | top |
| | | | | | middle |
| | | | | | bottom |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.479 kPa.

a. An additional 8 feet is permitted for gable end walls. See also story height limitations of Section R301.3.

b. Maximum weight is installed weight and includes weight of mortar, grout, lath and other materials used for installation. Where veneer is placed on both faces of a wall, the combined weight shall not exceed that specified in this table.

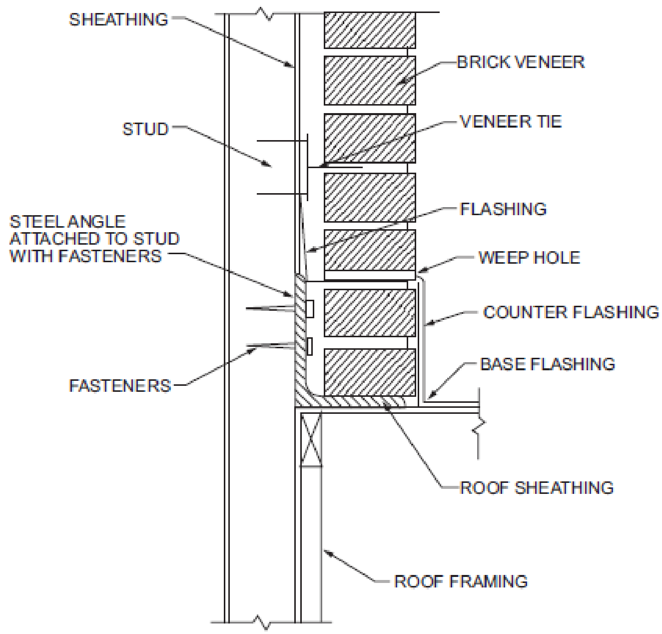
**R703.8.1 Interior veneer support.** Veneers used as interior wall finishes shall be permitted to be supported on wood or cold-formed steel floors that are designed to support the loads imposed.

**R703.8.2 Exterior veneer support.** Exterior masonry veneers having an installed weight of 40 pounds per square foot (195 kg/m2) or less shall be permitted to be supported on wood or cold-formed steel construction. Where masonry veneer supported by wood or cold-formed steel construction adjoins masonry veneer supported by the foundation, there shall be a movement joint between the veneer supported by the wood or cold-formed steel construction and the veneer supported by the foundation. The wood or cold-formed steel construction supporting the masonry veneer shall be designed to limit the deflection to $^{1}/_{600}$ of the span for the supporting members. The design of the wood or cold-formed steel construction shall consider the weight of the veneer and any other loads.

~~**R703.8.2.1 Support by steel angle.** A minimum 6-inch by 4-inch by $^{5}/_{16}$-inch (152 mm by 102 mm by 8 mm) steel angle, with the long leg placed vertically, shall be anchored to double 2-inch by 4-inch (51 mm by 102 mm) wood studs or double 350S162 cold-formed steel studs at a maximum on-center spacing of 16 inches (406 mm). Anchorage of the steel angle at every double stud spacing shall be not less than two $^{7}/_{16}$-inch-diameter (11 mm) by 4-inch (102 mm) lag screws for wood construction or two $^{7}/_{16}$-inch (11.1 mm) bolts with washers for cold-formed steel construction. The steel angle shall have a minimum clearance to underlying construction of $^{1}/_{16}$-inch (1.6 mm). Not less than two-thirds the width of the masonry veneer thickness shall bear on the steel angle. Flashing and weep holes shall be located in the masonry veneer in accordance with Figure R703.8.2.1. The maximum height of masonry veneer above the steel angle support shall be 12 feet 8 inches (3861 mm). The airspace separating the masonry veneer from the wood backing shall be in accordance with Sections R703.8.4 and R703.8.4.2. The method of support for the masonry veneer on wood construction shall be constructed in accordance with Figure R703.8.2.1.~~

**R703.8.2.1 Support by steel angle.** A minimum 6-inch by 4-inch by 5 / 16 -inch (152 mm by 102 mm by 8 mm) steel angle, with the long leg placed vertically, shall be anchored to double 2-inch by 4-inch (51 mm by 102 mm) wood studs at a maximum on-center spacing of 16 inches (406 mm) or shall be anchored to solid double 2x blocking firmly attached between single 2-inch by 4-inch (51 mm by 102 mm) wood studs at a maximum on center spacing of 16 inches (406 mm). Anchorage of the steel angle at every double stud spacing shall be not less than two 7 / 16 -inch-diameter (11 mm) by 4-inch (102 mm) lag screws for wood construction. The steel angle shall have a minimum clearance to underlying construction of 1 / 16 inch (1.6 mm). Not less than two-thirds the width of the masonry veneer thickness shall bear on the steel angle. Flashing and weep holes shall be located in the masonry veneer in accordance with Figure R703.8.2.1. The maximum height of masonry veneer above the steel angle support shall be 12 feet 8 inches (3861 mm). The airspace separating the masonry veneer from the wood backing shall be in accordance with Sections R703.8.4 and R703.8.4.2. The method of support for the masonry veneer on wood construction shall be constructed in accordance with Figure R703.8.2.1

The maximum slope of the roof construction without stops shall be 7:12. Roof construction with slopes greater than 7:12 but not more than 12:12 shall have stops of a minimum 3-inch by 3-inch by $^{1}/_{4}$-inch (76 mm by 76 mm by 6.4 mm) steel plate welded to the angle at 24 inches (610 mm) on center along the angle or as *approve*d by the *building official*.




SUPPORT BY STEEL ANGLE

**FIGURE R703.8.2.1**
**EXTERIOR MASONRY VENEER SUPPORT BY STEEL ANGLES**

**R703.8.2.2 Support by roof construction.** A steel angle shall be placed directly on top of the roof construction. The roof supporting construction for the steel angle shall consist of not fewer than three 2-inch by 6-inch (51 mm by 152 mm) wood members for wood construction or three 550S162 cold-formed steel members for cold-formed steel light frame construction. A wood member abutting the vertical wall stud construction shall be anchored with not fewer than three $^{5}/_{8}$-inch (15.9 mm) diameter by 5-inch (127 mm) lag screws to every wood stud spacing. Each additional wood roof member shall be anchored by the use of two 10d nails at every wood stud spacing. A cold-formed steel member abutting the vertical wall stud shall be anchored with not fewer than nine No. 8 screws to every cold-formed steel stud. Each additional cold-formed steel roof member shall be anchored to the adjoining roof member using two No. 8 screws at every stud spacing. Not less than two-thirds the width of the masonry veneer thickness shall bear on the steel angle. Flashing and weep holes shall be located in the masonry veneer wythe in accordance with Figure R703.8.2.2. The maximum height of the masonry veneer above the steel angle support shall be 12 feet 8 inches (3861 mm). The airspace separating the masonry veneer from the wood backing shall be in accordance with Sections R703.8.4 and R703.8.4.2. The support for the masonry veneer shall be constructed in accordance with Figure R703.8.2.2.

The maximum slope of the roof construction without stops shall be 7:12. Roof construction with slopes greater than 7:12 but not more than 12:12 shall have stops of a minimum 3-inch by 3-inch by $^{1}/_{4}$-inch (76 mm by 76 mm by 6.4 mm) steel plate welded to the angle at 24 inches (610 mm) on center along the angle or as *approved* by the *building official*.

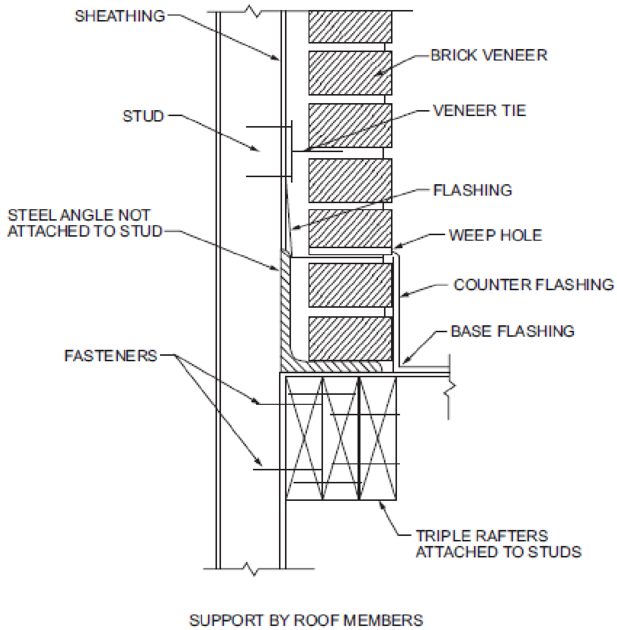


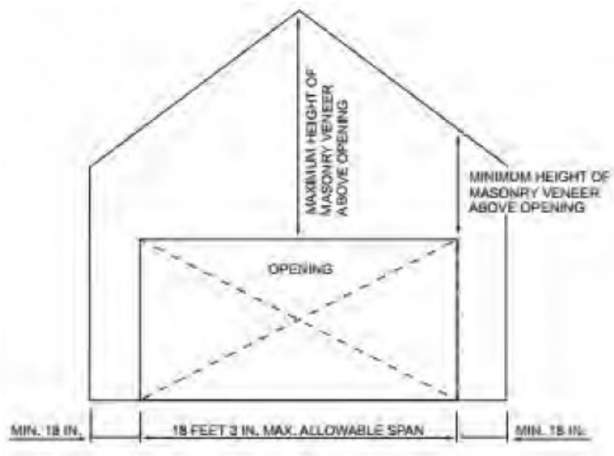

**FIGURE R703.8.2.2**
**EXTERIOR MASONRY VENEER SUPPORT BY ROOF MEMBERS**

**R703.8.3 Lintels.** Masonry veneer shall not support any vertical load other than the dead load of the veneer above. Veneer above openings shall be supported on lintels of *noncombustible materials*. The lintels shall have a length of bearing not less than 4 inches (102 mm). Steel lintels shall be shop coated with a rust-inhibitive paint, except for lintels made of corrosion-resistant steel or steel treated with coatings to provide corrosion resistance. Construction of openings shall comply with either Section R703.8.3.1 or 703.8.3.2.

**R703.8.3.1 Allowable span.** The allowable span shall not exceed the values set forth in Table R703.8.3.1.

**R703.8.3.2 Maximum span.** The allowable span shall not exceed 18 feet 3 inches (5562 mm) and shall be constructed to comply with Figure R703.8.3.2 and the following:

1. Provide a minimum length of 18 inches (457 mm) of masonry veneer on each side of opening as shown in Figure R703.8.3.2.
2. Provide a minimum 5-inch by $3^1/_2$-inch by $^5/_{16}$-inch (127 mm by 89 mm by 7.9 mm) steel angle above the opening and shore for a minimum of 7 days after installation.
3. Provide double-wire joint reinforcement extending 12 inches (305 mm) beyond each side of the opening. Lap splices of joint reinforcement not less than 12 inches (305 mm). Comply with one of the following:
    3.1. Double-wire joint reinforcement shall be $^3/_{16}$-inch (4.8 mm) diameter and shall be placed in the first two bed joints above the opening.
    3.2. Double-wire joint reinforcement shall be 9 gauge (0.144 inch or 3.66 mm diameter) and shall be placed in the first three bed joints above the opening.
4. Provide the height of masonry veneer above opening, in accordance with Table R703.8.3.2.




1 inch = 25.4 mm, 1 foot = 304.8 mm.

**FIGURE R703.8.3.2**
**MASONRY VENEER OPENING**

**TABLE R703.8.3.1**
**ALLOWABLE SPANS FOR LINTELS SUPPORTING MASONRY VENEER[a, b, c, d]**

| SIZE OF STEEL ANGLE[a, c, d] (inches) | NO STORY ABOVE | ONE STORY ABOVE | TWO STORIES ABOVE | NO. OF $^1/_2$-INCH OR EQUIVALENT REINFORCING BARS IN REINFORCED LINTEL[b, d] |
|---|---|---|---|---|
| $3 \times 3 \times {}^1/_4$ | 6′-0″ | 4′-6″ | 3′-0″ | 1 |
| $4 \times 3 \times {}^1/_4$ | 8′-0″ | 6′-0″ | 4′-6″ | 1 |
| $5 \times 3^1/_2 \times {}^5/_{16}$ | 10′-0″ | 8′-0″ | 6′-0″ | 2 |
| $6 \times 3^1/_2 \times {}^5/_{16}$ | 14′-0″ | 9′-6″ | 7′-0″ | 2 |
| $2\text{-}6 \times 3^1/_2 \times {}^5/_{16}$ | 20′-0″ | 12′-0″ | 9′-6″ | 4 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Long leg of the angle shall be placed in a vertical position.
b. Depth of reinforced lintels shall be not less than 8 inches and all cells of hollow masonry lintels shall be grouted solid. Reinforcing bars shall extend not less than 8 inches into the support.
c. Steel members indicated are adequate typical examples; other steel members meeting structural design requirements shall be permitted to be used.
d. Either steel angle or reinforced lintel shall span opening.
e. Span over 4 feet (1219 mm) shall be shored until cured.

**TABLE R703.8.3.2**
**HEIGHT OF MASONRY VENEER ABOVE OPENING**

| MINIMUM HEIGHT OF MASONRY VENEER ABOVE OPENING (inches) | MAXIMUM HEIGHT OF MASONRY VENEER ABOVE OPENING (feet) |
|---|---|
| 13 | < 5 |
| 24 | 5 to < 12 |

| | |
|---|---|
| 60 | 12 to height above support allowed by Section R703.8 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

**R703.8.4 Anchorage.** Masonry veneer shall be anchored to the supporting wall studs with corrosion-resistant metal ties embedded in mortar or grout and extending into the veneer a minimum of $1^{1}/_{2}$ inches (38 mm), with not less than $^{5}/_{8}$-inch (15.9 mm) mortar or grout cover to outside face. Masonry veneer shall conform to Table ~~R703.8.4~~ R703.8.4(1). Where the masonry veneer tie attachment is fastened to wood structural panel not less than 7/16 performance category through insulating sheathing not greater than 2 inches (51 mm) in thickness, see Table R703.8.4(2). Where Table R703.8.4(2) is used, attachment to the studs behind the sheathing is not required.

**TABLE R703.8.4(1)**
**TIE ATTACHMENT AND AIRSPACE REQUIREMENTS**

| BACKING AND TIE | MINIMUM TIE | MINIMUM TIE FASTENER[a] | AIRSPACE[b] | |
|---|---|---|---|---|
| Wood stud backing with corrugated sheet metal | 22 U.S. gage (0.0299 in.) × $^{7}/_{8}$ in. wide | 8d common nail[c] ($2^{1}/_{2}$ in. × 0.131 in.) | Nominal 1 in. between sheathing and veneer | |
| Wood stud backing with adjustable metal strand wire | W1.7 (No. 9 U.S. gage; 0.148 in. dia.) with hook embedded in mortar joint[d] | 8d common nail[c] ($2^{1}/_{2}$ in. × 0.131 in.) | Minimum nominal 1 in. between sheathing and veneer | Maximum ~~4 ½~~ $4^{5}/_{8}$ in. between backing and veneer |
| Wood stud backing with adjustable metal strand wire | W2.8 (0.187 in. dia.) with hook embedded in mortar joint[e, f] | 8d common nail[c] ($2^{1}/_{2}$ in. × 0.131 in.) | Greater than $4^{5}/_{8}$ in. between backing and veneer | Maximum $6^{5}/_{8}$ in. between backing and veneer |

For SI: 1 inch = 25.4 mm.

a. All fasteners shall have rust-inhibitive coating suitable for the installation in which they are being used, or be manufactured from material not susceptible to corrosion.
b. An airspace that provides drainage shall be permitted to contain mortar from construction.
c. Deleted.
d. Adjustable tie pintles shall include not fewer than 1 pintle leg of wire size W2.8 (MW18) with a maximum offset of $1^{1}/_{4}$ inches.
e. Adjustable tie pintles shall include not fewer than 2 pintle legs with a maximum offset of $1^{1}/_{4}$ inches. Distance between inside face of brick and end of pintle shall be a maximum of 2 inches.
f. Adjustable tie backing attachment components shall consist of one of the following: eyes with minimum wire W2.8 (MW18), barrel with minimum $^{1}/_{4}$-inch outside diameter, or plate with minimum thickness of 0.074 inch and minimum width of $1^{1}/_{4}$ inches.

**TABLE R703.8.4(2)**
**REQUIRED BRICK TIE SPACING FOR DIRECT APPLICATION TOWOOD STRUCTURAL PANEL SHEATHING[a, b, c]**

| FASTENER TYPE[d] | SIZE (DIA. OR SCREW #) | REQUIRED BRICK-TIE SPACING (VERTICAL-TIE SPACING/HORIZONTAL-TIE SPACING) (inches/inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 110 mph $V_{ult}$ | | | 115 mph $V_{ult}$ | | | 130 mph $V_{ult}$ | | | 140 mph $V_{ult}$ | | |
| | | Zone 5, Exposure B | Zone 5, Exposure C | Zone 5, Exposure D | Zone 5, Exposure B | Zone 5, Exposure C | Zone 5, Exposure D | Zone 5, Exposure B | Zone 5, Exposure C | Zone 5, Exposure D | Zone 5, Exposure B | Zone 5, Exposure C | Zone 5, Exposure D |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ring Shank Nails | 0.091 | 16/16, 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 | 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 | 12/12 | 16/12, 12/16, 12/12 | 12/12 | — | 12/12 | — | — |
| | 0.148 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 | 12/12 |
| Screws | #6 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 | 12/12 |
| | #8 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 |
| | #10 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/12, 12/16, 12/12 |
| | #14 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 24/16, 16/24, 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 | 16/16, 16/12, 12/16, 12/12 |

For SI: 1 inch = 25.4 mm, 1 mph = 0.447 m/s.

a. This table is based on attachment of brick ties directly to wood structural panel sheathing only. Additional attachment of the brick tie to lumber framing is not required. The brick ties shall be permitted to be placed over any insulating sheathing, not to exceed 2 inches in thickness. Wood structural panel sheathing shall be a minimum 7/16 performance category. The table is based on a building height of 30 feet or less.

b. Wood structural panels shall have a specific gravity of 0.42 or greater in accordance with NDS.

c. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C578 or ASTM C1289.

d. Fasteners shall be sized such that the tip of the fastener passes completely through the wood structural panel sheathing by not less than $^1/_4$ inch.

**R703.8.4.1 Size and spacing.** Veneer ties, if strand wire, shall be not less in thickness than No. 9 U.S. gage [(0.148 inch) (4 mm)] wire and shall have a hook embedded in the mortar joint, or if sheet metal, shall be not less than No. 22 U.S. gage by [(0.0299 inch) (0.76 mm)] $^7/_8$ inch (22 mm) corrugated. Each tie shall support not more than 2.67 square feet (0.25 $m^2$) of wall area and shall be spaced not more than 32 inches (813 mm) on center horizontally and 24 inches (635 mm) on center vertically.

**Exception:** In townhouses in Seismic Design Category C or in wind areas of more than 30 pounds per square foot pressure (1.44 kPa), each tie shall support not more than 2 square feet (0.2 $m^2$) of wall area.

**R703.8.4.1.1 Veneer ties around wall openings.** Additional metal ties shall be provided around wall openings greater than 16 inches (406 mm) in either dimension. Metal ties around the perimeter of openings shall be spaced not more than 3 feet (9144 mm) on center and placed within 12 inches (305 mm) of the wall opening.

**R703.8.4.2 Grout fill.** As an alternative to the airspace required by Table R703.8.4(1), grout shall be permitted to fill the airspace. Where the airspace is filled with grout, a *water-resistive barrier* is required over studs or sheathing. Where the airspace is filled, replacing the sheathing and *water-resistive barrier* with a wire mesh and *approved water-resistive barrier* or an *approved water-resistive barrier*-backed reinforcement attached directly to the studs is permitted.

**R703.8.5 Flashing.** Flashing of 6 mil (0.152 mm) poly or other corrosion-resistant material shall be located beneath the first course of masonry above finished ground level above the foundation wall or slab and at other points of support, including structural floors, shelf angles and lintels where masonry veneers are designed in accordance with Section R703.8. Top of base flashing shall be installed with a minimum 2-inch (51 mm) lap behind building paper or water repellant sheathing. See Section R703.4 for additional requirements.

**R703.8.6 Weepholes.** Weepholes shall be provided in the outside wythe of masonry walls at a maximum spacing of 48 inches (1219 mm) on center. Weepholes shall be not less than $^{3}/_{16}$ inch (5 mm) in diameter. Weepholes shall be located immediately above the flashing.

**R703.9 Exterior insulation and finish system (EIFS)/EIFS with drainage.** Exterior insulation and finish systems (EIFS) shall comply with this chapter and Section R703.9.1. EIFS with drainage shall comply with this chapter and Section R703.9.2.

**R703.9.1 Exterior insulation and finish systems (EIFS).** EIFS shall comply with the following:

Non-drainable EIFS shall not be permitted.

**R703.9.2 Exterior insulation and finish system (EIFS) with drainage.** EIFS with drainage shall comply with the following:

1. ASTM E2568.
2. EIFS with drainage shall be required over all wall assemblies with the exception of substrates of concrete or masonry wall assemblies.
3. EIFS with drainage shall have an average minimum drainage efficiency of 90 percent when tested in accordance with ASTM E2273.
4. The *water-resistive barrier* shall comply with Section R703.2 or ASTM E2570.
5. The *water-resistive barrier* shall be applied between the EIFS and the wall sheathing.
6. Flashing of EIFS with drainage shall be provided in accordance with the requirements of Section R703.4.
7. EIFS with drainage shall be installed in accordance with the manufacturer's instructions.
8. EIFS with drainage shall terminate not less than 6 inches (152 mm) above the finished ground level.
9. Decorative *trim* shall not be face-nailed through the EIFS with drainage.

**R703.10 Fiber cement siding.**

**R703.10.1 Panel siding.** Fiber-cement panels shall comply with the requirements of ASTM C1186, Type A, minimum Grade II or ISO 8336, Category A, minimum Class 2. Panels shall be installed with the long dimension either parallel or perpendicular to framing. Vertical and horizontal joints shall occur over framing members and shall be protected with caulking, or with battens or flashing, or be vertical or horizontal shiplap, or otherwise designed to comply with Section R703.1. Panel siding shall be installed with fasteners in accordance with Table R703.3(1) or the approved manufacturer's instructions.

**R703.10.2 Lap siding.** Fiber-cement lap siding having a maximum width of 12 inches (305 mm) shall comply with the requirements of ASTM C1186, Type A, minimum Grade II or ISO 8336, Category A, minimum Class 2. Lap siding shall be lapped a minimum of $1^{1}/_{4}$ inches (32 mm) and lap siding not having tongue-and-groove end joints shall have the ends protected with caulking, covered with an H-section joint cover, located over a strip of flashing, or shall be designed to comply with Section R703.1. Lap siding courses shall be installed with the fastener heads exposed or concealed, in accordance with Table R703.3(1) or approved manufacturer's instructions.

**R703.11 Vinyl siding.** Vinyl siding shall be certified and *labeled* as conforming to the requirements of ASTM D3679 by an *approved* quality control agency.

**R703.11.1 Installation.** Vinyl siding, soffit and accessories shall be installed in accordance with the manufacturer's instructions.

**R703.11.1.1 Fasteners.** Deleted.

**R703.11.1.2 Penetration depth.** Deleted.

**R703.11.1.3 Spacing.** Deleted.

~~**R703.11.1.4 Vinyl soffit panels.** Soffit panels shall be individually fastened to a supporting component such as a nailing strip, fascia or subfascia component or as specified by the manufacturer's instructions.~~

**R703.11.2 Installation over foam plastic sheathing.** Where vinyl siding ~~and~~ or *insulated vinyl siding* ~~used with~~ is installed over foam plastic sheathing ~~shall be installed in accordance~~, the vinyl siding shall comply with ~~Section R703.11.2.1, R703.11.2.2 or R703.11.2.3~~ Section R703.11 ~~and shall have a wind load design pressure rating in accordance with Table R703.11.2.~~

**Exceptions:**

1. Where the foam plastic sheathing is applied directly over *wood structural panels*, fiberboard, gypsum sheathing or other *approved* backing capable of independently resisting the design wind pressure, the vinyl siding shall be installed in accordance with ~~Section R703.11.1~~ Sections R703.3.3 and R703.11.1.
2. Deleted.
3. Deleted.

~~**R703.11.2.1 Basic wind speed not exceeding 115 miles per hour and Exposure Category B.**~~

~~Where the ultimate design wind speed does not exceed 115 miles per hour (51 m/s), the exposure category is B and gypsum board, gypsum panel product or equivalent is installed on the side of the wall opposite the foam plastic sheathing, the minimum siding fastener penetration into wood framing shall be 11/4 inches (32 mm) using minimum 0.120-inch-diameter (3 mm) nail (shank) with a minimum 0.313-inch-diameter head, 16 inches (406 mm) on center. The foam plastic sheathing shall be minimum ½ -inch-thick (12.7 mm) (nominal) extruded polystyrene in accordance with ASTM C 578,1/2-inch-thick (12.7 mm) (nominal) polyisocyanurate in accordance with ASTM C 1289 or 1-inch-thick (25 mm) (nominal) expanded polystyrene in accordance with ASTM C 578.~~

~~**R703.11.2.2 Basic wind speed exceeding 115 miles per hour or Exposure Categories C and D.**~~

~~Where the ultimate design wind speed exceeds 115 miles per hour (51 m/s), the exposure category is C or D, or all conditions of Section R703.11.2.1 are not met, the adjusted design pressure rating for the assembly shall meet or exceed the loads listed in Table R301.2(2) adjusted for height and exposure using Table R301.2(3). The design wind pressure rating of the vinyl siding for installation over solid sheathing as provided in the vinyl siding manufacturer's product specifications shall be adjusted for the following wall assembly conditions:~~

~~1. For wall assemblies with foam plastic sheathing on the exterior side and gypsum wall board, gypsum panel product or equivalent on the interior side of the wall, the vinyl siding's design wind pressure rating shall be multiplied by 0.39.~~

~~2. For wall assemblies with foam plastic sheathing on the exterior side and without gypsum wall board, gypsum panel product or equivalent on the interior side of wall, the vinyl siding's design wind pressure rating shall be multiplied by 0.27.~~

~~**R703.11.2.3 Manufacturer specification.**~~

~~Where the vinyl siding manufacturer's product specifications provide an approved design wind pressure rating for installation over foam plastic sheathing, use of this design wind pressure rating shall be permitted and the siding shall be installed in accordance with the manufacturer's instructions.~~

**R703.12 Adhered masonry veneer installation.** Adhered masonry veneer shall comply with the requirements of Section R703.7.3 and the requirements in Sections 12.1 and 12.3 of TMS 402~~/ACI 530/ASCE 5~~. Adhered masonry veneer shall be installed in accordance with Section R703.7.1, Article 3.3C of TMS 602~~/ACI 530.1/ASCE 6~~ or the manufacturer's instructions.

**R703.12.1 Clearances.** On exterior stud walls, adhered masonry veneer shall be installed:

1. Minimum of 4 inches (102 mm) above the earth;
2. Minimum of 2 inches (51 mm) above paved areas; or
3. Minimum of $^{1}/_{2}$ inch (12.7 mm) above exterior walking surfaces that are supported by the same foundation that supports the exterior wall.

**R703.12.2 Flashing at foundation.** A corrosion-resistant screed or flashing of a minimum 0.019-inch (0.48 mm) or 26-gage galvanized or plastic with a minimum vertical attachment flange of $3^{1}/_{2}$ inches (89 mm) shall be installed to extend a minimum of 1 inch (25 mm) below the foundation plate line on exterior stud walls in accordance with Section R703.4.

**R703.12.3 Water-resistive barrier.** A *water-resistive barrier* shall be installed as required by Section R703.2 and shall comply with the requirements of Section R703.7.3. The *water-resistive barrier* shall lap over the exterior of the attachment flange of the screed or flashing provided in accordance with Section R703.12.2.

**R703.13 Insulated vinyl siding.** *Insulated vinyl siding* shall be certified and *labeled* as conforming to the requirements of ASTM D7793 by an *approved* quality control agency.

**R703.13.1 Insulated vinyl siding and accessories.** *Insulated vinyl siding* and accessories shall be installed in accordance with <u>the</u> manufacturer's <u>installation</u> instructions.

**R703.14 Polypropylene siding.** *Polypropylene siding* shall be certified and *labeled* as conforming to the requirements of ASTM D7254, <u>and those of Section R703.14.2 or Section R703.14.3, by an *approved* quality control agency.</u>

**R703.14.1 Polypropylene siding and accessories.** *Polypropylene siding* and accessories shall be installed in accordance with manufacturer's installation instructions.

**R703.14.1.1 Installation.** *Polypropylene siding* shall be installed over and attached to wood structural panel sheathing with minimum thickness of $^{7}/_{16}$ inch (11.1 mm), or other substrate, composed of wood or wood-based material and fasteners having equivalent withdrawal resistance.

**R703.14.1.2 Fastener requirements.** Unless otherwise specified in the approved manufacturer's instructions, nails shall be corrosion resistant, with a minimum 0.120-inch (3 mm) shank and minimum 0.313-inch (8 mm) head diameter. Nails shall be a minimum of $1^{1}/_{4}$ inches (32 mm) long or as necessary to penetrate sheathing or substrate not less than $^{3}/_{4}$ inch (19.1 mm). Where the nail fully penetrates the sheathing or *nailable substrate*, the end of the fastener shall extend not less than $^{1}/_{4}$ inch (6.4 mm) beyond the opposite face of the sheathing or substrate. Staples are not permitted.

**R703.14.2 Fire separation.** *Polypropylene siding* shall not be installed on walls with a *fire separation distance* of less than 5 feet (1524 mm) and walls closer than 10 feet (3048 mm) to a building on another lot.

**Exception:** Walls perpendicular to the line used to determine the *fire separation distance*.

<u>**R703.14.3 Flame spread index.** The certification of the flame spread index shall be accompanied by a test report stating that all portions of the test specimen ahead of the flame front remained in position during the test in accordance with ASTM E84 or UL 723.</u>

**R703.15 Cladding attachment over foam sheathing to wood framing.** Cladding shall be specified and installed in accordance with Section R703, the cladding manufacturer's approved instructions, including any limitations for use over foam plastic sheathing, or an *approved* design. In addition, the cladding or furring attachments through foam sheathing to framing shall meet or exceed the minimum fastening requirements of Section R703.15.1, Section R703.15.2, or an *approved* design for support of cladding weight.

**Exceptions:**

1. Where the cladding manufacturer has provided *approved* installation instructions for application over foam sheathing, those requirements shall apply.
2. For exterior insulation and finish systems, refer to Section R703.9.
3. For anchored masonry or stone veneer installed over foam sheathing, refer to Section ~~R703.7~~ <u>R703.8</u>.

**R703.15.1 Direct attachment.** Where cladding is installed directly over foam sheathing without the use of furring, cladding minimum fastening requirements to support the cladding weight shall be as specified in Table R703.15.1.

**R703.15.2 Furred cladding attachment.** Where wood furring is used to attach cladding over foam sheathing, furring minimum fastening requirements to support the cladding weight shall be as specified in Table R703.15.2. Where placed horizontally, wood furring shall be preservative-treated wood in accordance with Section R317.1 or *naturally durable wood* and fasteners shall be corrosion resistant in accordance Section R317.3.

**TABLE R703.15.1**
**CLADDING MINIMUM FASTENING REQUIREMENTS FOR DIRECT ATTACHMENT OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a]**

| CLADDING FASTENER THROUGH FOAD SHEATHING | CLADDING FASTENER TYPE AND MINIMUM SIZE[b] | CLADDING FASTENER VERTICAL SPACING (inches) | MAXIMUM THICKNESS OF FOAM SHEATHING[c] (inches) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 16″ o.c. Fastener Horizontal Spacing | | | 24″ o.c. Fastener Horizontal Spacing | | |
| | | | Cladding Weight: | | | Cladding Weight: | | |
| | | | 3 psf | 11 psf | 25 psf | 3 psf | 11 psf | 25 psf |
| Wood Framing (minimum $1^1/_4$-inch penetration) | 0.113″ diameter nail | 6 | 2 | 1 | DR | 2 | 0.75 | DR |
| | | 8 | 2 | 1 | DR | 2 | 0.5 | DR |
| | | 12 | 2 | 0.5 | DR | 2 | DR | DR |
| | 0.120″ diameter nail | 6 | 3 | 1.5 | 0.5 | 3 | 0.75 | DR |
| | | 8 | 3 | 1 | DR | 3 | 0.5 | DR |
| | | 12 | 3 | 0.5 | DR | 2 | DR | DR |
| | 0.131″ diameter nail | 6 | 4 | 2 | 0.75 | 4 | 1 | DR |
| | | 8 | 4 | 1.5 | 0.5 | 4 | 0.75 | DR |
| | | 12 | 4 | 0.75 | DR | 2 | 0.5 | DR |
| | 0.162″ diameter nail | 6 | 4 | 4 | 1.5 | 4 | 2 | 1 |
| | | 8 | 4 | 3 | 1 | 4 | 1.5 | 0.75 |
| | | 12 | 4 | 2 | 0.75 | 4 | 1 | DR |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.
DR = Design required.
o.c. = On center.
a. Wood framing shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.
b. Nail fasteners shall comply with ASTM F1667, except nail length shall be permitted to exceed ASTM F1667 standard lengths.
c. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C578 or ASTM C1289.

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**TABLE R703.15.1**
**CLADDING MINIMUM FASTENING REQUIREMENTS FOR DIRECT ATTACHMENT OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a]**

| CLADDING FASTENER THROUGH FOAM SHEATHING[b] | CLADDING FASTENER TYPE AND MINIMUM SIZE[c] | CLADDING FASTENER VERTICAL SPACING (inches) | MAXIMUM THICKNESS OF FOAM SHEATHING[d] (inches) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 16″ o.c. Fastener Horizontal Spacing | | | | | 24″ o.c. Fastener Horizontal Spacing | | | | |
| | | | Cladding Weight: | | | | | Cladding Weight: | | | | |
| | | | 3 psf | 11 psf | 15 psf | 18 psf | 25 psf | 3 psf | 11 psf | 15 psf | 18 psf | 25 psf |
| Wood framing (minimum $1^1/_4$-inch penetration) | 0.113″ diameter nail | 6 | 2.00 | 1.45 | 1.00 | 0.75 | DR | 2.00 | 0.85 | 0.55 | DR | DR |
| | | 8 | 2.00 | 1.00 | 0.65 | DR | DR | 2.00 | 0.55 | DR | DR | DR |
| | | 12 | 2.00 | 0.55 | DR | DR | DR | 1.85 | DR | DR | DR | DR |
| | 0.120″ diamete rnail | 6 | 3.00 | 1.70 | 1.15 | 0.90 | 0.55 | 3.00 | 1.05 | 0.65 | 0.50 | DR |
| | | 8 | 3.00 | 1.20 | 0.80 | 0.60 | DR | 3.00 | 0.70 | DR | DR | DR |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12 | 3.00 | 0.70 | DR | DR | DR | 2.15 | DR | DR | DR | DR |
| | 0.131″ diameter nail | 6 | 4.00 | 2.15 | 1.50 | 1.20 | 0.75 | 4.00 | 1.35 | 0.90 | 0.70 | DR |
| | | 8 | 4.00 | 1.55 | 1.05 | 0.80 | DR | 4.00 | 0.90 | 0.55 | DR | DR |
| | | 12 | 4.00 | 0.90 | 0.55 | DR | DR | 2.70 | 0.50 | DR | DR | DR |
| | 0.162″ diameter nail | 6 | 4.00 | 3.55 | 2.50 | 2.05 | 1.40 | 4.00 | 2.25 | 1.55 | 1.25 | 0.80 |
| | | 8 | 4.00 | 2.55 | 1.80 | 1.45 | 0.95 | 4.00 | 1.60 | 1.10 | 0.85 | 0.50 |
| | | 12 | 4.00 | 1.60 | 1.10 | 0.85 | 0.50 | 4.00 | 0.95 | 0.60 | DR | DR |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.

DR = Design Required.

o.c. = On Center.

a. Wood framing shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.

b. The thickness of wood structural panels complying with the specific gravity requirement of Note a shall be permitted to be included in satisfying the minimum penetration into framing. For cladding connections to wood structural panels, refer to Table R703.3.3. For brick veneer tie connections to wood structural panels, refer to Table R703.8.4(2).

c. Nail fasteners shall comply with ASTM F1667, except nail length shall be permitted to exceed ASTM F1667 standard lengths.

d. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C578 or ASTM C1289.

**TABLE R703.15.2**
**FURRING MINIMUM FASTENING REQUIREMENTS FOR APPLICATION OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a, b]**

| FURRING MATERIAL | FRAMING MEMBER | FASTENER TYPE AND MINIMUM SIZE | MINIMUM PENETRATION INTO WALL FRAMING (inches) | FASTENER SPACING IN FURRING (inches) | MAXIMUM THICKNESS OF FOAM SHEATHING[d] (inches) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 16" o.c. Furring[e] | | | 24" o.c. Furring[e] | | |
| | | | | | Siding Weight: | | | Siding Weight: | | |
| | | | | | 3 psf | 11 psf | 25 psf | 3 psf | 11 psf | 25 psf |
| Minimum 1× Wood Furring[c] | Minimum 2× Wood Stud | 0.131″ diameter nail | $1^1/_4$ | 8 | 4 | 2 | 1 | 4 | 1.5 | DR |
| | | | | 12 | 4 | 1.5 | DR | 3 | 1 | DR |
| | | | | 16 | 4 | 1 | DR | 3 | 0.5 | DR |
| | | 0.162″ diameter nail | $1^1/_4$ | 8 | 4 | 4 | 1.5 | 4 | 2 | 0.75 |
| | | | | 12 | 4 | 2 | 0.75 | 4 | 1.5 | DR |
| | | | | 16 | 4 | 1.5 | DR | 4 | 1 | DR |
| | | No.10 wood screw | 1 | 12 | 4 | 2 | 0.75 | 4 | 1.5 | DR |
| | | | | 16 | 4 | 1.5 | DR | 4 | 1 | DR |
| | | | | 24 | 4 | 1 | DR | 3 | DR | DR |
| | | $^1/_4$″ lag screw | $1^1/_2$ | 12 | 4 | 3 | 1 | 4 | 2 | 0.5 |
| | | | | 16 | 4 | 1.5 | DR | 4 | 1.5 | DR |
| | | | | 24 | 4 | 1.5 | DR | 4 | 0.75 | DR |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.

DR = Design required.

o.c. = On center.

a. Wood framing and furring shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.

b. Nail fasteners shall comply with ASTM F1667, except nail length shall be permitted to exceed ASTM F1667 standard lengths.

c. Where the required cladding fastener penetration into wood material exceeds $^3/_4$ inch and is not more than $1^1/_2$ inches, a minimum 2× wood furring or an approved design shall be used.

d. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C578 or ASTM C1289.

e. Furring shall be spaced not more than 24 inches on center, in a vertical or horizontal orientation. In a vertical orientation, furring shall be located over wall studs and attached with the required fastener spacing. In a horizontal orientation, the indicated 8-inch and 12-inch fastener spacing in furring shall be achieved by use of two fasteners into studs at 16 inches and 24 inches on center, respectively.

**TABLE R703.15.2**

**FURRING MINIMUM FASTENING REQUIREMENTS FOR APPLICATION OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a, b]**

| | | | | | |
|---|---|---|---|---|---|
| | | | | | MAXIMUM THICKNESS OF FOAM SHEATHING[e] (inches) |

| FURRING MATERIAL | FRAMING MEMBER | FASTENER TYPE AND MINIMUM SIZE | MINIMUM PENETRATION INTO WALL FRAMING (inches)[c] | FASTENER SPACING IN FURRING (inches) | 16″ o.c. Furring[f] | | | | | 24″ o.c. Furring[f] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Siding Weight: | | | | | Siding Weight: | | | | |
| | | | | | 3 psf | 11 psf | 15 psf | 18 psf | 25 psf | 3 psf | 11 psf | 15 psf | 18 psf | 25 psf |
| Minimum 1× wood furring[d] | Minimum 2× wood stud | 0.131″ diameter nail | $1^{1}/_{4}$ | 8 | 4.00 | 2.45 | 1.75 | 1.45 | 0.95 | 4.00 | 1.60 | 1.10 | 0.85 | DR |
| | | | | 12 | 4.00 | 1.60 | 1.10 | 0.85 | DR | 4.00 | 0.95 | 0.55 | DR | DR |
| | | | | 16 | 4.00 | 1.10 | 0.70 | DR | DR | 3.05 | 0.60 | DR | DR | DR |
| | | 0.162″ diameter nail | $1^{1}/_{4}$ | 8 | 4.00 | 4.00 | 3.05 | 2.45 | 1.60 | 4.00 | 2.75 | 1.85 | 1.45 | 0.85 |
| | | | | 12 | 4.00 | 2.75 | 1.85 | 1.45 | 0.85 | 4.00 | 1.65 | 1.05 | 0.75 | DR |
| | | | | 16 | 4.00 | 1.90 | 1.25 | 0.95 | DR | 4.00 | 1.05 | 0.60 | DR | DR |
| | | No.10 wood screw | 1 | 12 | 4.00 | 2.30 | 1.60 | 1.20 | 0.70 | 4.00 | 1.40 | 0.85 | 0.60 | DR |
| | | | | 16 | 4.00 | 1.65 | 1.05 | 0.75 | DR | 4.00 | 0.90 | DR | DR | DR |
| | | | | 24 | 4.00 | 0.90 | DR | DR | DR | 2.85 | DR | DR | DR | DR |
| | | $^{1}/_{4}$″ lag screw | $1^{1}/_{2}$ | 12 | 4.00 | 2.65 | 1.90 | 1.50 | 0.90 | 4.00 | 1.65 | 1.05 | 0.80 | DR |
| | | | | 16 | 4.00 | 1.95 | 1.25 | 0.95 | 0.50 | 4.00 | 1.10 | 0.65 | DR | DR |
| | | | | 24 | 4.00 | 1.10 | 0.65 | DR | DR | 3.25 | 0.50 | DR | DR | DR |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.

DR = Design Required.

o.c. = On Center.

a. Wood framing and furring shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.

b. Nail fasteners shall comply with ASTM F1667, except nail length shall be permitted to exceed ASTM F1667 standard lengths.

c. The thickness of wood structural panels complying with the specific gravity requirements of Note a shall be permitted to be included in satisfying the minimum required penetration into framing.

d. Where the required cladding fastener penetration into wood material exceeds $^{3}/_{4}$ inch and is not more than $1^{1}/_{2}$ inches, a minimum 2× wood furring or an *approved* design shall be used.

e. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C578 or ASTM C1289.

f. Furring shall be spaced not more than 24 inches on center, in a vertical or horizontal orientation. In a vertical orientation, furring shall be located over wall studs and attached with the required fastener spacing. In a horizontal orientation, the indicated 8-inch and 12-inch fastener spacing in furring shall be achieved by use of two fasteners into studs at 16 inches and 24 inches on center, respectively.

**R703.16 Cladding attachment over foam sheathing to cold-formed steel framing.** Deleted.

**R703.17 Cladding attachment over foam sheathing to masonry or concrete wall construction.** Cladding shall be specified and installed in accordance with Section 703.3 and the cladding manufacturer's instructions or an *approved* design. Foam sheathing shall be attached to masonry or concrete construction in accordance with the insulation manufacturer's installation instructions or an *approved* design. Furring and furring attachments through foam sheathing into concrete or masonry substrate shall be designed to resist design loads determined in accordance with Section R301, including support of cladding weight as applicable. Fasteners used to attach cladding or furring through foam sheathing to masonry or concrete substrates shall be *approved* for application into masonry or concrete material and shall be installed in accordance with the fastener manufacturer's instructions.

**Exceptions:**

1. Where the cladding manufacturer has provided approved installation instructions for application over foam sheathing and connection to a masonry or concrete substrate, those requirements shall apply.
2. For exterior insulation and finish systems, refer to Section R703.9.
3. For anchored masonry or stone veneer installed over foam sheathing, refer to Section ~~R703.~~7 R703.8.

## SECTION R704
## SOFFITS

**R704.1 General wind limitations.** Where the design wind pressure is 30 pounds per square foot (1.44 kPa) or less, soffits shall comply with Section R704.2. Where the design wind pressure exceeds 30 pounds per square foot (1.44 kPa), soffits shall comply with Section R704.3. The design wind pressure on soffits shall be determined using the component and cladding loads specified in Table R301.2.1(1) for walls using an effective wind area of 10 square feet (0.93 $m^2$) and adjusted for height and exposure in accordance with Table R301.2.1(2).

**R704.2 Soffit installation where the design wind pressure is 30 psf or less.** Where the design wind pressure is 30 pounds per square foot (1.44 kPa) or less, soffit installation shall comply with Section R704.2.1, R704.2.2, R704.2.3 or R704.2.4. Soffit materials not addressed in Sections R704.2.1 through R704.2.4 shall be in accordance with the manufacturer's installation instructions.

**R704.2.1 Vinyl soffit panels.** Vinyl soffit panels shall be installed using fasteners specified by the manufacturer and shall be fastened at both ends to a supporting component such as a nailing strip, fascia or subfascia component in accordance with Figure R704.2.1(1). Where the unsupported span of soffit panels is greater than 16 inches (406 mm), intermediate nailing strips shall be provided in accordance with Figure R704.2.1(2). Vinyl soffit panels shall be installed in accordance with the manufacturer's installation instructions. Fascia covers shall be installed in accordance with the manufacturer's installation instructions.

**R704.2.2 Fiber-cement soffit panels.** Fiber-cement soffit panels shall be a minimum of $^1/_4$ inch (6.4 mm) in thickness and shall comply with the requirements of ASTM C1186, Type A, minimum Grade II, or ISO 8336, Category A, minimum Class 2. Panel joints shall occur over framing or over wood structural panel sheathing. Soffit panels shall be installed with spans and fasteners in accordance with the manufacturer's installation instructions.

**R704.2.3 Hardboard soffit panels.** Hardboard soffit panels shall be not less than $^7/_{16}$ inch (11.11 mm) in thickness and shall be fastened to framing or nailing strips with $2^1/_2$-inch by 0.113-inch (64 mm by 2.9 mm) siding nails spaced not more than 6 inches (152 mm) on center at panel edges and 12 inches (305 mm) on center at intermediate supports.

**R704.2.4 Wood structural panel soffit.** The minimum nominal thickness for wood structural panel soffits shall be $^3/_8$ inch (9.5 mm) and shall be fastened to framing or nailing strips with 2-inch by 0.099-inch (51 mm by 2.5 mm) nails. Fasteners shall be spaced not less than 6 inches (152 mm) on center at panel edges and 12 inches (305 mm) on center at intermediate supports.

**R704.3 Soffit installation where the design wind pressure exceeds 30 psf.** Where the design wind pressure is greater than 30 psf, soffit installation shall comply with Section R704.3.1, R704.3.2, R704.3.3 or R704.3.4. Soffit materials not addressed in Sections R704.3.1 through R704.3.4 shall be in accordance with the manufacturer's installation instructions.

**R704.3.1 Vinyl soffit panels.** Vinyl soffit panels and their attachments shall be capable of resisting wind loads specified in Table R301.2.1(1) for walls using an effective wind area of 10 square feet (0.929 $m^2$) and adjusted for height and exposure in accordance with Table R301.2.1(2). Vinyl soffit panels shall be installed using fasteners specified by the manufacturer and shall be fastened at both ends to a supporting component such as a nailing strip, fascia or subfascia component in accordance with Figure R704.2.1(1). Where the unsupported span of soffit panels is greater than 12 inches (305 mm), intermediate nailing strips shall be provided in accordance with Figure R704.2.1(2). Vinyl soffit panels shall be installed in accordance with the manufacturer's installation instructions. Fascia covers shall be installed in accordance with the manufacturer's installation instructions.

**R704.3.2 Fiber-cement soffit panels.** Fiber-cement soffit panels shall comply with Section R704.2.2 and shall be capable of resisting wind loads specified in Table R301.2.1(1) for walls using an effective wind area of 10 square feet (0.929 $m^2$) and adjusted for height and exposure in accordance with Table R301.2.1(2).

**R704.3.3 Hardboard soffit panels.** Hardboard soffit panels shall comply with the manufacturer's installation instructions and shall be capable of resisting wind loads specified in Table R301.2.1(1) for walls using an effective wind area of 10 square feet (0.929 $m^2$) and adjusted for height and exposure in accordance with Table R301.2.1(2).

**R704.3.4 Wood structural panel soffit.** Wood structural panel soffits shall be capable of resisting wind loads specified in Table R301.2.1(1) for walls using an effective wind area of 10 square feet (0.929 $m^2$) and adjusted for height and exposure in accordance with Table R301.2.1(2). Alternatively, wood structural panel soffits shall be installed in accordance with Table R704.3.4.

**TABLE R704.3.4**

**PRESCRIPTIVE ALTERNATIVE FOR WOOD STRUCTURAL PANEL SOFFIT [b, c, d, e]**

| MAXIMUM DESIGN PRESSURE (+ or - psf) | MINIMUM PANEL SPAN RATING | MINIMUM PANEL PERFORMANCE CATEGORY | NAIL TYPE AND SIZE | FASTENER[a] SPACING ALONG EDGES AND INTERMEDIATE SUPPORTS | |
|---|---|---|---|---|---|
| | | | | Galvanized Steel | Stainless Steel |
| 30 | 24/0 | 3/8 | 6d box (2 × 0.099 × 0.266 head diameter) | 6[f] | 4 |
| 40 | 24/0 | 3/8 | 6d box (2 × 0.099 × 0.266 head diameter) | 6 | 4 |
| 50 | 24/0 | 3/8 | 6d box (2 × 0.099 × 0.266 head diameter) | 4 | 4 |
| | | | 8d common ($2^1/_2$ × 0.131 × 0.281 head diameter) | 6 | 6 |
| 60 | 24/0 | 3/8 | 6d box (2 × 0.099 × 0.266 head diameter) | 4 | 3 |
| | | | 8d common ($2^1/_2$ × 0.131 × 0.281 head diameter) | 6 | 4 |
| 70 | 24/16 | 7/16 | 8d common ($2^1/_2$× 0.131 × 0.281 head diameter) | 4 | 4 |
| | | | 10d box (3 × 0.128 × 0.312 head diameter) | 6 | 4 |
| 80 | 24/16 | 7/16 | 8d common ($2^1/_2$ × 0.131 × 0.281 head diameter) | 4 | 4 |
| | | | 10d box (3 × 0.128 × 0.312 head diameter) | 6 | 4 |
| 90 | 32/16 | 15/32 | 8d common ($2^1/_2$ × 0.131 × 0.281 head diameter) | 4 | 3 |
| | | | 10d box (3 × 0.128 × 0.312 head diameter) | 6 | 4 |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.

a. Fasteners shall comply with Sections R703.3.2 and R703.3.3.

b. Maximum spacing of soffit framing members shall not exceed 24 inches.

c. Wood structural panels shall be of an exterior exposure grade.

d. Wood structural panels shall be installed with strength axis perpendicular to supports with not fewer than two continuous spans.

e. Wood structural panels shall be attached to soffit framing members with specific gravity of at least 0.42. Framing members shall be minimum 2 × 3 nominal with the larger dimension in the cross section aligning with the length of fasteners to provide sufficient embedment depths.

f. Spacing at intermediate supports shall be not greater than 12 inches on center.

## CHAPTER 8
# ROOF-CEILING CONSTRUCTION

### SECTION R801
### GENERAL

**R801.1 Application.** The provisions of this chapter shall control the design and construction of the roof-ceiling system for buildings.

**R801.2 Requirements.** Roof and ceiling construction shall be capable of accommodating all loads imposed in accordance with Section R301 and of transmitting the resulting loads to the supporting structural elements.

**R801.3 Roof drainage.** Deleted. ~~In areas where *expansive soils* or *collapsible soils* are known to exist, all *dwellings* shall have a controlled method of water disposal from roofs that will collect and discharge roof drainage to the ground surface not less than 5 feet (1524 mm) from foundation walls or to an *approved* drainage system.~~

### SECTION R802
### WOOD ROOF FRAMING

**R802.1 General.** Wood and wood-based products used for load-supporting purposes shall conform to the applicable provisions of this section.

**R802.1.1 Sawn lumber.** Sawn lumber shall be identified by a grade *mark* of an accredited lumber grading or inspection agency and have design values certified by an accreditation body that complies with DOC PS 20. In lieu of a grade mark, a certificate of inspection issued by a lumber grading or inspection agency meeting the requirements of this section shall be accepted.

**R802.1.1.1 End-jointed lumber.** *Approved* end-jointed lumber identified by a grade *mark* conforming to Section R802.1.1 shall be permitted to be used interchangeably with solid-sawn members of the same species and grade. End-jointed lumber used in an assembly required elsewhere in this code to have a fire-resistance rating shall have the designation "Heat-Resistant Adhesive" or "HRA" included in its grade *mark*.

**R802.1.2 Structural glued-laminated timbers.** Glued-laminated timbers shall be manufactured and identified as required in ANSI~~/AITC~~ A190.1, ANSI 117 and ASTM D3737.

**R802.1.3 Structural log members.** Structural log members shall comply with the provisions of ICC 400.

**R802.1.4 Structural composite lumber.** Structural capacities for *structural composite lumber* shall be established and monitored in accordance with ASTM D5456.

**R802.1.5 Fire-retardant-treated wood.** Fire-retardant-treated wood (FRTW) is any wood product that, when impregnated with chemicals by a pressure process or other means during manufacture, shall have, when tested in accordance with ASTM E84 or UL 723, a listed flame spread index of 25 or less ~~and does not show evidence of significant progressive combustion where the test is~~. In addition, the ASTM E84 or UL 723 test shall be continued for an additional 20-minute period ~~In addition,~~ and the flame front shall not progress more than 10.5 feet (3200 mm) beyond the center line of the burners at any time during the test.

**R802.1.5.1 Pressure process.** For wood products impregnated with chemicals by a pressure process, the process shall be performed in closed vessels under pressures not less than 50 pounds per square inch gauge (psig) (344.7 kPa).

**R802.1.5.2 Other means during manufacture.** For wood products ~~produced~~ impregnated with chemicals by other means during manufacture, the treatment shall be an integral part of the manufacturing process of the wood product. The treatment shall provide permanent protection to all surfaces of the wood product. The use of paints, coating, stains or other surface treatments is not an *approved* method of protection as required by this section.

**R802.1.5.3 Testing.** For ~~wood products produced by other means during manufacture, other than a pressure process, all sides~~ fire-retardant-treated wood products, the front and back faces of the wood product shall be tested in accordance with and produce the results required in Section R802.1.5. ~~Testing of only the front and back faces of wood structural panels shall be permitted.~~

**R802.1.5.3.1 Fire testing of wood structural panels.** *Wood structural panels* shall be tested with a ripped or cut longitudinal gap of $^{1}/_{8}$ inch (3.2 mm).

**R802.1.5.4 Labeling.** ~~Fire-retardant-treated~~ In addition to the *labels* required by Section 802.1.1 for sawn lumber and Section 803.2.1 for *wood structural panels*, each piece of *fire-retardant-treated* lumber and *wood structural panel* shall be *labeled*. The *label* shall contain:

1. The identification *mark* of an *approved agency* in accordance with Section 1703.5 of the *International Building Code.*
2. Identification of the treating manufacturer.
3. The name of the fire-retardant treatment.
4. The species of wood treated.
5. Flame spread index and *smoke-developed index*.
6. Method of drying after treatment.
7. Conformance to applicable standards in accordance with Sections R802.1.5.5 through R802.1.5.10.
8. For FRTW exposed to weather, or a damp or wet location, the words “No increase in the listed classification when subjected to the Standard Rain Test” (ASTM D2898).

**R802.1.5.5 Strength adjustments.** Design values for untreated lumber and *wood structural panels* as specified in Section R802.1 shall be adjusted for fire-retardant-treated wood. Adjustments to design values shall be based ~~upon~~ on an *approved* method of investigation that takes into consideration the effects of the anticipated temperature and humidity to which the fire-retardant-treated wood will be subjected, the type of treatment and redrying procedures.

**R802.1.5.6 Wood structural panels.** The effect of treatment and the method of redrying after treatment, and exposure to high temperatures and high humidities on the flexure properties of fire-retardant-treated softwood plywood shall be determined in accordance with ASTM D5516. The test data developed by ASTM D5516 shall be used to develop adjustment factors, maximum loads and spans, or both for untreated plywood design values in accordance with ASTM D6305. Each manufacturer shall publish the allowable maximum loads and spans for service as floor and roof sheathing for their treatment.

**R802.1.5.7 Lumber.** For each species of wood treated, the effect of the treatment and the method of redrying after treatment and exposure to high temperatures and high humidities on the allowable design properties of fire-retardant-treated lumber shall be determined in accordance with ASTM D5664. The test data developed by ASTM D5664 shall be used to develop modification factors for use at or near room temperature and at elevated temperatures and humidity in accordance with ASTM D6841. Each manufacturer shall publish the modification factors for service at temperatures of not less than 80°F (27°C) and for roof framing. The roof framing modification factors shall take into consideration the climatological location.

**R802.1.5.8 Exposure to weather.** Where fire-retardant-treated wood is exposed to weather or damp or wet locations, it shall be identified as “Exterior” to indicate there is not an increase in the *listed* flame spread index as defined in Section R802.1.5 when subjected to ASTM D2898.

**R802.1.5.9 Interior applications.** Interior fire-retardant-treated wood shall have a moisture content of not over 28 percent when tested in accordance with ASTM D3201 procedures at 92-percent relative humidity. Interior fire-retardant-treated wood shall be tested in accordance with Section R802.1.5.6 or R802.1.5.7. Interior fire-retardant-treated wood designated as Type A shall be tested in accordance with the provisions of this section.

**R802.1.5.10 Moisture content.** Fire-retardant-treated wood shall be dried to a moisture content of 19 percent or less for lumber and 15 percent or less for *wood structural panels* before use. For wood kiln dried after treatment (KDAT) the kiln temperatures shall not exceed those used in kiln drying the lumber and plywood submitted for the tests described in Section R802.1.5.6 for plywood and R802.1.5.7 for lumber.

**R802.1.6 Cross-laminated timber.** Cross-laminated timber shall be manufactured and identified as required by ANSI/APA PRG 320.

**R802.1.7 Engineered wood rim board.** Engineered wood rim boards shall conform to ANSI/APA PRR 410 or shall be evaluated in accordance with ASTM D7672. Structural capacities shall be in accordance with ANSI/APA

PRR 410 or established in accordance with ASTM D7672. Rim boards conforming to ANSI/APA PRR 410 shall be marked in accordance with that standard.

**R802.1.8 Prefabricated wood I-joists.** Structural capacities and design provisions for prefabricated wood I-joists shall be established and monitored in accordance with ASTM D5055.

**R802.2 Design and construction.** The ~~framing details required in Section R802 apply to roofs having a minimum slope of three units vertical in 12 units horizontal (25-percent slope) or greater. Roof-ceilings~~ roof and ceiling assembly shall provide continuous ties across the structure to prevent roof thrust from being applied to the supporting walls. The assembly shall be designed and constructed in accordance with the provisions of this chapter and Figures R606.11(1), R606.11(2) and R606.11(3) or in accordance with AWC NDS.

**R802.3 ~~Framing details~~ Ridge.** ~~Rafters shall be framed not more than 11/2 inches (38 mm) offset from each other to ridge board or directly opposite from each other with a gusset plate as a tie. Ridge board shall be not less than 1-inch (25 mm) nominal thickness and not less in depth than the cut end of the rafter. At valleys and hips there shall be a valley or hip rafter not less than 2-inch (51 mm) nominal thickness and not less in depth than the cut end of the rafter. Hip and valley rafters shall be supported at the ridge by a brace to a bearing partition or be designed to carry and distribute the specific load at that point. Where the roof pitch is less than three units vertical in 12 units horizontal (25-percent slope), structural members that support rafters and ceiling joists, such as ridge beams, hips and valleys, shall be designed as beams.~~ A ridge board used to connect opposing rafters shall be not less than 1 inch (25 mm) nominal thickness and not less in depth than the cut end of the rafter. Opposing rafters at the ridge must align within the thickness of the ridge member. Regularly spaced hip and valley rafters need not align. Where ceiling joist or rafter ties do not provide continuous ties across the structure as required by Section R802.5.2, the ridge shall be supported by a wall or ridge beam designed in accordance with accepted engineering practice and supported on each end by a wall or column.

**~~R802.3.1 Ceiling joist and rafter connections.~~**

~~Ceiling joists and rafters shall be nailed to each other in accordance with TableR802.5.1(9), and the rafter shall be nailed to the top wall plate in accordancewith Table R602.3(1). Ceiling joists shall be continuous or securely joined in accordance with Table R802.5.1(9) where they meet over interior partitions and are nailed to adjacent rafters to provide a continuous tie across the building where such joists are parallel to the rafters.~~

~~Where ceiling joists are not connected to the rafters at the top wall plate, joists connected higher in the attic shall be installed as rafter ties, or rafter ties shall be installed to provide a continuous tie. Where ceiling joists are not parallel to rafters, rafter ties shall be installed. Rafter ties shall be not less than 2 inches by 4 inches (51 mm by 102 mm) (nominal), installed in accordance with the connection requirements in Table R802.5.1(9), or connections of equivalent capacities shall be provided. Where ceiling joists or rafter ties are not provided, the ridge formed by these rafters shall be supported by a wall or girder designed in accordance with accepted engineering practice.~~

~~Collar ties or ridge straps to resist wind uplift shall be connected in the upper third of the attic space in accordance with Table R602.3(1).~~

~~Collar ties shall be not less than 1 inch by 4 inches (25 mm by 102 mm) (nominal), spaced not more than 4 feet (1219 mm) on center.~~

**~~R802.3.2 Ceiling joists lapped.~~**

~~Ends of ceiling joists shall be lapped not less than 3 inches (76 mm) or butted over bearing partitions or beams and toenailed to the bearing member. Where ceiling joists are used to provide resistance to rafter thrust, lapped joists shall be nailed together in accordance with Table R802.5.1(9) and butted joists shall be tied together in a manner to resist such thrust. Joists that do not resist thrust shall be permitted to be nailed in accordance with Table R602.3(1).~~

**~~R802.3.3 Blocking.~~**

~~Blocking shall be a minimum of utility grade lumber.~~

**R802.4 ~~Allowable ceiling joist spans~~ Rafters.** ~~Spans for ceiling joists shall be in accordance with Tables R802.4(1) and R802.4(2). For other grades and species and for other loading conditions, refer to the AWC STJR.~~ Rafters shall be in accordance with this section.

**R802.4.1 Rafter size.** Rafters shall be sized based on the rafter spans in Tables R802.4.1(1) through R802.4.1(8). Rafter spans shall be measured along the horizontal projection of the rafter. For other grades and species and for other loading conditions, refer to the AWC STJR.

**TABLE R802.4.1(1)**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Roof live load = 20 psf, ceiling not attached to rafters, $L/\Delta$ = 180)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 12 | Douglas fir-larch | SS | 11-6 | 18-0 | 23-9 | Note b | Note b | 11-6 | 18-0 | 23-9 | Note b | Note b |
| | Douglas fir-larch | #1 | 11-1 | 17-4 | 22-5 | Note b | Note b | 10-6 | 15-4 | 19-5 | 23-9 | Note b |
| | Douglas fir-larch | #2 | 10-10 | 16-10 | 21-4 | 26-0 | Note b | 10-0 | 14-7 | 18-5 | 22-6 | 26-0 |
| | Douglas fir-larch | #3 | 8-9 | 12-10 | 16-3 | 19-10 | 23-0 | 7-7 | 11-1 | 14-1 | 17-2 | 19-11 |
| | Hem-fir | SS | 10-10 | 17-0 | 22-5 | Note b | Note b | 10-10 | 17-0 | 22-5 | Note b | Note b |
| | Hem-fir | #1 | 10 -7 | 16-8 | 22-0 | Note b | Note b | 10-4 | 15-2 | 19-2 | 23-5 | Note b |
| | Hem-fir | #2 | 10-1 | 15-11 | 20-8 | 25-3 | Note b | 9-8 | 14-2 | 17-11 | 21-11 | 25-5 |
| | Hem-fir | #3 | 8-7 | 12-6 | 15-10 | 19-5 | 22-6 | 7-5 | 10-10 | 13-9 | 16-9 | 19-6 |
| | Southern pine | SS | 11-3 | 17-8 | 23-4 | Note b | Note b | 11-3 | 17-8 | 23-4 | Note b | Note b |
| | Southern pine | #1 | 10-10 | 17-0 | 22-5 | Note b | Note b | 10-6 | 15-8 | 19-10 | 23-2 | Note b |
| | Southern pine | #2 | 10-4 | 15-7 | 19-8 | 23-5 | Note b | 9-0 | 13-6 | 17-1 | 20-3 | 23-10 |
| | Southern pine | #3 | 8-0 | 11-9 | 14-10 | 18-0 | 21-4 | 6-11 | 10-2 | 12-10 | 15-7 | 18-6 |
| | Spruce-pine-fir | SS | 10-7 | 16-8 | 21-11 | Note b | Note b | 10-7 | 16-8 | 21-9 | Note b | Note b |
| | Spruce-pine-fir | #1 | 10-4 | 16-3 | 21-0 | 25-8 | Note b | 9-10 | 14-4 | 18-2 | 22-3 | 25-9 |
| | Spruce-pine-fir | #2 | 10-4 | 16-3 | 21-0 | 25-8 | Note b | 9-10 | 14-4 | 18-2 | 22-3 | 25-9 |
| | Spruce-pine-fir | #3 | 8-7 | 12-6 | 15-10 | 19-5 | 22-6 | 7-5 | 10-10 | 13-9 | 16-9 | 19-6 |
| 16 | Douglas fir-larch | SS | 10-5 | 16-4 | 21-7 | Note b | Note b | 10-5 | 16-3 | 20-7 | 25-2 | Note b |
| | Douglas fir-larch | #1 | 10-0 | 15-4 | 19-5 | 23-9 | Note b | 9-1 | 13-3 | 16-10 | 20-7 | 23-10 |
| | Douglas fir-larch | #2 | 9-10 | 14-7 | 18-5 | 22-6 | 26-0 | 8-7 | 12-7 | 16-0 | 19-6 | 22-7 |
| | Douglas fir-larch | #3 | 7-7 | 11-1 | 14-1 | 17-2 | 19-11 | 6-7 | 9-8 | 12-12 | 14-11 | 17-3 |
| | Hem-fir | SS | 9-10 | 15-6 | 20-5 | Note b | Note b | 9-10 | 15-6 | 19-11 | 24-4 | Note b |
| | Hem-fir | #1 | 9-8 | 15-2 | 19-2 | 23-5 | Note b | 9-0 | 13-1 | 16-7 | 20-4 | 23-7 |
| | Hem-fir | #2 | 9-2 | 14-2 | 17-11 | 21-11 | 25-5 | 8-5 | 12-3 | 15-6 | 18-11 | 22-0 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hem-fir | #3 | 7-5 | 10-10 | 13-9 | 16-9 | 19-6 | 6-5 | 9-5 | 11-11 | 14-6 | 16-10 |
| | Southern pine | SS | 10-3 | 16-1 | 21-2 | Note b | Note b | 10-3 | 16-1 | 21-2 | 25-7 | Note b |
| | Southern pine | #1 | 9-10 | 15-6 | 19-10 | 23-2 | Note b | 9-1 | 13-7 | 17-2 | 20-1 | 23-10 |
| | Southern pine | #2 | 9-0 | 13-6 | 17-1 | 20-3 | 23-10 | 7-9 | 11-8 | 14-9 | 17-6 | 20-8 |
| | Southern pine | #3 | 6-11 | 10-2 | 12-10 | 15-7 | 18-6 | 6-0 | 8-10 | 11-2 | 13-6 | 16-0 |
| | Spruce-pine-fir | SS | 9-8 | 15-2 | 19-11 | 25-5 | Note b | 9-8 | 14-10 | 18-10 | 23-0 | Note b |
| | Spruce-pine-fir | #1 | 9-5 | 14-4 | 18-2 | 22-3 | 25-9 | 8-6 | 12-5 | 15-9 | 19-3 | 22-4 |
| | Spruce-pine-fir | #2 | 9-5 | 14-4 | 18-2 | 22-3 | 25-9 | 8-6 | 12-5 | 15-9 | 19-3 | 22-4 |
| | Spruce-pine-fir | #3 | 7-5 | 10-10 | 13-9 | 16-9 | 19-6 | 6-5 | 9-5 | 11-11 | 14-6 | 16-10 |

*(continued)*

**TABLE R802.4.1(1)—continued**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Roof live load = 20 psf, ceiling not attached to rafters, *L*/Δ = 180)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 19.2 | Douglas fir-larch | SS | 9-10 | 15-5 | 20-4 | 25-11 | Note b | 9-10 | 14-10 | 18-10 | 23-0 | Note b |
| | Douglas fir-larch | #1 | 9-5 | 14-0 | 17-9 | 21-8 | 25-2 | 8-4 | 12-2 | 15-4 | 18-9 | 21-9 |
| | Douglas fir-larch | #2 | 9-1 | 13-3 | 16-10 | 20-7 | 23-10 | 7-10 | 11-6 | 14-7 | 17-10 | 20-8 |
| | Douglas fir-larch | #3 | 6-11 | 10-2 | 12-10 | 15-8 | 18-3 | 6-0 | 8-9 | 11-2 | 12-7 | 15-9 |
| | Hem-fir | SS | 9-3 | 14-7 | 19-2 | 24-6 | Note b | 9-3 | 14-4 | 18-2 | 22-3 | 25-9 |
| | Hem-fir | #1 | 9-1 | 13-10 | 17-6 | 21-5 | 24-10 | 8-2 | 12-0 | 15-2 | 18-6 | 21-6 |
| | Hem-fir | #2 | 8-8 | 12-11 | 16-4 | 20-0 | 23-2 | 7-8 | 11-2 | 14-2 | 17-4 | 20-1 |
| | Hem-fir | #3 | 6-9 | 9-11 | 12-7 | 15-4 | 17-9 | 5-10 | 8-7 | 10-10 | 13-3 | 15-5 |
| | Southern pine | SS | 9-8 | 15-2 | 19-11 | 25-5 | Note b | 9-8 | 15-2 | 19-7 | 23-4 | Note b |
| | Southern pine | #1 | 9-3 | 14-3 | 18-1 | 21-2 | 25-2 | 8-4 | 12-4 | 15-8 | 18-4 | 21-9 |
| | Southern pine | #2 | 8-2 | 12-3 | 15-7 | 18-6 | 21-9 | 7-1 | 10-8 | 13-6 | 16-0 | 18-10 |
| | Southern pine | #3 | 6-4 | 9-4 | 11-9 | 14-3 | 16-10 | 5-6 | 8-1 | 10-2 | 12-4 | 14-7 |
| | Spruce-pine-fir | SS | 9-1 | 14-3 | 18-9 | 23-11 | Note b | 9-1 | 13-7 | 17-2 | 21-0 | 24-4 |
| | Spruce-pine-fir | #1 | 8-10 | 13-1 | 16-7 | 20-3 | 23-6 | 7-9 | 11-4 | 14-4 | 17-7 | 20-4 |
| | Spruce-pine-fir | #2 | 8-10 | 13-1 | 16-7 | 20-3 | 23-6 | 7-9 | 11-4 | 14-4 | 17-7 | 20-4 |
| | Spruce-pine-fir | #3 | 6-9 | 9-11 | 12-7 | 15-4 | 17-9 | 5-10 | 8-7 | 10-10 | 13-3 | 15-5 |
| 24 | Douglas fir-larch | SS | 9-1 | 14-4 | 18-10 | 23-9 | Note b | 9-1 | 13-3 | 16-10 | 20-7 | 23-10 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Douglas fir-larch | #1 | 8-7 | 12-6 | 15-10 | 19-5 | 22-6 | 7-5 | 10-10 | 13-9 | 16-9 | 19-6 |
| | Douglas fir-larch | #2 | 8-2 | 11-11 | 15-1 | 18-5 | 21-4 | 7-0 | 10-4 | 13-0 | 15-11 | 18-6 |
| | Douglas fir-larch | #3 | 6-2 | 9-1 | 11-6 | 14-1 | 16-3 | 5-4 | 7-10 | 10-0 | 12-2 | 14-1 |
| | Hem-fir | SS | 8-7 | 13-6 | 17-10 | 22-9 | Note b | 8-7 | 12-10 | 16-3 | 19-10 | 23-0 |
| | Hem-fir | #1 | 8-5 | 12-4 | 15-8 | 19-2 | 22-2 | 7-4 | 10-9 | 13-7 | 16-7 | 19-3 |
| | Hem-fir | #2 | 7-11 | 11-7 | 14-8 | 17-10 | 20-9 | 6-10 | 10-0 | 12-8 | 15-6 | 17-11 |
| | Hem-fir | #3 | 6-1 | 8-10 | 11-3 | 13-8 | 15-11 | 5-3 | 7-8 | 9-9 | 11-10 | 13-9 |
| | Southern pine | SS | 8-11 | 14-1 | 18-6 | 23-8 | Note b | 8-11 | 13-10 | 17-6 | 20-10 | 24-8 |
| | Southern pine | #1 | 8-7 | 12-9 | 16-2 | 18-11 | 22-6 | 7-5 | 11-1 | 14-0 | 16-5 | 19-6 |
| | Southern pine | #2 | 7-4 | 11-0 | 13-11 | 16-6 | 19-6 | 6-4 | 9-6 | 12-1 | 14-4 | 16-10 |
| | Southern pine | #3 | 5-8 | 8-4 | 10-6 | 12-9 | 15-1 | 4-11 | 7-3 | 9-1 | 11-0 | 13-1 |
| | Spruce-pine-fir | SS | 8-5 | 13-3 | 17-5 | 21-8 | 25-2 | 8-4 | 12-2 | 15-4 | 18-9 | 21-9 |
| | Spruce-pine-fir | #1 | 8-0 | 11-9 | 14-10 | 18-2 | 21-0 | 6-11 | 10-2 | 12-10 | 15-8 | 18-3 |
| | Spruce-pine-fir | #2 | 8-0 | 11-9 | 14-10 | 18-2 | 21-0 | 6-11 | 10-2 | 12-10 | 15-8 | 18-3 |
| | Spruce-pine-fir | #3 | 6-1 | 8-10 | 11-3 | 13-8 | 15-11 | 5-3 | 7-8 | 9-9 | 11-10 | 13-9 |

Check sources for availability of lumber in lengths greater than 20 feet.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the adjustment factors in Table R802.4.1(9).

b. Span exceeds 26 feet in length.

**TABLE R802.4.1(2)**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Roof live load = 20 psf, ceiling attached to rafters, *L*/Δ = 240)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 12 | Douglas fir-larch | SS | 10-5 | 16-4 | 21-7 | Note b | Note b | 10-5 | 16-4 | 21-7 | Note b | Note b |
| | Douglas fir-larch | #1 | 10-0 | 15-9 | 20-10 | Note b | Note b | 10-0 | 15-4 | 19-5 | 23-9 | Note b |
| | Douglas fir-larch | #2 | 9-10 | 15-6 | 20-5 | 26-0 | Note b | 9-10 | 14-7 | 18-5 | 22-6 | 26-0 |
| | Douglas fir-larch | #3 | 8-9 | 12-10 | 16-3 | 19-10 | 23-0 | 7-7 | 11-1 | 14-1 | 17-2 | 19-11 |
| | Hem-fir | SS | 9-10 | 15-6 | 20-5 | Note b | Note b | 9-10 | 15-6 | 20-5 | Note b | Note b |
| | Hem-fir | #1 | 9-8 | 15-2 | 19-11 | 25-5 | Note b | 9-8 | 15-2 | 19-2 | 23-5 | Note b |
| | Hem-fir | #2 | 9-2 | 14-5 | 19-0 | 24-3 | Note b | 9-2 | 14-2 | 17-11 | 21-11 | 25-5 |
| | Hem-fir | #3 | 8-7 | 12-6 | 15-10 | 19-5 | 22-6 | 7-5 | 10-10 | 13-9 | 16-9 | 19-6 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Southern pine | SS | 10-3 | 16-1 | 21-2 | Note b | Note b | 10-3 | 16-1 | 21-2 | Note b | Note b |
| | Southern pine | #1 | 9-10 | 15-6 | 20-5 | Note b | Note b | 9-10 | 15-6 | 19-10 | 23-2 | Note b |
| | Southern pine | #2 | 9-5 | 14-9 | 19-6 | 23-5 | Note b | 9-0 | 13-6 | 17-1 | 20-3 | 23-10 |
| | Southern pine | #3 | 8-0 | 11-9 | 14-10 | 18-0 | 21-4 | 6-11 | 10-2 | 12-10 | 15-7 | 18-6 |
| | Spruce-pine-fir | SS | 9-8 | 15-2 | 19-11 | 25-5 | Note b | 9-8 | 15-2 | 19-11 | 25-5 | Note b |
| | Spruce-pine-fir | #1 | 9-5 | 14-9 | 19-6 | 24-10 | Note b | 9-5 | 14-4 | 18-2 | 22-3 | 25-9 |
| | Spruce-pine-fir | #2 | 9-5 | 14-9 | 19-6 | 24-10 | Note b | 9-5 | 14-4 | 18-2 | 22-3 | 25-9 |
| | Spruce-pine-fir | #3 | 8-7 | 12-6 | 15-10 | 19-5 | 22-6 | 7-5 | 10-10 | 13-9 | 16-9 | 19-6 |
| 16 | Douglas fir-larch | SS | 9-6 | 14-11 | 19-7 | 25-0 | Note b | 9-6 | 14-11 | 19-7 | 25-0 | Note b |
| | Douglas fir-larch | #1 | 9-1 | 14-4 | 18-11 | 23-9 | Note b | 9-1 | 13-3 | 16-10 | 20-7 | 23-10 |
| | Douglas fir-larch | #2 | 8-11 | 14-1 | 18-5 | 22-6 | 26-0 | 8-7 | 12-7 | 16-0 | 19-6 | 22-7 |
| | Douglas fir-larch | #3 | 7-7 | 11-1 | 14-1 | 17-2 | 19-11 | 6-7 | 9-8 | 12-2 | 14-11 | 17-3 |
| | Hem-fir | SS | 8-11 | 14-1 | 18-6 | 23-8 | Note b | 8-11 | 14-1 | 18-6 | 23-8 | Note b |
| | Hem-fir | #1 | 8-9 | 13-9 | 18-1 | 23-1 | Note b | 8-9 | 13-1 | 16-7 | 20-4 | 23-7 |
| | Hem-fir | #2 | 8-4 | 13-1 | 17-3 | 21-11 | 25-5 | 8-4 | 12-3 | 15-6 | 18-11 | 22-0 |
| | Hem-fir | #3 | 7-5 | 10-10 | 13-9 | 16-9 | 19-6 | 6-5 | 9-5 | 11-11 | 14-6 | 16-10 |
| | Southern pine | SS | 9-4 | 14-7 | 19-3 | 24-7 | Note b | 9-4 | 14-7 | 19-3 | 24-7 | Note b |
| | Southern pine | #1 | 8-11 | 14-1 | 18-6 | 23-2 | Note b | 8-11 | 13-7 | 17-2 | 20-1 | 23-10 |
| | Southern pine | #2 | 8-7 | 13-5 | 17-1 | 20-3 | 23-10 | 7-9 | 11-8 | 14-9 | 17-6 | 20-8 |
| | Southern pine | #3 | 6-11 | 10-2 | 12-10 | 15-7 | 18-6 | 6-0 | 8-10 | 11-2 | 13-6 | 16-0 |
| | Spruce-pine-fir | SS | 8-9 | 13-9 | 18-1 | 23-1 | Note b | 8-9 | 13-9 | 18-1 | 23-0 | Note b |
| | Spruce-pine-fir | #1 | 8-7 | 13-5 | 17-9 | 22-3 | 25-9 | 8-6 | 12-5 | 15-9 | 19-3 | 22-4 |
| | Spruce-pine-fir | #2 | 8-7 | 13-5 | 17-9 | 22-3 | 25-9 | 8-6 | 12-5 | 15-9 | 19-3 | 22-4 |
| | Spruce-pine-fir | #3 | 7-5 | 10-10 | 13-9 | 16-9 | 19-6 | 6-5 | 9-5 | 11-11 | 14-6 | 16-10 |

*(continued)*

**TABLE R802.4.1(2)—continued**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Roof live load = 20 psf, ceiling attached to rafters, *L*/Δ = 240)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 19.2 | Douglas fir-larch | SS | 8-11 | 14-0 | 18-5 | 23-7 | Note b | 8-11 | 14-0 | 18-5 | 23-0 | Note b |
| | Douglas fir-larch | #1 | 8-7 | 13-6 | 17-9 | 21-8 | 25-2 | 8-4 | 12-2 | 15-4 | 18-9 | 21-9 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Douglas fir-larch | #2 | 8-5 | 13-3 | 16-10 | 20-7 | 23-10 | 7-10 | 11-6 | 14-7 | 17-10 | 20-8 |
| | Douglas fir-larch | #3 | 6-11 | 10-2 | 12-10 | 15-8 | 18-3 | 6-0 | 8-9 | 11-2 | 13-7 | 15-9 |
| | Hem-fir | SS | 8-5 | 13-3 | 17-5 | 22-3 | Note b | 8-5 | 13-3 | 17-5 | 22-3 | 25-9 |
| | Hem-fir | #1 | 8-3 | 12-11 | 17-1 | 21-5 | 24-10 | 8-2 | 12-0 | 15-2 | 18-6 | 21-6 |
| | Hem-fir | #2 | 7-10 | 12-4 | 16-3 | 20-0 | 23-2 | 7-8 | 11-2 | 14-2 | 17-4 | 20-1 |
| | Hem-fir | #3 | 6-9 | 9-11 | 12-7 | 15-4 | 17-9 | 5-10 | 8-7 | 10-10 | 13-3 | 15-5 |
| | Southern pine | SS | 8-9 | 13-9 | 18-2 | 23-1 | Note b | 8-9 | 13-9 | 18-2 | 23-1 | Note b |
| | Southern pine | #1 | 8-5 | 13-3 | 17-5 | 21-2 | 25-2 | 8-4 | 12-4 | 15-8 | 18-4 | 21-9 |
| | Southern pine | #2 | 8-1 | 12-3 | 15-7 | 18-6 | 21-9 | 7-1 | 10-8 | 13-6 | 16-0 | 18-10 |
| | Southern pine | #3 | 6-4 | 9-4 | 11-9 | 14-3 | 16-10 | 5-6 | 8-1 | 10-2 | 12-4 | 14-7 |
| | Spruce-pine-fir | SS | 8-3 | 12-11 | 17-1 | 21-9 | Note b | 8-3 | 12-11 | 17-1 | 21-0 | 24-4 |
| | Spruce-pine-fir | #1 | 8-1 | 12-8 | 16-7 | 20-3 | 23-6 | 7-9 | 11-4 | 14-4 | 17-7 | 20-4 |
| | Spruce-pine-fir | #2 | 8-1 | 12-8 | 16-7 | 20-3 | 23-6 | 7-9 | 11-4 | 14-4 | 17-7 | 20-4 |
| | Spruce-pine-fir | #3 | 6-9 | 9-11 | 12-7 | 15-4 | 17-9 | 5-10 | 8-7 | 10-10 | 13-3 | 15-5 |
| 24 | Douglas fir-larch | SS | 8-3 | 13-0 | 17-2 | 21-10 | Note b | 8-3 | 13-0 | 16-10 | 20-7 | 23-10 |
| | Douglas fir-larch | #1 | 8-0 | 12-6 | 15-10 | 19-5 | 22-6 | 7-5 | 10-10 | 13-9 | 16-9 | 19-6 |
| | Douglas fir-larch | #2 | 7-10 | 11-11 | 15-1 | 18-5 | 21-4 | 7-0 | 10-4 | 13-0 | 15-11 | 18-6 |
| | Douglas fir-larch | #3 | 6-2 | 9-1 | 11-6 | 14-1 | 16-3 | 5-4 | 7-10 | 10-0 | 12-2 | 14-1 |
| | Hem-fir | SS | 7-10 | 12-3 | 16-2 | 20-8 | 25-1 | 7-10 | 12-3 | 16-2 | 19-10 | 23-0 |
| | Hem-fir | #1 | 7-8 | 12-0 | 15-8 | 19-2 | 22-2 | 7-4 | 10-9 | 13-7 | 16-7 | 19-3 |
| | Hem-fir | #2 | 7-3 | 11-5 | 14-8 | 17-10 | 20-9 | 6-10 | 10-0 | 12-8 | 15-6 | 17-11 |
| | Hem-fir | #3 | 6-1 | 8-10 | 11-3 | 13-8 | 15-11 | 5-3 | 7-8 | 9-9 | 11-10 | 13-9 |
| | Southern pine | SS | 8-1 | 12-9 | 16-10 | 21-6 | Note b | 8-1 | 12-9 | 16-10 | 20-10 | 24-8 |
| | Southern pine | #1 | 7-10 | 12-3 | 16-2 | 18-11 | 22-6 | 7-5 | 11-1 | 14-0 | 16-5 | 19-6 |
| | Southern pine | #2 | 7-4 | 11-0 | 13-11 | 16-6 | 19-6 | 6-4 | 9-6 | 12-1 | 14-4 | 16-10 |
| | Southern pine | #3 | 5-8 | 8-4 | 10-6 | 12-9 | 15-1 | 4-11 | 7-3 | 9-1 | 11-0 | 13-1 |
| | Spruce-pine-fir | SS | 7-8 | 12-0 | 15-10 | 20-2 | 24-7 | 7-8 | 12-0 | 15-4 | 18-9 | 21-9 |
| | Spruce-pine-fir | #1 | 7-6 | 11-9 | 14-10 | 18-2 | 21-0 | 6-11 | 10-2 | 12-10 | 15-8 | 18-3 |
| | Spruce-pine-fir | #2 | 7-6 | 11-9 | 14-10 | 18-2 | 21-0 | 6-11 | 10-2 | 12-10 | 15-8 | 18-3 |
| | Spruce-pine-fir | #3 | 6-1 | 8-10 | 11-3 | 13-8 | 15-11 | 5-3 | 7-8 | 9-9 | 11-10 | 13-9 |

Check sources for availability of lumber in lengths greater than 20 feet.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the adjustment factors in Table R802.4.1(9).

b. Span exceeds 26 feet in length.

**TABLE R802.4.1(3)**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 30 psf, ceiling not attached to rafters, $L/\Delta$ = 180)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 12 | Douglas fir-larch | SS | 10-0 | 15-9 | 20-9 | Note b | Note b | 10-0 | 15-9 | 20-5 | 24-11 | Note b |
| | Douglas fir-larch | #1 | 9-8 | 14-9 | 18-8 | 22-9 | Note b | 9-0 | 13-2 | 16-8 | 20-4 | 23-7 |
| | Douglas fir-larch | #2 | 9-6 | 14-0 | 17-8 | 21-7 | 25-1 | 8-6 | 12-6 | 15-10 | 19-4 | 22-5 |
| | Douglas fir-larch | #3 | 7-3 | 10-8 | 13-6 | 16-6 | 19-2 | 6-6 | 9-6 | 12-1 | 14-9 | 17-1 |
| | Hem-fir | SS | 9-6 | 14-10 | 19-7 | 25-0 | Note b | 9-6 | 14-10 | 19-7 | 24-1 | Note b |
| | Hem-fir | #1 | 9-3 | 14-6 | 18-5 | 22-6 | 26-0 | 8-11 | 13-0 | 16-6 | 20-1 | 23-4 |
| | Hem-fir | #2 | 8-10 | 13-7 | 17-2 | 21-0 | 24-4 | 8-4 | 12-2 | 15-4 | 18-9 | 21-9 |
| | Hem-fir | #3 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 | 6-4 | 9-4 | 11-9 | 14-5 | 16-8 |
| | Southern pine | SS | 9-10 | 15-6 | 20-5 | Note b | Note b | 9-10 | 15-6 | 20-5 | 25-4 | Note b |
| | Southern pine | #1 | 9-6 | 14-10 | 19-0 | 22-3 | Note b | 9-0 | 13-5 | 17-0 | 19-11 | 23-7 |
| | Southern pine | #2 | 8-7 | 12-11 | 16-4 | 19-5 | 22-10 | 7-8 | 11-7 | 14-8 | 17-4 | 20-5 |
| | Southern pine | #3 | 6-7 | 9-9 | 12-4 | 15-0 | 17-9 | 5-11 | 8-9 | 11-0 | 13-5 | 15-10 |
| | Spruce-pine-fir | SS | 9-3 | 14-7 | 19-2 | 24-6 | Note b | 9-3 | 14-7 | 18-8 | 22-9 | Note b |
| | Spruce-pine-fir | #1 | 9-1 | 13-9 | 17-5 | 21-4 | 24-8 | 8-5 | 12-4 | 15-7 | 19-1 | 22-1 |
| | Spruce-pine-fir | #2 | 9-1 | 13-9 | 17-5 | 21-4 | 24-8 | 8-5 | 12-4 | 15-7 | 19-1 | 22-1 |
| | Spruce-pine-fir | #3 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 | 6-4 | 9-4 | 11-9 | 14-5 | 16-8 |
| 16 | Douglas fir-larch | SS | 9-1 | 14-4 | 18-10 | 24-1 | Note b | 9-1 | 14-0 | 17-8 | 21-7 | 25-1 |
| | Douglas fir-larch | #1 | 8-9 | 12-9 | 16-2 | 19-9 | 22-10 | 7-10 | 11-5 | 14-5 | 17-8 | 20-5 |
| | Douglas fir-larch | #2 | 8-3 | 12-1 | 15-4 | 18-9 | 21-8 | 7-5 | 10-10 | 13-8 | 16-9 | 19-5 |
| | Douglas fir-larch | #3 | 6-4 | 9-3 | 11-8 | 14-3 | 16-7 | 5-8 | 8-3 | 10-6 | 12-9 | 14-10 |
| | Hem-fir | SS | 8-7 | 13-6 | 17-10 | 22-9 | Note b | 8-7 | 13-6 | 17-1 | 20-10 | 24-2 |
| | Hem-fir | #1 | 8-5 | 12-7 | 15-11 | 19-6 | 22-7 | 7-8 | 11-3 | 14-3 | 17-5 | 20-2 |
| | Hem-fir | #2 | 8-0 | 11-9 | 14-11 | 18-2 | 21-1 | 7-2 | 10-6 | 13-4 | 16-3 | 18-10 |
| | Hem-fir | #3 | 6-2 | 9-0 | 11-5 | 13-11 | 16-2 | 5-6 | 8-1 | 10-3 | 12-6 | 14-6 |
| | Southern pine | SS | 8-11 | 14-1 | 18-6 | 23-8 | Note b | 8-11 | 14-1 | 18-5 | 1-11 | 25-11 |
| | Southern pine | #1 | 8-7 | 13-0 | 16-6 | 19-3 | 22-10 | 7-10 | 11-7 | 14-9 | 17-3 | 20-5 |
| | Southern pine | #2 | 7-6 | 11-2 | 14-2 | 16-10 | 19-10 | 6-8 | 10-0 | 12-8 | 15-1 | 17-9 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Southern pine | #3 | 5-9 | 8-6 | 10-8 | 13-0 | 15-4 | 5-2 | 7-7 | 9-7 | 11-7 | 13-9 |
| | Spruce-pine-fir | SS | 8-5 | 13-3 | 17-5 | 22-1 | 25-7 | 8-5 | 12-9 | 16-2 | 19-9 | 22-10 |
| | Spruce-pine-fir | #1 | 8-2 | 11-11 | 15-1 | 18-5 | 21-5 | 7-3 | 10-8 | 13-6 | 16-6 | 19-2 |
| | Spruce-pine-fir | #2 | 8-2 | 11-11 | 15-1 | 18-5 | 21-5 | 7-3 | 10-8 | 13-6 | 16-6 | 19-2 |
| | Spruce-pine-fir | #3 | 6-2 | 9-0 | 11-5 | 13-11 | 16-2 | 5-6 | 8-1 | 10-3 | 12-6 | 14-6 |

*(continued)*

**TABLE R802.4.1(3)—continued**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 30 psf, ceiling not attached to rafters, $L/\Delta$ = 180)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 19.2 | Douglas fir-larch | SS | 8-7 | 13-6 | 17-9 | 22-1 | 25-7 | 8-7 | 12-9 | 16-2 | 19-9 | 22-10 |
| | Douglas fir-larch | #1 | 7-11 | 11-8 | 14-9 | 18-0 | 20-11 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 |
| | Douglas fir-larch | #2 | 7-7 | 11-0 | 14-0 | 17-1 | 19-10 | 6-9 | 9-10 | 12-6 | 15-3 | 17-9 |
| | Douglas fir-larch | #3 | 5-9 | 8-5 | 10-8 | 13-1 | 15-2 | 5-2 | 7-7 | 9-7 | 11-8 | 13-6 |
| | Hem-fir | SS | 8-1 | 12-9 | 16-9 | 21-4 | 24-8 | 8-1 | 12-4 | 15-7 | 19-1 | 22-1 |
| | Hem-fir | #1 | 7-10 | 11-6 | 14-7 | 17-9 | 20-7 | 7-0 | 10-3 | 13-0 | 15-11 | 18-5 |
| | Hem-fir | #2 | 7-4 | 10-9 | 13-7 | 16-7 | 19-3 | 6-7 | 9-7 | 12-2 | 14-10 | 17-3 |
| | Hem-fir | #3 | 5-7 | 8-3 | 10-5 | 12-9 | 14-9 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 |
| | Southern pine | SS | 8-5 | 13-3 | 17-5 | 22-3 | Note b | 8-5 | 13-3 | 16-10 | 20-0 | 23-7 |
| | Southern pine | #1 | 8-0 | 11-10 | 15-1 | 17-7 | 20-11 | 7-1 | 10-7 | 13-5 | 15-9 | 18-8 |
| | Southern pine | #2 | 6-10 | 10-2 | 12-11 | 15-4 | 18-1 | 6-1 | 9-2 | 11-7 | 13-9 | 16-2 |
| | Southern pine | #3 | 5-3 | 7-9 | 9-9 | 11-10 | 14-0 | 4-8 | 6-11 | 8-9 | 10-7 | 12-6 |
| | Spruce-pine-fir | SS | 7-11 | 12-5 | 16-5 | 20-2 | 23-4 | 7-11 | 11-8 | 14-9 | 18-0 | 20-11 |
| | Spruce-pine-fir | #1 | 7-5 | 10-11 | 13-9 | 16-10 | 19-6 | 6-8 | 9-9 | 12-4 | 15-1 | 17-6 |
| | Spruce-pine-fir | #2 | 7-5 | 10-11 | 13-9 | 16-10 | 19-6 | 6-8 | 9-9 | 12-4 | 15-1 | 17-6 |
| | Spruce-pine-fir | #3 | 5-7 | 8-3 | 10-5 | 12-9 | 14-9 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 |
| 24 | Douglas fir-larch | SS | 8-0 | 12-6 | 16-2 | 19-9 | 22-10 | 7-10 | 11-5 | 14-5 | 17-8 | 20-5 |
| | Douglas fir-larch | #1 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 | 6-4 | 9-4 | 11-9 | 14-5 | 16-8 |
| | Douglas fir-larch | #2 | 6-9 | 9-10 | 12-6 | 15-3 | 17-9 | 6-0 | 8-10 | 11-2 | 13-8 | 15-10 |
| | Douglas fir-larch | #3 | 5-2 | 7-7 | 9-7 | 11-8 | 13-6 | 4-7 | 6-9 | 8-7 | 10-5 | 12-1 |
| | Hem-fir | SS | 7-6 | 11-10 | 15-7 | 19-1 | 22-1 | 7-6 | 11-0 | 13-11 | 17-0 | 19-9 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hem-fir | #1 | 7-0 | 10-3 | 13-0 | 15-11 | 18-5 | 6-3 | 9-2 | 11-8 | 14-3 | 16-6 |
| | Hem-fir | #2 | 6-7 | 9-7 | 12-2 | 14-10 | 17-3 | 5-10 | 8-7 | 10-10 | 13-3 | 15-5 |
| | Hem-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-6 | 6-7 | 8-4 | 10-2 | 11-10 |
| | Southern pine | SS | 7-10 | 12-3 | 16-2 | 20-0 | 23-7 | 7-10 | 11-10 | 15-0 | 17-11 | 21-2 |
| | Southern pine | #1 | 7-1 | 10-7 | 13-5 | 15-9 | 18-8 | 6-4 | 9-6 | 12-0 | 14-1 | 16-8 |
| | Southern pine | #2 | 6-1 | 9-2 | 11-7 | 13-9 | 16-2 | 5-5 | 8-2 | 10-4 | 12-3 | 14-6 |
| | Southern pine | #3 | 4-8 | 6-11 | 8-9 | 10-7 | 12-6 | 4-2 | 6-2 | 7-10 | 9-6 | 11-2 |
| | Spruce-pine-fir | SS | 7-4 | 11-7 | 14-9 | 18-0 | 20-11 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 |
| | Spruce-pine-fir | #1 | 6-8 | 9-9 | 12-4 | 15-1 | 17-6 | 5-11 | 8-8 | 11-0 | 13-6 | 15-7 |
| | Spruce-pine-fir | #2 | 6-8 | 9-9 | 12-4 | 15-1 | 17-6 | 5-11 | 8-8 | 11-0 | 13-6 | 15-7 |
| | Spruce-pine-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-6 | 6-7 | 8-4 | 10-2 | 11-10 |

Check sources for availability of lumber in lengths greater than 20 feet.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the adjustment factors in Table R802.4.1(9).

b. Span exceeds 26 feet in length.

**TABLE R802.4.1(4)**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 30 psf, ceiling attached to rafters, *L*/Δ = 240)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 12 | Douglas fir-larch | SS | 9-1 | 14-4 | 18-10 | 24-1 | Note b | 9-1 | 14-4 | 18-10 | 24-1 | Note b |
| | Douglas fir-larch | #1 | 8-9 | 13-9 | 18-2 | 22-9 | Note b | 8-9 | 13-2 | 16-8 | 20-4 | 23-7 |
| | Douglas fir-larch | #2 | 8-7 | 13-6 | 17-8 | 21-7 | 25-1 | 8-6 | 12-6 | 15-10 | 19-4 | 22-5 |
| | Douglas fir-larch | #3 | 7-3 | 10-8 | 13-6 | 16-6 | 19-2 | 6-6 | 9-6 | 12-1 | 14-9 | 17-1 |
| | Hem-fir | SS | 8-7 | 13-6 | 17-10 | 22-9 | Note b | 8-7 | 13-6 | 17-10 | 22-9 | Note b |
| | Hem-fir | #1 | 8-5 | 13-3 | 17-5 | 22-3 | 26-0 | 8-5 | 13-0 | 16-6 | 20-1 | 23-4 |
| | Hem-fir | #2 | 8-0 | 12-7 | 16-7 | 21-0 | 24-4 | 8-0 | 12-2 | 15-4 | 18-9 | 21-9 |
| | Hem-fir | #3 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 | 6-4 | 9-4 | 11-9 | 14-5 | 16-8 |
| | Southern pine | SS | 8-11 | 14-1 | 18-6 | 23-8 | Note b | 8-11 | 14-1 | 18-6 | 23-8 | Note b |
| | Southern pine | #1 | 8-7 | 13-6 | 17-10 | 22-3 | Note b | 8-7 | 13-5 | 17-0 | 19-11 | 23-7 |
| | Southern pine | #2 | 8-3 | 12-11 | 16-4 | 19-5 | 22-10 | 7-8 | 11-7 | 14-8 | 17-4 | 20-5 |
| | Southern pine | #3 | 6-7 | 9-9 | 12-4 | 15-0 | 17-9 | 5-11 | 8-9 | 11-0 | 13-5 | 15-10 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Spruce-pine-fir | SS | 8-5 | 13-3 | 17-5 | 22-3 | Note b | 8-5 | 13-3 | 17-5 | 22-3 | Note b |
| | Spruce-pine-fir | #1 | 8-3 | 12-11 | 17-0 | 21-4 | 24-8 | 8-3 | 12-4 | 15-7 | 19-1 | 22-1 |
| | Spruce-pine-fir | #2 | 8-3 | 12-11 | 17-0 | 21-4 | 24-8 | 8-3 | 12-4 | 15-7 | 19-1 | 22-1 |
| | Spruce-pine-fir | #3 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 | 6-4 | 9-4 | 11-9 | 14-5 | 16-8 |
| 16 | Douglas fir-larch | SS | 8-3 | 13-0 | 17-2 | 21-10 | Note b | 8-3 | 13-0 | 17-2 | 21-7 | 25-1 |
| | Douglas fir-larch | #1 | 8-0 | 12-6 | 16-2 | 19-9 | 22-10 | 7-10 | 11-5 | 14-5 | 17-8 | 20-5 |
| | Douglas fir-larch | #2 | 7-10 | 12-1 | 15-4 | 18-9 | 21-8 | 7-5 | 10-10 | 13-8 | 16-9 | 19-5 |
| | Douglas fir-larch | #3 | 6-4 | 9-3 | 11-8 | 14-3 | 16-7 | 5-8 | 8-3 | 10-6 | 12-9 | 14-10 |
| | Hem-fir | SS | 7-10 | 12-3 | 16-2 | 20-8 | 25-1 | 7-10 | 12-3 | 16-2 | 20-8 | 24-2 |
| | Hem-fir | #1 | 7-8 | 12-0 | 15-10 | 19-6 | 22-7 | 7-8 | 11-3 | 14-3 | 17-5 | 20-2 |
| | Hem-fir | #2 | 7-3 | 11-5 | 14-11 | 18-2 | 21-1 | 7-2 | 10-6 | 13-4 | 16-3 | 18-10 |
| | Hem-fir | #3 | 6-2 | 9-0 | 11-5 | 13-11 | 16-2 | 5-6 | 8-1 | 10-3 | 12-6 | 14-6 |
| | Southern pine | SS | 8-1 | 12-9 | 16-10 | 21-6 | Note b | 8-1 | 12-9 | 16-10 | 21-6 | 25-11 |
| | Southern pine | #1 | 7-10 | 12-3 | 16-2 | 19-3 | 22-10 | 7-10 | 11-7 | 14-9 | 17-3 | 20-5 |
| | Southern pine | #2 | 7-6 | 11-2 | 14-2 | 16-10 | 19-10 | 6-8 | 10-0 | 12-8 | 15-1 | 17-9 |
| | Southern pine | #3 | 5-9 | 8-6 | 10-8 | 13-0 | 15-4 | 5-2 | 7-7 | 9-7 | 11-7 | 13-9 |
| | Spruce-pine-fir | SS | 7-8 | 12-0 | 15-10 | 20-2 | 24-7 | 7-8 | 12-0 | 15-10 | 19-9 | 22-10 |
| | Spruce-pine-fir | #1 | 7-6 | 11-9 | 15-1 | 18-5 | 21-5 | 7-3 | 10-8 | 13-6 | 16-6 | 19-2 |
| | Spruce-pine-fir | #2 | 7-6 | 11-9 | 15-1 | 18-5 | 21-5 | 7-3 | 10-8 | 13-6 | 16-6 | 19-2 |
| | Spruce-pine-fir | #3 | 6-2 | 9-0 | 11-5 | 13-11 | 16-2 | 5-6 | 8-1 | 10-3 | 12-6 | 14-6 |

*(continued)*

**TABLE R802.4.1(4)—continued**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 30 psf, ceiling attached to rafters, $L/\Delta$ = 240)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 19.2 | Douglas fir-larch | SS | 7-9 | 12-3 | 16-1 | 20-7 | 25-0 | 7-9 | 12-3 | 16-1 | 19-9 | 22-10 |
| | Douglas fir-larch | #1 | 7-6 | 11-8 | 14-9 | 18-0 | 20-11 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 |
| | Douglas fir-larch | #2 | 7-4 | 11-0 | 14-0 | 17-1 | 19-10 | 6-9 | 9-1 | 12-6 | 15-3 | 17-9 |
| | Douglas fir-larch | #3 | 5-9 | 8-5 | 10-8 | 13-1 | 15-2 | 5-2 | 7-7 | 9-7 | 11-8 | 13-6 |
| | Hem-fir | SS | 7-4 | 11-7 | 15-3 | 19-5 | 23-7 | 7-4 | 11-7 | 15-3 | 19-1 | 22-1 |
| | Hem-fir | #1 | 7-2 | 11-4 | 14-7 | 17-9 | 20-7 | 7-0 | 16-3 | 13-0 | 15-11 | 18-5 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hem-fir | #2 | 6-10 | 10-9 | 13-7 | 16-7 | 19-3 | 6-7 | 9-7 | 12-2 | 14-10 | 17-3 |
| | Hem-fir | #3 | 5-7 | 8-3 | 10-5 | 12-9 | 14-9 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 |
| | Southern pine | SS | 7-8 | 12-0 | 15-10 | 20-2 | 24-7 | 7-8 | 12-0 | 15-10 | 20-0 | 23-7 |
| | Southern pine | #1 | 7-4 | 11-7 | 15-1 | 17-7 | 20-11 | 7-1 | 10-7 | 13-5 | 15-9 | 18-8 |
| | Southern pine | #2 | 6-10 | 10-2 | 12-11 | 15-4 | 18-1 | 6-1 | 9-2 | 11-7 | 13-9 | 16-2 |
| | Southern pine | #3 | 5-3 | 7-9 | 9-9 | 11-10 | 14-0 | 4-8 | 6-11 | 8-9 | 10-7 | 12-6 |
| | Spruce-pine-fir | SS | 7-2 | 11-4 | 14-11 | 19-0 | 23-1 | 7-2 | 11-4 | 14-9 | 18-0 | 20-11 |
| | Spruce-pine-fir | #1 | 7-0 | 10-11 | 13-9 | 16-10 | 19-6 | 6-8 | 9-9 | 12-4 | 15-1 | 17-6 |
| | Spruce-pine-fir | #2 | 7-0 | 10-11 | 13-9 | 16-10 | 19-6 | 6-8 | 9-9 | 12-4 | 15-1 | 17-6 |
| | Spruce-pine-fir | #3 | 5-7 | 8-3 | 10-5 | 12-9 | 14-9 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 |
| 24 | Douglas fir-larch | SS | 7-3 | 11-4 | 15-0 | 19-1 | 22-10 | 7-3 | 11-4 | 14-5 | 17-8 | 20-5 |
| | Douglas fir-larch | #1 | 7-0 | 10-5 | 13-2 | 16-1 | 18-8 | 6-4 | 9-4 | 11-9 | 14-5 | 16-8 |
| | Douglas fir-larch | #2 | 6-9 | 9-10 | 12-6 | 15-3 | 17-9 | 6-0 | 8-10 | 11-2 | 13-8 | 15-10 |
| | Douglas fir-larch | #3 | 5-2 | 7-7 | 9-7 | 11-8 | 13-6 | 4-7 | 6-9 | 8-7 | 10-5 | 12-1 |
| | Hem-fir | SS | 6-10 | 10-9 | 14-2 | 18-0 | 21-11 | 6-10 | 10-9 | 13-11 | 17-0 | 19-9 |
| | Hem-fir | #1 | 6-8 | 10-3 | 13-0 | 15-11 | 18-5 | 6-3 | 9-2 | 11-8 | 14-3 | 16-6 |
| | Hem-fir | #2 | 6-4 | 9-7 | 12-2 | 14-10 | 17-3 | 5-10 | 8-7 | 10-10 | 13-3 | 15-5 |
| | Hem-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-6 | 6-7 | 8-4 | 10-2 | 11-10 |
| | Southern pine | SS | 7-1 | 11-2 | 14-8 | 18-9 | 22-10 | 7-1 | 11-2 | 14-8 | 17-11 | 21-2 |
| | Southern pine | #1 | 6-10 | 10-7 | 13-5 | 15-9 | 18-8 | 6-4 | 9-6 | 12-0 | 14-1 | 16-8 |
| | Southern pine | #2 | 6-1 | 9-2 | 11-7 | 13-9 | 16-2 | 5-5 | 8-2 | 10-4 | 12-3 | 14-6 |
| | Southern pine | #3 | 4-8 | 6-11 | 8-9 | 10-7 | 12-6 | 4-2 | 6-2 | 7-10 | 9-6 | 11-2 |
| | Spruce-pine-fir | SS | 6-8 | 10-6 | 13-10 | 17-8 | 20-11 | 6-8 | 10-5 | 13-2 | 16-1 | 18-8 |
| | Spruce-pine-fir | #1 | 6-6 | 9-9 | 12-4 | 15-1 | 17-6 | 5-11 | 8-8 | 11-0 | 13-6 | 15-7 |
| | Spruce-pine-fir | #2 | 6-6 | 9-9 | 12-4 | 15-1 | 17-6 | 5-11 | 8-8 | 11-0 | 13-6 | 15-7 |
| | Spruce-pine-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-6 | 6-7 | 8-4 | 10-2 | 11-10 |

Check sources for availability of lumber in lengths greater than 20 feet.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the adjustment factors in Table R802.4.1(9).

b. Span exceeds 26 feet in length.

**TABLE R802.4.1(5)**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 50 psf, ceiling not attached to rafters, $L/\Delta$ = 180)**

| | SPECIES AND GRADE | DEAD LOAD = 10 psf | DEAD LOAD = 20 psf |
|---|---|---|---|

| RAFTER SPACING (inches) | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 12 | Douglas fir-larch | SS | 8-5 | 13-3 | 17-6 | 22-4 | 26-0 | 8-5 | 13-3 | 17-3 | 21-1 | 24-5 |
| | Douglas fir-larch | #1 | 8-2 | 12-0 | 15-3 | 18-7 | 21-7 | 7-7 | 11-2 | 14-1 | 17-3 | 20-0 |
| | Douglas fir-larch | #2 | 7-10 | 11-5 | 14-5 | 17-8 | 20-5 | 7-3 | 10-7 | 13-4 | 16-4 | 18-11 |
| | Douglas fir-larch | #3 | 6-0 | 8-9 | 11-0 | 13-6 | 15-7 | 5-6 | 8-1 | 10-3 | 12-6 | 14-6 |
| | Hem-fir | SS | 8-0 | 12-6 | 16-6 | 21-1 | 25-6 | 8-0 | 12-6 | 16-6 | 20-4 | 23-7 |
| | Hem-fir | #1 | 7-10 | 11-10 | 15-0 | 18-4 | 21-3 | 7-6 | 11-0 | 13-11 | 17-0 | 19-9 |
| | Hem-fir | #2 | 7-5 | 11-1 | 14-0 | 17-2 | 19-11 | 7-0 | 10-3 | 13-0 | 15-10 | 18-5 |
| | Hem-fir | #3 | 5-10 | 8-6 | 10-9 | 13-2 | 15-3 | 5-5 | 7-10 | 10-0 | 12-2 | 14-1 |
| | Southern pine | SS | 8-4 | 13-1 | 17-2 | 21-11 | Note b | 8-4 | 13-1 | 17-2 | 21-5 | 25-3 |
| | Southern pine | #1 | 8-0 | 12-3 | 15-6 | 18-2 | 21-7 | 7-7 | 11-4 | 14-5 | 16-10 | 20-0 |
| | Southern pine | #2 | 7-0 | 10-6 | 13-4 | 15-10 | 18-8 | 6-6 | 9-9 | 12-4 | 14-8 | 17-3 |
| | Southern pine | #3 | 5-5 | 8-0 | 10-1 | 12-3 | 14-6 | 5-0 | 7-5 | 9-4 | 11-4 | 13-5 |
| | Spruce-pine-fir | SS | 7-10 | 12-3 | 16-2 | 20-8 | 24-1 | 7-10 | 12-3 | 15-9 | 19-3 | 22-4 |
| | Spruce-pine-fir | #1 | 7-8 | 11-3 | 14-3 | 17-5 | 20-2 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 |
| | Spruce-pine-fir | #2 | 7-8 | 11-3 | 14-3 | 17-5 | 20-2 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 |
| | Spruce-pine-fir | #3 | 5-10 | 8-6 | 10-9 | 13-2 | 15-3 | 5-5 | 7-10 | 10-0 | 12-2 | 14-1 |
| 16 | Douglas fir-larch | SS | 7-8 | 12-1 | 15-11 | 19-9 | 22-10 | 7-8 | 11-10 | 14-11 | 18-3 | 21-2 |
| | Douglas fir-larch | #1 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 | 6-7 | 9-8 | 12-2 | 14-11 | 17-3 |
| | Douglas fir-larch | #2 | 6-9 | 9-10 | 12-6 | 15-3 | 17-9 | 6-3 | 9-2 | 11-7 | 14-2 | 16-5 |
| | Douglas fir-larch | #3 | 5-2 | 7-7 | 9-7 | 11-18 | 13-6 | 4-9 | 7-0 | 8-10 | 10-10 | 12-6 |
| | Hem-fir | SS | 7-3 | 11-5 | 15-0 | 19-1 | 22-1 | 7-3 | 11-5 | 14-5 | 17-8 | 20-5 |
| | Hem-fir | #1 | 7-0 | 10-3 | 13-0 | 15-11 | 18-5 | 6-6 | 9-6 | 12-1 | 14-9 | 17-1 |
| | Hem-fir | #2 | 6-7 | 9-7 | 12-2 | 14-10 | 17-3 | 6-1 | 8-11 | 11-3 | 13-9 | 15-11 |
| | Hem-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-8 | 6-10 | 8-8 | 10-6 | 12-3 |
| | Southern pine | SS | 7-6 | 11-10 | 15-7 | 19-11 | 23-7 | 7-6 | 11-10 | 15-7 | 18-6 | 21-10 |
| | Southern pine | #1 | 7-1 | 10-7 | 13-5 | 15-9 | 18-8 | 6-7 | 9-10 | 12-5 | 14-7 | 17-3 |
| | Southern pine | #2 | 6-1 | 9-2 | 11-7 | 13-9 | 16-2 | 5-8 | 8-5 | 10-9 | 12-9 | 15-0 |
| | Southern pine | #3 | 4-8 | 6-11 | 8-9 | 10-7 | 12-6 | 4-4 | 6-5 | 8-1 | 9-10 | 11-7 |
| | Spruce-pine-fir | SS | 7-1 | 11-2 | 14-8 | 18-0 | 20-11 | 7-1 | 10-9 | 13-8 | 15-11 | 19-4 |
| | Spruce-pine-fir | #1 | 6-8 | 9-9 | 12-4 | 15-1 | 17-6 | 6-2 | 9-0 | 11-5 | 13-11 | 16-2 |
| | Spruce-pine-fir | #2 | 6-8 | 9-9 | 12-4 | 15-1 | 17-6 | 6-2 | 9-0 | 11-5 | 13-11 | 16-2 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Spruce-pine-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-8 | 6-10 | 8-8 | 10-6 | 12-3 |

(continued)

**TABLE R802.4.1(5)—continued**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 50 psf, ceiling not attached to rafters, *L*/Δ = 180)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 19.2 | Douglas fir-larch | SS | 7-3 | 11-4 | 14-9 | 18-0 | 20-11 | 7-3 | 10-9 | 13-8 | 16-8 | 19-4 |
| | Douglas fir-larch | #1 | 6-6 | 9-6 | 12-0 | 14-8 | 17-1 | 6-0 | 8-10 | 11-2 | 13-7 | 15-9 |
| | Douglas fir-larch | #2 | 6-2 | 9-0 | 11-5 | 13-11 | 16-2 | 5-8 | 8-4 | 10-9 | 12-11 | 15-0 |
| | Douglas fir-larch | #3 | 4-8 | 6-11 | 8-9 | 10-8 | 12-4 | 4-4 | 6-4 | 8-1 | 9-10 | 11-5 |
| | Hem-fir | SS | 6-10 | 10-9 | 14-2 | 17-5 | 20-2 | 6-10 | 10-5 | 13-2 | 16-1 | 18-8 |
| | Hem-fir | #1 | 6-5 | 9-5 | 11-11 | 14-6 | 16-10 | 8-11 | 8-8 | 11-0 | 13-5 | 15-7 |
| | Hem-fir | #2 | 6-0 | 8-9 | 11-1 | 13-7 | 15-9 | 5-7 | 8-1 | 10-3 | 12-7 | 14-7 |
| | Hem-fir | #3 | 4-7 | 6-9 | 8-6 | 10-5 | 12-1 | 4-3 | 6-3 | 7-11 | 9-7 | 11-2 |
| | Southern pine | SS | 7-1 | 11-2 | 14-8 | 18-3 | 21-7 | 7-1 | 11-2 | 14-2 | 16-11 | 20-0 |
| | Southern pine | #1 | 6-6 | 9-8 | 12-3 | 14-4 | 17-1 | 6-0 | 9-0 | 11-4 | 13-4 | 15-9 |
| | Southern pine | #2 | 5-7 | 8-4 | 10-7 | 12-6 | 14-9 | 5-2 | 7-9 | 9-9 | 11-7 | 13-8 |
| | Southern pine | #3 | 4-3 | 6-4 | 8-0 | 9-8 | 11-5 | 4-0 | 5-10 | 7-4 | 8-11 | 10-7 |
| | Spruce-pine-fir | SS | 6-8 | 10-6 | 13-5 | 16-5 | 19-1 | 6-8 | 9-10 | 12-5 | 15-3 | 17-8 |
| | Spruce-pine-fir | #1 | 6-1 | 8-11 | 11-3 | 13-9 | 15-11 | 5-7 | 8-3 | 10-5 | 12-9 | 14-9 |
| | Spruce-pine-fir | #2 | 6-1 | 8-11 | 11-3 | 13-9 | 15-11 | 5-7 | 8-3 | 10-5 | 12-9 | 14-9 |
| | Spruce-pine-fir | #3 | 4-7 | 6-9 | 8-6 | 10-5 | 12-1 | 4-3 | 6-3 | 7-11 | 9-7 | 11-2 |
| 24 | Douglas fir-larch | SS | 6-8 | 10-5 | 13-2 | 16-1 | 18-8 | 6-7 | 9-8 | 12-2 | 14-11 | 17-3 |
| | Douglas fir-larch | #1 | 5-10 | 8-6 | 10-9 | 13-2 | 15-3 | 5-5 | 7-10 | 10-0 | 12-2 | 14-1 |
| | Douglas fir-larch | #2 | 5-6 | 8-1 | 10-3 | 12-6 | 14-6 | 5-1 | 7-6 | 9-5 | 11-7 | 13-5 |
| | Douglas fir-larch | #3 | 4-3 | 6-2 | 7-10 | 9-6 | 11-1 | 3-11 | 5-8 | 7-3 | 8-10 | 10-3 |
| | Hem-fir | SS | 6-4 | 9-11 | 12-9 | 15-7 | 18-0 | 6-4 | 9-4 | 11-9 | 14-5 | 16-8 |
| | Hem-fir | #1 | 5-9 | 8-5 | 10-8 | 13-0 | 15-1 | 8-4 | 7-9 | 9-10 | 12-0 | 13-11 |
| | Hem-fir | #2 | 5-4 | 7-10 | 9-11 | 12-1 | 14-1 | 4-11 | 7-3 | 9-2 | 11-3 | 13-0 |
| | Hem-fir | #3 | 4-1 | 6-0 | 7-7 | 9-4 | 10-9 | 3-10 | 5-7 | 7-1 | 8-7 | 10-0 |
| | Southern pine | SS | 6-7 | 10-4 | 13-8 | 16-4 | 19-3 | 6-7 | 10-0 | 12-8 | 15-2 | 17-10 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Southern pine | #1 | 5-10 | 8-8 | 11-0 | 12-10 | 15-3 | 5-5 | 8-0 | 10-2 | 11-11 | 14-1 |
| | Southern pine | #2 | 5-0 | 7-5 | 9-5 | 11-3 | 13-2 | 4-7 | 6-11 | 8-9 | 10-5 | 12-3 |
| | Southern pine | #3 | 3-10 | 5-8 | 7-1 | 8-8 | 10-3 | 3-6 | 5-3 | 6-7 | 8-0 | 9-6 |
| | Spruce-pine-fir | SS | 6-2 | 9-6 | 12-0 | 14-8 | 17-1 | 6-0 | 8-10 | 11-2 | 13-7 | 15-9 |
| | Spruce-pine-fir | #1 | 5-5 | 7-11 | 10-1 | 12-4 | 14-3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 |
| | Spruce-pine-fir | #2 | 5-5 | 7-11 | 10-1 | 12-4 | 14-3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 |
| | Spruce-pine-fir | #3 | 4-1 | 6-0 | 7-7 | 9-4 | 10-9 | 3-10 | 5-7 | 7-1 | 8-7 | 10-0 |

Check sources for availability of lumber in lengths greater than 20 feet.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the adjustment factors in Table R802.4.1(9).

b. Span exceeds 26 feet in length.

**TABLE R802.4.1(6)**
**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 50 psf, ceiling attached to rafters, *L*/Δ = 240)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 12 | Douglas fir-larch | SS | 7-8 | 12-1 | 15-11 | 20-3 | 24-8 | 7-8 | 12-1 | 15-11 | 20-3 | 24-5 |
| | Douglas fir-larch | #1 | 7-5 | 11-7 | 15-3 | 18-7 | 21-7 | 7-5 | 11-2 | 14-1 | 17-3 | 20-0 |
| | Douglas fir-larch | #2 | 7-3 | 11-5 | 14-5 | 17-8 | 20-5 | 7-3 | 10-7 | 13-4 | 16-4 | 18-11 |
| | Douglas fir-larch | #3 | 6-0 | 8-9 | 11-0 | 13-6 | 15-7 | 5-6 | 8-1 | 10-3 | 12-6 | 14-6 |
| | Hem-fir | SS | 7-3 | 11-5 | 15-0 | 19-2 | 23-4 | 7-3 | 11-5 | 15-0 | 19-2 | 23-4 |
| | Hem-fir | #1 | 7-1 | 11-2 | 14-8 | 18-4 | 21-3 | 7-1 | 11-0 | 13-11 | 17-0 | 19-9 |
| | Hem-fir | #2 | 6-9 | 10-8 | 14-0 | 17-2 | 19-11 | 6-9 | 10-3 | 13-0 | 15-10 | 18-5 |
| | Hem-fir | #3 | 5-10 | 8-6 | 10-9 | 13-2 | 15-3 | 5-5 | 7-10 | 10-0 | 12-2 | 14-1 |
| | Southern pine | SS | 7-6 | 11-10 | 15-7 | 19-11 | 24-3 | 7-6 | 11-10 | 15-7 | 19-11 | 24-3 |
| | Southern pine | #1 | 7-3 | 11-5 | 15-0 | 18-2 | 21-7 | 7-3 | 11-4 | 14-5 | 16-10 | 20-0 |
| | Southern pine | #2 | 6-11 | 10-6 | 13-4 | 15-10 | 18-8 | 6-6 | 9-9 | 12-4 | 14-8 | 17-3 |
| | Southern pine | #3 | 5-5 | 8-0 | 10-1 | 12-3 | 14-6 | 5-0 | 7-5 | 9-4 | 11-4 | 13-5 |
| | Spruce-pine-fir | SS | 7-1 | 11-2 | 14-8 | 18-9 | 22-10 | 7-1 | 11-2 | 14-8 | 18-9 | 22-4 |
| | Spruce-pine-fir | #1 | 6-11 | 10-11 | 14-3 | 17-5 | 20-2 | 6-11 | 10-5 | 13-2 | 16-1 | 18-8 |
| | Spruce-pine-fir | #2 | 6-11 | 10-11 | 14-3 | 17-5 | 20-2 | 6-11 | 10-5 | 13-2 | 16-1 | 18-8 |
| | Spruce-pine-fir | #3 | 5-10 | 8-6 | 10-9 | 13-2 | 15-3 | 5-5 | 7-10 | 10-0 | 12-2 | 14-1 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | Douglas fir-larch | SS | 7-0 | 11-0 | 14-5 | 18-5 | 22-5 | 7-0 | 11-0 | 14-5 | 18-3 | 21-2 |
| | Douglas fir-larch | #1 | 6-9 | 10-5 | 13-2 | 16-1 | 18-8 | 6-7 | 9-8 | 12-2 | 14-11 | 17-3 |
| | Douglas fir-larch | #2 | 6-7 | 9-10 | 12-6 | 15-3 | 17-9 | 6-3 | 9-2 | 11-7 | 14-2 | 16-5 |
| | Douglas fir-larch | #3 | 5-2 | 7-7 | 9-7 | 11-8 | 13-6 | 4-9 | 7-0 | 8-10 | 10-10 | 12-6 |
| | Hem-fir | SS | 6-7 | 10-4 | 13-8 | 17-5 | 21-2 | 6-7 | 10-4 | 13-8 | 17-5 | 20-5 |
| | Hem-fir | #1 | 6-5 | 10-2 | 13-0 | 15-11 | 18-5 | 6-5 | 9-6 | 12-1 | 14-9 | 17-1 |
| | Hem-fir | #2 | 6-2 | 9-7 | 12-2 | 14-10 | 17-3 | 6-1 | 8-11 | 11-3 | 13-9 | 15-11 |
| | Hem-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-8 | 6-10 | 8-8 | 10-6 | 12-3 |
| | Southern pine | SS | 6-10 | 10-9 | 14-2 | 18-1 | 22-0 | 6-10 | 10-9 | 14-2 | 18-1 | 21-10 |
| | Southern pine | #1 | 6-7 | 10-4 | 13-5 | 15-9 | 18-8 | 6-7 | 9-10 | 12-5 | 14-7 | 17-3 |
| | Southern pine | #2 | 6-1 | 9-2 | 11-7 | 13-9 | 16-2 | 5-8 | 8-5 | 10-9 | 12-9 | 15-0 |
| | Southern pine | #3 | 4-8 | 6-11 | 8-9 | 10-7 | 12-6 | 4-4 | 6-5 | 8-1 | 9-10 | 11-7 |
| | Spruce-pine-fir | SS | 6-5 | 10-2 | 13-4 | 17-0 | 20-9 | 6-5 | 10-2 | 13-4 | 16-8 | 19-4 |
| | Spruce-pine-fir | #1 | 6-4 | 9-9 | 12-4 | 15-1 | 17-6 | 6-2 | 9-0 | 11-5 | 13-11 | 16-2 |
| | Spruce-pine-fir | #2 | 6-4 | 9-9 | 12-4 | 15-1 | 17-6 | 6-2 | 9-0 | 11-5 | 13-11 | 16-2 |
| | Spruce-pine-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-8 | 6-10 | 8-8 | 10-6 | 12-3 |

*(continued)*

**TABLE R802.4.1(6)—continued**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 50 psf, ceiling attached to rafters, *L*/Δ = 240)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feet-inches) | (feet-inches) | (feet-inches) | (feet-inches) | (feet-inches) | (feet-inches) | (feet-inches) | (feet-inches) | (feet-inches) | (feet-inches) |
| 19.2 | Douglas fir-larch | SS | 6-7 | 10-4 | 13-7 | 17-4 | 20-11 | 6-7 | 10-4 | 13-7 | 16-8 | 19-4 |
| | Douglas fir-larch | #1 | 6-4 | 9-6 | 12-0 | 14-8 | 17-1 | 6-0 | 8-10 | 11-2 | 13-7 | 15-9 |
| | Douglas fir-larch | #2 | 6-2 | 9-0 | 11-5 | 13-11 | 16-2 | 5-8 | 8-4 | 10-7 | 12-11 | 15-0 |
| | Douglas fir-larch | #3 | 4-8 | 6-11 | 8-9 | 10-8 | 12-4 | 4-4 | 6-4 | 8-1 | 9-10 | 11-5 |
| | Hem-fir | SS | 6-2 | 9-9 | 12-10 | 16-5 | 19-11 | 6-2 | 9-9 | 12-10 | 16-1 | 18-8 |
| | Hem-fir | #1 | 6-1 | 9-5 | 11-11 | 14-6 | 16-10 | 5-11 | 8-8 | 11-0 | 13-5 | 15-7 |
| | Hem-fir | #2 | 5-9 | 8-9 | 11-1 | 13-7 | 15-9 | 5-7 | 8-1 | 10-3 | 12-7 | 14-7 |
| | Hem-fir | #3 | 4-7 | 6-9 | 8-6 | 10-5 | 12-1 | 4-3 | 6-3 | 7-11 | 9-7 | 11-2 |
| | Southern pine | SS | 6-5 | 10-2 | 13-4 | 17-0 | 20-9 | 6-5 | 10-2 | 13-4 | 16-11 | 20-0 |
| | Southern pine | #1 | 6-2 | 9-8 | 12-3 | 14-4 | 17-1 | 6-0 | 9-0 | 11-4 | 13-4 | 15-9 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Southern pine | #2 | 5-7 | 8-4 | 10-7 | 12-6 | 14-9 | 5-2 | 7-9 | 9-9 | 11-7 | 13-8 |
| | Southern pine | #3 | 4-3 | 6-4 | 8-0 | 9-8 | 11-5 | 4-0 | 5-10 | 7-4 | 8-11 | 10-7 |
| | Spruce-pine-fir | SS | 6-1 | 9-6 | 12-7 | 16-0 | 19-1 | 6-1 | 9-6 | 12-5 | 15-3 | 17-8 |
| | Spruce-pine-fir | #1 | 5-11 | 8-11 | 11-3 | 13-9 | 15-11 | 5-7 | 8-3 | 10-5 | 12-9 | 14-9 |
| | Spruce-pine-fir | #2 | 5-11 | 8-11 | 11-3 | 13-9 | 15-11 | 5-7 | 8-3 | 10-5 | 12-9 | 14-9 |
| | Spruce-pine-fir | #3 | 4-7 | 6-9 | 8-6 | 10-5 | 12-1 | 4-3 | 6-3 | 7-11 | 9-7 | 11-2 |
| 24 | Douglas fir-larch | SS | 6-1 | 9-7 | 12-7 | 16-1 | 18-8 | 6-1 | 9-7 | 12-2 | 14-11 | 17-3 |
| | Douglas fir-larch | #1 | 5-10 | 8-6 | 10-9 | 13-2 | 15-3 | 5-5 | 7-10 | 10-0 | 12-2 | 14-1 |
| | Douglas fir-larch | #2 | 5-6 | 8-1 | 10-3 | 12-6 | 14-6 | 5-1 | 7-6 | 9-5 | 11-7 | 13-5 |
| | Douglas fir-larch | #3 | 4-3 | 6-2 | 7-10 | 9-6 | 11-1 | 3-11 | 5-8 | 7-3 | 8-10 | 10-3 |
| | Hem-fir | SS | 5-9 | 9-1 | 11-11 | 15-2 | 18-0 | 5-9 | 9-1 | 11-9 | 14-5 | 15-11 |
| | Hem-fir | #1 | 5-8 | 8-5 | 10-8 | 13-0 | 15-1 | 5-4 | 7-9 | 9-10 | 12-0 | 13-11 |
| | Hem-fir | #2 | 5-4 | 7-10 | 9-11 | 12-1 | 14-1 | 4-11 | 7-3 | 9-2 | 11-3 | 13-0 |
| | Hem-fir | #3 | 4-1 | 6-0 | 7-7 | 9-4 | 10-9 | 3-10 | 5-7 | 7-1 | 8-7 | 10-0 |
| | Southern pine | SS | 6-0 | 9-5 | 12-5 | 15-10 | 19-3 | 6-0 | 9-5 | 12-5 | 15-2 | 17-10 |
| | Southern pine | #1 | 5-9 | 8-8 | 11-0 | 12-10 | 15-3 | 5-5 | 8-0 | 10-2 | 11-11 | 14-1 |
| | Southern pine | #2 | 5-0 | 7-5 | 9-5 | 11-3 | 13-2 | 4-7 | 6-11 | 8-9 | 10-5 | 12-3 |
| | Southern pine | #3 | 3-10 | 5-8 | 7-1 | 8-8 | 10-3 | 3-6 | 5-3 | 6-7 | 8-0 | 9-6 |
| | Spruce-pine-fir | SS | 5-8 | 8-10 | 11-8 | 14-8 | 17-1 | 5-8 | 8-10 | 11-2 | 13-7 | 15-9 |
| | Spruce-pine-fir | #1 | 5-5 | 7-11 | 10-1 | 12-4 | 14-3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 |
| | Spruce-pine-fir | #2 | 5-5 | 7-11 | 10-1 | 12-4 | 14-3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 |
| | Spruce-pine-fir | #3 | 4-1 | 6-0 | 7-7 | 9-4 | 10-9 | 3-10 | 5-7 | 7-1 | 8-7 | 10-0 |

Check sources for availability of lumber in lengths greater than 20 feet.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the adjustment factors in Table R802.4.1(9).

**TABLE R802.4.1(7)**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 70 psf, ceiling not attached to rafters, $L/\Delta$ = 180)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum Rafter Spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 12 | Douglas fir-larch | SS | 7-7 | 11-10 | 15-8 | 19-9 | 22-10 | 7-7 | 11-10 | 15-3 | 18-7 | 21-7 |
| | Douglas fir-larch | #1 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 | 6-8 | 9-10 | 12-5 | 15-2 | 17-7 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Douglas fir-larch | #2 | 6-9 | 9-10 | 12-6 | 15-3 | 17-9 | 6-4 | 9-4 | 11-9 | 14-5 | 16-8 |
| | Douglas fir-larch | #3 | 5-2 | 7-7 | 9-7 | 11-8 | 13-6 | 4-10 | 7-1 | 9-0 | 11-0 | 12-9 |
| | Hem-fir | SS | 7-2 | 11-3 | 14-9 | 18-10 | 22-1 | 7-2 | 11-3 | 14-8 | 18-0 | 20-10 |
| | Hem-fir | #1 | 7-0 | 10-3 | 13-0 | 15-11 | 18-5 | 6-7 | 9-8 | 12-3 | 15-0 | 17-5 |
| | Hem-fir | #2 | 6-7 | 9-7 | 12-2 | 14-10 | 17-3 | 6-2 | 9-1 | 11-5 | 14-0 | 16-3 |
| | Hem-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-9 | 6-11 | 8-9 | 10-9 | 12-5 |
| | Southern pine | SS | 7-5 | 11-8 | 15-4 | 19-7 | 23-7 | 7-5 | 11-8 | 15-4 | 18-10 | 22-3 |
| | Southern pine | #1 | 7-1 | 10-7 | 13-5 | 15-9 | 18-8 | 6-9 | 10-0 | 12-8 | 14-10 | 17-7 |
| | Southern pine | #2 | 6-1 | 9-2 | 11-7 | 13-9 | 16-2 | 5-9 | 8-7 | 10-11 | 12-11 | 15-3 |
| | Southern pine | #3 | 4-8 | 6-11 | 8-9 | 10-7 | 12-6 | 4-5 | 6-6 | 8-3 | 10-0 | 11-10 |
| | Spruce-pine-fir | SS | 7-0 | 11-0 | 14-6 | 18-0 | 20-11 | 7-0 | 11-0 | 13-11 | 17-0 | 19-8 |
| | Spruce-pine-fir | #1 | 6-8 | 9-9 | 12-4 | 15-1 | 17-6 | 6-3 | 9-2 | 11-8 | 14-2 | 16-6 |
| | Spruce-pine-fir | #2 | 6-8 | 9-9 | 12-4 | 15-1 | 17-6 | 6-3 | 9-2 | 11-8 | 14-2 | 16-6 |
| | Spruce-pine-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-9 | 6-11 | 8-9 | 10-9 | 12-5 |
| 16 | Douglas fir-larch | SS | 6-10 | 10-9 | 14-0 | 17-1 | 19-10 | 6-10 | 10-5 | 13-2 | 16-1 | 18-8 |
| | Douglas fir-larch | #1 | 6-2 | 9-0 | 11-5 | 13-11 | 16-2 | 5-10 | 8-6 | 10-9 | 13-2 | 15-3 |
| | Douglas fir-larch | #2 | 5-10 | 8-7 | 10-10 | 13-3 | 15-4 | 5-6 | 8-1 | 10-3 | 12-6 | 14-6 |
| | Douglas fir-larch | #3 | 4-6 | 6-6 | 8-3 | 10-1 | 11-9 | 4-3 | 6-2 | 7-10 | 9-6 | 11-1 |
| | Hem-fir | SS | 6-6 | 10-2 | 13-5 | 16-6 | 19-2 | 6-6 | 10-1 | 12-9 | 15-7 | 18-0 |
| | Hem-fir | #1 | 6-1 | 8-11 | 11-3 | 13-9 | 16-0 | 5-9 | 8-5 | 10-8 | 13-0 | 15-1 |
| | Hem-fir | #2 | 5-8 | 8-4 | 10-6 | 12-10 | 14-11 | 5-4 | 7-10 | 9-11 | 12-1 | 14-1 |
| | Hem-fir | #3 | 4-4 | 6-4 | 8-1 | 9-10 | 11-5 | 4-1 | 6-0 | 7-7 | 9-4 | 10-9 |
| | Southern pine | SS | 6-9 | 10-7 | 14-0 | 17-4 | 20-5 | 6-9 | 10-7 | 13-9 | 16-4 | 19-3 |
| | Southern pine | #1 | 6-2 | 9-2 | 11-8 | 13-8 | 16-2 | 5-10 | 8-8 | 11-0 | 12-10 | 15-3 |
| | Southern pine | #2 | 5-3 | 7-11 | 10-0 | 11-11 | 14-0 | 5-0 | 7-5 | 9-5 | 11-3 | 13-2 |
| | Southern pine | #3 | 4-1 | 6-0 | 7-7 | 9-2 | 10-10 | 3-10 | 5-8 | 7-1 | 8-8 | 10-3 |
| | Spruce-pine-fir | SS | 6-4 | 10-0 | 12-9 | 15-7 | 18-1 | 6-4 | 9-6 | 12-0 | 14-8 | 17-1 |
| | Spruce-pine-fir | #1 | 5-9 | 8-5 | 10-8 | 13-1 | 15-2 | 5-5 | 7-11 | 10-1 | 12-4 | 14-3 |
| | Spruce-pine-fir | #2 | 5-9 | 8-5 | 10-8 | 13-1 | 15-2 | 5-5 | 7-11 | 10-1 | 12-4 | 14-3 |
| | Spruce-pine-fir | #3 | 4-4 | 6-4 | 8-1 | 9-10 | 11-5 | 4-1 | 6-0 | 7-7 | 9-4 | 10-9 |

*(continued)*

**TABLE R802.4.1(7)—continued**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 70 psf, ceiling not attached to rafters, *L*/Δ = 180)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum Rafter Spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 19.2 | Douglas fir-larch | SS | 6-6 | 10-1 | 12-9 | 15-7 | 18-1 | 6-6 | 9-6 | 12-0 | 14-8 | 17-1 |
| | Douglas fir-larch | #1 | 5-7 | 8-3 | 10-5 | 12-9 | 14-9 | 5-4 | 7-9 | 9-10 | 12-0 | 13-11 |
| | Douglas fir-larch | #2 | 5-4 | 7-10 | 9-11 | 12-1 | 14-0 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 |
| | Douglas fir-larch | #3 | 4-1 | 6-0 | 7-7 | 9-3 | 10-8 | 3-10 | 5-7 | 7-1 | 8-8 | 10-1 |
| | Hem-fir | SS | 6-1 | 9-7 | 12-4 | 15-1 | 17-4 | 6-1 | 9-2 | 11-8 | 14-2 | 15-5 |
| | Hem-fir | #1 | 5-7 | 8-2 | 10-3 | 12-7 | 14-7 | 5-3 | 7-8 | 9-8 | 11-10 | 13-9 |
| | Hem-fir | #2 | 5-2 | 7-7 | 9-7 | 11-9 | 13-7 | 4-11 | 7-2 | 9-1 | 11-1 | 12-10 |
| | Hem-fir | #3 | 4-0 | 5-10 | 7-4 | 9-0 | 10-5 | 3-9 | 5-6 | 6-11 | 8-6 | 9-10 |
| | Southern pine | SS | 6-4 | 10-0 | 13-2 | 15-10 | 18-8 | 6-4 | 9-10 | 12-6 | 14-11 | 17-7 |
| | Southern pine | #1 | 5-8 | 8-5 | 10-8 | 12-5 | 14-9 | 5-4 | 7-11 | 10-0 | 11-9 | 13-11 |
| | Southern pine | #2 | 4-10 | 7-3 | 9-2 | 10-10 | 12-9 | 4-6 | 6-10 | 8-8 | 10-3 | 12-1 |
| | Southern pine | #3 | 3-8 | 5-6 | 6-11 | 8-4 | 9-11 | 3-6 | 5-2 | 6-6 | 7-11 | 9-4 |
| | Spruce-pine-fir | SS | 6-0 | 9-2 | 11-8 | 14-3 | 16-6 | 5-11 | 8-8 | 11-0 | 13-5 | 15-7 |
| | Spruce-pine-fir | #1 | 5-3 | 7-8 | 9-9 | 11-11 | 13-10 | 5-0 | 7-3 | 9-2 | 11-3 | 13-0 |
| | Spruce-pine-fir | #2 | 5-3 | 7-8 | 9-9 | 11-11 | 13-10 | 5-0 | 7-3 | 9-2 | 11-3 | 13-0 |
| | Spruce-pine-fir | #3 | 4-0 | 5-10 | 7-4 | 9-0 | 10-5 | 3-9 | 5-6 | 6-11 | 8-6 | 9-10 |
| 24 | Douglas fir-larch | SS | 6-0 | 9-0 | 11-5 | 13-11 | 16-2 | 5-10 | 8-6 | 10-9 | 13-2 | 15-3 |
| | Douglas fir-larch | #1 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-9 | 6-11 | 8-9 | 10-9 | 12-5 |
| | Douglas fir-larch | #2 | 4-9 | 7-0 | 8-10 | 10-10 | 12-6 | 4-6 | 6-7 | 8-4 | 10-2 | 11-10 |
| | Douglas fir-larch | #3 | 3-8 | 5-4 | 6-9 | 8-3 | 9-7 | 3-5 | 5-0 | 6-4 | 7-9 | 9-10 |
| | Hem-fir | SS | 5-8 | 8-8 | 11-0 | 13-6 | 13-11 | 5-7 | 8-3 | 10-5 | 12-4 | 12-4 |
| | Hem-fir | #1 | 5-0 | 7-3 | 9-2 | 11-3 | 13-0 | 4-8 | 6-10 | 8-8 | 10-7 | 12-4 |
| | Hem-fir | #2 | 4-8 | 6-9 | 8-7 | 10-6 | 12-2 | 4-4 | 6-5 | 8-1 | 9-11 | 11-6 |
| | Hem-fir | #3 | 3-7 | 5-2 | 6-7 | 8-1 | 9-4 | 3-4 | 4-11 | 6-3 | 7-7 | 8-10 |
| | Southern pine | SS | 5-11 | 9-3 | 11-11 | 14-2 | 16-8 | 5-11 | 8-10 | 11-2 | 13-4 | 15-9 |
| | Southern pine | #1 | 5-0 | 7-6 | 9-6 | 11-1 | 13-2 | 4-9 | 7-1 | 9-0 | 10-6 | 12-5 |
| | Southern pine | #2 | 4-4 | 6-5 | 8-2 | 9-9 | 11-5 | 4-1 | 6-1 | 7-9 | 9-2 | 10-9 |
| | Southern pine | #3 | 3-4 | 4-11 | 6-2 | 7-6 | 8-10 | 3-1 | 4-7 | 5-10 | 7-1 | 8-4 |
| | Spruce-pine-fir | SS | 5-6 | 8-3 | 10-5 | 12-9 | 14-9 | 5-4 | 7-9 | 9-10 | 12-0 | 12-11 |
| | Spruce-pine-fir | #1 | 4-8 | 6-11 | 8-9 | 10-8 | 12-4 | 4-5 | 6-6 | 8-3 | 10-0 | 11-8 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Spruce-pine-fir | #2 | 4-8 | 6-11 | 8-9 | 10-8 | 12-4 | 4-5 | 6-6 | 8-3 | 10-0 | 11-8 |
| | Spruce-pine-fir | #3 | 3-7 | 5-2 | 6-7 | 8-1 | 9-4 | 3-4 | 4-11 | 6-3 | 7-7 | 8-10 |

Check sources for availability of lumber in lengths greater than 20 feet.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the adjustment factors in Table R802.4.1(9).

**TABLE R802.4.1(8)**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 70 psf, ceiling attached to rafters, *L*/Δ = 240)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 12 | Douglas fir-larch | SS | 6-10 | 10-9 | 14-3 | 18-2 | 22-1 | 6-10 | 10-9 | 14-3 | 18-2 | 21-7 |
| | Douglas fir-larch | #1 | 6-7 | 10-5 | 13-2 | 16-1 | 18-8 | 6-7 | 9-10 | 12-5 | 15-2 | 17-7 |
| | Douglas fir-larch | #2 | 6-6 | 9-10 | 12-6 | 15-3 | 17-9 | 6-4 | 9-4 | 11-9 | 14-5 | 16-8 |
| | Douglas fir-larch | #3 | 5-2 | 7-7 | 9-7 | 11-8 | 13-6 | 4-10 | 7-1 | 9-0 | 11-0 | 12-9 |
| | Hem-fir | SS | 6-6 | 10-2 | 13-5 | 17-2 | 20-10 | 6-6 | 10-2 | 13-5 | 17-2 | 20-10 |
| | Hem-fir | #1 | 6-4 | 10-0 | 13-0 | 15-11 | 18-5 | 6-4 | 9-8 | 12-3 | 15-0 | 17-5 |
| | Hem-fir | #2 | 6-1 | 9-6 | 12-2 | 14-10 | 17-3 | 6-1 | 9-1 | 11-5 | 14-0 | 16-3 |
| | Hem-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-9 | 6-11 | 8-9 | 10-9 | 12-5 |
| | Southern pine | SS | 6-9 | 10-7 | 14-0 | 17-10 | 21-8 | 6-9 | 10-7 | 14-0 | 17-10 | 21-8 |
| | Southern pine | #1 | 6-6 | 10-2 | 13-5 | 15-9 | 18-8 | 6-6 | 10-0 | 12-8 | 14-10 | 17-7 |
| | Southern pine | #2 | 6-1 | 9-2 | 11-7 | 13-9 | 16-2 | 5-9 | 8-7 | 10-11 | 12-11 | 15-3 |
| | Southern pine | #3 | 4-8 | 6-11 | 8-9 | 10-7 | 12-6 | 4-5 | 6-6 | 8-3 | 10-0 | 11-10 |
| | Spruce-pine-fir | SS | 6-4 | 10-0 | 13-2 | 16-9 | 20-5 | 6-4 | 10-0 | 13-2 | 16-9 | 19-8 |
| | Spruce-pine-fir | #1 | 6-2 | 9-9 | 12-4 | 15-1 | 17-6 | 6-2 | 9-2 | 11-8 | 14-2 | 16-6 |
| | Spruce-pine-fir | #2 | 6-2 | 9-9 | 12-4 | 15-1 | 17-6 | 6-2 | 9-2 | 11-8 | 14-2 | 16-6 |
| | Spruce-pine-fir | #3 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-9 | 6-11 | 8-9 | 10-9 | 12-5 |
| 16 | Douglas fir-larch | SS | 6-3 | 9-10 | 12-11 | 16-6 | 19-10 | 6-3 | 9-10 | 12-11 | 16-1 | 18-8 |
| | Douglas fir-larch | #1 | 6-0 | 9-0 | 11-5 | 13-11 | 16-2 | 5-10 | 8-6 | 10-9 | 13-2 | 15-3 |
| | Douglas fir-larch | #2 | 5-10 | 8-7 | 10-10 | 13-3 | 15-4 | 5-6 | 8-1 | 10-3 | 12-6 | 14-6 |
| | Douglas fir-larch | #3 | 4-6 | 6-6 | 8-3 | 10-1 | 11-9 | 4-3 | 6-2 | 7-10 | 9-6 | 11-1 |
| | Hem-fir | SS | 5-11 | 9-3 | 12-2 | 15-7 | 18-11 | 5-11 | 9-3 | 12-2 | 15-7 | 18-0 |
| | Hem-fir | #1 | 5-9 | 8-11 | 11-3 | 13-9 | 16-0 | 5-9 | 8-5 | 10-8 | 13-0 | 15-1 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hem-fir | #2 | 5-6 | 8-4 | 10-6 | 12-10 | 14-11 | 5-4 | 7-10 | 9-11 | 12-1 | 14-1 |
| | Hem-fir | #3 | 4-4 | 6-4 | 8-1 | 9-10 | 11-5 | 4-1 | 6-0 | 7-7 | 9-4 | 10-9 |
| | Southern pine | SS | 6-1 | 9-7 | 12-8 | 16-2 | 19-8 | 6-1 | 9-7 | 12-8 | 16-2 | 19-3 |
| | Southern pine | #1 | 5-11 | 9-2 | 11-8 | 13-8 | 16-2 | 5-10 | 8-8 | 11-0 | 12-10 | 15-3 |
| | Southern pine | #2 | 5-3 | 7-11 | 10-0 | 11-11 | 14-0 | 5-0 | 7-5 | 9-5 | 11-3 | 13-2 |
| | Southern pine | #3 | 4-1 | 6-0 | 7-7 | 9-2 | 10-10 | 3-10 | 5-8 | 7-1 | 8-8 | 10-3 |
| | Spruce-pine-fir | SS | 5-9 | 9-1 | 11-11 | 15-3 | 18-1 | 5-9 | 9-1 | 11-11 | 14-8 | 17-1 |
| | Spruce-pine-fir | #1 | 5-8 | 8-5 | 10-8 | 13-1 | 15-2 | 5-5 | 7-11 | 10-1 | 12-4 | 14-3 |
| | Spruce-pine-fir | #2 | 5-8 | 8-5 | 10-8 | 13-1 | 15-2 | 5-5 | 7-11 | 10-1 | 12-4 | 14-3 |
| | Spruce-pine-fir | #3 | 4-4 | 6-4 | 8-1 | 9-10 | 11-5 | 4-1 | 6-0 | 7-7 | 9-4 | 10-9 |

*(continued)*

**TABLE R802.4.1(8)—continued**

**RAFTER SPANS FOR COMMON LUMBER SPECIES (Ground snow load = 70 psf, ceiling attached to rafters, *L*/Δ = 240)**

| RAFTER SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | | | DEAD LOAD = 20 psf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 | 2 × 12 |
| | | | Maximum rafter spans[a] | | | | | | | | | |
| | | | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) | (feetinches) |
| 19.2 | Douglas fir-larch | SS | 5-10 | 9-3 | 12-2 | 15-6 | 18-1 | 5-10 | 9-3 | 12-0 | 14-8 | 17-1 |
| | Douglas fir-larch | #1 | 5-7 | 8-3 | 10-5 | 12-9 | 14-9 | 5-4 | 7-9 | 9-10 | 12-0 | 13-11 |
| | Douglas fir-larch | #2 | 5-4 | 7-10 | 9-11 | 12-1 | 14-0 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 |
| | Douglas fir-larch | #3 | 4-1 | 6-0 | 7-7 | 9-3 | 10-8 | 3-10 | 5-7 | 7-1 | 8-8 | 10-1 |
| | Hem-fir | SS | 5-6 | 8-8 | 11-6 | 14-8 | 17-4 | 5-6 | 8-8 | 11-6 | 14-2 | 15-5 |
| | Hem-fir | #1 | 5-5 | 8-2 | 10-3 | 12-7 | 14-7 | 5-3 | 7-8 | 9-8 | 11-10 | 13-9 |
| | Hem-fir | #2 | 5-2 | 7-7 | 9-7 | 11-9 | 13-7 | 4-11 | 7-2 | 9-1 | 11-1 | 12-10 |
| | Hem-fir | #3 | 4-0 | 5-10 | 7-4 | 9-0 | 10-5 | 3-9 | 5-6 | 6-11 | 8-6 | 9-10 |
| | Southern pine | SS | 5-9 | 9-1 | 11-11 | 15-3 | 18-6 | 5-9 | 9-1 | 11-11 | 14-11 | 17-7 |
| | Southern pine | #1 | 5-6 | 8-5 | 10-8 | 12-5 | 14-9 | 5-4 | 7-11 | 10-0 | 11-9 | 13-11 |
| | Southern pine | #2 | 4-10 | 7-3 | 9-2 | 10-10 | 12-9 | 4-6 | 6-10 | 8-8 | 10-3 | 12-1 |
| | Southern pine | #3 | 3-8 | 5-6 | 6-11 | 8-4 | 9-11 | 3-6 | 5-2 | 6-6 | 7-11 | 9-4 |
| | Spruce-pine-fir | SS | 5-5 | 8-6 | 11-3 | 14-3 | 16-6 | 5-5 | 8-6 | 11-0 | 13-5 | 15-7 |
| | Spruce-pine-fir | #1 | 5-3 | 7-8 | 9-9 | 11-11 | 13-10 | 5-0 | 7-3 | 9-2 | 11-3 | 13-0 |
| | Spruce-pine-fir | #2 | 5-3 | 7-8 | 9-9 | 11-11 | 13-10 | 5-0 | 7-3 | 9-2 | 11-3 | 13-0 |
| | Spruce-pine-fir | #3 | 4-0 | 5-10 | 7-4 | 9-0 | 10-5 | 3-9 | 5-6 | 6-11 | 8-6 | 9-10 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Douglas fir-larch | SS | 5-5 | 8-7 | 11-3 | 13-11 | 16-2 | 5-5 | 8-6 | 10-9 | 13-2 | 15-3 |
| | Douglas fir-larch | #1 | 5-0 | 7-4 | 9-4 | 11-5 | 13-2 | 4-9 | 6-11 | 8-9 | 10-9 | 12-5 |
| | Douglas fir-larch | #2 | 4-9 | 7-0 | 8-10 | 10-10 | 12-6 | 4-6 | 6-7 | 8-4 | 10-2 | 11-10 |
| | Douglas fir-larch | #3 | 3-8 | 5-4 | 6-9 | 8-3 | 9-7 | 3-5 | 5-0 | 6-4 | 7-9 | 9-0 |
| | Hem-fir | SS | 5-2 | 8-1 | 10-8 | 13-6 | 13-11 | 5-2 | 8-1 | 10-5 | 12-4 | 12-4 |
| | Hem-fir | #1 | 5-0 | 7-3 | 9-2 | 11-3 | 13-0 | 4-8 | 6-10 | 8-8 | 10-7 | 12-4 |
| | Hem-fir | #2 | 4-8 | 6-9 | 8-7 | 10-6 | 12-2 | 4-4 | 6-5 | 8-1 | 9-11 | 11-6 |
| | Hem-fir | #3 | 3-7 | 5-2 | 6-7 | 8-1 | 9-4 | 3-4 | 4-11 | 6-3 | 7-7 | 8-10 |
| | Southern pine | SS | 5-4 | 8-5 | 11-1 | 14-2 | 16-8 | 5-4 | 8-5 | 11-1 | 13-4 | 15-9 |
| | Southern pine | #1 | 5-0 | 7-6 | 9-6 | 11-1 | 13-2 | 4-9 | 7-1 | 9-0 | 10-6 | 12-5 |
| | Southern pine | #2 | 4-4 | 6-5 | 8-2 | 9-9 | 11-5 | 4-1 | 6-1 | 7-9 | 9-2 | 10-9 |
| | Southern pine | #3 | 3-4 | 4-11 | 6-2 | 7-6 | 8-10 | 3-1 | 4-7 | 5-10 | 7-1 | 8-4 |
| | Spruce-pine-fir | SS | 5-0 | 7-11 | 10-5 | 12-9 | 14-9 | 5-0 | 7-9 | 9-10 | 12-0 | 12-11 |
| | Spruce-pine-fir | #1 | 4-8 | 6-11 | 8-9 | 10-8 | 12-4 | 4-5 | 6-6 | 8-3 | 10-0 | 11-8 |
| | Spruce-pine-fir | #2 | 4-8 | 6-11 | 8-9 | 10-8 | 12-4 | 4-5 | 6-6 | 8-3 | 10-0 | 11-8 |
| | Spruce-pine-fir | #3 | 3-7 | 5-2 | 6-7 | 8-1 | 9-4 | 3-4 | 4-11 | 6-3 | 7-7 | 8-10 |

Check sources for availability of lumber in lengths greater than 20 feet.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the adjustment factors in Table R802.4.1(9).

**TABLE R802.4.1(9)**
**RAFTER SPAN ADJUSTMENT FACTOR**

| $H_C/H_R$[a] | RAFTER SPAN ADJUSTMENT FACTOR |
|---|---|
| 1/3 | 0.67 |
| 1/4 | 0.76 |
| 1/5 | 0.83 |
| 1/6 | 0.90 |
| 1/7.5 or less | 1.00 |

a. $H_C$ = Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls; $H_R$ = Height of roof ridge measured vertically above the top of the rafter support walls.

**R802.4.2 Framing details.** Rafters shall be framed opposite from each other to a ridge board, shall not be offset more than $1^1/_2$ inches (38 mm) from each other and shall be connected with a collar tie or ridge strap in accordance with Section R802.4.6 or directly opposite from each other to a gusset plate in accordance with Table R602.3(1).

Rafters shall be nailed to the top wall plates in accordance with Table R602.3(1) unless the *roof assembly* is required to comply with the uplift requirements of Section R802.11.

**R802.4.3 Hips and valleys.** Hip and valley rafters shall be not less than 2 inches (51 mm) nominal in thickness and not less in depth than the cut end of the rafter. Hip and valley rafters shall be supported at the ridge by a brace to a bearing partition or be designed to carry and distribute the specific load at that point.

**R802.4.4 Rafter supports.** Where the roof pitch is less than 3:12 (25-percent slope), structural members that support rafters, such as ridges, hips and valleys, shall be designed as beams, and bearing shall be provided for rafters in accordance with Section R802.6.

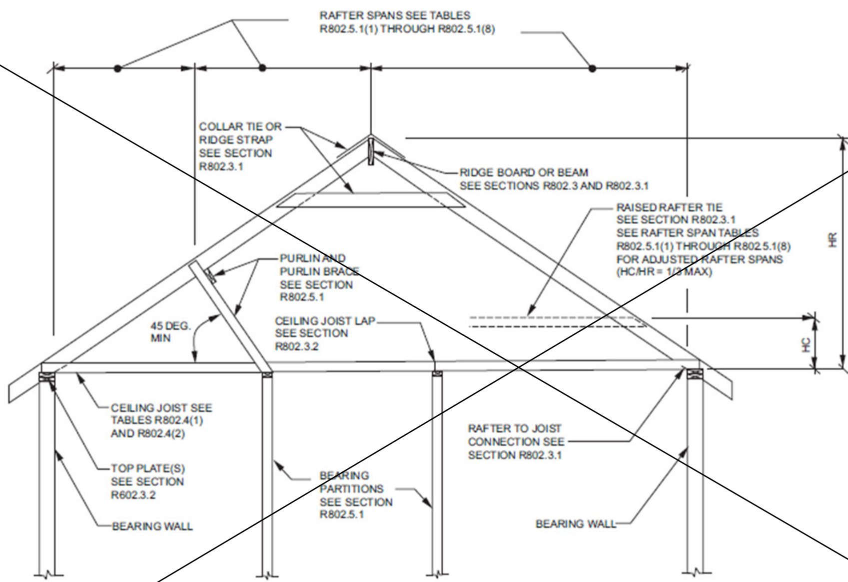
**R802.4.5 Purlins.** Installation of purlins to reduce the span of rafters is permitted as shown in Figure R802.4.5. Purlins shall be sized not less than the required size of the rafters that they support. Purlins shall be continuous and shall be supported by 2-inch by 4-inch (51 mm by 102 mm) braces installed to bearing walls at a slope not less than 45 degrees (0.79 rad) from the horizontal. The braces shall be spaced not more than 4 feet (1219 mm) on center and the unbraced length of braces shall not exceed 8 feet (2438 mm).

**R802.4.6 Collar ties.** Where collar ties are used to connect opposing rafters, they shall be located in the upper third of the attic space and fastened in accordance with Table R602.3(1). Collar ties shall be not less than 1 inch by 4 inches (25 mm × 102 mm) nominal, spaced not more than 4 feet (1219 mm) on center. Ridge straps shall be permitted to replace collar ties. Ridge straps shall be not less than $1\frac{1}{4}$-inch (32 mm) × 20 gage and shall be nailed to the top edge of each rafter with not fewer than three 10d common (3″ × 0.148″) nails with the closest nail not closer than $2\frac{3}{8}$ inches (60.3 mm) from the end of the rafter.

**R802.5 ~~Allowable rafter spans~~ Ceiling joists.** ~~Spans for rafters shall be in accordance with Tables R802.5.1(1) through R802.5.1(8). For other grades and species and for other loading conditions, refer to the AWC STJR.~~

~~The span of each rafter shall be measured along the horizontal projection of the rafter.~~ Ceiling joists shall be continuous across the structure or securely joined where they meet over interior partitions in accordance with Section R802.5.2.1. Ceiling joists shall be fastened to the top plate in accordance with Table R602.3(1).

**R802.5.1 ~~Purlins~~ Ceiling joist size.** Ceiling joists shall be sized based on the joist spans in Tables R802.5.1(1) and R802.5.1(2). For other grades and species and for other loading conditions, refer to the AWC STJR. ~~Installation of purlins to reduce the span of rafters is permitted as shown in Figure R802.5.1. Purlins shall be sized not less than the required size of the rafters that they support. Purlins shall be continuous and shall be supported by 2-inch by 4-inch (51 mm by 102 mm) braces installed to bearing walls at a slope not less than 45 degrees (0.79 rad) from the horizontal. The braces shall be spaced not more than 4 feet (1219 mm) on center and the unbraced length of braces shall not exceed 8 feet (2438 mm)~~




For SI: 1 inch = 25.4 mm, 1 foot = 305 mm, 1 degree = 0.018 rad.

**Note:** Where ceiling joists run perpendicular to the rafter, rafter ties shall be installed in accordance with Section R802.3.1.

$H_C$ = Height of ceiling joists or rafter ties measured vertically above the top of rafter support walls.

$H_R$ = Height of roof ridge measured vertically above the top of the rafter support walls.

**FIGURE R802.5.1**
**BRACED RAFTER CONSTRUCTION**

**TABLE R802.5.1(1)**

**CEILING JOIST SPANS FOR COMMON LUMBER SPECIES (Uninhabitable attics without storage, live load = 10 psf, *L*/Δ = 240)**

| CEILING JOIST SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 5 psf | | | |
|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 |
| | | | Maximum ceiling joist spans | | | |
| | | | (feet-inches) | (feet-inches) | (feet-inches) | (feet-inches) |
| 12 | Douglas fir-larch | SS | 13-2 | 20-8 | Note a | Note a |
| | Douglas fir-larch | #1 | 12-8 | 19-11 | Note a | Note a |
| | Douglas fir-larch | #2 | 12-5 | 19-6 | 25-8 | Note a |
| | Douglas fir-larch | #3 | 11-1 | 16-3 | 20-7 | 25-2 |
| | Hem-fir | SS | 12-5 | 19-6 | 25-8 | Note a |
| | Hem-fir | #1 | 12-2 | 19-1 | 25-2 | Note a |
| | Hem-fir | #2 | 11-7 | 18-2 | 24-0 | Note a |
| | Hem-fir | #3 | 10-10 | 15-10 | 20-1 | 24-6 |
| | Southern pine | SS | 12-11 | 20-3 | Note a | Note a |
| | Southern pine | #1 | 12-5 | 19-6 | 25-8 | Note a |
| | Southern pine | #2 | 11-10 | 18-8 | 24-7 | Note a |
| | Southern pine | #3 | 10-1 | 14-11 | 18-9 | 22-9 |
| | Spruce-pine-fir | SS | 12-2 | 19-1 | 25-2 | Note a |
| | Spruce-pine-fir | #1 | 11-10 | 18-8 | 24-7 | Note a |
| | Spruce-pine-fir | #2 | 11-10 | 18-8 | 24-7 | Note a |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Spruce-pine-fir | #3 | 10-10 | 15-10 | 20-1 | 24-6 |
| 16 | Douglas fir-larch | SS | 11-11 | 18-9 | 24-8 | Note a |
| | Douglas fir-larch | #1 | 11-6 | 18-1 | 23-10 | Note a |
| | Douglas fir-larch | #2 | 11-3 | 17-8 | 23-4 | Note a |
| | Douglas fir-larch | #3 | 9-7 | 14-1 | 17-10 | 21-9 |
| | Hem-fir | SS | 11-3 | 17-8 | 23-4 | Note a |
| | Hem-fir | #1 | 11-0 | 17-4 | 22-10 | Note a |
| | Hem-fir | #2 | 10-6 | 16-6 | 21-9 | Note a |
| | Hem-fir | #3 | 9-5 | 13-9 | 17-5 | 21-3 |
| | Southern pine | SS | 11-9 | 18-5 | 24-3 | Note a |
| | Southern pine | #1 | 11-3 | 17-8 | 23-10 | Note a |
| | Southern pine | #2 | 10-9 | 16-11 | 21-7 | 25-7 |
| | Southern pine | #3 | 8-9 | 12-11 | 16-3 | 19-9 |
| | Spruce-pine-fir | SS | 11-0 | 17-4 | 22-10 | Note a |
| | Spruce-pine-fir | #1 | 10-9 | 16-11 | 22-4 | Note a |
| | Spruce-pine-fir | #2 | 10-9 | 16-11 | 22-4 | Note a |
| | Spruce-pine-fir | #3 | 9-5 | 13-9 | 17-5 | 21-3 |

*(continued)*

**TABLE R802.5.1(1)—continued**

**CEILING JOIST SPANS FOR COMMON LUMBER SPECIES (Uninhabitable attics without storage, live load = 10 psf, *L*/Δ = 240)**

| CEILING JOIST SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 5 psf | | | |
|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 |
| | | | Maximum ceiling joist spans | | | |
| | | | (feet-inches) | (feet-inches) | (feet-inches) | (feet-inches) |
| 19.2 | Douglas fir-larch | SS | 11-3 | 17-8 | 23-3 | Note a |
| | Douglas fir-larch | #1 | 10-10 | 17-0 | 22-5 | Note a |
| | Douglas fir-larch | #2 | 10-7 | 16-8 | 21-4 | 26-0 |
| | Douglas fir-larch | #3 | 8-9 | 12-10 | 16-3 | 19-10 |
| | Hem-fir | SS | 10-7 | 16-8 | 21-11 | Note a |
| | Hem-fir | #1 | 10-4 | 16-4 | 21-6 | Note a |
| | Hem-fir | #2 | 9-11 | 15-7 | 20-6 | 25-3 |
| | Hem-fir | #3 | 8-7 | 12-6 | 15-10 | 19-5 |
| | Southern -pine | SS | 11-0 | 17-4 | 22-10 | Note a |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Southern pine | #1 | 10-7 | 16-8 | 22-0 | Note a |
| | Southern pine | #2 | 10-2 | 15-7 | 19-8 | 23-5 |
| | Southern pine | #3 | 8-0 | 11-9 | 14-10 | 18-0 |
| | Spruce-pine-fir | SS | 10-4 | 16-4 | 21-6 | Note a |
| | Spruce-pine-fir | #1 | 10-2 | 15-11 | 21-0 | 25-8 |
| | Spruce-pine-fir | #2 | 10-2 | 15-11 | 21-0 | 25-8 |
| | Spruce-pine-fir | #3 | 8-7 | 12-6 | 15-10 | 19-5 |
| 24 | Douglas fir-larch | SS | 10-5 | 16-4 | 21-7 | Note a |
| | Douglas fir-larch | #1 | 10-0 | 15-9 | 20-1 | 24-6 |
| | Douglas fir-larch | #2 | 9-10 | 15-0 | 19-1 | 23-3 |
| | Douglas fir-larch | #3 | 7-10 | 11-6 | 14-7 | 17-9 |
| | Hem-fir | SS | 9-10 | 15-6 | 20-5 | Note a |
| | Hem-fir | #1 | 9-8 | 15-2 | 19-10 | 24-3 |
| | Hem-fir | #2 | 9-2 | 14-5 | 18-6 | 22-7 |
| | Hem-fir | #3 | 7-8 | 11-2 | 14-2 | 17-4 |
| | Southern pine | SS | 10-3 | 16-1 | 21-2 | Note a |
| | Southern pine | #1 | 9-10 | 15-6 | 20-5 | 24-0 |
| | Southern pine | #2 | 9-3 | 13-11 | 17-7 | 20-11 |
| | Southern pine | #3 | 7-2 | 10-6 | 13-3 | 16-1 |
| | Spruce-pine-fir | SS | 9-8 | 15-2 | 19-11 | 25-5 |
| | Spruce-pine-fir | #1 | 9-5 | 14-9 | 18-9 | 22-11 |
| | Spruce-pine-fir | #2 | 9-5 | 14-9 | 18-9 | 22-11 |
| | Spruce-pine-fir | #3 | 7-8 | 11-2 | 14-2 | 17-4 |

Check sources for availability of lumber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
a. Span exceeds 26 feet in length.

**TABLE R802.5.1(2)**

**CEILING JOIST SPANS FOR COMMON LUMBER SPECIES (Uninhabitable attics with limited storage, live load = 20 psf, *L*/Δ = 240)**

| CEILING JOIST SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | |
|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 |
| | | | Maximum ceiling joist spans | | | |
| | | | (feet-inches) | (feet-inches) | (feet-inches) | (feet-inches) |
| 12 | Douglas fir-larch | SS | 10-5 | 16-4 | 21-7 | Note a |
| | Douglas fir-larch | #1 | 10-0 | 15-9 | 20-1 | 24-6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Douglas fir-larch | #2 | 9-10 | 15-0 | 19-1 | 23-3 |
| | Douglas fir-larch | #3 | 7-10 | 11-6 | 14-7 | 17-9 |
| | Hem-fir | SS | 9-10 | 15-6 | 20-5 | Note a |
| | Hem-fir | #1 | 9-8 | 15-2 | 19-10 | 24-3 |
| | Hem-fir | #2 | 9-2 | 14-5 | 18-6 | 22-7 |
| | Hem-fir | #3 | 7-8 | 11-2 | 14-2 | 17-4 |
| | Southern pine | SS | 10-3 | 16-1 | 21-2 | Note a |
| | Southern pine | #1 | 9-10 | 15-6 | 20-5 | 24-0 |
| | Southern pine | #2 | 9-3 | 13-11 | 17-7 | 20-11 |
| | Southern pine | #3 | 7-2 | 10-6 | 13-3 | 16-1 |
| | Spruce-pine-fir | SS | 9-8 | 15-2 | 19-11 | 25-5 |
| | Spruce-pine-fir | #1 | 9-5 | 14-9 | 18-9 | 22-11 |
| | Spruce-pine-fir | #2 | 9-5 | 14-9 | 18-9 | 22-11 |
| | Spruce-pine-fir | #3 | 7-8 | 11-2 | 14-2 | 17-4 |
| 16 | Douglas fir-larch | SS | 9-6 | 14-11 | 19-7 | 25-0 |
| | Douglas fir-larch | #1 | 9-1 | 13-9 | 17-5 | 21-3 |
| | Douglas fir-larch | #2 | 8-11 | 13-0 | 16-6 | 20-2 |
| | Douglas fir-larch | #3 | 6-10 | 9-11 | 12-7 | 15-5 |
| | Hem-fir | SS | 8-11 | 14-1 | 18-6 | 23-8 |
| | Hem-fir | #1 | 8-9 | 13-7 | 17-2 | 21-0 |
| | Hem-fir | #2 | 8-4 | 12-8 | 16-0 | 19-7 |
| | Hem-fir | #3 | 6-8 | 9-8 | 12-4 | 15-0 |
| | Southern pine | SS | 9-4 | 14-7 | 19-3 | 24-7 |
| | Southern pine | #1 | 8-11 | 14-0 | 17-9 | 20-9 |
| | Southern pine | #2 | 8-0 | 12-0 | 15-3 | 18-1 |
| | Southern pine | #3 | 6-2 | 9-2 | 11-6 | 14-0 |
| | Spruce-pine-fir | SS | 8-9 | 13-9 | 18-1 | 23-1 |
| | Spruce-pine-fir | #1 | 8-7 | 12-10 | 16-3 | 19-10 |
| | Spruce-pine-fir | #2 | 8-7 | 12-10 | 16-3 | 19-10 |
| | Spruce-pine-fir | #3 | 6-8 | 9-8 | 12-4 | 15-0 |

*(continued)*

**TABLE R802.5.1(2)—continued**

**CEILING JOIST SPANS FOR COMMON LUMBER SPECIES (Uninhabitable attics with limited storage, live load = 20 psf, *L*/Δ = 240)**

| CEILING JOIST SPACING (inches) | SPECIES AND GRADE | | DEAD LOAD = 10 psf | | | |
|---|---|---|---|---|---|---|
| | | | 2 × 4 | 2 × 6 | 2 × 8 | 2 × 10 |
| | | | Maximum ceiling joist spans | | | |
| | | | (feet-inches) | (feet-inches) | (feet-inches) | (feet-inches) |
| 19.2 | Douglas fir-larch | SS | 8-11 | 14-0 | 18-5 | 23-7 |
| | Douglas fir-larch | #1 | 8-7 | 12-6 | 15-10 | 19-5 |
| | Douglas fir-larch | #2 | 8-2 | 11-11 | 15-1 | 18-5 |
| | Douglas fir-larch | #3 | 6-2 | 9-1 | 11-6 | 14-1 |
| | Hem-fir | SS | 8-5 | 13-3 | 17-5 | 22-3 |
| | Hem-fir | #1 | 8-3 | 12-4 | 15-8 | 19-2 |
| | Hem-fir | #2 | 7-10 | 11-7 | 14-8 | 17-10 |
| | Hem-fir | #3 | 6-1 | 8-10 | 11-3 | 13-8 |
| | Southern pine | SS | 8-9 | 13-9 | 18-2 | 23-1 |
| | Southern pine | #1 | 8-5 | 12-9 | 16-2 | 18-11 |
| | Southern pine | #2 | 7-4 | 11-0 | 13-11 | 16-6 |
| | Southern pine | #3 | 5-8 | 8-4 | 10-6 | 12-9 |
| | Spruce-pine-fir | SS | 8-3 | 12-11 | 17-1 | 21-8 |
| | Spruce-pine-fir | #1 | 8-0 | 11-9 | 14-10 | 18-2 |
| | Spruce-pine-fir | #2 | 8-0 | 11-9 | 14-10 | 18-2 |
| | Spruce-pine-fir | #3 | 6-1 | 8-10 | 11-3 | 13-8 |
| 24 | Douglas fir-larch | SS | 8-3 | 13-0 | 17-2 | 21-3 |
| | Douglas fir-larch | #1 | 7-8 | 11-2 | 14-2 | 17-4 |
| | Douglas fir-larch | #2 | 7-3 | 10-8 | 13-6 | 16-5 |
| | Douglas fir-larch | #3 | 5-7 | 8-1 | 10-3 | 12-7 |
| | Hem-fir | SS | 7-10 | 12-3 | 16-2 | 20-6 |
| | Hem-fir | #1 | 7-7 | 11-1 | 14-0 | 17-1 |
| | Hem-fir | #2 | 7-1 | 10-4 | 13-1 | 16-0 |
| | Hem-fir | #3 | 5-5 | 7-11 | 10-0 | 12-3 |
| | Southern pine | SS | 8-1 | 12-9 | 16-10 | 21-6 |
| | Southern pine | #1 | 7-8 | 11-5 | 14-6 | 16-11 |
| | Southern pine | #2 | 6-7 | 9-10 | 12-6 | 14-9 |
| | Southern pine | #3 | 5-1 | 7-5 | 9-5 | 11-5 |
| | Spruce-pine-fir | SS | 7-8 | 12-0 | 15-10 | 19-5 |
| | Spruce-pine-fir | #1 | 7-2 | 10-6 | 13-3 | 16-3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Spruce-pine-fir | #2 | 7-2 | 10-6 | 13-3 | 16-3 |
| | Spruce-pine-fir | #3 | 5-5 | 7-11 | 10-0 | 12-3 |

Check sources for availability of lumber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
a. Span exceeds 26 feet in length.

**R802.5.2 Ceiling joist and rafter connections.** Where ceiling joists run parallel to rafters and are located in the bottom third of the rafter height, they shall be installed in accordance with Figure R802.4.5 and fastened to rafters in accordance with Table R802.5.2(1). Where the ceiling joists are installed above the bottom third of the rafter height, the ridge shall be designed as a beam in accordance with Section R802.3. Where ceiling joists do not run parallel to rafters, rafters shall be tied across the structure with a rafter tie in accordance with Section R802.5.2.2, , or the ridge shall be designed as a beam in accordance with Section R802.3.

**TABLE R802.5.2(1)**
**RAFTER/CEILING JOIST HEEL JOINT CONNECTIONS[g]**

| RAFTER SLOPE | RAFTER SPACING (inches) | GROUND SNOW LOAD (psf) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 20[e] | | | 30 | | | 50 | | | 70 | | |
| | | Roof span (feet) | | | | | | | | | | | |
| | | 12 | 24 | 36 | 12 | 24 | 36 | 12 | 24 | 36 | 12 | 24 | 36 |
| | | Required number of 16d common nails per heel joint splices [a, b,c, d, f] | | | | | | | | | | | |
| 3:12 | 12 | 3 | 5 | 8 | 3 | 6 | 9 | 5 | 9 | 13 | 6 | 12 | 17 |
| | 16 | 4 | 7 | 10 | 4 | 8 | 12 | 6 | 12 | 17 | 8 | 15 | 23 |
| | 19.2 | 4 | 8 | 12 | 5 | 10 | 14 | 7 | 14 | 21 | 9 | 18 | 27 |
| | 24 | 5 | 10 | 15 | 6 | 12 | 18 | 9 | 17 | 26 | 12 | 23 | 34 |
| 4:12 | 12 | 3 | 4 | 6 | 3 | 5 | 7 | 4 | 7 | 10 | 5 | 9 | 13 |
| | 16 | 3 | 5 | 8 | 3 | 6 | 9 | 5 | 9 | 13 | 6 | 12 | 17 |
| | 19.2 | 3 | 6 | 9 | 4 | 7 | 11 | 6 | 11 | 16 | 7 | 14 | 21 |
| | 24 | 4 | 8 | 11 | 5 | 9 | 13 | 7 | 13 | 19 | 9 | 17 | 26 |
| 5:12 | 12 | 3 | 3 | 5 | 3 | 4 | 6 | 3 | 6 | 8 | 4 | 7 | 11 |
| | 16 | 3 | 4 | 6 | 3 | 5 | 7 | 4 | 7 | 11 | 5 | 9 | 14 |
| | 19.2 | 3 | 5 | 7 | 3 | 6 | 9 | 5 | 9 | 13 | 6 | 11 | 17 |
| | 24 | 3 | 6 | 9 | 4 | 7 | 11 | 6 | 11 | 16 | 7 | 14 | 21 |
| 7:12 | 12 | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 4 | 6 | 3 | 5 | 8 |
| | 16 | 3 | 3 | 5 | 3 | 4 | 5 | 3 | 5 | 8 | 4 | 7 | 10 |
| | 19.2 | 3 | 4 | 5 | 3 | 4 | 6 | 3 | 6 | 9 | 4 | 8 | 12 |
| | 24 | 3 | 5 | 7 | 3 | 5 | 8 | 4 | 8 | 11 | 5 | 10 | 15 |
| 9:12 | 12 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 3 | 4 | 6 |
| | 16 | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 4 | 6 | 3 | 5 | 8 |
| | 19.2 | 3 | 3 | 4 | 3 | 4 | 5 | 3 | 5 | 7 | 3 | 6 | 9 |
| | 24 | 3 | 4 | 5 | 3 | 4 | 6 | 3 | 6 | 9 | 4 | 8 | 12 |
| 12:12 | 12 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 5 |
| | 16 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 3 | 4 | 6 |
| | 19.2 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 6 | 3 | 5 | 7 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 24 | 3 | 3 | 4 | 3 | 3 | 5 | 3 | 5 | 7 | 3 | 6 | 9 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. 10d common (3″ × 0.148″) nails shall be permitted to be substituted for 16d common ($3^1/_2$″ × 0.162″) nails where the required number of nails is taken as 1.2 times the required number of 16d common nails, rounded up to the next full nail.

b. Heel joint connections are not required where the ridge is supported by a load-bearing wall, header or ridge beam.

c. Where intermediate support of the rafter is provided by vertical struts or purlins to a load-bearing wall, the tabulated heel joint connection requirements shall be permitted to be reduced proportionally to the reduction in span.

d. Equivalent nailing patterns are required for ceiling joist to ceiling joist lap splices.

e. Applies to roof live load of 20 psf or less.

f. Tabulated heel joint connection requirements assume that ceiling joists or rafter ties are located at the bottom of the attic space. Where ceiling joists or rafter ties are located higher in the attic, heel joint connection requirements shall be increased by the adjustment factors in Table 802.5.2(2).

g. Tabulated requirements are based on 10 psf roof dead load in combination with the specified ground snow load and roof live load.

**R802.5.2.1 Ceiling joists lapped.** Ends of ceiling joists shall be lapped not less than 3 inches (76 mm) or butted over bearing partitions or beams and toenailed to the bearing member. Where ceiling joists are used to provide the continuous tie across the building, lapped joists shall be nailed together in accordance with Table R802.5.2(1) and butted joists shall be tied together with a connection of equivalent capacity. Laps in joists that do not provide the continuous tie across the building shall be permitted to be nailed in accordance with Table R602.3(1).

**R802.5.2.2 Rafter ties.** Wood rafter ties shall be not less than 2 inches by 4 inches (51 mm × 102 mm) installed in accordance with Table R802.5.2(1) at a maximum of 48 inches (610 mm) on center. Other *approved* rafter tie methods shall be permitted.

**R802.5.2.3 Blocking.** Blocking shall be not less than utility grade lumber.

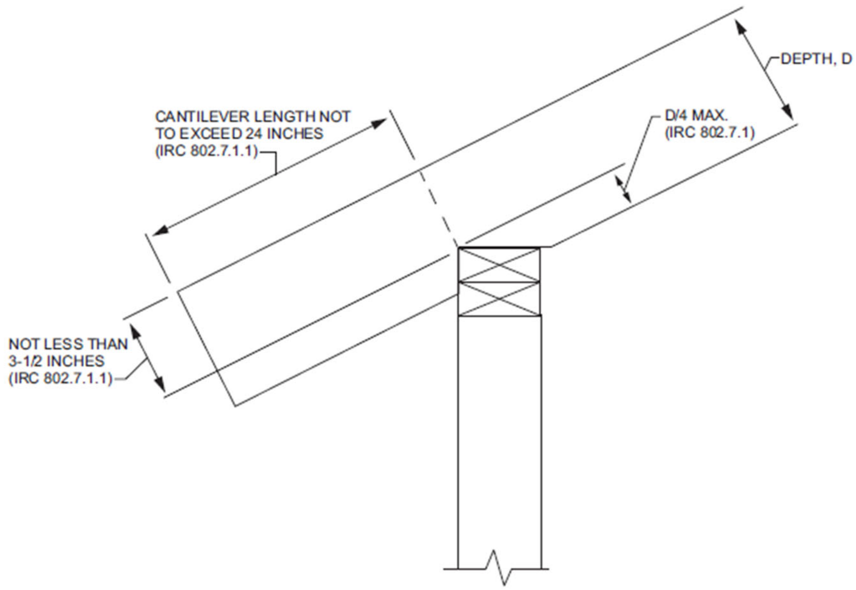
**R802.6 Bearing.** The ends of each rafter or ceiling joist shall have not less than $1^1/_2$ inches (38 mm) of bearing on wood or metal and not less than 3 inches (76 mm) on masonry or concrete. The bearing on masonry or concrete shall be direct, or a sill plate of 2-inch (51 mm) minimum nominal thickness shall be provided under the rafter or ceiling joist. The sill plate shall provide a minimum nominal bearing area of 48 square inches (30 968 mm$^2$). Where the roof pitch is greater than or equal to 3 units vertical in 12 units horizontal (25-percent slope), and ceiling joists or rafter ties are connected to rafters to provide a continuous tension tie in accordance with Section R802.5.2, vertical bearing of the top of the rafter against the ridge board shall satisfy this bearing requirement.

**R802.6.1 Finished ceiling material.** If the finished ceiling material is installed on the ceiling prior to the attachment of the ceiling to the walls, such as in construction at a factory, a compression strip of the same thickness as the finished ceiling material shall be installed directly above the top plate of bearing walls if the compressive strength of the finished ceiling material is less than the loads it will be required to withstand. The compression strip shall cover the entire length of such top plate and shall be not less than one-half the width of the top plate. It shall be of material capable of transmitting the loads transferred through it.

**R802.7 Cutting, drilling and notching.** Structural roof members shall not be cut, bored or notched in excess of the limitations specified in this section.

**R802.7.1 Sawn lumber.** Cuts, notches and holes in solid lumber joists, rafters, blocking and beams shall comply with the provisions of Section R502.8.1 except that cantilevered portions of rafters shall be permitted in accordance with Section R802.7.1.1.

**R802.7.1.1 Cantilevered portions of rafters.** Notches on cantilevered portions of rafters are permitted provided the dimension of the remaining portion of the rafter is not less than $3^1/_2$ inches (89 mm) and the length of the cantilever does not exceed 24 inches (610 mm) in accordance with Figure R802.7.1.1.




For SI: 1 inch = 25.4 mm.

**FIGURE R802.7.1.1**
**RAFTER NOTCH**

**R802.7.1.2 Ceiling joist taper cut.** Taper cuts at the ends of the ceiling joist shall not exceed one-fourth the depth of the member in accordance with Figure R802.7.1.2.

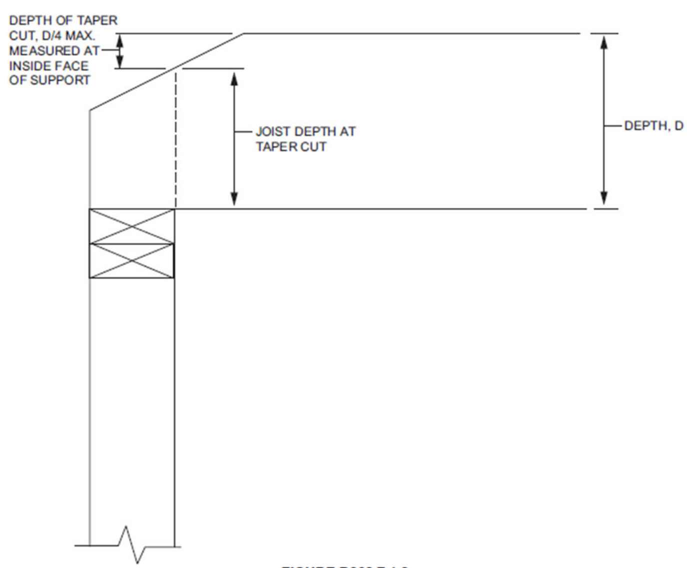



**FIGURE R802.7.1.2**
**CEILING JOIST TAPER CUT**

**R802.7.2 Engineered wood products.** Cuts, notches and holes bored in trusses, *structural composite lumber*, structural glue-laminated members, cross-laminated timber members or I-joists are prohibited except where permitted by the manufacturer's recommendations or where the effects of such alterations are specifically considered in the design of the member by a *registered design professional*.

**R802.8 Lateral support.** Roof framing members and ceiling joists having a depth-to-thickness ratio exceeding 5 to 1 based on nominal dimensions shall be provided with lateral support at points of bearing to prevent rotation. For roof rafters with ceiling joists attached in accordance with Table R602.3(1), the depth-to-thickness ratio for the total assembly shall be determined using the combined thickness of the rafter plus the attached ceiling joist.

**Exception:** Roof trusses shall be braced in accordance with Section R802.10.3.

**R802.8.1 Bridging.** Rafters and ceiling joists having a depth-to-thickness ratio exceeding 6 to 1 based on nominal dimensions shall be supported laterally by solid blocking, diagonal bridging (wood or metal) or a continuous 1-inch by 3-inch (25 mm by 76 mm) wood strip nailed across the rafters or ceiling joists at intervals not exceeding 8 feet (2438 mm).

**R802.9 Framing of openings.** Openings in roof and ceiling framing shall be framed with header and trimmer joists. Where the header joist span does not exceed 4 feet (1219 mm), the header joist shall be permitted to be a single member the same size as the ceiling joist or rafter. Single trimmer joists shall be permitted to be used to carry a single header joist that is located within 3 feet (914 mm) of the trimmer joist bearing. Where the header joist span exceeds 4 feet (1219 mm), the trimmer joists and the header joist shall be doubled and of sufficient cross section to support the ceiling joists or rafter framing into the header. *Approved* hangers shall be used for the header joist to trimmer joist connections where the header joist span exceeds 6 feet (1829 mm). Tail joists over 12 feet (3658 mm) long shall be supported at the header by framing anchors or on ledger strips not less than 2 inches by 2 inches (51 mm by 51 mm).

**R802.10 Wood trusses.**

**R802.10.1 Truss design drawings.** *Truss design drawings*, prepared in conformance to Section R802.10.1, shall be provided to the *building official* and *approved* prior to installation. *Truss design drawings* shall be provided with the shipment of trusses delivered to the job site. *Truss design drawings* shall include, at a minimum, the following information:

1. Slope or depth, span and spacing.
2. Location of all joints.
3. Required bearing widths.
4. Design loads as applicable.
    - 4.1. Top chord *live load* (as determined from Section R301.6).
    - 4.2. Top chord dead load.
    - 4.3. Bottom chord *live load*.
    - 4.4. Bottom chord dead load.
    - 4.5. Concentrated loads and their points of application.
    - 4.6. Controlling wind and earthquake loads.
5. Adjustments to lumber and joint connector design values for conditions of use.
6. Each reaction force and direction.
7. Joint connector type and description such as size, thickness or gage and the dimensioned location of each joint connector except where symmetrically located relative to the joint interface.
8. Lumber size, species and *grade for each member.*
9. Connection requirements for:
    - 9.1. Truss to girder-truss.
    - 9.2. Truss ply to ply.
    - 9.3. Field splices.
10. Calculated deflection ratio or maximum description for live and total load.
11. Maximum axial compression forces in the truss members to enable the building designer to design the size, connections and anchorage of the permanent continuous lateral bracing. Forces shall be shown on the *truss design drawing* or on supplemental documents.
12. Required permanent truss member bracing location.

**R802.10.2 Design.** Wood trusses shall be designed in accordance with accepted engineering practice. The design and manufacture of metal-plate-connected wood trusses shall comply with ANSI/TPI 1. The *truss design drawings* shall be prepared by a *registered design professional.*

**R802.10.2.1 Applicability limits.** The provisions of this section shall control the design of truss roof framing ~~when~~ <u>where</u> snow controls for buildings <u>that are</u> not greater than 60 feet (18 288 mm) in length perpendicular to the joist, rafter or truss span, not greater than 36 feet (10 973 mm) in width parallel to the joist, rafter or truss span, not more than three stories above *grade plane* in height, and have roof slopes not smaller than 3:12 (25-percent slope) or greater than 12:12 (100-percent slope). Truss roof framing constructed in accordance with the provisions of this section shall be limited to sites subjected to a maximum design wind speed of 140 miles per hour (63 m/s), Exposure B or C, and a maximum ground snow load of 70 psf (3352 Pa). For consistent loading of all truss types, roof snow load is to be computed as: 0.7 $p_g$.

**R802.10.3 Bracing.** Trusses shall be braced to prevent rotation and provide lateral stability in accordance with the requirements specified in the *construction documents* for the building and on the individual *truss design drawings*. In the absence of specific bracing requirements, trusses shall be braced in accordance with accepted industry practice such as the SBCA *Building Component Safety Information (BCSI) Guide to Good Practice for Handling, Installing & Bracing of Metal Plate Connected Wood Trusses*.

**R802.10.4 Alterations to trusses.** Truss members shall not be cut, notched, drilled, spliced or otherwise altered in any way without the approval of a registered *design professional. Alterations* resulting in the addition of load such as HVAC equipment water heater that exceeds the design load for the truss shall not be permitted without verification that the truss is capable of supporting such additional loading.

**~~R802.11.1~~ R802.11 Roof tie uplift resistance.** *Roof assemblies* shall have uplift resistance in accordance with Sections R802.11.1 and R802.11.2. ~~Where the uplift force does not exceed 200 pounds (90.8 kg), rafters and trusses spaced not more than 24 inches (610 mm) on center shall be permitted to be attached to their supporting wall assemblies in accordance with Table R602.3(1).Where the basic wind speed does not exceed 115 mph, the wind exposure category is B, the roof pitch is 5:12 (42-percent slope) or greater, and the roof span is 32 feet (9754 mm) or less, rafters and trusses spaced not more than 24 inches (610 mm) on center shall be permitted to be attached to their supporting wall assemblies in accordance with Table R602.3(1).~~

**Exceptions:** Rafters or trusses shall be permitted to be attached to their supporting wall assemblies in accordance with Table R602.3(1) where either of the following occur:

1. Where the uplift force per rafter or truss does not exceed 200 pounds (90.8 kg) as determined by Table R802.11.
2. Where the basic wind speed does not exceed 115 miles per hour (51.4 m/s), the wind exposure category is B, the roof pitch is 5 units vertical in 12 units horizontal (42-percent slope) or greater, the roof span is 32 feet (9754 mm) or less, and rafters and trusses are spaced not more than 24 inches (610 mm) on center.

**TABLE R802.11**

**RAFTER OR TRUSS UPLIFT CONNECTION FORCES FROM WIND (ASD) (POUNDS PER CONNECTION)[a, b, c, d, e, f, g, h]**

| RAFTER OR TRUSS SPACING | ROOF SPAN (feet) | EXPOSURE B | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ultimate Design Wind Speed $V_{ULT}$ (mph) | | | | | | | | | |
| | | 110 | | 115 | | 120 | | 130 | | 140 | |
| | | Roof Pitch | | Roof Pitch | | Roof Pitch | | Roof Pitch | | Roof Pitch | |
| | | < 5:12 | ≥ 5:12 | < 5:12 | ≥ 5:12 | < 5:12 | ≥ 5:12 | < 5:12 | ≥ 5:12 | < 5:12 | ≥ 5:12 |
| 12″ o.c. | 12 | 48 | 43 | 59 | 53 | 70 | 64 | 95 | 88 | 122 | 113 |
| | 18 | 59 | 52 | 74 | 66 | 89 | 81 | 122 | 112 | 157 | 146 |
| | 24 | 71 | 62 | 89 | 79 | 108 | 98 | 149 | 137 | 192 | 178 |
| | 28 | 79 | 69 | 99 | 88 | 121 | 109 | 167 | 153 | 216 | 200 |
| | 32 | 86 | 75 | 109 | 97 | 134 | 120 | 185 | 170 | 240 | 222 |
| | 36 | 94 | 82 | 120 | 106 | 146 | 132 | 203 | 186 | 264 | 244 |
| | 42 | 106 | 92 | 135 | 120 | 166 | 149 | 230 | 211 | 300 | 278 |
| | 48 | 118 | 102 | 151 | 134 | 185 | 166 | 258 | 236 | 336 | 311 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16″ o.c. | 12 | 64 | 57 | 78 | 70 | 93 | 85 | 126 | 117 | 162 | 150 |
| | 18 | 78 | 69 | 98 | 88 | 118 | 108 | 162 | 149 | 209 | 194 |
| | 24 | 94 | 82 | 118 | 105 | 144 | 130 | 198 | 182 | 255 | 237 |
| | 28 | 105 | 92 | 132 | 117 | 161 | 145 | 222 | 203 | 287 | 266 |
| | 32 | 114 | 100 | 145 | 129 | 178 | 160 | 246 | 226 | 319 | 295 |
| | 36 | 125 | 109 | 160 | 141 | 194 | 176 | 270 | 247 | 351 | 325 |
| | 42 | 141 | 122 | 180 | 160 | 221 | 198 | 306 | 281 | 399 | 370 |
| | 48 | 157 | 136 | 201 | 178 | 246 | 221 | 343 | 314 | 447 | 414 |
| 24″ o.c. | 12 | 96 | 86 | 118 | 106 | 140 | 128 | 190 | 176 | 244 | 226 |
| | 18 | 118 | 104 | 148 | 132 | 178 | 162 | 244 | 224 | 314 | 292 |
| | 24 | 142 | 124 | 178 | 158 | 216 | 196 | 298 | 274 | 384 | 356 |
| | 28 | 158 | 138 | 198 | 176 | 242 | 218 | 334 | 306 | 432 | 400 |
| | 32 | 172 | 150 | 218 | 194 | 268 | 240 | 370 | 340 | 480 | 444 |
| | 36 | 188 | 164 | 240 | 212 | 292 | 264 | 406 | 372 | 528 | 488 |
| | 42 | 212 | 184 | 270 | 240 | 332 | 298 | 460 | 422 | 600 | 556 |
| | 48 | 236 | 204 | 302 | 268 | 370 | 332 | 516 | 472 | 672 | 622 |
| | | **EXPOSURE C** | | | | | | | | | |
| 12″ o.c. | 12 | 95 | 88 | 110 | 102 | 126 | 118 | 161 | 151 | 198 | 186 |
| | 18 | 121 | 111 | 141 | 131 | 163 | 151 | 208 | 195 | 257 | 242 |
| | 24 | 148 | 136 | 173 | 160 | 200 | 185 | 256 | 239 | 317 | 298 |
| | 28 | 166 | 152 | 195 | 179 | 225 | 208 | 289 | 269 | 358 | 335 |
| | 32 | 184 | 168 | 216 | 199 | 249 | 231 | 321 | 299 | 398 | 373 |
| | 36 | 202 | 185 | 237 | 219 | 274 | 254 | 353 | 329 | 438 | 411 |
| | 42 | 229 | 210 | 269 | 248 | 312 | 289 | 402 | 375 | 499 | 468 |
| | 48 | 256 | 234 | 302 | 278 | 349 | 323 | 450 | 420 | 560 | 524 |
| 16″ o.c. | 12 | 126 | 117 | 146 | 136 | 168 | 157 | 214 | 201 | 263 | 247 |
| | 18 | 161 | 148 | 188 | 174 | 217 | 201 | 277 | 259 | 342 | 322 |
| | 24 | 197 | 181 | 230 | 213 | 266 | 246 | 340 | 318 | 422 | 396 |
| | 28 | 221 | 202 | 259 | 238 | 299 | 277 | 384 | 358 | 476 | 446 |
| | 32 | 245 | 223 | 287 | 265 | 331 | 307 | 427 | 398 | 529 | 496 |
| | 36 | 269 | 246 | 315 | 291 | 364 | 338 | 469 | 438 | 583 | 547 |
| | 42 | 305 | 279 | 358 | 330 | 415 | 384 | 535 | 499 | 664 | 622 |
| | 48 | 340 | 311 | 402 | 370 | 464 | 430 | 599 | 559 | 745 | 697 |

*(continued)*

**TABLE R802.11—continued**
**RAFTER OR TRUSS UPLIFT CONNECTION FORCES FROM WIND (ASD) (POUNDS PER CONNECTION)[a, b, c, d, e, f, g, h]**

| RAFTER OR TRUSS SPACING | ROOF SPAN (feet) | EXPOSURE B | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ultimate Design Wind Speed $V_{ULT}$ (mph) | | | | | | | | | |
| | | 110 | | 115 | | 120 | | 130 | | 140 | |
| | | Roof Pitch | | Roof Pitch | | Roof Pitch | | Roof Pitch | | Roof Pitch | |
| | | < 5:12 | ≥ 5:12 | < 5:12 | ≥ 5:12 | < 5:12 | ≥ 5:12 | < 5:12 | ≥ 5:12 | < 5:12 | ≥ 5:12 |
| 24″ o.c. | 12 | 190 | 176 | 220 | 204 | 252 | 236 | 322 | 302 | 396 | 372 |
| | 18 | 242 | 222 | 282 | 262 | 326 | 302 | 416 | 390 | 514 | 484 |
| | 24 | 296 | 272 | 346 | 320 | 400 | 370 | 512 | 478 | 634 | 596 |
| | 28 | 332 | 304 | 390 | 358 | 450 | 416 | 578 | 538 | 716 | 670 |
| | 32 | 368 | 336 | 432 | 398 | 498 | 462 | 642 | 598 | 796 | 746 |
| | 36 | 404 | 370 | 474 | 438 | 548 | 508 | 706 | 658 | 876 | 822 |
| | 42 | 458 | 420 | 538 | 496 | 624 | 578 | 804 | 750 | 998 | 936 |
| | 48 | 512 | 468 | 604 | 556 | 698 | 646 | 900 | 840 | 1,120 | 1,048 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound = 0.454 kg, 1 pound per square foot = 47.9 N/m$^2$, 1 pound per linear foot = 14.6 N/m.

a. The uplift connection forces are based on a maximum 33-foot mean roof height and Wind Exposure Category B or C. For Exposure D, the uplift connection force shall be selected from the Exposure C portion of the table using the next highest tabulated ultimate design wind speed. The adjustment coefficients in Table R301.2.1(2) shall not be used to multiply the tabulated forces for Exposures C and D or for other mean roof heights.
b. The uplift connection forces include an allowance for roof and ceiling assembly dead load of 15 psf.
c. The tabulated uplift connection forces are limited to a maximum roof overhang of 24 inches.
d. The tabulated uplift connection forces shall be permitted to be multiplied by 0.75 for connections not located within 8 feet of building corners.
e. For buildings with hip roofs with 5:12 and greater pitch, the tabulated uplift connection forces shall be permitted to be multiplied by 0.70. This reduction shall not be combined with any other reduction in tabulated forces.
f. For wall-to-wall and wall-to-foundation connections, the uplift connection force shall be permitted to be reduced by 60 pounds per linear foot for each full wall above.
g. Linear interpolation between tabulated roof spans and wind speeds shall be permitted.
h. The tabulated forces for a 12-inch on-center spacing shall be permitted to be used to determine the uplift load in pounds per linear foot.

~~**R802.11.1.1**~~ **R802.11.1 Truss uplift resistance.** Trusses shall be attached to supporting wall assemblies by connections capable of resisting uplift forces as specified on the *truss design drawings* for the ultimate design wind speed as determined by Table R301.2(4) and listed in Table R301.2 or as shown on the *construction documents*. Uplift forces shall be permitted to be determined as specified by Table R802.11, if applicable, or as determined by accepted engineering practice.

~~**R802.11.1.2**~~ **R802.11.2 Rafter uplift resistance.** Individual rafters shall be attached to supporting wall assemblies by connections capable of resisting uplift forces as determined by Table R802.11 or as determined by accepted engineering practice. Connections for beams used in a roof system shall be designed in accordance with accepted engineering practice.

## SECTION R803
## ROOF SHEATHING

**R803.1 Lumber sheathing.** Allowable spans for lumber used as roof sheathing shall conform to Table R803.1. Spaced lumber sheathing for wood shingle and shake roofing shall conform to the requirements of Sections R905.7 and R905.8. Spaced lumber sheathing is not allowed in Seismic Design Category $D_2$.

**TABLE R803.1**
**MINIMUM THICKNESS OF LUMBER ROOF SHEATHING**

| RAFTER OR BEAM SPACING (inches) | MINIMUM NET THICKNESS (inches) |
|---|---|
| 24 | $^5/_8$ |
| 48[a] | $1^1/_2$ T & G |
| 60[b] | |
| 72[c] | |

For SI: 1 inch = 25.4 mm.
a. Minimum $270F_b$, $340,000E$.
b. Minimum $420F_b$, $660,000E$.
c. Minimum $600F_b$, $1,150,000E$.

**R803.2 Wood structural panel sheathing.**

**R803.2.1 Identification and grade.** *Wood structural panels* shall conform to DOC PS 1, DOC PS 2, CSA O325 or CSA O437, and shall be identified for grade, bond classification and performance category by a grade mark or certificate of inspection issued by an *approved* agency. *Wood structural panels* shall comply with the grades specified in Table R503.2.1.1(1).

**R803.2.1.1 Exposure durability.** *Wood structural panels*, when designed to be permanently exposed in outdoor applications, shall be of an exterior exposure durability. *Wood structural panel* roof sheathing exposed to the underside shall be permitted to be of interior type bonded with exterior glue, identified as Exposure 1.

**R803.2.1.2 Fire-retardant-treated plywood.** The allowable unit stresses for fire-retardant-treated plywood, including fastener values, shall be developed from an *approved* method of investigation that considers the effects of anticipated temperature and humidity to which the fire-retardant-treated plywood will be subjected, the type of treatment and redrying process. The fire-retardant-treated plywood shall be graded by an *approved agency*.

**R803.2.2 Allowable spans.** The maximum allowable spans for *wood structural panel* roof sheathing shall not exceed the values set forth in Table R503.2.1.1(1) or APA E30.

**R803.2.3 Installation.** *Wood structural panel* used as roof sheathing shall be installed with joints staggered or not staggered in accordance with Table R602.3(1), APA E30 for wood roof framing or with Table R804.3 for cold-formed steel roof framing. <u>Wood structural panel roof sheathing in accordance with Table R503.2.1.1(1) shall not cantilever more than 9 inches (229 mm) beyond the gable endwall unless supported by gable overhang framing.</u>

## SECTION R804
## COLD-FORMED STEEL ROOF FRAMING

**Deleted.**

## SECTION R805
## CEILING FINISHES

**R805.1 Ceiling installation.** Ceilings shall be installed in accordance with the requirements for interior wall finishes as provided in Sections ~~R702~~ <u>R702.1 through R702.6</u>.

## SECTION R806
## ROOF VENTILATION

**R806.1 Ventilation required.** Enclosed attics and enclosed rafter spaces formed where ceilings are applied directly to the underside of roof rafters shall have cross *ventilation* for each separate space by ventilating openings protected against the entrance of rain or snow. Ventilation openings shall have a least dimension of $^1/_{16}$ inch (1.6 mm) minimum and $^1/_4$ inch (6.4 mm) maximum. Ventilation openings having a least dimension larger than $^1/_4$ inch (6.4 mm) shall be provided with corrosion-resistant wire cloth screening, hardware cloth, perforated vinyl or similar material with openings having a least dimension of $^1/_{16}$ inch (1.6 mm) minimum and $^1/_4$ inch (6.4 mm) maximum. Openings in roof framing members shall conform to the requirements of Section R802.7. Required ventilation openings shall open directly to the outside air and shall be protected to prevent the entry of birds, rodents, snakes and other similar creatures.

**R806.2 Minimum vent area.** The total net free ventilating area shall not be less than 1/150 of the area of the space ventilated except that reduction of the total area to 1/300 is permitted provided that at least 50 percent and not more than 80 percent of the required ventilating area is provided by ventilators located in the upper portion of the space to be ventilated at least 3 feet (914 mm) above the eave or cornice vents, with the balance of the required ventilation provided by eave or cornice vents. As an alternative, the net free cross-ventilation area may be reduced to 1/300 when a Class I or II vapor retarder is installed on the warm-in-winter side of the ceiling.

**Exceptions:**

1. Enclosed attic/rafter spaces requiring less than 1 square foot (0.0929 m2) of ventilation may be vented with continuous soffit ventilation only.
2. Enclosed attic/rafter spaces over unconditioned space may be vented with continuous soffit vent only.

**R806.3 Vent and insulation clearance.** Where eave or cornice vents are installed, blocking, bridging and insulation shall not block the free flow of air. Not less than a 1-inch (25 mm) space shall be provided between the insulation and the roof sheathing and at the location of the vent.

**R806.4 Installation and weather protection.** Ventilators shall be installed in accordance with manufacturer's instructions. Installation of ventilators in roof systems shall be in accordance with the requirements of Section R903. Installation of ventilators in wall systems shall be in accordance with the requirements of Section R703.1.

**R806.5 Unvented attic and unvented enclosed rafter assemblies.** Unvented *attics* and unvented enclosed roof framing assemblies created by ceilings that are applied directly to the underside of the roof framing members and structural roof sheathing applied directly to the top of the roof framing members/rafters, shall be permitted where all the following conditions are met:

1. The unvented *attic* space is completely within the *building thermal envelope*.
2. ~~No~~ Interior Class I vapor retarders are not installed on the ceiling side (*attic* floor) of the unvented *attic* assembly or on the ceiling side of the unvented enclosed roof framing assembly.
3. Where wood shingles or shakes are used, a minimum $^1/_4$-inch (6.4 mm) vented airspace separates the shingles or shakes and the roofing underlayment above the structural sheathing.
4. ~~Deleted.~~ In Climate Zones 5, any *air-impermeable insulation* shall be a Class II vapor retarder, or shall have a Class II vapor retarder coating or covering in direct contact with the underside of the insulation.
5. Insulation shall ~~be located in accordance~~ comply with ~~the following~~ Item 5.3 and either Item 5.1 or 5.2:
    - 5.1. Item 5.1.1, 5.1.2, 5.1.3 or 5.1.4 shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.
        - 5.1.1. Where only *air-impermeable insulation* is provided, it shall be applied in direct contact with the underside of the structural roof sheathing.
        - 5.1.2. Where *air-permeable insulation* is ~~provided inside the building thermal envelope, it shall be installed in accordance with Section 5.1. In addition to the air-permeable insulation~~ installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing in accordance with the *R*-values in Table R806.5 for condensation control.
        - 5.1.3. Where both *air-impermeable* and *air-permeable insulation* are provided, the *air-impermeable insulation* shall be applied in direct contact with the underside of the structural

roof sheathing in accordance with Item 5.1.1 and shall be in accordance with the *R*-values in Table R806.5 for condensation control. The *air-permeable insulation* shall be installed directly under the *air-impermeable insulation*.

5.1.4. Alternatively, sufficient rigid board or sheet insulation shall be installed directly above the structural roof sheathing to maintain the monthly average temperature of the underside of the structural roof sheathing above 45°F (7°C). For calculation purposes, an interior air temperature of 68°F (20°C) is assumed and the exterior air temperature is assumed to be the monthly average outside air temperature of the three coldest months.

5.2. In Climate Zones 1, 2 and 3, air-permeable insulation installed in unvented *attics* shall meet the following requirements:

5.2.1. An approved *vapor diffusion port* shall be installed not more than 12 inches (305 mm) from the highest point of the roof, measured vertically from the highest point of the roof to the lower edge of the port.

5.2.2. The port area shall be greater than or equal to 1:600 of the ceiling area. Where there are multiple ports in the attic, the sum of the port areas shall be greater than or equal to the area requirement.

5.2.3. The vapor-permeable membrane in the *vapor diffusion port* shall have a vapor permeance rating of greater than or equal to 20 perms when tested in accordance with Procedure A of ASTM E96.

5.2.4. The *vapor diffusion port* shall serve as an air barrier between the *attic* and the exterior of the building.

5.2.5. The *vapor diffusion port* shall protect the *attic* against the entrance of rain and snow.

5.2.6. Framing members and blocking shall not block the free flow of water vapor to the port. Not less than a 2-inch (51 mm) space shall be provided between any blocking and the roof sheathing. Air-permeable insulation shall be permitted within that space.

5.2.7. The roof slope shall be greater than or equal to 3:12 (vertical/horizontal).

5.2.8. Where only air-permeable insulation is used, it shall be installed directly below the structural roof sheathing, on top of the attic floor, or on top of the ceiling.

5.2.9. *Air-impermeable insulation*, where used in conjunction with air-permeable insulation, shall be directly above or below the structural roof sheathing and is not required to meet the *R*-value in Table R806.5. Where directly below the structural roof sheathing, there shall be no space between the *air-impermeable insulation* and air-permeable insulation.

5.2.10. Where air-permeable insulation is used and is installed directly below the roof structural sheathing, air shall be supplied at a flow rate greater than or equal to 50 CFM (23.6 L/s) per 1,000 square feet (93 m$^2$) of ceiling. The air shall be supplied from ductwork providing supply air to the occupiable space when the conditioning system is operating. Alternatively, the air shall be supplied by a supply fan when the conditioning system is operating.

**Exceptions:**

1. Where both air-impermeable and air-permeable insulation are used, and the *R*-value in Table 806.5 is met, air supply to the attic is not required.
2. Where only air-permeable insulation is used and is installed on top of the attic floor, or on top of the ceiling, air supply to the attic is not required.

~~5.2~~ 5.3. Where preformed insulation board is used as the air-impermeable insulation layer, it shall be sealed at the perimeter of each individual sheet interior surface to form a continuous layer.

**TABLE R806.5**

**INSULATION FOR CONDENSATION CONTROL**

| CLIMATE ZONE | MINIMUM RIGID BOARD ON AIR-IMPERMEABLE INSULATION *R*-VALUE[a, b] |
|---|---|
| ~~2B and 3B tile roof only~~ | ~~0 (none required)~~ |

| | |
|---|---|
| ~~1, 2A, 2B,~~ 3A~~, 3B, 3C~~ | R-5 |
| ~~4C~~ | ~~R-10~~ |
| 4A~~, 4B~~ | R-15 |
| 5 | R-20 |
| ~~6~~ | ~~R-25~~ |
| ~~7~~ | ~~R-30~~ |
| ~~8~~ | ~~R-35~~ |

a. Contributes to but does not supersede the requirements in Section N1102.
b. Alternatively, sufficient continuous insulation shall be installed directly above the structural roof sheathing to maintain the monthly average temperature of the underside of the structural roof sheathing above 45°F (7°C). For calculation purposes, an interior air temperature of 68°F (20°C) is assumed and the exterior air temperature is assumed to be the monthly average outside air temperature of the three coldest months.

## SECTION R807
## ATTIC ACCESS

**R807.1 Attic access.** An attic access opening shall be provided to attic areas that exceed 400 square feet (37.16 $m^2$) and have a vertical height of 60 inches (1524 mm) or greater. The net clear opening shall not be less than 20 inches by 30 inches (508 mm by 762 mm) and shall be located in a hallway or other readily accessible location. A 30-inch (762 mm) minimum unobstructed headroom in the attic space shall be provided at some point above the access opening. See Section M1305.1.2 for access requirements where mechanical equipment is located in attics.

**Exceptions:**

1. Concealed areas not located over the main structure including porches, areas behind knee walls, dormers, bay windows, etc. are not required to have access.
2. Pull down stair treads, stringers, handrails, and hardware may protrude into the net clear opening.

# CHAPTER 9
# ROOF ASSEMBLIES

## SECTION R901
## GENERAL

**R901.1 Scope.** The provisions of this chapter shall govern the design, materials, construction and quality of *roof assemblies*.

## SECTION R902
## FIRE CLASSIFICATION

**R902.1 Roof covering materials.** Roofs shall be covered with materials as set forth in Sections R904 and R905. Class A, B or C roofing shall be installed in *jurisdictions* designated by law as requiring their use or where the edge of the roof is less than 3 feet (914 mm) from a *lot line*. Class A, B and C roofing required by this section to be *listed* shall be tested in accordance with ASTM E108 or UL 790.

**Exceptions:**

1. Class A *roof assemblies* include those with coverings of brick, masonry and exposed concrete *roof deck*.
2. Class A *roof assemblies* include ferrous or copper shingles or sheets, metal sheets and shingles, clay or concrete roof tile, or slate installed on noncombustible decks.
3. Class A *roof assemblies* include minimum 16 ounces per square foot (4.882 kg/$m^2$) copper sheets installed over combustible decks.
4. Class A *roof assemblies* include slate installed over *underlayment* over combustible decks.

**R902.2 Fire-retardant-treated shingles and shakes.** Fire-retardant-treated wood shakes and shingles shall be treated by impregnation with chemicals by the full-cell vacuum-pressure process, in accordance with AWPA C1. Each bundle shall be marked to identify the manufactured unit and the manufacturer, and shall be *labeled* to identify the classification of the material in accordance with the testing required in Section R902.1, the treating company and the quality control agency.

**R902.3 Building-integrated photovoltaic product.** *Building-integrated photovoltaic (BIPV) products* installed as the roof covering shall be tested, *listed* and *labeled* for fire classification in accordance with ~~Section R902.1~~ UL 7103. Class A, B or C BIPV products shall be installed where the edge of the roof is less than 3 feet (914 mm) from a *lot line*.

**R902.4 Rooftop-mounted photovoltaic panel systems.** Rooftop-mounted *photovoltaic* ~~*panels and modules*~~ *panel systems* installed on or above the roof covering shall be tested, *listed* and identified with a fire classification in accordance with UL ~~1703~~ 2703. Class A, B or C *photovoltaic* ~~*panels*~~ *panel systems* and modules shall be installed in *jurisdictions* designated by law as requiring their use or where the edge of the roof is less than 3 feet (914 mm) from a *lot line*.

## SECTION R903
## WEATHER PROTECTION

**R903.1 General.** *Roof decks* shall be covered with *approved* roof coverings secured to the building or structure in accordance with the provisions of this chapter. *Roof assemblies* shall be designed and installed in accordance with this code and the *approved* manufacturer's instructions such that the *roof assembly* shall serve to protect the building or structure.

**R903.2 Flashing.** Flashings shall be installed in a manner that prevents moisture from entering the wall and roof through joints in copings, through moisture permeable materials and at intersections with parapet walls and other penetrations through the roof plane.

**R903.2.1 Locations.** Flashings shall be installed at wall and roof intersections, wherever there is a change in roof slope or direction and around roof openings. A flashing shall be installed to divert the water away from where the eave of a sloped roof intersects a vertical sidewall. Where flashing is of metal, the metal shall be corrosion resistant with a thickness of not less than 0.019 inch (0.5 mm) (No. 26 galvanized sheet).

**R903.2.2 Crickets and saddles.** A cricket or saddle shall be installed on the ridge side of any chimney or penetration more than 30 inches (762 mm) wide as measured perpendicular to the slope. Cricket or saddle coverings shall be sheet metal or of the same material as the roof covering.

**Exception:** *Unit skylights* installed in accordance with Section R308.6 and flashed in accordance with the manufacturer's instructions shall be permitted to be installed without a cricket or saddle.

**R903.3 Coping.** Parapet walls shall be properly coped with noncombustible, weatherproof materials of a width not less than the thickness of the parapet wall. Parapet coping shall extend 2 inches (51 mm) minimum down the faces of the parapet.

**R903.4 Roof drainage.** Unless roofs are sloped to drain over roof edges, roof drains shall be installed at each low point of the roof.

**R903.4.1 Secondary (emergency overflow) drains or scuppers.** Where roof drains are required, secondary emergency overflow roof drains or *scuppers* shall be provided where the roof perimeter construction extends above the roof in such a manner that water will be entrapped if the primary drains allow buildup for any reason. Overflow drains having the same size as the roof drains shall be installed with the inlet flow line located 2 inches (51 mm) above the low point of the roof, or overflow *scuppers* having three times the size of the roof drains and having a minimum opening height of 4 inches (102 mm) shall be installed in the adjacent parapet walls with the inlet flow located 2 inches (51 mm) above the low point of the roof served. The installation and sizing of overflow drains, leaders and conductors shall comply with Sections 1106 and 1108 of the *International Plumbing Code*, as applicable.

Overflow drains shall discharge to an *approved* location and shall not be connected to roof drain lines.

## SECTION R904
## MATERIALS

**R904.1 Scope.** The requirements set forth in this section shall apply to the application of roof covering materials specified herein. *Roof assemblies* shall be applied in accordance with this chapter and the manufacturer's installation instructions. Installation of *roof assemblies* shall comply with the applicable provisions of Section R905.

**R904.2 Compatibility of materials.** *Roof assemblies* shall be of materials that are compatible with each other and with the building or structure to which the materials are applied.

**R904.3 Material specifications and physical characteristics.** Roof covering materials shall conform to the applicable standards listed in this chapter.

**R904.4 Product identification.** Roof covering materials shall be delivered in packages bearing the manufacturer's identifying marks and *approved* testing agency *labels* required. Bulk shipments of materials shall be accompanied by the same information issued in the form of a certificate or on a bill of lading by the manufacturer.

## SECTION R905
## REQUIREMENTS FOR ROOF COVERINGS

**R905.1 Roof covering application.** Roof coverings shall be applied in accordance with the applicable provisions of this section and the manufacturer's installation instructions. Unless otherwise specified in this section, roof coverings shall be installed to resist the component and cladding loads specified in Table R301.2.1(1), adjusted for height and exposure in accordance with Table R301.2.1(2).

**R905.1.1 Underlayment.** *Underlayment* for asphalt shingles, clay and concrete tile, *metal roof shingles*, mineral-surfaced roll roofing, slate and slate-type shingles, wood shingles, wood shakes, ~~and~~ *metal roof panels* and *photovoltaic shingles* shall conform to the applicable standards listed in this chapter. *Underlayment* materials required to comply with ASTM D226, D1970, D4869 and D6757 shall bear a *label* indicating compliance to the standard designation and, if applicable, type classification indicated in Table R905.1.1(1). *Underlayment* shall be applied in accordance with Table R905.1.1(2). *Underlayment* shall be attached in accordance with Table R905.1.1(3).

**Exceptions:**

1. As an alternative, self-adhering polymer-modified bitumen underlayment ~~complying~~ bearing a label indicating compliance with ASTM D1970. ~~installed in accordance with both the underlayment manufacturer's and roof covering manufacturer's instructions for the deck material, roof ventilation configuration and climate exposure for the roof covering to be installed, shall be permitted.~~
2. As an alternative, a minimum 4-inch-wide (102 mm) strip of self-adhering polymer-modified bitumen membrane ~~complying~~ bearing a *label* indicating compliance with ASTM D1970, installed in accordance with the *manufacturer's installation instructions* for the deck material, shall be applied over all joints in the roof decking. An *approved underlayment* complying with Table R905.1.1(1) for the applicable roof covering for ~~maximum ultimate design wind speeds, Vult, less than 140 miles per hour~~ areas where wind design is not required in accordance with Figure R301.2.1.1 shall be applied over the entire roof over the 4-inch-wide (102 mm) membrane strips. Underlayment shall be applied in accordance with Table R905.1.1(2) using the application requirements for areas where wind design is not required in accordance with Figure R301.2.1.1. Underlayment shall be attached in accordance with Table R905.1.1(3).

**TABLE R905.1.1(1)**
**UNDERLAYMENT TYPES**

| ROOF COVERING | SECTION | MAXIMUM ULTIMATE DESIGN WIND SPEED, Vult < 130 MPH | ~~MAXIMUM ULTIMATE DESIGN WIND SPEED, Vult > 140 MPH~~ |
|---|---|---|---|
| Asphalt shingles | R905.2 | ASTM D226 Type I or II<br>ASTM D48696 Type I, II, III or IV<br>ASTM D6757 | ~~ASTM D226 Type II~~<br>~~ASTM D4869 Type III or Type IV~~<br>~~ASTM D6757~~ |
| Clay and concrete tile | R905.3 | ASTM D226 Type II<br>ASTM D2626 Type I<br>ASTM D6380 Class M mineral-surfaced roll roofing | ~~ASTM D226 Type II~~<br>~~ASTM D2626 Type I~~<br>~~ASTM D6380 Class M mineral-surfaced roll roofing~~ |
| Metal roof shingles | R905.4 | ASTM D226 Type I or II<br>ASTM D4869 Type I, II, III or IV | ~~ASTM D226 Type II~~<br>~~ASTM D4869 Type IV~~ |
| Mineral-surfaced roll roofing | R905.5 | ASTM D226 Type I or II<br>ASTM D4869 Type I, II, III or IV | ~~ASTM D226 Type II~~<br>~~ASTM D4869 Type IV~~ |
| Slate and slate-type shingles | R905.6 | ASTM D226 Type I<br>ASTM D4869 Type I, II, III or IV | ~~ASTM D226 Type II~~<br>~~ASTM D4869 Type IV~~ |
| Wood shingles | R905.7 | ASTM D226 Type I or II<br>ASTM D4869 Type I, II, III or IV | ~~ASTM D226 Type II~~<br>~~ASTM D4869 Type III or Type IV~~ |
| Wood shakes | R905.8 | ASTM D226 Type I or II<br>ASTM D4869 Type I, II, III or IV | ~~ASTM D226 Type II~~<br>~~ASTM D4869 Type IV~~ |
| Metal panels | R905.10 | Manufacturer's instructions | ~~ASTM D226 Type II~~<br>~~ASTM D4869 Type IV~~ |
| Photovoltaic shingles | R905.16 | ASTM D4869 Type I, II, III or IV<br>ASTM D6757 | ~~ASTM D4869 Type III or Type IV~~ |

For SI: 1 mile per hour = 0.447 m/s.

**TABLE R905.1.1(2)**
**UNDERLAYMENT APPLICATION**

| ROOF COVERING | SECTION | MAXIMUM ULTIMATE DESIGN WIND SPEED, Vult < 130 MPH | ~~MAXIMUM ULTIMATE DESIGN WIND SPEED, Vult > 140 MPH~~<br><br>~~AREAS WHERE WIND DESIGN IS REQUIRED IN ACCORDANCE WITH FIGURE R301.2.1.1 Table 301.2(4) and Table 301.2(5)~~ |
|---|---|---|---|
| Asphalt shingles | R905.2 | For roof slopes from 2 units vertical in 12 units horizontal (2:12), up to 4 units vertical in 12 units horizontal (4:12), underlayment shall be two layers applied in the following manner: apply a 19-inch strip of underlayment felt parallel to and starting at the eaves. Starting at the eave, apply 36-inch-wide sheets of underlayment, overlapping successive sheets 19 inches. Distortions in the underlayment shall not interfere with the ability of the shingles to seal. End laps shall be 4 inches and shall be offset by 6 feet.<br>For roof slopes of 4 units vertical in 12 units horizontal (4:12) or greater, underlayment shall be one layer applied in the following manner: underlayment shall be applied shingle fashion, parallel to and starting from the eave and lapped 2 inches, Distortions in the underlayment shall not interfere with the ability of the shingles to seal. End laps shall be 4 inches and shall be offset by 6 feet. | ~~Same as Maximum Ultimate Design Wind Speed, V ult < 140 mph except all laps shall be not less than 4 inches.~~ |
| Clay and concrete tile | R905.3 | For roof slopes from $2^1/_2$ units vertical in 12 units horizontal ($2^1/_2$:12), up to 4 units vertical in 12 units horizontal (4:12), underlayment shall be ~~a minimum of~~ not fewer than two layers applied as follows: starting at the eave, apply a 19-inch strip of underlayment parallel with the eave. Starting at the eave, apply 36-inch-wide strips of underlayment felt, overlapping successive sheets 19 inches. End laps shall be 4 inches and shall be offset by 6 feet. For roof slopes of 4 units vertical in 12 units horizontal (4:12) or greater, underlayment shall be ~~a minimum of~~ not fewer than one layer of underlayment felt applied shingle fashion, parallel to and starting from the eaves and lapped 2 inches. End laps shall be 4 inches and shall be offset by 6 feet. | ~~Same as Maximum Ultimate Design Wind Speed, V ult < 140 mph except all laps shall be not less than 4 inches.~~ |
| Metal roof shingles | R905.4 | Apply in accordance with the manufacturer's installation instructions. | ~~For roof slopes from two units vertical in 12 units horizontal (2:12), up to four units vertical in 12 units horizontal (4:12), underlayment shall be two layers applied in the following manner: apply a 19-inch strip of underlayment felt parallel to and starting at the eaves. Starting at the eave, apply 36-inch-wide sheets of underlayment, overlapping successive sheets 19 inches, and fastened sufficiently to hold in place.~~ |
| Mineral-surfaced roll roofing | R905.5 | | |
| Slate and slate-type shingles | R905.6 | | |
| Wood shingles | R905.7 | | |
| Wood shakes | R905.8 | | |
| Metal panels | R905.10 | | |

| | | | |
|---|---|---|---|
| | | | ~~End laps shall be 4 inches and shall be offset by 6 feet. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, underlayment shall be one layer applied in the following manner: underlayment shall be applied shingle fashion, parallel to and starting from the eave and lapped 4 inches. End laps shall be 4 inches and shall be offset by 6 feet.~~ |
| Photovoltaic shingles | R905.16 | For roof slopes from 2 units vertical in 12 units horizontal (2:12), up to 4 units vertical in 12 units horizontal (4:12), underlayment shall be two layers applied in the following manner: apply a 19-inch strip of underlayment felt parallel to and starting at the eaves. Starting at the eave, apply 36-inch-wide sheets of underlayment, overlapping successive sheets 19 inches. Distortions in the underlayment shall not interfere with the ability of the shingles to seal. End laps shall be 4 inches and shall be offset by 6 feet. For roof slopes of 4 units vertical in 12 units horizontal (4:12) or greater, underlayment shall be one layer applied in the following manner: underlayment shall be applied shingle fashion, parallel to and starting from the eave and lapped 2 inches. Distortions in the underlayment shall not interfere with the ability of the shingles to seal. End laps shall be 4 inches and shall be offset by 6 feet. | ~~Underlayment shall be two layers applied in the following manner: apply a 19-inch strip of underlayment felt parallel to and starting at the eaves. Starting at the eave, apply 36-inch-wide sheets of underlayment, overlapping successive sheets 19 inches. Distortions in the underlayment shall not interfere with the ability of the shingles to seal. End laps shall be 4 inches and shall be offset by 6 feet.~~ |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

**TABLE R905.1.1(3)**
**UNDERLAYMENT APPLICATION**

| ROOF COVERING | SECTION | MAXIMUM ULTIMATE DESIGN WIND SPEED, Vult < 130 MPH | ~~MAXIMUM ULTIMATE DESIGN WIND SPEED, Vult > 140 MPH~~ |
|---|---|---|---|
| Asphalt shingles | R905.2 | Fastened sufficiently to hold in place | ~~The underlayment shall be attached with corrosion-resistant fasteners in a grid pattern of 12 inches between side~~ |
| Clay and concrete tile | R905.3 | | |

| | | | |
|---|---|---|---|
| Photovoltaic | R905.16 | | ~~laps with a 6-inch spacing at side and end laps. Underlayment shall be attached using annular ring or deformed shank nails with 1-inch-diameter metal or plastic caps. Metal caps shall have a thickness of not less than 32-gage sheet metal. Power-driven metal caps shall have a minimum thickness of 0.010 inch. Minimum thickness of the outside edge of plastic caps shall be 0.035 inch. The cap nail shank shall be not less than 0.083 inch. The cap nail shank shall have a length sufficient to penetrate through the roof sheathing or not less than 3/4 inch into the roof sheathing.~~ |
| Metal roof shingles | R905.4 | Manufacturer's installation instructions. | ~~The underlayment shall be attached with corrosion-resistant fasteners in a grid pattern of 12 inches between side laps with a 6-inch spacing at side and end laps. Underlayment shall be attached using annular ring or deformed shank nails with 1-inch-diameter metal or plastic caps. Metal caps shall have a thickness of not less than 32-gage sheet metal. Power-driven metal caps shall have a minimum thickness of 0.010 inch. Minimum thickness of the outside edge of plastic caps shall be 0.035 inch. The cap nail shank shall be not less than 0.083 inch. The cap nail shank shall have a length sufficient to penetrate through the roof sheathing or not less than 3/4 inch into the roof sheathing.~~ |
| Mineral-surfaced roll roofing | R905.5 | | |
| Slate and slate-type shingles | R905.6 | | |
| Wood shingles | R905.7 | | |
| Wood shakes | R905.8 | | |
| Metal panels | R905.10 | | |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

**R905.1.2 Ice barriers.** In areas where the average daily temperature in January is 25°F (-4° C) or less or when Table R301.2(1) criteria so designates, an ice barrier shall be installed for asphalt shingles, metal roof shingles, mineral-surfaced roll roofing, slate and slate-type shingles, wood shingles and wood shakes. The ice barrier shall consist of not fewer than two layers of *underlayment* cemented together, or a self-adhering polymer-modified bitumen sheet shall be used in place of normal *underlayment* and extend from the lowest edges of all roof surfaces to a point not less than 24 inches (610 mm) inside the exterior wall line of the building. On roofs with slope equal to or greater than 8 units vertical in 12 units horizontal (67-percent slope), the ice barrier shall also be applied not less than 36 inches (914 mm) measured along the roof slope from the eave edge of the building.

**Exception:** Detached *accessory structures* not containing conditioned floor area.

**R905.2 Asphalt shingles.** The installation of asphalt shingles shall comply with the provisions of this section.

**R905.2.1 Sheathing requirements.** Asphalt shingles shall be fastened to solidly sheathed decks.

**R905.2.2 Slope.** Asphalt shingles shall be used only on roof slopes of 2 units vertical in 12 units horizontal ~~(2:12)~~ (17-percent slope) or greater. For roof slopes from 2 units vertical in 12 units horizontal ~~(2:12)~~ (17-percent slope) up to 4 units vertical in 12 units horizontal ~~(4:12)~~ (33-percent slope), double *underlayment* application is required in accordance with Section R905.1.1.

**R905.2.3 Underlayment.** *Underlayment* shall comply with Section R905.1.1.

**R905.2.4 Asphalt shingles.** Asphalt shingles shall comply with ASTM D3462.

**R905.2.4.1 Wind resistance of asphalt shingles.** Asphalt shingles shall be tested in accordance with ASTM D7158. Asphalt shingles shall meet the classification requirements of Table R905.2.4.1 for the appropriate ultimate design wind speed. Asphalt shingle packaging shall bear a *label* to indicate compliance with ASTM D7158 and the required classification in Table R905.2.4.1.

**Exception:** Asphalt shingles not included in the scope of ASTM D7158 shall be tested and *labeled* in accordance with ASTM D3161. Asphalt shingle packaging shall bear a *label* to indicate compliance with ASTM D3161 and the required classification in Table R905.2.4.1.

**TABLE R905.2.4.1**
**CLASSIFICATION OF ASPHALT ROOF SHINGLES**

| MAXIMUM ULTIMATE DESIGN WIND SPEED, $V_{ult}$ FROM Table R301.2(4) ~~Figure R301.2(4)A~~ (mph) | MAXIMUM BASIC WIND SPEED, $V_{ASD}$ FROM TABLE R301.2.1.3 (mph) | ASTM D7158[a] SHINGLE CLASSIFICATION | ASTM D3161 SHINGLE CLASSIFICATION |
|---|---|---|---|
| 110 | 85 | D, G or H | A, D or F |
| 116 | 90 | D, G or H | A, D or F |
| 129 | 100 | G or H | A, D or F |
| 142 | 110 | G or H | F |
| 155 | 120 | G or H | F |
| 168 | 130 | H | F |
| 181 | 140 | H | F |
| 194 | 150 | H | F |

For SI: 1 foot = 304.8 mm, 1 ~~mph~~ mile per hour = 0.447 m/s.

a. The standard calculations contained in ASTM D7158 assume Exposure Category B or C and a building height of 60 feet or less. Additional calculations are required for conditions outside of these assumptions.

**R905.2.5 Fasteners.** Fasteners for asphalt shingles shall be galvanized steel, stainless steel, aluminum or copper roofing nails, minimum 12-gage [0.105 inch (3 mm)] shank with a minimum $^3/_8$-inch-diameter (9.5 mm) head, complying with ASTM F1667, of a length to penetrate through the roofing materials and not less than $^3/_4$ inch (19.1 mm) into the roof sheathing. Where the roof sheathing is less than $^3/_4$ inch (19.1 mm) thick, the fasteners shall penetrate through the sheathing.

**R905.2.6 Attachment.** Asphalt shingles shall have the minimum number of fasteners required by the ~~manufacturer~~ manufacturer's *approved* installation instructions, but not less than four fasteners per strip shingle or two fasteners per individual shingle. Where the roof slope exceeds 21 units vertical in 12 units horizontal (21:12, 175-percent slope), shingles shall be installed ~~as required by~~ in accordance with the ~~manufacturer~~ manufacturer's *approved* installation instructions.

**Exception:** Asphalt strip shingles shall have a minimum of six fasteners per shingle where the roof is in one of the following categories:

1. The ultimate wind speed in accordance with Table R301.2(4) is 130 miles per hour (58 m/s) or greater and the eave is 20 feet (6096 mm) or higher above grade.
2. The ultimate wind speed in accordance with Table R301.2(4) is 140 miles per hour (63 m/s) or greater.
3. Special mountain regions in accordance with Table R301.2(5) that meet Items 1 or 2 in this section.

**R905.2.7 Ice barrier.** Where required, ice barriers shall comply with Section R905.1.2.

**R905.2.8 Flashing.** Flashing for asphalt shingles shall comply with this section and the asphalt shingle manufacturer's *approved* installation instructions.

**R905.2.8.1 Base and cap flashing.** Base and cap flashing shall be installed in accordance with manufacturer's instructions. Base flashing shall be of either corrosion-resistant metal of minimum nominal 0.019-inch (0.5 mm) thickness or mineral-surfaced roll roofing weighing not less than 77 pounds per 100 square feet (4 kg/$m^2$). Cap flashing shall be corrosion-resistant metal of minimum nominal 0.019-inch (0.5 mm) thickness.

**R905.2.8.2 Valleys.** Valley linings shall be installed in accordance with the manufacturer's instructions before applying shingles. Valley linings of the following types shall be permitted:

1. For open valleys (valley lining exposed) lined with metal, the valley lining shall be not less than 24 inches (610 mm) wide and of any of the corrosion-resistant metals in Table R905.2.8.2.
2. For open valleys, valley lining of two plies of mineral-surfaced roll roofing, complying with ASTM D3909 or ASTM D6380 Class M, shall be permitted. The bottom layer shall be 18 inches (457 mm) and the top layer not less than 36 inches (914 mm) wide.
3. For closed valleys (valley covered with shingles), valley lining of one ply of smooth roll roofing complying with ASTM D6380 and not less than 36 inches wide (914 mm) or valley lining as described in Item 1 or 2 shall be permitted. Self-adhering polymer-modified bitumen *underlayment* complying with ASTM D1970 shall be permitted in lieu of the lining material.

**TABLE R905.2.8.2**
**VALLEY LINING MATERIAL**

| MATERIAL | MINIMUM THICKNESS (inches) | GAGE | WEIGHT (pounds) |
|---|---|---|---|
| Aluminum | 0.024 | — | — |
| Cold-rolled copper | 0.0216 nominal | — | ASTM B370, 16 oz. per square foot |
| Galvanized steel | 0.0179 | 26 (zinc coated G90) | — |
| High-yield copper | 0.0162 nominal | — | ASTM B370, 12 oz. per square foot |
| Lead | — | — | $2^1/_2$ |
| Lead-coated copper | 0.0216 nominal | — | ASTM B101, 16 oz. per square foot |
| Lead-coated high-yield copper | 0.0162 nominal | — | ASTM B101, 12 oz. per square foot |
| Painted terne | — | — | 20 |
| Stainless steel | — | 28 | — |
| Zinc alloy | 0.027 | — | — |

For SI: 1 inch = 25.4 mm, 1 pound = 0.454 kg, 1 square foot = 0.93 $m^2$.

**R905.2.8.3 Sidewall flashing.** Base flashing against a vertical sidewall shall be continuous at horizontal surfaces or step flashing at sloped surfaces and shall be not less than 4 inches (102 mm) in height and 4 inches (102 mm) in width and shall direct water away from the vertical sidewall onto the roof or into the gutter. Where siding is provided on the vertical sidewall, the vertical leg of the flashing shall be continuous under the siding. Where anchored masonry veneer is provided on the vertical sidewall, the base flashing shall be provided in accordance with this section and counterflashing shall be provided in accordance with Section R703.8.5. Where exterior plaster or adhered masonry veneer is provided on the vertical sidewall, the base flashing shall be provided in accordance with this section and Section R703.6.3.

**R905.2.8.4 Other flashing.** Flashing against a vertical front wall, as well as soil stack, vent pipe and chimney flashing, shall be applied in accordance with the asphalt shingle manufacturer's printed instructions.

**R905.2.8.5 Drip edge.** ~~Deleted.~~ Not required unless required by the roof covering manufacturer installation instructions. The drip edge placed around the edge of a roof prior to installing the roofing material shall be designed so that water runs off over the drip edge and falls from a slight projection at the bottom edge of the roof rather than running back under, or along the eaves. Metal, wood or exterior composite materials can be used for the drip edge.

**R905.3 Clay and concrete tile.** The installation of clay and concrete tile shall comply with the provisions of this section.

**R905.3.1 Deck requirements.** Concrete and clay tile shall be installed only over solid sheathing ~~or spaced structural sheathing boards.~~

**Exception:** Spaced lumber sheathing in accordance with Section R803.1 shall be permitted in *Seismic Design Categories* A, B and C.

**R905.3.2 Deck slope.** Clay and concrete roof tile shall be installed on roof slopes of $2^1/_2$ units vertical in 12 units horizontal ~~(2 1/2: 12)~~ (25-percent slope) or greater. For roof slopes from $2^1/_2$ units vertical in 12 units horizontal ~~(2 1/2: 12)~~(25-percent slope) to 4 units vertical in 12 units horizontal (4:12) (33-percent slope), double *underlayment* application is required in accordance with Section R905.3.3.

**R905.3.3 Underlayment.** *Underlayment* shall comply with Section R905.1.1.

**R905.3.4 Clay tile.** Clay roof tile shall comply with ASTM C1167.

**R905.3.5 Concrete tile.** Concrete roof tile shall comply with ASTM C1492.

**R905.3.6 Fasteners.** Nails shall be corrosion resistant and not less than 11-gage [0.120 inch (3 mm)], $^5/_{16}$-inch (11 mm) head, and of sufficient length to penetrate the deck not less than $^3/_4$ inch (19 mm) or through the thickness of the deck, whichever is less. Attaching wire for clay or concrete tile shall not be smaller than 0.083 inch (2 mm). Perimeter fastening areas include three tile courses but not less than 36 inches (914 mm) from either side of hips or ridges and edges of eaves and gable rakes.

**R905.3.7 Application.** Tile shall be applied in accordance with this chapter and the manufacturer's installation instructions, based on the following:

1. Climatic conditions.
2. Roof slope.
3. *Underlayment* system.
4. Type of tile being installed.

Clay and concrete roof tiles shall be fastened in accordance with this section and the manufacturer's installation instructions. Perimeter tiles shall be fastened with not less than one fastener per tile. Tiles with installed weight less than 9 pounds per square foot (0.4 kg/m$^2$) require not less than one fastener per tile regardless of roof slope. Clay and concrete roof tile attachment shall be in accordance with the manufacturer's installation instructions where applied in areas where the ultimate design wind speed exceeds 130 miles per hour (58 m/s) and on buildings where the roof is located more than 40 feet (12 192 mm) above grade. In areas subject to snow, not less than two fasteners per tile are required. In other areas, clay and concrete roof tiles shall be attached in accordance with Table R905.3.7.

**TABLE R905.3.7**
**CLAY AND CONCRETE TILE ATTACHMENT**

| SHEATHING | ROOF SLOPE | NUMBER OF FASTENERS |
|---|---|---|
| Solid without battens | All | One per tile |
| Spaced or solid with battens and slope < 5:12 | Fasteners not required | — |
| Spaced sheathing without battens | 5:12 ≤ slope < 12:12 | One per tile/ every other row |
| | 12:12 ≤ slope < 24:12 | One per tile |

**R905.3.8 Flashing.** At the juncture of roof vertical surfaces, flashing and counterflashing shall be provided in accordance with this chapter and the manufacturer's installation instructions and, where of metal, shall be not less than 0.019 inch (0.5 mm) (No. 26 galvanized sheet gage) corrosion-resistant metal. The valley flashing shall extend not less than 11 inches (279 mm) from the centerline each way and have a splash diverter rib not less than 1 inch (25 mm) in height at the flow line formed as part of the flashing. Sections of flashing shall have an end lap of not less than 4 inches (102 mm). For roof slopes of 3 units vertical in 12 units horizontal (25-percent slope) and greater, valley flashing shall have a 36-inch-wide (914 mm) *underlayment* of one layer of Type I *underlayment* running the full length of the valley, in addition to other required *underlayment*. In areas where the average daily temperature in January is 25°F (-4°C) or less, metal valley flashing *underlayment* shall be solid-cemented to the roofing *underlayment* for slopes less than 7 units vertical in 12 units horizontal (58-percent slope) or be of self-adhering polymer-modified bitumen sheet.

**R905.4 Metal roof shingles.** The installation of metal roof shingles shall comply with the provisions of this section.

**R905.4.1 Deck requirements.** *Metal roof shingles* shall be applied to a solid or closely fitted deck, except where the roof covering is specifically designed to be applied to spaced sheathing.

**R905.4.2 Deck slope.** *Metal roof shingles* shall not be installed on roof slopes below 3 units vertical in 12 units horizontal (25-percent slope).

**R905.4.3 Underlayment.** *Underlayment* shall comply with Section R905.1.1.

**R905.4.3.1 Ice barrier.** Where required, ice barriers shall comply with Section R905.1.2.

**R905.4.4 Material standards.** *Metal roof shingle* roof coverings shall comply with Table R905.10.3(1). The materials used for *metal roof shingle* roof coverings shall be naturally corrosion resistant or be made corrosion resistant in accordance with the standards and minimum thicknesses listed in Table R905.10.3(2).

**R905.4.4.1 Wind resistance of metal roof shingles.** *Metal roof shingles* applied to a solid or closely fitted deck shall be tested in accordance with ASTM D3161, FM 4474, UL 580 or UL 1897. *Metal roof shingles* tested in accordance with ASTM D3161 shall meet the classification requirements of Table R905.4.4.1 for the appropriate maximum basic wind speed and the metal shingle packaging shall bear a *label* to indicate compliance with ASTM D3161 and the required classification in Table R905.2.4.1.

**TABLE R905.4.4.1**
**CLASSIFICATION OF STEEP SLOPE METAL ROOF SHINGLES TESTED IN ACCORDANCE WITH ASTM D3161**

| MAXIMUM ULTIMATE DESIGN WIND SPEED, $V_{ult}$, FROM Table 301.2(4) and Table 301.2(5) (mph) | ASTM D3161 SHINGLE CLASSIFICATION |
|---|---|
| 110 | A, D or F |
| 116 | A, D or F |
| 129 | A, D or F |
| 142 | F |
| 155 | F |
| 168 | F |
| 181 | F |
| 194 | F |

For SI: 1 mile per hour = 1.609 kph.

**R905.4.5 Application.** *Metal roof shingles* shall be secured to the roof in accordance with this chapter and the *approved* manufacturer's installation instructions.

**R905.4.6 Flashing.** Roof valley flashing shall be of corrosion-resistant metal of the same material as the roof covering or shall comply with the standards in Table R905.10.3(1). The valley flashing shall extend not less than 8 inches (203 mm) from the centerline each way and shall have a splash diverter rib not less than $^3/_4$ inch (19 mm) in height at the flow line formed as part of the flashing. Sections of flashing shall have an end lap of not less than 4 inches (102 mm). The metal valley flashing shall have a 36-inch-wide (914 mm) *underlayment* directly under it consisting of one layer of *underlayment* running the full length of the valley, in addition to *underlayment* required for *metal roof shingles*. In areas where the average daily temperature in January is 25°F (-4°C) or less, the metal valley flashing *underlayment* shall be solid-cemented to the roofing *underlayment* for roof slopes under 7 units vertical in 12 units horizontal (58-percent slope) or self-adhering polymer-modified bitumen sheet.

**R905.5 Mineral-surfaced roll roofing.** The installation of mineral-surfaced roll roofing shall comply with this section.

**R905.5.1 Deck requirements.** Mineral-surfaced roll roofing shall be fastened to solidly sheathed roofs.

**R905.5.2 Deck slope.** Mineral-surfaced roll roofing shall not be applied on roof slopes below 1 unit vertical in 12 units horizontal (8-percent slope).

**R905.5.3 Underlayment.** *Underlayment* shall comply with Section R905.1.1.

**R905.5.3.1 Ice barrier.** Where required, ice barriers shall comply with Section R905.1.2.

**R905.5.4 Material standards.** Mineral-surfaced roll roofing shall conform to ASTM D3909 or ASTM D6380, Class M.

**R905.5.5 Application.** Mineral-surfaced roll roofing shall be installed in accordance with this chapter and the manufacturer's instructions.

**R905.6 Slate shingles.** The installation of slate shingles shall comply with the provisions of this section.

**R905.6.1 Deck requirements.** Slate shingles shall be fastened to solidly sheathed roofs.

**R905.6.2 Deck slope.** Slate shingles shall be used only on slopes of 4 units vertical in 12 units horizontal (33-percent slope) or greater.

**R905.6.3 Underlayment.** *Underlayment* shall comply with Section R905.1.1.

**R905.6.3.1 Ice barrier.** Where required, ice barriers shall comply with Section R905.1.2.

**R905.6.4 Material standards.** Slate shingles shall comply with ASTM C406.

**R905.6.5 Application.** Minimum headlap for slate shingles shall be in accordance with Table R905.6.5. Slate shingles shall be secured to the roof with two fasteners per slate. Slate shingles shall be installed in accordance with this chapter and the manufacturer's instructions.

**TABLE R905.6.5**
**SLATE SHINGLE HEADLAP**

| SLOPE | HEADLAP (inches) |
|---|---|
| 4:12 ≤ slope < 8:12 | 4 |
| 8:12 ≤ slope < 20:12 | 3 |
| Slope ≤ ≥ 20:12 | 2 |

For SI: 1 inch = 25.4 mm.

**R905.6.6 Flashing.** Flashing and counterflashing shall be made with sheet metal. Valley flashing shall be not less than 15 inches (381 mm) wide. Valley and flashing metal shall be a minimum uncoated thickness of 0.0179-inch (0.5 mm) zinc coated G90. Chimneys, stucco or brick walls shall have not less than two plies of felt for a cap flashing consisting of a 4-inch-wide (102 mm) strip of felt set in plastic cement and extending 1 inch (25 mm) above the first felt and a top coating of plastic cement. The felt shall extend ~~over the base flashing~~ 2 inches (51 mm) over the base flashing.

**R905.7 Wood shingles.** The installation of wood shingles shall comply with the provisions of this section.

**R905.7.1 Deck requirements.** Wood shingles shall be installed on solid or spaced sheathing. Where spaced sheathing is used, sheathing boards shall be not less than 1-inch by 4-inch (25 mm by 102 mm) nominal dimensions and shall be spaced on centers equal to the weather exposure to coincide with the placement of fasteners.

**R905.7.1.1 Solid sheathing required.** In areas where the average daily temperature in January is 25°F (-4°C) or less, solid sheathing is required on that portion of the roof requiring the application of an ice barrier.

**R905.7.2 Deck slope.** Wood shingles shall be installed on slopes of 3 units vertical in 12 units horizontal (25-percent slope) or greater.

**R905.7.3 Underlayment.** *Underlayment* shall comply with Section R905.1.1.

**R905.7.3.1 Ice barrier.** Where required, ice barriers shall comply with Section R905.1.2.

**R905.7.4 Material standards.** Wood shingles shall be of *naturally durable wood* and comply with the requirements of Table R905.7.4.

**TABLE R905.7.4**
**WOOD SHINGLE MATERIAL REQUIREMENTS**

| MATERIAL | MINIMUM GRADES | APPLICABLE GRADING RULES |
|---|---|---|
| Wood shingles of naturally durable wood | 1, 2 or 3 | ~~Cedar Shake and Shingle Bureau~~ CSSB |

**R905.7.5 Application.** Wood shingles shall be installed in accordance with this chapter and the manufacturer's instructions. Wood shingles shall be laid with a side lap not less than $1^1/_2$ inches (38 mm) between joints in courses, and two joints shall not be in direct alignment in any three adjacent courses. Spacing between shingles shall be not less than $^1/_4$ inch to $^3/_8$ inch (6.4 mm to 9.5 mm). Weather exposure for wood shingles shall not exceed those set in Table R905.7.5(1). Fasteners for untreated (naturally durable) wood shingles shall be box nails in accordance with Table R905.7.5(2). Nails shall be stainless steel Type 304 or 316 or hot-dipped galvanized with a coating weight of ASTM A153 Class D (1.0 oz/ft$^2$). Alternatively, two 16-gage stainless steel Type 304 or 316 staples with crown widths $^7/_{16}$ inch (11.1 mm) minimum, $^3/_4$ inch (19.1 mm) maximum, shall be used. Fasteners installed within 15 miles (24 km) of ~~salt water~~ saltwater coastal areas shall be stainless steel Type 316. ~~All~~ Fasteners for fire-retardant-treated shingles in accordance with Section R902 or pressure-impregnated-preservative-treated shingles of naturally durable wood in accordance with AWPA U1 shall be stainless steel Type 316. Fasteners shall have a minimum penetration into the sheathing of $^3/_4$ inch (19.1 mm). For sheathing less than $^3/_4$ inch in (19.1 mm) thickness, each fastener shall penetrate through the sheathing. Wood shingles shall be attached to the roof with two fasteners per shingle, positioned in accordance with the manufacturer's installation instructions. Fastener packaging shall bear a *label* indicating the appropriate grade material or coating weight.

**TABLE R905.7.5(1)**
**WOOD SHINGLE WEATHER EXPOSURE AND ROOF SLOPE**

| ROOFING MATERIAL | LENGTH (inches) | GRADE | EXPOSURE (inches) | |
|---|---|---|---|---|
| | | | 3:12 pitch to < 4:12 | 4:12 pitch or steeper |
| Shingles of naturally durable wood | 16 | No. 1 | $3^3/_4$ | 5 |
| | | No. 2 | $3^1/_2$ | 4 |
| | | No. 3 | 3 | $3^1/_2$ |
| | 18 | No. 1 | $4^1/_4$ | $5^1/_2$ |

| | | | | |
|---|---|---|---|---|
| | | No. 2 | 4 | $4^{1}/_{2}$ |
| | | No. 3 | $3^{1}/_{2}$ | 4 |
| | 24 | No. 1 | $5^{3}/_{4}$ | $7^{1}/_{2}$ |
| | | No. 2 | $5^{1}/_{2}$ | $6^{1}/_{2}$ |
| | | No. 3 | 5 | $5^{1}/_{2}$ |

For SI: 1 inch = 25.4 mm.

**TABLE R905.7.5(2)**

**NAIL REQUIREMENTS FOR WOOD SHAKES AND WOOD SHINGLES**

| SHAKES | NAIL TYPE AND MINIMUM LENGTH | MINIMUM HEAD SIZE | MINIMUM SHANK DIAMETER |
|---|---|---|---|
| 18″ straight-split | 5d box $1^{3}/_{4}$″ | 0.19″ | .080″ |
| 18″ and 24″ handsplit and resawn | 6d box 2″ | 0.19″ | .0915″ |
| 24″ taper-split | 5d box $1^{3}/_{4}$″ | 0.19″ | .080″ |
| 18″ and 24″ tapersawn | 6d box 2″ | 0.19″ | .0915″ |
| **Shingles** | **Nail Type and Minimum Length** | | |
| 16″ and 18″ | 3d box $1^{1}/_{4}$″ | 0.19″ | .080″ |
| 24″ | 4d box $1^{1}/_{2}$″ | 0.19″ | .080″ |

| PRODUCT TYPE | NAIL TYPE, MINIMUM LENGTH AND SHANK DIAMETER (inches) |
|---|---|
| **Shakes** | |
| 18″ straight-split | 5d box $1^{3}/_{4}$″ × 0.080 |
| 18″ and 24″ handsplit and resawn | 6d box 2″ × 0.099 |
| 24″ taper-split | 5d box $1^{3}/_{4}$″ × 0.080 |
| 18″ and 24″ tapersawn | 6d box 2″ × 0.099 |
| **Shingles** | |
| 16″ and 18″ | 3d box $1^{1}/_{4}$″ × 0.076 |
| 24″ | 4d box $1^{1}/_{2}$″ × 0.076 |

For SI: 1 inch = 25.4 mm.

**R905.7.6 Valley flashing.** Roof flashing shall be not less than No. 26 gage [0.019 inches (0.5 mm)] corrosion-resistant sheet metal and shall extend 10 inches (254 mm) from the centerline each way for roofs having slopes less than 12 units vertical in 12 units horizontal (100-percent slope), and 7 inches (178 mm) from the centerline each way for slopes of 12 units vertical in 12 units horizontal (100-percent slope) and greater. Sections of flashing shall have an end lap of not less than 4 inches (102 mm).

**R905.7.7 Label required.** Each bundle of shingles shall be identified by a *label* of an *approved* grading or inspection bureau or agency.

**R905.8 Wood shakes.** The installation of wood shakes shall comply with the provisions of this section.

**R905.8.1 Deck requirements.** Wood shakes shall be used only on solid or spaced sheathing. Where spaced sheathing is used, sheathing boards shall be not less than 1-inch by 4-inch (25 mm by 102 mm) nominal dimensions and shall be spaced on centers equal to the weather exposure to coincide with the placement of fasteners. Where 1-inch by 4-inch (25 mm by 102 mm) spaced sheathing is installed at 10 inches (254 mm) on center, additional 1-inch by 4-inch (25 mm by 102 mm) boards shall be installed between the sheathing boards.

**R905.8.1.1 Solid sheathing required.** In areas where the average daily temperature in January is 25°F (-4°C) or less, solid sheathing is required on that portion of the roof requiring an ice barrier.

**R905.8.2 Deck slope.** Wood shakes shall only be used on slopes of 3 units vertical in 12 units horizontal (25-percent slope) or greater.

**R905.8.3 Underlayment.** *Underlayment* shall comply with Section R905.1.1.

**R905.8.3.1 Ice barrier.** Where required, ice barriers shall comply with Section R905.1.2.

**R905.8.4 Interlayment.** Interlayment shall comply with ASTM D226, Type I.

**R905.8.5 Material standards.** Wood shakes shall comply with the requirements of Table R905.8.5.

**TABLE R905.8.5**
**WOOD SHAKE MATERIAL REQUIREMENTS**

| MATERIAL | MINIMUM GRADES | APPLICABLE GRADING RULES |
|---|---|---|
| Wood shakes of naturally durable wood | 1 | Cedar Shake and Shingle Bureau |
| Tapersawn shakes of naturally durable wood | 1 or 2 | Cedar Shake and Shingle Bureau |
| Preservative-treated shakes and shingles of naturally durable wood | 1 | Cedar Shake and Shingle Bureau |
| Fire-retardant-treated shakes and shingles of naturally durable wood | 1 | Cedar Shake and Shingle Bureau |
| Preservative-treated tapersawn shakes of Southern pine treated in accordance with AWPA Standard U1 (Commodity Specification A, ~~Use Category 3B and Section 5.6~~Special Requirement 4.6) | 1 or 2 | Forest Products Laboratory of the Texas Forest Services |

**R905.8.6 Application.** Wood shakes shall be installed in accordance with this chapter and the manufacturer's installation instructions. Wood shakes shall be laid with a side lap not less than $1^1/_2$ inches (38 mm) between joints in adjacent courses. Spacing between shakes in the same course shall be $^3/_8$ inch to $^5/_8$ inch (9.5 mm to 15.9 mm) including tapersawn shakes. Weather exposures for wood shakes shall not exceed those set in Table R905.8.6. Fasteners for untreated (naturally durable) wood shakes shall be box nails in accordance with Table R905.7.5(2). Nails shall be stainless steel Type 304, or Type 316 or hot-dipped with a coating weight of ASTM A153 Class D (1.0 oz/ft$^2$). Alternatively, two 16-gage Type 304 or Type 316 stainless steel staples, with crown widths $^7/_{16}$ inch (11.1 mm) minimum, $^3/_4$ inch (19.1 mm) maximum, shall be used. Fasteners installed within 15 miles (24 km) of ~~salt water~~ saltwater coastal areas shall be stainless steel Type 316. Wood shakes shall be attached to the roof with two fasteners per shake positioned in accordance with the manufacturer's installation instructions. Fasteners for fire-retardant-treated (as defined in Section R902) shakes or pressure-impregnated-preservative-treated shakes of *naturally durable wood* in accordance with AWPA U1 shall be stainless steel Type 316. Fasteners shall have a minimum penetration into the sheathing of $^3/_4$ inch (19.1 mm). Where the sheathing is less than $^3/_4$ inch (19.1 mm) thick, each fastener shall penetrate through the sheathing. Fastener packaging shall bear a *label* indicating the appropriate grade material or coating weight.

**TABLE R905.8.6**

**WOOD SHAKE WEATHER EXPOSURE AND ROOF SLOPE**

| ROOFING MATERIAL | LENGTH (inches) | GRADE | EXPOSURE (inches) |
|---|---|---|---|
| | | | 4:12 pitch or steeper |
| Shakes of *naturally durable wood* | 18 | No. 1 | $7^{1}/_{2}$ |
| | 24 | No. 1 | 10[a] |
| Preservative-treated tapersawn shakes of Southern Yellow Pine | 18 | No. 1 | $7^{1}/_{2}$ |
| | 24 | No. 1 | 10 |
| | 18 | No. 2 | $5^{1}/_{2}$ |
| | 24 | No. 2 | $7^{1}/_{2}$ |
| Taper-sawn shakes of naturally durable wood | 18 | No. 1 | $7^{1}/_{2}$ |
| | 24 | No. 1 | 10 |
| | 18 | No. 2 | $5^{1}/_{2}$ |
| | 24 | No. 2 | $7^{1}/_{2}$ |

For SI: 1 inch = 25.4 mm.

a. For 24-inch by $^{3}/_{8}$-inch handsplit shakes, the maximum exposure is $7^{1}/_{2}$ inches.

**R905.8.7 Shake placement.** The starter course at the eaves shall be doubled and the bottom layer shall be either 15-inch (381 mm), 18-inch (457 mm) or 24-inch (610 mm) wood shakes or wood shingles. Fifteen-inch (381 mm) or 18-inch (457 mm) wood shakes shall be permitted to be used for the final course at the ridge. Shakes shall be interlaid with 18-inch-wide (457 mm) strips of not less than No. 30 felt shingled between each course in such a manner that ~~no~~ felt is not exposed to the weather by positioning the lower edge of each felt strip above the butt end of the shake it covers a distance equal to twice the weather exposure.

**R905.8.8 Valley flashing.** Roof valley flashing shall be not less than No. 26 gage [0.019 inch (0.5 mm)] corrosion-resistant sheet metal and shall extend not less than 11 inches (279 mm) from the centerline each way. Sections of flashing shall have an end lap of not less than 4 inches (102 mm).

**R905.8.9 Label required.** Each bundle of shakes shall be identified by a *label* of an *approved* grading or inspection bureau or agency.

**R905.9 Built-up roofs.** The installation of built-up roofs shall comply with the provisions of this section and the manufacturer's *approved* installation instructions.

**R905.9.1 Slope.** Built-up roofs shall have a design slope of not less than $^{1}/_{4}$ unit vertical in 12 units horizontal (2-percent slope) for drainage, except for coal-tar built-up roofs, which shall have a design slope of a minimum $^{1}/_{8}$ unit vertical in 12 units horizontal (1-percent slope).

**R905.9.2 Material standards.** *Built-up roof covering* materials shall comply with the standards in Table R905.9.2 or UL 55A.

**R905.9.3 Application.** Built-up roofs shall be installed in accordance with this chapter and the manufacturer's instructions.

**TABLE R905.9.2**

**BUILT-UP ROOFING MATERIAL STANDARDS**

| MATERIAL STANDARD | STANDARD |
|---|---|
| Acrylic coatings used in roofing | ASTM D6083 |
| Aggregate surfacing | ASTM D1863 |
| Asphalt adhesive used in roofing | ASTM D3747 |
| Asphalt cements used in roofing | ASTM D2822; D3019; D4586 |
| Asphalt-coated glass fiber base sheet | ASTM D4601 |
| Asphalt coatings used in roofing | ASTM D1227; D2823; D2824; D4479 |
| Asphalt glass felt | ASTM D2178 |
| Asphalt primer used in roofing | ASTM D41 |
| Asphalt-saturated and asphalt-coated organic felt base sheet | ASTM D2626 |
| Asphalt-saturated organic felt (perforated) | ASTM D2626 |
| Asphalt used in roofing | ASTM D312 |
| Coal-tar cements used in roofing | ASTM D4022; D5643 |
| Coal-tar primer used in roofing, dampproofing and waterproofing | ASTM D43 |
| Coal-tar saturated organic felt | ASTM D227 |
| Coal-tar used in roofing | ASTM D450, Type I or II |
| Glass mat, coal tar | ASTM D4990 |
| Glass mat, venting type | ASTM D4897 |
| Mineral-surfaced inorganic cap sheet | ASTM D3909 |
| Thermoplastic fabrics used in roofing | ASTM D5665; D5726 |

**R905.10 Metal roof panels.** The installation of *metal roof panels* shall comply with the provisions of this section.

**R905.10.1 Deck requirements.** *Metal roof panel* roof coverings shall be applied to solid or spaced sheathing, except where the roof covering is specifically designed to be applied to spaced supports.

**R905.10.2 Slope.** Minimum slopes for *metal roof panels* shall comply with the following:

1. The minimum slope for lapped, nonsoldered-seam metal roofs without applied lap sealant shall be 3 units vertical in 12 units horizontal (25-percent slope).
2. The minimum slope for lapped, nonsoldered-seam metal roofs with applied lap sealant shall be $^1/_2$ unit vertical in 12 units horizontal (4-percent slope). Lap sealants shall be applied in accordance with the *approved* manufacturer's installation instructions.
3. The minimum slope for standing-seam roof systems shall be $^1/_4$ unit vertical in 12 units horizontal (2-percent slope).

**R905.10.3 Material standards.** Metal-sheet roof covering systems that incorporate supporting structural members shall be designed in accordance with the *International Building Code*. Metal-sheet roof coverings installed over structural decking shall comply with Table R905.10.3(1). The materials used for metal-sheet roof coverings shall be naturally corrosion resistant or provided with corrosion resistance in accordance with the standards and minimum thicknesses shown in Table R905.10.3(2).

**TABLE R905.10.3(1)**
**METAL ROOF COVERING STANDARDS**

| ROOF COVERING TYPE | STANDARD APPLICATION RATE/THICKNESS |
|---|---|
| Aluminum | ASTM B209, 0.024 minimum thickness for roll-formed panels and 0.019-inch minimum thickness for press-formed shingles. |
| Cold-rolled copper | ASTM B370 minimum 16 oz/sq ft and 12 oz/sq ft high-yield copper for metal-sheet roof-covering systems; 12 oz/sq ft for preformed metal shingle systems. |
| Galvanized steel | ASTM A653 G90 Zinc coated |
| Hard lead | 2 lb/sq ft |
| Lead-coated copper | ASTM B101 |
| Soft lead | 3 lb/sq ft |
| Stainless steel | ASTM A240, 300 Series alloys |
| Steel | ASTM A924 |
| Terne (tin) and terne-coated stainless | Terne coating of 40 lb per double base box, field painted where applicable in accordance with manufacturer's installation instructions. |
| Zinc | 0.027 inch minimum thickness: 99.995% electrolytic high-grade zinc with alloy additives of copper (0.08–0.20%), titanium (0.07%–0.12%) and aluminum (0.015%). |

For SI: 1 ounce per square foot = 0.305 kg/m$^2$, 1 pound per square foot = 4.214 kg/m$^2$, 1 inch = 25.4 mm, 1 pound = 0.454 kg.

**TABLE R905.10.3(2)**
**MINIMUM CORROSION RESISTANCE**

| | |
|---|---|
| 55% aluminum-zinc-alloy-coated steel | ASTM A792 AZ 50 |
| 5% aluminum alloy-coated steel | ASTM A875 GF60 |
| Aluminum-coated steel | ASTM A463 T2 65 |
| Galvanized steel | ASTM A653 G-90 |
| Prepainted steel | ASTM A755[a] |

a. Paint systems in accordance with ASTM A755 shall be applied over steel products with corrosion-resistant coatings complying with ASTM A792, ASTM A875, ASTM A463 or ASTM A653.

**R905.10.4 Attachment.** *Metal roof panels* shall be secured to the supports in accordance with this chapter and the manufacturer's installation instructions. In the absence of manufacturer's installation instructions, the following fasteners shall be used:

1. Galvanized fasteners shall be used for steel roofs.
2. Copper, brass, bronze, copper alloy and 300-series stainless steel fasteners shall be used for copper roofs.
3. Stainless steel fasteners are acceptable for metal roofs.

**R905.10.5 Underlayment.** *Underlayment* shall comply with Section R905.1.1.

**R905.11 Modified bitumen roofing.** The installation of modified bitumen roofing shall comply with the provisions of this section and the manufacturer's *approved* installation instructions.

**R905.11.1 Slope.** Modified bitumen ~~membrane roofs~~ roofing shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope) for drainage.

**R905.11.2 Material standards.** Modified bitumen ~~roof coverings~~ roofing shall comply with the standards in Table R905.11.2.

**R905.11.2.1 Base sheet.** A base sheet that complies with the requirements of Section 1507.11.2 of the *International Building Code*, ASTM D1970 or ASTM D4601 shall be permitted to be used with a modified bitumen cap sheet.

**TABLE R905.11.2**

**MODIFIED BITUMEN ROOFING MATERIAL STANDARDS**

| MATERIAL | STANDARD |
|---|---|
| Acrylic coating | ASTM D6083 |
| Asphalt adhesive | ASTM D3747 |
| Asphalt cement | ASTM D3019 |
| Asphalt coating | ASTM D1227; D2824 |
| Asphalt primer | ASTM D41 |
| Modified bitumen roof membrane | ASTM D6162; D6163; D6164; D6222; D6223; D6298 |

**R905.11.3 Application.** Modified bitumen roofs shall be installed in accordance with this chapter and the manufacturer's instructions.

**R905.12 Thermoset single-ply roofing.** The installation of thermoset single-ply roofing shall comply with the provisions of this section.

**R905.12.1 Slope.** Thermoset *single-ply membrane* roofs shall have a design slope of not less than $^1/_4$ unit vertical in 12 units horizontal (2-percent slope) for drainage.

**R905.12.2 Material standards.** Thermoset single-ply roof coverings shall comply with ASTM D4637 or ASTM D5019 ~~or CGSB 37-GP-52M~~.

**R905.12.3 Application.** Thermoset single-ply roofs shall be installed in accordance with this chapter and the manufacturer's instructions.

**R905.13 Thermoplastic single-ply roofing.** The installation of thermoplastic single-ply roofing shall comply with the provisions of this section.

**R905.13.1 Slope.** Thermoplastic *single-ply membrane* roofs shall have a design slope of not less than $^1/_4$ unit vertical in 12 units horizontal (2-percent slope).

**R905.13.2 Material standards.** Thermoplastic single-ply roof coverings shall comply with ASTM D4434, D6754 or D6878 ~~or CGSB CAN/CGSB 37.54~~.

**R905.13.3 Application.** Thermoplastic single-ply roofs shall be installed in accordance with this chapter and the manufacturer's instructions.

**R905.14 Sprayed polyurethane foam roofing.** The installation of sprayed polyurethane foam roofing shall comply with the provisions of this section.

**R905.14.1 Slope.** Sprayed polyurethane foam roofs shall have a design slope of not less than $^1/_4$ unit vertical in 12 units horizontal (2-percent slope) for drainage.

**R905.14.2 Material standards.** Spray-applied polyurethane foam insulation shall comply with ASTM C1029, Type III or IV or ASTM D7425.

**R905.14.3 Application.** Foamed-in-place roof insulation shall be installed in accordance with this chapter and the manufacturer's instructions. A liquid-applied protective coating that complies with Table R905.14.3 shall be applied not less than 2 hours nor more than 72 hours following the application of the foam.

**TABLE R905.14.3**

**PROTECTIVE COATING MATERIAL STANDARDS**

| MATERIAL | STANDARD |
|---|---|
| Acrylic coating | ASTM D6083 |
| Moisture-cured polyurethane coating | ASTM D6947 |
| Silicone coating | ASTM D6694 |

**R905.14.4 Foam plastics.** Foam plastic materials and installation shall comply with Section R316.

**R905.15 Liquid-applied roofing.** The installation of liquid-applied roofing shall comply with the provisions of this section.

**R905.15.1 Slope.** Liquid-applied roofing shall have a design slope of not less than $^{1}/_{4}$ unit vertical in 12 units horizontal (2-percent slope).

**R905.15.2 Material standards.** Liquid-applied roofing shall comply with ASTM C836, C957, D1227, D3468, D6083, D6694 or D6947.

**R905.15.3 Application.** Liquid-applied roofing shall be installed in accordance with this chapter and the manufacturer's installation instructions.

**R905.16 Photovoltaic shingles.** ~~Deleted.~~ The installation of *photovoltaic shingles* shall comply with the provisions of this section, Section R324 and NFPA 70.

**R905.16.1 Deck requirements.** *Photovoltaic shingles* shall be applied to a solid or closely-fitted deck, except where the roof covering is specifically designed to be applied over spaced sheathing.

**R905.16.2 Deck slope.** *Photovoltaic shingles* shall be used only on roof slopes of 2 units vertical in 12 units horizontal (2:12) or greater.

**R905.16.3 Underlayment.** *Underlayment* shall comply with Section R905.1.1.

**R905.16.3.1 Ice barrier.** Where required, ice barriers shall comply with Section R905.1.2.

**R905.16.4 Material standards.** *Photovoltaic shingles* shall be *listed* and *labeled* in accordance with UL 7103 or with both UL 61730-1 and UL 61730-2.

**R905.16.5 Attachment.** *Photovoltaic shingles* shall be attached in accordance with the manufacturer's installation instructions.

**R905.16.6 Wind resistance.** *Photovoltaic shingles* shall comply with the classification requirements of Table R905.16.6 for the appropriate maximum basic wind speed.

**TABLE R905.16.6**
**CLASSIFICATION OF PHOTOVOLTAIC SHINGLES**

| MAXIMUM ULTIMATE DESIGN WIND SPEED, $V_{ult}$, FROM FIGURE R301.2(2) (mph) | MAXIMUM BASIC WIND SPEED, $V_{ASD}$, FROM TABLE R301.2.1.3 (mph) | UL 7103 SHINGLE CLASSIFICATION |
|---|---|---|
| 110 | 85 | A, D or F |
| 116 | 90 | A, D or F |
| 129 | 100 | A, D or F |

For SI: 1 mile per hour = 1.609 kph.

**R905.17 Building-integrated photovoltaic (BIPV) roof panels applied directly to the roof deck.** The installation of *BIPV roof panels* shall comply with the provisions of this section, Section R324 and NFPA 70.

**R905.17.1 Deck requirements.** *BIPV roof panels* shall be applied to a solid or closely-fitted deck, except where the roof covering is specifically designed to be applied over spaced sheathing.

**R905.17.2 Deck slope.** *BIPV roof panels* shall be used only on roof slopes of 2 units vertical in 12 units horizontal (17-percent slope) or greater.

**R905.17.3 Underlayment.** *Underlayment* shall comply with Section 905.1.1.

**R905.17.3.1 Ice barrier.** Where required, an ice barrier shall comply with Section R905.1.2.

**R905.17.4 Ice barrier.** In areas where there has been a history of ice forming along the eaves causing a backup of water, as designated in Table R301.2, an ice barrier that consists of not less than two layers of *underlayment* cemented together or of a self-adhering polymer-modified bitumen sheet shall be used in lieu of normal *underlayment* and extend from the lowest edges of all roof surfaces to a point not less than 24 inches (610 mm) inside the exterior wall line of the building.

**Exception:** Detached *accessory structures* that do not contain conditioned floor area.

**R905.17.5 Material standards.** *BIPV roof panels* shall be *listed* and *labeled* in accordance with UL 7103 or with both UL 61730-1 and UL 61730-2.

**R905.17.6 Attachment.** *BIPV roof panels* shall be attached in accordance with the manufacturer's installation instructions.

## SECTION R906
## ROOF INSULATION

**R906.1 General.** ~~The use of~~ Where above-deck thermal insulation is installed, such insulation shall be ~~permitted provided that such insulation is~~ covered with an approved roof covering and ~~complies with FM 4450~~ shall comply with NFPA 276 or UL 1256.

**R906.2 Material standards.** Above-deck thermal insulation board shall comply with the standards in Table R906.2.

**TABLE R906.2**
**MATERIAL STANDARDS FOR ROOF INSULATION**

| | |
|---|---|
| Cellular glass board | ASTM C552 |
| Composite boards | ASTM C1289,<br>Type III, IV, V or VI |
| Expanded polystyrene | ASTM C578 |
| Extruded polystyrene board | ASTM C578 |
| Fiber-reinforced gypsum board | ASTM C1278 |
| Glass-faced gypsum board | ASTM C1177 |
| Mineral wool board | ASTM C726 |
| Perlite board | ASTM C728 |
| Polyisocyanurate board | ASTM C1289, Type I or II |
| Wood fiberboard | ASTM C208 |

## SECTION R907
## ROOFTOP-MOUNTED
## PHOTOVOLTAIC PANEL SYSTEMS

**R907.1 Rooftop-mounted photovoltaic panel systems.** ~~Deleted.~~ Rooftop-mounted *photovoltaic panel systems* shall be designed and installed in accordance with Section R324 and NFPA 70.

## SECTION R908
## REROOFING

**R908.1 General.** Materials and methods of application used for recovering or replacing an existing roof covering shall comply with the requirements of Chapter 9.

**Exceptions:**

1. *Reroofing* shall not be required to meet the minimum design slope requirement of one-quarter unit vertical in 12 units horizontal (2-percent slope) in Section R905 for roofs that provide *positive roof drainage*.
2. For roofs that provide positive drainage, recovering or replacing an existing roof covering shall not require the secondary (emergency overflow) drains or *scuppers* of Section R903.4.1 to be added to an existing roof.

**R908.2 Structural and construction loads.** The structural roof components shall be capable of supporting the roof covering system and the material and equipment loads that will be encountered during installation of the roof covering system.

**R908.3 Roof replacement.** *Roof replacement* shall include the removal of existing layers of roof coverings down to the *roof deck*, and replacement of up to 15% of the total existing roof deck. Replacement of up to 15% of the total roof deck shall not be considered structural work.

**Exception:** Where the existing *roof assembly* includes an ice barrier membrane that is adhered to the *roof deck*, the existing ice barrier membrane shall be permitted to remain in place and covered with an additional layer of ice barrier membrane in accordance with Section R905.

**R908.3.1 Roof ~~re-cover~~ recover.** The installation of a new roof covering over an existing roof covering shall be permitted where any of the following conditions occur:

1. Where the new roof covering is installed in accordance with the roof covering manufacturer's approved instructions
2. Complete and separate roofing systems, such as standing-seam metal roof systems, that are designed to transmit the roof loads directly to the building's structural system and do not rely on existing roofs and roof coverings for support, shall not require the removal of existing roof coverings.
3. Metal panel, metal shingle and concrete and clay tile roof coverings shall be permitted to be installed over existing wood shake roofs where applied in accordance with Section R908.4.
4. The application of a new protective *roof coating* over an existing protective *roof coating*, *metal roof panel*, *metal roof shingle*, mineral surfaced roll roofing, built-up roof, modified bitumen roofing, thermoset and thermoplastic single-ply roofing and spray polyurethane foam roofing system shall be permitted without tear-off of existing roof coverings.

**R908.3.1.1 Roof ~~re-cover~~ recover not allowed.** A *roof recover* shall not be permitted where any of the following conditions occur:

1. Where the existing roof or roof covering is water soaked or has deteriorated to the point that the existing roof or roof covering is not adequate as a base for additional roofing.
2. Where the existing roof covering is slate, clay, cement or asbestos-cement tile.
3. Where the existing roof has two or more applications of any type of roof covering.

**R908.4 Roof ~~re-covering~~ recovering.** Where the application of a new roof covering over wood shingle or shake roofs creates a combustible concealed space, the entire existing surface shall be covered with gypsum board, mineral fiber, glass fiber or other *approved* materials securely fastened in place.

**R908.5 Reinstallation of materials.** Existing slate, clay or cement tile shall be permitted for reinstallation, except that damaged, cracked or broken slate or tile shall not be reinstalled. Any existing flashings, edgings, outlets, vents or similar devices that are a part of the assembly shall be replaced where rusted, damaged or deteriorated. Aggregate surfacing materials shall not be reinstalled.

**R908.6 Flashings.** Flashings shall be reconstructed in accordance with *approved* manufacturer's installation instructions. Metal flashing to which bituminous materials are to be adhered shall be primed prior to installation.

# CHAPTER 10
# CHIMNEYS AND FIREPLACES

## SECTION R1001
## MASONRY FIREPLACES

**R1001.1 General.** Masonry fireplaces shall be constructed in accordance with this section and the applicable provisions of Chapters 3 and 4.

**R1001.2 Footings and foundations.** Footings for masonry fireplaces and their chimneys shall be constructed of concrete or *solid masonry* not less than 12 inches (305 mm) thick and shall extend not less than ~~6~~ 12 inches (~~152~~ 305 mm) beyond the face of the fireplace or foundation wall on all sides. Footings shall be founded on natural, undisturbed earth or engineered fill below frost depth. In areas not subjected to freezing, footings shall be not less than 12 inches (305 mm) below finished *grade*.

**TABLE R1001.1**
**SUMMARY OF REQUIREMENTS FOR MASONRY FIREPLACES AND CHIMNEYS**

| ITEM | LETTER[a] | REQUIREMENTS |
|---|---|---|
| Hearth slab thickness | A | 4 inches |
| Hearth extension<br>(each side of opening) | B | 8-inch fireplace opening < 6 square feet.<br>12-inch fireplace opening ≥ 6 square feet. |
| Hearth extension<br>(front of opening) | C | 16-inch fireplace opening < 6 square feet.<br>20-inch fireplace opening ≥ 6 square feet. |
| Hearth slab reinforcing | D | Reinforced to carry its own weight and all imposed loads. |
| Thickness of wall of firebox | E | 10-inch solid brick or 8 inches where a firebrick lining is used. Joints in firebrick $^{1}/_{4}$-inch maximum. |
| Distance from top of opening to throat | F | 8 inches |
| Smoke chamber wall thickness<br>Unlined walls | G | 6 inches<br>8 inches |
| Chimney<br>Vertical reinforcing[b] | H | Four No. 4 full-length bars for chimney up to 40 inches wide. Add two No. 4 bars for each additional 40 inches or fraction of width or each additional flue. |
| Horizontal reinforcing | J | $^{1}/_{4}$-inch ties at 18 inches and two ties at each bend in vertical steel. |
| Bond beams | K | No specified requirements. |
| Fireplace lintel | L | Noncombustible material. |
| Chimney walls with flue lining | M | Solid masonry units or hollow masonry units grouted solid with not less than 4-inch nominal thickness. |
| Distances between adjacent flues | — | See Section R1003.13. |
| Effective flue area (based on area of fireplace opening) | P | See Section R1003.15. |
| Clearances<br>Combustible material<br>Mantel and *trim*<br>Above roof | R | <br>See Sections R1001.11 and R1003.18.<br>See Section R1001.11, Exception 4.<br>3 feet at roofline and 2 feet at 10 feet. |

| | | |
|---|---|---|
| Anchorage[b]<br>Strap<br>Number<br>Embedment into chimney<br>Fasten to<br>Bolts | S | <br>$^{3}/_{16}$-inch × 1-inch<br>Two<br>12 inches hooked around outer bar with 6-inch extension.<br>4 joists<br>~~Two~~ Three $^{1}/_{2}$-inch diameter. |
| Footing<br>Thickness<br>Width | T | <br>12 inches min.<br>~~6~~ 12 inches each side of fireplace wall. |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 square foot = 0.0929 $m^2$.

**Note:** This table provides a summary of major requirements for the construction of masonry chimneys and fireplaces. Letter references are to Figure R1001.1, which shows examples of typical construction. This table does not cover all requirements, nor does it cover all aspects of the indicated requirements. For the actual mandatory requirements of the code, see the indicated section of text.

a. The letters refer to Figure R1001.1.

b. Not required in Seismic Design Category A, B or C.

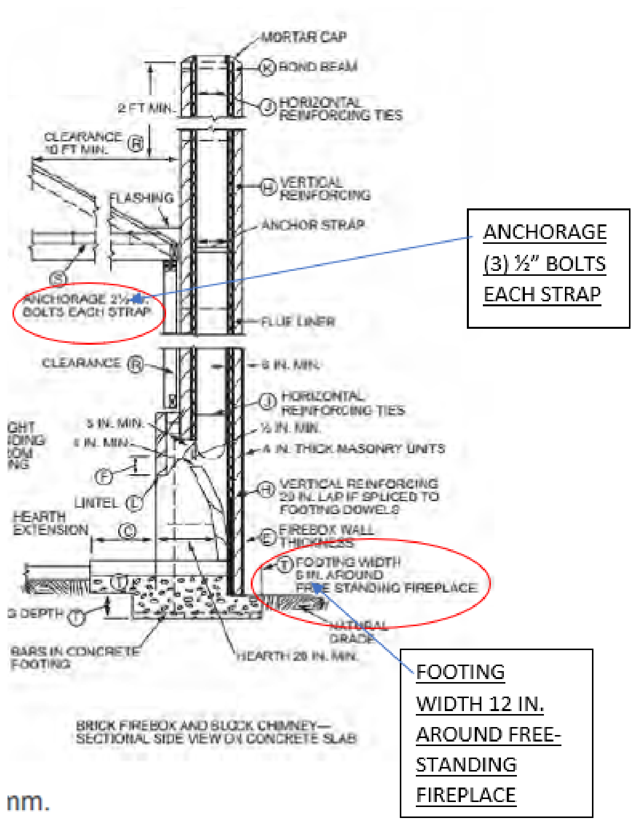



**FIGURE R1001.1**
**FIREPLACE AND CHIMNEY DETAILS**

**R1001.2.1 Ash dump cleanout.** Cleanout openings located within foundation walls below fireboxes, ~~when~~ where provided, shall be equipped with ferrous metal or masonry doors and frames constructed to remain tightly closed except when in use. Cleanouts shall be ~~accessible and~~ located to allow *access* so that ash removal will not create a hazard to *combustible materials*.

**R1001.3 Seismic reinforcing.** Deleted.

**R1001.4 Seismic anchorage.** Deleted.

**R1001.5 Firebox walls.** Masonry fireboxes shall be constructed of *solid masonry* units, *hollow masonry units* grouted solid, stone or concrete. Where a lining of firebrick not less than 2 inches (51 mm) thick or other *approved* lining is provided, the minimum thickness of back and sidewalls shall each be 8 inches (203 mm) of *solid masonry*, including the lining. The width of joints between firebricks shall not be greater than $^1/_4$ inch (6.4 mm). Where a lining is not provided, the total minimum thickness of back and side walls shall be 10 inches (254 mm) of *solid masonry*. Firebrick shall conform to ASTM C27 or C1261 and shall be laid with ~~medium duty~~ medium-duty refractory mortar conforming to ASTM C199.

**R1001.5.1 Steel fireplace units.** Installation of steel fireplace units with *solid masonry* to form a masonry fireplace is permitted ~~when~~ where installed either in accordance with the requirements of their listing or the requirements of this section. Steel fireplace units incorporating a steel firebox lining shall be constructed with steel not less than $^1/_4$ inch (6.4 mm) thick, and an air-circulating chamber that is ducted to the interior of the building. The firebox lining shall be encased with *solid masonry* to provide a total thickness at the back and sides of not less than 8 inches (203 mm), of which not less than 4 inches (102 mm) shall be of *solid masonry* or concrete. Circulating air ducts used with steel fireplace units shall be constructed of metal or masonry.

**R1001.6 Firebox dimensions.** The firebox of a concrete or masonry fireplace shall have a ~~minimum~~ depth of not less than 20 inches (508 mm). The throat shall ~~not~~ be not less than 8 inches (203 mm) above the fireplace opening. The throat opening shall ~~not~~ be not less than 4 inches (102 mm) deep. The cross-sectional area of the passageway above the firebox, including the throat, damper and smoke chamber, shall ~~not~~ be not less than the cross-sectional area of the flue.

**Exception:** Rumford fireplaces shall be permitted provided that the depth of the fireplace is not less than 12 inches (305 mm) and not less than one-third of the width of the fireplace opening, that the throat is not less than 12 inches (305 mm) above the lintel and is not less than ~~1/20~~ one-twentieth the cross-sectional area of the fireplace opening.

**R1001.7 Lintel and throat.** Masonry over a fireplace opening shall be supported by a lintel of *noncombustible material*. The minimum required bearing length on each end of the fireplace opening shall be 4 inches (102 mm). The fireplace throat or damper shall be located not less than 8 inches (203 mm) above the lintel.

**R1001.7.1 Damper.** Masonry fireplaces shall be equipped with a ferrous metal damper located not less than 8 inches (203 mm) above the top of the fireplace opening. Dampers shall be installed in the fireplace or the chimney venting the fireplace, and shall be operable from the room containing the fireplace.

**R1001.8 Smoke chamber.** Smoke chamber walls shall be constructed of *solid masonry* units, *hollow masonry units* grouted solid, stone or concrete. The total minimum thickness of front, back and side walls shall be 8 inches (203 mm) of *solid masonry*. The inside surface shall be parged smooth with refractory mortar conforming to ASTM C199. Where a lining of firebrick not less than 2 inches (51 mm) thick, or a lining of vitrified clay not less than $^5/_8$ inch (16 mm) thick, is provided, the total minimum thickness of front, back and side walls shall be 6 inches (152 mm) of *solid masonry*, including the lining. Firebrick shall conform to ASTM C1261 and shall be laid with ~~medium duty~~ medium-duty refractory mortar conforming to ASTM C199. Vitrified clay linings shall conform to ASTM C315.

**R1001.8.1 Smoke chamber dimensions.** The inside height of the smoke chamber from the fireplace throat to the beginning of the flue shall not be greater than the inside width of the fireplace opening. The inside surface of the smoke chamber shall not be inclined more than 45 degrees (0.79 rad) from vertical where prefabricated smoke chamber linings are used or where the smoke chamber walls are rolled or sloped rather than corbeled. Where the inside surface of the smoke chamber is formed by corbeled masonry, the walls shall not be corbeled more than 30 degrees (0.52 rad) from vertical.

**R1001.9 Hearth and hearth extension.** Masonry fireplace hearths and hearth extensions shall be constructed of concrete or masonry, supported by *noncombustible materials*, and reinforced to carry their own weight and all imposed loads. *Combustible material* shall not remain against the underside of hearths and hearth extensions after construction.

**R1001.9.1 Hearth thickness.** The minimum thickness of fireplace hearths shall be 4 inches (102 mm).

**R1001.9.2 Hearth extension thickness.** The minimum thickness of hearth extensions shall be 2 inches (51 mm).

**Exception:** Where the bottom of the firebox opening is raised not less than 8 inches (203 mm) above the top of the hearth extension, a hearth extension of not less than $^3/_8$-inch-thick (10 mm) brick, concrete, stone, tile or other *approved noncombustible material* is permitted.

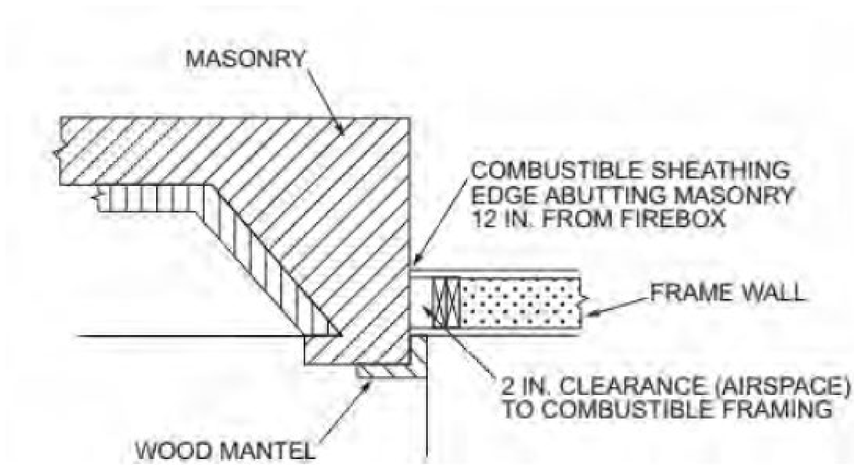
**R1001.10 Hearth extension dimensions.** Hearth extensions shall extend not less than 16 inches (406 mm) in front of and not less than 8 inches (203 mm) beyond each side of the fireplace opening. Where the fireplace opening is 6 square feet (0.6 $m^2$) or larger, the hearth extension shall extend not less than 20 inches (508 mm) in front of and not less than 12 inches (305 mm) beyond each side of the fireplace opening.

**R1001.11 Fireplace clearance.** Wood beams, joists, studs and other *combustible material* shall have a clearance of not less than 2 inches (51 mm) from the front faces and sides of masonry fireplaces and not less than 4 inches (102 mm) from the back faces of masonry fireplaces. The airspace shall not be filled, except to provide fireblocking in accordance with Section R1001.12.

**Exceptions:**

1. Masonry fireplaces *listed* and *labeled* for use in contact with combustibles in accordance with UL 127 and installed in accordance with the manufacturer's instructions are permitted to have *combustible material* in contact with their exterior surfaces.
2. Where masonry fireplaces are part of masonry or concrete walls, *combustible materials* shall not be in contact with the masonry or concrete walls less than 12 inches (306 mm) from the inside surface of the nearest firebox lining.
3. Exposed combustible *trim* and the edges of sheathing materials such as wood siding, flooring and gypsum board shall be permitted to abut the masonry fireplace sidewalls and hearth extension in accordance with Figure R1001.11, provided such combustible *trim* or sheathing is not less than 12 inches (305 mm) from the inside surface of the nearest firebox lining.
4. Exposed combustible mantels or *trim* ~~may~~ is permitted to be placed directly on the masonry fireplace front surrounding the fireplace opening providing such *combustible materials* are not placed within 6 inches (152 mm) of a fireplace opening. *Combustible material* within 12 inches (306 mm) of the fireplace opening shall not project more than $^1/_8$ inch (3 mm) for each 1-inch (25 mm) distance from such an opening.

**R1001.12 Fireplace fireblocking.** Fireplace fireblocking shall comply with the provisions of Section R602.8.




For SI: 1 inch = 25.4 mm.

**FIGURE R1001.11**
**CLEARANCE FROM COMBUSTIBLES**

**R1001.12 Fireplace fireblocking.** Fireplace fireblocking shall comply with the provisions of Section R602.8.

**R1001.13 Fireplace accessories.** *Listed* and *labeled* fireplace accessories shall be installed in accordance with the conditions of the listing and the manufacturer's instructions. Fireplace accessories shall comply with UL 907.

## SECTION R1002
## MASONRY HEATERS

**R1002.1 Definition.** A *masonry heater* is a heating *appliance* constructed of concrete or *solid masonry*, hereinafter referred to as masonry, that is designed to absorb and store heat from a solid-fuel fire built in the firebox by routing the exhaust gases through internal heat exchange channels in which the flow path downstream of the firebox includes flow in a horizontal or downward direction before entering the chimney and that delivers heat by radiation from the masonry surface of the heater.

**R1002.2 Installation.** *Masonry heaters* shall be installed in accordance with this section and comply with one of the following:

1. *Masonry heaters* shall comply with the requirements of ASTM E1602.
2. *Masonry heaters* shall be *listed* and *labeled* in accordance with UL 1482 or CEN 15250 and installed in accordance with the manufacturer's instructions.

**R1002.3 Footings and foundation.** The firebox floor of a *masonry heater* shall be a minimum thickness of 4 inches (102 mm) of *noncombustible material* and be supported on a noncombustible footing and foundation in accordance with Section R1003.2.

**R1002.4 Seismic reinforcing.** Deleted.

**R1002.5 Masonry heater clearance.** *Combustible materials* shall not be placed within 36 inches (914 mm) of the outside surface of a *masonry heater* in accordance with NFPA 211 Section 8-7 (clearances for solid-fuel-burning *appliances*), and the required space between the heater and *combustible material* shall be fully vented to permit the free flow of air around all heater surfaces.

**Exceptions:**

1. Where the *masonry heater* wall is not less than 8 inches (203 mm) thick of *solid masonry* and the wall of the heat exchange channels is not less than 5 inches (127 mm) thick of *solid masonry*, *combustible materials* shall not be placed within 4 inches (102 mm) of the outside surface of a *masonry heater*. A clearance of not less than 8 inches (203 mm) shall be provided between the gas-tight capping slab of the heater and a combustible ceiling.
2. *Masonry heaters listed* and *labeled* in accordance with UL 1482 or CEN 15250 shall be installed in accordance with the listing specifications and the manufacturer's written instructions.

## SECTION R1003
## MASONRY CHIMNEYS

**R1003.1 Definition.** A *masonry chimney* is a chimney constructed of *solid masonry* units, *hollow masonry units* grouted solid, stone or concrete, hereinafter referred to as masonry. *Masonry chimneys* shall be constructed, anchored, supported and reinforced as required in this chapter.

**R1003.2 Footings and foundations.** Footings for *masonry chimneys* shall be constructed of concrete or *solid masonry* not less than 12 inches (305 mm) thick and shall extend not less than 6 inches (152 mm) beyond the face of the foundation or support wall on all sides. Footings shall be founded on natural undisturbed earth or engineered fill below frost depth. In areas not subjected to freezing, footings shall be not less than 12 inches (305 mm) below finished *grade*.

**R1003.3 Seismic reinforcing.** Masonry or concrete chimneys shall be constructed, anchored, supported and reinforced as required in this chapter. In Seismic Design Category A, B or C, reinforcement and seismic anchorage are not required.

**R1003.3.1 Vertical reinforcing.** Deleted.

**R1003.3.2 Horizontal reinforcing.** Deleted.

**R1003.4 Seismic anchorage.** Deleted.

**R1003.5 Corbeling.** *Masonry chimneys* shall not be corbeled more than one-half of the chimney's wall thickness from a wall or foundation, nor shall a chimney be corbeled from a wall or foundation that is less than 12 inches (305 mm) thick unless it projects equally on each side of the wall, except that on the second *story* of a two-story *dwelling*, corbeling of chimneys on the exterior of the enclosing walls ~~may~~ shall be permitted to be equal to the wall thickness. The projection of a single course shall not exceed one-half the unit height or one-third of the unit bed depth, whichever is less.

**R1003.6 Changes in dimension.** The chimney wall or chimney flue lining shall not change in size or shape within 6 inches (152 mm) above or below where the chimney passes through floor components, ceiling components or roof components.

**R1003.7 Offsets.** Where a *masonry chimney* is constructed with a fireclay flue liner surrounded by one wythe of masonry, the maximum offset shall be such that the centerline of the flue above the offset does not extend beyond the center of the chimney wall below the offset. Where the chimney offset is supported by masonry below the offset in an *approved* manner, the maximum offset limitations shall not apply. Each individual corbeled masonry course of the offset shall not exceed the projection limitations specified in Section R1003.5.

**R1003.8 Additional load.** Chimneys shall not support loads other than their own weight unless they are designed and constructed to support the additional load. Construction of *masonry chimneys* as part of the masonry walls or reinforced concrete walls of the building shall be permitted.

**R1003.9 Termination.** Chimneys shall extend not less than 2 feet (610 mm) higher than any portion of a building within 10 feet (3048 mm), but shall be not less than 3 feet (914 mm) above the highest point where the chimney passes through the roof.

**R1003.9.1 Chimney caps.** *Masonry chimneys* shall have a concrete, metal or stone cap, a drip edge and a caulked bond break around any flue liners in accordance with ASTM C1283. The concrete, metal or stone cap shall be sloped to shed water.

**R1003.9.2 Spark arrestors.** Where a spark arrestor is installed on a *masonry chimney*, the spark arrestor shall meet all of the following requirements:

1. The net free area of the arrestor shall be not less than four times the net free area of the outlet of the chimney flue it serves.
2. The arrestor screen shall have heat and corrosion resistance equivalent to 19-gage galvanized steel or 24-gage stainless steel.
3. Openings shall not permit the passage of spheres having a diameter greater than $^1/_2$ inch (12.7 mm) nor block the passage of spheres having a diameter less than $^3/_8$ inch (9.5 mm).
4. The spark arrestor shall be ~~accessible~~ located with *access* for cleaning and the screen or chimney cap shall be removable to allow for cleaning of the chimney flue.

**R1003.9.3 Rain caps.** Where a masonry or metal rain cap is installed on a *masonry chimney*, the net free area under the cap shall be not less than four times the net free area of the outlet of the chimney flue it serves.

**R1003.10 Wall thickness.** *Masonry chimney* walls shall be constructed of *solid masonry* units or *hollow masonry units* grouted solid with not less than a 4-inch (102 mm) nominal thickness.

**R1003.10.1 Masonry veneer chimneys.** Where masonry is used to veneer a frame chimney, through-flashing and weep holes shall be installed as required by Section R703.

**R1003.11 Flue lining (material).** *Masonry chimneys* shall be lined. The lining material shall be appropriate for the type of *appliance* connected, in accordance with the terms of the *appliance* listing and manufacturer's instructions.

**R1003.11.1 Residential-type appliances (general).** Flue lining systems shall comply with one of the following:

1. Clay flue lining complying with the requirements of ASTM C315.
2. *Listed* and *labeled* chimney lining systems complying with UL 1777.
3. Factory-built chimneys or chimney units *listed* for installation within *masonry chimneys.*
4. Other *approved* materials that will resist corrosion, erosion, softening or cracking from flue gases and condensate at temperatures up to 1,800°F (982°C).

**R1003.11.2 Flue linings for specific appliances.** Flue linings other than these covered in Section R1003.11.1, intended for use with specific types of *appliances*, shall comply with Sections R1003.11.3 through R1003.11.6.

**R1003.11.3 Gas appliances.** Flue lining systems for gas *appliances* shall be in accordance with Chapter 24.

**R1003.11.4 Pellet fuel-burning appliances.** Flue lining and vent systems for use in *masonry chimneys* with pellet fuel-burning *appliances* shall be limited to the following:

1. Flue lining systems complying with Section R1003.11.1.
2. Pellet vents *listed* for installation within *masonry chimneys* (see Section R1003.11.6 for marking).

**R1003.11.5 Oil-fired appliances approved for use with Type L vent.** Flue lining and vent systems for use in *masonry chimneys* with oil-fired *appliances approved* for use with Type L vent shall be limited to the following:

1. Flue lining systems complying with Section R1003.11.1.
2. *Listed* chimney liners complying with UL 641 (see Section R1003.11.6 for marking).

**R1003.11.6 Notice of usage.** ~~When~~ Where a flue is relined with a material not complying with Section R1003.11.1, the chimney shall be plainly and permanently identified by a *label* attached to a wall, ceiling or other conspicuous location adjacent to where the connector enters the chimney. The *label* shall include the following message or equivalent language:

THIS CHIMNEY FLUE IS FOR USE ONLY WITH [TYPE OR CATEGORY OF APPLIANCE] APPLIANCES THAT BURN [TYPE OF FUEL]. DO NOT CONNECT OTHER TYPES OF APPLIANCES.

**R1003.12 Clay flue lining (installation).** Clay flue liners shall be installed in accordance with ASTM C1283 and extend from a point not less than 8 inches (203 mm) below the lowest inlet or, in the case of fireplaces, from the top of the smoke chamber to a point above the enclosing walls. The lining shall be carried up vertically, with a ~~maximum~~ slope not greater than 30 degrees (0.52 rad) from the vertical.

Clay flue liners shall be laid in medium-duty water insoluble refractory mortar conforming to ASTM C199 (Type M and S) with tight mortar joints left smooth on the inside and installed to maintain an airspace or insulation not to exceed the thickness of the flue liner separating the flue liners from the interior face of the chimney masonry walls. Flue liners shall be supported on all sides. Only enough mortar shall be placed to make the joint and hold the liners in position.

**R1003.12.1 Listed materials.** *Listed* materials used as flue linings shall be installed in accordance with the terms of their listings and manufacturer's instructions.

**R1003.12.2 Space around lining.** The space surrounding a chimney lining system or vent installed within a *masonry chimney* shall not be used to vent any other *appliance*.

**Exception:** This shall not prevent the installation of a separate flue lining in accordance with the manufacturer's instructions.

**R1003.13 Multiple flues.** Where two or more flues are located in the same chimney, masonry wythes shall be built between adjacent flue linings. The masonry wythes shall be not less than 4 inches (102 mm) thick and bonded into the walls of the chimney.

**Exception:** Where venting only one *appliance*, two flues shall be permitted to adjoin each other in the same chimney with only the flue lining separation between them. The joints of the adjacent flue linings shall be staggered not less than 4 inches (102 mm).

**R1003.14 Flue area (appliance).** Chimney flues shall not be smaller in area than that of the area of the connector from the *appliance* [see Tables R1003.14(1) and R1003.14(2)]. The sizing of a chimney flue to which multiple *appliance* venting systems are connected shall be in accordance with Section M1805.3.

**TABLE R1003.14(1)**
**NET CROSS-SECTIONAL AREA OF ROUND FLUE SIZES[a]**

| FLUE SIZE, INSIDE DIAMETER (inches) | CROSS-SECTIONAL AREA (square inches) |
|---|---|
| 6 | 28 |
| 7 | 38 |
| 8 | 50 |
| 10 | 78 |
| $10^3/_4$ | 90 |
| 12 | 113 |
| 15 | 176 |
| 18 | 254 |

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 $mm^2$.
a. Flue sizes are based on ASTM C315.

**TABLE R1003.14(2)**

**NET CROSS-SECTIONAL AREA OF SQUARE AND RECTANGULAR FLUE SIZES**

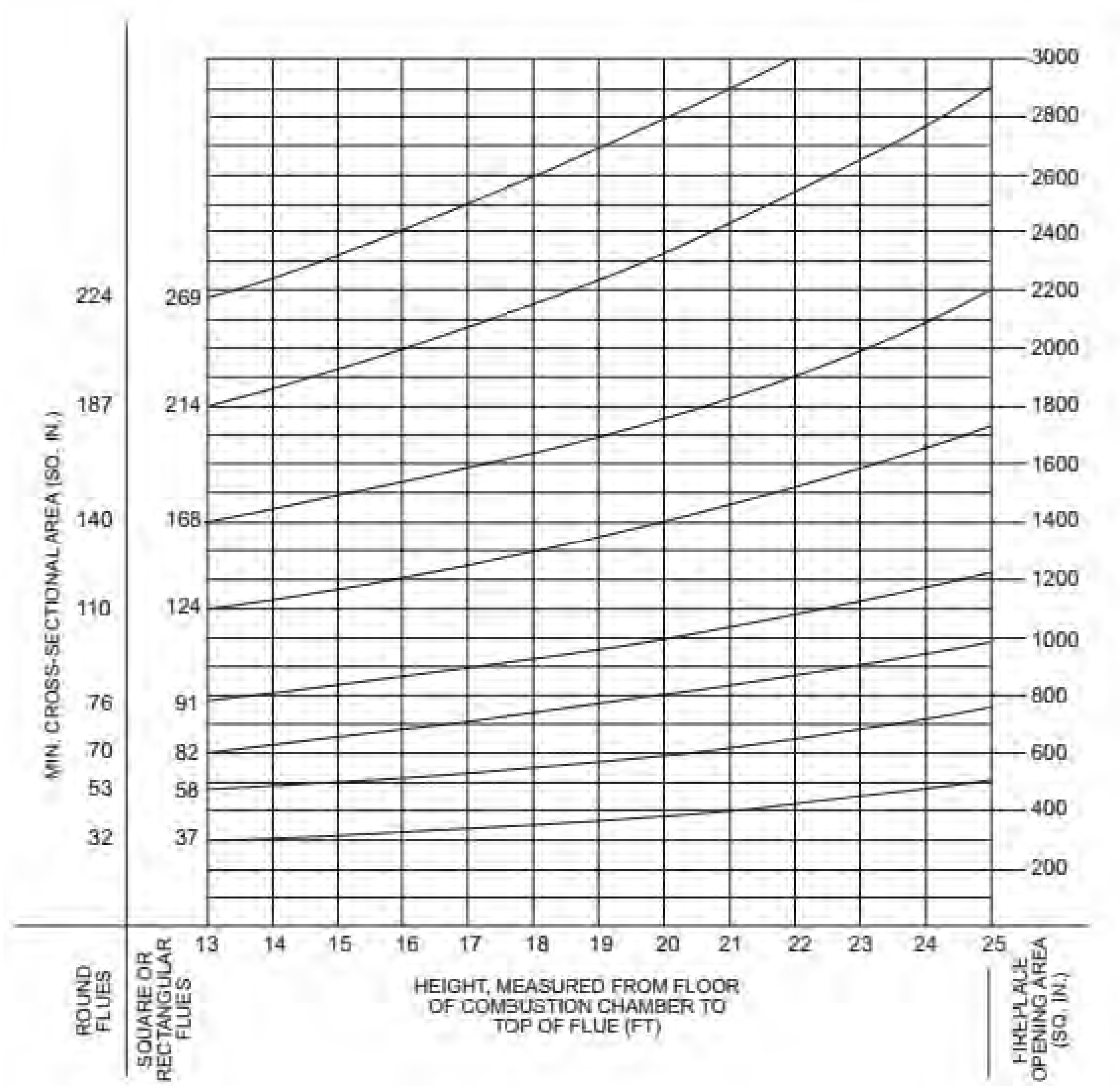
| FLUE SIZE, OUTSIDE NOMINAL DIMENSIONS (inches) | CROSS-SECTIONAL AREA (square inches) |
|---|---|
| 4.5 × 8.5 | 23 |
| 4.5 × 13 | 34 |
| 8 × 8 | 42 |
| 8.5 × 8.5 | 49 |
| 8 × 12 | 67 |
| 8.5 × 13 | 76 |
| 12 × 12 | 102 |
| 8.5 × 18 | 101 |
| 13 × 13 | 127 |
| 12 × 16 | 131 |
| 13 × 18 | 173 |
| 16 × 16 | 181 |
| 16 × 20 | 222 |
| 18 × 18 | 233 |
| 20 × 20 | 298 |
| 20 × 24 | 335 |
| 24 × 24 | 431 |

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 $mm^2$.

**R1003.15 Flue area (masonry fireplace).** Flue sizing for chimneys serving fireplaces shall be in accordance with Section R1003.15.1 or R1003.15.2.

**R1003.15.1 Option 1.** Round chimney flues shall have a minimum net cross-sectional area of not less than ~~1/12~~ <u>one-twelfth</u> of the fireplace opening. Square chimney flues shall have a minimum net cross-sectional area of ~~1/10~~ <u>one-tenth</u> of the fireplace opening. Rectangular chimney flues with an *aspect ratio* less than 2 to 1 shall have a minimum net cross-sectional area of ~~1/10~~ <u>one-tenth</u> of the fireplace opening. Rectangular chimney flues with an *aspect ratio* of 2 to 1 or more shall have a minimum net cross-sectional area of ~~1/8~~ <u>one-eighth</u> of the fireplace opening. Cross-sectional areas of clay flue linings are shown in Tables R1003.14(1) and R1003.14(2) or as provided by the manufacturer or as measured in the field.

**R1003.15.2 Option 2.** The minimum net cross-sectional area of the chimney flue shall be determined in accordance with Figure R1003.15.2. A flue size providing not less than the equivalent net cross-sectional area shall be used. Cross-sectional areas of clay flue linings are shown in Tables R1003.14(1) and R1003.14(2) or as provided by the manufacturer or as measured in the field. The height of the chimney shall be measured from the firebox floor to the top of the chimney flue.




For SI: 1 foot = 304.8 mm, 1 square inch = 645.16 mm2.

**FIGURE R1003.15.2**

**FLUE SIZES FOR MASONRY CHIMNEYS**

**R1003.16 Inlet.** Inlets to *masonry chimneys* shall enter from the side. Inlets shall have a thimble of fireclay, rigid refractory material or metal that will prevent the connector from pulling out of the inlet or from extending beyond the wall of the liner.

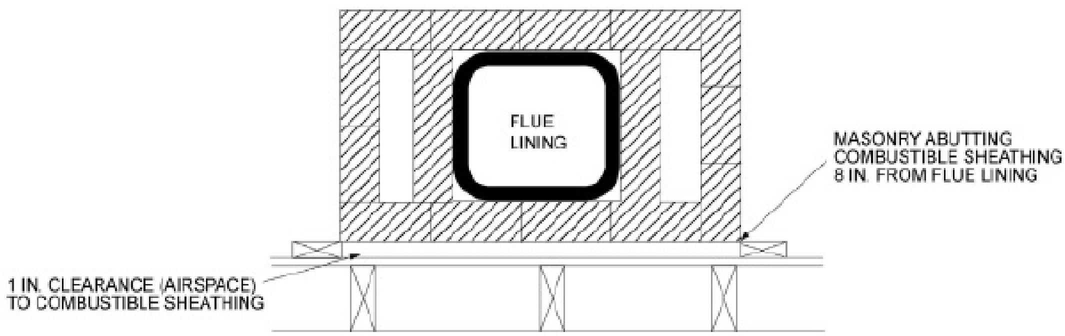
**R1003.17 Masonry chimney cleanout openings.** Cleanout openings shall be provided within 6 inches (152 mm) of the base of each flue within every *masonry chimney*. The upper edge of the cleanout shall be located not less than 6 inches (152 mm) below the lowest chimney inlet opening. The height of the opening shall be not less than 6 inches (152 mm). The cleanout shall be provided with a noncombustible cover.

**Exception:** Chimney flues serving masonry fireplaces where cleaning is possible through the fireplace opening.

**R1003.18 Chimney clearances.** Any portion of a *masonry chimney* located in the interior of the building or within the exterior wall of the building shall have a minimum airspace clearance to combustibles of 2 inches (51 mm). Chimneys located entirely outside the exterior walls of the building, including chimneys that pass through the soffit or cornice, shall have a minimum airspace clearance of 1 inch (25 mm). The airspace shall not be filled, except to provide fire blocking in accordance with Section R1003.19.

**Exceptions:**

1. *Masonry chimneys* equipped with a chimney lining system *listed* and *labeled* for use in chimneys in contact with combustibles in accordance with UL 1777 and installed in accordance with the manufacturer's instructions are permitted to have *combustible material* in contact with their exterior surfaces.
2. Where *masonry chimneys* are constructed as part of masonry or concrete walls, *combustible materials* shall not be in contact with the masonry or concrete wall less than 12 inches (305 mm) from the inside surface of the nearest flue lining.
3. Exposed combustible *trim* and the edges of sheathing materials, such as wood siding and flooring, shall be permitted to abut the *masonry chimney* side walls, in accordance with Figure R1003.18, provided such combustible trim or sheathing is not less than 8 inches (203 mm) from the inside surface of the nearest flue lining.




For SI: 1 inch = 25.4 mm.

**FIGURE R1003.18**
**CLEARANCE FROM COMBUSTIBLES**

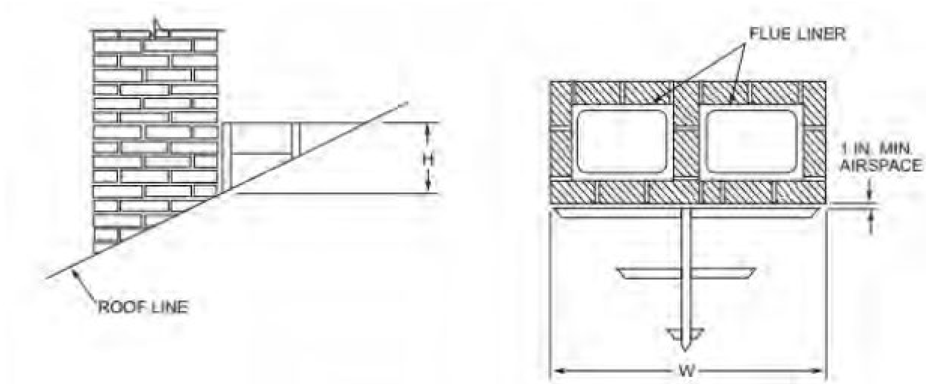
**R1003.19 Chimney fireblocking.** Spaces between chimneys and floors and ceilings through which chimneys pass shall be fireblocked with *noncombustible material* securely fastened in place. The fireblocking of spaces between chimneys and wood joists, beams or headers shall be self-supporting or be placed on strips of metal or metal lath laid across the spaces between *combustible material* and the chimney.

**R1003.20 Chimney crickets.** Chimneys shall be provided with crickets where the dimension parallel to the ridgeline is greater than 30 inches (762 mm) and does not intersect the ridgeline. The intersection of the cricket and the chimney shall be flashed and counterflashed in the same manner as normal roof-chimney intersections. Crickets shall be constructed in compliance with Figure R1003.20 and Table R1003.20.

**TABLE R1003.20**
**CRICKET DIMENSIONS**

| ROOF SLOPE | H |
|---|---|
| 12:12 | $^1/_2$ of W |
| 8:12 | $^1/_3$ of W |
| 6:12 | $^1/_4$ of W |
| 4:12 | $^1/_6$ of W |

| | |
|---|---|
| 3:12 | $^1/_8$ of W |




For SI: 1 inch = 25.4 mm.

**FIGURE R1003.20**
**CHIMNEY CRICKET**

## SECTION R1004
## FACTORY-BUILT FIREPLACES

**R1004.1 General.** Factory-built fireplaces shall be *listed* and *labeled* and shall be installed in accordance with the conditions of the *listing*. Factory-built fireplaces shall be tested in accordance with UL 127.

**R1004.2 Hearth extensions.** Hearth extensions of *approved* factory-built fireplaces shall be installed in accordance with the *listing* of the fireplace. The hearth extension shall be readily distinguishable from the surrounding floor area. *Listed* and *labeled* hearth extensions shall comply with UL 1618.

**R1004.3 Decorative shrouds.** Decorative shrouds shall not be installed at the termination of chimneys for factory-built fireplaces except where the shrouds are *listed* and *labeled* for use with the specific factory-built fireplace system and installed in accordance with the manufacturer's instructions.

**R1004.4 Unvented gas log heaters.** An unvented gas log heater shall not be installed in a factory-built fireplace unless the fireplace system has been specifically tested, *listed* and *labeled* for such use in accordance with UL 127.

**R1004.5 Gasketed fireplace doors.** A gasketed fireplace door shall not be installed on a factory-built fireplace except where the fireplace system has been specifically tested, *listed* and *labeled* for such use in accordance with UL 127.

## SECTION R1005
## FACTORY-BUILT CHIMNEYS

**R1005.1 Listing.** *Factory-built chimneys* shall be *listed* and *labeled* and shall be installed and terminated in accordance with the *manufacturer's installation instructions*.

**R1005.2 Decorative shrouds.** Decorative shrouds shall not be installed at the termination of *factory-built chimneys* except where the shrouds are *listed* and *labeled* for use with the specific *factory-built chimney* system and installed in accordance with the *manufacturer's installation instructions*.

**R1005.3 Solid-fuel appliances.** *Factory-built chimneys* installed in *dwelling units* with solid-fuel-burning *appliances* shall comply with the Type HT requirements of UL 103 and shall be marked “Type HT” and “Residential Type and Building Heating Appliance Chimney.”

**Exception:** *Chimneys* for use with open combustion chamber fireplaces shall comply with the requirements of UL 103 and shall be marked “Residential Type and Building Heating Appliance Chimney.”

*Chimneys* for use with open combustion chamber *appliances* installed in buildings other than *dwelling units* shall comply with the requirements of UL 103 and shall be marked “Building Heating Appliance Chimney” or “Residential Type and Building Heating Appliance Chimney.”

**R1005.4 Factory-built fireplaces.** *Chimneys* for use with factory-built fireplaces shall comply with the requirements of UL 127.

**R1005.5 Support.** Where *factory-built chimneys* are supported by structural members, such as joists and rafters, those members shall be designed to support the additional load.

**R1005.6 Medium-heat appliances.** *Factory-built chimneys* for medium-heat *appliances* producing flue gases having a temperature above 1,000°F (538°C), measured at the entrance to the *chimney*, shall comply with UL 959.

**R1005.7 Factory-built chimney offsets.** Where a *factory-built chimney* assembly incorporates offsets, no part of the *chimney* shall be at an angle of more than 30 degrees (0.52 rad) from vertical at any point in the assembly and the chimney assembly shall not include more than four elbows.

**R1005.8 Insulation shield.** Where *factory-built chimneys* pass through insulated assemblies, an insulation shield constructed of steel having a thickness of not less than 0.0187 inch (0.4712 mm) (No. 26 gage) shall be installed to provide clearance between the *chimney* and the insulation material. The clearance shall be not less than the clearance to combustibles specified by the chimney *manufacturer’s installation instructions*. Where *chimneys* pass through attic space, the shield shall terminate not less than 2 inches (51 mm) above the insulation materials and shall be secured in place to prevent displacement. Insulation shields provided as part of a *listed* chimney system shall be installed in accordance with the manufacturer’s installation instructions.

## SECTION R1006
## EXTERIOR AIR SUPPLY

**R1006.1 Exterior air.** Factory-built or masonry fireplaces covered in this chapter shall be equipped with an exterior air supply to ensure proper fuel combustion unless the room is mechanically ventilated and controlled so that the indoor pressure is neutral or positive.

**R1006.1.1 Factory-built fireplaces.** Exterior *combustion air* ducts for factory-built fireplaces shall be a *listed* component of the fireplace and shall be installed in accordance with the fireplace manufacturer’s instructions.

**R1006.1.2 Masonry fireplaces.** *Listed combustion air* ducts for masonry fireplaces shall be installed in accordance with the terms of their *listing* and the manufacturer’s instructions.

**R1006.2 Exterior air intake.** The exterior air intake shall be capable of supplying all *combustion air* from the exterior of the *dwelling* or from spaces within the *dwelling* ventilated with outdoor air such as nonmechanically ventilated crawl or attic spaces. The exterior air intake shall not be located within the garage or *basement* of the dwelling. The exterior air intake, for other than *listed* factory-built fireplaces, shall not be located at an elevation higher than the firebox. The exterior air intake shall be covered with a corrosion-resistant screen of $^1/_4$-inch (6.4 mm) mesh.

**R1006.3 Clearance.** Unlisted *combustion air* ducts shall be installed with a minimum 1-inch (25 mm) clearance to combustibles for all parts of the duct within 5 feet (1524 mm) of the duct outlet.

**R1006.4 Passageway.** The *combustion air* passageway shall be not less than 6 square inches (3870 $mm^2$) and not more than 55 square inches (0.035 $m^2$), except that *combustion air* systems for *listed* fireplaces shall be constructed in accordance with the fireplace manufacturer’s instructions.

**R1006.5 Outlet.** The exterior air outlet shall be located in the back or side of the firebox chamber or shall be located outside of the firebox, at the level of the hearth and not greater than 24 inches (610 mm) from the firebox opening.

The outlet shall be closable and designed to prevent burning material from dropping into concealed combustible spaces.

# *Part VII—Plumbing*

## CHAPTER 25
## PLUMBING ADMINISTRATION

The text of this chapter is extracted from the ~~2018~~ 2024 edition of the *North Carolina Plumbing Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One- and Two-Family Dwellings*. ~~The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Plumbing Code*~~.

### SECTION P2501
### GENERAL

**P2501.1 Scope.** The provisions of Chapters 25 through 33 of this code shall apply to the erection, installation, alteration, repairs, relocation, replacement, addition to, use or maintenance of plumbing systems within this jurisdiction. The installation of fuel gas distribution piping and equipment, fuel-gas-fired water heaters and water heater venting systems shall be regulated by the *International Fuel Gas Code*. Provisions in the appendices shall not apply unless specifically adopted.

**P2501.2 Application.** In addition to the general administration requirements of Chapter 1, the administrative provisions of this chapter shall apply to the plumbing requirements of Chapters 25 through 33.

**P2501.3 Intent**. The purpose of this code is to establish minimum standards to provide a reasonable level of safety, health, property protection and public welfare by regulating and controlling the design, construction, installation, quality of materials, location, operation and maintenance or use of plumbing equipment and systems.

**P2501.4 Severability**. If any section, subsection, sentence, clause or phrase of this code is for any reason held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this code.

**P2501.5 Appendices.** Provisions in the appendices shall not apply unless specifically adopted or referenced in this code.

**P2501.6 Requirements of other State agencies, occupational licensing board or commissions.** The North Carolina State Building Codes do not include all additional requirements for buildings and structures that may be imposed by other State agencies, occupational licensing boards and commissions. It shall be the responsibility of a permit holder, design professional, contractor or occupational license holder to determine whether any additional requirements exist.

### SECTION P2502
### EXISTING PLUMBING SYSTEMS

**P2502.1 Existing building sewers and building drains**. Plumbing systems lawfully in existence at the time of the adoption of this code shall be permitted to have their use and maintenance continued if the use, maintenance or repair is in accordance with the original design; and if hazard to life, health or property is not created by such plumbing system.

**P2502.2 Additions, alterations or repairs.** Additions, *alterations*, renovations or repairs to any plumbing system shall conform to that required for a new plumbing system without requiring the existing plumbing system to comply with the requirements of this code. Additions, *alterations* or repairs shall not cause an existing system to become unsafe, insanitary or overloaded.

Minor additions, *alterations*, renovations and repairs to existing plumbing systems shall be permitted in the same manner and arrangement as in the existing system, provided that such repairs or replacement are not hazardous and are *approved*.

**P2502.3 Change in occupancy.** It shall be unlawful to make any change in the *occupancy* of any structure that will subject the structure to any special provision of this code applicable to the new *occupancy* without approval of the code official. The code official shall certify that such structure meets the intent of the provisions of law governing building construction for the proposed new *occupancy* and that such change of *occupancy* does not result in any hazard to the public health, safety or welfare.

**P2502.4 Historic buildings.** The provisions of this code relating to the construction, alteration, repair, enlargement, restoration, relocation or moving of buildings or structures shall not be mandatory for existing buildings or structures identified and classified by the state or local jurisdiction as historic buildings where such buildings or structures are judged by the code official to be safe and in the public interest of health, safety and welfare regarding any proposed construction, alteration, repair, enlargement, restoration, relocation or moving of buildings.

**P2502.5 Moved buildings.** Except as determined by Section P2502.1, plumbing systems that are a part of buildings or structures moved into or within the jurisdiction shall comply with the provisions of this code for new installations.

**P2502.6 Referenced codes and standards.** The codes and standards referenced in this code shall be those that are listed in Chapter 44 and such codes and standards shall be considered as part of the requirements of this code to the prescribed extent of each such reference and as further regulated in Sections P2502.6.1 and P2502.6.2.

**P2502.6.1 Conflicts.** Where conflicts occur between provisions of this code and the referenced standards, the provisions of this code shall apply

**P2502.6.2 Provisions in referenced codes and standards.** Where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code, the provisions of this code shall be the minimum requirements.

P**2502.7 Requirements not covered by code.** Any requirements necessary for the strength, stability or proper operation of an existing or proposed plumbing system, or for the public safety, health and general welfare, not specifically covered by this code shall be determined by the code official.

**P2502.8 Other laws.** The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law.

**P2502.9 Application of references.** Reference to chapter section numbers, or to provisions not specifically identified by number, shall be construed to refer to such chapter, section or provision of this code.

## SECTION P2503
## INSPECTION AND TESTS

**P2503.1 Inspection required.** New plumbing work and parts of existing systems affected by new work or *alterations* shall be inspected by the *building official* to ensure compliance with the requirements of this code.

**P2503.2 Concealment.** A plumbing or drainage system, or part thereof, shall not be covered, concealed or put into use until it has been tested, inspected and *approved* by the *building official*.

**P2503.3 Responsibility of permittee.** The permit holder shall make the applicable tests prescribed in Sections P2503.4 through P2503.8 to determine compliance with the provisions of this code. The permit holder shall give reasonable advance notice to the code official when the plumbing work is ready for tests. The equipment, material, power and labor necessary for the inspection and test shall be furnished by the permit holder and the permit holder shall be responsible for determining that the work will withstand the test pressure prescribed in the following tests.

All plumbing system piping shall be tested with either water or by air. After the plumbing fixtures have been set and their traps filled with water, the entire drainage system shall be submitted to final tests. The code official shall require the removal of any cleanouts if necessary to ascertain whether the pressure has reached all parts of the system.

**P2503.4 Building sewer testing.** Deleted.

**P2503.5 Drain, waste and vent systems testing.** Rough-in and finished plumbing installations of drain, waste and vent systems shall be tested in accordance with Sections P2503.5.1 and P2503.5.2.

**P2503.5.1 Rough plumbing.** DWV systems shall be tested on completion of the rough piping installation by water, by air for piping systems or by vacuum or air for plastic piping systems, without evidence of leakage**.** The test shall be applied to the drainage system in its entirety or in sections after rough-in piping has been installed, as follows:

1. Water test. ~~A water test shall be applied to the drainage system within the building either in its entirety or in sections~~. If applied to the entire system, all openings in the piping shall be tightly closed, except the highest opening, and the system shall be filled with water to the point of overflow. If the system is tested in sections, each opening shall be tightly plugged except the highest openings of the section under test, and each section shall be filled with water, but no section shall be tested with less than a 10-foot (3048 mm) head of water. In testing successive sections, at least the upper 10 feet (3048 mm) of the next preceding section shall be tested so that no joint or pipe in the building, except the uppermost 10 feet (3048 mm) of the system, shall have been submitted to a test of less than a 10-foot (3048 mm) head of water. This pressure shall be held for not less than 15 minutes. The system shall then be tight at all points.

   **Exception:** Rough plumbing testing for one- and two-family dwellings shall be as specified above except the water level shall be a minimum of 3 feet (914 mm) above the highest drainage fitting. Under slab piping systems shall be tested with a minimum of 10 feet (3048 mm) of head.

2. **Drainage and vent air test**. An air test shall be made by forcing air into the system until there is a uniform gauge pressure of 5 psi (34.5 kPa) or sufficient to balance a 10-inch (254 mm) column of mercury. This pressure shall be held for a test period of not less than 15 minutes. Any adjustments to the test pressure required because of changes in ambient temperatures or the seating of gaskets shall be made prior to the beginning of the test period.
3. Vacuum test. The portion under test shall be evacuated of air by a vacuum-type pump to achieve a uniform gauge pressure of -5 pounds per square inch or a negative 10 inches of mercury column (-34 kPa). This pressure shall be held without the removal of additional air for a period of 15 minutes.

**P2503.5.2 Finished plumbing.** After the plumbing fixtures have been set and their traps filled with water, their connections shall be tested and proved gastight or watertight as follows:

1. Watertightness. Each fixture shall be filled and then drained. Traps and fixture connections shall be proven watertight by visual inspection.
2. Gas tightness. Where required by the local administrative authority, a final test for gas tightness of the DWV system shall be made by the smoke or peppermint test as follows:
   2.1. Smoke test. Introduce a pungent, thick smoke into the system. When the smoke appears at vent terminals, such terminals shall be sealed and a pressure equivalent to a 1-inch water column (249 Pa) shall be applied and maintained for a test period of not less than 15 minutes.
   2.2. Peppermint test. Introduce 2 ounces (59 mL) of oil of peppermint into the system. Add 10 quarts (9464 mL) of hot water and seal the vent terminals. The odor of peppermint shall not be detected at any trap or other point in the system.

**P2503.6 Shower liner or pan test.** Where shower floors and receptors are made watertight by the application of materials required by Section P2709.2, the completed liner installation shall be tested. The pipe from the shower drain shall be plugged watertight for the test. The floor and receptor area shall be filled with ~~potable~~ water to a depth of not less than 2 inches (51 mm) measured at the threshold. Where a threshold of not less than 2 inches (51 mm) in height does not exist, a temporary threshold shall be constructed to retain the test water in the lined floor or receptor area to a level not less than 2 inches (51 mm) in depth measured at the threshold. The water shall be retained for a test period of not less than 15 minutes and there shall not be evidence of leakage.

**P2503.7 Water-~~supply~~ distribution system testing.** Upon completion of a section of or the entire water distribution system, the system, or portion completed, shall be tested and proved tight under a water or air test of not less than 100 psi (688 kPa). Repaired sections of existing water systems shall be tested at existing operating pressure. This pressure shall be held for not less than 15 minutes. The water utilized for tests shall be obtained from a potable source of supply. The required tests shall be performed in accordance with this section.

**P2503.8 Inspection and testing of backflow prevention devices. Deleted.**

**P2503.9 Test gauges.** Gauges used for testing shall be as follows:

1. Tests requiring a pressure of 10 psi or less shall utilize a testing gauge having increments of 0.10 psi (0.69 kPa) or less.
2. Tests requiring a pressure greater than 10 psi (0.69 kPa) but less than or equal to 100 psi (690 kPa) shall use a testing gauge having increments of 1 psi (6.9 kPa) or less.
3. Tests requiring a pressure greater than 100 psi (690 kPa) shall use a testing gauge having increments of 2 psi (14 kPa) or less.

## SECTION P2504
## APPROVAL

**P2504.1 Modifications.**
Where there are practical difficulties involved in carrying out the provisions of this code, the code official shall have the authority to grant modifications for individual cases, upon application of the owner or owner's authorized agent, provided the code official shall first find that special individual reason makes the strict letter of this code impractical and the modification conforms to the intent and purpose of this code and that such modification does not lessen health, life and fire safety requirements. The details of action granting modifications shall be recorded and entered in the files of the plumbing inspection department.

**P2504.2 Alternative materials, methods and equipment.**
The provisions of this code are not intended to prevent the installation of any material or to prohibit any method of construction not specifically prescribed by this code, provided that any such alternative has been *approved.* An alternative material or method of construction shall be *approved* where the code official finds that the proposed alternative material, method or equipment complies with the intent of the provisions of this code and is not less than the equivalent of that prescribed in this code. Where the alternative material, design or method of construction is not *approved*, the code official shall respond in writing, stating the reasons why the alternative was not *approved*.

**P2504.2.1** Research reports.
Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from *approved* sources.

**P2504.3 Required testing.**
Where there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternate materials or methods, the code official shall have the authority to require tests as evidence of compliance to be made at no expense to the jurisdiction.

**P2504.3.1** Test methods.
Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the code official shall approve the testing procedures.

**P2504.3.2** Testing agency.
Tests shall be performed by an *approved agency*.

**P2504.3.3** Test reports.
Reports of tests shall be retained by the code official for the period required for retention of public records.

**P2504.4 Alternative engineered design.**

The design, documentation, inspection, testing and approval of an *alternative engineered design* plumbing system shall comply with Sections P2504.4.1 through P2504.4.6.

**P2504.4.1 Design criteria.**

An *alternative engineered design* shall conform to the intent of the provisions of this code and shall provide an equivalent level of quality, strength, effectiveness, fire resistance, durability and safety. Material, equipment or components shall be designed and installed in accordance with the manufacturer's installation instructions.

**P2504.4.2 Submittal.**

The registered design professional shall indicate on the permit application that the plumbing system is an *alternative engineered design*. The permit and permanent permit records shall indicate that an *alternative engineered design* was part of the *approved* installation.

**P2504.4.3 Technical data.**

The registered design professional shall submit sufficient technical data to substantiate the proposed *alternative engineered design* and to prove that the performance meets the intent of this code.

**P2504.4.4 Construction documents.**

The registered design professional shall submit to the code official two complete sets of signed and sealed construction documents for the *alternative engineered design*. The construction documents shall include floor plans and a riser diagram of the work. Where appropriate, the construction documents shall indicate the direction of flow, all pipe sizes, grade of horizontal piping, loading, and location of fixtures and appliances.

**P2504.4.5 Design approval.**

Where the code official determines that the *alternative engineered design* conforms to the intent of this code, the plumbing system shall be *approved*. If the *alternative engineered design* is not *approved*, the code official shall notify the registered design professional in writing, stating the reasons thereof.

**P2504.4.6 Inspection and testing.**

The *alternative engineered design* shall be tested and inspected in accordance with the requirements of Section P2503.

**P2504.5 Approved materials and equipment.**
Materials, equipment and devices *approved* by the code official shall be constructed and installed in accordance with such approval.

**P2504.5.1** Material and equipment reuse.
Materials, equipment and devices shall not be reused unless such elements have been reconditioned, tested, placed in good and proper working condition and *approved*.

## SECTION P2505
## TEMPORARY EQUIPMENT, SYSTEMS AND USES

**P2505.1 General.**
The code official is authorized to issue a permit for temporary equipment, systems and uses. Such permits shall be limited as to time of service, but shall not be permitted for more than 180 days. The code official is authorized to grant extensions for demonstrated cause.

**P2505.2 Conformance.**
Temporary equipment, systems and uses shall conform to the structural strength, fire safety, means of egress, accessibility, light, ventilation and sanitary requirements of this code as necessary to ensure the public health, safety and general welfare.

**P2505.3 Temporary utilities.**
The code official is authorized to give permission to temporarily supply utilities before an installation has been fully completed and the final certificate of completion has been issued. The part covered by the temporary certificate shall comply with the requirements specified for temporary lighting, heat or power in the code.

**P2505.4 Termination of approval.**
The code official is authorized to terminate such permit for temporary equipment, systems or uses and to order the temporary equipment, systems or uses to be discontinued.

**P2505.5 (311.1)Toilet Facilities**

Toilet facilities shall be provided for construction workers in accordance with the table below and such facilities shall be maintained in a sanitary condition.  Construction worker toilet facilities of the non-sewer type shall conform to ANSI Z4.3.

**~~Table P2505.5 Toilet Facilities~~**

| Number of Employees | Minimum Number of Facilities |
|---|---|
| Less than 20 | 1 toilet |
| 20 to 200 | 1 toilet & 1 urinal per 40 workers |
| More than 200 | 1 toilet & urinal per 50 workers |

There shall be at least one facility for every two contiguous construction sites. Such facilities may be portable, enclosed, chemically treated, tank-tight units. Portable toilets shall be enclosed, screened and weatherproofed with internal latches. Temporary toilet facilities need not be provided on site for crews on a job site for no more than one working day and having transportation readily available to toilet facilities.

# CHAPTER 26
# GENERAL PLUMBING REQUIREMENTS

The text of this chapter is extracted from the ~~2018~~ 2024 edition of the *North Carolina Plumbing Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One- and Two-Family Dwellings*. ~~The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Plumbing Code*.~~

## SECTION P2601
## GENERAL

**P2601.1 Scope.** The provisions of this chapter shall govern the installation of plumbing not specifically covered in other chapters applicable to plumbing systems. The installation of plumbing, *appliances, equipment* and systems not addressed by this code shall comply with the applicable provisions of the *International Plumbing Code*.

**P2601.2 Connections to drainage system.** Plumbing fixtures, drains, appurtenances and *appliances* used to receive or discharge liquid wastes or sewage shall be directly connected to the sanitary drainage system of the building or premises, in accordance with the requirements of this code. This section shall not be construed to prevent indirect waste connections where required by the code.

**Exception:** ~~All drain, waste and vent piping associated with gray water or rain water recycling systems shall be installed in compliance with this code.~~ Bathtubs, showers, lavatories, clothes washers and laundry trays shall not be required to discharge to the sanitary drainage system where such fixtures discharge to systems complying with Sections P2910 and P2911.

**P2601.3 Flood hazard areas.** In flood hazard areas as established by Table R301.2(1), plumbing fixtures, drains, and *appliances* shall be located or installed in accordance with Section R322.1.6.

## SECTION P2602
## INDIVIDUAL WATER SUPPLY
## AND SEWAGE DISPOSAL

~~**P2602.1 General.** The water-distribution and drainage system of any building or premises where plumbing fixtures are installed shall be connected to a public water supply or sewer system, respectively, if available. Where either a public water supply or sewer system, or both, are not available, or connection to them is not feasible, an individual water supply or individual (private) sewage-disposal system, or both, shall be provided.~~

~~**Exception:** All drain, waste and vent piping associated with gray water or rain water recycling systems shall be installed in compliance with this code.~~

**P2602.1 General.** The water-distribution system of any building or premises where plumbing fixtures are installed shall be connected to a public water supply. Where a public water-supply system is not available, or connection to the supply is not feasible, an individual water supply shall be provided. Individual water supplies shall be constructed and installed in accordance with the applicable state and local laws.

Sanitary drainage piping from plumbing fixtures in buildings and sanitary drainage piping systems from premises shall be connected to a public sewer. Where a public sewer is not available, the sanitary drainage piping and systems shall be connected to a private sewage disposal system in compliance with state or local requirements.

**Exception:** Sanitary drainage piping and systems that convey only the discharge from bathtubs, showers, lavatories, clothes washers and laundry trays shall not be required to connect to a public sewer or to a private sewage disposal system provided that the piping or systems are connected to a system in accordance with Section P2910 or P2911.

**P2602.2 Flood-resistant installation.** In flood hazard areas as established by Table R301.2(1):

1. Water supply systems shall be designed and constructed to prevent infiltration of floodwaters.
2. Pipes for sewage disposal systems shall be designed and constructed to prevent infiltration of floodwaters into the systems and discharges from the systems into floodwaters.

## SECTION P2603
## STRUCTURAL AND PIPING PROTECTION

**P2603.1 General.** In the process of installing or repairing any part of a plumbing and drainage installation, the finished floors, walls, ceilings, tile work or any other part of the building or premises that must be changed or replaced shall be left in a safe structural condition in accordance with the requirements of the building portion of this code.

**P2603.2 Drilling and notching.** Wood-framed structural members shall not be drilled, notched or altered in any manner except as provided in Sections R502.8, R602.6, R802.7 and R802.7.1. Holes in load-bearing members of cold-formed steel *light-frame construction* shall be made only in accordance with Sections R505.2.6, R603.2.6 and R804.2.6. In accordance with the provisions in Sections R505.3.5, R603.3.3 and R804.3.4, cutting and notching of flanges and lips of load-bearing members of cold-formed steel *light-frame construction* shall be prohibited. Structural insulated panels (SIPs) shall be drilled and notched or altered in accordance with the provisions of Section ~~R613.7~~ R610.7.

**P2603.2.1 Protection against physical damage.** In concealed locations, where piping, other than cast-iron or galvanized steel, is installed through holes or notches in studs, joists, rafters or similar members less than $1^1/_4$ inches (31.8 mm) from the nearest edge of the member, the pipe shall be protected by steel shield plates. Such shield plates shall have a thickness of not less than 0.0575 inch (1.463 mm) (No. 16 Gage). Such plates shall cover the area of the pipe where the member is notched or bored, and shall extend not less than 2 inches (51 mm) above sole plates and below top plates.

**P2603.3 Protection against corrosion.** Metallic piping, except for cast iron, ductile iron and galvanized steel, shall not be placed in direct contact with steel framing members, concrete or masonry. Metallic piping shall not be placed in direct contact with corrosive soil. Where sheathing is used to prevent direct contact, the sheathing material thickness shall be not less than 0.008 inch (8 mil) (0.203 mm) and shall be made of plastic. Where sheathing protects piping that penetrates concrete or masonry walls or floors, the sheathing shall be installed in a manner that allows movement of the piping within the sheathing.

**P2603.4 Pipes through ~~or under footings or~~ foundation walls.** Any pipe that passes within 12 inches (305 mm) of the bottom of the footing or through a foundation wall shall be provided with a relieving arch or a pipe sleeve. Pipe sleeves for foundation walls shall be built into the foundation wall. The sleeve shall be two pipe sizes greater than the pipe passing through the wall. Piping shall not be run under pier footings (refer to Section P2604). Annular spaces between sleeves and pipes shall be filled or tightly sealed in an *approved* manner. Annular spaces between sleeves and pipes in fire-resistance-rated assemblies shall be filled or tightly sealed in accordance with the *North Carolina Building Code*. Only sleeves through foundation or exterior building walls shall be sealed on both sides.

**P2603.5 Freezing.** Water pipes installed in a wall or ceiling exposed to the exterior shall be located on the heated side of the wall insulation. ~~In other cases, water~~ Water, soil and waste pipes shall not be installed outside of a ~~building,~~ building. ~~In unconditioned attics, unconditioned utility rooms or in any other place subjected to freezing temperatures unless adequate provisions is made to protect such pipes from freezing by a minimum of R-6.5 insulation determined at 75F (24C) in accordance with ASTM C177 or heat or both.~~ When soil and waste piping is installed under a non-enclosed area of a building or structure, freeze protections shall be installed at the discretion of the authority having jurisdiction. When installed in unconditioned utility rooms, or in the building in any other place subjected to freezing temperatures, adequate provision shall be made to protect such pipes from freezing by a minimum of R6.5 insulation determined at 75°F (24°C) in accordance with ASTM C177 or heat, or both.

Exterior water supply system piping shall be installed ~~not less than 6 inches~~ below the frost line and in no case less than ~~not less than~~ 12 inches (305 mm) below grade.

**Note:** These provisions are minimum requirements, which have been found suitable for normal weather conditions. Abnormally low temperatures for extended periods may require additional provisions to prevent freezing.

**P2603.5.1 Frost protection.**

No traps of soil or waste pipe shall be installed or permitted outside of a building, or concealed in outside walls or in any place where they may be subjected to freezing temperatures, unless adequate provision is made to protect them from freezing.

~~**P2603.5.1**~~ **P2603.5.2 Sewer depth.** *Building sewers* that connect to private sewage disposal systems shall be installed not less than 3-inches (76.2 mm) below finished grade at the point of septic tank connection. *Building sewers* shall be not less than 3-inches (76.2 mm) below grade.

## SECTION P2604
## TRENCHING AND BACKFILLING

~~**P2604.1 (306.2) Trenching and bedding.** Where trenches are excavated such that the bottom of the trench forms the bed for the pipe, solid and continuous load-bearing support shall be provided between joints. Bell holes, hub holes and coupling holes shall be provided at points where the pipe is joined. Such pipe shall not be supported on blocks to grade. In instances where the materials manufacturer's installation instructions are more restrictive than those prescribed by the code, the material shall be installed in accordance with the more restrictive requirement.~~

~~**P2604.1.1 Over-excavation.** Where trenches are excavated below the installation level of the pipe such that the bottom of the trench does not form the bed for the pipe, the trench shall be backfilled to the installation level of the bottom of the pipe with sand or fine gravel placed in layers not greater than 6 inches (152 mm) in depth and such backfill shall be compacted after each placement.~~

~~**P2604.1.2 Rock removal.** Where rock is encountered in trenching, the rock shall be removed to not less than 3 inches (76 mm) below the installation level of the bottom of the pipe, and the trench shall be backfilled to the installation level of the bottom of the pipe with sand tamped in place so as to provide uniform load-bearing support for the pipe between joints. The pipe, including the joints, shall not rest on rock at any point.~~

~~**P2604.1.3 Soft load-bearing materials.** If soft materials of poor load-bearing quality are found at the bottom of the trench, stabilization shall be achieved by over excavating not less than two pipe diameters and backfilling to the installation level of the bottom of the pipe with fine gravel, crushed stone or a concrete foundation. The concrete foundation shall be bedded with sand tamped into place to provide uniform load-bearing support for the pipe between joints.~~

**P2604.1 Trenching and bedding.** Where trenches are excavated such that the bottom of the trench forms the bed for the pipe, solid and continuous load-bearing support shall be provided between joints. Where over-excavated, the trench shall be backfilled to the proper grade with compacted earth, sand, fine gravel or similar granular material. Piping shall not be supported on rocks or blocks at any point. Rocky or unstable soil shall be over-excavated by two or more pipe diameters and brought to the proper grade with suitable compacted granular material.

**P2604.2 Water service and building sewer in same trench.** Where the water service piping and *building sewer* piping is installed in same trench, the installation shall be in accordance with Section P2906.4.1.

**P2604.3 Backfilling.** Backfill shall be free from discarded construction material and debris. Backfill shall be free from rocks, broken concrete and frozen chunks until the pipe is covered by not less than 12 inches (305 mm) of tamped earth. Backfill shall be placed evenly on both sides of the pipe and tamped to retain proper alignment. Loose earth shall be carefully placed in the trench in 6-inch (152 mm) layers and tamped in place.

**P2604.4 Protection of footings.** Trenching installed parallel to footings and walls shall not extend into the bearing plane of a footing or wall. The upper boundary of the bearing plane is a line that extends downward, at an angle of 45 degrees (0.79 rad) from horizontal, from the outside bottom edge of the footing or wall.

**P2604.5 Tracer Wire.** For plastic sewer piping, an insulated copper tracer wire or other *approved* conductor shall be installed adjacent to and over the full length of the piping. Access shall be provided to the tracer wire or the tracer wire shall terminate at the cleanout between the building drain and the building sewer. The tracer wire shall be not less than 14 AWG and the insulation type shall be listed for direct burial.

## SECTION P2605
## SUPPORT

**P2605.1 General.** Piping shall be supported in accordance with the following:

1. Piping shall be supported to ensure alignment and prevent sagging, and allow movement associated with the expansion and contraction of the piping system.
2. Piping in the ground shall be laid on a firm bed for its entire length, except where support is otherwise provided.
3. Hangers and *anchors* shall be of sufficient strength to maintain their proportional share of the weight of pipe and contents and of sufficient width to prevent distortion to the pipe. Hangers and strapping shall be of *approved* material that will not promote galvanic action.
4. Where horizontal pipes 4 inches (102 mm) and larger convey drainage or waste, and where a pipe fitting changes the flow direction greater than 45 degrees (0.79 rad), rigid bracing or other rigid support arrangements shall be installed to resist movement of the upstream pipe in the direction of flow. A change of flow direction into a vertical pipe shall not require the upstream pipe to be braced.
5. Piping shall be supported at distances not to exceed those indicated in Table P2605.1.
6. A thermal expansion tank shall be supported in accordance with the manufacturer's instructions. Thermal expansion tanks shall not be supported by the piping that connects to such tanks.

## SECTION P2606
## PENETRATIONS

**P2606.1 Sealing of annular spaces.** The annular space between the outside of a pipe and the inside of a pipe sleeve or between the outside of a pipe and an opening in a building envelope wall, floor, or ceiling assembly penetrated by a pipe shall be sealed with caulking material or foam sealant or closed with a gasketing system. The caulking material, foam sealant or gasketing system shall be designed for the conditions at the penetration location and shall be compatible with the pipe, sleeve and building materials in contact with the sealing materials. Annular spaces created by pipes penetrating fire-resistance-rated assemblies or membranes of such assemblies shall be sealed or closed in accordance with the building portion of this code.

## SECTION P2607
## WATERPROOFING OF OPENINGS

**P2607.1 Pipes penetrating roofs.** Where a pipe penetrates a roof, a flashing of lead, copper, galvanized steel or an *approved* elastomeric material shall be installed in a manner that prevents water entry into the building. Counterflashing into the opening of pipe serving as a vent terminal shall not reduce the required internal cross-sectional area of the vent pipe to less than the internal cross-sectional area of one pipe size smaller. ~~Joints at the roof and around vent pipes shall be made watertight by the use of lead, copper, galvanized steel, aluminum, plastic or other *approved* flashings or flashing material.~~

**P2607.2 Pipes penetrating exterior walls.** Where a pipe penetrates an exterior wall, a waterproof seal shall be made on the exterior of the wall by one of the following methods:

1. A waterproof sealant applied at the joint between the wall and the pipe.
2. A flashing of an *approved* elastomeric material.

## SECTION P2608
## WORKMANSHIP

**P2608.1 General.** Valves, pipes and fittings shall be installed in correct relationship to the direction of the flow. Burred ends shall be reamed to the full bore of the pipe.

## SECTION P2609
## MATERIALS EVALUATION AND LISTING

**P2609.1 Identification.** Each length of pipe and each pipe fitting, trap, fixture, material and device utilized in a plumbing system shall bear the identification of the manufacturer and any markings required by the applicable referenced standards. Nipples created from the cutting and threading of *approved* pipe shall not be required to be identified.

**Exception:** Where the manufacturer identification cannot be marked on pipe fittings and pipe nipples because of the small size of such fittings, the identification shall be printed on the item packaging or on documentation provided with the item.

**P2609.2 Installation of materials.** Materials used shall be installed in strict accordance with the standards under which the materials are accepted and *approved*. In the absence of such installation procedures, the manufacturer's instructions shall be followed. Where the requirements of referenced standards or manufacturer's instructions do not conform to the minimum provisions of this code, the provisions of this code shall apply.

**P2609.2.1 Materials for specialty fixtures.**
Materials for specialty fixtures not otherwise covered in this code shall be of stainless steel, soapstone, chemical stoneware or plastic, or shall be lined with lead, copper-base alloy, nickel-copper alloy, corrosion-resistant steel or other material especially suited to the application for which the fixture is intended.

~~**P2609.2.2 (402.3) Sheet copper.** Sheet copper for general applications shall conform to ASTM B152 and shall not weigh less than 12 ounces per square foot (3.7 kg/m2).~~

~~**P2609.2.3 (402.4) Sheet lead.** Sheet lead for pans shall not weigh less than 4 pounds per square foot (19.5 kg/m2) and shall be coated with an asphalt paint or other *approved* coating.~~

**P2609.3 Plastic pipe, fittings and components.** Plastic pipe, fittings and components shall be third-party certified as conforming to NSF 14.

**P2609.4 Third-party certification.** Plumbing products and materials required by the code to be in compliance with a referenced standard shall be *listed* by a third-party certification agency as complying with the referenced standards. Products and materials shall be identified in accordance with Section P2609.1.

**P2609.5 Water supply systems.** Water service pipes, water distribution pipes and the necessary connecting pipes, fittings, control valves, faucets and appurtenances used to dispense water intended for human ingestion shall be evaluated and *listed* as conforming to the requirements of NSF 61.

**TABLE P2605.1**
**PIPING SUPPORT**

| PIPING MATERIAL | MAXIMUM HORIZONTAL SPACING (feet) | MAXIMUM VERTICAL SPACING (feet) |
|---|---|---|
| ABS pipe | 4 | 10[b] |
| Aluminum tubing | 10 | 15 |
| Cast-iron pipe | 5[a] | 15 |
| Copper or copper-alloy pipe | 12 | 10 |
| Copper or copper-alloy tubing (1$^1/_4$ inches in diameter and smaller) | 6 | 10 |
| Copper or copper-alloy tubing (1$^1/_2$ inches in diameter and larger) | 10 | 10 |
| Cross-linked polyethylene (PEX) pipe, 1 inch and smaller | 2.67 (32 inches) | 10[b] |
| Cross-linked polyethylene (PEX) pipe, 1$^1/_4$ inches and larger | 4 | 10[b] |
| Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe | 2.67 (32 inches) | 4[b] |
| CPVC pipe or tubing (1 inch in diameter and smaller) | 3 | 10[b] |

| | | |
|---|---|---|
| CPVC pipe or tubing (1¼ inches in diameter and larger) | 4 | 10[b] |
| Lead pipe | Continuous | 4 |
| PB pipe or tubing | 2.67 (32 inches) | 4 |
| Polyethylene of raised temperature (PE-RT) pipe, 1 inch and smaller | 2.67 (32 inches) | 10[b] |
| Polyethylene of raised temperature (PE-RT) pipe, 1¼ inches and larger | 4 | 10[b] |
| Polypropylene (PP) pipe or tubing (1 inch and smaller) | 2.67 (32 inches) | 10[b] |
| Polypropylene (PP) pipe or tubing (1¼ inches and larger) | 4 | 10[b] |
| PVC pipe | 4 | 10[b] |
| Stainless steel drainage systems | 10 | 10[b] |
| Steel pipe | 12 | 15 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. The maximum horizontal spacing of cast-iron pipe hangers shall be increased to 10 feet where 10-foot lengths of pipe are installed.

b. For sizes 2 inches and smaller, a guide shall be installed midway between required vertical supports. Such guides shall prevent pipe movement in a direction perpendicular to the axis of the pipe.

# CHAPTER 27
# PLUMBING FIXTURES

The text of this chapter is extracted from the ~~2018~~ 2024 edition of the *North Carolina Plumbing Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code* for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Plumbing Code*.

## SECTION P2701
## FIXTURES, FAUCETS AND FIXTURE FITTINGS

**P2701.1 Quality of fixtures.** Plumbing fixtures, faucets and fixture fittings shall have smooth impervious surfaces, shall be free from defects, shall not have concealed fouling surfaces, and shall conform to the standards indicated in Table P2701.1 and elsewhere in this code. All porcelain enameled surfaces on plumbing fixtures shall be acid resistant.

## SECTION P2702
## FIXTURE ACCESSORIES

**P2702.1 Plumbing fixtures.** Plumbing fixtures, other than water closets, shall be provided with *approved* strainers.

**Exception:** Hub drains receiving only clear water waste and standpipes shall not require strainers.

**P2702.2 Waste fittings.** Waste fittings shall conform to ASME A112.18.2/CSA B125.2, ASTM F409 or shall be made from pipe and pipe fittings complying with any of the standards indicated in Tables P3002.1(1) and P3002.3.

**P2702.3 Plastic tubular fittings.** Plastic tubular fittings shall conform to ASTM F409 as indicated in Table P2701.1.

**P2702.4 Carriers for wall-hung water closets.** Carriers for wall-hung water closets shall conform to ~~ASME A112.6.1~~ or ASME A112.6.2. Wall hung water closet bowls shall be supported by a concealed metal carrier that is attached to the building structural members so that strain is not transmitted to the closet connector or any other part of the plumbing system.

## SECTION P2703
## TAIL PIECES

**P2703.1 Minimum size.** Fixture tail pieces shall be not less than $1^1/_2$ inches (38 mm) in diameter for sinks, dishwashers, laundry tubs, bathtubs and similar fixtures, and not less than $1^1/_4$ inches (32 mm) in diameter for bidets, lavatories and similar fixtures.

## SECTION P2704
## SLIP-JOINT CONNECTIONS

**P2704.1 Slip joints.** Slip-joint connections shall be installed only for tubular waste piping and only between the trap outlet of a fixture and the connection to the drainage piping. Slip-joint connections shall be made with an *approved* elastomeric sealing gasket. Slip-joint connections shall be accessible. Such access shall provide an opening that is not less than 12 inches (305 mm) in its smallest dimension. Where such access cannot be provided, access doors shall not be required, provided that all joints are soldered, solvent cemented or screwed to form a solid connection.

## SECTION P2705
## INSTALLATION

**P2705.1 General.** The installation of fixtures shall conform to the following:

1. Floor-outlet or floor-mounted fixtures shall be secured to the drainage connection and to the floor, where so designed, by screws, bolts, washers, nuts and similar fasteners of copper, copper alloy or other corrosion-resistant material.
2. Wall-hung fixtures shall be rigidly supported so that strain is not transmitted to the plumbing system.

3. Where fixtures come in contact with walls and floors, the contact area shall be watertight.
4. Plumbing fixtures shall be usable.
5. See Figure R307.1 for minimum fixture clearances.
6. The location of piping, fixtures or equipment shall not interfere with the operation of windows or doors.
7. In flood hazard areas as established by Table R301.2, plumbing fixtures shall be located or installed in accordance with Section R322.1.6.
8. Integral fixture-fitting mounting surfaces on manufactured plumbing fixtures or plumbing fixtures constructed on site, shall meet the design requirements of ASME A112.19.2/CSA B45.1 or ASME A112.19.3/CSA B45.4.
9. Floor flanges for water closets or similar fixtures shall be not less than 0.125 inch (3.2 mm) thick for brass, 0.25 inch (6.4 mm) thick for plastic and 0.25 inch (6.4 mm) thick and not less than a 2-inch (51 mm) caulking depth for cast iron or galvanized malleable iron. Floor flanges of hard lead shall weigh not less than 1 pound, 9 ounces (0.7 kg) and shall be composed of lead alloy with not less than 7.75-percent antimony by weight. Flanges shall be secured to the building structure with corrosion-resistant screws or bolts.
10. Where any fixture is provided with an overflow, the waste shall be designed and installed so that standing water in the fixture will not rise in the overflow when the stopper is closed, and no water will remain in the overflow when the fixture is empty. The overflow from any fixture shall discharge into the drainage system on the inlet or fixture side of the trap.

    **Exception:** The overflow from a flush tank serving a water closet or urinal shall discharge into the fixture served.

11. Fixtures shall be set level and in proper alignment with reference to adjacent walls.

## SECTION P2706
## WASTE RECEPTORS

**P2706.1 General.** Every waste receptor shall be of an *approved* type. A removable strainer or basket shall cover the waste outlet of waste receptors. Waste receptors shall be installed in ventilated spaces. Waste receptors shall not be installed in concealed spaces. Waste receptors shall not be installed in plenums, attics, crawl spaces or interstitial spaces above ceilings and below floors. Waste receptors shall be *readily accessible*.

**Exceptions**:
1. ~~Hub drains.~~ Where hub drains are installed in a crawl space for condensate waste.
2. This section shall not apply to hub drains in equipment rooms and furnace rooms in dwelling units.
3. Hub drains shall not be required to have strainers.

**P2706.1.1 Hub drains.** Hub drains shall be in the form of a hub or a pipe that extends not less than 1 inch (25.4 mm) above a water-impervious floor and shall not be required to have a strainer.

**P2706.1.2 Standpipes.** Standpipes shall be individually trapped. *Access* shall be provided to standpipes and drains for rodding. Standpipes shall be not less than 2 inches (51 mm) in diameter and not less than 18 inches (762 mm) or more than 48 inches (1219 mm) in height as measured from the crown weir. The standpipe shall extend 34 inches (864 mm) minimum above the base of the clothes washer unless recommended otherwise by the manufacturer. The connection of a laundry tray waste line may be made into a standpipe for the automatic clothes-washer drain. The standpipe shall extend above the flood level rim of the laundry tray. The outlet of the laundry tray shall be a maximum horizontal distance of 30 inches (762 mm) from the standpipe trap.

**P2706.1.2.1 Laundry tray connection to standpipe.** ~~Deleted~~. Where a laundry tray waste line connects into a standpipe for an automatic clothes washer drain, the standpipe shall extend not less than 30 inches (762 mm) above the standpipe trap weir and shall extend above the flood level rim of the laundry tray. The outlet of the laundry tray shall not be greater than 30 inches (762 mm) horizontally from the standpipe trap.

**P2706.2 Prohibited waste receptors.** Plumbing fixtures that are used for washing or bathing shall not be used to receive the discharge of indirect waste piping.

**Exceptions:**

1. A kitchen sink trap is acceptable for use as a receptor for a dishwasher.
2. A laundry tray is acceptable for use as a receptor for a clothes washing machine.

## SECTION P2707
## DIRECTIONAL FITTINGS

**P2707.1 Directional fitting required.** ~~Deleted.~~ *Approved* directional-type branch fittings shall be installed in fixture tailpieces receiving the discharge from food-waste disposer units or dishwashers.

## SECTION P2708
## SHOWERS

**P2708.1 General.** Shower compartments shall have not less than 900 square inches (0.6 $m^2$) of interior cross-sectional area. Shower compartments shall be not less than 30 inches (762 mm) in minimum dimension measured from the finished interior dimension of the shower compartment, exclusive of fixture valves, shower heads, soap dishes, and safety grab bars or rails. The minimum required area and dimension shall be measured from the finished interior dimension at a height equal to the top of the threshold and at a point tangent to its centerline and shall be continued to a height of not less than 70 inches (1778 mm) above the shower drain outlet. Hinged shower doors shall open outward. The wall area above built-in tubs having installed shower heads and in shower compartments shall be constructed in accordance with Section R702.4. Such walls shall form a watertight joint with each other and with either the tub, receptor or shower floor.

**Exceptions:**

1. Fold-down seats shall be permitted in the shower, provided that the required 900-square-inch (0.6 $m^2$) dimension is maintained when the seat is in the folded-up position.
2. Shower compartments having not less than 25 inches (635 mm) in minimum dimension measured from the finished interior dimension of the compartment provided that the shower compartment has a cross-sectional area of not less than 1,300 square inches (0.838 $m^2$).

~~3. Shower compartments with prefabricated receptors conforming to the standards listed in Table P2708.1 (417.4).~~

4 3. Where load-bearing, bonded, waterproof membranes meeting ANSI A118.10 are used, integrated bonding flange drains shall be approved. Clamping devices and weep holes are not required where shower drains include an integrated bonding flange. Manufacturer's installation instructions shall be followed to achieve a watertight seal between the bonded waterproof membrane and the integrated bonding flange drain. Integrated bonding flange drains shall conform to ASME A112.6.3, ASME A112.18.2/CSA B125.2, or CSA B79.

**P2708.1.1 Access.** The shower compartment access and egress opening shall have a clear and unobstructed finished width of not less than 22 inches (559 mm).

**P2708.2 Shower drain.**
Shower drains shall have an outlet size of not less than 2 inches [51 mm] in diameter, and for other than waste outlets in bathtubs, shall have removable strainers not less than 3 inches (76 mm) in diameter with strainer openings not less than 1/4 inch (6.4 mm) in least dimension. Where each shower space is not provided with an individual waste outlet, the waste outlet shall be located and the floor pitched so that waste from one shower does not flow over the floor area serving another shower. Waste outlets shall be fastened to the waste pipe in an *approved* manner

**Exception:** Retaining pre-existing 1-1/2 inch (38 mm) in diameter waste outlets shall be permitted when removing an existing bathtub and installing a shower in its place.

**P2708.2.1 Waste fittings.** Waste fittings shall conform to ASME A112.18.2/CSA B125.2.

**P2708.3 Water supply riser.** Water supply risers from the shower valve to the shower head outlet, whether exposed or concealed, shall be attached to the structure using support devices designed for use with the specific piping material or fittings anchored with corrosion resistant screws of a minimum nominal length of ¾ inch (19 mm)

**P2708.4 Shower control valves.** Individual shower and tub/shower combination valves shall be balanced-pressure, thermostatic or combination balanced-pressure/thermostatic valves that conform to the requirements of ASSE 1016/ASME 112.1016/CSA B125.16 or ASME A112.18.1/CSA B125.1. Shower control valves shall be rated for the flow rate of the installed shower head. Such valves shall be installed at the point of use. ~~The high limit stop shall be set~~ Shower and tub/shower combination valves required by this section shall be equipped with a means to limit the maximum setting of the valve to 120°F (49°C), which shall be field adjusted in accordance with the manufacturer's instructions to provide water at a temperature not to exceed 120ºF (49°C). In-line thermostatic valves shall not be utilized for compliance with this section. Scald preventative valves are not required in dwelling units with individual water heaters set at 120°F (49°C).

**P2708.5 Hand showers.** Hand-held showers shall conform to ASME A112.18.1/CSA B125.1. Hand-held showers shall provide backflow protection in accordance with ASME A112.18.1/CSA B125.1 or shall be protected against backflow by a device complying with ASME A112.18.3.

## SECTION P2709
## SHOWER RECEPTORS

**P2709.1 Construction.** Where a shower receptor has a finished curb threshold, it shall be not less than 1 inch (25.4 mm) below the sides and back of the receptor. The curb shall be not less than 2 inches (51 mm) and not more than 9 inches (229 mm) deep when measured from the top of the curb to the top of the drain. The finished floor shall slope uniformly toward the drain not less than $^{1}/_{4}$ unit vertical in 12 units horizontal (2-percent slope) nor more than $^{1}/_{2}$ unit vertical per 12 units horizontal (4-percent slope) and floor drains shall be flanged to provide a watertight joint in the floor.

**P2709.2 Lining required.** The adjoining walls and floor framing enclosing on-site built-up shower receptors shall be lined with one of the following materials:

1. Sheet lead. Sheet lead shall weigh not less than 4 pounds per square foot (19.5 kg/m$^2$) and shall be coated with an asphalt paint or other *approved* coating. The lead sheet shall be insulated from conducting substances other than the connecting drain by 15-pound (6.80 kg) asphalt felt or an equivalent. Sheet lead shall be joined by burning.
2. Sheet copper. Sheet copper shall conform to ASTM B 152 and shall weigh not less than 12 ounces per square foot (3.7 kg/m$^2$). The copper sheet shall be insulated from conducting substances other than the connecting drain by 15-pound (6.80 kg) asphalt felt or an equivalent. Sheet copper shall be joined by brazing or soldering.
3. Plastic liner material shall be a minimum of 0.040 inch (1.02mm) thick and shall comply with ASTM D4068 or ASTM D4551.
4. Hot mopping in accordance with Section P2709.2.3.
5. Sheet-applied load-bearing, bonded waterproof membranes that comply with ANSI A118.10.

The lining material shall extend not less than 2 inches (51 mm) beyond or around the rough jambs and not less than 2 inches (51 mm) above finished thresholds. Sheet-applied load bearing, bonded waterproof membranes shall be applied in accordance with the manufacturer's instructions.

**P2709.2.1 PVC sheets.** Plasticized polyvinyl chloride (PVC) sheet shall be a minimum of 0.040 inch (1.02 mm) thick and shall meet the requirements of ASTM D4551. Sheets shall be joined by solvent welding in accordance with the manufacturer's instructions.

**P2709.2.2 Chlorinated polyethylene (CPE) sheets.** Non-plasticized chlorinated polyethylene sheet shall be a minimum of 0.040 inch (1.02 mm) thick and shall meet the requirements of ASTM D4068. The liner shall be joined in accordance with the manufacturer's instructions.

**P2709.2.3 Hot-mopping.** Shower receptors lined by hot mopping shall be built-up with not less than three layers of standard grade Type 15 asphalt-impregnated roofing felt. The bottom layer shall be fitted to the formed subbase and each succeeding layer thoroughly hot-mopped to that below. Corners shall be carefully fitted and shall be made strong and watertight by folding or lapping, and each corner shall be reinforced with suitable webbing hot-mopped in place. Folds, laps and reinforcing webbing shall extend not less than 4 inches (102 mm) in all directions from the corner and webbing shall be of *approved* type and mesh, producing a tensile strength of not less than 50 pounds per inch (893 kg/m) in either direction.

**P2709.2.4 Liquid-type, trowel-applied, load-bearing, bonded waterproof materials.** Liquid-type, trowel-applied, load-bearing, bonded waterproof materials shall meet the requirements of ANSI A118.10 and shall be applied in accordance with the manufacturer's instructions.

**P2709.3 Installation.** Lining materials shall be sloped a minimum of_ $^1/_4$ unit vertical in 12 units horizontal (2-percent slope) to weep holes in the subdrain by means of a smooth, solidly formed subbase, shall be properly recessed and fastened to *approved* backing so as not to occupy the space required for the wall covering, and shall not be nailed or perforated at any point less than 1 inch (25.4 mm) above the finished threshold.

**P2709.3.1 Materials.** Lead and copper linings shall be insulated from conducting substances other than the connecting drain by 15-pound (6.80 kg) asphalt felt or its equivalent. Sheet lead liners shall weigh not less than 4 pounds per square foot (19.5 kg/m$^2$) ~~and shall be coated with an asphalt paint or other *approved* coating~~. Sheet copper liners shall weigh not less than 12 ounces per square foot (3.7 kg/m$^2$). Joints in lead and copper pans or liners shall be burned or silver brazed, respectively. Joints in plastic liner materials shall be joined in accordance with the manufacturer's instructions.

**P2709.4 Receptor drains.** An *approved* flanged drain shall be installed with shower subpans or linings. The flange shall be placed flush with the subbase and be equipped with a clamping ring or other device to make a watertight connection between the lining and the drain. The flange shall have weep holes into the drain.

**P2709.4.1 Waste fittings.** Flanged drains shall conform to ASME A112.18.2/CSA B125.2.

## SECTION P2710
## SHOWER WALLS

**P2710.1 Bathtub and shower spaces.** Walls in shower compartments and walls above bathtubs that have a wall-mounted showerhead shall be finished in accordance with Section R307.2.

## SECTION P2711
## LAVATORIES

**P2711.1 Approval.** Lavatories shall conform to ASME A112.19.1/CSA B45.2, ASME A112.19.2/CSA B45.1, ASME A112.19.3/CSA B45.4 or CSA B45.5/IAPMO Z124.

**P2711.2 Cultured marble lavatories.** Cultured marble vanity tops with an integral lavatory shall conform to CSA B45.5/IAPMO Z124.

**P2711.3 Lavatory waste outlets.** Lavatories shall have waste outlets not less than $1^1/_4$ inch (32 mm) in diameter. A strainer, pop-up stopper, crossbar or other device shall be provided to restrict the clear opening of the waste outlet.

**P2711.4 Movable lavatory systems.** Movable lavatory systems shall comply with ASME A112.19.12.

## SECTION P2712
## WATER CLOSETS

**P2712.1 Approval.** Water closets shall conform to the water consumption requirements of Section P2903.2 and shall conform to ASME A112.19.2/CSA B45.1, ASME A112.19.3/CSA B45.4 or CSA B45.5/IAPMO Z124. Water closets shall conform to the hydraulic performance requirements of ASME A112.19.2/CSA B45.1. Water closet tanks shall conform to ASME A112.19.2/CSA B45.1, ASME A112.19.3/CSA B45.4 or CSA B45.5/IAPMO Z124. Water closets that have an invisible seal and unventilated space or walls that are not thoroughly washed at each discharge shall be prohibited. Water closets that allow backflow of the contents of the bowl into the flush tank shall be prohibited. Water closets equipped with a dual flushing device shall comply with ASME A112.19.14.

**P2712.2 Flushing devices required.** Water closets shall be provided with a flush tank, flushometer tank or flushometer valve designed and installed to supply water in sufficient quantity and flow to flush the contents of the fixture, to cleanse the fixture and refill the fixture trap in accordance with ASME A112.19.2/CSA B45.1.

**P2712.3 Water supply for flushing devices.** An adequate quantity of water shall be provided to flush and clean the fixture served. The water supply to flushing devices equipped for manual flushing shall be controlled by a float valve or other automatic device designed to refill the tank after each discharge and to completely shut off the water flow to the tank when the tank is filled to operational capacity. Provision shall be made to automatically supply water to the fixture so as to refill the trap after each flushing.

**P2712.4 Flush valves in flush tanks.** Flush valve seats in tanks for flushing water closets shall be not less than 1 inch (25.4 mm) above the flood-level rim of the bowl connected thereto, except an *approved* water closet and flush tank combination designed so that when the tank is flushed and the fixture is clogged or partially clogged, the flush valve will close tightly so that water will not spill continuously over the rim of the bowl or backflow from the bowl to the tank.

**P2712.5 Overflows in flush tanks.** Flush tanks shall be provided with overflows discharging to the water closet connected thereto and such overflow shall be of sufficient size to prevent flooding the tank at the maximum rate at which the tanks are supplied with water according to the manufacturer's design conditions.

**P2712.6 Access.** Parts in a flush tank shall be accessible for repair and replacement.

**P2712.7 Water closet seats.** Water closets shall be equipped with seats of smooth, nonabsorbent material and shall be properly sized for the water closet bowl type.

**P2712.8 Flush tank lining.** Sheet copper used for flush tank linings shall have a weight of not less than 10 ounces per square foot (3 $kg/m^2$).

**P2712.9 Electro-hydraulic water closets.** Electro-hydraulic water closets shall conform to ASME A112.19.2/CSA B45.1.

**P2712.10 (420.4) Water closet connections.**
A 4-inch by 3-inch (102 mm by 76 mm) closet bend shall be acceptable. Where a 3-inch (76 mm) bend is utilized on water closets, a 4-inch by 3-inch (102 mm by 76 mm) flange shall be installed to receive the fixture horn.

## SECTION P2713
## BATHTUBS

**P2713.1 Bathtub waste outlets and overflows.** Bathtubs shall be equipped with a waste outlet and an overflow outlet. The outlets shall be connected to waste tubing or piping not less than 1-1/2 inches (38 mm) in diameter. The waste outlet shall be equipped with a water-tight stopper.

<u>**Exception:** An overflow outlet is not required for bathtubs located on an impervious floor with a floor drain or trench drain, or installed in a shower enclosure.</u>

**P2713.2 Bathtub enclosures.** Doors within a bathtub enclosure shall conform to ASME A112.19.15.

~~**P2713.3 Bathtub and whirlpool bathtub valves.** Hot water supplied to bathtubs and whirlpool bathtubs shall be limited to a temperature of not greater than 120°F (49°C) by a water temperature limiting device that conforms to ASSE 1070 or CSA B125.3, except where such protection is otherwise provided by a combination tub/shower valve in accordance with Section P2708.4.~~

<u>**P2713.3 Bathtub and whirlpool bathtub valves.** Bathtubs and whirlpool bathtub valves shall have or be supplied by a water-temperature-limiting device that conforms to ASSE 1070/ASME A112.1070/CSA B125.70, except where such valves are combination tub/shower valves in accordance with Section P2708.4. The water-temperature-limiting device required by this section shall be equipped with a means to limit the maximum setting of the device to 120ºF</u>

(49ºC), and, where adjustable, shall be field adjusted in accordance with the manufacturer's instructions to provide hot water at a temperature not to exceed 120ºF (49ºC). Access shall be provided to water-temperature-limiting devices that conform to ASSE 10705/ASME A112.1070/CSA B125.70.

**Exception:** Access is not required for nonadjustable water-temperature-limiting devices that conform to ASSE 1070/ASME A112.1070/CSA B125.70 and are integral with a fixture fitting, provided that the fixture fitting itself can be accessed for replacement.

~~**P2713.4 (407.1) Approval.** Bathtubs shall conform to ASME A112.19.1/CSA B45.2, ASME A112.19.2/CSA B45.1, ASME A112.19.3/ CSA B45.4 or CSA B45.5/IAPMO Z124.~~

## SECTION P2714
## SINKS

**P2714.1 Sink waste outlets.** Sinks shall be provided with waste outlets not less than $1^{1}/_{2}$ inches (38 mm) in diameter. A strainer, crossbar or other device shall be provided to restrict the clear opening of the waste outlet.

**P2714.2 Movable sink systems.** Movable sink systems shall comply with ASME A112.19.12.

## SECTION P2715
## LAUNDRY TUBS

**P2715.1 Laundry tub waste outlet.** Each compartment of a laundry tub shall be provided with a waste outlet not less than $1^{1}/_{2}$ inches (38 mm) in diameter. A strainer or crossbar shall restrict the clear opening of the waste outlet.

## SECTION P2716
## FOOD-WASTE DISPOSER

**P2716.1 Food-waste disposer waste outlets.** Food-waste disposers shall be connected to a drain of not less than $1^{1}/_{2}$ inches (38 mm) in diameter.

**P2716.2 Water supply required.** A sink equipped with a food-waste disposer shall be provided with a faucet.

## SECTION P2717
## DISHWASHING MACHINES

**P2717.1 Protection of water supply.** The water supply to a dishwasher shall be protected against backflow by an *air gap* complying with ASME A112.1.3 or A112.1.2 that is installed integrally within the machine or a backflow preventer in accordance with Section P2902.

**P2717.2 Sink and dishwasher.** The combined discharge from a dishwasher and a one- or two-compartment sink, with or without a food-waste disposer, shall be served by a trap of not less than 11/2 inches (38 mm) in outside diameter. The dishwasher discharge pipe or tubing shall rise to the underside of the counter ~~and shall be securely fastened to the underside of the sink rim or counter~~ and be fastened or otherwise held in that position before connecting to the head of the food-waste disposer or to a wye fitting in the sink tailpiece.

## SECTION P2718
## CLOTHES WASHING MACHINE

**P2718.1 Waste connection.** The waste from an automatic clothes washer shall connect to a vertical drain of not less than 2 inches (51 mm) in diameter, or a horizontal drain of not less than 3 inches (76 mm) in diameter. The 2-inch (51 mm) trap in the waste connection may be used as a cleanout for both the 2-inch (51 mm) and the 3-inch (76 mm). In retrofit or remodel work automatic domestic clothes washers shall be permitted to drain to a laundry sink. Automatic clothes washers that discharge by gravity shall be permitted to drain to a waste receptor or an approved trench drain.

**P2718.2 (406.1) Water connection.**
The water supply to an automatic clothes washer shall be protected against backflow by an *air gap* that is integral

with the machine or a backflow preventer shall be installed in accordance with Section 608. *Air gaps* shall comply with ASME A112.1.2 or A112.1.3.

## SECTION P2719
## FLOOR DRAINS

**P2719.1 Floor drains.** Floor drains shall have waste outlets not less than 2 inches (51 mm) in diameter and a removable strainer. Floor drains shall be constructed so that the drain can be cleaned. Access shall be provided to the drain inlet. Floor drains shall not be located under or have their access restricted by permanently installed appliances.

**P2719.2 (412.5) Location.** Floor drains shall be located to drain the entire floor area.

## SECTION P2720
## WHIRLPOOL BATHTUBS

**P2720.1 Access to pump.** Access shall be provided to circulation pumps in accordance with the fixture or pump manufacturer's installation instructions. Where the manufacturer's instructions do not specify the location and minimum size of field-fabricated access openings, an opening of not less than 12 inches by 12 inches (305 mm by 305 mm) shall be installed for access to the circulation pump. Where pumps are located more than 2 feet (610 mm) from the access opening, an opening of not less than 18 inches by 18 inches (457 mm by 457 mm) shall be installed. A door or panel shall be permitted to close the opening. The access opening shall be unobstructed and be of the size necessary to permit the removal and replacement of the circulation pump. A minimum clearance of 21 inches (533 mm) is required in front of the access door. Removal of a toilet cannot be used to obtain the required clearance.

**P2720.2 Piping drainage.** The circulation pump shall be accessibly located above the crown weir of the trap. ~~The pump drain and circulation piping shall be sloped to drain the water in the volute and the circulation piping when the whirlpool bathtub is empty.~~ The pump drain line shall be properly graded to ensure minimum water retention in the volute after fixture use. The circulation piping shall be installed to be self-draining.

**P2720.3 Leak testing.** Leak testing and pump operation shall be performed in accordance with the manufacturer's instructions.

**P2720.4 Manufacturer's instructions.** The product shall be installed in accordance with the manufacturer's instructions.

**P2720.5 Suction fittings.**
Suction fittings for whirlpool bathtubs shall comply with ASME A112.19.7/CSA B45.10.

## SECTION P2721
## BIDET INSTALLATIONS

**P2721.1 Water supply.** The bidet shall be equipped with either an air-gap-type or vacuum-breaker-type fixture supply fitting.

**P2721.2 Bidet water temperature.** The discharge water temperature from a bidet fitting shall be limited to not greater than 110°F (43°C) by a water-temperature-limiting device conforming to ASSE 1070/ASME A112.1070/CSA B125.70.

**P2721.3 Approval.**
Bidets shall conform to ASME A112.19.2/ CSA B45.1.

## SECTION P2722
## FIXTURE FITTING

**P2722.1 General.** Fixture supply valves and faucets shall comply with ASME A112.18.1/CSA B125.1 as indicated in Table P2701.1. Faucets and fixture fittings that supply drinking water for human ingestion shall conform to the requirements of NSF 61, Section 9. Flexible water connectors shall conform to the requirements of Section P2906.7.

**P2722.2 Hot water.** Fixture fittings supplied with both hot and cold water shall be installed and adjusted so that the left-hand side of the water temperature control represents the flow of hot water when facing the outlet.

**Exception:** Shower and tub/shower mixing valves conforming to ASSE 1016/ASME 112.1016/CSA B125.16, where the water temperature control corresponds to the markings on the device.

**P2722.3 Hose-connected outlets.** Faucets and fixture fittings with hose-connected outlets shall conform to ASME A112.18.3 or ASME A112.18.1/CSA B125.1.

**P2722.4 Individual pressure-balancing in-line valves for individual fixture fittings.** Individual pressure-balancing in-line valves for individual fixture fittings shall comply with ASSE 1066. Such valves shall be installed in an accessible location and shall not be used as a substitute for the balanced pressure, thermostatic or combination shower valves required in Section P2708.4.

**P2722.5 Water closet personal hygiene devices.** Personal hygiene devices integral to water closets or water closet seats shall conform to ASME A112.4.2/CSA B45.16.

## SECTION P2723
## MACERATING TOILET SYSTEMS

**P2723.1 General.** Macerating toilet systems shall be installed in accordance with shall comply with ASME A112.3.4/CSA B45.9 and with ~~shall be installed in accordance with manufacturer's instructions.~~ manufacturer's instructions.

**P2723.2 Drain.** The size of the drain from the macerating toilet system shall be not less than $^{3}/_{4}$ inch (19 mm) in diameter.

## SECTION P2724
## SPECIALTY TEMPERATURE CONTROL
## DEVICES AND VALVES

**P2724.1 Temperature-actuated mixing valves.** Temperature-actuated mixing valves, which are installed to reduce water temperatures to defined limits, shall comply with ASSE 1017. Such valves shall be installed at the hot water source.

**P2724.2 Temperature-actuated, flow-reduction devices for individual fixtures.** Temperature-actuated, flow-reduction devices, where installed for individual fixture fittings, shall conform to ASSE 1062. Such valves shall not be used as a substitute for the balanced pressure, thermostatic or combination shower valves required for showers in Section P2708.4.

## SECTION P2725
## NONLIQUID SATURATED TREATMENT SYSTEMS

**P2725.1 General.** Materials, design, construction and performance of nonliquid saturated treatment systems shall comply with NSF 41.

**TABLE P2701.1**
**PLUMBING FIXTURES, FAUCETS AND FIXTURE FITTINGS**

| MATERIAL | STANDARD |
|---|---|
| Air gap fittings for use with plumbing fixtures, appliances and appurtenances | ASME A112.1.3 |
| Bathtub/whirlpool pressure-sealed doors | ASME A112.19.15 |
| Diverters for faucets with hose spray, anti-syphon type, residential application | ASME A112.18.1/CSA B125.1 |
| Enameled cast-iron plumbing fixtures | ASME A112.19.1/CSA B45.2 |
| Floor drains | ASME A112.6.3 |
| Framing-affixed supports for off-the-floor water closets with concealed tanks | ASME A112.6.2 |
| Hose connection vacuum breaker | ASSE 1052 |
| Hot water dispensers, household storage type, electrical | ASSE 1023 |
| Household disposers | ASSE 1008 |
| Hydraulic performance for water closets and urinals | ASME A112.19.2/CSA B45.1 |
| Individual automatic compensating valves for individual fixture fittings | ASME A112.18.1/CSA B125.1 |
| Individual shower control valves anti-scald | ASSE 1016/ASME A112.1016/CSA B125.16 |
| Macerating toilet systems and related components | ASME A112.3.4/CSA B45.9 |
| Nonvitreous ceramic plumbing fixtures | ASME A112.19.2/CSA B45.1 |
| Plastic bathtub units | CSA B45.5/IAPMO Z124; ASME A112.19.2/ CSA B45.1 |
| Plastic lavatories | CSA B45.5/IAPMO Z124 |
| Plastic shower receptors and shower stalls | CSA B45.5/IAPMO Z124 |
| Plastic sinks | CSA B45.5/IAPMO Z124 |
| Plastic water closet bowls and tanks | CSA B45.5/IAPMO Z124 |
| Plumbing fixture fittings | ASME A112.18.1/CSA B125.1 |
| Plumbing fixture waste fittings | ASME A112.18.2/CSA B125.2; ASTM F409 |
| Porcelain-enameled formed steel plumbing fixtures | ASME A112.19.1/CSA B45.2 |
| Pressurized flushing devices for plumbing fixtures | ASSE 1016/ASME 112.1016/CSA B125.16; CSA B125.3 |
| Specification for copper sheet and strip for building construction | ASTM B370 |
| Stainless steel plumbing fixtures | ASME A112.19.3/CSA B45.4 |
| Suction fittings for use in whirlpool bathtub appliances | ASME A112.19.7/CSA B45.10 |
| Temperature-actuated, flow reduction valves to individual fixture fittings | ASSE 1062 |
| Thermoplastic accessible and replaceable plastic tube and tubular fittings | ASTM F409 |
| Trench drains | ASME A112.6.3 |

| | |
|---|---|
| Trim for water closet bowls, tanks and urinals | ASME A112.19.5/CSA B45.15 |
| Vacuum breaker wall hydrant-frost-resistant, automatic-draining type | ASSE 1019 |
| Vitreous china plumbing fixtures | ASME A112.19.2/CSA B45.1 |
| Wall-mounted and pedestal-mounted, adjustable and pivoting lavatory and sink carrier systems | ASME A112.19.12 |
| Water closet flush tank fill valves | ASSE 1002/ASME A112.1002/CSA B125.12; CSA B125.3 |
| Whirlpool bathtub appliances | ASME A112.19.7/CSA B45.10 |

# CHAPTER 28
# WATER HEATERS

The text of this chapter is extracted from the ~~2018~~ 2024 edition of the North Carolina Plumbing Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings.

## SECTION P2801
## GENERAL

**P2801.1 Required.** *Hot water* shall be supplied to plumbing fixtures and plumbing *appliances* intended for bathing, washing or culinary purposes.

**P2801.2 Drain valves.** Drain valves for emptying shall be installed at the bottom of each tank-type water heater and hot water storage tank. Drain valves shall conform to ASSE 1005. The drain valve inlet shall be not less than $^3/_4$-inch (19.1 mm) nominal iron pipe size and the outlet shall be provided with a male hose thread.

**P2801.3 Installation.** Water heaters shall be installed in accordance with this chapter and Chapters 20 and 24.

**P2801.4 Location.** Water heaters and storage tanks shall be installed in accordance with Section M1305 and shall be located and connected to provide access for observation, maintenance, servicing and replacement.

**P2801.5 Prohibited locations.** Water heaters shall be located in accordance with Chapter 20, Section 2005.2 and as elsewhere required in this code.

~~**P2801.6 Required pan.** Where a storage tank-type water heater or a hot water storage tank is installed in: (a) remote locations such as a suspended ceiling, (b) attics, (c) above occupied spaces, (d) unventilated crawl spaces, or (e) a location where water leakage from the tank will cause damage to primary structural members, the tank or water heater shall be installed in a galvanized steel or aluminum pan having a material thickness of not less than 0.0236 inch (0.6010 mm) (No. 24 gage for steel or No. 26 gage for aluminum), or other pans *approved* for such use.~~
~~**Exceptions:**~~
~~1. Electric water heaters may rest in a high-impact plastic pan of at least 1/16 inch (1.6 mm) thickness.~~
~~2. Water heater mounted on concrete floor with a floor drain.~~

**P2801.6 Required pan.** Where a storage tank-type water heater or a hot water storage tank is installed in: (a) remote locations such as a suspended ceiling, (b) attics, (c) above occupied spaces, (d) above crawl spaces or (e) in unventilated crawl spaces, a location where water leakage from the tank will cause damage to primary structural framing, the tank or water heater shall be installed in a galvanized steel or aluminum pan constructed of one of the following:

1. Galvanized steel or aluminum of not less than 0.0236 inch (0.6010 mm) in thickness.
2. Plastic not less than 0.036 inch (0.9 mm) in thickness.
3. Other *approved* materials.

A plastic pan beneath a gas-fired water heater shall be constructed of material having a flame spread index of 25 or less and a *smoke-developed index* of 450 or less when tested in accordance with ASTM E84 or UL 723.

> **Exception:** Water heater(s) installed on concrete slab construction and located on the lowest floor or in a private garage.

**P2801.6.1 Pan size and drain.** The pan shall be not less than $1^1/_2$ inches (38 mm) deep and shall be of sufficient size and shape to receive dripping or condensate from the tank or water heater. The pan shall be drained by an indirect waste pipe of not less than ~~1inch~~ $^3/_4$ inch (19 mm) diameter. Piping for safety pan drains shall be of those materials indicated in Table P2906.5.

Where a pan drain was not previously ~~installed~~ required, a pan drain shall not be required for a replacement water heater installation.

**P2801.6.1.1** **Water Heater Located in a Pan**. Where Water Heater(s) are subject to water damage when drain pans fill, that portion of the Water Heater shall be installed above the rim of the pan. Supports located inside of the pan to support the appliance or equipment shall be water resistant and approved.

**P2801.6.2 Pan drain termination.** The pan drain shall extend full-size and terminate over a suitably located indirect waste receptor or shall extend to the exterior of the building and terminate not less than 6 inches (152 mm) and not more than 24 inches (610 mm) above the adjacent ground surface.

**P2801.7 Water heaters installed in garages.** Water heaters having an *ignition source* shall be elevated such that the source of ignition is not less than 18 inches (457 mm) above the garage floor. ~~Appliances shall be located or protected so that they are not subject to physical damage by a moving vehicle. The ignition source would apply to both electric and gas water heaters. The ignition source (not the bottom of the water heater) shall be elevated to minimum of 18 inches (457 mm) above the garage floor.~~

**Exception:** Elevation of the *ignition source* is not required for *appliances* that are *listed* as flammable vapor ignition-resistant. (FVIR)

**P2801.8 Water heater seismic bracing.** In *Seismic Design Categories* $D_0$, $D_1$ and $D_2$ and townhouses in Seismic Design Category C, water heaters shall be anchored or strapped in the upper one-third and in the lower one-third of the *appliance* to resist a horizontal force equal to one-third of the operating weight of the water heater, acting in any horizontal direction, or in accordance with the *appliance* manufacturer's recommendations.

**P2801.9 Rooms used as a plenum.**
Water heaters using solid, liquid or gas fuel shall not be installed in a room containing air-handling machinery where such room is used as a plenum.

**P2801.10 Water heaters installed in attics.**
Attics containing a water heater shall be provided with an opening and unobstructed passageway large enough to allow removal of the water heater. The passageway shall be not less than 30 inches (762 mm) in height and 22 inches (559 mm) in width and not more than 20 feet (6096 mm) in length when measured along the centerline of the passageway from the opening to the water heater. If 6 feet (1829 mm) of headroom is provided along the centerline of the passageway from the opening to the water heater, the length of the passageway is permitted to exceed 20 feet (6096 mm) in length. The passageway shall have continuous solid flooring not less than 24 inches (610 mm) in width. A level service space not less than 30 inches (762 mm) in length and 30 inches (762 mm) in width shall be present at the front or service side of the water heater. The clear access opening dimensions shall be not less than 20 inches by 30 inches (508 mm by 762 mm) where such dimensions are large enough to allow removal of the water heater.

**P2801.11 Installation in crawl spaces.**

Under-floor spaces containing appliances requiring access shall be provided with an access opening and unobstructed passageway large enough to remove the largest component of the appliance. The passageway shall not be less than 22 inches (559 mm) high and 36 inches (914 mm) wide, nor more than 20 feet (6096 mm) in length when measured along the centerline of the passageway from the opening to the equipment. A level service space not less than 30 inches (762 mm) deep and 30 inches (762 mm) wide shall be present at the front or service side of the appliance. If the depth of the passageway or the service space exceeds 12 inches (305mm) below the adjoining grade, the walls of the passageway shall be lined with concrete or masonry extending 4 inches (102 mm) above the adjoining grade and having sufficient lateral-bearing capacity to resist collapse. The clear access opening dimensions shall be a minimum of 22 inches by 30 inches (559 mm by 762 mm), where such dimensions are large enough to allow removal of the largest component of the appliance.

**Exceptions:**

1. The passageway is not required where the level service space is present when the access is open and the appliance is capable of being serviced and removed through the required opening.

2. Where the passageway is not less than 6 feet high (1829 mm) for its entire length, the passageway shall not be limited in length.

**P2801.12 Under-floor and exterior-grade installation.**

**P2801.12.1 Exterior-grade installations.**

Equipment and appliances installed above grade level shall be supported on a solid base or approved material a minimum of 2 inches (51 mm) thick.

**P2801.12.2 Under-floor installation.**

Suspended equipment shall be a minimum of 6 inches (152 mm) above the adjoining grade.

**P2801.12.3 Crawl space supports.**

The support shall be a minimum of a 2-inch (51 mm) thick solid base, 2-inch (51 mm) thick formed concrete, or stacked masonry units held in place by mortar or other approved method. The water heater shall be supported not less than 2 inches (51 mm) above grade.

**P2801.12.4 Drainage.**

Below-grade installations shall be provided with a natural drain or an automatic lift or sump pump. Existing installation that can be terminated outdoors must terminate outdoors. Where the installation is such that outdoor termination is impossible, indoor termination is allowable.

**P2801.13 Prohibited installations.**

Water heaters, (using solid, liquid or gas fuel) with the exception of those having direct vent systems, shall not be installed in bathrooms and bedrooms or in a closet with access only through a bedroom or bathroom. However, water heaters of the automatic storage type may be installed as replacement in a bathroom, when approved by the plumbing official, provided they are vented and supplied with adequate combustion air.

**Exception:** When a closet, having a weather-stripped solid door with an approved closing device, has been designed exclusively for the water heater and where all air for combustion and ventilation is supplied from outdoors.

## SECTION P2802
## SOLAR WATER HEATING SYSTEMS

**P2802.1 Water temperature control.** Where heated water is discharged from a solar thermal system to a hot water distribution system, a ~~thermostatic~~ <u>temperature-actuated</u> mixing valve complying with ASSE 1017 shall be installed to temper the water to a temperature of not greater than 140°F (60°C). Solar thermal systems supplying hot water for both space heating and domestic uses shall comply with Section P2803.2. A temperature-indicating device shall be installed to indicate the temperature of the water discharged from the outlet of the mixing valve. The ~~thermostatic~~ <u>temperature-actuated</u> mixing valve required by this section shall not be a substitute for water-temperature limiting devices required by Chapter 27 for specific fixtures.

**P2802.2 Isolation valves.** Isolation valves in accordance with Section P2903.9.2 shall be provided on the cold water feed to the water heater. Isolation valves and associated piping shall be provided to bypass solar storage tanks where the system contains multiple storage tanks.

## SECTION P2803 WATER HEATERS USED FOR SPACE HEATING

**P2803.1 Protection of potable water.** Piping and components connected to a water heater for space heating applications shall be suitable for use with potable water in accordance with Chapter 29. Water heaters that will be used to supply potable water shall not be connected to a heating system or components previously used with non-potable-water heating *appliances*. Chemicals for boiler treatment shall not be introduced into the water heater.

**P2803.2 Temperature control.** Where a combination water heater-space heating system requires water for space heating at temperatures exceeding 140°F (60°C), a ~~master thermostatic~~ temperature-actuated mixing valve complying with ASSE 1017 shall be installed to temper the water to a temperature of not greater than 140°F (60°C) for domestic uses.

## SECTION P2804 RELIEF VALVES

**P2804.1 Relief valves required.** *Appliances* and equipment used for heating water or storing hot water shall be protected by one of the following:

1. A separate pressure-relief valve and a separate temperature-relief valve.
2. A combination pressure-and-temperature relief valve.

**P2804.2 Rating.** Relief valves shall have a minimum rated capacity for the equipment served and shall conform to ANSI Z21.22.

**P2804.3 Pressure relief valves.** Pressure relief valves shall have a relief rating adequate to meet the pressure conditions for the *appliances* or equipment protected. In tanks, they shall be installed directly into a tank tapping or in a water line close to the tank. They shall be set to open at not less than 25 psi (172 kPa) above the system pressure and not greater than 150 psi (1034 kPa). The relief-valve setting shall not exceed the rated working pressure of the tank.

**P2804.4 Temperature relief valves.** Temperature relief valves shall have a relief rating compatible with the temperature conditions of the *appliances* or equipment protected. The valves shall be installed such that the temperature-sensing element monitors the water within the top 6 inches (152 mm) of the tank. The valve shall be set to open at a temperature of not greater than 210°F (99°C).

**P2804.5 Combination pressure-and-temperature relief valves.** Combination-pressure-and-temperature relief valves shall comply with the requirements for separate pressure and temperature relief valves.

**P2804.6 Installation of relief valves.** A check or shutoff valve shall not be installed in any of the following locations:

1. Between a relief valve and the termination point of the relief valve discharge pipe.
2. Between a relief valve and a tank.
3. Between a relief valve and heating *appliances* or equipment.

**P2804.6.1 Requirements for discharge pipe.** The discharge piping serving a pressure relief valve, temperature relief valve or combination valve shall:

1. Not be directly connected to the drainage system.

~~2. Discharge in the same room as the water heater either on the floor, into an indirect waste receptor or into a water heater pan.~~

~~a. Discharge through an *air gap* or air gap fitting to a remote termination point that is observable by the building occupants.~~

2. Discharge through an *air gap* located in the same room as the water heater.

3. Not be smaller than the diameter of the outlet of the valve served and shall discharge full size to the *air gap*.
4. Serve a single relief device and shall not connect to piping serving any other relief device or equipment.
5. Discharge to the floor, to the pan serving the water heater or storage tank, to a waste receptor or to the outdoors.
6. Discharge in a manner that does not cause personal injury or structural damage.

~~7. Deleted.~~

7. Discharge to a termination point that is readily observable by the building occupants.
8. Not be trapped.
9. Be installed to flow by gravity.
10. Terminate not more than 6 inches (152 mm) and not less than two times the discharge pipe diameter above the floor or waste receptor flood level rim.
11. Not have a threaded connection at the end of the piping.
12. Not have valves or tee fittings.
13. Be constructed of those materials indicated in Section P2906.5 or materials tested, rated and *approved* for such use in accordance with ASME A112.4.1.
14. The discharge pipe shall be clamped or otherwise supported with not less than one clamp or support within 12-inches (305 mm) of the point of discharge.

**P2804.7 Vacuum relief valve.** Bottom fed tank-type water heaters and bottom fed tanks connected to water heaters shall have a vacuum relief valve installed that complies with ANSI Z21.22.

**P2804.8 (501.9) Relief valve installation by manufacturer.**

The following is a reprint of GS 66-27.1, ~~"Certain automatic hot water tanks or heaters to have approved relief valves; installation or sale of unapproved relief valves forbidden."~~ "Safety Features of Hot Water Heaters."

a. No individual, firm, corporation or business shall install, sell or offer for sale any automatic hot water tank or heater of 120-gallon (454 L) capacity or less, except for a tankless water heater, which does not have installed thereon by the manufacturer of the tank or heater an American Society of Mechanical Engineers and National Board of Boiler and Pressure Vessel Inspectors approved type pressure-temperature relief valve set at or below the safe working pressure of the tank as indicated, and so labeled by the manufacturer's Identification stamped or cast upon the tank or heater or upon a plate secured to it.

b. No individual, firm, corporation or business shall install, sell or offer for sale any relief valve, whether it be pressure type, temperature type or pressure-temperature type, which does not carry the stamp of approval of the American Society of Mechanical Engineers and the National Board of Boiler and Pressure Vessel Inspectors.

The following is a reprint of GS 66-27.1A, "Water heater thermostat settings."

a. The thermostat of any new residential water heater offered for sale or lease for use in a single-family or multifamily dwelling in the State shall be preset by the manufacturer or installer no higher than approximately 120°F (49°C). A water heater reservoir temperature may be set higher if it is supplying space heaters that require higher temperatures. For purposes of this section, a water heater shall mean the primary source of hot water for any single-family or multifamily residential dwelling including, but not limited to any solar or other hot water heating systems.

b. Nothing in this section shall prohibit the occupant of a single-family or multiunit residential dwelling with an individual water heater from resetting or having reset the thermostat on the water heater. Any such resetting shall relieve the manufacturer or installer of the water heater and, in the case of a residential dwelling that is leased or rented, also the unit's owner, from liability for damages attributed to the resetting.

c. A warning tag or sticker shall be placed on or near the operating thermostat control of any residential water heater. This tag or sticker shall state that the thermostat settings above the preset temperature may cause severe burns. This tag or sticker may carry such other appropriate warnings as may be agreed upon by manufacturers, installers and other interested parties.

**P2804.9 (501.10) Fossil fuel equipment installation.**
The installation of the following equipment and systems shall comply with the *North Carolina Fuel Gas Code*:

a. Fuel piping for any fossil fuel-burning equipment.

b. Venting systems for fossil fuel-burning equipment which is part of the plumbing system.

## SECTION P2805 (503)
## CONNECTIONS

**P2805.1 Cold water line valve.**
The cold water *branch* line from the main water supply line to each hot water storage tank or water heater shall be provided with a valve, located within 3 feet (914 mm) of the equipment and serving only the hot water storage tank or water heater. The valve shall not interfere or cause a disruption of the cold water supply to the remainder of the cold water system. The valve shall be provided with *access* on the same floor level as the water heater served.

**P2805.2 Water circulation.**
The method of connecting a circulating water heater to the tank shall provide circulation of water through the water heater. The pipe or tubes required for the installation of appliances that will draw from the water heater or storage tank shall comply with the provisions of this code for material and installation. Installation shall comply with the manufacturer's instructions and the requirements of the *North Carolina Energy Conservation Code*.

## SECTION P2806
## SAFETY DEVICES

**P2806.1 Antisiphon devices.**
An *approved* means, such as a cold water "dip" tube with a hole at the top or a vacuum relief valve installed in the cold water supply line above the top of the heater or tank, shall be provided to prevent siphoning of any storage water heater or tank.

**P2806.2 Shutdown.**
A means for disconnecting an electric hot water supply system from its energy supply shall be provided in accordance with NFPA 70. A separate valve shall be provided to shut off the energy fuel supply to all other types of hot water supply systems**.**

## SECTION P2807
## INSULATION

**P2807.1 Unfired vessel insulation.**

Unfired hot water storage tanks shall be insulated to R-12.5 $(h \cdot ft^2 \cdot {}^\circ F)/Btu$ (R-2.2 $m^2 \cdot K/W$).

## SECTION P2808
## VEHICLE IMPACT PROTECTION

**P2808.1 General.** Equipment and appliances shall be installed as required by the terms of their approval, in accordance with the conditions of the listing, the manufacturer's installation instructions and this code. Manufacturer's installation instructions shall be available on the job site at the time of inspection.

**P2808.2 Protection from impact.** *Appliances* located in private garages and carports shall be installed with a minimum clearance of 6 feet (1829 mm) above the floor. *Appliances* located out of the normal path of travel are not required to be protected.

> **Exception:** The requirements of this section shall not apply where the appliances are protected from motor vehicle impact and installed in accordance with Figure P2808.1.

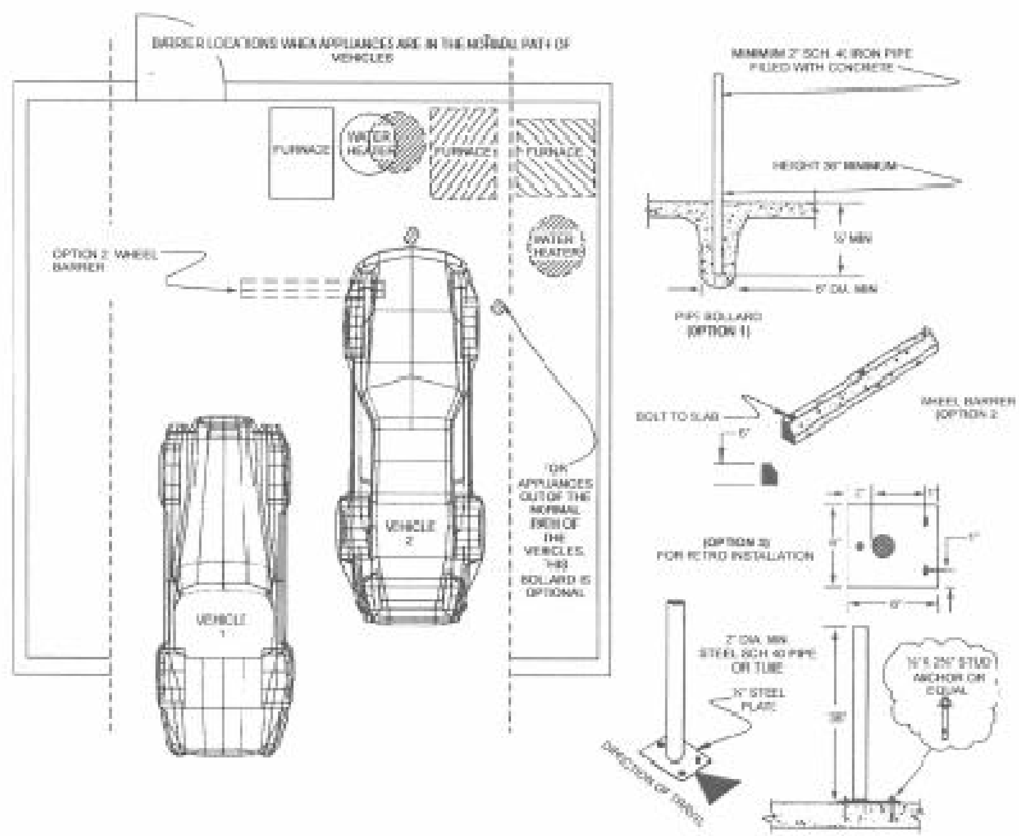



**Figure 2808.1**
**MOTOR VEHICLE IMPACT PROTECTION**

# CHAPTER 29
# WATER SUPPLY AND DISTRIBUTION

## SECTION P2901
## GENERAL

**P2901.1 Potable water required.** Potable water shall be supplied to plumbing fixtures and plumbing *appliances* except where treated rainwater, treated graywater or municipal reclaimed water is supplied to water closets, urinals and trap primers. The requirements of this section shall not be construed to require signage for water closets and urinals.

**P2901.2 Identification of non-potable water systems.** Where *non-potable* water systems are installed, the piping conveying the non-potable water shall be identified either by color marking, metal tags or tape in accordance with Sections P2901.2.1 through P2901.2.2.3.

**P2901.2.1 Signage required.** Non-potable water outlets such as hose connections, open-ended pipes and faucets shall be identified with signage that reads as follows: "Non-potable water is utilized for [application name]. CAUTION: NONPOTABLE WATER. DO NOT DRINK." The words shall be legibly and indelibly printed on a tag or sign constructed of corrosion-resistant waterproof material or shall be indelibly printed on the fixture. The letters of the words shall be not less than 0.5 inches (12.7 mm) in height and in colors in contrast to the background on which they are applied. In addition to the required wordage, the pictograph shown in Figure P2901.2.1 shall appear on the required signage.

**FIGURE P2901.2.1**

**PICTOGRAPH—DO NOT DRINK**

**(ADD FIGURE P2901.2.1 HERE)**

**P2901.2.2 Distribution pipe labeling and marking.** Non-potable distribution piping shall be: purple in color and embossed or integrally stamped or marked with the words, "CAUTION: NON-POTABLE WATER. DO NOT DRINK"; or installed with a purple identification tape or wrap. Pipe identification shall include the contents of the piping system and an arrow indicating the direction of flow. Hazardous piping systems shall contain information addressing the nature of the hazard. Pipe identification shall be repeated at intervals not exceeding 25 feet (7620 mm) and at each point where the piping passes through a wall, floor or roof. Lettering shall be readily observable within the room or space where the piping is located.

**P2901.2.2.1 Color.** The color of the pipe identification shall be discernable and consistent throughout the building. The color purple shall be used to identify reclaimed water, rainwater and graywater distribution systems.

**P2901.2.2.2 Lettering size.** The size of the background color field and lettering shall comply with Table P2901.2.2.2.

**TABLE P2901.2.2.2**
**SIZE OF PIPE IDENTIFICATION**

| PIPE DIAMETER (inches) | LENGTH OF BACKGROUND COLOR FIELD (inches) | SIZE OF LETTERS (inches) |
|---|---|---|
| $^3/_4$ to $1^1/_4$ | 8 | 0.5 |
| $1^1/_2$ to 2 | 8 | 0.75 |
| $2^1/_2$ to 6 | 12 | 1.25 |
| 8 to 10 | 2 | 2.5 |
| Over 10 | 32 | 3.5 |

For SI: 1 inch = 25.4 mm.

**P2901.2.2.3 Identification tape.** Where used, identification tape shall be not less than 3 inches (76 mm) wide and have white or black lettering on a purple field stating, "CAUTION: NONPOTABLE WATER—DO NOT DRINK." Identification tape shall be installed on top of non-potable rainwater distribution pipes and fastened not greater than every 10 feet (3048 mm) to each pipe length, and run continuously the entire length of the pipe.

**P2901.3 (608.10) Reuse of piping.**
Piping that has been utilized for any purpose other than conveying potable water shall not be utilized for conveying potable water.

## SECTION P2902
## PROTECTION OF POTABLE WATER SUPPLY

**P2902.1 General.** A potable water supply system shall be designed and installed as to prevent contamination from non-potable liquids, solids or gases being introduced into the potable water supply. Connections shall not be made to a potable water supply in a manner that could contaminate the water supply or provide a cross connection between the supply and a source of contamination except where *approved* backflow prevention assemblies, backflow prevention devices or other means or methods are installed to protect the potable water supply. Cross connections between an individual water supply and a potable public water supply shall be prohibited.

**P2902.2 Plumbing fixtures.** The supply lines and fittings for every plumbing fixture shall be installed so as to prevent backflow. Plumbing fixture fittings shall provide backflow protection in accordance with ASME A112.18.1/CSA B125.1.

**P2902.3 Backflow protection.** A means of protection against backflow shall be provided in accordance with Sections P2902.3.1 through P2902.3.7. Backflow prevention applications shall conform to Table P2902.3, except as specifically stated in Sections P2902.4 through P2902.5.5.

**TABLE P2902.3**

**APPLICATION FOR BACKFLOW PREVENTERS**

**(ADD TABLE P2902.3 HERE)**

**P2902.3.1 Air gaps.** *Air gaps* shall comply with ASME A112.1.2 and *air gap* fittings shall comply with ASME A112.1.3. An *air gap* shall be measured vertically from the lowest end of a water outlet to the flood level rim of the fixture or receptor into which the water outlets discharges to the floor. The required *air gap* shall be not less than twice the diameter of the effective opening of the outlet and not less than the values specified in Table P2902.3.1.

**TABLE P2902.3.1**

**MINIMUM AIR GAPS (ADD TABLE HERE)**

**P2902.3.2 Atmospheric-type vacuum breakers.** Atmospheric-type vacuum breakers shall conform to ASSE 1001 or CSA B64.1.1. Hose-connection vacuum breakers shall conform to ASSE 1011, ASSE 1019, ASSE 1035, ASSE 1052, CSA B64.2, CSA B64.2.1, CSA B64.2.1.1, CSA B64.2.2 or CSA B64.7. Both types of vacuum breakers shall be installed with the outlet continuously open to the atmosphere. The critical level of the atmospheric vacuum breaker shall be set at not less than 6 inches (152 mm) above the highest elevation of downstream piping and the flood level rim of the fixture or device.

**P2902.3.3 Backflow preventer with intermediate atmospheric vent.** Backflow preventers with intermediate atmospheric vents shall conform to ASSE 1012, ASSE 1081 or CSA B64.3. These devices shall be permitted to be installed where subject to continuous pressure conditions. These devices shall be prohibited as a means of protection where any hazardous chemical additives are introduced downstream of the device. The relief opening shall discharge by *air gap* and shall be prevented from being submerged.

**P2902.3.4 Pressure vacuum breaker assemblies.** Pressure vacuum breaker assemblies shall conform to ASSE 1020 or CSA B64.1.2. Spill-resistant vacuum breaker assemblies shall comply with ASSE 1056. These assemblies are designed for installation under continuous pressure conditions where the critical level is installed at the required height. The critical level of a pressure vacuum breaker and a spill-resistant vacuum breaker assembly shall be set at not less than 12 inches (304 mm) above the highest elevation of downstream piping and the flood level rim of the fixture or device. Pressure vacuum breaker assemblies shall not be installed in locations where spillage could cause damage to the structure.

**P2902.3.5 Reduced pressure principle backflow prevention assemblies.** Reduced pressure principle backflow prevention assemblies and reduced pressure principle fire protection backflow prevention assemblies shall conform to ASSE 1013, AWWA C511, CSA B64.4 or CSA B64.4.1. Reduced pressure detector fire protection backflow prevention assemblies shall conform to ASSE 1047. These devices shall be permitted to be installed where subject to continuous pressure conditions. The relief opening shall discharge by *air gap* and shall be prevented from being submerged.

**P2902.3.6 Double-check backflow prevention assemblies.** Double-check backflow prevention assemblies shall conform to ASSE 1015, AWWA C510, CSA B64.5 or CSA B64.5.1. Double-check detector fire protection backflow prevention assemblies shall conform to ASSE 1048. These assemblies shall be capable of operating under continuous pressure conditions.

**P2902.3.7 Dual check backflow preventer.** Dual check backflow preventers shall conform with ASSE 1024 or CSA B64.6.

**P2902.4 Protection of potable water outlets.** Potable water openings and outlets shall be protected by an *air gap*, a reduced pressure principle backflow prevention assembly, an atmospheric vent, an atmospheric-type vacuum breaker, a pressure-type vacuum breaker assembly or a hose connection backflow preventer.

**P2902.4.1 Fill valves.** Flush tanks shall be equipped with an antisiphon fill valve conforming to ASSE 1002/ASME A112.1002/CSA B125.12 or CSA B125.3. The critical level of the fill valve shall be located not less than 1 inch (25 mm) above the top of the flush tank overflow pipe.

**P2902.4.2 Deck-mounted and integral vacuum breakers.** *Approved* deck-mounted or equipment-mounted vacuum breakers and faucets with integral atmospheric vacuum breakers or spill-resistant vacuum breaker assemblies shall be installed in accordance with the manufacturer's instructions and the requirements for labeling. The critical level of the breakers and assemblies shall be located at not less than 1 inch (25 mm) above the *flood level rim*.

**P2902.4.3 Hose connection.** Sillcocks, hose bibbs, wall hydrants and other openings with a hose connection shall be protected by an atmospheric-type or pressure-type vacuum breaker, a pressure vacuum-breaker assembly or a permanently attached hose connection vacuum breaker.

**Exceptions:**

1. This section shall not apply to water heater and boiler drain valves that are provided with hose connection threads and that are intended only for tank or vessel draining.
2. This section shall not apply to water supply valves intended for connection of clothes washing machines where backflow prevention is otherwise provided or is integral with the machine.

**P2902.5 Protection of potable water connections.** Connections to the potable water shall conform to Sections P2902.5.1 through P2902.5.5.

**P2902.5.1 Connections to boilers.** Where chemicals will not be introduced into a boiler, the potable water supply to the boiler shall be protected from the boiler by a backflow preventer with an intermediate atmospheric vent complying with ASSE 1012 or CSA B64.3. Where chemicals will be introduced into a boiler, the potable water supply to the boiler shall be protected from the boiler by an *air gap* or a reduced pressure principle backflow prevention assembly complying with ASSE 1013, AWWA C511 or CSA B64.4.

**P2902.5.2 Heat exchangers.** Heat exchangers using an essentially toxic transfer fluid shall be separated from the potable water by double-wall construction. An *air gap* open to the atmosphere shall be provided between the two walls. Single-wall construction heat exchangers shall be used only where an *essentially nontoxic transfer fluid* is utilized.

**P2902.5.3 Lawn irrigation systems.** The potable water supply to lawn irrigation systems shall be protected against backflow by an atmospheric vacuum breaker, a pressure vacuum-breaker assembly or a reduced pressure principle backflow prevention assembly. Valves shall not be installed downstream from an atmospheric vacuum breaker.

Where chemicals are introduced into the system, the potable water supply shall be protected against backflow by a reduced pressure principle backflow prevention assembly.

**P2902.5.4 Connections to automatic fire sprinkler systems.** The potable water supply to automatic fire sprinkler systems shall be protected against backflow by a double-check backflow prevention assembly, a double-check fire protection backflow prevention assembly, a reduced pressure principle backflow prevention assembly or a reduced pressure principle fire protection backflow prevention assembly.

**Exception:** ~~Where systems are installed as a portion of the water distribution system in accordance with the requirements of this code and are not provided with a fire department connection, backflow protection for the water supply system shall not be required.~~ Where sprinkler systems are installed in accordance with Section P2904.1, backflow protection for the water supply system shall not be required.

**P2902.5.4.1 Additives or non-potable source.** Where systems contain chemical additives or antifreeze, or where systems are connected to a non-potable secondary water supply, the potable water supply shall be protected against backflow by a reduced pressure principle backflow prevention assembly or a reduced pressure principle fire protection backflow prevention assembly. Where chemical additives or antifreeze is added to only a portion of an automatic fire sprinkler or standpipe system, the reduced pressure principle fire protection backflow preventer shall be permitted to be located so as to isolate that portion of the system.

**P2902.5.5 Solar thermal systems.** Where a solar thermal system heats potable water to supply a potable hot water distribution or any other type of heating system, the solar thermal system shall be in accordance with Section P2902.5.5.1, P2902.5.5.2 or P2902.5.5.3 as applicable. Solar energy systems used for heating potable water or using an independent medium for heating potable water shall comply with the applicable requirements of this code. The use of solar energy shall not compromise the requirements for cross connection or protection of the potable water supply system required by this code.

**P2902.5.5.1 Indirect systems.** Water supplies of any type shall not be connected to the solar heating loop of an indirect solar thermal hot water heating system. This requirement shall not prohibit the presence of inlets or outlets on the solar heating loop for the purposes of servicing the fluid in the solar heating loop.

**P2902.5.5.2 Direct systems for potable water distribution systems.** Where a solar thermal system directly heats potable water for a potable water distribution system, the pipe, fittings, valves and other components that are in contact with the potable water in the system shall comply with the requirements of Chapter 29.

**P2902.5.5.3 Direct systems for other than potable water distribution systems.** Where a solar thermal system directly heats water for a system other than a potable water distribution system, a potable water supply connected to such system shall be protected by a backflow preventer with an intermediate atmospheric vent complying with ASSE 1012. Where a solar thermal system directly heats chemically treated water for a system other than a potable water distribution system, a potable water supply connected to such system shall be protected by a reduced pressure principle backflow prevention assembly complying with ASSE 1013.

**P2902.6 Location of backflow preventers.** Access shall be provided to backflow preventers as specified by the manufacturer's installation instructions.

**P2902.6.1 Outdoor enclosures for backflow prevention devices.** Outdoor enclosures for backflow prevention devices shall comply with ASSE 1060.

**P2902.6.2 Protection of backflow preventers.** Backflow preventers shall not be located in areas subject to freezing except where they can be removed by means of unions, or are protected by heat, insulation or both.

**P2902.6.3 Relief port piping.** The indirect waste receptor and drainage piping shall be sized to drain the maximum discharge flow rate from the relief port as published by the backflow preventer manufacturer. The termination of the piping from the relief port or air gap fitting of the backflow preventer shall discharge to an *approved* indirect waste receptor or to the outdoors where it will not cause damage or create a nuisance.

## SECTION P2903
## WATER SUPPLY SYSTEM

**P2903.1 Water supply system design criteria.** The water service and water distribution systems shall be designed and sized for peak demand using values shown in Table P2903.1.

TABLE P2903.1

REQUIRED CAPACITIES AT POINT OF OUTLET DISCHARGE (ADD TABLE HERE)

**P2903.2 Maximum flow and water consumption.** The maximum water consumption flow rates and quantities for plumbing fixtures and fixture fittings shall be in accordance with Table P2903.2.

TABLE P2903.2 (Add Table Here)

MAXIMUM FLOW RATES AND CONSUMPTION FOR PLUMBING FIXTURES AND FIXTURE FITTINGS

**P2903.3 Minimum pressure.** Where the water pressure supplied by the public water main or an individual water supply system is insufficient to provide for the minimum pressures and quantities for the plumbing fixtures in the building, the pressure shall be increased by means of an elevated water tank, a hydropneumatic pressure booster system or a water pressure booster pump.

**P2903.3.1 Pumps handling drinking water.** Pumps intended to supply drinking water shall conform to NSF 61.

**P2903.3.2 Maximum pressure.** The static water pressure shall be not greater than 80 psi (551 kPa). Where the main pressure exceeds 80 psi (551 kPa), an *approved* pressure-reducing valve conforming to ASSE 1003 or CSA B356 shall be installed on the domestic water branch main or riser at the connection to the water service pipe.

**Exception:** Service lines to sill cocks and outside hydrants when equipped with a shutoff valve.

**P2903.4 Thermal expansion control.** A means for controlling increased pressure caused by thermal expansion shall be installed where required in accordance with Sections P2903.4.1 and P2903.4.2.

**P2903.4.1 Pressure-reducing valve.** For water service system sizes up to and including 2 inches (51 mm), a device for controlling pressure shall be installed where, because of thermal expansion, the pressure on the downstream side of a pressure-reducing valve exceeds the pressure-reducing valve setting.

**P2903.4.2 Backflow prevention device or check valve.** Where a backflow prevention device, check valve or other device is installed on a water supply system using storage water heating equipment such that thermal expansion causes an increase in pressure, a device for controlling pressure shall be installed.

**P2903.5 Water hammer.** The flow velocity of the water distribution system shall be controlled to reduce the possibility of water hammer. ~~A water-hammer arrestor shall be installed where quick-closing valves example: clothes washers, dishwashers, ice makers) and metallic piping are used. The water hammer arrestor shall not be required on any valves where plastic pipe is used for water distribution piping.~~ A water-hammer arrestor shall be installed where quick-closing valves are utilized for clothes washers, dishwashers, ice makers, or similar applications. Water-hammer arrestors shall be installed in accordance with the manufacturer's instructions. Water-hammer arrestors shall conform to ASSE 1010.

**P2903.6 Determining water supply fixture units.** Supply loads in the building water distribution system shall be determined by total load on the pipe being sized, in terms of water supply fixture units (w.s.f.u.), as shown in Table P2903.6, and gallon per minute (gpm) flow rates [see Table P2903.6(1)]. For fixtures not listed, choose a w.s.f.u. value of a fixture with similar flow characteristics.

TABLE P2903.6 (Add Table Here)

WATER SUPPLY FIXTURE UNIT VALUES FOR VARIOUS PLUMBING FIXTURES AND FIXTURE GROUPS

TABLE P2903.6(1) (Add Table Here)

CONVERSIONS FROM WATER SUPPLY FIXTURE UNIT TO GALLON PER MINUTE FLOW RATES

**P2903.7 Size of water-service mains, branch mains and risers.** The size of the water service pipe shall be not less than $^{3}/_{4}$ inch (19 mm) diameter. The size of water service mains, branch mains and risers shall be determined from the water supply demand [gpm (L/m)], available water pressure [psi (kPa)] and friction loss caused by the water meter and *developed length* of pipe [feet (m)], including *equivalent length* of fittings. The size of each water distribution system shall be determined according to design methods conforming to acceptable engineering practice, such as those methods in Appendix P and shall be *approved* by the *building official.*

**P2903.8 Gridded and parallel water distribution systems.** Hot water and cold water manifolds installed with parallel-connected individual distribution lines and cold water manifolds installed with gridded distribution lines to each fixture or fixture fitting shall be designed in accordance with Sections P2903.8.1 through P2903.8.5. Gridded systems for hot water distribution systems shall be prohibited.

**P2903.8.1 Sizing of manifolds.** Manifolds shall be sized in accordance with Table P2903.8.1. Total gallons per minute is the demand for all outlets.

**TABLE P2903.8.1**

**MANIFOLD SIZING[a]**

| PLASTIC | | METALLIC | |
|---|---|---|---|
| Nominal Size ID (inches) | Maximum[b] gpm | Nominal Size ID (inches) | Maximum[b] gpm |
| $^{3}/_{4}$ | 17 | $^{3}/_{4}$ | 11 |
| 1 | 29 | 1 | 20 |
| $1^{1}/_{4}$ | 46 | $1^{1}/_{4}$ | 31 |
| $1^{1}/_{2}$ | 66 | $1^{1}/_{2}$ | 44 |

For SI: 1 inch = 25.4 mm, 1 gallon per minute = 3.785 L/m, 1 foot per second = 0.3048 m/s.
a. See Table P2903.6 for w.s.f.u and Table P2903.6(1) for gallon-per-minute (gpm) flow rates.
b. Based on velocity limitation: plastic, 12 feet per second; metal, 8 feet per second.

**P2903.8.2 Minimum size.** Where the *developed length* of the distribution line is 60 feet (18 288 mm) or less, and the available pressure at the meter is not less than 40 pounds per square inch (276 kPa), the size of individual distribution lines shall be not less than $^{3}/_{8}$ inch (10 mm) diameter. Certain fixtures such as one-piece water closets and whirlpool bathtubs shall require a larger size where specified by the manufacturer. ~~If~~ Where a water heater is fed from the end of a cold water manifold, the manifold shall be one size larger than the water heater feed.

**P2903.8.3 Support and protection.** Plastic piping bundles shall be secured in accordance with the manufacturer's instructions and supported in accordance with Section P2605. Bundles that have a change in direction equal to or greater than 45 degrees (0.79 rad) shall be protected from chafing at the point of contact with framing members by sleeving or wrapping.

**P2903.8.4 Valving.** Fixture valves, when installed, shall be located either at the fixture or at the manifold. Valves installed at the manifold shall be *labeled* indicating the fixture served.

**P2903.8.5 Hose bibb bleed.** A *readily accessible* air bleed shall be installed in hose bibb supplies at the manifold or at the hose bibb exit point.

**P2903.9 Valves.** Valves shall be installed in accordance with Sections P2903.9.1 through P2903.9.5.

~~**P2903.9.1 Service valve.** Each *dwelling unit* shall be provided with an accessible main shutoff valve near the entrance of the water service. The valve shall be of a full open type having nominal restriction to flow, with provision for drainage such as a bleed orifice or installation of a separate drain valve.~~

**P2903.9.1 Service valve.** Each *dwelling unit* shall be provided with an accessible main shutoff valve located either inside or outside the dwelling within 5 feet (1524 mm) of the foundation wall in a readily accessible valve box, in the crawl space within 3 feet (914 mm) of the crawl space access door or within the dwelling in a location where it may be accessed without the use of a ladder or a tool. The valve shall be of a full-open type having nominal restriction to flow, with provision for drainage such as a bleed orifice or installation of a separate drain valve.

**P2903.9.2 Water heater valve.** A *readily accessible* full-open valve shall be installed in the cold-water supply pipe to each water heater within 3 feet (914 mm) the water heater. The valve shall not interfere or cause a disruption of the cold water supply to the remainder of the cold water system. The valve shall be provided with *access* on the same floor level as the water heater served.

**P2903.9.3 Fixture valves and access.** Shutoff valves shall be required on each fixture supply pipe to each plumbing *appliance* and to each plumbing fixture other than bathtubs and showers. Valves serving individual plumbing fixtures, *plumbing appliances,* risers and branches shall be accessible.

**P2903.9.4 Valve requirements.** Valves shall be compatible with the type of piping material installed in the system. Valves shall conform to one of the standards ~~listed~~ indicated in Table P2903.9.4 or shall be *approved*. Valves intended to supply drinking water shall meet the requirements of NSF 61.

**TABLE P2903.9.4 (Add Table Here)**

**VALVES**

**P2903.9.5 Valves and outlets prohibited below grade.** Potable water outlets and combination stop-and-waste valves shall not be installed underground or below grade. Freezeproof yard hydrants that drain the riser into the ground are considered to be stop-and-waste valves.

**Exception:** Installation of freezeproof yard hydrants that drain the riser into the ground shall be permitted if the potable water supply to such hydrants is protected upstream of the hydrants in accordance with Section P2902 and the hydrants are permanently identified as non-potable outlets by *approved* signage that reads, "CAUTION, NON-POTABLE WATER. DO NOT DRINK."

**P2903.10 Hose bibb.** Hose bibbs subject to freezing, including the "frost-proof" type, shall be equipped with an accessible stop-and-waste-type valve inside the building so that they can be controlled and drained during cold periods.

**Exception:** Frostproof hose bibbs installed such that the stem extends through the building insulation into an open heated or *semi-conditioned space* need not be separately valved (see Figure P2903.10).

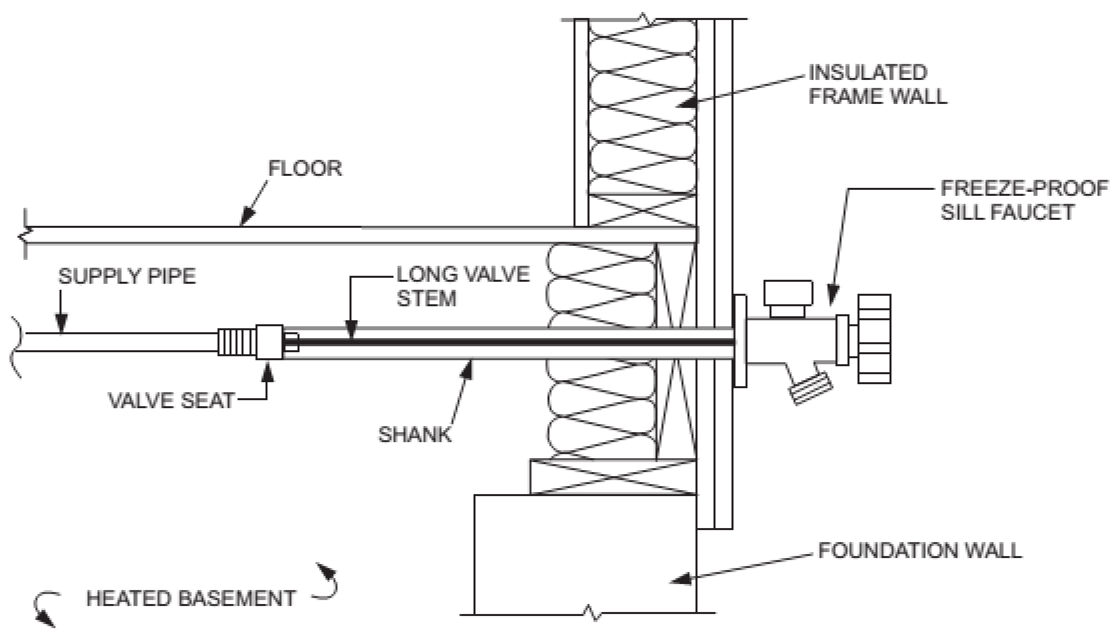



**FIGURE P2903.10**
**TYPICAL FROSTPROOF HOSE BIBB INSTALLATION NOT REQUIRING SEPARATE VALVE**

**P2903.11 Drain water heat recovery units.** Drain water heat recovery units shall be in accordance with Section ~~N1103.5.4~~ N1103.5.3.

## SECTION P2904
## DWELLING UNIT FIRE SPRINKLER SYSTEMS

**P2904.1 General.** The design and installation of residential fire sprinkler systems shall be in accordance with NFPA 13D or Section P2904, which shall be considered to be equivalent to NFPA 13D. Partial residential sprinkler systems shall be permitted to be installed only in buildings not required to be equipped with a residential sprinkler system. Section P2904 shall apply to stand-alone and multipurpose wet-pipe sprinkler systems that do not include the use of antifreeze. A multipurpose fire sprinkler system shall provide domestic water to both fire sprinklers and plumbing fixtures. A stand-alone sprinkler system shall be separate and independent from the water distribution system. A backflow preventer shall not be required to separate a sprinkler system from the water distribution system, provided that the sprinkler system complies with all of the following:

1. The system complies with NFPA 13D or Section P2904.
2. The piping material complies with Section P2906.
3. The system does not contain antifreeze.
4. The system does not have a fire department connection.

**P2904.1.1 Required sprinkler locations.** Sprinklers shall be installed to protect all areas of a *dwelling unit*.

**Exceptions:**

1. *Attics*, crawl spaces and normally unoccupied concealed spaces that do not contain fuel-fired *appliances* do not require sprinklers. In *attics*, crawl spaces and normally unoccupied concealed spaces that contain fuel-fired equipment, a sprinkler shall be installed above the equipment; however, sprinklers shall not be required in the remainder of the space.
2. Clothes closets, linen closets and pantries not exceeding 24 square feet (2.2 $m^2$) in area, with the smallest dimension not greater than 3 feet (915 mm) and having wall and ceiling surfaces of gypsum board.
3. Bathrooms not more than 55 square feet (5.1 $m^2$) in area.
4. Garages; carports; exterior porches; unheated entry areas, such as mud rooms, that are adjacent to an exterior door; and similar areas.

**P2904.2 Sprinklers.** Sprinklers shall be new *listed* residential sprinklers and shall be installed in accordance with the sprinkler manufacturer's instructions.

**P2904.2.1 Temperature rating and separation from heat sources.** Except as provided for in Section P2904.2.2, sprinklers shall have a temperature rating of not less than 135°F (57°C) and not more than ~~170F~~ 225°F (107°C). Sprinklers shall be separated from heat sources as required by the sprinkler manufacturer's installation instructions.

**P2904.2.2 Intermediate temperature sprinklers.** Sprinklers shall have an intermediate temperature rating not less than 175°F (79°C) and not more than 225°F (107°C) where installed in the following locations:

1. Directly under skylights, where the sprinkler is exposed to direct sunlight.
2. In *attics*.
3. In concealed spaces located directly beneath a roof.
4. Within the distance to a heat source as specified in Table P2904.2.2.

**TABLE P2904.2.2 (Add Table Here)**

**LOCATIONS WHERE INTERMEDIATE TEMPERATURE SPRINKLERS ARE REQUIRED**

**P2904.2.3 Freezing areas.** ~~Piping shall be protected from freezing as required by Section P2603.5. Where sprinklers are required in areas that are subject to freezing, dry-sidewall or dry-pendent sprinklers extending from a nonfreezing area into a freezing area shall be installed.~~ Piping shall be protected from freezing as required by Section P2603.5 or by using one of the following:

1. A dry-pipe automatic sprinkler system that is listed for residential occupancy applications.

2. Dry-sidewall or dry-pendent sprinklers extending from a nonfreezing area into a freezing area.

**P2904.2.4 Sprinkler coverage.** Sprinkler coverage requirements and sprinkler obstruction requirements shall be in accordance with Sections P2904.2.4.1 and P2904.2.4.2.

**P2904.2.4.1 Coverage area limit.** The area of coverage of a single sprinkler shall not exceed 400 square feet (37 $m^2$) and shall be based on the sprinkler *listing* and the sprinkler manufacturer's installation instructions.

**P2904.2.4.2 Obstructions to coverage.** Sprinkler discharge shall not be blocked by obstructions unless additional sprinklers are installed to protect the obstructed area. Additional sprinklers shall not be required where the sprinkler separation from obstructions complies with either the minimum distance indicated in Figure P2904.2.4.2 or the minimum distances specified in the sprinkler manufacturer's instructions where the manufacturer's instructions permit a lesser distance.

**P2904.2.4.2 (Add Figure Here)**

**MINIMUM ALLOWABLE DISTANCE BETWEEN SPRINKLER AND OBSTRUCTION**

**P2904.2.4.2.1 Additional requirements for pendent sprinklers.** Pendent sprinklers within 3 feet (915 mm) of the center of a ceiling fan, surface-mounted ceiling luminaire or similar object shall be considered to be obstructed, and additional sprinklers shall be installed.

**P2904.2.4.2.2 Additional requirements for side-wall sprinklers.** Sidewall sprinklers within 5 feet (1524 mm) of the center of a ceiling fan, surface-mounted ceiling luminaire or similar object shall be considered to be obstructed, and additional sprinklers shall be installed.

**P2904.2.5 Sprinkler installation on systems assembled with solvent cement.** The solvent cementing of threaded adapter fittings shall be completed and threaded adapters for sprinklers shall be verified as being clear of excess cement prior to the installation of sprinklers on systems assembled with solvent cement.

**P2904.2.6 Sprinkler modifications prohibited.** Painting, caulking or modifying of sprinklers shall be prohibited. Sprinklers that have been painted, caulked, modified or damaged shall be replaced with new sprinklers.

**P2904.3 Sprinkler piping system.** Sprinkler piping shall be supported in accordance with requirements for cold water distribution piping. Sprinkler piping shall comply with the requirements for cold water distribution piping. For multipurpose piping systems, the sprinkler piping shall connect to and be a part of the cold water distribution piping system.

**Exception:** For plastic piping, it shall be permissible to follow the manufacturer's installation instructions.

**P2904.3.1 Nonmetallic pipe and tubing.** Nonmetallic pipe and tubing, such as CPVC, PEX, and PE-RT shall be *listed* for use in residential fire sprinkler systems.

**P2904.3.1.1 Nonmetallic pipe protection.** Nonmetallic pipe and tubing systems shall be protected from exposure to the living space by a layer of not less than $^3/_8$-inch-thick (9.5 mm) gypsum wallboard, $^1/_2$-inch-thick (13 mm) plywood, or other material having a 15-minute fire rating.

**Exceptions:**

1. Pipe protection shall not be required in areas that do not require protection with sprinklers as specified in Section P2904.1.1.
2. Pipe protection shall not be required where exposed piping is permitted by the pipe *listing.*

**P2904.3.2 Shutoff valves prohibited.** With the exception of shutoff valves for the entire water distribution system or a single master control valve for the automatic sprinkler system that is locked in the open position, valves shall not be installed in any location where the valve would isolate piping serving one or more sprinklers.

**P2904.3.3 Single dwelling limit.** Piping beyond the service valve located at the beginning of the water distribution system shall not serve more than one *dwelling*.

**P2904.3.4 Drain.** A means to drain the sprinkler system shall be provided on the system side of the water distribution shutoff valve.

**P2904.4 Determining system design flow.** The flow for sizing the sprinkler piping system shall be based on Sections P2904.4.1 and P2904.4.2.

**P2904.4.1 Determining required flow rate for each sprinkler.** The minimum required flow for each sprinkler shall be determined using the sprinkler manufacturer's published data for the specific sprinkler model based on all of the following:

1. The area of coverage.
2. The ceiling configuration, in accordance with Sections P2904.4.1.1 through P2904.4.1.3.
3. The temperature rating.
4. Any additional conditions specified by the sprinkler manufacturer.

**P2904.4.1.1 Ceiling configurations.** Manufacturer's published flow rates for sprinklers tested under a ceiling 8 feet (2438 mm) in height, in accordance with the sprinkler listing, shall be used for the following ceiling configurations, provided that the ceiling surface does not have significant irregularities, lumps or indentations and is continuous in a single plane.

1. Ceilings that are horizontal or that have a slope not exceeding 8 units vertical in 12 units horizontal (67 percent), without beams, provided that the ceiling height, measured to the highest point, does not exceed 24 feet (7315 mm) above the floor. Where the slope exceeds 2 units vertical in 12 units horizontal (17 percent), the highest sprinkler installed along the sloped portion of a ceiling shall be positioned above all communicating openings connecting the sloped ceiling compartment with an adjacent space.
2. Ceilings that are horizontal or that have a slope not exceeding 8 units vertical in 12 units horizontal (67 percent), with beams, provided that the ceiling height, measured to the highest point, does not exceed 24 feet (7315 mm) above the floor. Beams shall not exceed 14 inches (350 mm) in depth, and pendent sprinklers shall be installed under the beams as described at the end of this section. The compartment containing the beamed ceiling shall not exceed 600 square feet (56 $m^2$) in area. Where the slope does not exceed 2 units vertical in 12 units horizontal (17 percent), the highest sprinkler in the compartment shall be above all communicating openings connecting the compartment with an adjacent space. Where the slope exceeds 2 units vertical in 12 units horizontal (17 percent), the highest sprinkler installed along the sloped portion of a ceiling shall be positioned above all communicating openings connecting the sloped ceiling compartment with an adjacent space.
3. Ceilings that have a slope exceeding 2 units vertical in 12 units horizontal (17 percent) but not exceeding 8 units vertical in 12 units horizontal (67 percent), with beams of any depth, provided that the ceiling height, measured to the highest point, does not exceed 24 feet (7315 mm) above the floor. Sidewall or pendent sprinklers shall be installed in each pocket formed by beams. The compartment containing the sloped, beamed ceiling shall not exceed 600 square feet (56 $m^2$) in area.

Pendent, recessed pendent and flush-type pendent sprinklers installed directly under a beam having a maximum depth of 14 inches (356 mm) shall have the sprinkler deflector located not less than 1 inch (25 mm) or more than 2 inches (51 mm) below the bottom of the beam. Pendent sprinklers installed adjacent to the bottom of a beam having a maximum depth of 14 inches (356 mm) shall be positioned such that the vertical centerline of the sprinkler is not more than 2 inches (51 mm) from the edge of the beam, with the sprinkler deflector located not less than 1 inch (25 mm) or more than 2 inches (51 mm) below the bottom of the beam. Pendent sprinklers shall also be permitted to be installed less than 1 inch (25 mm) below the bottom of a beam where in accordance with manufacturer's instructions for installation of flush sprinklers.

**P2904.4.1.2 Ceiling configurations with special sprinkler listings.** For ceiling configurations not specified in Section 2904.4.1.1, the manufacturer's published flow rate for sprinklers that have been listed for protection of such configurations shall be used.

**P2904.4.1.3 Other ceiling configurations.** For ceiling configurations not addressed by Section P2904.4.1.1 or P2904.4.1.2, the flow rate shall be subject to approval by the building official.

**P2904.4.2 System design flow rate.** The design flow rate for the system shall be based on the following:

1. The design flow rate for a room having only one sprinkler shall be the flow rate required for that sprinkler, as determined by Section P2904.4.1.
2. The design flow rate for a room having two or more sprinklers shall be determined by identifying the sprinkler in that room with the highest required flow rate, based on Section P2904.4.1, and multiplying that flow rate by 2.
3. Where the sprinkler manufacturer specifies different criteria for ceiling configurations that are not smooth, flat and horizontal, the required flow rate for that room shall comply with the sprinkler manufacturer's instructions.

4. The design flow rate for the sprinkler system shall be the flow required by the room with the largest flow rate, based on Items 1, 2 and 3.
5. For the purpose of this section, it shall be permissible to reduce the design flow rate for a room by subdividing the space into two or more rooms, where each room is evaluated separately with respect to the required design flow rate. Each room shall be bounded by walls and a ceiling. Openings in walls shall have a lintel not less than 8 inches (203 mm) in depth and each lintel shall form a solid barrier between the ceiling and the top of the opening.

**P2904.5 Water supply.** The water supply shall provide not less than the required design flow rate for sprinklers in accordance with Section P2904.4.2 at a pressure not less than that used to comply with Section P2904.6.

**P2904.5.1 Water supply from individual sources.** Where a *dwelling unit* water supply is from a tank system, a private well system or a combination of these, the available water supply shall be based on the minimum pressure control setting for the pump.

**P2904.5.2 Required capacity.** The water supply shall have the capacity to provide the required design flow rate for sprinklers for a period of time as follows:

1. Seven minutes for *dwelling units* one *story* in height and less than 2,000 square feet (186 $m^2$) in area.
2. Ten minutes for *dwelling units* two or more stories in height or equal to or greater than 2,000 square feet (186 $m^2$) in area.

Where a well system, a water supply tank system or a combination thereof is used, any combination of well capacity and tank storage shall be permitted to meet the capacity requirement.

**P2904.6 Pipe sizing.** The piping to sprinklers shall be sized for the flow required by Section P2904.4.2. The flow required to supply the plumbing fixtures shall not be required to be added to the sprinkler design flow.

**P2904.6.1 Method of sizing pipe.** Piping supplying sprinklers shall be sized using the prescriptive method in Section P2904.6.2 or by hydraulic calculation in accordance with NFPA 13D. The minimum pipe size from the water supply source to any sprinkler shall be $^3/_4$ inch (19 mm) nominal. Threaded adapter fittings at the point where sprinklers are attached to the piping shall be not less than $^1/_2$ inch (13 mm) nominal.

**P2904.6.2 Prescriptive pipe sizing method.** Pipe shall be sized by determining the available pressure to offset friction loss in piping and identifying a piping material, diameter and length using the equation in Section P2904.6.2.1 and the procedure in Section P2904.6.2.2.

**TABLE P2904.6.2(1) (Add Table Here)**

**WATER SERVICE PRESSURE LOSS (*PLsvc*)a, b**

**TABLE P2904.6.2(2) (Add Table Here)**

**MINIMUM WATER METER PRESSURE LOSS (*PLm*)a**

**TABLE P2904.6.2(3) (Add Table Here)**

**ELEVATION LOSS (*PLe*)**

**TABLE P2904.6.2(4) (Add Table Here)**

**ALLOWABLE PIPE LENGTH FOR 3/4-INCH TYPE M COPPER WATER TUBING**

**TABLE P2904.6.2(5) (Add Table Here)**

**ALLOWABLE PIPE LENGTH FOR 1-INCH TYPE M COPPER WATER TUBING**

**TABLE P2904.6.2(6) (Add Table Here)**

**ALLOWABLE PIPE LENGTH FOR 3/4-INCH CPVC PIPE**

**TABLE P2904.6.2(7) (Add Table Here)**
**ALLOWABLE PIPE LENGTH FOR 1-INCH CPVC PIPE**

**TABLE P2904.6.2(8) (Add Table Here)**
**ALLOWABLE PIPE LENGTH FOR 3/4-INCH PEX AND PE-RT TUBING**

**TABLE P2904.6.2(9) (Add Table Here)**
**ALLOWABLE PIPE LENGTH FOR 1-INCH PEX AND PE-RT TUBING**

**P2904.6.2.1 Available pressure equation.** The pressure available to offset friction loss in the interior piping system ($P_t$) shall be determined in accordance with the Equation 29-1.

$$P_t = P_{sup} - PL_{svc} - PL_m - PL_d - PL_e - P_{sp}$$

**(Equation 29-1)**

where:

$P_t$ = Pressure used in applying Tables P2904.6.2(4) through P2904.6.2(9).

$P_{sup}$ = Pressure available from the water supply source.

$PL_{svc}$ = Pressure loss in the water service pipe. [Table P2904.6.2(1)]

$PL_m$ = Pressure loss in the water meter. [Table P2904.6.2(2)]

$PL_d$ = Pressure loss from devices other than the water meter.

$PL_e$ = Pressure loss associated with changes in elevation. [Table P2904.6.2(3)]

$P_{sp}$ = Maximum pressure required by a sprinkler.

**P2904.6.2.2 Calculation procedure.** Determination of the required size for water distribution piping shall be in accordance with the following procedure:

**Step 1—Determine** $P_{sup}$

Obtain the static supply pressure that will be available from the water main from the water purveyor, or for an individual source, the available supply pressure shall be in accordance with Section P2904.5.1.

**Step 2—Determine** $PL_{svc}$

Use Table P2904.6.2(1) to determine the pressure loss in the water service pipe based on the selected size of the water service.

**Step 3—Determine** $PL_m$

Use Table P2904.6.2(2) to determine the pressure loss from the water meter, based on the selected water meter size.

**Step 4—Determine** $PL_d$

Determine the pressure loss from devices other than the water meter installed in the piping system supplying sprinklers, such as pressure-reducing valves, backflow preventers, water softeners or water filters. Device pressure losses shall be based on the device manufacturer's specifications. The flow rate used to determine pressure loss shall be the rate from Section P2904.4.2, except that 5 gpm (0.3 L/s) shall be added where the device is installed in a water service pipe that supplies more than one *dwelling*. As an alternative to deducting pressure loss for a device, an automatic bypass valve shall be installed to divert flow around the device when a sprinkler activates.

**Step 5—Determine** $PL_e$

Use Table P2904.6.2(3) to determine the pressure loss associated with changes in elevation. The elevation used in applying the table shall be the difference between the elevation where the water source pressure was measured and the elevation of the highest sprinkler.

**Step 6—Determine** $P_{sp}$

Determine the maximum pressure required by any individual sprinkler based on the flow rate from Section P2904.4.1. The required pressure is provided in the sprinkler manufacturer's published data for the specific sprinkler model based on the selected flow rate.

**Step 7—Calculate** $P_t$

Using Equation 29-1, calculate the pressure available to offset friction loss in water-distribution piping between the service valve and the sprinklers.

**Step 8—Determine the maximum allowable pipe length**

Use Tables P2904.6.2(4) through P2904.6.2(9) to select a material and size for water distribution piping. The piping material and size shall be acceptable if the *developed length* of pipe between the service valve and the most remote sprinkler does not exceed the maximum allowable length specified by the applicable table. Interpolation of $P_t$ between the tabular values shall be permitted.

The maximum allowable length of piping in Tables P2904.6.2(4) through P2904.6.2(9) incorporates an adjustment for pipe fittings. Additional consideration of friction losses associated with pipe fittings shall not be required.

**P2904.7 Instructions and signs.** An owner's manual for the fire sprinkler system shall be provided to the *owner*. A sign or valve tag shall be installed at the main shutoff valve to the water distribution system stating, "Warning, the water system for this home supplies fire sprinklers that require certain flows and pressures to fight a fire. Devices that restrict the flow or decrease the pressure or automatically shut off the water to the fire sprinkler system, such as water softeners, filtration systems and automatic shutoff valves, shall not be added to this system without a review of the fire sprinkler system by a fire protection specialist. Do not remove this sign."

**P2904.8 Inspections.** The water distribution system shall be inspected in accordance with Sections P2904.8.1 and P2904.8.2.

**P2904.8.1 Preconcealment inspection.** The following items shall be verified prior to the concealment of any sprinkler system piping:

1. Sprinklers are installed in all areas as required by Section P2904.1.1.
2. Where sprinkler water spray patterns are obstructed by construction features, luminaires or ceiling fans, additional sprinklers are installed as required by Section P2904.2.4.2.
3. Sprinklers are the correct temperature rating and are installed at or beyond the required separation distances from heat sources as required by Sections P2904.2.1 and P2904.2.2.
4. The pipe size equals or exceeds the size used in applying Tables P2904.6.2(4) through P2904.6.2(9) or, if the piping system was hydraulically calculated in accordance with Section P2904.6.1, the size used in the hydraulic calculation.
5. The pipe length does not exceed the length permitted by Tables P2904.6.2(4) through P2904.6.2(9) or, if the piping system was hydraulically calculated in accordance with Section P2904.6.1, pipe lengths and fittings do not exceed those used in the hydraulic calculation.
6. Nonmetallic piping that conveys water to sprinklers is *listed* for use with fire sprinklers.
7. Piping is supported in accordance with the pipe manufacturer's and sprinkler manufacturer's installation instructions.
8. The piping system is tested in accordance with Section P2503.7.

**P2904.8.2 Final inspection.** The following items shall be verified upon completion of the system:

1. Sprinklers are not painted, damaged or otherwise hindered from operation.
2. Where a pump is required to provide water to the system, the pump starts automatically upon system water demand.
3. Pressure-reducing valves, water softeners, water filters or other impairments to water flow that were not part of the original design have not been installed.

4. The sign or valve tag required by Section P2904.7 is installed and the owner's manual for the system is present.

## SECTION P2905 HEATED WATER DISTRIBUTION SYSTEMS

**P2905.1 Heated water circulation systems and heat trace systems.** Circulation systems and heat trace systems that are installed to bring heated water in close proximity to one or more fixtures shall meet the requirements of Section ~~N1103.5.1~~ N1103.5.2.

**P2905.2 Demand recirculation systems.** *Demand recirculation water systems* shall be in accordance with Section ~~N1103.5.2~~ N1103.5.2.1.1.

**P2905.3 Hot water supply to fixtures**. The *developed length* of hot water piping, from the source of the hot water to the fixtures that require hot water, shall not exceed 100 feet (30 480 mm). Water heaters and recirculating system piping shall be considered to be sources of hot water.

## SECTION P2906 MATERIALS, JOINTS AND CONNECTIONS

**P2906.1 Soil and groundwater.** The installation of water service pipe, water distribution pipe, fittings, valves, appurtenances and gaskets shall be prohibited in soil and groundwater that is contaminated with solvents, fuels, organic compounds or other detrimental materials that cause permeation, corrosion, degradation or structural failure of the water service or water distribution piping material.

**P2906.1.1 Investigation required.** Where detrimental conditions are suspected by or brought to the attention of the *building official*, a chemical analysis of the soil and groundwater conditions shall be required to ascertain the acceptability of the water service material for the specific installation.

**P2906.1.2 Detrimental condition.** Where a detrimental condition exists, *approved* alternate materials or alternate routing shall be required.

**P2906.2 Lead content.** The lead content in pipe and fittings used in the water supply system shall be in accordance with Section P2906.2.1.

**P2906.2.1 Lead content of drinking water pipe and fittings.** Pipe, pipe fittings, joints, valves, faucets and fixture fittings utilized to supply water for drinking or cooking purposes shall comply with NSF 372 and shall have a weighted average lead content of 0.25-percent lead or less.

**P2906.3 Polyethylene plastic piping installation.** Polyethylene pipe shall be cut square using a cutter designed for plastic pipe. Except where joined by heat fusion, pipe ends shall be chamfered to remove sharp edges. Pipe that has been kinked shall not be installed. For bends, the installed radius of pipe curvature shall be greater than 30 pipe diameters or the coil radius where bending with the coil. Coiled pipe shall not be bent beyond straight. Bends within 10 pipe diameters of any fitting or valve shall be prohibited. Joints between polyethylene plastic pipe and fittings shall comply with Section P2906.3.1 or P2906.3.2.

**P2906.3.1 Heat-fusion joints.** Joint surfaces shall be clean and free from moisture. Joint surfaces shall be heated to melting temperature and joined. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM D2657.

**P2906.3.2 Mechanical joints.** Mechanical joints shall be installed in accordance with the manufacturer's instructions.

**P2906.4 Water service pipe.** Water service pipe shall conform to NSF 61 and shall conform to one of the standards indicated in Table P2906.4. Water service pipe or tubing, installed underground and outside of the structure, shall have a working pressure rating of not less than 160 pounds per square inch at 73°F (1103 kPa at 23°C). Where the water pressure exceeds 160 pounds per square inch (1103 kPa), piping material shall have a rated working pressure equal to or greater than the highest available pressure. Water service pipe shall terminate 5 feet (1524 mm) outside of the building. Water service piping materials not third-party certified for water distribution shall terminate at or before the full open valve located at the entrance to the structure. Ductile iron water service piping shall be cement mortar lined in accordance with AWWA C104/A21.4.

**P2906.4.1 Separation of water service and building sewer.** Trenching, pipe installation and backfilling shall be in accordance with Section P2604. ~~Where water service piping is located in the same trench with the building sewer, such sewer shall be constructed of materials listed in Table P3002.1(2). Where the building sewer piping is not constructed of materials indicated in Table P3002.1(2), the water service pipe and the building sewer shall be horizontally separated by not less than 5 feet (1524 mm) of undisturbed or compacted earth. The required separation distance shall not apply where a water service pipe crosses a sewer pipe, provided the water service is sleeved to a point not less than 5 feet (1524 mm) horizontally from the sewer pipe centerline on both sides of such crossing. The sleeve shall be of pipe materials indicated in Table P2906.4, P3002.1(2) or P3002.2. The required separation distance shall not apply where the bottom of the water service pipe that is located within 5 feet (1524 mm) of the sewer is not less than 12 inches (305 mm) above the highest point of the top of the building sewer.~~

1. Where water service piping is located in the same trench with the *building sewer*, such sewer shall be constructed of materials listed in Table P3002.1(2).
2. Where the *building sewer* piping is not constructed of materials indicated in Table P3002.1(2), the water service pipe and the *building sewer* shall be horizontally separated by not less than 5 feet (1524 mm) of undisturbed or compacted earth.
3. The required separation distance shall not apply where a water service pipe crosses a sewer pipe, provided that the water service is sleeved to a point not less than 5 feet (1524 mm) horizontally from the sewer pipe centerline on both sides of such crossing. The sleeve shall be of pipe materials indicated in Table P2906.4, P3002.1(2) or P3002.2.
4. The required separation distance shall not apply where the bottom of the water service pipe that is located within 5 feet (1524 mm) of the sewer is not less than 12 inches (305 mm) above the highest point of the top of the *building sewer*.

**P2906.5 Water distribution pipe.** Water distribution piping within *dwelling units* shall conform to NSF 61 and shall conform to one of the standards indicated in Table P2906.5. Hot water distribution pipe and tubing shall have a pressure rating of not less than 100 psi at 180°F (689 kPa at 82°C). Cold water distribution pipe and tubing shall have a pressure rating of not less than 160 psi at 73.4°F (1100 kPa at 23°C).

**P2906.6 Fittings.** Pipe fittings shall be *approved* for installation with the piping material installed and shall comply with the applicable standards indicated in Table P2906.6. Pipe fittings used in water supply systems shall comply with NSF 61.

**P2906.6.1 Saddle tap fittings.** The use of saddle tap fittings and combination saddle tap and valve fittings shall be prohibited.

**P2906.7 Flexible water connectors.** Flexible water connectors, exposed to continuous pressure, shall conform to ASME A112.18.6/CSA B125.6. Access shall be provided to flexible water connectors.

**P2906.8 Joint and connection tightness.** Joints and connections in the plumbing system shall be gastight and watertight for the intended use or required test pressure.

**P2906.9 Plastic pipe joints.** Joints in plastic piping shall be made with *approved* fittings by solvent cementing, heat fusion, corrosion-resistant metal clamps with insert fittings or compression connections. Flared joints for polyethylene pipe shall be permitted in accordance with Section ~~P2906.3~~ P2906.10.1.

**P2906.9.1 Solvent cementing.** Solvent-cemented joints shall comply with Sections P2906.9.1.1 through P2906.9.1.4.

**TABLE P2906.4 (Add Table Here)**
**WATER SERVICE PIPE**

**P2906.9.1.1 ABS plastic pipe.** Joint surfaces shall be clean and free from moisture. Solvent cement that conforms to ASTM D 2235 shall be applied to all joint surfaces. The joint shall be made while the cement is wet. Joints shall be made in accordance with ASTM D 2235. Solvent-cement joints shall be permitted above or below ground.

**P2906.9.1.2 CPVC plastic pipe.** Joint surfaces shall be clean and free from moisture. Joints shall be made in accordance with the pipe, fitting or solvent cement manufacturer's installation instructions. Where such instructions require a primer to be used, an *approved* primer shall be applied, and a solvent cement, orange in color and conforming to ASTM F493, shall be applied to joint surfaces. Where such instructions allow for a one-step solvent cement, yellow or red in color and conforming to ASTM F493, to be used, the joint surfaces shall not require application of a primer before the solvent cement is applied. The joint shall be made while the cement is wet, and in accordance with ASTM D2846 or ASTM F493. Solvent cement joints shall be permitted above or below ground.

**P2906.9.1.3 CPVC/AL/CPVC pipe.** Joint surfaces shall be clean and free from moisture, and an *approved* primer shall be applied. Solvent cement, orange in color and conforming to ASTM F493, shall be applied to all joint surfaces. The joint shall be made while the cement is wet, and in accordance with ASTM D2846 or ASTM F493. Solvent-cemented joints shall be installed above or below ground.

**Exception:** A primer shall not be required where all of the following conditions apply:

1. The solvent cement used is third-party certified as conforming to ASTM F493.
2. The solvent cement used is yellow in color.
3. The solvent cement is used only for joining $^{1}/_{2}$-inch (12.7 mm) through 1-inch (25 mm) diameter CPVC/AL/CPVC pipe and CPVC fittings.
4. The CPVC ~~systems~~ fittings are ~~installed~~ manufactured in accordance with ASTM D2846.

**P2906.9.1.4 PVC plastic pipe.** A purple primer or an ultraviolet purple primer that conforms to ASTM F 656 shall be applied to PVC solvent-cemented joints. When an ultraviolet primer is used, the installer shall provide an ultraviolet light to the inspector to be used during the inspection. Solvent cement for PVC plastic pipe conforming to ASTM D 2564 shall be applied to all joint surfaces.

**TABLE P2906.5 (Add Table Here)**
**WATER DISTRIBUTION PIPE**

**TABLE P2906.6 (Add Table Here)**
**PIPE FITTINGS**

**~~P2906.9.1.5~~ P2906.10 Cross-linked polyethylene plastic (PEX).** Joints between cross-linked polyethylene plastic tubing or fittings shall comply with Section P2906.9.10.1 or Section P2906.9.10.2.

**~~P2906.9.1.5.1~~ P2906.10.1 Flared joints.** Flared pipe ends shall be made by a tool designed for that operation.

**~~P2906.9.1.5.2~~ P2906.10.2 Mechanical joints.** Mechanical joints shall be installed in accordance with the manufacturer's instructions. Fittings for cross-linked polyethylene (PEX) plastic tubing shall comply with the applicable standards indicated in Table P2906.6 and shall be installed in accordance with the manufacturer's instructions. PEX tubing shall be factory marked with the applicable standards for the fittings that the PEX manufacturer specifies for use with the tubing.

**~~P2906.10~~ P2906.11 Polypropylene (PP) plastic.** Joints between polypropylene plastic pipe and fittings shall comply with Section P2906.11.1 or P2906.11.2.

**~~P2906.10.1~~ P2906.11.1 Heat-fusion joints.** Heat fusion joints for polypropylene pipe and tubing joints shall be installed with socket-type heat-fused polypropylene fittings, butt fusion polypropylene fittings or electrofusion polypropylene fittings. Joint surfaces shall be clean and free from moisture. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM F2389.

**~~P2906.10.2~~ P2906.11.2 Mechanical and compression sleeve joints.** Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer's instructions.

**~~P2906.11~~ P2906.12 Cross-linked polyethylene/aluminum/crosslinked polyethylene.** Joints between polyethylene/aluminum/polyethylene (PE-AL-PE) and cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe and fittings shall comply with Section P2906.12.1.

**~~P2906.11.1~~ P2906.12.1 Mechanical joints.** Mechanical joints shall be installed in accordance with the manufacturer's instructions. Fittings for PE-AL-PE and PEX-AL-PEX as described in ASTM F1281, ASTM F1282, ASTM F1974, CSA B137.9 and CSA B137.10 shall be installed in accordance with the manufacturer's instructions.

~~**P2906.12**~~ **P2906.13 Stainless steel.** Joints between stainless steel pipe and fittings shall comply with Section P2906.13.1 or P2906.13.2.

~~**P2906.12.1**~~ **P2906.13.1 Mechanical joints.** Mechanical joints shall be installed in accordance with the manufacturer's instructions.

~~**P2906.12.2**~~ **P2906.13.2 Welded joints.** Joint surfaces shall be cleaned. The joint shall be welded autogenously or with an *approved* filler metal in accordance with ASTM A312.

~~**P2906.13**~~ **P2906.14 Threaded pipe joints.** Threaded joints shall conform to American National Taper Pipe Thread specifications. Pipe ends shall be deburred and chips removed. Pipe joint compound shall be used only on male threads.

~~**P2906.14**~~ **P2906.15 Soldered and brazed joints.** Soldered joints in copper and copper alloy tubing shall be made with fittings *approved* for water piping and shall conform to ASTM B828. Surfaces to be soldered shall be cleaned bright. Fluxes for soldering shall be in accordance with ASTM B813. Brazing fluxes shall be in accordance with AWS A5.31M/A5.31. Solders and fluxes used in potable water-supply systems shall have a lead content of not greater than 0.2 percent. Solder and flux joining pipe or fittings intended to supply drinking water shall conform to NSF 61.

~~**P2906.15**~~ **P2906.16 Flared joints.** Flared joints in water tubing shall be made with *approved* fittings. The tubing shall be reamed and then expanded with a flaring tool.

~~**P2906.16**~~ **P2906.17 Above-ground joints.** Joints within the building between copper pipe or CPVC tubing, in any combination with compatible outside diameters, shall be permitted to be made with the use of *approved* push-in mechanical fittings of a pressure-lock design.

~~**P2906.17**~~ **P2906.18 Joints between different materials.** Joints between different piping materials shall be made in accordance with Section ~~P2906.17.1, P2906.17.2 or P2906.17.3~~ P2906.18.1, P2906.18.2, P2906.18.3 or P2906.18.4, or with a mechanical joint of the compression or mechanical sealing type having an elastomeric seal conforming to ASTM D1869 or ASTM F477. Joints shall be installed in accordance with the manufacturer's instructions.

~~**P2906.17.1**~~ **P2906.18.1 Copper or copper-alloy tubing to galvanized steel pipe.** Joints between copper or copper-alloy tubing and galvanized steel pipe shall be made with a copper alloy fitting or dielectric fitting. The copper tubing shall be joined to the fitting in an *approved* manner, and the fitting shall be screwed to the threaded pipe.

**P2906.18.2 Joint between PVC water service and CPVC water distribution.** Where a PVC water service pipe connects to a CPVC pipe at the beginning of a water distribution system, the transition shall be by a mechanical fitting, an *approved* adapter fitting, or transition fitting.

~~**P2906.17.2**~~ **P2906.18.3 Plastic pipe or tubing to other piping material.** Joints between different types of plastic pipe or between plastic pipe and other piping material shall be made with an *approved* adapter fitting. ~~or transition fittings~~

~~**P2906.17.3**~~ **P2906.18.4 Stainless steel.** Joints between stainless steel and different piping materials shall be made with a mechanical joint of the compression or mechanical-sealing type or a dielectric fitting. ~~or a dielectric union conforming to ASSE 1079.~~

~~**P2906.18**~~ **P2906.19 Press-connected joints.** Press-connected joints shall conform to one of the standards indicated in Table P2906.6. Press-type mechanical joints in copper tubing shall be made in accordance with the manufacturer's instructions. Cut tube ends shall be reamed to the full inside diameter of the tube end. Joint surfaces shall be cleaned. The tube shall be fully inserted into the press-connected fitting. Press-connected joints shall be pressed with a tool certified by the manufacturer.

~~**P2906.19**~~ **P2906.20 Polyethylene of raised temperature plastic.** Joints between polyethylene of raised temperature plastic tubing and fittings shall be in accordance with Sections ~~P2906.19.1~~ P2906.20.1, P2906.20.2 and P2906.20.3.

~~**P2906.19.1**~~ **P2906.20.1 Mechanical joints.** Mechanical joints shall be installed in accordance with the manufacturer's instructions. Fittings for polyethylene of raised temperature plastic tubing shall comply with the applicable standards indicated in Table P2906.6 and shall be installed in accordance with the manufacturer's instructions. Polyethylene of raised temperature plastic tubing shall be factory marked with the applicable standards for the fittings that the manufacturer of the tubing specifies for use with the tubing.

**P2906.20.2 Heat fusion joints.** Joints shall be of the socket-fusion, saddle-fusion, or butt-fusion type, and shall be joined in accordance with ASTM D2657. Joint surfaces shall be clean and free of moisture. Joint surfaces shall be heated to melt temperatures and joined. The joint shall remain undisturbed until cool. Fittings shall be manufactured in accordance with ASTM D2683 or ASTM D3261.

**P2906.20.3 Electrofusion joints.** Joints shall be of the electrofusion type. Joint surfaces shall be clean and free of moisture and scoured to expose virgin resin. Joint surfaces shall be heated to melt temperatures for a period of time specified by the manufacturer and joined. The joint shall remain undisturbed until cool. Fittings shall be manufactured in accordance with ASTM F1055.

**P2906.21 Push-fit fitting joints.** Push-fit fittings shall be used only on copper-tube-size outside diameter dimensioned CPVC, PEX, PE-RT and copper tubing. Push-fit fittings shall conform to ASSE 1061 and shall be installed in accordance with the manufacturer's instructions.

**~~P2906.20~~ P2906.22 Polybutylene plastic.**

Joints between polybutylene plastic pipe and tubing or fittings shall comply with Sections P2906.22.1 through P2906.22.3.

**P2906.22.1 (605.26.1) Flared joints**.

Flared pipe ends shall be made by a tool designed for that operation.

**P2906.22.2 (605.26.2) Heat-fusion joints.**

Joints shall be of the socket-fusion or butt-fusion type. Joint surfaces shall be clean and free from moisture. All joint surfaces shall be heated to the melting temperature and joined. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM D 2657, ASTM D 3309 or CAN3-B137.8M.

**P2906.22.3 (605.26.3) Mechanical joints.**

Mechanical joints shall be installed in accordance with the manufacturer's installation instructions.

## SECTION P2907
## CHANGES IN DIRECTION

**P2907.1 Bends.** Changes in direction in copper tubing shall be permitted to be made with bends having a radius of not less than four diameters of the tube, provided that such bends are made by use of forming equipment that does not deform or create loss in cross-sectional area of the tube.

## SECTION P2908
## SUPPORT

**P2908.1 General.** Pipe and tubing support shall conform to Section P2605.

## SECTION P2909
## DRINKING WATER TREATMENT UNITS

**P2909.1 Design.** Drinking water treatment units shall meet the requirements of NSF42, NSF 44, NSF 53, NSF 62 or CSA B483.1.

**P2909.2 Reverse osmosis drinking water treatment units.** Point-of-use reverse osmosis drinking water treatment units, designed for residential use, shall meet the requirements of CSA B483.1 or NSF 58. Waste or discharge from reverse osmosis drinking water treatment units shall enter the drainage system through an *air gap* or an *air gap* device that meets the requirements of NSF 58.

**P2909.3 Connection tubing.** The tubing to and from drinking water treatment units shall be of a size and material as recommended by the manufacturer. The tubing shall comply with NSF 14, NSF 42, NSF 44, NSF 53, NSF 58 or NSF 61.

## SECTION P2910
## NON-POTABLE WATER SYSTEMS

**P2910.1 Scope.** The provisions of this section shall govern the materials, design, construction and installation of systems for the collection, storage, treatment and distribution of non-potable water. The use and application of non-potable water shall comply with laws, rules and ordinances applicable in the *jurisdiction*.

**P2910.2 Water quality.** Non-potable water for each end use application shall meet the minimum water quality requirements as established for the intended application by the laws, rules and ordinances applicable in the *jurisdiction*. Where non-potable water from different sources is combined in a system, the system shall comply with the most stringent requirements of this code applicable to such sources.

**P2910.2.1 Residual disinfectants.** Where chlorine is used for disinfection, the non-potable water shall contain not more than 4 ppm (4 mg/L) of chloramines or free chlorine. Where ozone is used for disinfection, the nonpotable water shall not contain gas bubbles having elevated levels of ozone at the point of use.

**Exception:** Reclaimed water sources shall not be required to comply with the requirements of this section.

**P2910.2.2 Filtration required.** Nonpotable water utilized for water closet and urinal flushing applications shall be filtered by a 100 micron or finer filter. Non-potable water for use within a building shall be colored blue or green.

**Exception:** Reclaimed water sources shall not be required to comply with the requirements of this section.

**P2910.2.3 Applications.**
Untreated *rainwater* shall be utilized in accordance with Section P2910.2.3.1. Treated *rainwater* shall be utilized in accordance with Section P2910.2.3.2.

**P2910.2.3.1 Examples of acceptable uses without treatment.**

1. Outdoor Irrigation
2. Decorative Fountains
3. Yard Hydrants
4. Industrial Processes (eg. Dust Control, Indoor Hose Bibs Spray)
5. Vehicle Washing
6. Outdoor Hose Bibs (not routed through building wall)

**P2910.2.3.2 Examples of acceptable uses with disinfection and filtration.**

1. Toilet Flushing
2. Urinal Flushing
3. Evaporative Cooling Tower Make-up
4. Trap Primers
5. Fire Suppression Systems
6. Clothes Washers
7. Outdoor Pools and Spas

8. Hose Bibs – Residential

**P2910.3 Signage required.** Nonpotable water outlets such as hose connections, sillcocks, hose bibs, wall hydrants, yard hydrants, other outdoor outlets, open-ended pipes and faucets shall be identified at the point of use for each outlet with signage that reads, "Nonpotable water is utilized for [application name]. CAUTION: NONPOTABLE WATER. DO NOT DRINK." The words shall be legibly and indelibly printed on a tag or sign constructed of corrosion-resistant, waterproof material or shall be indelibly printed on the fixture. The letters of the words shall be not less than 0.5 inches (12.7 mm) in height and in colors contrasting the background on which they are applied. In addition to the required wordage, the pictograph shown in Figure P2910.3 shall appear on the signage required by this section.

**FIGURE P2910.3**
**PICTOGRAPH—DO NOT DRINK**

**P2910.4 Permits.** *Permits* shall be required for the construction, installation, *alteration* and *repair* of nonpotable water systems. *Construction documents*, engineering calculations, diagrams and other such data pertaining to the nonpotable water system shall be submitted with each *permit* application.

**P2910.5 Potable water connections.** Where a potable system is connected to a nonpotable water system, the potable water supply shall be protected against backflow in accordance with Section P2902.

**P2910.6 Approved components and materials.** Piping, plumbing components and materials used in collection and conveyance systems shall be manufactured of material *approved* for the intended application and compatible with any disinfection and treatment systems used.

**P2910.6.1 Identification of non-potable water systems.**

Where non-potable plumbing systems (drainage or supply within gray water, rain water or reclaimed water systems) are installed, the piping conveying the non-potable water shall be identified either by color marking, metal tags or tape in accordance with Section P2910.6.2.

**P2910.6.2** Non-potable pipe labeling and marking.
Non-potable distribution piping shall be purple in color or shall be embossed, or integrally stamped or marked, with the words: "CAUTION: NON-POTABLE WATER – DO NOT DRINK" or the piping shall be installed with a purple identification tape or wrap. Pipe identification shall include the contents of the piping system and an arrow indicating the direction of flow. Hazardous piping systems shall also contain information addressing the nature of the hazard. Pipe identification shall be repeated at intervals not exceeding 25 feet (7620 mm) and at each point where the piping passes through a wall, floor or roof. Lettering shall be readily observable within the room or space where the piping is located.

**P2910.6.2.1 Color.**
The color of the pipe identification shall be discernable and consistent throughout the building. The color purple shall be used to identify reclaimed, rain and gray water distribution systems.

**P2910.6.2.2 (1301.6.2.2) Lettering size.**

The size of the background color field and lettering shall comply with Table P2910.6.2.2.

**TABLE P2910.6.2.2 (1301.6.2.2)**
**SIZE OF PIPE IDENTIFICATION**

| PIPE DIAMETER (inches) | LENGTH BACKGROUND COLOR FIELD (inches) | SIZE OF LETTERS (inches) |
|---|---|---|
| 3/8 to 1-1/4 | 8 | 0.5 |
| 1-1/2 to 2 | 8 | 0.75 |
| 2-1/2 to 6 | 12 | 1.25 |
| 8 to 10 | 24 | 2.5 |
| over 10 | 32 | 3.5 |

For SI 1 inch = 25.4 mm.

**P2910.6.2.3 Identification tape.**
Where used, identification tape shall be at least 3 inches (76 mm) wide and have white or black lettering on a purple field stating "CAUTION: NON-POTABLE WATER – DO NOT DRINK." Identification tape shall be installed on top of non-potable rainwater distribution pipes, fastened at least every 10 feet (3048 mm) to each pipe length and run continuously the entire length of the pipe.

**P2910.7 Insect and vermin control.** The system shall be protected to prevent the entrance of insects and vermin into storage tanks and piping systems. Screens installed on vent pipes, inlets, and overflow pipes shall have an aperture of not greater than 1/16 inch (1.59 mm) and shall be close-fitting or other *approved* methods. Screen materials shall be compatible with contacting system components and shall not accelerate the corrosion of system components.

**P2910.8 Freeze protection.** Where sustained freezing temperatures occur, provisions shall be made to keep storage tanks and the related piping from freezing.

**P2910.9 Nonpotable water storage tanks.** Nonpotable water storage tanks shall comply with Sections P2910.9.1 through P2910.9.11.

**P2910.9.1 Sizing.** The holding capacity of the storage tank shall be sized in accordance with the anticipated demand.

**P2910.9.2 Location.** Storage tanks shall be installed above or below grade. Above-grade storage tanks shall be protected from direct sunlight and shall be constructed using opaque, UV-resistant materials such as, but not limited to, heavily tinted plastic, lined metal, concrete and wood; or painted to prevent algae growth; or shall have specially constructed sun barriers including, but not limited to, installation in garages, crawl spaces or sheds. Storage tanks and their manholes shall not be located directly under any soil piping, waste piping or any source of contamination.

**P2910.9.3 Materials.** Where collected on site, water shall be collected in an *approved* tank constructed of durable, nonabsorbent and corrosion-resistant materials. The storage tank shall be constructed of materials compatible with any disinfection systems used to treat water upstream of the tank and with any systems used to maintain water quality within the tank. Wooden storage tanks that are not equipped with a makeup water source shall be provided with a flexible liner.

**P2910.9.4 Foundation and supports.** Storage tanks shall be supported on a firm base capable of withstanding the weight of the storage tank when filled to capacity. Storage tanks shall be supported in accordance with this code.

**P2910.9.4.1 Ballast.** Where the soil can become saturated, an underground storage tank shall be ballasted or otherwise secured to prevent the tank from floating out of the ground when empty. The combined weight of the tank and hold-down ballast shall meet or exceed the buoyancy force of the tank. Where the installation requires a foundation, the foundation shall be flat and shall be designed to support the storage tank weight when full, consistent with the bearing capability of adjacent soil.

**P2910.9.4.2 Structural support.** Where installed below grade, storage tank installations shall be designed to withstand earth and surface structural loads without damage and with minimal deformation when empty or filled with water.

**P2910.9.5 Makeup water.** Where an uninterrupted nonpotable water supply is required for the intended application, potable or reclaimed water shall be provided as a source of makeup water for the storage tank. The makeup water supply shall be protected against backflow by means of an *air gap* not less than 4 inches (102 mm) above the overflow or an *approved* backflow device in accordance with Section P2902. A full-open valve located on the makeup water supply line to the storage tank shall be provided. Inlets to the storage tank shall be controlled by fill valves or other automatic supply valves installed to prevent the tank from overflowing and to prevent the water level from dropping below a predetermined point. Where makeup water is provided, the water level shall be prohibited from dropping below the source water inlet or the intake of any attached pump.

**P2910.9.5.1 Inlet control valve alarm.** Makeup water systems shall be fitted with a warning mechanism that alerts the user to a failure of the inlet control valve to close correctly. The alarm shall activate before the water within the storage tank begins to discharge into the overflow system.

**P2910.9.6 Overflow.** The storage tank shall be equipped with an overflow pipe having a diameter not less than that shown in Table P2910.9.6. The overflow outlet shall discharge at a point not less than 6 inches (152 mm) above the roof or roof drain; floor or floor drain; or over an open water-supplied fixture. The overflow outlet shall be covered with a corrosion-resistant screen of not less than 16 by 20 mesh per inch (630 by 787 mesh per m) and by $^{1}/_{4}$-inch (6.4 mm) hardware cloth or shall terminate in a horizontal angle seat check valve. Drainage from overflow pipes shall be directed to prevent freezing on roof walks. The overflow drain shall not be equipped with a shutoff valve. Not less than one cleanout shall be provided on each overflow pipe in accordance with Section P3005.2.

**TABLE P2910.9.6**
**SIZE OF DRAIN PIPES FOR WATER TANKS**

| TANK CAPACITY (gallons) | DRAIN PIPE (inches) |
|---|---|
| Up to 750 | 1 |
| 751 to 1,500 | $1^{1}/_{2}$ |
| 1,501 to 3,000 | 2 |
| 3,001 to 5,000 | $2^{1}/_{2}$ |
| 5,001 to 7,500 | 3 |
| Over 7,500 | 4 |

For SI: 1 gallon = 3.875 liters, 1 inch = 25.4 mm.

**P2910.9.7 Access.** Not less than one access opening shall be provided to allow inspection and cleaning of the tank interior. Access openings shall have an *approved* locking device or other *approved* method of securing access. Below-grade storage tanks, located outside of the building, shall be provided with a manhole either not less than 24 inches (610 mm) square or with an inside diameter not less than 24 inches (610 mm). Manholes shall extend not less than 4 inches (102 mm) above ground or shall be designed to prevent water infiltration. Finished grade shall be sloped away from the manhole to divert surface water. Manhole covers shall be secured to prevent unauthorized access. Service ports in manhole covers shall be not less than 8 inches (203 mm) in diameter and shall be not less than 4 inches (102 mm) above the finished grade level. The service port shall be secured to prevent unauthorized access.

**Exception:** Storage tanks under 800 gallons (3028 L) in volume installed below grade shall not be required to be equipped with a manhole, but shall have a service port not less than 8 inches (203 mm) in diameter.

**P2910.9.8 Venting.** Storage tanks shall be provided with a vent sized in accordance with Chapter 31 and based on the aggregate diameter of all tank influent pipes. The reservoir vent shall not be connected to sanitary drainage system vents. Vents shall be protected from contamination by means of an *approved* cap or a U-bend installed with the opening directed downward. Vent outlets shall extend not less than 4 inches (102 mm) above grade, or as necessary to prevent surface water from entering the storage tank. Vent openings shall be protected against the entrance of vermin and insects in accordance with the requirements of Section ~~P2902.7~~ P2910.7.

**P2910.9.9 Drain.** A drain shall be located at the lowest point of the storage tank. The tank drain pipe shall discharge as required for overflow pipes and shall not be smaller in size than specified in Table P2910.9.6. Not less than one cleanout shall be provided on each drain pipe in accordance with Section P3005.2.

**P2910.10 Marking and signage.** Each nonpotable water storage tank shall be *labeled* with its rated capacity. The contents of storage tanks shall be identified with the words, "CAUTION: NONPOTABLE WATER. DO NOT DRINK." Where an opening is provided that could allow the entry of personnel, the opening shall be marked with the words, "DANGER—CONFINED SPACE." Markings shall be indelibly printed on the tank, or on a tag or sign constructed of corrosion-resistant waterproof material that is mounted on the tank. The letters of the words shall be not less than 0.5 inches (12.7 mm) in height and shall be of a color in contrast with the background on which they are applied.

**P2910.11 Storage tank tests.** Storage tanks shall be tested in accordance with the following:

1. Storage tanks shall be filled with water to the overflow line prior to and during inspection. Seams and joints shall be left exposed and the tank shall remain watertight without leakage for a period of 24 hours.

   **Exception:** If air testing, system shall be pressurized with air equivalent to the water pressure for the full depth of the tank in accordance with Section P2503.7.

2. After 24 hours, supplemental water shall be introduced for a period of 15 minutes to verify proper drainage of the overflow system and leaks do not exist.
3. Following a successful test of the overflow, the water level in the tank shall be reduced to a level that is 2 inches (51 mm) below the makeup water trigger point by using the tank drain. The tank drain shall be observed for proper operation. The makeup water system shall be observed for proper operation, and successful automatic shutoff of the system at the refill threshold shall be verified. Water shall not be drained from the overflow at any time during the refill test.

**P2910.12 System abandonment.** If the *owner* of an on-site nonpotable water reuse system or rainwater collection and conveyance system elects to cease use of or fails to properly maintain such system, the system shall be abandoned and shall comply with the following:

1. System piping connecting to a utility-provided water system shall be removed or disabled.
2. The distribution piping system shall be replaced with an *approved* potable water supply piping system. Where an existing potable water pipe system is already in place, the fixtures shall be connected to the existing system.
3. The storage tank shall be secured from accidental access by sealing or locking tank inlets and access points, or filled with sand or equivalent.

**P2910.13 Separation requirements for nonpotable water piping.** Nonpotable water collection and distribution piping and reclaimed water piping shall be separated from the *building sewer* and potable water piping underground by 5 feet (1524 mm) of undisturbed or compacted earth. Nonpotable water collection and distribution piping shall not be located in, under or above cesspools, septic tanks, septic tank drainage fields or seepage pits. Buried nonpotable water piping shall comply with the requirements of Section P2604.

**Exceptions:**

1. The required separation distance shall not apply where the bottom of the nonpotable water pipe within 5 feet (1524 mm) of the sewer is not less than 12 inches (305 mm) above the top of the highest point of the sewer and the pipe materials conforms to Table P3002.2.
2. The required separation distance shall not apply where the bottom of the potable water service pipe within 5 feet (1524 mm) of the nonpotable water pipe is not less than 12 inches (305 mm) above the top of the highest point of the nonpotable water pipe and the pipe materials comply with the requirements of Table P2906.5.
3. The required separation distance shall not apply where a nonpotable water pipe is located in the same trench with a *building sewer* that is constructed of materials that comply with the requirements of Table P3002.2.
4. The required separation distance shall not apply where a nonpotable water pipe crosses a sewer pipe provided that the nonpotable water pipe is sleeved to not less than 5 feet (1524 mm) horizontally from the sewer pipe centerline on both sides of such crossing, with pipe materials that comply with Table P3002.2.
5. The required separation distance shall not apply where a potable water service pipe crosses a nonpotable water pipe, provided that the potable water service pipe is sleeved for a distance of not less than 5 feet (1524 mm) horizontally from the centerline of the nonpotable pipe on both sides of such crossing, with pipe materials that comply with Table P3002.2.
6. The required separation distance shall not apply to irrigation piping located outside of a building and downstream of the backflow preventer where nonpotable water is used for outdoor applications.

**P2910.14 Outdoor outlet access.** Sillcocks, hose bibbs, wall hydrants, yard hydrants and other outdoor outlets supplied by nonpotable water shall be located in a locked vault or shall be operable only by means of a removable key.

## SECTION P2911
## ON-SITE NONPOTABLE WATER REUSE SYSTEMS

**P2911.1 General.** The provisions of this section shall govern the construction, installation, *alteration* and *repair* of on-site nonpotable water reuse systems for the collection, storage, treatment and distribution of on-site sources of nonpotable water as permitted by the *jurisdiction*.

**P2911.2 Sources.** On-site nonpotable water reuse systems shall collect waste discharge only from the following sources: bathtubs, showers, lavatories, clothes washers and laundry trays. Water from other *approved* nonpotable sources including swimming pool backwash operations, air conditioner condensate, rainwater, foundation drain water, fluid cooler discharge water and fire pump test water shall be permitted to be collected for reuse by on-site nonpotable water reuse systems, as *approved* by the *building official* and as appropriate for the intended application.

**P2911.2.1 Prohibited sources.** Reverse osmosis system reject water, water softener backwash water, kitchen sink wastewater, dishwasher wastewater and wastewater containing urine or fecal matter shall not be collected for reuse within an on-site nonpotable water reuse system.

**P2911.3 Traps.** Traps serving fixtures and devices discharging wastewater to on-site nonpotable water reuse systems shall comply with the Section P3201.2.

**P2911.4 Collection pipe.** On-site nonpotable water reuse systems shall utilize drainage piping *approved* for use within plumbing drainage systems to collect and convey untreated water for reuse. Vent piping *approved* for use within plumbing venting systems shall be utilized for vents within the graywater system. Collection and vent piping materials shall comply with Section P3002.

**P2911.4.1 Installation.** Collection piping conveying untreated water for reuse shall be installed in accordance with Section P3005.

**P2911.4.2 Joints.** Collection piping conveying untreated water for reuse shall utilize joints *approved* for use with the distribution piping and appropriate for the intended applications as specified in Section P3002.

**P2911.4.3 Size.** Collection piping conveying untreated water for reuse shall be sized in accordance with drainage sizing requirements specified in Section P3005.4.

**P2911.4.4 Marking.** Additional marking of collection piping conveying untreated water for reuse shall not be required beyond that required for sanitary drainage, waste and vent piping by Chapter 30.

**P2911.5 Filtration.** Untreated water collected for reuse shall be filtered as required for the intended end use. Filters shall be accessible for inspection and maintenance. Filters shall utilize a pressure gauge or other *approved* method to provide indication when a filter requires servicing or replacement. Filters shall be installed with shutoff valves immediately upstream and downstream to allow for isolation during maintenance. Non-potable water for use within a building shall be colored blue or green.

**P2911.6 Disinfection.** Nonpotable water collected on site for reuse shall be disinfected, treated or both as determined by a *registered design professional* to provide the quality of water needed for the intended end-use application. Where the intended end-use application does not have requirements for the quality of water, disinfection and treatment of water collected on site for reuse shall not be required. Nonpotable water collected on site containing untreated graywater shall be retained in collection reservoirs for not more than 24 hours.

**P2911.6.1 Graywater used for fixture flushing.** Graywater used for flushing water closets and urinals shall be disinfected and treated by an on-site water reuse treatment system complying with NSF 350.

**P2911.7 Storage tanks.** Storage tanks utilized in on-site nonpotable water reuse systems shall comply with Section P2910.9 and Sections P2911.7.1 through P2911.7.3.

**P2911.7.1 Location.** Storage tanks shall be located with a minimum horizontal distance between various elements as indicated in Table P2911.7.1.

**TABLE P2911.7.1**

**LOCATION OF NONPOTABLE WATER REUSE STORAGE TANKS**

| ELEMENT | MINIMUM HORIZONTAL DISTANCE FROM STORAGE TANK (feet) |
|---|---|
| Critical root zone (CRZ) of protected trees | 2 |
| *Lot line* adjoining private lots | 5 |
| Public water main | 10 |
| Seepage pits | 5 |
| Septic tanks | 5 |
| Streams and lakes | 50 |
| Water service | 5 |
| Water wells | 50 |

For SI: 1 foot = 304.8 mm

**P2911.7.2 Inlets.** Storage tank inlets shall be designed to introduce water into the tank with minimum turbulence, and shall be located and designed to avoid agitating the contents of the storage tank.

**P2911.7.3 Outlets.** Outlets shall be located not less than 4 inches (102 mm) above the bottom of the storage tank, and shall not skim water from the surface.

**P2911.8 Valves.** Valves shall be supplied on on-site non-potable water reuse systems in accordance with Sections P2911.8.1 and P2911.8.2.

**P2911.8.1 Bypass valve.** One three-way diverter valve certified to NSF 50 or other *approved* device shall be installed on collection piping upstream of each storage tank, or drainfield, as applicable, to divert untreated on-site reuse sources to the sanitary sewer to allow servicing and inspection of the system. Bypass valves shall be installed downstream of fixture traps and vent connections. Bypass valves shall be *labeled* to indicate the direction of flow, connection and storage tank or drainfield connection. Bypass valves shall be installed in accessible locations. Two shutoff valves shall not be installed to serve as a bypass valve.

**P2911.8.2 Backwater valve.** Backwater valves shall be installed on each overflow and tank drain pipe. Backwater valves shall be in accordance with Section P3008.

**P2911.9 Pumping and control system.** Mechanical equipment including pumps, valves and filters shall be accessible and removable in order to perform repair, maintenance and cleaning. The minimum flow rate and flow pressure delivered by the pumping system shall be appropriate for the application and in accordance with Section P2903.

**P2911.10 Water pressure-reducing valve or regulator.** Where the water pressure supplied by the pumping system exceeds 80 psi (552 kPa) static, a pressure-reducing valve shall be installed to reduce the pressure in the nonpotable water distribution system piping to 80 psi (552 kPa) static or less. Pressure-reducing valves shall be specified and installed in accordance with Section P2903.3.2.

**Exception:** Service lines to sill cocks and outside hydrants, and main supply risers where pressure from the mains is reduced to 80 psi (552 kPa) or less at individual fixtures.

**P2911.11 Distribution pipe.** Distribution piping utilized in on-site nonpotable water reuse systems shall comply with Sections PP2911.11.1 through P2911.11.3.

**Exception:** Irrigation piping located outside of the building and downstream of a backflow preventer.

**P2911.11.1 Materials, joints and connections.** Distribution piping shall conform to the standards and requirements specified in Section P2906 for nonpotable water.

**P2911.11.2 Design.** On-site nonpotable water reuse distribution piping systems shall be designed and sized in accordance with Section P2903 for the intended application.

**P2911.11.3 Marking.** On-site nonpotable water distribution piping labeling and marking shall comply with Section P2901.2

**P2911.12 Tests and inspections.** Tests and inspections shall be performed in accordance with Sections P2911.12.1 through P2911.12.6.

**P2911.12.1 Collection pipe and vent test.** Drain, waste and vent piping used for on-site water reuse systems shall be tested in accordance with Section P2503.

**P2911.12.2 Storage tank test.** Storage tanks shall be tested in accordance with Section P2910.11.

**P2911.12.3 Water supply system test.** The testing of makeup water supply piping and distribution piping shall be conducted in accordance with Section P2503.7.

**P2911.12.4 Inspection and testing of backflow prevention assemblies.** ~~Deleted.~~

**P2911.12.5 Inspection of vermin and insect protection.** Inlets and vents to the system shall be inspected to verify that each is protected to prevent the entrance of insects and vermin into the storage tank and piping systems in accordance with Section P2910.7.

**P2911.12.6 Water quality test.** The quality of the water for the intended application shall be verified at the point of use in accordance with the requirements of the *jurisdiction*.

**P2911.13 Operation and maintenance manuals.** Operation and maintenance materials shall be supplied with nonpotable on-site water reuse systems in accordance with Sections P2911.13.1 through P2911.13.4.

**P2911.13.1 Manual.** A detailed operations and maintenance manual shall be supplied in hard-copy form for each system.

**P2911.13.2 Schematics.** The manual shall include a detailed system schematic, the location of system components and a list of system components that includes the manufacturers and model numbers of the components.

**P2911.13.3 Maintenance procedures.** The manual shall provide a schedule and procedures for system components requiring periodic maintenance. Consumable parts including filters shall be noted along with part numbers.

**P2911.13.4 Operations procedures.** The manual shall include system startup and shutdown procedures. The manual shall include detailed operating procedures for the system.

## SECTION P2912
## NONPOTABLE RAINWATER
## COLLECTION AND DISTRIBUTION SYSTEMS

**P2912.1 General.** The provisions of this section shall govern the construction, installation, *alteration* and repair of rainwater collection and conveyance systems for the collection, storage, treatment and distribution of rainwater for nonpotable applications. For nonpotable rainwater systems, the provisions of CSA B805/ICC 805 shall be an alternative for regulating the materials, design, construction and installation of systems for rainwater collection, storage, treatment and distribution of nonpotable water. The use and application of nonpotable water shall comply with laws, rules and ordinances applicable in the *jurisdiction*.

**P2912.2 Collection surface.** Rainwater shall be collected only from above-ground impervious roofing surfaces constructed from *approved* materials for acceptable uses without treatment listed in Section P2910.2.3 or where additional appropriate treatment is designed by a *registered design professional*. Collection of water from vehicular parking or pedestrian walkway surfaces shall be prohibited except where the water is used exclusively for landscape irrigation. Overflow and bleed-off pipes from roof-mounted *appliances* including, but not limited to, evaporative coolers, water heaters and solar water heaters shall not discharge onto rainwater collection surfaces.

**P2912.3 Debris excluders.** Downspouts and leaders shall be connected to a roof washer and shall be equipped with a debris excluder or equivalent device to prevent the contamination of collected rainwater with leaves, sticks, pine needles and similar ~~undesirable~~ material. Debris excluders and equivalent devices shall be self-cleaning.

**P2912.4 Roof washer.** An amount of rainwater shall be diverted at the beginning of each rain event, and not allowed to enter the storage tank, to wash accumulated debris from the collection surface. The amount of rainfall to be diverted shall be field adjustable as necessary to minimize storage tank water contamination. The roof washer shall not rely on manually operated valves or devices, and shall operate automatically. Diverted rainwater shall not be drained to the roof surface, and shall be discharged in a manner consistent with the stormwater runoff requirements of the *jurisdiction*. Roof washers shall be accessible for maintenance and service.

**P2912.5 Roof gutters and downspouts.** Gutters and downspouts shall be constructed of materials that are compatible with the collection surface and the rainwater quality for the desired end use. Joints shall be watertight.

**P2912.5.1 Slope.** Roof gutters, leaders and rainwater collection piping shall slope continuously toward collection inlets and shall be free of leaks. Gutters and downspouts shall have a slope of not less than $^1/_8$ inch per foot (10.4 mm/m) along their entire length. Gutters and downspouts shall be installed so that water does not pool at any point.

~~**Exception:** Siphonic drainage systems installed in accordance with the manufacturer's instructions shall not be required to have a slope.~~

**P2912.5.2 Cleanouts.** Cleanouts shall be provided in the water conveyance system to allow access to filters, flushes, pipes and downspouts.

**P2912.6 Drainage.** Water drained from the roof washer ~~(first flush diverter)~~ or debris excluder shall not be drained to the sanitary sewer. Such water shall be diverted from the storage tank and shall discharge to a location that will not cause erosion or damage to property. Roof washers and debris excluders shall be provided with an automatic means of self-draining between rain events and shall not drain onto roof surfaces.

**P2912.7 Collection pipe.** Rainwater collection and conveyance systems shall utilize drainage piping *approved* for use within plumbing drainage systems to collect and convey captured rainwater. Vent piping *approved* for use within plumbing venting systems shall be utilized for vents within the rainwater system. Collection and vent piping materials shall comply with Section P3002.

**P2912.7.1 Installation.** Collection piping conveying captured rainwater shall be installed in accordance with Section P3005.3.

**P2912.7.2 Joints.** Collection piping conveying captured rainwater shall utilize joints *approved* for use with the distribution piping and appropriate for the intended applications as specified in Section P3003.

**P2912.7.3 Size.** Collection piping conveying captured rainwater shall be sized in accordance with drainage-sizing requirements specified in Section P3005.4.

**P2912.7.4 Marking.** Additional marking of collection piping conveying captured rainwater for reuse shall not be required beyond that required for sanitary drainage, waste, and vent piping by Chapter 30.

**P2912.8 Filtration.** Collected rainwater shall be filtered as required for the intended end use. Filters shall be accessible for inspection and maintenance. Filters shall utilize a pressure gauge or other *approved* method to provide indication when a filter requires servicing or replacement. Filters shall be installed with shutoff valves installed immediately upstream and downstream to allow for isolation during maintenance. Non-potable water for use within a building shall be colored blue or green.

**P2912.9 Disinfection.** Where the intended application for rainwater requires disinfection or other treatment or both, it shall be disinfected as determined by a *registered design professional* to ensure that the required water quality is delivered at the point of use.

**P2912.10 Storage tanks.** Storage tanks utilized in nonpotable rainwater collection and conveyance systems shall comply with Section P2910.9 and Sections P2912.10.1 through P2912.10.3.

**P2912.10.1 Location.** Storage tanks shall be located with a minimum horizontal distance between various elements as indicated in Table P2912.10.1.

**TABLE P2912.10.1**
**LOCATION OF RAINWATER STORAGE TANKS**

| ELEMENT | MINIMUM HORIZONTAL DISTANCE FROM STORAGE TANK (feet) |
|---|---|
| Critical root zone (CRZ) of protected trees | 2 |
| Lot line adjoining private lots | 5 |
| Seepage pits | 5 |
| Septic tanks | 5 |

For SI: 1 foot = 304.8 mm

**P2912.10.2 Inlets.** Storage tank inlets shall be designed to introduce collected rainwater into the tank with minimum turbulence, and shall be located and designed to avoid agitating the contents of the storage tank.

**P2912.10.3 Outlets.** Outlets shall be located not less than 4 inches (102 mm) above the bottom of the storage tank and shall not skim water from the surface.

**P2912.11 Valves.** Valves shall be supplied on rainwater collection and conveyance systems in accordance with Sections P2912.11.1 and P2912.11.2.

**P2912.11.1 Influent diversion.** A means shall be provided to divert storage tank influent to allow for maintenance and repair of the storage tank system.

**P2912.11.2 Backwater valve.** Backwater valves shall be installed on each overflow and tank drain pipe. Backwater valves shall be in accordance with Section P3008.

**P2912.12 Pumping and control system.** Mechanical equipment including pumps, valves and filters shall be easily accessible and removable in order to perform repair, maintenance and cleaning. The minimum flow rate and flow pressure delivered by the pumping system shall appropriate for the application and in accordance with Section P2903.

**P2912.13 Water pressure-reducing valve or regulator.** Where the water pressure supplied by the pumping system exceeds 80 psi (552 kPa) static, a pressure-reducing valve shall be installed to reduce the pressure in the rainwater distribution system piping to 80 psi (552 kPa) static or less. Pressure-reducing valves shall be specified and installed in accordance with Section P2903.3.2.

**Exception:** Service lines to sill cocks and outside hydrants, and main supply risers where pressure from the mains is reduced to 80 psi (552 kPa) or less at individual fixtures.

**P2912.14 Distribution pipe.** Distribution piping utilized in rainwater collection and conveyance systems shall comply with Sections P2912.14.1 through P2912.14.3.

**Exception:** Irrigation piping located outside of the building and downstream of a backflow preventer.

**P2912.14.1 Materials, joints and connections.** Distribution piping shall conform to the standards and requirements specified in Section P2906 for nonpotable water.

**P2912.14.2 Design.** Distribution piping systems shall be designed and sized in accordance with the Section P2903 for the intended application.

**P2912.14.3 Labeling and marking.** Nonpotable rainwater distribution piping labeling and marking shall comply with Section P2901.2.

**P2912.15 Tests and inspections.** Tests and inspections shall be performed in accordance with Sections P2912.15.1 through P2912.15.8.

**P2912.15.1 Roof gutter inspection and test.** DELETED.

**P2912.15.2 Roofwasher test.** DELETED.

**P2912.15.3 Collection pipe and vent test.** Drain, waste and vent piping used for rainwater collection and conveyance systems shall be tested in accordance with Section P2503.

**P2912.15.4 Storage tank test.** Storage tanks shall be tested in accordance with the Section P2910.11.

**P2912.15.5 Water supply system test.** The testing of makeup water supply piping and distribution piping shall be conducted in accordance with Section P2503.7.

**P2912.15.6 Inspection and testing of backflow prevention assemblies.** The testing of backflow preventers and backwater valves shall be conducted in accordance with Section P2503.8.

**P2912.15.7 Inspection of vermin and insect protection.** Inlets and vents to the system shall be inspected to verify that each is protected to prevent the entrance of insects and vermin into the storage tank and piping systems in accordance with Section P2910.7.

**P2912.15.8 Water quality test.** The quality of the water for the intended application shall be verified at the point of use in accordance with the requirements of the *jurisdiction*.

**P2912.16 Operation and maintenance manuals.** Operation and maintenance manuals shall be supplied with rainwater collection and conveyance systems in accordance with Sections P2912.16.1 through P2912.16.4.

**P2912.16.1 Manual.** A detailed operations and maintenance manual shall be supplied ~~in hard-copy form~~ for each system.

**P2912.16.2 Schematics.** The manual shall include a detailed system schematic, the location of system components and a list of system components that includes the manufacturers and model numbers of the components.

**P2912.16.3 Maintenance procedures.** The manual shall provide a maintenance schedule and procedures for system components requiring periodic maintenance. Consumable parts, including filters, shall be noted along with part numbers.

**P2912.16.4 Operations procedures.** The manual shall include system startup and shutdown procedures, and detailed operating procedures.

## SECTION P2913
## RECLAIMED WATER SYSTEMS

**P2913.1 General.** The provisions of this section shall govern the construction, installation, *alteration* and *repair* of systems supplying non-potable reclaimed water.

**P2913.2 Water pressure-reducing valve or regulator.** Where the reclaimed water pressure supplied to the building exceeds 80 psi (552 kPa) static, a pressure-reducing valve shall be installed to reduce the pressure in the reclaimed water distribution system piping to 80 psi (552 kPa) static or less. Pressure-reducing valves shall be specified and installed in accordance with Section ~~P2903.3.1~~ P2903.3.2.

**Exception:** Service lines to sill cocks and outside hydrants, and main supply risers where pressure from the mains is reduced to 80 psi (552 kPa) or less at individual fixtures.

**P2913.3 Reclaimed water systems.** The design of the reclaimed water systems shall conform to accepted engineering practice.

**P2913.3.1 Distribution pipe.** Distribution piping shall comply with Sections P2913.3.1.1 through P2913.3.1.3.

**Exception:** Irrigation piping located outside of the building and downstream of a backflow preventer.

**P2913.3.1.1 Materials, joints and connections.** Distribution piping conveying reclaimed water shall conform to standards and requirements specified in Section P2906 for non-potable water.

**P2913.3.1.2 Design.** Distribution piping systems shall be designed and sized in accordance with Section P2903 for the intended application.

**P2913.3.1.3 Labeling and marking.** Non-potable rainwater distribution piping labeling and marking shall comply with Section P2901.2.

**P2913.4 Tests and inspections.** Tests and inspections shall be performed in accordance with Sections P2913.4.1 and P2913.4.2.

**P2913.4.1 Water supply system test.** The testing of makeup water supply piping and reclaimed water distribution piping shall be conducted in accordance with Section P2503.7.

**P2913.4.2 Inspection and testing of backflow prevention assemblies.** DELETED.

**TABLE P2902.3**
**APPLICATION FOR BACKFLOW PREVENTERS**

| DEVICE | DEGREE OF HAZARD[a] | APPLICATION[b] | APPLICABLE STANDARDS |
|---|---|---|---|
| Backflow Prevention Assemblies | | | |
| Double-check backflow prevention assembly and double-check fire protection backflow prevention assembly | Low hazard | Backpressure or backsiphonage sizes $^3/_8$″ – 16″ | ASSE 1015, AWWA C510, CSA B64.5, CSA B64.5.1 |
| Double-check detector fire protection backflow prevention assemblies | Low hazard | Backpressure or backsiphonage sizes 2″ – 16″ | ASSE 1048 |
| Pressure vacuum breaker assembly | High or low hazard | Backsiphonage only sizes $^1/_2$″ – 2″ | ASSE 1020, CSA B64.1.2 |
| Reduced pressure principle backflow prevention assembly and reduced pressure principle fire protection backflow prevention assembly | High or low hazard | Backpressure or backsiphonage sizes $^3/_8$″ – 16″ | ASSE 1013, AWWA C511, CSA B64.4, CSA B64.4.1 |
| Reduced pressure detector fire protection backflow prevention assemblies | High or low hazard | Backsiphonage or backpressure (automatic sprinkler systems) | ASSE 1047 |
| Spill-resistant vacuum breaker | High or low hazard | Backsiphonage only sizes $^1/_4$″ – 2″ | ASSE 1056, CSA B64.1.3 |
| Backflow Preventer Plumbing Devices | | | |
| Antisiphon-type fill valves for gravity water closet flush tanks | High hazard | Backsiphonage only | ASSE 1002/ASME A112.1002/CSA B125.12, CSA B125.3 |
| Backflow preventer with intermediate atmospheric vents | Low hazard | Backpressure or backsiphonage sizes $^1/_4$″ – $^3/_8$″ | ASSE 1012, CSA B64.3 |
| Backflow preventer with intermediate atmospheric vent and pressure-reducing valve | Low hazard | Backpressure or backsiphonage sizes $^1/_4$″ – $^3/_8$″ | ASSE 1081 |
| Dual-check-valve-type backflow preventers | Low hazard | Backpressure or backsiphonage sizes $^1/_4$″ – 1″ | ASSE 1024, CSA B64.6 |
| Hose-connection backflow preventer | High or low hazard | Low head backpressure, rated working pressure backpressure or backsiphonage sizes $^1/_2$″ – 1″ | ASSE 1052, CSA B64.2.1.1 |
| Hose-connection vacuum breaker | High or low hazard | Low head backpressure or backsiphonage sizes $^1/_2$″, $^3/_4$″, 1″ | ASSE 1011, CSA B64.2, CSA B64.2.1 |
| Laboratory faucet backflow preventer | High or low hazard | Low head backpressure and backsiphonage | ASSE 1035, CSA B64.7 |
| Pipe-applied atmospheric-type vacuum breaker | High or low hazard | Backsiphonage only sizes $^1/_4$″ – 4″ | ASSE 1001, CSA B64.1.1 |
| Vacuum breaker wall hydrants, frost-resistant, automatic-draining type | High or low hazard | Low head backpressure or back siphonage sizes $^3/_4$″ – 1″ | ASSE 1019, CSA B64.2.2 |
| Other Means or Methods | | | |
| Air gap | High or low hazard | Backsiphonage only | ASME A112.1.2 |
| Air gap fittings for use with plumbing fixtures, appliances and appurtenances | High or low hazard | Backsiphonage or backpressure | ASME A112.1.3 |

For SI: 1 inch = 25.4 mm.

a. Low hazard—See "*Pollution*" (Section R202). High hazard—See "*Contamination*" (Section R202).

b. See "*Backpressure*" (Section R202). See "*Backpressure, Low Head*" (Section R202). See "*Backsiphonage*" (Section R202).

**TABLE P2902.3.1**
**MINIMUM AIR GAPS**

| FIXTURE | MINIMUM AIR GAP | |
|---|---|---|
| | Away from a wall[a] (inches) | Close to a wall (inches) |
| Effective openings greater than 1 inch | Two times the diameter of the effective opening | Three times the diameter of the effective opening |
| Lavatories and other fixtures with effective openings not greater than $^1/_2$ inch in diameter | 1 | 1.5 |
| Over-rim bath fillers and other fixtures with effective openings not greater than 1 inch in diameter | 2 | 3 |
| Sink, laundry trays, gooseneck back faucets and other fixtures with effective openings not greater than $^3/_4$ inch in diameter | 1.5 | 2.5 |

For SI: 1 inch = 25.4 mm.
a. Applicable where walls or obstructions are spaced from the nearest inside edge of the spout opening a distance greater than three times the diameter of the effective opening for a single wall, or a distance greater than four times the diameter of the effective opening for two intersecting walls.

**TABLE P2903.1**
**REQUIRED CAPACITIES AT POINT OF OUTLET DISCHARGE**

| FIXTURE SUPPLY OUTLET SERVING | FLOW RATE (gpm) | FLOW PRESSURE (psi) |
|---|---|---|
| Bathtub, balanced-pressure, thermostatic or combination balanced-pressure/thermostatic mixing valve | 4 | 20 |
| Bidet, thermostatic mixing valve | 2 | 20 |
| Dishwasher | 2.75 | 8 |
| Laundry tray | 4 | 8 |
| Lavatory | 0.8 | 8 |
| Shower, balanced-pressure, thermostatic or combination balanced-pressure/thermostatic mixing valve | 2.5[a] | 20 |
| Sillcock, hose bibb | 5 | 8 |
| Sink | 1.75 | 8 |
| Water closet, flushometer tank | 1.6 | 20 |
| Water closet, tank, close coupled | 3 | 20 |
| Water closet, tank, one-piece | 6 | 20 |

For SI: 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 3.785 L/m.
a. Where the shower mixing valve manufacturer indicates a lower flow rating for the mixing valve, the lower value shall be applied.

**TABLE P2903.2**
**MAXIMUM FLOW RATES AND CONSUMPTION FOR PLUMBING FIXTURES AND FIXTURE FITTINGS[b]**

| PLUMBING FIXTURE OR FIXTURE FITTING | MAXIMUM FLOW RATE OR QUANTITY |
|---|---|
| Lavatory faucet | 2.2 gpm at 60 psi |
| Shower head[a] | 2.5 gpm at 80 psi |
| Sink faucet | 2.2 gpm at 60 psi |
| Water closet | 1.6 gallons per flushing cycle |

For SI: 1 gallon per minute = 3.785 L/m, 1 pound per square inch = 6.895 kPa.
a. A hand-held shower spray shall be considered to be a shower head.
b. Consumption tolerances shall be determined from referenced standards.

**TABLE P2903.6**
**WATER SUPPLY FIXTURE UNIT VALUES FOR VARIOUS PLUMBING FIXTURES AND FIXTURE GROUPS**

| TYPE OF FIXTURES OR GROUP OF FIXTURES | WATER-SUPPLY FIXTURE-UNIT VALUE (w.s.f.u.) | | |
|---|---|---|---|
| | Hot | Cold | Combined |
| Bathtub (with/without overhead shower head) | 1.0 | 1.0 | 1.4 |
| Clothes washer | 1.0 | 1.0 | 1.4 |
| Dishwasher | 1.4 | — | 1.4 |
| Full-bath group with bathtub (with/without shower head) or shower stall | 1.5 | 2.7 | 3.6 |
| Half-bath group (water closet and lavatory) | 0.5 | 2.5 | 2.6 |
| Hose bibb (sillcock)[a] | — | 2.5 | 2.5 |
| Kitchen group (dishwasher and sink with or without food-waste disposer) | 1.9 | 1.0 | 2.5 |
| Kitchen sink | 1.0 | 1.0 | 1.4 |
| Laundry group (clothes washer standpipe and laundry tub) | 1.8 | 1.8 | 2.5 |
| Laundry tub | 1.0 | 1.0 | 1.4 |
| Lavatory | 0.5 | 0.5 | 0.7 |
| Shower stall | 1.0 | 1.0 | 1.4 |
| Water closet (tank type) | — | 2.2 | 2.2 |

For SI: 1 gallon per minute = 3.785 L/m.
a. The fixture-unit value 2.5 assumes a flow demand of 2.5 gallons per minute, such as for an individual lawn sprinkler device. If a hose bibb or sill cock will be required to furnish a greater flow, the equivalent fixture-unit value may be obtained from this table or Table P2903.6(1).

**TABLE P2903.9.4**
**VALVES**

| MATERIAL | STANDARD |
|---|---|
| Chlorinated polyvinyl chloride (CPVC) plastic | ASME A112.4.14, ASME A112.18.1/CSA B125.1, ASTM F1970, CSA B125.3, MSS SP-122 |
| Copper or copper alloy | ASME A112.4.14, ASME A112.18.1/CSA B125.1, ASME B16.34, CSA B125.3, MSS SP-67, MSS SP-80, MSS SP-110, MSS SP-139 |
| Gray and ductile iron | ASTM A126, AWWA C500, AWWA C504, AWWA C507, MSS SP-42, MSS SP-67, MSS SP-70, MSS SP-71, MSS SP-72, MSS SP-78 |

| | |
|---|---|
| Cross-linked polyethylene (PEX) plastic | ASME A112.4.14, ASME A112.18.1/CSA B125.1, CSA B125.3, NSF 359 |
| Polypropylene (PP) plastic | ASME A112.4.14, ASTM F2389 |
| Polyvinyl chloride (PVC) plastic | ASME A112.4.14, ASTM F1970, MSS SP-122 |

**TABLE P2903.6(1)**
**CONVERSIONS FROM WATER SUPPLY FIXTURE UNIT TO GALLON PER MINUTE FLOW RATES**

| SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH TANKS | | | SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSHOMETER VALVES | | |
|---|---|---|---|---|---|
| Load | Demand | | Load | Demand | |
| (Water supply fixture units) | (Gallons per minute) | (Cubic feet per minute) | (Water supply fixture units) | (Gallons per minute) | (Cubic feet per minute) |
| 1 | 3.0 | 0.04104 | — | — | — |
| 2 | 5.0 | 0.0684 | — | — | — |
| 3 | 6.5 | 0.86892 | — | — | — |
| 4 | 8.0 | 1.06944 | — | — | — |
| 5 | 9.4 | 1.256592 | 5 | 15.0 | 2.0052 |
| 6 | 10.7 | 1.430376 | 6 | 17.4 | 2.326032 |
| 7 | 11.8 | 1.577424 | 7 | 19.8 | 2.646364 |
| 8 | 12.8 | 1.711104 | 8 | 22.2 | 2.967696 |
| 9 | 13.7 | 1.831416 | 9 | 24.6 | 3.288528 |
| 10 | 14.6 | 1.951728 | 10 | 27.0 | 3.60936 |
| 11 | 15.4 | 2.058672 | 11 | 27.8 | 3.716304 |
| 12 | 16.0 | 2.13888 | 12 | 28.6 | 3.823248 |
| 13 | 16.5 | 2.20572 | 13 | 29.4 | 3.930192 |
| 14 | 17.0 | 2.27256 | 14 | 30.2 | 4.037136 |
| 15 | 17.5 | 2.3394 | 15 | 31.0 | 4.14408 |
| 16 | 18.0 | 2.90624 | 16 | 31.8 | 4.241024 |
| 17 | 18.4 | 2.459712 | 17 | 32.6 | 4.357968 |
| 18 | 18.8 | 2.513184 | 18 | 33.4 | 4.464912 |
| 19 | 19.2 | 2.566656 | 19 | 34.2 | 4.571856 |
| 20 | 19.6 | 2.620128 | 20 | 35.0 | 4.6788 |
| 25 | 21.5 | 2.87412 | 25 | 38.0 | 5.07984 |
| 30 | 23.3 | 3.114744 | 30 | 42.0 | 5.61356 |
| 35 | 24.9 | 3.328632 | 35 | 44.0 | 5.88192 |
| 40 | 26.3 | 3.515784 | 40 | 46.0 | 6.14928 |
| 45 | 27.7 | 3.702936 | 45 | 48.0 | 6.41664 |
| 50 | 29.1 | 3.890088 | 50 | 50.0 | 6.684 |

For SI: 1 gallon per minute = 3.785 L/m, 1 cubic foot per minute = 0.4719 L/s.

**TABLE P2904.2.2**
**LOCATIONS WHERE INTERMEDIATE TEMPERATURE SPRINKLERS ARE REQUIRED**

| HEAT SOURCE | RANGE OF DISTANCE FROM HEAT SOURCE WITHIN WHICH INTERMEDIATE TEMPERATURE SPRINKLERS ARE REQUIRED[a, b] (inches) |
|---|---|
| Coal and wood burning stove | 12 to 42 |
| Fireplace, front of recessed fireplace | 36 to 60 |
| Fireplace, side of open or recessed fireplace | 12 to 36 |
| Front of wall-mounted warm-air register | 18 to 36 |
| Heating duct, not insulated | 9 to 18 |
| Hot water pipe, not insulated | 6 to 12 |
| Kitchen range top | 9 to 18 |
| Luminaire up to 250 watts | 3 to 6 |
| Luminaire 250 watts up to 499 watts | 6 to 12 |
| Oven | 9 to 18 |
| Side of ceiling or wall warm-air register | 12 to 24 |
| Vent connector or chimney connector | 9 to 18 |
| Water heater, furnace or boiler | 3 to 6 |

For SI: 1 inch = 25.4 mm.
a. Sprinklers shall not be located at distances less than the minimum table distance unless the sprinkler listing allows a lesser distance.
b. Distances shall be measured in a straight line from the nearest edge of the heat source to the nearest edge of the sprinkler.

**TABLE P2904.6.2(1)**
**WATER SERVICE PRESSURE LOSS $(PL_{svc})$[a, b]**

| FLOW RATE[c] (gpm) | $^3/_4$-INCH WATER SERVICE PRESSURE LOSS (psi) | | | | 1-INCH WATER SERVICE PRESSURE LOSS (psi) | | | | $1^1/_4$ -INCH WATER SERVICE PRESSURE LOSS (psi) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Length of water service pipe (feet) | | | | Length of water service pipe (feet) | | | | Length of water service pipe (feet) | | | |
| | 40 or less | 41 to 75 | 76 to 100 | 101 to 150 | 40 or less | 41 to 75 | 76 to 100 | 101 to 150 | 40 or less | 41 to 75 | 76 to 100 | 101 to 150 |
| 8 | 5.1 | 8.7 | 11.8 | 17.4 | 1.5 | 2.5 | 3.4 | 5.1 | 0.6 | 1.0 | 1.3 | 1.9 |
| 10 | 7.7 | 13.1 | 17.8 | 26.3 | 2.3 | 3.8 | 5.2 | 7.7 | 0.8 | 1.4 | 2.0 | 2.9 |
| 12 | 10.8 | 18.4 | 24.9 | NP | 3.2 | 5.4 | 7.3 | 10.7 | 1.2 | 2.0 | 2.7 | 4.0 |
| 14 | 14.4 | 24.5 | NP | NP | 4.2 | 7.1 | 9.6 | 14.3 | 1.6 | 2.7 | 3.6 | 5.4 |
| 16 | 18.4 | NP | NP | NP | 5.4 | 9.1 | 12.4 | 18.3 | 2.0 | 3.4 | 4.7 | 6.9 |
| 18 | 22.9 | NP | NP | NP | 6.7 | 11.4 | 15.4 | 22.7 | 2.5 | 4.3 | 5.8 | 8.6 |
| 20 | 27.8 | NP | NP | NP | 8.1 | 13.8 | 18.7 | 27.6 | 3.1 | 5.2 | 7.0 | 10.4 |
| 22 | NP | NP | NP | NP | 9.7 | 16.5 | 22.3 | NP | 3.7 | 6.2 | 8.4 | 12.4 |
| 24 | NP | NP | NP | NP | 11.4 | 19.3 | 26.2 | NP | 4.3 | 7.3 | 9.9 | 14.6 |
| 26 | NP | NP | NP | NP | 13.2 | 22.4 | NP | NP | 5.0 | 8.5 | 11.4 | 16.9 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | NP | NP | NP | NP | 15.1 | 25.7 | NP | NP | 5.7 | 9.7 | 13.1 | 19.4 |
| 30 | NP | NP | NP | NP | 17.2 | NP | NP | NP | 6.5 | 11.0 | 14.9 | 22.0 |
| 32 | NP | NP | NP | NP | 19.4 | NP | NP | NP | 7.3 | 12.4 | 16.8 | 24.8 |
| 34 | NP | NP | NP | NP | 21.7 | NP | NP | NP | 8.2 | 13.9 | 18.8 | NP |
| 36 | NP | NP | NP | NP | 24.1 | NP | NP | NP | 9.1 | 15.4 | 20.9 | NP |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gallon per minute = 0.063 L/s, 1 pound per square inch = 6.895 kPa.
NP = Not Permitted. Pressure loss exceeds reasonable limits.
a. Values are applicable for underground piping materials listed in Table P2906.4 and are based on an SDR of 11 and a Hazen Williams C Factor of 150.
b. Values include the following length allowances for fittings: 25-percent length increase for actual lengths up to 100 feet and 15-percent length increase for actual lengths over 100 feet.
c. Flow rate from Section P2904.4.2. Add 5 gpm to the flow rate required by Section P2904.4.2 where the water service pipe supplies more than one dwelling.

**TABLE P2904.6.2(2)**
**MINIMUM WATER METER PRESSURE LOSS (*$PL_m$*)[a]**

| FLOW RATE (gallons per minute, gpm)[b] | 5/8-INCH METER PRESSURE LOSS (pounds per square inch, psi) | 3/4-INCH METER PRESSURE LESS (pounds per square inch, psi) | 1-INCH METER PRESSURE LOSS (pounds per square inch, psi) |
|---|---|---|---|
| 8 | 3 | 3 | 1 |
| 10 | 3 | 3 | 1 |
| 12 | 4 | 3 | 1 |
| 14 | 6 | 5 | 1 |
| 16 | 7 | 6 | 1 |
| 18 | 9 | 7 | 2 |
| 20 | 11 | 9 | 2 |
| 23 | 14 | 11 | 3 |
| 26 | 18 | 14 | 3 |
| 31 | 26 | 22 | 4 |
| 39 | 38 | 35 | 6 |
| 52 | NP | NP | 10 |

For SI: 1 inch = 25.4 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.063 L/s.
NP = Not permitted unless the actual water meter pressure loss is known.
a. Table P2904.6.2(2) establishes conservative values for water meter pressure loss or installations where the water meter loss is unknown. Where the actual water meter pressure loss is published and available from the meter manufacturer, $PL_m$ shall be the published pressure loss for the selected meter.
b. Flow rate from Section P2904.4.2. Add 5 gpm to the flow rate required by Section P2904.4.2 where the water service pipe supplies more than one dwelling.

**TABLE P2906.4**
**WATER SERVICE PIPE**

| MATERIAL | STANDARD |
|---|---|
| Acrylonitrile butadiene styrene (ABS) plastic pipe | ASTM D1527; ASTM D2282 |
| Chlorinated polyvinyl chloride (CPVC) plastic pipe | ASTM D2846; ASTM F441; ASTM F442/F442M; CSA B137.6 |
| Chlorinated polyvinyl chloride/aluminum/chlorinated polyvinyl chloride (CPVC/AL/CPVC) plastic pipe | ASTM F2855 |
| Copper or copper-alloy pipe | ASTM B42; ASTM B43; ASTM B302 |
| Copper or copper-alloy tubing (Type K, WK, L, WL, M or WM) | ASTM B75/B75M; ASTM B88; ASTM B251; ASTM B447 |
| Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe | ASTM F1281; ASTM F2262; CSA B137.10 |
| Cross-linked polyethylene/aluminum/high-density polyethylene (PEX-AL-HDPE) pipe | ASTM F1986 |
| Cross-linked polyethylene (PEX) plastic tubing | ASTM F876; AWWA C904; CSA 137.5 |
| Ductile iron water pipe | AWWA C115/A21.15; AWWA C151/A21.51 |
| Galvanized steel pipe | ASTM A53 |
| Polyethylene/aluminum/polyethylene (PE-AL-PE) pipe | ASTM F1282; CSA B137.9 |
| Polyethylene (PE) plastic pipe | ASTM D2104; ASTM D2239; AWWA C901; CSA 137.1 |
| Polyethylene (PE) plastic tubing | ASTM D2737; AWWA C901; CSA 137.1 |
| Polyethylene of raised temperature (PE-RT) plastic tubing | ASTM F2769; CSA B137.18 |
| Polypropylene (PP) plastic tubing | ASTM F2389; CSA B137.11 |
| Polyvinyl chloride (PVC) plastic pipe | ASTM D1785; ASTM D2241; ASTM D2672; CSA B137.3 |
| Stainless steel (Type 304/304L) pipe | ASTM A312; ASTM A778 |
| Stainless steel (Type 316/316L) pipe | ASTM A312; ASTM A778 |

**TABLE P2906.5**
**WATER DISTRIBUTION PIPE**

| MATERIAL | STANDARD |
|---|---|
| Chlorinated polyvinyl chloride (CPVC) plastic pipe and tubing | ASTM D2846; ASTM F441; ASTM F442/F442M; CSA B137.6 |
| Chlorinated polyvinyl chloride/aluminum/chlorinated polyvinyl chloride (CPVC/AL/CPVC) plastic pipe | ASTM F2855 |
| Copper or copper-alloy pipe | ASTM B42; ASTM B43; ASTM B302 |
| Copper or copper-alloy tubing (Type K, WK, L, WL, M or WM) | ASTM B75/B75M; ASTM B88; ASTM B251; ASTM B447 |
| Cross-linked polyethylene (PEX) plastic tubing | ASTM F876; CSA B137.5 |

| | |
|---|---|
| Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe | ASTM F1281; ASTM F2262; CSA B137.10 |
| Cross-linked polyethylene/aluminum/high-density polyethylene (PEX-AL-HDPE) pipe | ASTM F1986 |
| Galvanized steel pipe | ASTM A53 |
| Polyethylene/aluminum/polyethylene (PE-AL-PE) composite pipe | ASTM F1282 |
| Polyethylene of raised temperature (PE-RT) plastic tubing | ASTM F2769; CSA B137.18 |
| Polypropylene (PP) plastic pipe or tubing | ASTM F2389; CSA B137.11 |
| Stainless steel (Type 304/304L) pipe | ASTM A312; ASTM A778 |

**TABLE P2906.6**
**PIPE FITTINGS**

| MATERIAL | STANDARD |
|---|---|
| Acrylonitrile butadiene styrene (ABS) plastic | ASTM D2468 |
| Cast iron | ASME B16.4 |
| Chlorinated polyvinyl chloride (CPVC) plastic | ASSE 1061; ASTM D2846; ASTM F437; ASTM F438; ASTM F439; CSA B137.6 |
| Copper or copper alloy (Brass) | ASME B16.15; ASME B16.18; ASME B16.22; ASME B16.26; ASME B16.51; ASSE 1061; ASTM F3226 |
| Cross-linked polyethylene/aluminum/high-density polyethylene (PEX-AL-HDPE) | ASTM F1986 |
| Fittings for cross-linked polyethylene (PEX) plastic tubing | ASSE 1061; ASTM F877; ASTM F1807; ASTM F1960; ASTM F2080; ASTM F2098; ASTM F2159; ASTM F2434; ASTM F2735; CSA B137.5 |
| Gray iron and ductile iron | AWWA C110/A21.10; AWWA C153/A21.53 |
| Malleable iron | ASME B16.3 |
| Insert fittings for polyethylene/aluminum/polyethylene (PE-AL-PE) and cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) | ASTM F1281; ASTM F1282; ASTM F1974; CSA B137.9; CSA B137.10 |
| Polyethylene (PE) plastic | ASTM D2609; CSA B137.1 |
| Fittings for polyethylene of raised temperature (PE-RT) plastic tubing | ASSE 1061; ASTM D2683; ASTM D3261; ASTM F1055; ASTM F1807; ASTM F2098; ASTM F2159; ASTM F2735; ASTM F2769; CSA B137.18 |
| Polybutylene (PB) plastic | ASSE 1061; CSA B137.8 |
| Polypropylene (PP) plastic pipe or tubing | ASTM F2389; CSA B137.11 |

| | |
|---|---|
| Polyvinyl chloride (PVC) plastic | ASTM D2464; ASTM D2466; ASTM D2467; CSA B137.2; CSA B137.3 |
| Stainless steel (Type 304/304L) pipe | ASTM A312; ASTM A778 |
| Stainless steel (Type 316/316L) pipe | ASTM A312; ASTM A778 |
| Steel | ASME B16.9; ASME B16.11; ASME B16.28 |

**TABLE P2904.6.2(3)**
**ELEVATION LOSS ($PL_e$)**

| ELEVATION (feet) | PRESSURE LOSS (psi) |
|---|---|
| 5 | 2.2 |
| 10 | 4.4 |
| 15 | 6.5 |
| 20 | 8.7 |
| 25 | 10.9 |
| 30 | 13 |
| 35 | 15.2 |
| 40 | 17.4 |

For SI: 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa.

**TABLE P2904.6.2(4)**
**ALLOWABLE PIPE LENGTH FOR $^3/_4$-INCH TYPE M COPPER WATER TUBING**

| SPRINKLER FLOW RATE[a] (gpm) | WATER DISTRIBUTION SIZE (inch) | AVAILABLE PRESSURE—$P_t$ (psi) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| | | Allowable length of pipe from service valve to farthest sprinkler (feet) | | | | | | | | | |
| 8 | $^3/_4$ | 217 | 289 | 361 | 434 | 506 | 578 | 650 | 723 | 795 | 867 |
| 9 | $^3/_4$ | 174 | 232 | 291 | 349 | 407 | 465 | 523 | 581 | 639 | 697 |
| 10 | $^3/_4$ | 143 | 191 | 239 | 287 | 335 | 383 | 430 | 478 | 526 | 574 |
| 11 | $^3/_4$ | 120 | 160 | 200 | 241 | 281 | 321 | 361 | 401 | 441 | 481 |
| 12 | $^3/_4$ | 102 | 137 | 171 | 205 | 239 | 273 | 307 | 341 | 375 | 410 |
| 13 | $^3/_4$ | 88 | 118 | 147 | 177 | 206 | 235 | 265 | 294 | 324 | 353 |
| 14 | $^3/_4$ | 77 | 103 | 128 | 154 | 180 | 205 | 231 | 257 | 282 | 308 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 3/4 | 68 | 90 | 113 | 136 | 158 | 181 | 203 | 226 | 248 | 271 |
| 16 | 3/4 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 241 |
| 17 | 3/4 | 54 | 72 | 90 | 108 | 125 | 143 | 161 | 179 | 197 | 215 |
| 18 | 3/4 | 48 | 64 | 81 | 97 | 113 | 129 | 145 | 161 | 177 | 193 |
| 19 | 3/4 | 44 | 58 | 73 | 88 | 102 | 117 | 131 | 146 | 160 | 175 |
| 20 | 3/4 | 40 | 53 | 66 | 80 | 93 | 106 | 119 | 133 | 146 | 159 |
| 21 | 3/4 | 36 | 48 | 61 | 73 | 85 | 97 | 109 | 121 | 133 | 145 |
| 22 | 3/4 | 33 | 44 | 56 | 67 | 78 | 89 | 100 | 111 | 122 | 133 |
| 23 | 3/4 | 31 | 41 | 51 | 61 | 72 | 82 | 92 | 102 | 113 | 123 |
| 24 | 3/4 | 28 | 38 | 47 | 57 | 66 | 76 | 85 | 95 | 104 | 114 |
| 25 | 3/4 | 26 | 35 | 44 | 53 | 61 | 70 | 79 | 88 | 97 | 105 |
| 26 | 3/4 | 24 | 33 | 41 | 49 | 57 | 65 | 73 | 82 | 90 | 98 |
| 27 | 3/4 | 23 | 30 | 38 | 46 | 53 | 61 | 69 | 76 | 84 | 91 |
| 28 | 3/4 | 21 | 28 | 36 | 43 | 50 | 57 | 64 | 71 | 78 | 85 |
| 29 | 3/4 | 20 | 27 | 33 | 40 | 47 | 53 | 60 | 67 | 73 | 80 |
| 30 | 3/4 | 19 | 25 | 31 | 38 | 44 | 50 | 56 | 63 | 69 | 75 |
| 31 | 3/4 | 18 | 24 | 29 | 35 | 41 | 47 | 53 | 59 | 65 | 71 |
| 32 | 3/4 | 17 | 22 | 28 | 33 | 39 | 44 | 50 | 56 | 61 | 67 |
| 33 | 3/4 | 16 | 21 | 26 | 32 | 37 | 42 | 47 | 53 | 58 | 63 |
| 34 | 3/4 | NP | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| 35 | 3/4 | NP | 19 | 24 | 28 | 33 | 38 | 42 | 47 | 52 | 57 |
| 36 | 3/4 | NP | 18 | 22 | 27 | 31 | 36 | 40 | 45 | 49 | 54 |
| 37 | 3/4 | NP | 17 | 21 | 26 | 30 | 34 | 38 | 43 | 47 | 51 |
| 38 | 3/4 | NP | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 45 | 49 |
| 39 | 3/4 | NP | 15 | 19 | 23 | 27 | 31 | 35 | 39 | 42 | 46 |
| 40 | 3/4 | NP | NP | 18 | 22 | 26 | 29 | 33 | 37 | 40 | 44 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.963 L/s.
NP = Not Permitted.
a. Flow rate from Section P2904.4.2.

**TABLE P2904.6.2(5)**
**ALLOWABLE PIPE LENGTH FOR 1-INCH TYPE M COPPER WATER TUBING**

| SPRINKLER FLOW RATE[a] (gpm) | WATER DISTRIBUTION SIZE (inch) | AVAILABLE PRESSURE—$P_t$ (psi) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| | | Allowable length of pipe from service valve to farthest sprinkler (feet) | | | | | | | | | |
| 8 | 1 | 806 | 1,075 | 1,343 | 1,612 | 1,881 | 2,149 | 2,418 | 2,687 | 2,955 | 3,224 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 1 | 648 | 864 | 1,080 | 1,296 | 1,512 | 1,728 | 1,945 | 2,161 | 2,377 | 2,593 |
| 10 | 1 | 533 | 711 | 889 | 1,067 | 1,245 | 1,422 | 1,600 | 1,778 | 1,956 | 2,134 |
| 11 | 1 | 447 | 586 | 745 | 894 | 1,043 | 1,192 | 1,341 | 1,491 | 1,640 | 1,789 |
| 12 | 1 | 381 | 508 | 634 | 761 | 888 | 1,015 | 1,142 | 1,269 | 1,396 | 1,523 |
| 13 | 1 | 328 | 438 | 547 | 657 | 766 | 875 | 985 | 1,094 | 1,204 | 1,313 |
| 14 | 1 | 286 | 382 | 477 | 572 | 668 | 763 | 859 | 954 | 1,049 | 1,145 |
| 15 | 1 | 252 | 336 | 420 | 504 | 588 | 672 | 756 | 840 | 924 | 1,008 |
| 16 | 1 | 224 | 298 | 373 | 447 | 522 | 596 | 671 | 745 | 820 | 894 |
| 17 | 1 | 200 | 266 | 333 | 400 | 466 | 533 | 600 | 666 | 733 | 799 |
| 18 | 1 | 180 | 240 | 300 | 360 | 420 | 479 | 539 | 599 | 659 | 719 |
| 19 | 1 | 163 | 217 | 271 | 325 | 380 | 434 | 488 | 542 | 597 | 651 |
| 20 | 1 | 148 | 197 | 247 | 296 | 345 | 395 | 444 | 493 | 543 | 592 |
| 21 | 1 | 135 | 180 | 225 | 270 | 315 | 360 | 406 | 451 | 496 | 541 |
| 22 | 1 | 124 | 165 | 207 | 248 | 289 | 331 | 372 | 413 | 455 | 496 |
| 23 | 1 | 114 | 152 | 190 | 228 | 267 | 305 | 343 | 381 | 419 | 457 |
| 24 | 1 | 106 | 141 | 176 | 211 | 246 | 282 | 317 | 352 | 387 | 422 |
| 25 | 1 | 98 | 131 | 163 | 196 | 228 | 261 | 294 | 326 | 359 | 392 |
| 26 | 1 | 91 | 121 | 152 | 182 | 212 | 243 | 273 | 304 | 334 | 364 |
| 27 | 1 | 85 | 113 | 142 | 170 | 198 | 226 | 255 | 283 | 311 | 340 |
| 28 | 1 | 79 | 106 | 132 | 159 | 185 | 212 | 238 | 265 | 291 | 318 |
| 29 | 1 | 74 | 99 | 124 | 149 | 174 | 198 | 223 | 248 | 273 | 298 |
| 30 | 1 | 70 | 93 | 116 | 140 | 163 | 186 | 210 | 233 | 256 | 280 |
| 31 | 1 | 66 | 88 | 110 | 132 | 153 | 175 | 197 | 219 | 241 | 263 |
| 32 | 1 | 62 | 83 | 103 | 124 | 145 | 165 | 186 | 207 | 227 | 248 |
| 33 | 1 | 59 | 78 | 98 | 117 | 137 | 156 | 176 | 195 | 215 | 234 |
| 34 | 1 | 55 | 74 | 92 | 111 | 129 | 148 | 166 | 185 | 203 | 222 |
| 35 | 1 | 53 | 70 | 88 | 105 | 123 | 140 | 158 | 175 | 193 | 210 |
| 36 | 1 | 50 | 66 | 83 | 100 | 116 | 133 | 150 | 166 | 183 | 199 |
| 37 | 1 | 47 | 63 | 79 | 95 | 111 | 126 | 142 | 158 | 174 | 190 |
| 38 | 1 | 45 | 60 | 75 | 90 | 105 | 120 | 135 | 150 | 165 | 181 |
| 39 | 1 | 43 | 57 | 72 | 86 | 100 | 115 | 129 | 143 | 158 | 172 |
| 40 | 1 | 41 | 55 | 68 | 82 | 96 | 109 | 123 | 137 | 150 | 164 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.963 L/s.
a. Flow rate from Section P2904.4.2.

**TABLE P2904.6.2(6)**
**ALLOWABLE PIPE LENGTH FOR 3/4-INCH CPVC PIPE**

| SPRINKLER FLOW RATE[a] (gpm) | WATER DISTRIBUTION SIZE (inch) | AVAILABLE PRESSURE—$P_t$ (psi) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| | | Allowable length of pipe from service valve to farthest sprinkler (feet) | | | | | | | | | |
| 8 | 3/4 | 348 | 465 | 581 | 697 | 813 | 929 | 1,045 | 1,161 | 1,278 | 1,394 |
| 9 | 3/4 | 280 | 374 | 467 | 560 | 654 | 747 | 841 | 934 | 1,027 | 1,121 |
| 10 | 3/4 | 231 | 307 | 384 | 461 | 538 | 615 | 692 | 769 | 845 | 922 |
| 11 | 3/4 | 193 | 258 | 322 | 387 | 451 | 515 | 580 | 644 | 709 | 773 |
| 12 | 3/4 | 165 | 219 | 274 | 329 | 384 | 439 | 494 | 549 | 603 | 658 |
| 13 | 3/4 | 142 | 189 | 237 | 284 | 331 | 378 | 426 | 473 | 520 | 568 |
| 14 | 3/4 | 124 | 165 | 206 | 247 | 289 | 330 | 371 | 412 | 454 | 495 |
| 15 | 3/4 | 109 | 145 | 182 | 218 | 254 | 290 | 327 | 363 | 399 | 436 |
| 16 | 3/4 | 97 | 129 | 161 | 193 | 226 | 258 | 290 | 322 | 354 | 387 |
| 17 | 3/4 | 86 | 115 | 144 | 173 | 202 | 230 | 259 | 288 | 317 | 346 |
| 18 | 3/4 | 78 | 104 | 130 | 155 | 181 | 207 | 233 | 259 | 285 | 311 |
| 19 | 3/4 | 70 | 94 | 117 | 141 | 164 | 188 | 211 | 234 | 258 | 281 |
| 20 | 3/4 | 64 | 85 | 107 | 128 | 149 | 171 | 192 | 213 | 235 | 256 |
| 21 | 3/4 | 58 | 78 | 97 | 117 | 136 | 156 | 175 | 195 | 214 | 234 |
| 22 | 3/4 | 54 | 71 | 89 | 107 | 125 | 143 | 161 | 179 | 197 | 214 |
| 23 | 3/4 | 49 | 66 | 82 | 99 | 115 | 132 | 148 | 165 | 181 | 198 |
| 24 | 3/4 | 46 | 61 | 76 | 91 | 107 | 122 | 137 | 152 | 167 | 183 |
| 25 | 3/4 | 42 | 56 | 71 | 85 | 99 | 113 | 127 | 141 | 155 | 169 |
| 26 | 3/4 | 39 | 52 | 66 | 79 | 92 | 105 | 118 | 131 | 144 | 157 |
| 27 | 3/4 | 37 | 49 | 61 | 73 | 86 | 98 | 110 | 122 | 135 | 147 |
| 28 | 3/4 | 34 | 46 | 57 | 69 | 80 | 92 | 103 | 114 | 126 | 137 |
| 29 | 3/4 | 32 | 43 | 54 | 64 | 75 | 86 | 96 | 107 | 118 | 129 |
| 30 | 3/4 | 30 | 40 | 50 | 60 | 70 | 81 | 91 | 101 | 111 | 121 |
| 31 | 3/4 | 28 | 38 | 47 | 57 | 66 | 76 | 85 | 95 | 104 | 114 |
| 32 | 3/4 | 27 | 36 | 45 | 54 | 63 | 71 | 80 | 89 | 98 | 107 |
| 33 | 3/4 | 25 | 34 | 42 | 51 | 59 | 68 | 76 | 84 | 93 | 101 |
| 34 | 3/4 | 24 | 32 | 40 | 48 | 56 | 64 | 72 | 80 | 88 | 96 |
| 35 | 3/4 | 23 | 30 | 38 | 45 | 53 | 61 | 68 | 76 | 83 | 91 |
| 36 | 3/4 | 22 | 29 | 36 | 43 | 50 | 57 | 65 | 72 | 79 | 86 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 37 | $^3/_4$ | 20 | 27 | 34 | 41 | 48 | 55 | 61 | 68 | 75 | 82 |
| 38 | $^3/_4$ | 20 | 26 | 33 | 39 | 46 | 52 | 59 | 65 | 72 | 78 |
| 39 | $^3/_4$ | 19 | 25 | 31 | 37 | 43 | 50 | 56 | 62 | 68 | 74 |
| 40 | $^3/_4$ | 18 | 24 | 30 | 35 | 41 | 47 | 53 | 59 | 65 | 71 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.963 L/s.
a. Flow rate from Section P2904.4.2.

**TABLE P2904.6.2(7)**
**ALLOWABLE PIPE LENGTH FOR 1-INCH CPVC PIPE**

| SPRINKLER FLOW RATE[a] (gpm) | WATER DISTRIBUTION SIZE (inch) | AVAILABLE PRESSURE—$P_t$ (psi) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| | | Allowable length of pipe from service valve to farthest sprinkler (feet) | | | | | | | | | |
| 8 | 1 | 1,049 | 1,398 | 1,748 | 2,098 | 2,447 | 2,797 | 3,146 | 3,496 | 3,845 | 4,195 |
| 9 | 1 | 843 | 1,125 | 1,406 | 1,687 | 1,968 | 2,249 | 2,530 | 2,811 | 3,093 | 3,374 |
| 10 | 1 | 694 | 925 | 1,157 | 1,388 | 1,619 | 1,851 | 2,082 | 2,314 | 2,545 | 2,776 |
| 11 | 1 | 582 | 776 | 970 | 1,164 | 1,358 | 1,552 | 1,746 | 1,940 | 2,133 | 2,327 |
| 12 | 1 | 495 | 660 | 826 | 991 | 1,156 | 1,321 | 1,486 | 1,651 | 1,816 | 1,981 |
| 13 | 1 | 427 | 570 | 712 | 854 | 997 | 1,139 | 1,281 | 1,424 | 1,566 | 1,709 |
| 14 | 1 | 372 | 497 | 621 | 745 | 869 | 993 | 1,117 | 1,241 | 1,366 | 1,490 |
| 15 | 1 | 328 | 437 | 546 | 656 | 765 | 874 | 983 | 1,093 | 1,202 | 1,311 |
| 16 | 1 | 291 | 388 | 485 | 582 | 679 | 776 | 873 | 970 | 1,067 | 1,164 |
| 17 | 1 | 260 | 347 | 433 | 520 | 607 | 693 | 780 | 867 | 954 | 1,040 |
| 18 | 1 | 234 | 312 | 390 | 468 | 546 | 624 | 702 | 780 | 858 | 936 |
| 19 | 1 | 212 | 282 | 353 | 423 | 494 | 565 | 635 | 706 | 776 | 847 |
| 20 | 1 | 193 | 257 | 321 | 385 | 449 | 513 | 578 | 642 | 706 | 770 |
| 21 | 1 | 176 | 235 | 293 | 352 | 410 | 469 | 528 | 586 | 645 | 704 |
| 22 | 1 | 161 | 215 | 269 | 323 | 377 | 430 | 484 | 538 | 592 | 646 |
| 23 | 1 | 149 | 198 | 248 | 297 | 347 | 396 | 446 | 496 | 545 | 595 |
| 24 | 1 | 137 | 183 | 229 | 275 | 321 | 366 | 412 | 458 | 504 | 550 |
| 25 | 1 | 127 | 170 | 212 | 255 | 297 | 340 | 382 | 425 | 467 | 510 |
| 26 | 1 | 118 | 158 | 197 | 237 | 276 | 316 | 355 | 395 | 434 | 474 |
| 27 | 1 | 111 | 147 | 184 | 221 | 258 | 295 | 332 | 368 | 405 | 442 |
| 28 | 1 | 103 | 138 | 172 | 207 | 241 | 275 | 310 | 344 | 379 | 413 |
| 29 | 1 | 97 | 129 | 161 | 194 | 226 | 258 | 290 | 323 | 355 | 387 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 1 | 91 | 121 | 152 | 182 | 212 | 242 | 273 | 303 | 333 | 364 |
| 31 | 1 | 86 | 114 | 143 | 171 | 200 | 228 | 257 | 285 | 314 | 342 |
| 32 | 1 | 81 | 108 | 134 | 161 | 188 | 215 | 242 | 269 | 296 | 323 |
| 33 | 1 | 76 | 102 | 127 | 152 | 178 | 203 | 229 | 254 | 280 | 305 |
| 34 | 1 | 72 | 96 | 120 | 144 | 168 | 192 | 216 | 240 | 265 | 289 |
| 35 | 1 | 68 | 91 | 114 | 137 | 160 | 182 | 205 | 228 | 251 | 273 |
| 36 | 1 | 65 | 87 | 108 | 130 | 151 | 173 | 195 | 216 | 238 | 260 |
| 37 | 1 | 62 | 82 | 103 | 123 | 144 | 165 | 185 | 206 | 226 | 247 |
| 38 | 1 | 59 | 78 | 98 | 117 | 137 | 157 | 176 | 196 | 215 | 235 |
| 39 | 1 | 56 | 75 | 93 | 112 | 131 | 149 | 168 | 187 | 205 | 224 |
| 40 | 1 | 53 | 71 | 89 | 107 | 125 | 142 | 160 | 178 | 196 | 214 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.963 L/s.
a. Flow rate from Section P2904.4.2.

**TABLE P2904.6.2(8)**
**ALLOWABLE PIPE LENGTH FOR 3/4-INCH PEX AND PE-RT TUBING**

| SPRINKLER FLOW RATE[a] (gpm) | WATER DISTRIBUTION SIZE (inch) | AVAILABLE PRESSURE—$P_t$ (psi) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| | | Allowable length of pipe from service valve to farthest sprinkler (feet) | | | | | | | | | |
| 8 | 3/4 | 93 | 123 | 154 | 185 | 216 | 247 | 278 | 309 | 339 | 370 |
| 9 | 3/4 | 74 | 99 | 124 | 149 | 174 | 199 | 223 | 248 | 273 | 298 |
| 10 | 3/4 | 61 | 82 | 102 | 123 | 143 | 163 | 184 | 204 | 225 | 245 |
| 11 | 3/4 | 51 | 68 | 86 | 103 | 120 | 137 | 154 | 171 | 188 | 205 |
| 12 | 3/4 | 44 | 58 | 73 | 87 | 102 | 117 | 131 | 146 | 160 | 175 |
| 13 | 3/4 | 38 | 50 | 63 | 75 | 88 | 101 | 113 | 126 | 138 | 151 |
| 14 | 3/4 | 33 | 44 | 55 | 66 | 77 | 88 | 99 | 110 | 121 | 132 |
| 15 | 3/4 | 29 | 39 | 48 | 58 | 68 | 77 | 87 | 96 | 106 | 116 |
| 16 | 3/4 | 26 | 34 | 43 | 51 | 60 | 68 | 77 | 86 | 94 | 103 |
| 17 | 3/4 | 23 | 31 | 38 | 46 | 54 | 61 | 69 | 77 | 84 | 92 |
| 18 | 3/4 | 21 | 28 | 34 | 41 | 48 | 55 | 62 | 69 | 76 | 83 |
| 19 | 3/4 | 19 | 25 | 31 | 37 | 44 | 50 | 56 | 62 | 69 | 75 |
| 20 | 3/4 | 17 | 23 | 28 | 34 | 40 | 45 | 51 | 57 | 62 | 68 |
| 21 | 3/4 | 16 | 21 | 26 | 31 | 36 | 41 | 47 | 52 | 57 | 62 |
| 22 | 3/4 | NP | 19 | 24 | 28 | 33 | 38 | 43 | 47 | 52 | 57 |
| 23 | 3/4 | NP | 17 | 22 | 26 | 31 | 35 | 39 | 44 | 48 | 52 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 3/4 | NP | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | 49 |
| 25 | 3/4 | NP | NP | 19 | 22 | 26 | 30 | 34 | 37 | 41 | 45 |
| 26 | 3/4 | NP | NP | 17 | 21 | 24 | 28 | 31 | 35 | 38 | 42 |
| 27 | 3/4 | NP | NP | 16 | 20 | 23 | 26 | 29 | 33 | 36 | 39 |
| 28 | 3/4 | NP | NP | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 |
| 29 | 3/4 | NP | NP | NP | 17 | 20 | 23 | 26 | 28 | 31 | 34 |
| 30 | 3/4 | NP | NP | NP | 16 | 19 | 21 | 24 | 27 | 29 | 32 |
| 31 | 3/4 | NP | NP | NP | 15 | 18 | 20 | 23 | 25 | 28 | 30 |
| 32 | 3/4 | NP | NP | NP | NP | 17 | 19 | 21 | 24 | 26 | 28 |
| 33 | 3/4 | NP | NP | NP | NP | 16 | 18 | 20 | 22 | 25 | 27 |
| 34 | 3/4 | NP | NP | NP | NP | NP | 17 | 19 | 21 | 23 | 25 |
| 35 | 3/4 | NP | NP | NP | NP | NP | 16 | 18 | 20 | 22 | 24 |
| 36 | 3/4 | NP | NP | NP | NP | NP | 15 | 17 | 19 | 21 | 23 |
| 37 | 3/4 | NP | NP | NP | NP | NP | NP | 16 | 18 | 20 | 22 |
| 38 | 3/4 | NP | NP | NP | NP | NP | NP | 16 | 17 | 19 | 21 |
| 39 | 3/4 | NP | NP | NP | NP | NP | NP | NP | 16 | 18 | 20 |
| 40 | 3/4 | NP | NP | NP | NP | NP | NP | NP | 16 | 17 | 19 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.963 L/s.
NP = Not Permitted.
a. Flow rate from Section P2904.4.2.

**TABLE P2904.6.2(9)**
**ALLOWABLE PIPE LENGTH FOR 1-INCH PEX AND PE-RT TUBING**

| SPRINKLER FLOW RATE[a] (gpm) | WATER DISTRIBUTION SIZE (inch) | AVAILABLE PRESSURE—$P_t$ (psi) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| | | Allowable length of pipe from service valve to farthest sprinkler (feet) | | | | | | | | | |
| 8 | 1 | 314 | 418 | 523 | 628 | 732 | 837 | 941 | 1,046 | 1,151 | 1,255 |
| 9 | 1 | 252 | 336 | 421 | 505 | 589 | 673 | 757 | 841 | 925 | 1,009 |
| 10 | 1 | 208 | 277 | 346 | 415 | 485 | 554 | 623 | 692 | 761 | 831 |
| 11 | 1 | 174 | 232 | 290 | 348 | 406 | 464 | 522 | 580 | 638 | 696 |
| 12 | 1 | 148 | 198 | 247 | 296 | 346 | 395 | 445 | 494 | 543 | 593 |
| 13 | 1 | 128 | 170 | 213 | 256 | 298 | 341 | 383 | 426 | 469 | 511 |
| 14 | 1 | 111 | 149 | 186 | 223 | 260 | 297 | 334 | 371 | 409 | 446 |
| 15 | 1 | 98 | 131 | 163 | 196 | 229 | 262 | 294 | 327 | 360 | 392 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 1 | 87 | 116 | 145 | 174 | 203 | 232 | 261 | 290 | 319 | 348 |
| 17 | 1 | 78 | 104 | 130 | 156 | 182 | 208 | 233 | 259 | 285 | 311 |
| 18 | 1 | 70 | 93 | 117 | 140 | 163 | 187 | 210 | 233 | 257 | 280 |
| 19 | 1 | 63 | 84 | 106 | 127 | 148 | 169 | 190 | 211 | 232 | 253 |
| 20 | 1 | 58 | 77 | 96 | 115 | 134 | 154 | 173 | 192 | 211 | 230 |
| 21 | 1 | 53 | 70 | 88 | 105 | 123 | 140 | 158 | 175 | 193 | 211 |
| 22 | 1 | 48 | 64 | 80 | 97 | 113 | 129 | 145 | 161 | 177 | 193 |
| 23 | 1 | 44 | 59 | 74 | 89 | 104 | 119 | 133 | 148 | 163 | 178 |
| 24 | 1 | 41 | 55 | 69 | 82 | 96 | 110 | 123 | 137 | 151 | 164 |
| 25 | 1 | 38 | 51 | 64 | 76 | 89 | 102 | 114 | 127 | 140 | 152 |
| 26 | 1 | 35 | 47 | 59 | 71 | 83 | 95 | 106 | 118 | 130 | 142 |
| 27 | 1 | 33 | 44 | 55 | 66 | 77 | 88 | 99 | 110 | 121 | 132 |
| 28 | 1 | 31 | 41 | 52 | 62 | 72 | 82 | 93 | 103 | 113 | 124 |
| 29 | 1 | 29 | 39 | 48 | 58 | 68 | 77 | 87 | 97 | 106 | 116 |
| 30 | 1 | 27 | 36 | 45 | 54 | 63 | 73 | 82 | 91 | 100 | 109 |
| 31 | 1 | 26 | 34 | 43 | 51 | 60 | 68 | 77 | 85 | 94 | 102 |
| 32 | 1 | 24 | 32 | 40 | 48 | 56 | 64 | 72 | 80 | 89 | 97 |
| 33 | 1 | 23 | 30 | 38 | 46 | 53 | 61 | 68 | 76 | 84 | 91 |
| 34 | 1 | 22 | 29 | 36 | 43 | 50 | 58 | 65 | 72 | 79 | 86 |
| 35 | 1 | 20 | 27 | 34 | 41 | 48 | 55 | 61 | 68 | 75 | 82 |
| 36 | 1 | 19 | 26 | 32 | 39 | 45 | 52 | 58 | 65 | 71 | 78 |
| 37 | 1 | 18 | 25 | 31 | 37 | 43 | 49 | 55 | 62 | 68 | 74 |
| 38 | 1 | 18 | 23 | 29 | 35 | 41 | 47 | 53 | 59 | 64 | 70 |
| 39 | 1 | 17 | 22 | 28 | 33 | 39 | 45 | 50 | 56 | 61 | 67 |
| 40 | 1 | 16 | 21 | 27 | 32 | 37 | 43 | 48 | 53 | 59 | 64 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.963 L/s.
a. Flow rate from Section P2904.4.2.

# CHAPTER 30
# SANITARY DRAINAGE

## SECTION P3001
## GENERAL

**P3001.1 Scope.** The provisions of this chapter shall govern the materials, design, construction and installation of sanitary drainage systems. Plumbing materials shall conform to the requirements of this chapter. The drainage, waste and vent (DWV) system shall consist of piping for conveying wastes from plumbing fixtures, *appliances* and appurtenances, including fixture traps; above-grade drainage piping; below-grade drains within the building, such as a *building drain*; below- and above-grade venting systems; and piping to the public sewer or private septic system.

**P3001.2 Protection from freezing.** Water pipes installed in a wall or ceiling exposed to the exterior shall be located on the heated side of the wall insulation. Water, soil and waste pipes shall not be installed outside of a building. When soil and waste piping is installed under a non-enclosed area of a building or structure, freeze protections shall be installed at the discretion of the authority having jurisdiction. When installed in unconditioned utility rooms, or in the building in any other place subjected to freezing temperatures, adequate provision shall be made to protect such pipes from freezing by a minimum of R6.5 insulation determined at 75°F (24°C) in accordance with ASTM C177 or heat, or both.

No traps of soil or waste pipe shall be installed or permitted outside of a building, or concealed in outside walls or in any place where they may be subjected to freezing temperatures, unless adequate provision is made to protect them from freezing.

Exterior water supply system piping shall be installed below the frost line and in no case less than 12 inches (305 mm) below grade.

*Building sewers* that connect to private sewage disposal systems shall be installed not less than 3 inches (76.2 mm) below finished grade at the point of septic tank connection. *Building sewers* shall be installed not less than 3 inches (76.2 mm) below grade.

**Note:** These provisions are minimum requirements, which have been found suitable for normal weather conditions. Abnormally low temperatures for extended periods may require additional provisions to prevent freezing.

**P3001.3 Flood-resistant installation.** In flood hazard areas as established by Table R301.2, drainage, waste and vent systems shall be located and installed to prevent infiltration of floodwaters into the systems and discharges from the systems into floodwaters.

## SECTION P3002
## MATERIALS

**P3002.1 Piping within buildings.** Drain, waste and vent (DWV) piping in buildings shall be as indicated in Tables P3002.1(1) and P3002.1(2) except that galvanized wrought-iron or galvanized steel pipe shall not be used underground and shall be maintained not less than 6 inches (152 mm) above ground. Allowance shall be made for the thermal expansion and contraction of plastic piping.

**TABLE P3002.1(1) (Add Table Here)**
**ABOVE-GROUND DRAINAGE AND VENT PIPE**

**TABLE P3002.1(2) (Add Table Here)**

## UNDERGROUND BUILDING DRAINAGE AND VENT PIPE

**P3002.2 Building sewer.** *Building sewer* piping shall be as indicated in Table P3002.2 Forced main sewer piping shall conform to one of the standards for ABS plastic pipe, copper or copper-alloy tubing, PVC plastic pipe or pressure-rated pipe indicated in Table P3002.2.

**TABLE P3002.2 (Add Table Here)**
**BUILDING SEWER PIPE**

**P3002.2.1 Building sewer pipe near the water service.** The proximity of a *building sewer* to a water service shall comply with Section ~~P2905.4.1~~ P2906.4.1.

**P3002.3 Fittings.** Pipe fittings shall be *approved* for installation with the piping material installed and shall comply with the applicable standards indicated in Table P3002.3. Pipe fittings shall not be solvent cemented inside of plastic pipe.

**TABLE P3002.3 (Add Table Here)**
**PIPE FITTINGS**

**P3002.3.1 Drainage ~~fittings~~.** Drainage fittings shall have a smooth interior waterway of the same diameter as the piping served. Fittings shall conform to the type of pipe used. Drainage fittings shall not have ledges, shoulders or reductions that can retard or obstruct drainage flow in the piping. Threaded drainage pipe fittings shall be of the recessed drainage type, black or galvanized. Drainage fittings shall be designed to maintain $^1/_4$ unit vertical in 12 units horizontal (2-percent slope) grade. This section shall not be applicable to tubular waste fittings used to convey vertical flow upstream of the trap seal liquid level of a fixture trap.

**P3002.4 Other materials.** Sheet lead, lead bends, lead traps and sheet copper shall comply with Sections P3002.4.1 through P3002.4.3.

**P3002.4.1 Sheet lead.** Sheet lead shall weigh not less than indicated for the following applications:

1. Flashing of vent terminals, 3 psf (15 kg/$m^2$).
2. Prefabricated flashing for vent pipes, $2^1/_2$ psf (12 kg/$m^2$).

**P3002.4.2 Lead bends and traps.** Lead bends and lead traps shall be not less than $^1/_8$-inch (3 mm) wall thickness.

**P3002.4.3 Sheet copper.** Sheet copper shall weigh not less than indicated for the following applications:

1. General use, 12 ounces per square feet (4 kg/$m^2$).
2. Flashing for vent pipes, 8 ounces per square feet (2.5 kg/$m^2$).

## SECTION P3003
## JOINTS AND CONNECTIONS

**P3003.1 Tightness.** Joints and connections in the DWV system shall be gastight and watertight for the intended use or pressure required by test.

**P3003.1.1 Threaded joints, general.** Pipe and fitting threads shall be tapered.

**P3003.2 Prohibited joints.** Running threads and bands shall not be used in the drainage system. Drainage and vent piping shall not be drilled, tapped, burned or welded.

The following types of joints and connections shall be prohibited:

1. Cement or concrete.
2. Mastic or hot-pour bituminous joints.
3. Joints made with fittings not *approved* for the specific installation.
4. Joints between different diameter pipes made with elastomeric rolling O-rings.

5. Solvent-cement joints between different types of plastic pipe.
6. Saddle-type fittings.

**P3003.3 ABS plastic.** Joints between ABS plastic pipe or fittings shall comply with Sections P3003.3.1 through P3003.3.4.

**P3003.3.1 Mechanical joints.** Mechanical joints on drainage pipes shall be made with an elastomeric seal conforming to ASTM C1173, ASTM D3212 or CSA B602. Mechanical joints shall be installed only in underground systems unless otherwise *approved*. Joints shall be installed in accordance with the manufacturer's instructions.

**P3003.3.2 Solvent cementing.** Joint surfaces shall be clean and free from moisture. Solvent cement that conforms to ASTM D2235 or CSA B181.1 shall be applied to joint surfaces. The joint shall be made while the cement is wet. Joints shall be made in accordance with ASTM D2235, ASTM D2661, ASTM F628 or CSA B181.1. Solvent-cement joints shall be permitted above or below ground.

**P3003.3.3 Threaded joints.** Threads shall conform to ASME B1.20.1. Schedule 80 or heavier pipe shall be permitted to be threaded with dies specifically designed for plastic pipe. *Approved* thread lubricant or tape shall be applied on the male threads only.

**P3003.3.4 Push-fit fitting joints.** Push-fit DWV fittings shall be *listed* and *labeled* to ASME A112.4.4 and shall be installed in accordance with the manufacturer's instructions.

**P3003.4 Cast iron.** Joints between cast-iron pipe or fittings shall comply with Sections P3003.4.1 through P3003.4.3.

**P3003.4.1 Caulked joints.** Joints for hub and spigot pipe shall be firmly packed with oakum or hemp. Molten lead shall be poured in one operation to a depth of not less than 1 inch (25 mm). The lead shall not recede more than $^1/_8$ inch (3 mm) below the rim of the hub and shall be caulked tight. Paint, varnish or other coatings shall not be permitted on the jointing material until after the joint has been tested and *approved*. Lead shall be run in one pouring and shall be caulked tight.

**P3003.4.2 Compression gasket joints.** Compression gaskets for hub and spigot pipe and fittings shall conform to ASTM C564. Gaskets shall be compressed when the pipe is fully inserted.

**P3003.4.3 Mechanical joint coupling.** Mechanical joint couplings for hubless pipe and fittings shall consist of an elastomeric sealing sleeve and a metallic shield that comply with CISPI 310, ASTM C1277 or ASTM C1540. The elastomeric sealing sleeve shall conform to ASTM C564 or CSA B602 and shall have a center stop. Mechanical joint couplings shall be installed in accordance with the manufacturer's instructions.

**P3003.5 Concrete joints.** Joints between concrete pipe and fittings shall be made with an elastomeric seal conforming to ASTM C443, ASTM C1173, CSA A257.3 or CSA B602.

**P3003.6 Copper and copper-alloy (brass) pipe and tubing.** Joints between copper or copper-alloy pipe tubing or fittings shall comply with Sections P3003.6.1 through P3003.6.4.

**P3003.6.1 Brazed joints.** All joint surfaces shall be cleaned. An *approved* flux shall be applied where required. Brazing materials shall have a melting point in excess of 1,000°F (538°C). Brazing alloys filler metal shall be in accordance with AWS A5.8.

**P3003.6.2 Mechanical joints.** Mechanical joints shall be installed in accordance with the manufacturer's instructions.

**P3003.6.3 Soldered joints.** Copper and copper-alloy (brass) joints shall be soldered in accordance with ASTM B828. Cut tube ends shall be reamed to the full inside diameter of the tube end. Joint surfaces shall be cleaned. Fluxes for soldering shall be in accordance with ASTM B813 and shall become noncorrosive and nontoxic after soldering. The joint shall be soldered with a solder conforming to ASTM B32.

**P3003.6.4 Threaded joints.** Threads shall conform to ASME B1.20.1. Pipe-joint compound or tape shall be applied on the male threads only.

**P3003.7 Steel.** Joints between galvanized steel pipe or fittings shall comply with Sections P3003.7.1 and P3003.7.2.

**P3003.7.1 Threaded joints.** Threads shall conform to ASME B1.20.1. Pipe-joint compound or tape shall be applied on the male threads only.

**P3003.7.2 Mechanical joints.** Joints shall be made with an *approved* elastomeric seal. Mechanical joints shall be installed in accordance with the manufacturer's instructions.

**P3003.8 Lead.** Joints between lead pipe or fittings shall comply with Sections P3003.8.1 and P3003.8.2.

**P3003.8.1 Burned.** Burned joints shall be uniformly fused together into one continuous piece. The thickness of the joint shall be not less than the thickness of the lead being joined. The filler metal shall be of the same material as the pipe.

**P3003.8.2 Wiped.** Joints shall be fully wiped, with an exposed surface on each side of the joint not less than $^3/_4$ inch (19 mm). The joint shall be not less than $^3/_8$ inch (9.5 mm) thick at the thickest point.

**P3003.9 PVC plastic.** Joints between PVC plastic pipe or fittings shall comply with Sections P3003.9.1 through P3003.9.4.

**P3003.9.1 Mechanical joints.** Mechanical joints on drainage pipe shall be made with an elastomeric seal conforming to ASTM C1173, ASTM D3212 or CSA B602. Mechanical joints shall not be installed in above-ground systems, unless otherwise *approved*. Joints shall be installed in accordance with the manufacturer's instructions.

**P3003.9.2 Solvent cementing.** Joint surfaces shall be clean and free from moisture. A purple primer, or an ultraviolet purple primer~~,~~ that conforms to ASTM F656 shall be applied. When an ultraviolet primer is used, the installer shall provide an ultraviolet light to the inspector to be used during the inspection. Solvent cement not purple in color and conforming to ASTM D2564, CSA B137.3 or CSA B181.2 shall be applied to all joint surfaces. The joint shall be made while the cement is wet, and shall be in accordance with ASTM D2855. Solvent-cement joints shall be installed above or below ground. Clear primer conforming to ASTM F 656 may be applied to all joint surfaces where the piping is exposed under sinks and in buildings.

**P3003.9.3 Threaded joints.** Threads shall conform to ASME B1.20.1. Schedule 80 or heavier pipe shall be permitted to be threaded with dies specifically designed for plastic pipe. *Approved* thread lubricant or tape shall be applied on the male threads only.

**P3003.9.4 Push-fit joints.** Push-fit joints shall conform to ASME A112.4.4 and shall be installed in accordance with the manufacturer's instructions.

**P3003.10 Vitrified clay.** Joints between vitrified clay pipe or fittings shall be made with an elastomeric seal conforming to ASTM C425, ASTM C1173 or CSA B602.

**P3003.11 Polyolefin plastic.** Joints between polyolefin plastic pipe and fittings shall comply with Sections P3003.11.1 and P3003.11.2.

**P3003.11.1 Heat-fusion joints.** Heat-fusion joints for polyolefin pipe and tubing joints shall be installed with socket-type heat-fused polyolefin fittings or electrofusion polyolefin fittings. Joint surfaces shall be clean and free from moisture. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM F1412 or CSA B181.3.

**P3003.11.2 Mechanical and compression sleeve joints.** Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer's instructions.

**P3003.12 Polyethylene plastic pipe.** Joints between polyethylene plastic pipe and fittings shall be underground and shall comply with Section P3003.12.1 or P3003.12.2.

**P3003.12.1 Heat fusion joints.** Joint surfaces shall be clean and free from moisture. Joint surfaces shall be cut, heated to melting temperature and joined using tools specifically designed for the operation. Joints shall be undisturbed until cool. Joints shall be made in accordance with ASTM D2657 and the manufacturer's instructions.

**P3003.12.2 Mechanical joints.** Mechanical joints in drainage piping shall be made with an elastomeric seal conforming to ASTM C1173, ASTM D3212 or CSA B602. Mechanical joints shall be installed in accordance with the manufacturer's instructions.

**P3003.13 Joints between different materials.** Joints between different piping materials shall be made with a mechanical joint of the compression or mechanical-sealing type conforming to ASTM C1173, ASTM C1460 or ASTM C1461. Connectors and adapters shall be *approved* for the application and such joints shall have an elastomeric seal conforming to ASTM C425, ASTM C443, ASTM C564, ASTM C1440, ASTM D1869, ASTM F477, CSA A257.3 or CSA B602, or as required in Sections P3003.13.1 through P3003.13.6. Joints between glass pipe and other types of materials shall be made with adapters having a TFE seal. Joints shall be installed in accordance with the manufacturer's instructions.

**P3003.13.1 Copper pipe or tubing to cast-iron hub pipe.** Joints between copper pipe or tubing and cast-iron hub pipe shall be made with a copper-alloy (brass) ferrule or compression joint. The copper pipe or tubing shall be soldered to the ferrule in an *approved* manner, and the ferrule shall be joined to the cast-iron hub by a caulked joint or a mechanical compression joint.

**P3003.13.2 Copper pipe or tubing to galvanized steel pipe.** Joints between copper pipe or tubing and galvanized steel pipe shall be made with a copper-alloy (brass) or dielectric fitting. The copper tubing shall be soldered to the fitting in an *approved* manner, and the fitting shall be screwed to the threaded pipe.

**P3003.13.3 Cast-iron pipe to galvanized steel or copper-alloy (brass) pipe.** Joints between cast-iron and galvanized steel or copper-alloy (brass) pipe shall be made by either caulked or threaded joints or with an *approved* adapter fitting.

**P3003.13.4 Plastic pipe or tubing to other piping material.** Joints between different types of plastic pipe shall be made with an *approved* adapter fitting. Joints between plastic pipe and other piping material shall be made with an *approved* adapter fitting. Joints between plastic pipe and cast-iron hub pipe shall be made by a caulked joint or a mechanical compression joint.

**P3003.13.5 Lead pipe to other piping material.** Joints between lead pipe and other piping material shall be made by a wiped joint to a caulking ferrule, soldering nipple, or bushing or shall be made with an *approved* adapter fitting.

**P3003.13.6 Stainless steel drainage systems to other materials.** Joints between stainless steel drainage systems and other piping materials shall be made with *approved* mechanical couplings.

**P3003.14 Joints between drainage piping and water closets.** Joints between drainage piping and water closets or similar fixtures shall be made by means of a closet flange or a waste connector and sealing gasket compatible with the drainage system material, securely fastened to a structurally firm base. Floor outlet fixtures shall be secured to the floor or floor flanges by screws or bolts of corrosion-resistant material. The joint shall be bolted, with an *approved* gasket flange to fixture connection complying with ASME A112.4.3 or setting compound between the fixture and the closet flange or waste connector and sealing gasket. The waste connector and sealing gasket joint shall comply with the joint-tightness test of ASME A112.4.3 and shall be installed in accordance with the manufacturer's instructions.

**P3003.14.1 (405.4.1) Floor flanges.**
Floor flanges for water closets or similar fixtures shall be not less than 0.125 inch (3.2 mm) thick for brass, 0.25 inch (6.4 mm) thick for plastic and 0.25 inch (6.4 mm) thick and not less than a 2-inch (51 mm) caulking depth for cast iron or galvanized malleable iron.

Floor flanges of hard lead shall weigh not less than 1 pound, 9 ounces (0.7 kg) and shall be composed of lead alloy with not less than 7.75-percent antimony by weight.

**P3003.14.2 (405.4.3) Securing wall-hung water closet bowls.**
Wall hung water closet bowls shall be supported by a concealed metal carrier that is attached to the building structural members so that strain is not transmitted to the closet connector or any other part of the plumbing system. The carrier shall conform to ASME A112.6.1M or ASME A112.6.2.

## SECTION P3004
## DETERMINING DRAINAGE FIXTURE UNITS

**P3004.1 DWV system load.** The load on DWV-system piping shall be computed in terms of drainage fixture unit (d.f.u.) values in accordance with Table P3004.1.

**TABLE P3004.1 (Add Table Here)**

**DRAINAGE FIXTURE UNIT (d.f.u.) VALUES FOR VARIOUS PLUMBING FIXTURES**

## SECTION P3005
## DRAINAGE SYSTEM

**P3005.1 Drainage fittings and connections.** Fittings shall be installed to guide sewage and waste in the direction of flow. Changes in direction in drainage piping shall be made by the appropriate use of sanitary tees, wyes, sweeps, bends or by a combination of these drainage fittings in accordance with Table P3005.1. Change in direction by combination fittings, heel or side inlets or increasers shall be installed in accordance with Table P3005.1 and Sections P3005.1.1 through P3005.1.4, based on the pattern of flow created by the fitting. Double sanitary tee patterns shall not receive the discharge of appliances with pumping action discharge.

**P3005.1.1 Horizontal to vertical (multiple connection fittings).** Double fittings such as double sanitary tees and tee-wyes or *approved* multiple connection fittings and back-to-back fixture arrangements that connect two or more branches at the same level shall be permitted as long as directly opposing connections are the same size and the discharge into directly opposing connections is from similar fixture types or fixture groups. Double sanitary tee patterns shall not receive the discharge of *appliances* with pumping action discharge.

**Exception: Deleted.**

**TABLE P3005.1 (Add Table Here)**
**FITTINGS FOR CHANGE IN DIRECTION**

| TYPE OF FITTING PATTERN | CHANGE IN DIRECTION | | |
|---|---|---|---|
| | Horizontal to vertical | Vertical to horizontal | Horizontal to horizontal |
| Sixteenth bend | X | X | X |
| Eighth bend | X | X | X |
| Sixth bend | X | X | X |
| Quarter bend | X | X[d,f] | X[e] |
| Short sweep | X | X[a,b] | X[a] |
| Long sweep | X | X | X |
| Sanitary tee | X[c] | — | — |
| Wye | X | X | X |
| Combination wye and eighth bend | X | X | X |

For SI: 1 inch = 25.4 mm.

a. The fittings shall only be permitted for a 2-inch or smaller sink or lavatory fixture drain.

b. Two inches or larger.

c. For a limitation on double sanitary tees, see Section P3005.1.1.

d. May be used only within 12 inches below water closet flange measured to centerline of the quarter bend.

e. This fitting shall only be permitted to be used as the first fitting directly behind the fixture for drains 2 inches and smaller, except clothes washers.

f. The heel inlet connection of a quarter bend may be used as a wet or dry vent if the heel inlet connection of the quarter bend is located in the vertical position. The heel or side inlet connection may be used as a wet vent if the quarter bend is located directly below a water closet or other fixture with one integral trap.

**P3005.1.2 Heel- or side-inlet quarter bends, drainage. Deleted**.

**P3005.1.3 Heel- or side-inlet quarter bends, venting.** Heel-inlet or side-inlet quarter bends, or any arrangement of pipe and fittings producing a similar effect, shall be acceptable as a dry vent where the inlet is placed in a vertical position. The inlet is permitted to be placed in a *horizontal* position only where the entire fitting is part of a dry vent arrangement.

**P3005.1.4 Water closet connection between flange and pipe.** One-quarter bends 3 inches (76 mm) in diameter shall be acceptable for water closet or similar connections, provided that a 4-inch by 3-inch (102 mm by 76 mm) flange is installed to receive the closet fixture horn. Alternately, a 4-inch by 3-inch (102 mm by 76 mm) elbow shall be acceptable with a 4-inch (102 mm) flange.

**P3005.1.5 Provisions for future fixtures.** Where drainage has been roughed-in for future fixtures, the drainage unit values of the future fixtures shall be considered in determining the required drain sizes. Such future installations shall be terminated with an accessible permanent plug or cap fitting.

~~**P3005.1.6 (704.2) Change in size.** The size of the drainage piping shall not be reduced in size in the direction of the flow. A 4-inch by 3-inch (102 mm by 76 mm) water closet connection shall not be considered as a reduction in size.~~

**P3005.1.6 Drainage piping size reduction in the direction of flow.** The size of the drainage piping shall not be reduced in the direction of the flow. The following shall not be considered a reduction in size in the direction of flow:

1. A 4-inch by 3-inch (102 mm by 76 mm) water closet flange.
2. A water closet bend fitting having a 4-inch (102 mm) inlet and a 3-inch (76 mm) outlet provided that the 4-inch (102 mm) leg of the fitting is upright and below, but not necessarily directly connected to, the water closet flange.
3. An offset closet flange with a full flow, minimum 3-inch interior diameter throat.

**P3005.2 Cleanouts required.** Cleanouts shall be provided for drainage piping in accordance with Sections P3005.2.1 through P3005.2.11

**P3005.2.1 ) Gravity horizontal drains and building drains.** *Horizontal* drainage pipes in buildings shall have cleanouts located at intervals of not more than 100 feet (30 480 mm). *Building drains* shall have cleanouts located at intervals of not more than 100 feet (30 480 mm) except where manholes are used instead of cleanouts, the manholes shall be located at intervals of not more than 400 feet (122 m). The interval length shall be measured from the cleanout or manhole opening, along the *developed length* of the piping to the next drainage fitting providing access for cleaning, the end of the *horizontal* drain or the end of the *building drain*.

**Exception:** Horizontal *fixture drain* piping serving a nonremovable trap shall not be required to have a cleanout for the section of piping between the trap and the vent connection for such trap.

**P3005.2.2 Gravity building sewers.** *Building sewers* smaller than 8 inches (203 mm) shall have cleanouts located at intervals of not more than 100 feet (30 480 mm). *Building sewers* 8 inches (203 mm) and larger shall have a manhole located not more than 200 feet (60 960 mm) from the junction of the *building drain* and *building sewer* and at intervals of not more than 400 feet (122 m). The interval length shall be measured from the cleanout or manhole opening, along the *developed length* of the piping to the next drainage fitting providing access for cleaning, a manhole or the end of the *building sewer*.

**P3005.2.3 Building drain and building sewer junction.** There shall be a cleanout at the junction of the building drain and the building sewer. The cleanout shall be outside the building wall and shall be brought up to the finished ground level. An approved two-way cleanout is allowed to be used at this location to serve as a required cleanout for both the building drain and building sewer. The cleanout at the junction of the building drain and building sewer shall not be required if the cleanout on a 3 inch (76 mm) or larger diameter soil stack is located within a developed length of not more than 15 feet (4572 mm) from the building drain and building sewer connection and is extended to the outside of the building. The minimum size of the cleanout at the junction of the building drain and building sewer shall comply with Section P3005.2.5.

**P3005.2.4 Changes of direction.** One cleanout shall be required for every four horizontal 45 degree (0.79 rad) changes located in series. (A long sweep is equivalent to two 45 degree (0.79 rad) bends.)

**P3005.2.5 Cleanout size.** Cleanouts shall be the same size as the piping served by the cleanout, except cleanouts for piping larger than 4 inches (102 mm) need not be larger than 4 inches (102 mm).

**Exceptions:**

~~1. "P" traps connected to the drainage piping with slip joints or ground joint connections.~~
~~2. "P" traps into which floor drains, shower drains or tub drains with removable strainers discharge.~~
~~3. "P" traps into which the straight-through type waste and overflow discharge with the overflow connecting to the top of the tee.~~
~~4. "P" traps into which residential washing machines discharge.~~
~~5. Test tees or cleanouts in a vertical pipe.~~
~~6. Cleanout near the junction of the building drain and the building sewer which may be rodded both ways.~~
~~7. Water closets for the water closet fixture drain only.~~
~~8. Cast-iron cleanout sizing shall be in accordance with referenced standards in Table P3002.3, ASTM A74 for hub and spigot fittings or ASTM A888 or CISPI 301 for hubless fittings.~~
~~9. Cleanouts located on *stacks* can be one size smaller than the *stack* size.~~

1. A removable P-trap with slip- or ground-joint connections can serve as a cleanout for drain piping that is one size larger than the P-trap size.
2. Cleanouts located on stacks can be one size smaller than the stack size.
3. The size of cleanouts for cast-iron piping can be in accordance with the referenced standards for cast iron fittings as indicated in Table P3002.3.
4. "P" traps into which floor drains, shower drains or tub drains with removable strainers discharge.
5. "P" traps into which the straight-through type waste and overflow discharge with the overflow connecting to the top of the tee.
6. "P" traps into which residential washing machines discharge.
7. Test tees or cleanouts in a vertical pipe.
8. Cleanout near the junction of the building drain and the building sewer which may be rodded both ways.
9. Water closets for the water closet fixture drain only.

**P3005.2.6 Cleanout plugs.** Cleanout plugs shall be copper alloy, plastic or other *approved* materials. Cleanout plugs for borosilicate glass piping systems shall be of borosilicate glass. Copper-alloy cleanout plugs shall conform to ASTM A74 and shall be limited for use only on metallic piping systems. Plastic cleanout plugs shall conform to the referenced standards for plastic pipe fittings as indicated in Table P3002.3. Cleanout plugs shall have a raised square head, a countersunk square head or a countersunk slot head. Where a cleanout plug will have a trim cover screw installed into the plug, the plug shall be manufactured with a blind end threaded hole for such purpose.

**P3005.2.7 Manholes.** Manholes and manhole covers shall be of an *approved* type. Manholes located inside of a building shall have gastight covers that require tools for removal.

**P3005.2.8 Installation arrangement.** The installation arrangement of a cleanout shall enable cleaning of drainage piping only in the direction of drainage flow.

**Exceptions:**

1. Test tees serving as cleanouts.
2. A two-way cleanout installation that is *approved* for meeting the requirements of Section P3005.2.3.

**P3005.2.9 Required clearance.** Cleanouts for 6-inch (153 mm) and smaller piping shall be provided with a clearance of not less than 18 inches (457 mm) from, and perpendicular to, the face of the opening to any obstruction. Cleanouts for 8-inch (203 mm) and larger piping shall be provided with a clearance of not less than 36 inches (914 mm) from, and perpendicular to, the face of the opening to any obstruction.

**P3005.2.10 Cleanout access.** Required cleanouts shall not be installed in concealed locations. For the purposes of this section, concealed locations include, but are not limited to, the inside of plenums, within walls, within floor/ceiling assemblies, below grade and in crawl spaces where the height from the *crawl space* floor to the nearest obstruction along the path from the *crawl space* opening to the cleanout location is less than 24 inches (610 mm). Cleanouts with openings at a finished wall shall have the face of the opening located within $1^1/_2$ inches (38 mm) of the finished wall surface. Cleanouts located below grade shall be extended to grade level so that the top of the cleanout plug is at or above grade. A cleanout installed in a floor or walkway that will not have a trim cover installed shall have a counter-sunk plug installed so the top surface of the plug is flush with the finished surface of the floor or walkway.

<u>**P3005.2.10.1 Cleanout equivalent.** A fixture trap or a fixture with an integral trap, removable without altering the concealed piping, shall be acceptable as a cleanout equivalent.</u>

~~**P3005.2.10.1**~~ <u>**P3005.2.10.2**</u> **Cleanout plug trim covers.** Trim covers and access doors for cleanout plugs shall be designed for such purposes. Trim cover fasteners that thread into cleanout plugs shall be corrosion resistant. Cleanout plugs shall not be covered with mortar, plaster or any other permanent material.

~~**P3005.2.10.2**~~ <u>**P3005.2.10.3**</u> **Floor cleanout assemblies.** Where it is necessary to protect a cleanout plug from the loads of vehicular traffic, cleanout assemblies in accordance with ASME A112.36.2M shall be installed.

**P3005.2.11 Prohibited use.** The use of a threaded cleanout opening to add a fixture or extend piping shall be prohibited except where another cleanout of equal size is installed with the required access and clearance.

**P3005.3 Horizontal drainage piping slope.** *Horizontal* drainage piping shall be installed in uniform alignment at uniform slopes not less than $^1/_4$ unit vertical in 12 units horizontal (2-percent slope) for $2^1/_2$-inch (64 mm) diameter and less, and not less than $^1/_8$ unit vertical in 12 units horizontal (1-percent slope) for diameters of 3 inches (76 mm) or more.

**P3005.4 Drain pipe sizing.** Drain pipes shall be sized according to drainage fixture unit (d.f.u.) loads. The size of the drainage piping shall not be reduced in size in the direction of flow. The following general procedure is permitted to be used:

1. Draw an isometric layout or riser diagram denoting fixtures on the layout.
2. Assign d.f.u. values to each fixture group plus individual fixtures using Table P3004.1.
3. Starting with the top floor or most remote fixtures, work downstream toward the *building drain* accumulating d.f.u. values for fixture groups plus individual fixtures for each branch. Where multiple bath groups are being added, use the reduced d.f.u. values in Table P3004.1, which take into account probability factors of simultaneous use.
4. Size branches and stacks by equating the assigned d.f.u. values to pipe sizes shown in Table P3005.4.1.
5. Determine the pipe diameter and slope of the *building drain* and *building sewer* based on the accumulated d.f.u. values, using Table P3005.4.2.

**P3005.4.1 Branch and stack sizing.** Branches and stacks shall be sized in accordance with Table P3005.4.1. Below grade drain pipes shall be not less than 2 inches (51 mm) in diameter. Drain stacks shall be not smaller than the largest horizontal branch connected.

**Exceptions:**

1. A 4-inch by 3-inch (102 mm by 76 mm) closet bend or flange.
2. ~~A 4-inch (102 mm) closet bend connected to a 3-inch (76 mm) stack tee shall not be prohibited.~~

**TABLE P3005.4.1**

**MAXIMUM FIXTURE UNITS ALLOWED TO BE CONNECTED TO BRANCHES AND STACKS[d,e]**

| NOMINAL PIPE SIZE (inches) | ANY HORIZONTAL FIXTURE BRANCH | ANY ONE VERTICAL STACK OR DRAIN |
|---|---|---|
| $1^1/_4$[a, b] | — | — |
| $1^1/_2$[b] | 3 | 4 |
| 2[b] | 6 | 10 |
| $2^1/_2$[b] | 12 | 20 |
| 3[f] | 20[c] | 48 |
| 4 | 160 | 240 |

For SI: 1 inch = 25.4 mm.

a. $1^1/_4$-inch pipe size limited to a single-fixture drain. See Table P3201.7.

b. Water closets prohibited.

c. No more than ~~three~~ four water closets.

d. 50 percent less for circuit-vented fixture branches.

e. Minimum of 2-inch diameter underground.

f. The minimum size of any branches serving a water closet shall be 3 inches.

**P3005.4.2 Building drain and sewer size and slope.** Pipe sizes and slope shall be determined from Table P3005.4.2 on the basis of drainage load in fixture units (d.f.u.) computed from Table P3004.1.

**TABLE P3005.4.2**

**MAXIMUM NUMBER OF FIXTURE UNITS ALLOWED TO BE CONNECTED TO THE BUILDING DRAIN, BUILDING DRAIN BRANCHES OR THE BUILDING SEWER[c,e]**

| DIAMETER OF PIPE (inches) | SLOPE PER FOOT | | |
|---|---|---|---|
| | $^1/_8$ inch | $^1/_4$ inch | $^1/_2$ inch |
| $1^1/_2$[a, b] | — | Note a | Note a |
| 2[b] | — | 21 | 27 |
| $2^1/_2$[b] | — | 24 | 31 |
| 3[d] | 36 | 42 | 50 |
| 4 | 180 | 216 | 250 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. $1^1/_2$-inch pipe size limited to a building drain branch serving not more than two waste fixtures, or not more than one waste fixture if serving a pumped discharge fixture or food waste disposer discharge.

b. No water closets.

c. No building sewer shall be less than 4 inches in size.

d. No more than ~~three~~ four water closets.

e. Minimum of 2-inch diameter underground.

**P3005.5 Connections to offsets and bases of stacks.** Horizontal branches shall connect to the bases of stacks at a point located not less than 10 times the diameter of the drainage stack downstream from the stack. Horizontal branches shall connect to horizontal stack offsets at a point located not less than 10 times the diameter of the drainage stack downstream from the upper stack.

**P3005.6 Dead ends.** In the installation or removal of any part of a drainage system, dead ends shall be prohibited. Cleanout extensions and approved future fixture drainage piping shall not be considered as dead ends.

## SECTION P3006
## SIZING OF DRAIN PIPE OFFSETS

**P3006.1 Vertical offsets.** An offset in a vertical drain, with a change of direction of 45 degrees (0.79 rad) or less from the vertical, shall be sized as a straight vertical drain.

**P3006.2 Horizontal offsets above the lowest branch.** A stack with an offset of more than 45 degrees (0.79 rad) from the vertical shall be sized as follows:

1. The portion of the stack above the offset shall be sized as for a regular stack based on the total number of fixture units above the offset.
2. The offset shall be sized as for a *building drain* in accordance with Table P3005.4.2.
3. The portion of the stack below the offset shall be sized as for the offset or based on the total number of fixture units on the entire stack, whichever is larger.

**P3006.3 Horizontal offsets below the lowest branch.** In soil or waste stacks below the lowest horizontal branch, a change in diameter shall not be required if the offset is made at an angle not greater than 45 degrees (0.79 rad) from the vertical. If an offset greater than 45 degrees (0.79 rad) from the vertical is made, the offset and stack below it shall be sized as a *building drain* in accordance with Table P3005.4.2.

## SECTION P3007
## SUMPS AND EJECTORS

**P3007.1 Building subdrains.** Building subdrains that cannot be discharged to the sewer by gravity flow shall be discharged into a tightly covered and vented sump from which the liquid shall be lifted and discharged into the building gravity drainage system by automatic pumping equipment or other *approved* method. In other than existing structures, the sump shall not receive drainage from any piping within the building capable of being discharged by gravity to the *building sewer*.

**P3007.2 Valves required.** A check valve ~~and~~ a full open valve and a means for cleanout located on the discharge side of the check valve shall be installed in the pump or ejector discharge piping between the pump or ejector and the gravity drainage system. Access shall be provided to such valves. Such valves shall be located above the sump cover required by Section P3007.3.2 or, where the discharge pipe from the ejector is below grade, the valves shall be accessibly located outside the sump below grade in an access pit with a removable access cover.

**P3007.3 Sump design.** The sump pump, ~~pit~~ sump and discharge piping shall conform to the requirements of Sections P3007.3.1 through P3007.3.5.

**P3007.3.1 Sump pump.** The sump pump capacity and head shall be appropriate to anticipated use requirements.

**P3007.3.2 Sump ~~pit~~.** The sump ~~pit~~ shall be not less than 18 inches (457 mm) in diameter and 24 inches (610 mm) deep, unless otherwise *approved*. The ~~pit~~ sump shall be accessible and located so that drainage flows into the sump by gravity. The ~~pit~~ sump shall be constructed of tile, concrete, steel, plastic or other *approved* materials. The sump bottom shall be solid and provide permanent support for the pump. The ~~pit~~ sump shall be fitted with a gastight removable cover that is installed not more than 2 inches (51 mm) below grade or floor level. The cover shall be adequate to support anticipated loads in the area of use. The sump shall be vented in accordance with Chapter 31.

**P3007.3.3 Discharge pipe and fittings.** Discharge pipe and fittings serving sump pumps and ejectors shall be constructed of materials pressure-rated for not less than the maximum discharge pressure of the pump in accordance with Sections P3007.3.3.1 and P3007.3.3.2.

**P3007.3.3.1 Materials.**. Forced main sewer pipe and fitting material shall conform to one of the standards for ABS plastic pipe, copper or copper-alloy tubing, PVC plastic pipe or pressure-rated pipe indicated in Table P3002.2., excluding cell-core products.

**P3007.3.3.2 Ratings.** Pipe and fittings shall be rated for the maximum system operating pressure and temperature. Pipe fitting materials shall be compatible with the pipe material. Where pipe and fittings are buried in the earth, they shall be suitable for burial. DWV fittings with that are properly rated and allowed by the manufacturer's installation instructions shall be acceptable.

**P3007.3.4 Maximum effluent level.** The effluent level control shall be adjusted and maintained to at all times prevent the effluent in the sump from rising to within 2 inches (51 mm) of the invert of the gravity drain inlet into the sump.

**P3007.3.4.1 (712.3.4.1) Sump alarms**.

Sumps that discharge by means of automatic pumping equipment shall be provided with an approved, electrically operated high-water indicating alarm. A remote sensor shall activate the alarm when the fluid level exceeds a preset level that is less than the maximum capacity of the sump. The alarm shall function to provide an audiovisual signal to occupants within the building. Electrical power for the alarm shall be supplied through a branch circuit separate from that supplying the pump motor.

**Exception:** Sump alarms are not required for single point-of-use sump pumps and macerating toilet systems.

**P3007.3.5 Ejector connection to the drainage system.** Pumps connected to the drainage system shall connect to a *building sewer, building drain*, soil stack, waste stack or *horizontal* branch drain. Where the discharge line connects into *horizontal* drainage piping, the connection shall be made through a wye fitting into the top of the drainage piping and such wye fitting shall be located not less than 10 pipe diameters from the base of any soil stack, waste stack or *fixture drain*.

**P3007.4 Sewage pumps and sewage ejectors.** A sewage pump or sewage ejector shall automatically discharge the contents of the sump to the building drainage system. ~~The ejector pump discharge pipe shall not discharge directly into a septic tank. The pumped line shall discharge laterally into a 4-inch (102 mm) gravity line not less than 10 feet (3048 mm) from the connection to the tank through a lateral wye branch.~~

**P3007.5 Macerating toilet systems and pumped waste systems.** Macerating toilet systems and pumped waste systems shall comply with ASME A112.3.4/CSA B45.9 and shall be installed in accordance with the manufacturer's instructions.

**P3007.6 Capacity.** Sewage pumps and sewage ejectors shall have the capacity and head for the application requirements. Pumps and ejectors that receive the discharge of water closets shall be capable of handling spherical solids with a diameter of up to and including 2 inches (51 mm). Other pumps or ejectors shall be capable of handling spherical solids with a diameter of up to and including $^1/_2$ inch (13 mm). The minimum capacity of a pump or ejector based on the diameter of the discharge pipe shall be in accordance with Table 3007.6.

**Exceptions:**

1. Grinder pumps or grinder ejectors that receive the discharge of water closets shall have a discharge opening of not less than $1^1/_4$ inches (32 mm).

2. Macerating toilet assemblies that serve single water closets shall have a discharge opening of not less than $^3/_4$ inch (19 mm).

**TABLE 3007.6**

**MINIMUM CAPACITY OF SEWAGE PUMP OR SEWAGE EJECTOR**

| DIAMETER OF THE DISCHARGE PIPE (inches) | CAPACITY OF PUMP OR EJECTOR (gpm) |
|---|---|
| 2 | 21 |
| $2^1/_2$ | 30 |
| 3 | 46 |

For SI: 1 inch = 25.4 mm, 1 gallon per minute = 3.785 L/m.

## SECTION P3008
## BACKWATER VALVES

**P3008.1** ~~**Sewage backflow.**~~ **Where required.** Where plumbing fixtures are installed on a floor with a finished floor elevation below the elevation of the manhole cover of the next upstream manhole in the public *sewer,* such fixtures shall be protected by a backwater valve installed in the *building drain*, or horizontal *branch* serving such fixtures. Plumbing fixtures installed on a floor with a finished floor elevation above the elevation of the manhole cover of the next upstream manhole in the public *sewer* shall not discharge through a backwater valve.

**Exception:**

1. In existing buildings, fixtures above the elevation of the manhole cover of the next upstream manhole in the public *sewer* shall not be prohibited from discharging through a backwater valve.
2. Where the sewer service line ties directly to a manhole, that manhole is considered to be the next upstream manhole.
3. Where hub drains are located in the crawl space for condensate waste, a backwater valve shall be installed.

**P3008.2 Allowable installations. DELETED**

~~**P3008.2**~~ **P3008.3 Material.** Backwater valves shall comply with ASME A112.14.1, CSA B181.1 or CSA B181.2.

~~**P3008.5**~~ **P3008.4 Location.** Backwater valves shall be installed so that ~~the working parts are accessible for service and repair~~. access is provided to the working parts.

~~**P3008.4**~~ **P3008.5 Diameter.**
Backwater valves, when fully opened, shall have a capacity not less than that of the pipes in which they are installed.

**P3008.6 Crawl spaces.**
All hub drains or floor drains installed in crawl spaces shall be protected from backflow into the building by a check valve or back-water valve installed in the lateral serving the said hub drain or floor drain.

## SECTION P3009
## ~~SUBSURFACE LANDSCAPE IRRIGATION~~ GRAYWATER SOIL ABSORPTION SYSTEMS

## DELETED

## SECTION P3010
## REPLACEMENT OF UNDERGROUND BUILDING SEWERS AND BUILDING DRAINS BY PIPE BURSTING METHODS

**P3010.1 General.** This section shall govern the replacement of existing *building sewer* and *building drain* piping by pipe-bursting methods.

**P3010.2 Applicability.** The replacement of *building sewer* and *building drain* piping by pipe bursting methods shall be limited to gravity drainage piping of sizes 6 inches (150 mm) and smaller. The replacement piping shall be of the same nominal size as the existing piping.

**P3010.3 Preinstallation inspection.** The existing piping sections to be replaced shall be inspected internally by a recorded video camera survey. The survey shall include notations of the position of cleanouts and the depth of connections to the existing piping.

**P3010.4 Pipe.** ~~The replacement pipe shall be made of a high-density polyethylene (HDPE) that conforms to cell classification number PE3608, PE4608 or PE4710 as indicated in ASTM F714. The pipe fittings shall be Manufactured with an SDR of 17 and in compliance with ASTM F714.~~The replacement pipe shall be made of a high-density polyethylene (HDPE) and shall be in compliance with ASTM F714.

**P3010.5 Pipe fittings.** ~~Pipe fittings to be connected to the replacement piping shall be made of high-density polyethylene (HDPE) that conforms to cell classification number PE3608, PE4608 or PE4710 as indicated in ASTM F714. The pipe fittings shall be manufactured with an SDR of 17 and in compliance with ASTM D2683.~~Pipe fittings to be connected to the replacement piping pipe shall be made of high-density polyethylene (HDPE) and shall be in compliance with ASTM D2683.

**P3010.6 Cleanouts.** Where the existing *building sewer* or *building drain* did not have cleanouts meeting the requirements of this code, cleanout fittings shall be installed as required by this code.

**P3010.7 Post-installation inspection.** The completed replacement piping section shall be inspected internally by a recorded video camera survey. When a permit is issued, ~~the~~ a live video survey shall be reviewed and *approved* by the *building official* prior to pressure testing of the replacement piping system.

~~**P3010.8 Pressure testing.** Deleted.~~

**P3010.8 Pressure testing.** The replacement piping system and the connections to the replacement piping shall be tested in accordance with Section P2503.4.

## SECTION P3011
## RELINING OF BUILDING SEWERS AND BUILDING DRAINS

**P3011.1 General.** This section shall govern the relining of existing *building sewer* and building drainage piping.

**P3011.2 Applicability.** The relining of existing *building sewer* piping and building drainage piping shall be limited to gravity drainage piping 4 inches (102 mm) in diameter and larger. The relined piping shall be of the same nominal size as the existing piping.

**P3011.3 Preinstallation requirements.** Prior to commencement of the relining installation, the existing piping sections to be relined shall be descaled and cleaned. After the cleaning process has occurred and water has been flushed through the system, the piping shall be inspected internally by a recorded video camera survey.

**P3011.3.1 Preinstallation recorded video camera survey.** The video survey shall include verification of the project address location. The video shall include notations of the cleanout and fitting locations, and the approximate depth of the existing piping. The video shall also include notations of the length of piping at intervals not greater than 25 feet (7620 mm).

**P3011.4 Permitting.** Prior to issuing a permit for relining, the building official shall review and evaluate the preinstallation recorded video camera survey to determine whether the piping system is able to be relined in accordance with the proposed lining system manufacturer’s installation requirements and applicable referenced standards.

**P3011.5 Prohibited applications.** Where the preinstallation recorded video camera survey reveals that piping systems are not installed correctly, or defects exist, relining shall not be permitted. The defective portions of piping shall be exposed and repaired with pipe and fittings in accordance with this code. Defects shall include, but are not limited to, backslope or insufficient slope, complete pipe wall deterioration or complete separations such as from tree root invasion or improper support.

**P3011.6 Relining materials.** The relining materials shall be manufactured in compliance with applicable standards and certified as required in Section P2609. Fold-and-form pipe reline materials shall be manufactured in compliance with ASTM F1504 or ASTM F1871.

**P3011.7 Installation.** The installation of relining materials shall be performed in accordance with the manufacturer's installation instructions, applicable referenced standards and this code.

**P3011.7.1 Material data report.** The installer shall record the data as required by the relining material manufacturer and applicable standards. The recorded data shall include, but is not limited to, the location of the project, relining material type, amount of product installed and conditions of the installation. A copy of the data report shall be provided to the building official prior to final approval.

**P3011.8 Post-installation recorded video camera survey.** When a permit is issued, the completed relined piping system shall be inspected internally by a live ~~recorded~~ video camera survey after the system has been flushed and flow-tested with water. The video survey shall be submitted to the building official prior to finalization of the permit. The video survey shall be reviewed and evaluated to provide verification that no defects exist. Any defects identified shall be repaired and replaced in accordance with this code.

**P3011.9 Certification.** Certification shall be provided in writing to the building official, from the permit holder, that the relining materials have been installed in accordance with the manufacturer's installation instructions, the applicable standards and this code.

**P3011.10 Approval.** Upon verification of compliance with the requirements of Sections P3011.1 through P3011.9, the building official shall approve the installation.

**TABLE P3002.1(2)**
**UNDERGROUND BUILDING DRAINAGE AND VENT PIPE**

| PIPE | STANDARD |
|---|---|
| Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall | ASTM D2661; ASTM F628; ASTM F1488; CSA B181.1 |
| Cast-iron pipe | ASTM A74; ASTM A888; CISPI 301 |
| Copper or copper-alloy tubing (Type K, L, M or DWV) | ASTM B75/B75M; ASTM B88; ASTM B251; ASTM B306 |
| Polyethylene (PE) plastic pipe (SDR-PR) | ASTM F714 |
| Polyolefin pipe | ASTM F714; ASTM F1412; CSA B181.3 |
| Polyvinyl chloride (PVC) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall | ASTM D2665; ASTM F891; ASTM F1488; CSA B181.2 |
| Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch O.D. and a solid, cellular core or composite wall | ASTM D2949; ASTM F1488 |
| Stainless steel drainage systems, Type 316L | ASME A112.3.1 |

For SI: 1 inch = 25.4 mm.

**TABLE P3002.2**
**BUILDING SEWER PIPE**

| MATERIAL | STANDARD |
|---|---|
| Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall | ASTM D2661; ASTM F628; ASTM F1488 |
| Acrylonitrile butadiene styrene (ABS) plastic pipe in sewer and drain diameters, including SDR 42 (PS 20), PS35, SDR 35 (PS 45), PS50, PS100, PS140, SDR 23.5 (PS 150) and PS200; with a solid, cellular core or composite wall | ASTM D2751; ASTM F1488 |
| Polyvinyl chloride (PVC) plastic pipe in sewer and drain diameters, including PS 25, SDR 41 (PS 28), PS 35, SDR 35 (PS 46), PS 50, PS 100, SDR 26 (PS 115), PS140 and PS 200; with a solid, cellular core or composite wall | ASTM D3034; ASTM F891; ASTM F1488; CSA B182.2; CSA B182.4 ANSI/AWWA C900 |
| Cast-iron pipe | ASTM A74; ASTM A888; CISPI 301 |
| Concrete pipe | ASTM C14; ASTM C76; CSA A257.1; CSA A257.2 |
| Copper or copper-alloy tubing (Brass), (Type K or L) | ASTM B75/B75M; ASTM B88; ASTM B251/B251M |
| Ductile iron pipe | ANSI/AWWA C150/A21.50 |
| Polyethylene (PE) plastic pipe (SDR-PR) | ASTM F714 |
| Polyolefin pipe | ASTM F1412; CSA B181.3 |
| Polyvinyl chloride (PVC) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with solid, cellular core or composite wall | ASTM D2665; ASTM D2949; ASTM D3034; ASTM F1412; CSA B182.2; CSA B182.4 |
| Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch O.D. and a solid, cellular core or composite wall | ASTM D2949, ASTM F1488 |
| Stainless steel drainage systems, Types 304 and 316L | ASME A112.3.1 |
| Vitrified clay pipe | ASTM C425; ASTM C700 |

For SI: 1 inch = 25.4 mm.

**TABLE P3002.1(1)**
**ABOVE-GROUND DRAINAGE AND VENT PIPE**

| MATERIAL | STANDARD |
|---|---|
| Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall | ASTM D2661; ASTM D2680; ASTM F628; ASTM F1488; CSA B181.1 |
| Cast-iron pipe | ASTM A74; ASTM A888; CISPI 301 |
| Copper or copper-alloy pipe (Brass), | ASTM B42; ASTM B43; ASTM B302 |
| Copper or copper-alloy tubing (Brass), (Type K, L, M or DWV) | ASTM B75/B75M; ASTM B88; ASTM B251/B251M; ASTM B306 |
| Galvanized steel pipe | ASTM A53/A53M |
| Polyolefin pipe | CSA B181.3 |

| | |
|---|---|
| Polyvinyl chloride (PVC) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall | ASTM D2665; ASTM F891; ASTM F1488; CSA B181.2 |
| Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch O.D. and a solid, cellular core or composite wall | ASTM D2949; ASTM F1488 |
| Stainless steel drainage systems, Types 304 and 316L | ASME A112.3.1 |

For SI: 1 inch = 25.4 mm.

**TABLE P3002.3**
**PIPE FITTINGS**

| PIPE MATERIAL | FITTING STANDARD |
|---|---|
| Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters | ASME A112.4.4; ASTM D2661; ASTM D3311; ASTM F628; CSA B181.1 |
| Acrylonotrile butadiene styrene (ABS) plastic pipe in sewer and drain diameters | ASTM D2751 |
| Cast-iron | ASME B16.4; ASME B16.12; ASTM A74; ASTM A888; CISPI 301 |
| Copper or copper alloy (Brass), | ASME B16.15; ASME B16.18; ASME B16.22; ASME B16.23; ASME B16.26; ASME B16.29 |
| Gray iron and ductile iron | AWWA C110/A21.10 |
| Polyethylene | ASTM D2683 |
| Polyolefin | ASTM F1412; CSA B181.3 |
| Polyvinyl chloride (PVC) plastic in IPS diameters | ASME A112.4.4; ASTM D2665; ASTM D3311; ASTM F1866 |
| Polyvinyl chloride (PVC) plastic pipe in sewer and drain diameters | ASTM D3034 |
| Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch O.D. | ASTM D2949 |
| PVC fabricated fittings | ASTM F1866 |
| Stainless steel drainage systems, Types 304 and 316L | ASME A112.3.1 |
| Vitrified clay | ASTM C700 |

For SI: 1 inch = 25.4 mm.

**TABLE P3004.1**
**DRAINAGE FIXTURE UNIT (d.f.u.) VALUES FOR VARIOUS PLUMBING FIXTURES**

| TYPE OF FIXTURE OR GROUP OF FIXTURES | DRAINAGE FIXTURE UNIT VALUE (d.f.u.)[a] |
|---|---|

| | |
|---|---|
| Bar sink | 1 |
| Bathtub (with or without a shower head or whirlpool attachments) | 2 |
| Bidet | 1 |
| Clothes washer standpipe | 2 |
| Dishwasher | 2 |
| Floor drain[b] (including waste receptors or hub drains for condensate waste) | 0 |
| Kitchen sink | 2 |
| Lavatory | 1 |
| Laundry tub | 2 |
| Shower stall | 2 |
| Water closet (1.6 gallons per flush) | 3 |
| Water closet (greater than 1.6 gallons per flush) | 4 |
| Full-bath group with bathtub (with 1.6-gallons-per-flush water closet, and with or without shower head and/or whirlpool attachment on the bathtub or shower stall) | 5 |
| Full-bath group with bathtub (water closet greater than 1.6 gallons per flush, and with or without shower head and/or whirlpool attachment on the bathtub or shower stall) | 6 |
| Half-bath group (1.6-gallons-per-flush water closet plus lavatory) | 4 |
| Half-bath group (water closet greater than 1.6 gallons per flush plus lavatory) | 5 |
| Kitchen group (dishwasher and sink with or without food-waste disposer) | 2 |
| Laundry group (clothes washer standpipe and laundry tub) | 3 |
| Multiple-bath groups[c]:<br>1.5 baths<br>2 baths<br>2.5 baths<br>3 baths<br>3.5 baths | <br>7<br>8<br>9<br>10<br>11 |

For SI: 1 gallon = 3.785 L, 1 gallon per minute = 3.785 L/m.

a. For a continuous or semicontinuous flow into a drainage system, such as from a pump or similar device, ~~1.5~~ 2 fixture units shall be allowed per gpm of flow. For a fixture not listed, use the highest d.f.u. value for a similar *listed* fixture.

b. A floor drain itself does not add hydraulic load. Where used as a receptor, the fixture unit value of the fixture discharging into the receptor shall be applicable.

c. Add 2 d.f.u. for each additional full bath.

# CHAPTER 31
# VENTS

~~The text of this chapter is extracted from the 2018 edition of the *North Carolina Plumbing Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One- and Two-Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Plumbing Code*.~~

## SECTION P3101
## VENT SYSTEMS

**P3101.1 General.** This chapter shall govern the selection and installation of piping, tubing and fittings for vent systems. This chapter shall control the minimum diameter of vent pipes, circuit vents, branch vents and individual vents, and the size and length of vents and various aspects of vent stacks and stack vents. Additionally, this chapter regulates vent grades and connections, height above fixtures and relief vents for stacks and fixture traps, and the venting of sumps and sewers.

**P3101.2 Trap seal protection.** The plumbing system shall be provided with a system of vent piping that will allow the admission or emission of air so that the liquid seal of any fixture trap shall not be subjected to a pressure differential of more than 1 inch of water column (249 Pa).

**P3101.2.1 Venting required.** Every *trap* and trapped fixture shall be vented in accordance with one of the venting methods specified in this chapter. All fixtures discharging downstream from a water closet shall be individually vented. ~~except as provided in Section P3107.~~

**P3101.3 Use limitations.** The plumbing vent system shall not be used for purposes other than the venting of the plumbing system.

**P3101.4 Extension outside a structure**. **DELETED**.

**P3101.5 Flood resistance.** In flood hazard areas as established by Table R301.2, vents shall be located at or above the elevation required in Section R322.1 (flood hazard areas including A Zones) or R322.2 (coastal high-hazard areas including V Zones). The plumbing systems, pipes and fixtures shall not be mounted on or penetrate through walls intended to break away under flood loads.

**P3101.6 Tests.**
The vent system shall be tested in accordance with Section P2503.5.

**P3101.7 Materials**

The materials and methods utilized for the construction and installation of venting systems shall comply with the applicable provisions of Section P2906.

**P3101.7.1 Sheet copper.**
Sheet copper for vent pipe flashings shall conform to ASTM B 152 and shall weigh not less than 8 ounces per square foot (2.5 kg/m$^2$).

**P3101.7.2 Sheet lead.**
Sheet lead for vent pipe flashings shall weigh not less than 3 pounds per square foot (15 kg/m$^2$) for field-constructed flashings and not less than 2-1/2 pounds per square foot (12 kg/m$^2$) for prefabricated flashings.

## SECTION P3102
## VENT STACKS AND STACK VENTS

**P3102.1 Stack required**. Every building in which plumbing is installed shall have at least one stack the size of which is not less than one-half of the required diameter of the building drain, and not less than 2 inches (51 mm) in diameter.

Such stack shall run undiminished in size and as directly as possible from the building drain through to the open air or to a vent header that extends to the open air.

**P3102.1.1 Connection to drainage system**.
A vent stack shall connect to the building drain or to the base of a drainage stack in accordance with Section P3005.5. A stack vent shall be an extension of the drainage stack. For townhouses and one- and two-family dwellings, the main vent shall connect to the building drain, building stack or branch thereof not less than 3 inches (76 mm) in size.

**P3102.2 Installation.** The required vent shall be a dry vent that connects to the *building drain* or an extension of a drain that connects to the *building drain*. Such vent shall not be an island fixture vent as permitted by Section P3112.

**P3102.3 Size.** The required vent shall be sized in accordance with Section P3113.1 based on the required size of the *building drain*.

**P3102.4 Stack vent termination.**
*Stack vents* shall terminate outdoors to the open air or to a stack-type air admittance valve in accordance with Section P3114.

## SECTION P3103
## VENT TERMINALS

**P3103.1 Vent pipes terminating outdoors.** Vent pipes terminating outdoors shall be extended to the outdoors through the roof or a sidewall of the building in accordance with one of the methods identified in Sections P3103.1.1 through P3103.1.4.

~~**P3103.1**~~ **P3103.1.1 Roof extension.** Open vent pipes that extend through a roof that do not meet the conditions of Section P3103.1.2 or P3103.1.3 shall terminate not less than 6 inches (150 mm) above the roof or 6 inches (150 mm) above the anticipated snow accumulation, whichever is greater.

**P3103.1.2 Roof used for recreational purposes.** Where a roof is to be used for assembly, as a promenade, observation deck or sunbathing deck, or for similar purposes, open vent pipes shall terminate not less than 7 feet (2134 mm) above the roof.

**Exception:** Vent terminals greater than 10 feet from a demarcation line of the occupied area.

**P3103.1.3 Roof extension covered.** Where an open vent pipe terminates above a sloped roof and is covered by either a roof-mounted panel (such as a solar collector or *photovoltaic panel* mounted over the vent opening) or a roof element (such as an architectural feature or a decorative shroud), the vent pipe shall terminate not less than 6 inches above the roof surface. Such roof elements shall be designed to prevent the adverse effects of snow accumulation and wind on the function of the vent. The placement of a panel over a vent pipe and the design of a roof element covering the vent pipe shall provide for an open area for the vent pipe to the outdoors that is not less than the area of the pipe, as calculated from the inside diameter of the pipe. Such vent terminals shall be protected by a method that prevents birds and rodents from entering or blocking the vent pipe opening.

~~**P3103.6 Extension through the wall.**~~ **P3103.1.4 Sidewall vent terminal.** Vent terminals extending through the wall shall terminate not less than 10 feet (3048 mm) from a *lot line* and not less than 10 feet (3048 mm) above the highest grade elevation within 10 feet (3048 mm) in any direction horizontally of the vent terminal. Vent pipes shall not terminate under the overhang of a structure where the overhang includes soffit vents. Such vent terminals shall be protected by an *approved* method that prevents birds and rodents from entering or blocking the vent pipe opening and that does not reduce the open area of the vent pipe.

**P3103.2 Frost closure. DELETED.**

**P3103.3 Flashings and sealing.** The juncture of each vent pipe with the roof line shall be made watertight by an *approved* flashing. Vent extensions in walls and soffits shall be made weathertight by caulking.

**P3103.4 Prohibited use.** A vent terminal shall not be used for any purpose other than a vent terminal. Vent terminals shall not be used as a flag pole or to support flag poles, television aerials or similar items, except when the piping has been anchored in an approved manner.

**P3103.5 Location of vent terminal.** An open vent terminal from a drainage system shall not be located directly beneath any door, openable window, or other air intake opening of the building or of an adjacent building or property line, and any such vent terminal shall not be within 10 feet (3048 mm) horizontally of such an opening unless it is 2 feet (610 mm) or more above the top of such opening.

**P3103.6 Extension through the wall.**
Vent terminals extending through the wall shall terminate not less than 10 feet (3048 mm) from the *lot line* and 10 feet (3048 mm) above the highest adjacent *grade* within 10 feet (3048 mm) horizontally of the vent terminal. Vent terminals shall not terminate under the overhang of a structure with soffit vents. Side wall vent terminals shall be protected to prevent birds or rodents from entering or blocking the vent opening.

## SECTION P3104
## VENT CONNECTIONS AND GRADES

**P3104.1 Connection.** Individual branch and circuit vents shall connect to a vent stack, stack vent or extend to the open air.

**Exception:** Individual, branch and circuit vents shall be permitted to terminate at an *air admittance valve* in accordance with Section P3114.

**P3104.2 Grade.** Vent and branch vent pipes shall be graded, connected and supported to allow moisture and condensate to drain back to the soil or waste pipe by gravity.

**P3104.3 Vent connection to drainage system.** A dry vent connecting to a horizontal drain shall connect above the centerline of the horizontal drain pipe.

**P3104.4 Vertical rise of vent.** A dry vent shall rise vertically to not less than 6 inches (152 mm) above the flood level rim of the highest trap or trapped fixture being vented.

**Exceptions:**

1. Vents for interceptors located outdoors.
2. When vents for interceptors are not located near an adjacent wall, the vent must rise 6 inches (152 mm) vertically before turning horizontally and continuing to the nearest wall. For cleaning purposes, a cleanout of the same size as the vent shall be installed.

**P3104.5 Height above fixtures.** A connection between a vent pipe and a vent stack or stack vent shall be made not less than 6 inches (152 mm) above the flood level rim of the highest fixture served by the vent. *Horizontal* vent pipes forming branch vents shall be not less than 6 inches (152 mm) above the flood level rim of the highest fixture served.

**P3104.6 Vent for future fixtures.** Where the drainage piping has been roughed-in for future fixtures, a rough-in connection for a vent, not less than one-half the diameter of the drain, shall be installed. The vent rough-in shall connect to the vent system or shall be vented by other means as provided in this chapter. The connection shall be identified to indicate that the connection is a vent.

## SECTION P3105
## FIXTURE VENTS

**P3105.1 Distance of trap from vent.** Each fixture trap shall have a protecting vent located so that the slope and the *developed length* in the *fixture drain* from the trap weir to the vent fitting are within the limits indicated in Table P3105.1.

**Exception:** The *developed length* of the *fixture drain* from the trap weir to the vent fitting for self-siphoning fixtures, such as water closets, shall not be limited.

**TABLE P3105.1**
**MAXIMUM DISTANCE OF FIXTURE TRAP FROM VENT**

| SIZE OF TRAP (inches) | SLOPE (inch per foot) | DISTANCE FROM TRAP (feet) |
|---|---|---|
| $1^1/_4$ | $^1/_4$ | 5 |
| $1^1/_2$ | $^1/_4$ | 6 |
| 2 | $^1/_4$ | 8 |
| 3 | $^1/_8$ | 12 |
| 4 | $^1/_8$ | 16 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 inch per foot = 83.3 mm/m.

**P3105.2 Fixture drains.** The total fall in a *fixture drain* resulting from pipe slope shall not exceed one pipe diameter, nor shall the vent pipe connection to a *fixture drain*, except for water closets, be below the weir of the trap.

**P3105.3 Crown vent prohibited.** A vent shall not be installed within two pipe diameters of the trap weir.

## SECTION P3106
## INDIVIDUAL VENT

**P3106.1 Individual vent permitted.** Each trap and trapped fixture shall be permitted to be provided with an individual vent. The individual vent shall connect to the *fixture drain* of the trap or trapped fixture being vented.

## SECTION P3107
## COMMON VENT

**P3107.1 Individual vent as common vent.** An individual vent shall be permitted to vent two traps or trapped fixtures as a common vent. The traps or trapped fixtures being common vented shall be located on the same floor level.

**P3107.2 Connection at the same level.** Where the *fixture drains* being common vented connect at the same level, the vent connection shall be at the interconnection of the *fixture drains*.

**P3107.3 Connection at different levels.** Where the *fixture drains* connect at different levels, the vent shall connect as a vertical extension of the vertical drain. The vertical drain pipe connecting the two *fixture drains* shall be considered to be the vent for the lower *fixture drain*, and shall be sized in accordance with Table P3107.3. The upper fixture shall not be a water closet or clothes washer.

**TABLE P3107.3**
**COMMON VENT SIZES**

| PIPE SIZE (inches) | MAXIMUM DISCHARGE FROM UPPER FIXTURE DRAIN (d.f.u.) |
|---|---|
| $1^1/_2$ | 1 |
| 2 | 4 |
| $2^1/_2$ to 3 | 6 |

For SI: 1 inch = 25.4 mm.

## SECTION P3108
## WET VENTING

**P3108.1 Horizontal wet vent permitted.** Any combination of fixtures located on the same floor level shall be permitted to be vented by a wet vent. The wet vent shall be considered the vent for the fixtures and shall extend from the connection of the dry vent along the direction of the flow in the drain pipe to the most downstream *fixture drain* connection. Each *fixture drain* shall connect horizontally to the horizontal branch being wet vented or shall have a dry vent. Each wet-vented *fixture drain* shall connect independently to the horizontal wet vent. A residential clothes washer drain line shall not be used as a wet vent.

**P3108.2 Dry vent connection.** The required dry-vent connection for wet-vented systems shall comply with Sections P3108.2.1 and P3108.2.2.

**P3108.2.1 Horizontal wet vent.** The dry-vent connection for a horizontal wet-vent system shall be an individual vent or a common vent for any fixture, except an emergency floor drain. Where the dry vent connects to a water closet *fixture drain*, the drain shall connect horizontally to the horizontal wet vent system.

**P3108.2.2 Vertical wet vent.** The dry-vent connection for a vertical wet-vent system shall be an individual vent or common vent for the most upstream *fixture drain*.

**P3108.3 Size.** Horizontal and vertical wet vents shall be not less than the size as specified in Table P3108.3, based on the fixture unit discharge to the wet vent. The dry vent serving the wet vent shall be sized based on the largest required diameter of pipe within the wet-vent system served by the dry vent.

**TABLE P3108.3**
**WET VENT SIZE**

| WET VENT PIPE SIZE (inches) | FIXTURE UNIT LOAD (d.f.u.) |
|---|---|
| $1^1/_2$ | 1 |
| 2 | 4 |
| $2^1/_2$ | 6 |
| 3 | 12 |
| 4 | 32 |

For SI: 1 inch = 25.4 mm.

**P3108.4 Vertical wet vent permitted.** A combination of fixtures located on the same floor level shall be permitted to be vented by a vertical wet vent. The vertical wet vent shall be considered to be the vent for the fixtures and shall extend from the connection of the dry vent down to the lowest *fixture drain* connection. Each wet-vented fixture shall connect independently to the vertical wet vent. All water closet drains shall connect at the same elevation. Other *fixture drains* shall connect above or at the same elevation as the water closet *fixture drains*. The dry-vent connection to the vertical wet vent shall be an individual or common vent serving one or two fixtures.

**P3108.5 Trap weir to wet-vent distances.** The maximum *developed length* of wet-vented *fixture drains* shall comply with Table P3105.1.

## SECTION P3109
## WASTE STACK VENT

**P3109.1 Waste stack vent permitted.** A waste stack shall be considered to be a vent for all of the fixtures discharging to the stack where installed in accordance with the requirements of this section.

**P3109.2 Stack installation.** The waste stack shall be vertical, and both horizontal and vertical offsets shall be prohibited between the lowest *fixture drain* connection and the highest *fixture drain* connection to the stack. Every *fixture drain* shall connect separately to the waste stack. The stack shall not receive the discharge of water closets or urinals.

**P3109.3 Stack vent.** A stack vent shall be installed for the waste stack. The size of the stack vent shall be not less than the size of the waste stack. Offsets shall be permitted in the stack vent and shall be located not less than 6 inches (152 mm) above the flood level of the highest fixture, and shall be in accordance with Section P3104.5. The stack vent shall be permitted to connect with other stack vents and vent stacks in accordance with Section P3113.3.

**P3109.4 Waste stack size.** The waste stack shall be sized based on the total discharge to the stack and the discharge within a *branch interval* in accordance with Table P3109.4. The waste stack shall be the same size throughout the length of the waste stack.

**TABLE P3109.4**
**WASTE STACK VENT SIZE**

| STACK SIZE (inches) | MAXIMUM NUMBER OF FIXTURE UNITS (d.f.u.) | |
|---|---|---|
| | Total discharge into one branch interval | Total discharge for stack |
| $1^1/_2$ | 1 | 2 |
| 2 | 2 | 4 |
| $2^1/_2$ | No limit | 8 |
| 3 | No limit | 24 |
| 4 | No limit | 50 |

For SI: 1 inch = 25.4 mm.

## SECTION P3110
## CIRCUIT VENTING <u>(DELETED)</u>

~~**P3110.1 Circuit vent permitted.** Not greater than eight fixtures connected to a horizontal branch drain shall be permitted to be circuit vented. Each *fixture drain* shall connect horizontally to the horizontal branch being circuit vented. The horizontal branch drain shall be classified as a vent from the most downstream *fixture drain* connection to the most upstream *fixture drain* connection to the horizontal branch.~~

~~**P3110.1.1 (914.1.1) Multiple circuit-vented branches.** Circuit-vented horizontal branch drains are permitted to be connected together. Each group of a maximum of eight fixtures shall be considered a separate circuit vent and shall conform to the requirements of this section.~~

~~**P3110.2 Vent connection.** The circuit vent connection shall be located between the two most upstream *fixture drains*. The vent shall connect to the horizontal branch and shall be installed in accordance with Section P3104. The circuit vent pipe shall not receive the discharge of any soil or waste.~~

~~**P3110.3 Slope and size of horizontal branch.** The slope of the vent section of the horizontal branch drain shall be not greater than 1 unit vertical in 12 units horizontal (8-percent slope). The entire length of the vent section of the horizontal branch drain shall be sized for the total drainage discharge to the branch in accordance with Table P3005.4.1.~~ <u>Drainage discharge dfu values for horizontal fixture branches shall be reduced 50 percent in Table P3005.4.1 for circuit vented fixture branches.</u>

~~**P3110.4 Additional fixtures.** Fixtures, other than circuit-vented fixtures, shall be permitted to discharge to the horizontal branch drain. Such fixtures shall be located on the same floor as the circuit-vented fixtures and shall be either individually or common vented.~~

## SECTION P3111
## COMBINATION WASTE AND VENT SYSTEM (DELETED)

## SECTION P3112
## ISLAND FIXTURE VENTING

**P3112.1 Limitation.** Island fixture venting shall not be permitted for fixtures other than sinks and lavatories. Kitchen sinks with a dishwasher waste connection, a food waste disposer, or both, in combination with the kitchen sink waste, shall be permitted to be vented in accordance with this section.

**P3112.2 Vent connection.** The island fixture vent shall connect to the *fixture drain* as required for an individual or common vent. The vent shall rise vertically to above the drainage outlet of the fixture being vented before offsetting horizontally or vertically downward. The vent or branch vent for multiple island fixture vents shall extend not less than 6 inches (152 mm) above the highest island fixture being vented before connecting to the outside vent terminal.

**P3112.3 Vent installation below the fixture flood level rim.** The vent located below the flood level rim of the fixture being vented shall be installed as required for drainage piping in accordance with Chapter 30, except for sizing. The vent shall be sized in accordance with Section P3113.1. The lowest point of the island fixture vent shall connect full size to the drainage system. The connection shall be to a vertical drain pipe or to the top half of a horizontal drain pipe. Cleanouts shall be provided in the island fixture vent to permit rodding of all vent piping located below the flood level rim of the fixtures. Rodding in both directions shall be permitted through a cleanout.

## SECTION P3113
## VENT PIPE SIZING

**P3113.1 Size of vents.** The required diameter of individual vents, branch vents, circuit vents, vent stacks and stack vents shall be not less than one-half the required diameter of the drain served. The required size of the drain shall be determined in accordance with Chapter 30. Vent pipes shall be not less than $1^{1}/_{4}$ inches (32 mm) in diameter. Vents exceeding 40 feet (12 192 mm) in *developed length* shall be increased by one nominal pipe size for the entire *developed length* of the vent pipe.

**P3113.2 Developed length.** The *developed length* of individual, branch and circuit vents shall be measured from the farthest point of vent connection to the drainage system, to the point of connection to the vent stack, stack vent or termination outside of the building.

**P3113.3 Branch vents.** Where branch vents are connected to a common branch vent, the common branch vent shall be sized in accordance with this section, based on the size of the common horizontal drainage branch that is or would be required to serve the total drainage fixture unit (d.f.u.) load being vented.

**P3113.4 Sump vents.** Sump vent sizes shall be determined in accordance with Sections P3113.4.1 and P3113.4.2.

**P3113.4.1 Sewage pumps and sewage ejectors other than pneumatic.** Drainage piping below sewer level shall be vented in the same manner as that of a gravity system. Building sump vent sizes for sumps with sewage pumps or sewage ejectors, other than pneumatic, shall be determined in accordance with Table P3113.4.1. An open vent terminal from a drainage system shall not be located directly beneath any door, openable window, or other air intake opening of the building or of an adjacent building or property line, and any such vent terminal shall not be within 10 feet (3048 mm) horizontally of such an opening unless it is at least 2 feet (610 mm) above the top of such opening.

**P3113.4.2 Pneumatic sewage ejectors.** The air pressure relief pipe from a pneumatic sewage ejector shall be connected to an independent vent stack terminating as required for vent extensions through the roof. The relief pipe shall be sized to relieve air pressure inside the ejector to atmospheric pressure, but shall be not less than $1^{1}/_{4}$ inches (32 mm) in size.

## SECTION P3114
## AIR ADMITTANCE VALVES

**P3114.1 General.** Vent systems using *air admittance valves* shall comply with this section. Individual and branch-type air admittance valves shall conform to ASSE 1051. Stack-type air admittance valves shall conform to ASSE 1050.

**P3114.2 Installation.** The valves shall be installed in accordance with the requirements of this section and the manufacturer's instructions. *Air admittance valves* shall be installed after the DWV testing required by Section P2503.5.1 or P2503.5.2 has been performed.

**P3114.3 Where permitted.** Individual vents, branch vents, circuit vents and stack vents shall be permitted to terminate with a connection to an *air admittance valve*. Individual and branch-type air admittance valves shall vent only fixtures that are on the same floor level and connect to a horizontal branch drain.

**P3114.4 Location.** Individual and branch *air admittance valves* shall be located not less than 4 inches (102 mm) above the horizontal branch drain or *fixture drain* being vented. Stack-type air admittance valves shall be located not less than 6 inches (152 mm) above the flood level rim of the highest fixture being vented. The *air admittance valve* shall be located within the maximum *developed length* permitted for the vent. The *air admittance valve* shall be installed not less than 6 inches (152 mm) above insulation materials where installed in *attics*.

**P3114.5 Access and ventilation.** Access shall be provided to *air admittance valves*. Such valves shall be installed in a location that allows air to enter the valve.

**P3114.6 Size.** The *air admittance valve* shall be rated for the size of the vent to which the valve is connected.

**P3114.7 Vent required.** Within each plumbing system, not less than one stack vent or a vent stack shall extend outdoors to the open air.

**P3114.8 Prohibited installations.** *Air admittance valves* shall not be used to vent sumps or tanks except where the vent system for the sump or tank has been designed by an engineer. *Air admittance valves* shall not be installed on outdoor vent terminals for the sole purpose of reducing clearances to gravity or mechanical air intakes. Air admittance valves shall not be located in spaces utilized as supply or return air plenums.

**TABLE P3113.4.1**
**SIZE AND LENGTH OF SUMP VENTS**

| DISCHARGE CAPACITY OF PUMP (gpm) | MAXIMUM DEVELOPED LENGTH OF VENT (feet)[a] | | | | |
|---|---|---|---|---|---|
| | Diameter of vent (inches) | | | | |
| | $1\frac{1}{4}$ | $1\frac{1}{2}$ | 2 | $2\frac{1}{2}$ | 3 |
| 10 | No limit[b] | No limit | No limit | No limit | No limit |
| 20 | 270 | No limit | No limit | No limit | No limit |
| 40 | 72 | 160 | No limit | No limit | No limit |
| 60 | 31 | 75 | 270 | No limit | No limit |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gallon per minute (gpm) = 3.785 L/m.

a. Developed length plus an appropriate allowance for entrance losses and friction caused by fittings, changes in direction and diameter. Suggested allowances shall be obtained from NBS Monograph 31 or other approved sources. An allowance of 50 percent of the developed length shall be assumed if a more precise value is not available.

b. Actual values greater than 500 feet.

# CHAPTER 32
# TRAPS

~~The text of this chapter is extracted from the 2018 edition of the *North Carolina Plumbing Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One- and Two-Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Plumbing Code*.~~

## SECTION P3201
## FIXTURE TRAPS

**P3201.1 Design of traps.** Traps shall be of standard design, shall have smooth uniform internal waterways, shall be self-cleaning and shall not have interior partitions except where integral with the fixture. Traps shall be constructed of lead, cast iron, copper or copper alloy or *approved* plastic. Copper or copper-alloy traps shall be not less than No. 20 gage (0.8 mm) thickness. Solid connections, slip joints and couplings shall be permitted to be used on the trap inlet, trap outlet, or within the trap seal. Traps having slip-joint connections shall comply with Section P2704.1.

**P3201.2 Trap seals.** Each fixture trap shall have a liquid seal of not less than 2 inches (51 mm) and not more than 4 inches (102 mm).

> **Exception:** Trap seal protection for waste receptors or hub drains used for condensate waste shall be by the use of a deep seal trap.

**P3201.2.1 Trap seal protection.** Traps seals of emergency floor drain traps and traps subject to evaporation shall be protected by one of the methods in Sections P3201.2.1.1 through P3201.2.1.4.

**P3201.2.1.1 Potable water-supplied trap seal primer valve.** A potable water-supplied trap seal primer valve shall supply water to the trap. Water-supplied trap seal primer valves shall conform to ASSE 1018. The discharge pipe from the trap seal primer valve shall connect to the trap above the trap seal on the inlet side of the trap.

**P3201.2.1.2 Reclaimed or graywater-supplied trap seal primer valve.** A reclaimed or graywater-supplied trap seal primer valve shall supply water to the trap. Water-supplied trap seal primer valves shall conform to ASSE 1018. The quality of reclaimed or graywater supplied to trap seal primer valves shall be in accordance with the requirements of the manufacturer of the trap seal primer valve. The discharge pipe from the trap seal primer valve shall connect to the trap above the trap seal on the inlet side of the trap.

**P3201.2.1.3 Wastewater-supplied trap primer device.** A wastewater-supplied trap primer device shall supply water to the trap. Wastewater-supplied trap primer devices shall conform to ASSE 1044. The discharge pipe from the trap seal primer device shall connect to the trap above the trap seal on the inlet side of the trap.

**P3201.2.1.4 Barrier-type trap seal protection device.** ~~Deleted.~~ A barrier-type trap seal protection device shall protect the floor drain trap seal from evaporation. Barrier-type floor drain trap seal protection devices shall conform to ASSE 1072. The devices shall be installed in accordance with the manufacturer's instructions.

**P3201.3 Trap setting and protection.** Traps shall be set level with respect to their water seals and shall be protected from freezing. Trap seals shall be protected from siphonage, aspiration or back pressure by an *approved* system of venting (see Section P3101).

**P3201.4 Building traps.** Building traps shall be prohibited.

**P3201.5 Prohibited trap designs.** The following types of traps are prohibited:

1. Bell traps.
2. Separate fixture traps with interior partitions, except those lavatory traps made of plastic, stainless steel or other corrosion-resistant material.
3. "S" traps.
4. Drum traps.
5. Trap designs with moving parts.

**P3201.6 Number of fixtures per trap.** Each plumbing fixture shall be separately trapped by a water seal trap. The vertical distance from the fixture outlet to the trap weir shall not exceed 24 inches (610 mm) and the horizontal distance shall not exceed 30 inches (762 mm) measured from the centerline of the fixture outlet to the centerline of the inlet of the trap. The height of a clothes washer standpipe above a trap shall conform to Section P2706.1.2. Fixtures shall not be double trapped.

**Exceptions:**

1. Fixtures that have integral traps.
2. A single trap shall be permitted to serve two or three like fixtures limited to kitchen sinks, laundry tubs and lavatories. Such fixtures shall be adjacent to each other and located in the same room with a continuous waste arrangement. The trap shall be installed at the center fixture where three fixtures are installed. Common trapped fixture outlets shall be not more than 30 inches (762 mm) apart.
3. Connection of a laundry tray waste line into a standpipe for the automatic clothes-washer drain shall be permitted in accordance with Section P2706.1.2.1.

**P3201.7 Size of fixture traps.** Trap sizes for plumbing fixtures shall be as indicated in Table P3201.7. Where the tailpiece of a plumbing fixture is larger than that indicated in Table P3201.7, the trap size shall be the same nominal size as the fixture tailpiece. A trap shall not be larger than the drainage pipe into which the trap discharges.

**TABLE P3201.7**
**SIZE OF TRAPS FOR PLUMBING FIXTURES**

| PLUMBING FIXTURE | TRAP SIZE MINIMUM (inches) |
|---|---|
| Bathtub (with or without shower head and/or whirlpool attachments) | $1\frac{1}{2}$ |
| Bidet | $1\frac{1}{4}$ |
| Clothes washer standpipe | 2 |
| Dishwasher (on separate trap) | $1\frac{1}{2}$ |
| Floor drain | 2 |
| Kitchen sink (one or two traps, with or without dishwasher and food waste disposer) | $1\frac{1}{2}$ |
| Laundry tub (one or more compartments) | $1\frac{1}{2}$ |
| Lavatory | $1\frac{1}{4}$ |
| Shower (based on the total flow rate through showerheads and body sprays)<br>Flow rate: | |
| 5.7 gpm and less | ~~$1\frac{1}{2}$~~ 2 |
| More than 5.7 gpm up to 12.3 gpm | 2 |
| More than 12.3 gpm up to 25.8 gpm | 3 |
| More than 25.8 gpm up to 55.6 gpm | 4 |

For SI: 1 inch = 25.4 mm, 1 gallon per minute = 3.785 L/m.

# CHAPTER 33
# STORM DRAINAGE (DELETED)

# CHAPTER 45
# HIGH WIND ZONES

This chapter is a North Carolina addition and not part of the 2021 International Residential Code. There will be no underlined text.

## SECTION R4501
## GENERAL

**R4501.1 General.** The provisions of this chapter shall be applicable to buildings constructed in high wind zones as noted by the text. These provisions shall be in addition to or in lieu of previous chapters.

**R4501.2 Alternate construction.** In lieu of specific code requirements for structures in the 130, 140, and 150 miles per hour (58 m/s, 63 m/s and 67 m/s) wind zones, compliance with International Code Council ICC 600 *Standard for Residential Construction in High-Wind Regions* or AF&PA *Wood Frame Construction Manual for One- and Two-Family Dwellings* is acceptable.

## SECTION R4502
## DESIGN PRESSURE FOR DOORS AND WINDOWS

**R4502.1 Performance.** Exterior windows and doors shall be designed to resist the design wind pressures specified in Table R4502(a) through Table R4502(c). Garage door shall be designed to resist the design wind pressures specified in Table R4502(d) through Table R4502(f).

**TABLE R4502(a)**
**DESIGN PRESSURES FOR DOORS AND WINDOWS[a, b, c, d]**
**POSITIVE AND NEGATIVE IN PSF**

| VELOCITY (mph) | MEAN ROOF HEIGHT (feet) | | |
|---|---|---|---|
| | 15 | 25 | 35[e] |
| 130 | 25 | 29 | 32 |
| 140 | 31 | 35 | 39 |
| 150 | 37 | 43 | 47 |

For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s,
1 degree = 0.01745 rad.

a. Alternative pressures may be determined by using the *North Carolina Building Code*, ASCE-7, or the *International Building Code*.
b. If window or door is more than 4 feet from a corner, the pressure from this table shall be permitted to be multiplied by 0.87. This adjustment does not apply to garage doors.
c. For windows or doors in structures with a roof slope of 10 degrees (2:12) or less from the horizontal, the pressure from this table may be multiplied by 0.90.
d. Design pressure ratings based on the standards listed in Section R609 are adequate documentation of capacity to resist pressures from the table.
e. Where the mean roof height exceeds this table, values shall be determined by a design professional.

**TABLE R4502(a)**
**DESIGN PRESSURES FOR DOORS AND WINDOWS [a, b, c, d, e, f]**
**POSITIVE AND NEGATIVE IN PSF; EXPOSURE B**

| VELOCITY (mph) | MEAN ROOF HEIGHT (feet) | | | |
|---|---|---|---|---|
| | 15 | 20 | 30 | 40 |
| 130 | 21 | 22 | 25 | 27 |
| 140 | 24 | 26 | 29 | 31 |
| 150 | 27 | 29 | 33 | 36 |

**TABLE R4502(b)**
**DESIGN PRESSURES FOR DOORS AND WINDOWS [a, b, c, d, e, f]**
**POSITIVE AND NEGATIVE IN PSF; EXPOSURE C**

| VELOCITY (mph) | MEAN ROOF HEIGHT (feet) | | | |
|---|---|---|---|---|
| | **15** | **20** | **30** | **40** |
| 130 | 30 | 32 | 35 | 37 |
| 140 | 35 | 37 | 40 | 43 |
| 150 | 40 | 42 | 46 | 49 |

**TABLE R4502(c)**
**DESIGN PRESSURES FOR DOORS AND WINDOWS [a, b, c, d, e, f]**
**POSITIVE AND NEGATIVE IN PSF; EXPOSURE D**

| VELOCITY (mph) | MEAN ROOF HEIGHT (feet) | | | |
|---|---|---|---|---|
| | **15** | **20** | **30** | **40** |
| 130 | 36 | 38 | 41 | 43 |
| 140 | 42 | 44 | 47 | 50 |
| 150 | 48 | 51 | 54 | 57 |

For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 degree = 0.01745 rad.

a. Alternative pressures may be determined by using the *North Carolina Building Code*, ASCE-7, or the *International Building Code*.
b. If window or door is more than 4 feet from a corner, the pressure from this table shall be permitted to be multiplied by 0.81. This adjustment does not apply to garage doors.
c. For effective area between those given, the load shall be interpolated, or the load associated with the lower effective areas shall be used.
d. For windows or doors in structures with a roof slope of 10 degrees (2:12) or less from the horizontal, the pressure from this table may be multiplied by 0.90.
e. Design pressure ratings based on the standards listed in Section R609 are adequate documentation of capacity to resist pressures from the table.
f. Where the mean roof height exceeds this table, values shall be determined by a design professional.

**TABLE R4502(b)**
**DESIGN PRESSURES (IN PSF) GARAGE DOORS[a, b, c, d, e]**

| VELOCITY (mph) | MEAN ROOF HEIGHT (feet) | | |
|---|---|---|---|
| | **15** | **25** | **35[f]** |
| 130 | 20 | 23 | 26 |
| 140 | 25 | 29 | 32 |
| 150 | 30 | 35 | 39 |

For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 degree = 0.01745 rad.

## TABLE R4502(b)—continued
## DESIGN PRESSURES (IN PSF) GARAGE DOORS[a, b, c, d, e]

a. The pressures in this table are for garage doors at least 9 feet by 7 feet and at least 2 feet from the corner.

b. Alternative design pressures may be determined by using the *North Carolina Building Code*, ASCE-7, or the *International Building Code*.

c. For doors in a structure with a roof slope of 10 degrees (2:12) or less from the horizontal the pressures from this table may be multiplied by 0.90.

d. Design pressure ratings based on tests done according to ASTM E330 are adequate documentation.

e. Garage doors on the ground level of a structure in a flood zone do not have to meet the above design pressures provided all of the following conditions are met:

   1. Structure is anchored to the girders and top of the piling to resist the forces given in Chapter 45.
   2. The garage door occurs below the top of the piling.
   3. Provide openings at the garage level that comply with either of the following options:
      i. Design all exterior walls at the garage level to break away at 20 psf or less; or
      ii. Provide openings (in walls at the garage level without the garage level without the garage door) equal to at least 20 percent of the total wall area from the ground to the roof.

f. Where the mean roof height exceeds this table, values shall be determined by a design professional.

**TABLE R4502(~~b~~ d)**
**DESIGN PRESSURES ~~(IN PSF)~~ FOR GARAGE DOORS IN PSF; EXPOSURE B [a, b, c, d, e, f]**

| MEAN ROOF HEIGHT (feet) | DOOR SIZE | ULTIMATE DESIGN WIND SPEED $V_{ult}$ (mph) | | |
|---|---|---|---|---|
| | | 130 | 140 | 150 |
| 15 | Single (8' x 7') | 17 | 20 | 23 |
| | Double (16' x 7') | 16 | 19 | 21 |
| 20 | Single (8' x 7') | 19 | 22 | 25 |
| | Double (16' x 7') | 17 | 20 | 23 |
| 30 | Single (8' x 7') | 21 | 24 | 28 |
| | Double (16' x 7') | 19 | 22 | 26 |
| 40 | Single (8' x 7') | 23 | 27 | 30 |
| | Double (16' x 7') | 21 | 24 | 28 |

**TABLE R4502(e)**
**DESIGN PRESSURES FOR GARAGE DOORS IN PSF; EXPOSURE C [a, b, c, d, e, f]**

| MEAN ROOF HEIGHT (feet) | DOOR SIZE | ULTIMATE DESIGN WIND SPEED $V_{ult}$ (mph) | | |
|---|---|---|---|---|
| | | 130 | 140 | 150 |
| 15 | Single (8' x 7') | 25 | 29 | 34 |
| | Double (16' x 7') | 23 | 27 | 31 |
| 20 | Single (8' x 7') | 27 | 31 | 36 |
| | Double (16' x 7') | 25 | 29 | 33 |
| 30 | Single (8' x 7') | 29 | 34 | 39 |
| | Double (16' x 7') | 27 | 31 | 36 |
| 40 | Single (8' x 7') | 31 | 36 | 41 |
| | Double (16' x 7') | 29 | 33 | 38 |

**TABLE R4502(f)**
**DESIGN PRESSURES FOR GARAGE DOORS IN PSF; EXPOSURE D [a, b, c, d, e, f]**

| MEAN ROOF HEIGHT (feet) | DOOR SIZE | ULTIMATE DESIGN WIND SPEED $V_{ult}$ (mph) | | |
|---|---|---|---|---|
| | | 130 | 140 | 150 |
| 15 | Single (8' x 7') | 31 | 36 | 41 |
| | Double (16' x 7') | 28 | 33 | 38 |
| 20 | Single (8' x 7') | 32 | 38 | 43 |
| | Double (16' x 7') | 30 | 35 | 40 |
| 30 | Single (8' x 7') | 35 | 40 | 46 |
| | Double (16' x 7') | 32 | 37 | 42 |
| 40 | Single (8' x 7') | 36 | 42 | 48 |
| | Double (16' x 7') | 34 | 39 | 44 |

a. For door sizes or wind speeds between those given above the load may be interpolated, otherwise use the load associated with the smaller door size.
b. Alternative design pressures may be determined by using the *North Carolina Building Code*, ASCE-7, or the *International Building Code*.
c. For doors in a structure with a roof slope of 10 degrees (2:12) or less from the horizontal the pressures from this table may be multiplied by 0.90.
d. Garage door design pressure ratings based on tests ASTM E330 or ANSI/DASMA 108~~.~~
e. Garage doors on the ground level of a structure in a flood zone do not have to meet the above design pressures provided all of the following conditions are met:
   1. Structure is anchored to the girders and top of the piling to resist the forces given in Chapter 45.
   2. The garage door occurs below the top of the piling.
   3. Provide openings at the garage level that comply with either of the following options:
      i. Design all exterior walls at the garage level to break away at 20 psf or less; or
      ii. Provide openings (in walls at the garage level without the garage level without the garage door) equal to at least 20 percent of the total wall area from the ground to the roof.
f. Where the mean roof height exceeds this table, values shall be determined by a design professional.

## SECTION R4503

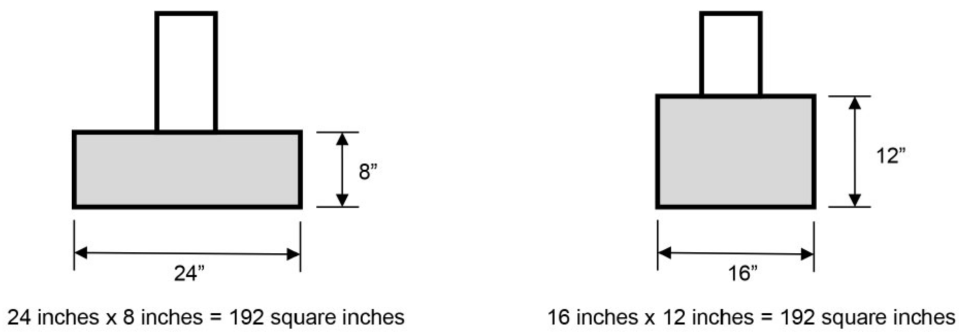
## FOOTINGS

**R4503.1 General.** All exterior walls shall be supported on continuous concrete footings in the 140 and 150 mph (63 m/s and 67 m/s) wind zones. Exterior wall footings in the 130 mph (58 m/s) wind zone shall be constructed in accordance with Section R403.1.

**Exception:** Pile foundations shall be constructed in accordance with Chapter 46.

**R4503.1.1 Footing size.** Footings shall be a minimum of 8 inches by 24 inches (203 mm by 610 mm) for houses two and one-half stories and less. The footings for a three-story building shall be 10 inches by 24 inches (254 mm by 610 mm).

**Exception:** Alternative footing sizes are permitted when a footing mass equivalent is provided to resist uplift forces. See Figure R4503.1.1.




For SI: 1 foot = 304.8 mm.

**FIGURE R4503.1.1**
**ALTERNATIVE FOOTING SIZE**

**R4503.1.2 Footing reinforcement.** Footings shall be reinforced with three #4 bars or two #5 bars at 3 inches (76 mm) above the bottom of the footing. The bars shall be equally spaced with 3 inches (76 mm) clear minimum from the side of the footing. The bars shall be continuous or lapped 25 inches at all splices.

**R4503.1.3 Interior piers and pier footings.** The dimensions for the interior piers and pier footings shall comply with Table R403.1(2).

**R4503.1.4 Interior thickened slabs.** Monolithic slabs with integral footings resisting uplift shall be reinforced in accordance with Section R4503.1.2.

**R4503.1.5 Interior foundation walls.** Interior foundation walls resisting uplift shall be reinforced in accordance with Section R4503.1.2.

**R4503.2 Pier and curtain wall footings.** Pier and curtain walls in the 140 and 150 mph (63 m/s and 67 m/s) wind zones shall be constructed in accordance with Sections R4503.2.1 and R4503.2.2 and Figures R4503.2(a) through R4503.2(d).

**R4503.2.1 Enlarged footings at piers.** The curtain wall footing must meet the minimum projection requirements in Figure R403.1(1) and footing dimensions for the pier footings shall comply with Table R4503.2.1.

**TABLE R4503.2.1**
**FOOTINGS TO RESIST UPLIFT FROM PIERS**
**IN 140 AND 150 MPH WIND ZONES SUPPORTING**
**GIRDERS IN EXTERIOR WALLS**

| | FOOTING SIZE GIRDER SPAN | | |
|---|---|---|---|
| VELOCITY (mph) | 4′-0″ | 6′-0″ | 8′-0″ |
| 140 | 2′-0″ × 2′-0″ × 10″ | 2′-4″ × 2′-4″ × 10″ | 2′-8″ × 2′-8″ × 10″ |
| 150 | 3′-0″ × 3′-0″ × 10″ | 3′-4″ × 3′-4″ × 12″ | 3′-8″ × 3′-8″ × 12″ |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.
Note: See Table R403.1(2) for 130 mph wind zone.

**R4503.2.2 Continuous width footings.** Uniform continuous width footings for pier and curtain wall foundations shall be a minimum of 8 inches (203 mm) thick and 24 inches (60 mm) wide. Footings shall be reinforced with three #4 bars (or two #5 bars) at 3 inches (76 mm) above the bottom of the footing. The bars shall be continuous or lapped 25 inches (635 mm) at all splices.

**R4503.3 Footing dowels.** All footings shall have reinforcing dowel bars to match the vertical reinforcing bars in the foundation wall above. Dowels or threaded rods shall have a standard hook length of 12 times the bar diameter embedded in the footing and shall lap the wall or pier reinforcing at least 25 inches (635 mm).

**R4503.4 Footing anchor bolts.** All anchor bolts shall have a standard hook length of 12 times the bolt diameter embedded in the footing or foundation wall. They shall not be permitted to be lapped.

**Exceptions:**

1. Anchor bolts in bond beams as permitted by Section R4504.2.1.1
2. Anchor bolts in slabs on grade as permitted by Section R4504.2.2

## SECTION R4504
## WALL AND FOUNDATION ANCHORAGE

**R4504.1 Anchorage in the 130 mph wind zone.** Exterior walls of structures in the 130 mph (58 m/s) wind zone shall be anchored to the foundation wall or slab on grade with 1/2- inch (13 mm) anchor bolts, 4 feet (1219 mm) on center extended 15 inches (381 mm) into masonry and 7 inches (178 mm) into concrete and are exempt from the other requirements of this section.

**R4504.2 Anchorage in the 140 and 150 mph wind zones.** Exterior walls of structures in the 140 and 150 mph (63 m/s and 67 m/s) wind zones shall be anchored to the footing to resist the forces specified in Section R4508.2, by the prescriptive requirements of this section and Figures R4504.2(a) through R4504.2(f), or as allowed by Section R4508.4.

**TABLE R4503.2.1**
**FOOTINGS TO RESIST UPLIFT FROM PIERS**
**IN 140 AND 150 MPH WIND ZONES SUPPORTING**
**GIRDERS IN EXTERIOR WALLS**

| | FOOTING SIZE GIRDER SPAN | | |
|---|---|---|---|
| VELOCITY (mph) | 4′-0″ | 6′-0″ | 8′-0″ |
| 140 | 2′-0″ × 2′-0″ × 10″ | 2′-4″ × 2′-4″ × 10″ | 2′-8″ × 2′-8″ × 10″ |
| 150 | 3′-0″ × 3′-0″ × 10″ | 3′-4″ × 3′-4″ × 12″ | 3′-8″ × 3′-8″ × 12″ |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.
Note: See Table R403.1(2) for 130 mph wind zone.

**R4504.2.1 Exterior foundation walls.** Vertical reinforcement bars shall be installed not more than 2 feet (51 mm) from each corner and at intervals not to exceed Table R4504.2.1 with all reinforced cells grouted solid. The reinforcement bars shall terminate in a bond beam in accordance with Section R4504.2.1.1 or continuous anchorage bolts shall terminate at the sill plate or exterior wall framing in accordance with Section R4504.2.1.2.

## TABLE R4504.2.1
## WALL REINFORCEMENT BARS OR CONTINUOUS ANCHORAGE BOLTS[a, b, c, d]

| BAR/BOLT SIZE (inches) | 5/8 | 1/2 | 3/8 |
|---|---|---|---|
| MAXIMUM SPACING (inches) | 96 | 72 | 42 |

For SI: 1 inch = 25.4 mm.

a. Applies to 140 and 150 mph wind zones.

b. Continuous anchorage from footing to girder or wall framing.

c. Applies to footing dowel bars, vertical reinforcement and anchor bolts.

d. Spacing may exceed the tabulated values by up to 8 inches provided the total number of required bars is installed.

**TABLE R4504.2.1**
**WALL REINFORCEMENT BARS OR CONTINUOUS ANCHORAGE BOLTS[a, b, c, d]**

For SI: 1 inch = 25.4 mm.
a. Applies to 140 and 150 mph wind zones.
b. Continuous anchorage from footing to girder or wall framing.
c. Applies to footing dowel bars, vertical reinforcement and anchor bolts.
d. Spacing may exceed the tabulated values by up to 8 inches provided the total number of required bars is installed.

**R4504.2.1.1 Bond beams.** The top of a concrete or masonry foundation wall shall have a bond beam in accordance with Figure R4504.2(a). The bond beam shall be reinforced with one #5 bar. The bar shall be continuous or lapped 25 inches (635 mm) at all splices.

**R4504.2.1.1.1 Bond beam plate anchorage.** A minimum of two 2 × 6 sill plates shall be anchored with 1/2-inch (13 mm) anchor bolts with 2 × 2 × 1/8 inch (51 × 51 × 3 mm) washers at intervals not to exceed Table R4504.2.1.1. An approved anchor from the sill plate to the wall framing shall be installed to resist the forces specified in Table R4508.2 or sheathing shall be fastened in accordance with Figure R4508.4(b). See Figure R4504.2(a).

## TABLE R4504.2.1.1
## ANCHOR BOLT SPACING[a]

| WIND SPEED (mph) | 140 | 150 |
|---|---|---|
| MAXIMUM SPACING (inches) | 21 | 18 |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. Required spacing of 1/2-inch anchor bolts where a bond beam is required and for slab on grade with a single sole plate. See Figure R403.1(1) for 130 mph or less.

**TABLE R4504.2.1.1**

**ANCHOR BOLT SPACING[a]**

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.
a. Required spacing of 1/2-inch anchor bolts where a bond beam is required
and for slab on grade with a single sole plate. See Figure R403.1(1) for 130 mph or less.

**R4504.2.1.2 Continuous anchorage bolts.** A minimum of two 2 × 6 sill plates shall be anchored with continuous anchor bolts in accordance with Table R4504.2.1 with 2 × 2 × 1/8 inch (51 × 51 × 3 mm) washers. Where the vertical anchorage bolts terminate at the sill plate, an approved anchor from the sill plate to the wall framing shall be installed to resist the forces specified in Table R4508.2 or sheathing shall be fastened in accordance with Figure R4508.4(b). See Figure R4504.2(b).

**Exception:** Where the uplift anchorage bolts from Table R4504.2.1 are continuous from the footing to the exterior wall framing, a single 2 × 6 sill plate is permitted. See Figure R4504.2(c).

**R4504.2.2 Exterior concrete slab-on-grade footings.** Anchorage shall be installed at intervals not to exceed Table R4504.2.1 and shall terminate in a minimum 2 × 4 double sole plate. See Figure 4504.2(d).

**Exceptions:**

1. Where the bolts terminate in a single sole plate, anchorage shall be installed at intervals not to exceed Table R4504.2.1.1. See Figure R4504.2(e).
2. Foundation anchorage spaced and installed in accordance with the manufacturer's installation instructions that provides equivalent anchorage to resist the forces in Table R4508.2 shall be installed to provide continuous load path from the single sole plate to the wall.

**R4504.2.3 Ground supported slab with masonry stem wall.** A minimum of two 2× sill plates shall be anchored with 1/2-inch (13 mm) continuous anchor bolts with 2 × 2 × 1/8 inch (51 × 51 × 3 mm) washers at intervals not to exceed Table R4504.2.1. An approved anchor from the sill plate to the wall framing shall be installed to resist the forces specified in Table R4508.2 or sheathing shall be fastened in accordance with Figure R4508.4(b). See Figure R4504.2(f).

## SECTION R4505
## WALL CONSTRUCTION

**R4505.1 Construction.** Exterior walls of wood frame construction shall be in accordance with Figures R602.3(1) and R602.3(2). Components of exterior walls shall be fastened in accordance with Table R602.3(1). Walls of wood frame construction shall be designed and constructed in accordance with ANSI AWC *National Design Specification for Wood Construction*, listed in Chapter 44.

Exterior walls subject to wind speeds of 130 mph (58 m/s) or greater as established in Table R301.2(1) shall be designed in accordance with accepted engineering practice. See Tables R4505(a) through R4505(c).

In bearing walls, studs which are not more than 10 feet (3048 mm) in length shall be spaced not more than is specified in Tables R4505(d) for the corresponding stud size.

**TABLE R4505(a)**
**STUDS IN 130, 140, AND 150 MPH ZONES**
**Requirements for Wood Stud In: Exterior Walls Supporting One Floor, Roof and Ceiling or Less/Exterior Nonloadbearing Walls in Two Story Structure or Less/Interior Walls Supporting One Floor, Roof and Ceiling or Less**

| STUD LENGTH | STUD SPACING | 130 MPH | | 130 MPH | | 140 MPH | | 150 MPH | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2 x 4 | 2 x 6 | 2 x 4 | 2 x 6 | 2 x 4 | 2 x 6 | 2 x 4 | 2 x 6 |
| | | Species: Spruce Pine Fir (South) without Structural Sheathing | | Species: Spruce Pine Fir (South) with $^3/_8$″ Wood Structural Sheathing | | | | | |
| 8 | 16 | #2 | Stud | Stud | Stud | Stud | Stud | #2 | Stud |
| 8 | 24 | #2 | Stud | #2 | Stud | #2 | Stud | #2 | Stud |
| 10 | 16 | #2 | Stud | #2 | Stud | #2 | Stud | #2 | Stud |
| 10 | 24 | Design | #2 | Design | #2 | Design | #2 | Design | #2 |
| | | Species: Spruce Pine Fir without Structural Sheathing | | Species: Spruce Pine Fir with $^3/_8$″ Wood Structural Sheathing | | | | | |
| 8 | 16 | Stud | Stud | Stand | Stud | Stud | Stud | #3 | Stud |
| 8 | 24 | #2 | Stud | #3 | Stud | #2 | Stud | #2 | Stud |
| 10 | 16 | #2 | Stud | #2 | Stud | #2 | Stud | #2 | Stud |
| 10 | 24 | Design | Stud | #2 | Stud | Design | Stud | Design | Stud |

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.
**Explanation of Table Entries:**
**Design** – Studs with this entry shall be in accordance with accepted engineering practice.
**#2** – #2 Grade construction
**#3** – #3 Grade
**Stud** – Stud grade
**Standard** – Standard grade
**Utility** – Utility grade
$^3/_8$″ wood structural sheathing shall be attached with 8d nails at 6″ at perimeter and 12″ at intermediate supports. When a grade is specified in the table any grade above it in this list may be used.

**TABLE R4505(a)**
**STUDS IN 130, 140, AND 150 MPH ZONES**
**Requirements for Wood Stud In: Exterior Walls Supporting One Floor, Roof and Ceiling or Less/Exterior Nonloadbearing Walls in Two Story Structure or Less/Interior Walls Supporting One Floor, Roof and Ceiling or Less**

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.
**Explanation of Table Entries:**
**Design** – Studs with this entry shall be in accordance with accepted engineering practice.
**#2** – #2 Grade construction
**#3** – #3 Grade
**Stud** – Stud grade
**Standard** – Standard grade
**Utility** – Utility grade
3/83 wood structural sheathing shall be attached with 8d nails at 63 at perimeter and 123 at intermediate supports. When a grade is specified in the table any grade above it in this list may be used.

**TABLE R4505(b)**
**EXTERIOR WALLS FOR FIRST FLOOR OF THREE STORY**

| EXTERIOR BEARING WALLS[a, b, c, d, e] FIRST FLOOR OF THREE STORY | | |
|---|---|---|
| | Spruce Pine Fir | |
| WIND ZONE (mph) | 2 × 4 @ 12″ o.c. Structural Sheathing | 3 × 4 or 2 × 6 @ 16″ o.c. Structural Sheathing |
| 130 | #2 | Any grade |
| 140 | #2 | Any grade |
| 150 | #2 | Any grade |

| Exterior Nonbearing Walls[a, b, c, d, e, f] First Floor of Three Story | | | |
|---|---|---|---|
| | Spruce Pine Fir | | |
| WIND ZONE (mph) | 2 ✕ 4 @ 12″ o.c. Blocking | 2 ✕ 4 @ 16″ o.c. Blocking | 3 ✕ 4 or 2 ✕ 6 @ 16″ o.c. Structural Sheathing |
| 130 | #2, Stud | #2 | Any grade |
| 140 | #2, Stud | NP | Any grade |
| 150 | #2 | NP | Any grade |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. Any grade = any grade except standard, utility and economy.
b. Corner bracing is required where blocking is specified.
c. 2 – 2 × 4s at 16 inches or 1 – 2 × 4 at 8 inches may be used where 3 × 4 at 16 inches is specified.
d. Refer to Sections R4506 and R4508.4 for sheathing requirements.
e. Bearing stud height is limited to 10 feet.
f. 2× full depth blocking at mid-height.

**TABLE 4505 (a)**
**MINIMUM LUMBER GRADE, SIZE, AND SPACING FOR EXTERIOR LOAD-BEARING STUDS USING SOUTHERN PINE (SP)**

| | | EXPOSURE B | | | | | | EXPOSURE C | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ULTIMATE DESIGN WIND SPEED $V_{ULT}$ (mph) | | | | | | | | | | | |
| STUD | STUD | 130 | | 140 | | 150 | | 130 | | 140 | | 150 | |
| LENGTH | SPACING (IN.) | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 |
| 8 | 12 | | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | |
| | 16 | | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | |
| | 24 | | | No.3/ Stud | | No. 2 | | No. 2 | | No. 2 | | No. 2 | |
| 9 | 12 | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | No.3/ Stud |
| | 16 | | No.3/ Stud | No.3/ Stud | No.3/ Stud | No.3/ Stud | No.3/ Stud | No.3/ Stud | No.3/ Stud | No. 2 | No.3/ Stud | No. 2 | |
| | 24 | | | No. 2 | | No. 2 | | No. 2 | | No. 2 | | - | |
| 10 | 12 | | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No. 2 | |
| | 16 | | | No.3/ Stud | | No. 2 | | No. 2 | | No. 2 | | No. 2 | |
| | 24 | No. 2 | | No. 2 | | No.1 | | - | | - | | - | No. 2 |

**TABLE 4505 (b)**
**MINIMUM LUMBER GRADE, SIZE, AND SPACING FOR EXTERIOR LOAD-BEARING STUDS USING SPRUCE-PINE-FIR (SPF)**

| | | EXPOSURE B | | | | | | EXPOSURE C | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ULTIMATE DESIGN WIND SPEED $V_{ULT}$ (mph) | | | | | | | | | | | |
| STUD | STUD | 130 | | 140 | | 150 | | 130 | | 140 | | 150 | |
| LENGTH | SPACING (IN.) | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 |
| 8 | 12 | | | | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | |
| | 16 | | | | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | |
| | 24 | | | | | No.3/ Stud | | No.3/ Stud | | No. 2 | | No. 2 | |
| 9 | 12 | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | |
| | 16 | | No.3/ Stud | | No.3/ Stud | No.3/ Stud | No.3/ Stud | No.3/ Stud | No.3/ Stud | No.3/ Stud | No.3/ Stud | No. 2 | No.3/ Stud |
| | 24 | | | | | No. 2 | | No. 2 | | No. 2 | | SS | |
| 10 | 12 | | | | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | | No.3/ Stud | |
| | 16 | | | | | No.3/ Stud | | No.3/ Stud | | No. 2 | | No. 2 | |
| | 24 | No. 2 | | No. 2 | | SS | | - | | - | | - | |

| TABLE 4505 (c) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAXIMUM STUD LENGTHS FOR EXTERIOR NON-LOAD-BEARING STUDS (ft)<br>(APPLIED TO STUDS USING SOUTHERN PINE (SP) AND SPRUCE-PINE-FIR (SPF)) | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | EXPOSURE B | | | | | | EXPOSURE C | | | | | |
| | ULTIMATE DESIGN WIND SPEED $V_{ULT}$ (mph) | | | | | | | | | | | |
| STUD SPACING (IN.) | 130 | | 140 | | 150 | | 130 | | 140 | | 150 | |
| | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 | 2X4 | 2X6 |
| 12 | 13 | 20 | 13 | 20 | 12 | 19 | 12 | 19 | 11 | 18 | 11 | 17 |
| 16 | 12 | 19 | 11 | 18 | 11 | 17 | 11 | 17 | 10 | 16 | 10 | 15 |
| 24 | 10 | 16 | 10 | 15 | 9 | 15 | 9 | 14 | 9 | 13 | 8 | 12 |

TABLE R4505(d)

SIZE, HEIGHT, AND SPACING LIMITS FOR WOOD STUDS (BASED ON DEAD AND LIVE LAOD)

| LOADING BEARING STUDS SUPPORTING | 2X4 | 2X6 | 2X8 |
|---|---|---|---|
| | MAXIMUM STUD SPACING (in. o.c.) | | |
| ROOF & CEILING ONLY | 24 | 24 | 24 |
| 1 FLOOR ONLY | 24 | 24 | 24 |
| ROOF & CEILING & 1 FLOOR ONLY | 16 | 24 | 24 |
| 2 FLOOR ONLY | 16 | 24 | 24 |
| ROOF, CEILING, & 2 FLOORS | - | 16 | 24 |
| - | - | - | - |
| NON-LOADING BEARING STUDS | MAXIMUM UNSUPPORTED STUD LENGTH (ft) | | |
| | 14 | 20 | 20 |
| | MAXIMUM STUD SPACING (in. o.c.) | | |
| | 24 | 24 | 24 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

SP = Southern Pine, SPF = Spruce-Pine Fir
"-" Limber Grade not available

a. Maximum mean roof height = 33 feet. (Per 2018 WFCM Section 2.1.3.1)
b. Total roof span shall not exceed 36 feet. (Per 2018 WFCM Section 3.1.3.4)
c. Exterior wall stud deflection limit = H/180
d. 3/8 inches thick wood structural sheathing shall be attached with 8d common nails (2.5" x 0.131") at 6 inches at perimeter and 12 inches at intermediate support.
e. Wind exposure category D is not covered by the tables and shall be designed in accordance with accepted engineering practice. (See 2018 NCRC Section R301.2.1.4 for definition of Exposure Category)
f. Load bearing wall shall not exceed 10 feet in height. (Per 2018 NCRC Table R602.3(5))
g. To address additional end zone loading requirements, end zone stud spacings shall be multiplied by 0.80 for framing located 4 feet of corners.

## SECTION R4506
## STRUCTURAL BRACING

**R4506.1 Structural bracing in 130 mph wind zone.** Structural bracing in the 130 mph (58 m/s) wind zone shall comply with Section R602.10.

**R4506.2 Structural bracing in 140 and 150 mph wind zones.** All stories shall be continuously sheathed with wood structural panels. All panels shall be fastened in accordance with Table R4506.2. Where sheathing is used to resist uplift, see Section R4508.4 for blocking requirements. Otherwise, blocking shall be installed if less than 50 percent of the wall length is sheathed. If a wall is sheathed less than 25 percent of its length, then that wall shall be designed in accordance with approved engineering practice.

**R4506.3 Gable endwalls.** Gable endwalls in the 130, 140 and 150 mph (58 m/s, 63 m/s and 67 m/s) wind zones shall either be supported by lateral bracing at the ceiling or have continuous studs from the floor to the roof. Non bearing studs in gable wall shall be limited to a height in accordance with Table 4505(c). ~~See Nonbearing 2 × 4 studs at 16 inches (406 mm) on center are limited to 14 feet (3048 mm) in length between supports. Nonbearing 2 × 6 SPF #2 studs at 16 inches (406 mm) on center with 3/8-inch (9 mm) wood structural panel sheathing are limited to unsupported lengths of 18 feet (5486 mm) in 130 mph (58 m/s), 16 feet (4877 mm) in 140 mph (53 m/s) and 14 feet (4267 mm) in 150 mph (67 m/s) wind zones.~~

Where open web trusses are installed, wood structural panel sheathing shall extend 12 inches (305 mm) beyond horizontal construction joints. Where the horizontal joint occurs over minimum 1 inch (25 mm) thick OSB or plywood or 2× rimboard, a minimum 11/2 inch (38 mm) overlap is required.

**R4506.4 Lateral support at ceiling.** Where studs are not continuous, the ceiling must be used to support the endwall. 2 × 4 lateral bracing shall be installed on the top of ceiling joists or truss bottom chords at 8 feet (2438 mm) on center and extend 8 feet (2438 mm) inward from the gable endwall. See Figure R4506.7(a).

**R4506.5 Full height studs.** Full height studs may be sized using the bracing at the ceiling to limit the stud length. See Figure R4506.5.

**R4506.6 Cathedral endwalls.** Studs shall be continuous from the uppermost floor to either the ceiling or the roof.

**R4506.7 Overhang at endwalls.** The overhang is limited to 12 inches (305 mm) where a laddered soffit is installed. The overhang may be increased to 24 inches (610 mm) where outlookers are framed over a dropped endwall into the first rafter or truss. See Figures R4506.7(a) and R4506.7(b). If the overhang exceeds 24 inches (610 mm), then the overhang shall be designed in accordance with approved engineering practice.

**R4506.8 Roof sheathing attachment.** The roof sheathing panel edges shall be blocked and nailed at the end two rafter or truss spaces. See Figure R4506.8.

> **Exception:** The panel edges need not be blocked where 2 × 4 diagonal braces are framed from the top of the endwall to the lateral bracing at the ceiling.

### TABLE R4507.1
### H/T LATERAL SUPPORT RATIOS FOR UNREINFORCED EXTERIOR MASONRY WALLS[a, b, d, e]

| | ULTIMATE WIND SPEED, MPH[c] | |
|---|---|---|
| **Wall Construction** | **140** | **150** |
| Solid masonry units | 13 | 11 |
| Hollow concrete masonry units or masonry bonded hollow walls | 9 | 8 |
| Cavity walls identical wythes | The *H*/*t* ratio shall be 0.70 of the *H*/*t* ratio for single wythe walls. The *t*-value shall be the sum of the nominal thickness of the individual wythes. | |
| Cavity walls with wythes of different types or size masonry | The wall shall be designed based on ACI-530 or the *H*/*t* ratio may be 0.70 of the *H*/*t* ratio of a single wythe hollow wall. The *t*-value shall be the sum of the nominal thickness of the individual wythes. | |

a. *H* = clear height or length between lateral supports.
*t* = nominal wall thickness.

b. All masonry units shall be laid in Type M, S or N mortar. Where Type N mortar is used and the wall spans in the vertical direction, the ratios shall be reduced by 10 percent.

c. Design based on partially enclosed building.

d. These values are based on using masonry cement mortar. If nonair-entrained Portland cement/lime mortar is used, the values in the table may be increased by 1.25. Larger *H*/*t* ratios may be used if the design is done in accordance with ACI-530.

e. Larger *H*/*t* ratios may be used if the design is done in accordance with ACI-530.

### TABLE R4508.2
### ROOF TIE DOWN REQUIREMENTS ALONG EXTERIOR WALLS (plf)[a, b, c, d]

| WIND SPEED (mph) | STRUCTURE WIDTH | |
|---|---|---|
| | **24 feet** | **36 feet** |
| 130 | 240 | 345 |
| 140 | 330 | 470 |
| 150 | 430 | 615 |

For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.R45 m/s.

a. Alternate to the requirements of this table or roof not covered by this table shall be designed in accordance with the *North Carolina Building Code* or ICC 600 *Standard for Residential Construction in High-Wind Regions*.

b. See Section 4505 for material requirements in Coastal High Hazard Areas and Ocean Hazard Areas and Ocean Hazard Areas.

c. Roof slope 2:12 to 12:12.

d. The uplift load requirements may be interpolated for intermediate structure widths.

## SECTION R4508
## ROOF TIE DOWN

**R4508.1 Roof tie down.** Roof assemblies in the 130, 140 and 150 mph (58 m/s, 63 m/s and 67 m/s) wind zones as established in Table R301.2(1) shall have rafter or truss ties provided in accordance with either Table R4508.2 through Table R4508.3 or the prescriptive requirements of Section R4508. Anchorage in the 130 mph (58 m/s) wind zone shall be continuous from the roof to the foundation wall or pier. Anchorage in the 140 and 150 mph (63 m/s and 67 m/s) wind zones shall be continuous from the roof to the footing. See Section R4504.

**R4508.2 Considerations.** For trusses, the nailing requirements from Table R4508.2 shall include the nailing requirements for both rafters and ceiling joists. As an alternative to the anchorage requirements of ~~Tables R602.3(1) and~~ R4508.2 and Table R4508.3, the anchorage for roof members may be based on a designed connection taking into account all horizontal and vertical forces. Forces for alternative anchorage design may result from wind uplift; wind lateral on roof; wind lateral on walls to be transferred to the top plate of the wall; roof/ceiling loads; and other loads depending on the specific building design. If roof members align with the studs, the connection may be made from the roof member directly to the studs. If the connection is from the roof member to the top plate, a double top plate is required and both connections must meet the requirements of Table R4508.2. Where ceiling joists are not parallel with and connect to the roof members, the anchorage requirements for each roof member shall be increased by 110 pound (50 kg). Hip end walls and hip rafters shall be anchored in accordance with this section.

**TABLE 4508.2**
**RAFTER OR TRUSS UPLIFT CONNECTION FORCE FROM WIND (POUNDS PER CONNECTION)[a,b,c,d,e,f,g]**

| RAFTER OR TRUSS SPACING | ROOF SPAN (feet) | EXPOSURE B ULTIMATE DESIGN WIND SPEED $V_{ULT}$ (mph) | | |
|---|---|---|---|---|
| | | 130 | 140 | 150 |
| 12" o.c. | 12 | 96 | 123 | 151 |
| | 16 | 113 | 146 | 181 |
| | 20 | 131 | 170 | 211 |
| | 24 | 149 | 193 | 241 |
| | 28 | 167 | 217 | 271 |
| | 32 | 186 | 241 | 301 |
| | 36 | 204 | 265 | 331 |
| 16" o.c. | 12 | 128 | 164 | 202 |
| | 16 | 151 | 195 | 241 |
| | 20 | 175 | 226 | 281 |
| | 24 | 199 | 258 | 321 |
| | 28 | 223 | 290 | 361 |
| | 32 | 248 | 322 | 401 |
| | 36 | 272 | 354 | 441 |
| 24" o.c. | 12 | 192 | 245 | 303 |
| | 16 | 227 | 292 | 362 |
| | 20 | 263 | 339 | 421 |
| | 24 | 299 | 387 | 481 |
| | 28 | 335 | 434 | 541 |
| | 32 | 371 | 482 | 602 |
| | 36 | 408 | 530 | 662 |

**TABLE 4508.2 - continued**
**RAFTER OR TRUSS UPLIFT CONNECTION FORCE FROM WIND (POUNDS PER CONNECTION)**

| RAFTER OR TRUSS SPACING | ROOF SPAN (feet) | EXPOSURE C ULTIMATE DESIGN WIND SPEED $V_{ULT}$ (mph) | | |
|---|---|---|---|---|
| | | 130 | 140 | 150 |
| 12" o.c. | 12 | 161 | 198 | 238 |
| | 16 | 193 | 238 | 286 |
| | 20 | 224 | 278 | 335 |
| | 24 | 256 | 318 | 383 |
| | 28 | 289 | 358 | 432 |
| | 32 | 321 | 398 | 481 |
| | 36 | 353 | 438 | 530 |
| 16" o.c. | 12 | 215 | 264 | 318 |
| | 16 | 257 | 317 | 382 |
| | 20 | 299 | 370 | 446 |
| | 24 | 342 | 423 | 511 |
| | 28 | 385 | 477 | 576 |
| | 32 | 428 | 531 | 641 |
| | 36 | 471 | 584 | 706 |
| 24" o.c. | 12 | 322 | 397 | 477 |
| | 16 | 385 | 475 | 572 |
| | 20 | 449 | 555 | 669 |
| | 24 | 513 | 635 | 766 |
| | 28 | 577 | 715 | 864 |
| | 32 | 642 | 796 | 962 |
| | 36 | 706 | 877 | 1059 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound = 0.454 kg, 1 pound per square foot = 47.9 N/m$^2$, 1 pound per linear foot = 14.6 N/m.

a. The uplift connection forces are based on a maximum 33-foot mean roof height and Wind Exposure Category B or C.

b. The uplift connection forces include an allowance for roof and ceiling assembly dead load of 15 psf and the tabulated uplift loads reduced with 0.6 factor.

c. The tabulated uplift connection forces are limited to a maximum roof overhang of 24 inches.

d. The tabulated uplift connection forces shall be permitted to be multiplied by 0.75 for connections not located within 8 feet of building corners.

e. For wall-to-wall and wall-to-foundation connections, the uplift connection force shall be permitted to be reduced by 60 pounds per linear foot for each full wall above.

f. Linear interpolation between tabulated roof spans and wind speeds shall be permitted.

g. The tabulated forces for a 12-inch on-center spacing shall be permitted to be used to determine the uplift load in pounds per linear foot.

h. Tabulated value limited from roof pitch 2:12 to 12:12

## TABLE 4508.3
## RAFTER OR TRUSS LATERAL CONNECTION FORCE FROM WIND

| RAFTER OR TRUSS SPACING | EXPOSURE B | | | | | |
|---|---|---|---|---|---|---|
| | ULTIMATE DESIGN WIND SPEED $V_{ULT}$ (mph) | | | | | |
| | 130 | | 140 | | 150 | |
| | POUNDS PER CONNECTOR | NUMBER OF FASTENERS | POUNDS PER CONNECTOR | NUMBER OF FASTENERS | POUNDS PER CONNECTOR | NUMBER OF FASTENERS |
| 12" o.c. | 111 | 2 | 129 | 2 | 148 | 2 |
| 16" o.c. | 148 | 2 | 171 | 2 | 197 | 2 |
| 24" o.c. | 222 | 3 | 257 | 3 | 295 | 3 |

## TABLE 4508.3 - continued
## RAFTER OR TRUSS LATERAL CONNECTION FORCE FROM WIND

| RAFTER OR TRUSS SPACING | EXPOSURE C | | | | | |
|---|---|---|---|---|---|---|
| | ULTIMATE DESIGN WIND SPEED $V_{ULT}$ (mph) | | | | | |
| | 130 | | 140 | | 150 | |
| | POUNDS PER CONNECTOR | NUMBER OF FASTENERS | POUNDS PER CONNECTOR | NUMBER OF FASTENERS | POUNDS PER CONNECTOR | NUMBER OF FASTENERS |
| 12" o.c. | 154 | 2 | 179 | 2 | 205 | 3 |
| 16" o.c. | 205 | 3 | 238 | 3 | 273 | 3 |
| 24" o.c. | 308 | 4 | 357 | 4 | 410 | 5 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound = 0.454 kg, 1 pound per square foot = 47.9 N/m$^2$, 1 pound per linear foot = 14.6 N/m.

a. Number of Fasteners = 8d common nails or 10d Box Nail (toenailed)

b. To avoid splitting, no more than 2 toenails shall be installed in each side of a rafter when fastened to a 2x4 top plate or 3 toenails in each side when fastened to a 2x6 top plate

c. Tabular lateral connections covered up to 36 feet roof span.

## TABLE 4508.4
## TOP AND BOTTOM PLATE TO STUD LATERAL CONNECTION FOR WIND LOAD
## REQUIRED NUMBER OF 16d COMMON NAILS (ENDNAIL) PER CONNECTION

| STUD SPACING (INCH) | EXPOSURE B | | | EXPOSURE C | | |
|---|---|---|---|---|---|---|
| | ULTIMATE DESIGN WIND SPEED $V_{ULT}$ (mph) | | | | | |
| | 130 | 140 | 150 | 130 | 140 | 150 |
| 12" o.c. | 2 | 2 | 2 | 2 | 2 | 2 |
| 16" o.c. | 2 | 2 | 2 | 2 | 2 | 2 |
| 24" o.c. | 2 | 2 | 2 | 3 | 3 | 3 |

**R4508.3 Anchorage from roof to wall.** One and one-half inch (38 mm) by 18 gage fabricated metal ties at 24 inches (610 mm) on center with five 8d nails at each end may be used to resist the uplift loads from the roof to the double top plate. Install one tie at each end of each rafter in 130 mph (58 m/s) and two ties at each end of each rafter in 140 mph (63 m/s) and 150 mph (67 m/s) wind zones. Truss anchorage shall be in accordance with design specifications. See Figure R4508.3.

**R4508.4 Anchorage using wood structural panels.** Wood structural panel sheathing may be used to resist both lateral load and uplift simultaneously. Panels shall be installed as follows:

1. Panels may be installed parallel or perpendicular to studs.
2. Panels shall be 3/8-inch (10 mm) minimum thickness.
3. Nail spacing shall be 8d at 6 inches (152 mm) on center along vertical edges of panel and 12 inches (305 mm) at intermediate vertical framing.
4. At double edge panel locations, the horizontal nail spacing shall be 8d staggered at 3 inches (76 mm) on center. See Figure R4508.4(b).
5. Where open web trusses are installed, panel shall extend 12 inches (305 mm) beyond horizontal construction joints and shall overlap girders their full depth. Where the horizontal joint occurs over minimum 1 inch (25 mm) thick OSB or plywood or 2× rimboard a minimum 11/2 inch (38 mm) overlap is required. See Figure R4508.4(a).
6. Panel attachment to framing shall be as illustrated in Figure R4508.4(b).
7. Blocking shall be required at all joints if sheathing is used to resist uplift.

**TABLE 4508.4**

**UPLIFT CAPACITY OF WOOD STRUCTURAL PANEL SHEATHING USED TO RESIST BOTH LATERAL LOAD AND UPLIFT [a,b]**

| | 8d COMMON NAIL 6" PANEL EDGE SPACING 12" FIELD SPACING | | |
|---|---|---|---|
| ALTERNATE NAIL SPACING AT TTOP AND BOTTOM PANEL EDGES | 6" | 4" | 3" |
| UPLIFT CAPACITY (plf) NAILS DOUBLE ROW | <u>216</u> | <u>432</u> | <u>648</u> |

For SI: 1 inch = 25.4 mm.

a. Tabulated values are for Spruce-Pine-Fir framing.

b. <u>Tabulated values are modified by the ASD reduction factor of 2.0.</u>

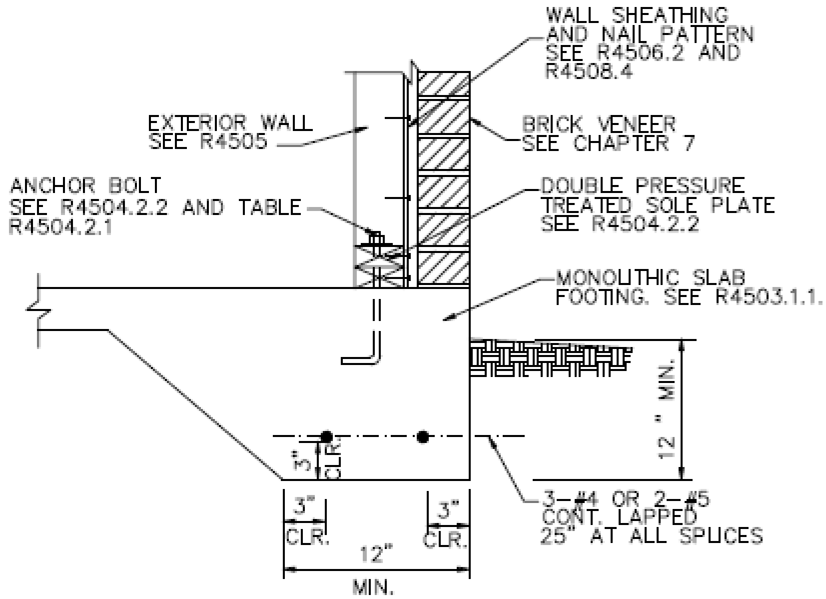



FIGURE R4504.2(d)
EXTERIOR CONCRETE SLAB ON
GRADE FOOTING – DOUBLE SOLE PLATE

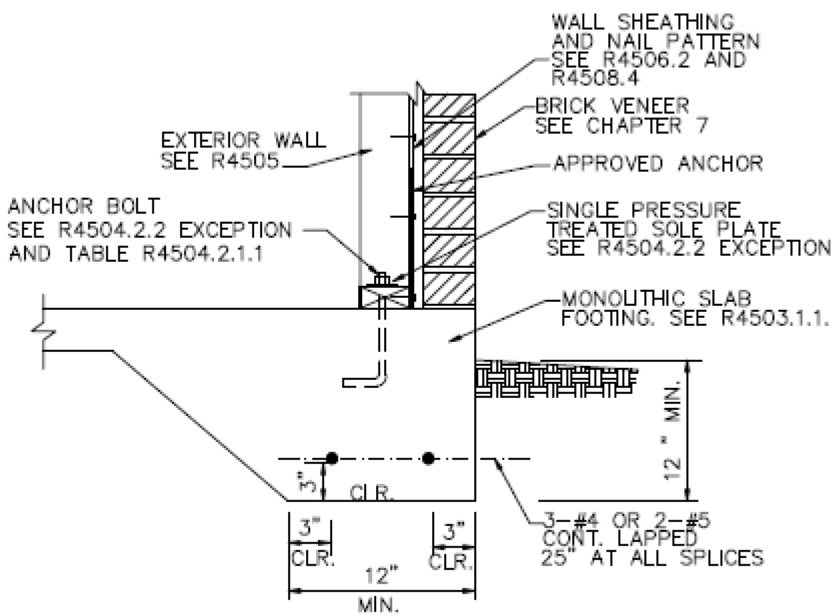



FIGURE R4504.2(e)
EXTERIOR CONCRETE SLAB ON
GRADE FOOTING – SINGLE SOLE PLATE

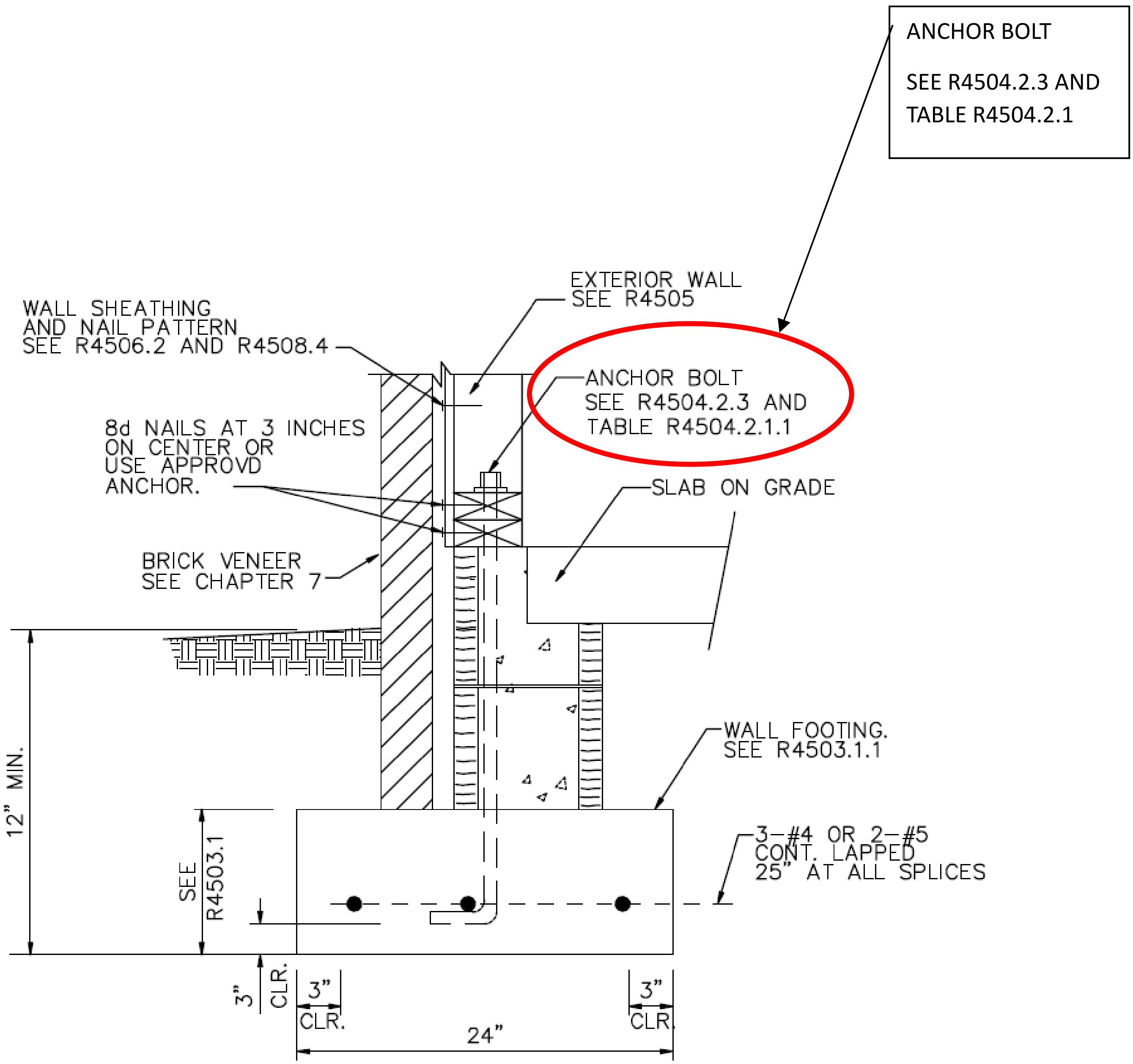
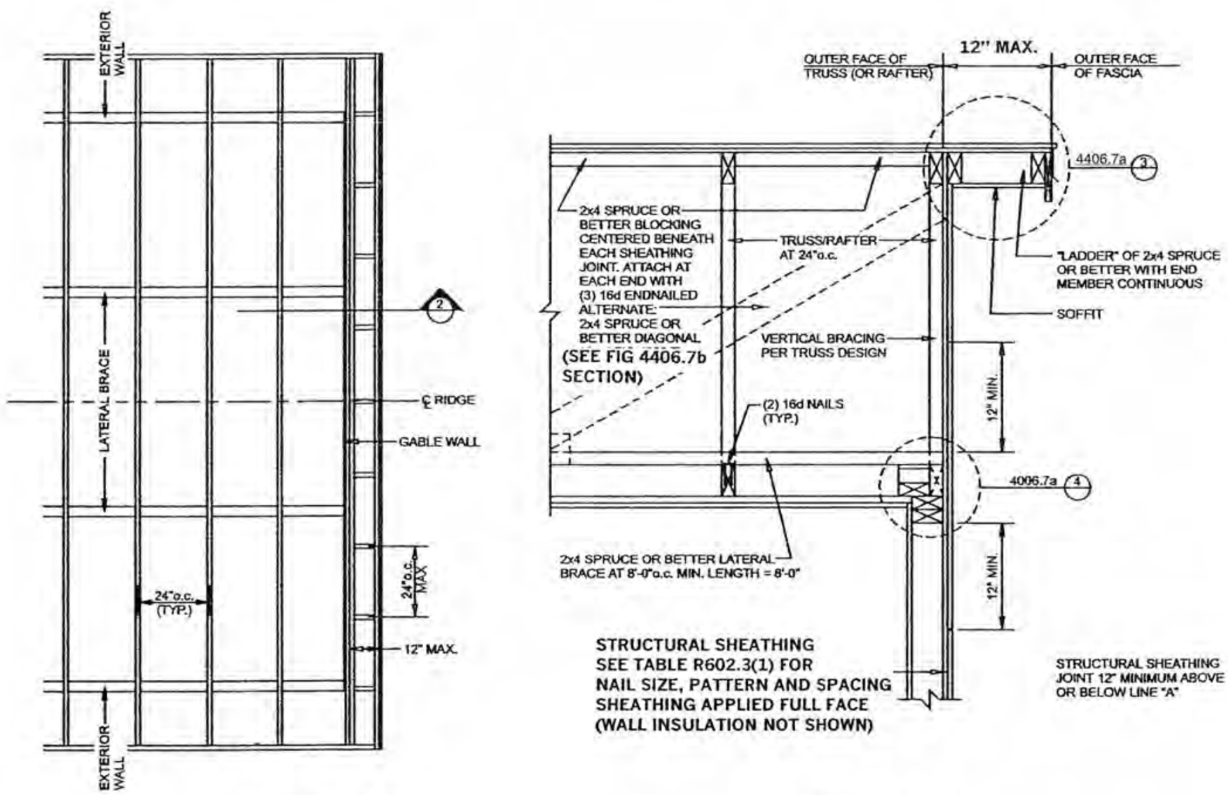
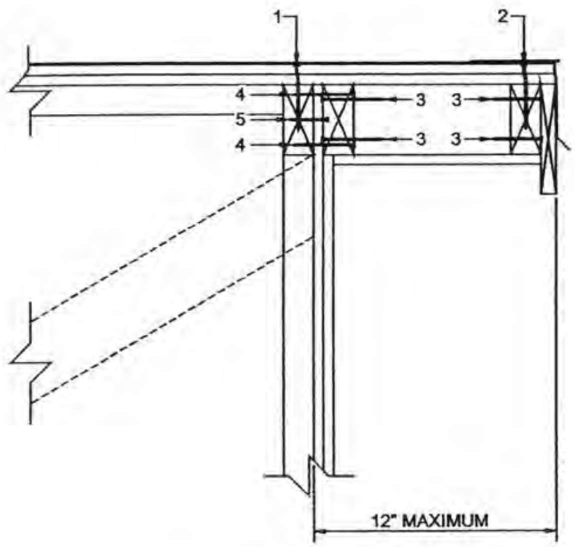



FIGURE R4504.2(f)
GROUND SUPPORTED SLAB WITH
MASONRY STEM WALL

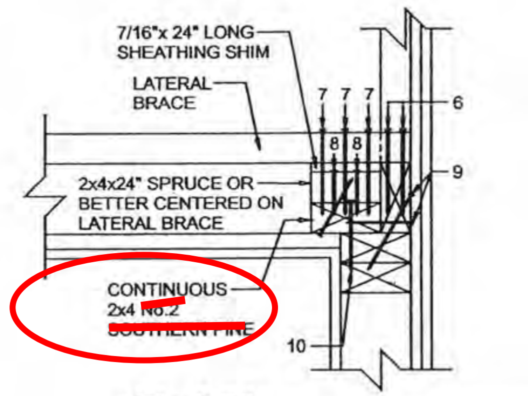



1) ROOF FRAMING PLAN

2) SECTION THRU "LADDER" SOFFIT




3 4406.7a "LADDER" ATTACHMENT
NAILING DETAIL AT TOP OF GABLE




4 4406.7a
NAILING DETAIL AT LATERAL BRACE

| NAIL SCHEDULE | | | |
|---|---|---|---|
| MARK | No. & SIZE | SPACING | REMARKS |
| 1 | 8d | 4"o.c. | |
| 2 | 8d | 6"o.c. | |
| 3 | (2) 16d | | EACH SIDE |
| 4 | (2) 16d | 24"o.c. | |
| 5 | 8d | 6"o.c. | |
| 6 | (2) 16d | | EACH TRUSS |
| 7 | (5) 16d | | TYPICAL |
| 8 | (6) 16d (* TO 2x4 BELOW) | | ALTERNATE: (8) 8d |
| 9 | 16d | 8"o.c. | ALTERNATE TOENAIL & ENDNAIL |
| 10 | 16d | 8"o.c. | |

**FIGURE R4506.7(a)—continued**
**OVERHANG AT ENDWALLS**

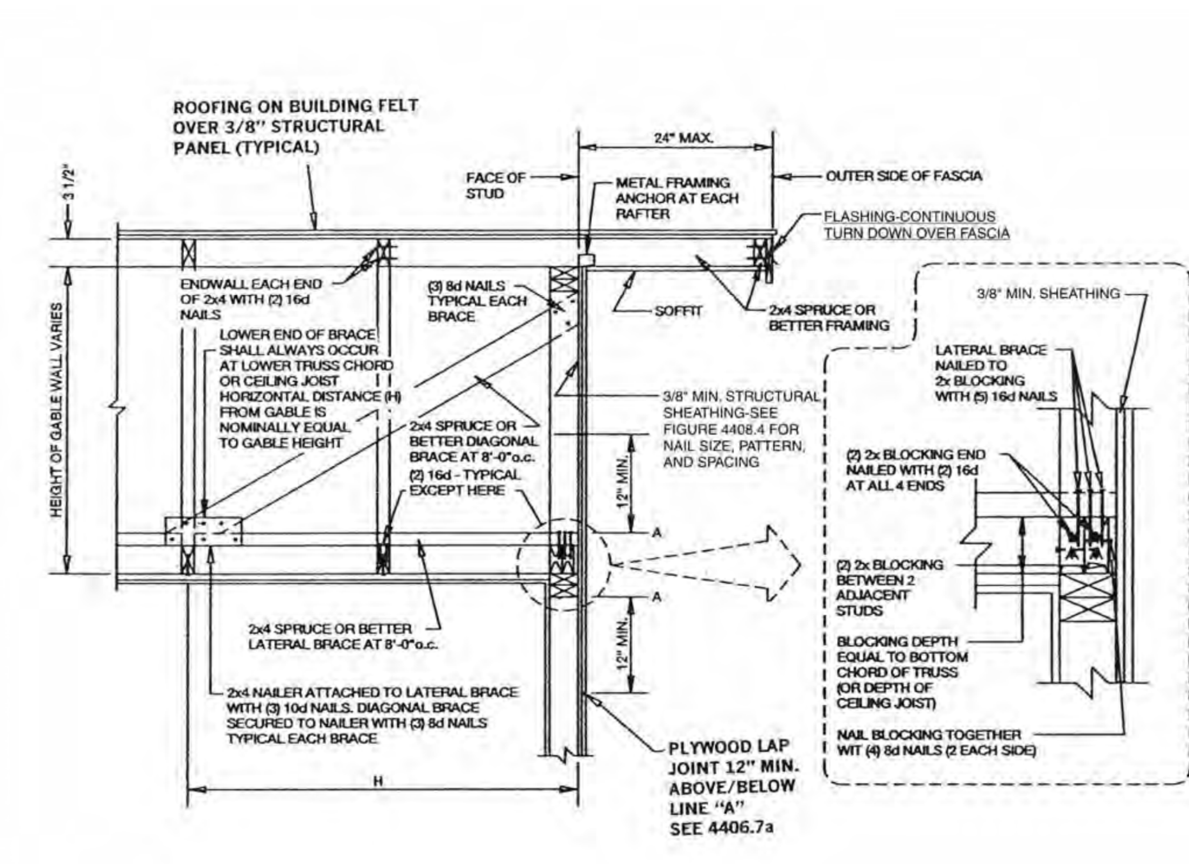



**FIGURE R4506.7(b)**
**GABLE END OVERHANG**

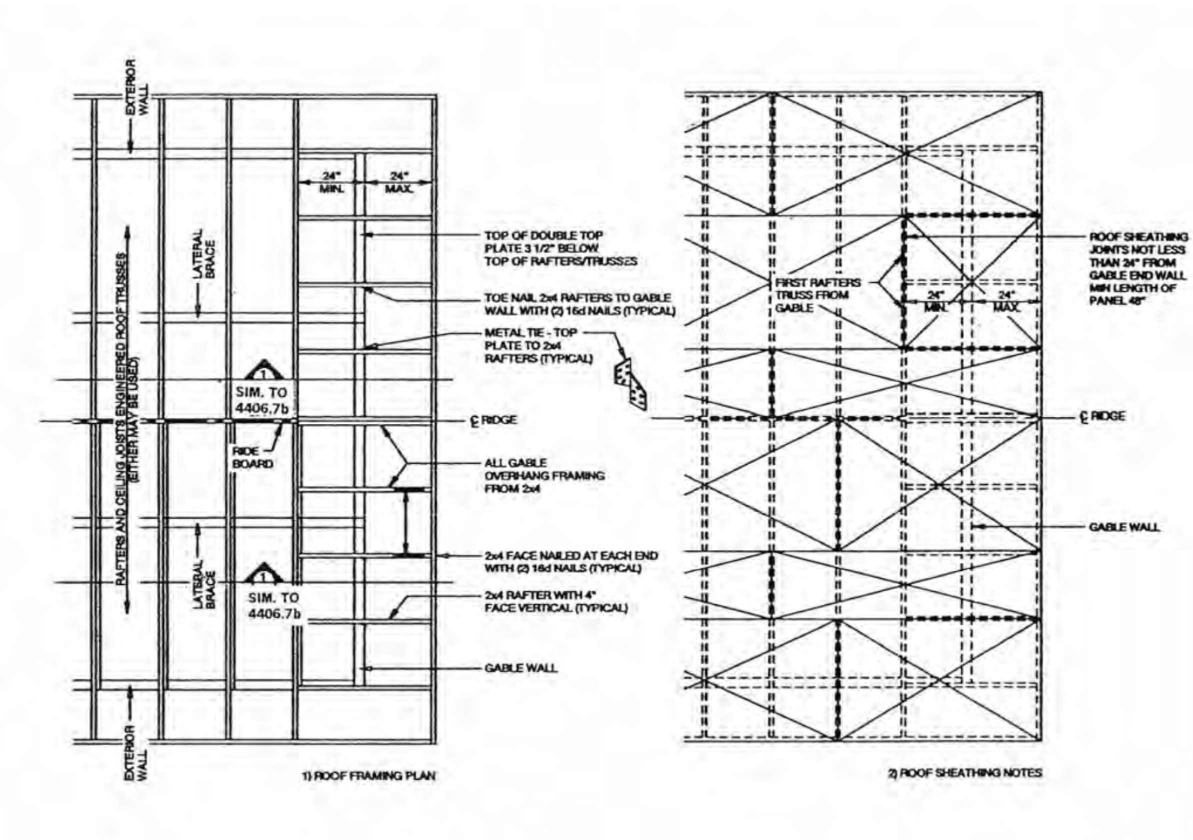



**FIGURE R4506.7(c)**
**GABLE END OVERHANG**

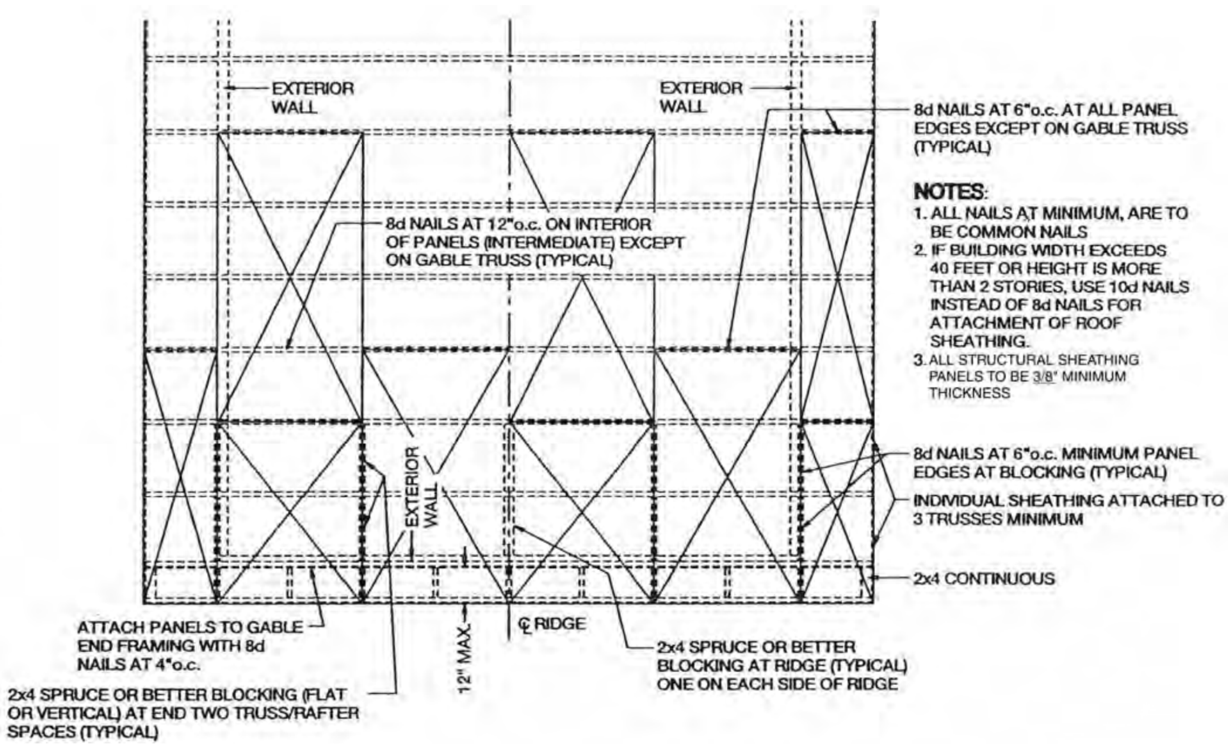



**FIGURE R4506.8**
**ROOF SHEATHING ATTACHMENT PLAN**

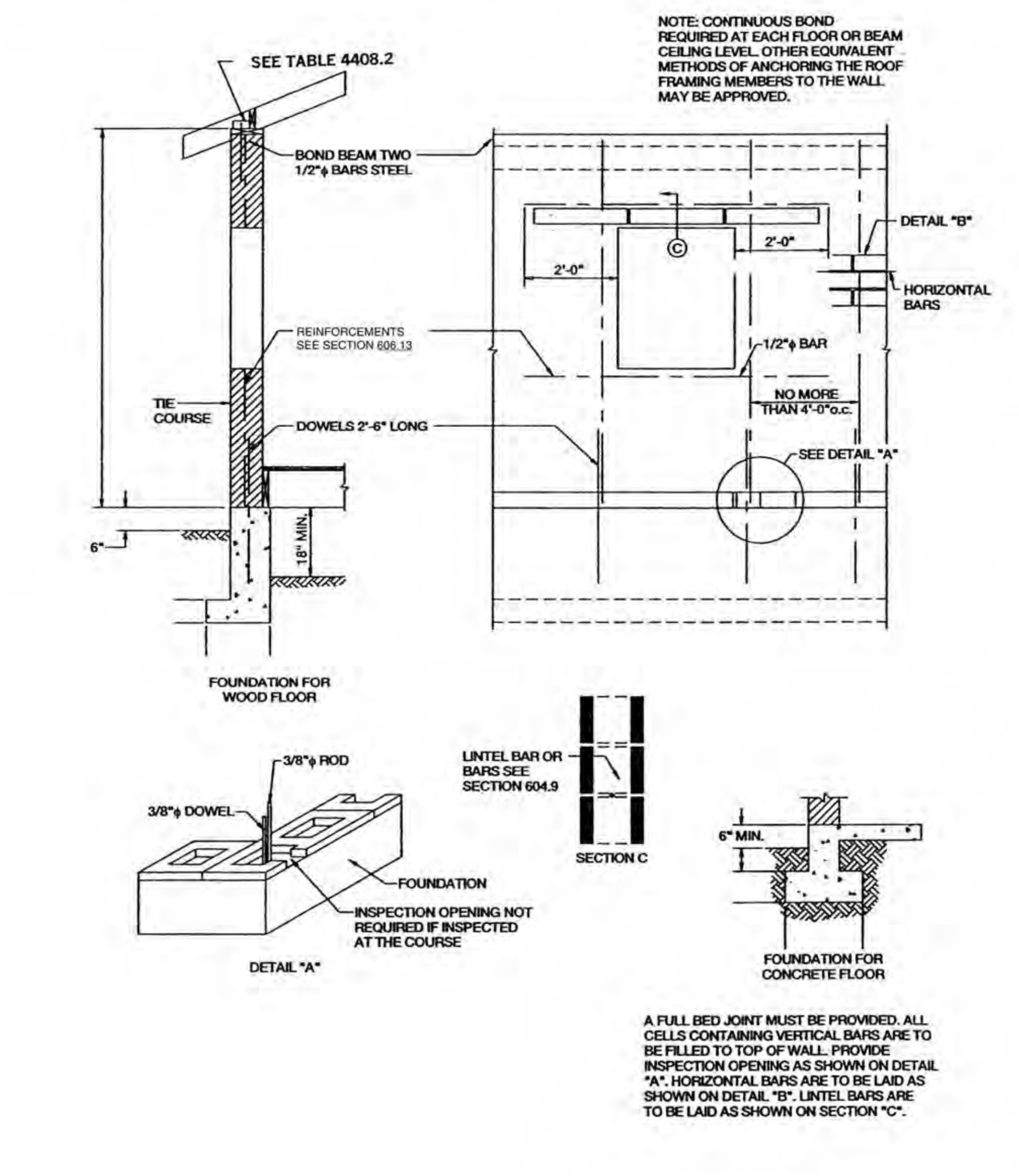



**FIGURE R4507.1(a)**
**REQUIREMENTS FOR REINFORCED GROUTED MASONRY CONSTRUCTION WHERE WIND ZONES ARE 140 MPH OR GREATER**

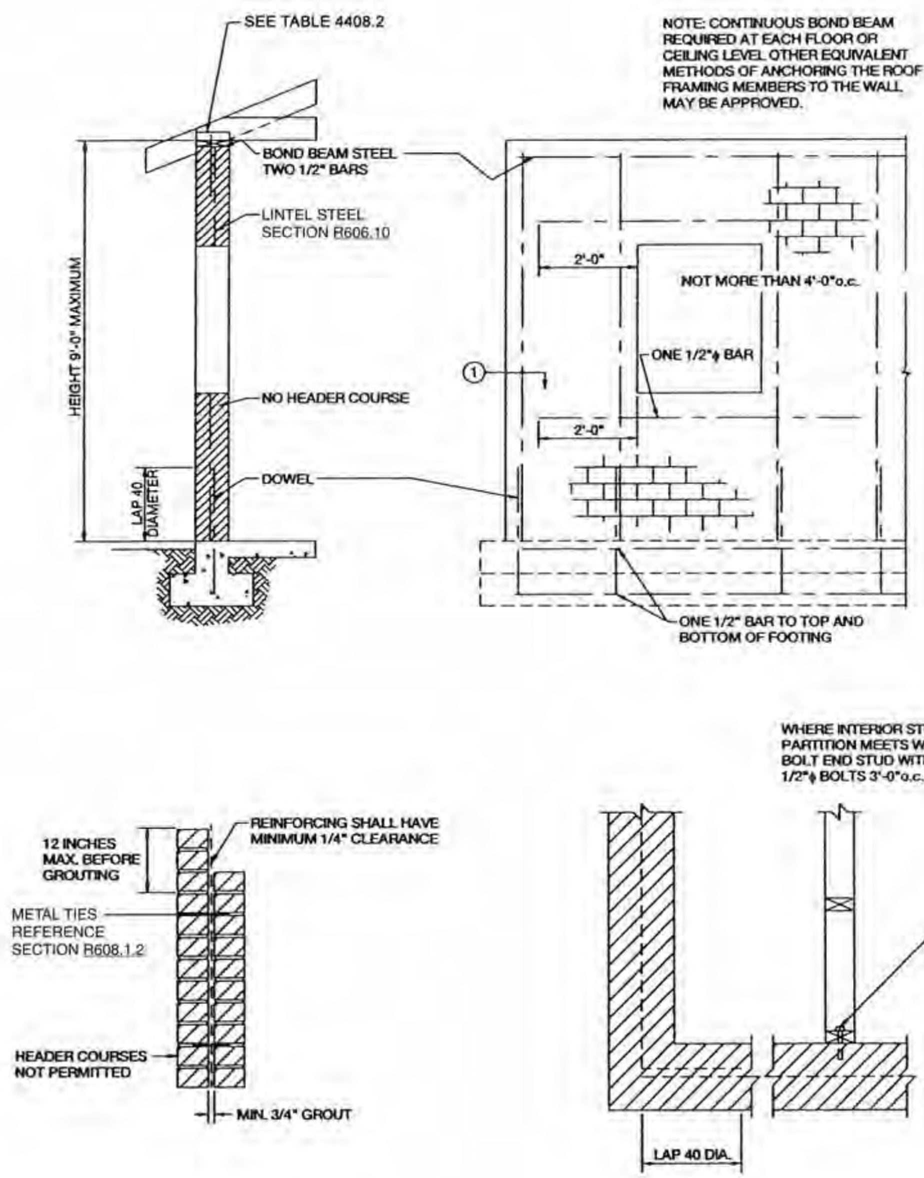



**FIGURE R4507.1(b)**
**REQUIREMENTS FOR REINFORCED HOLLOW-UNIT MASONRY CONSTRUCTIONWHERE WIND ZONES ARE 140 MPH OR GREATER**

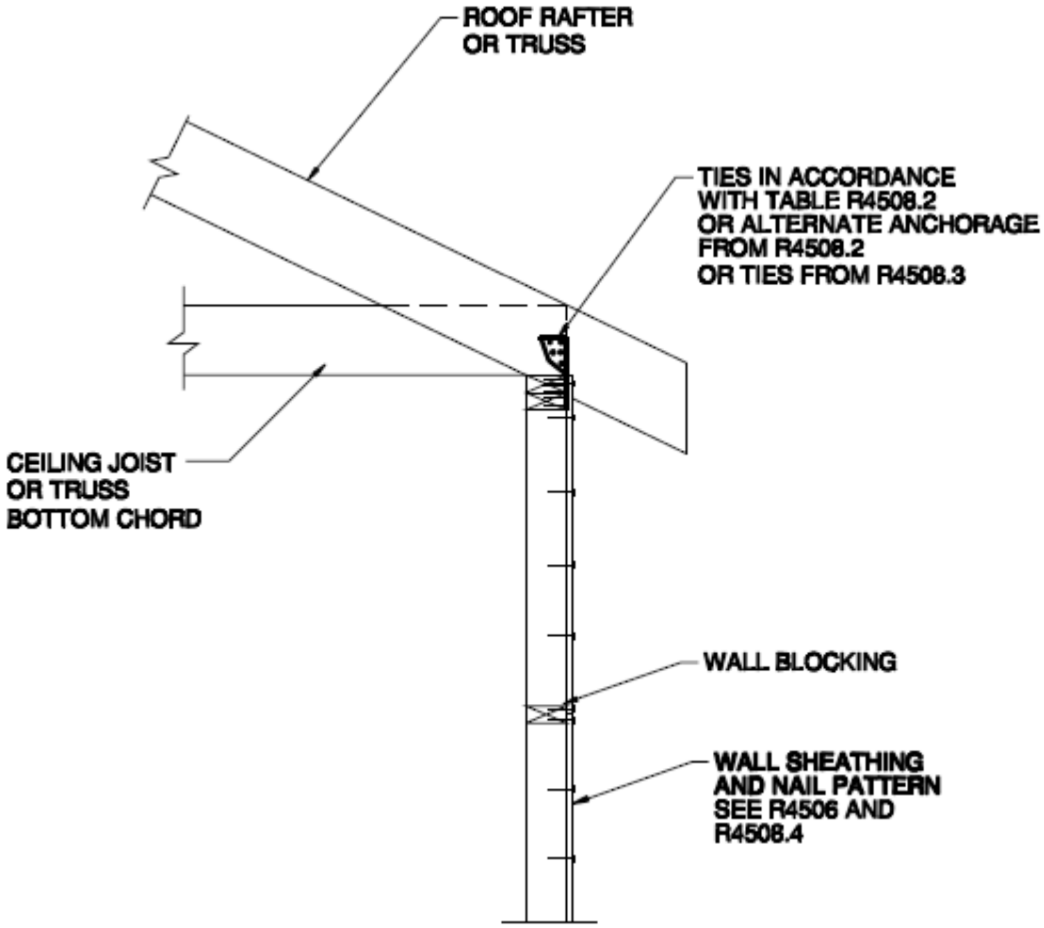



**FIGURE R4508.3**
**ROOF RAFTER/TRUSS ANCHORAGE**

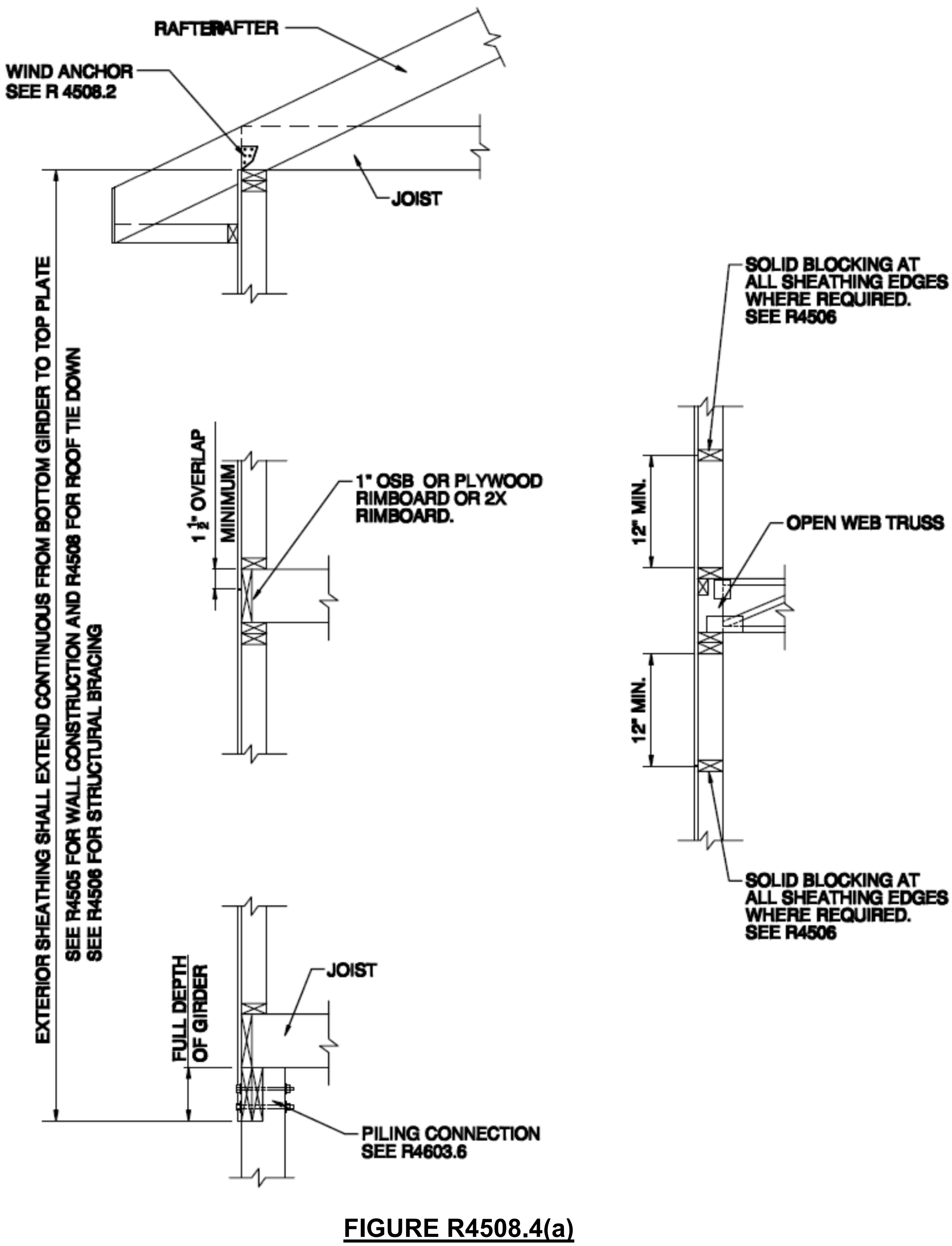



**FIGURE R4508.4(a)**
**TWO STORY WALL SECTION - PANEL ATTACHMENT**

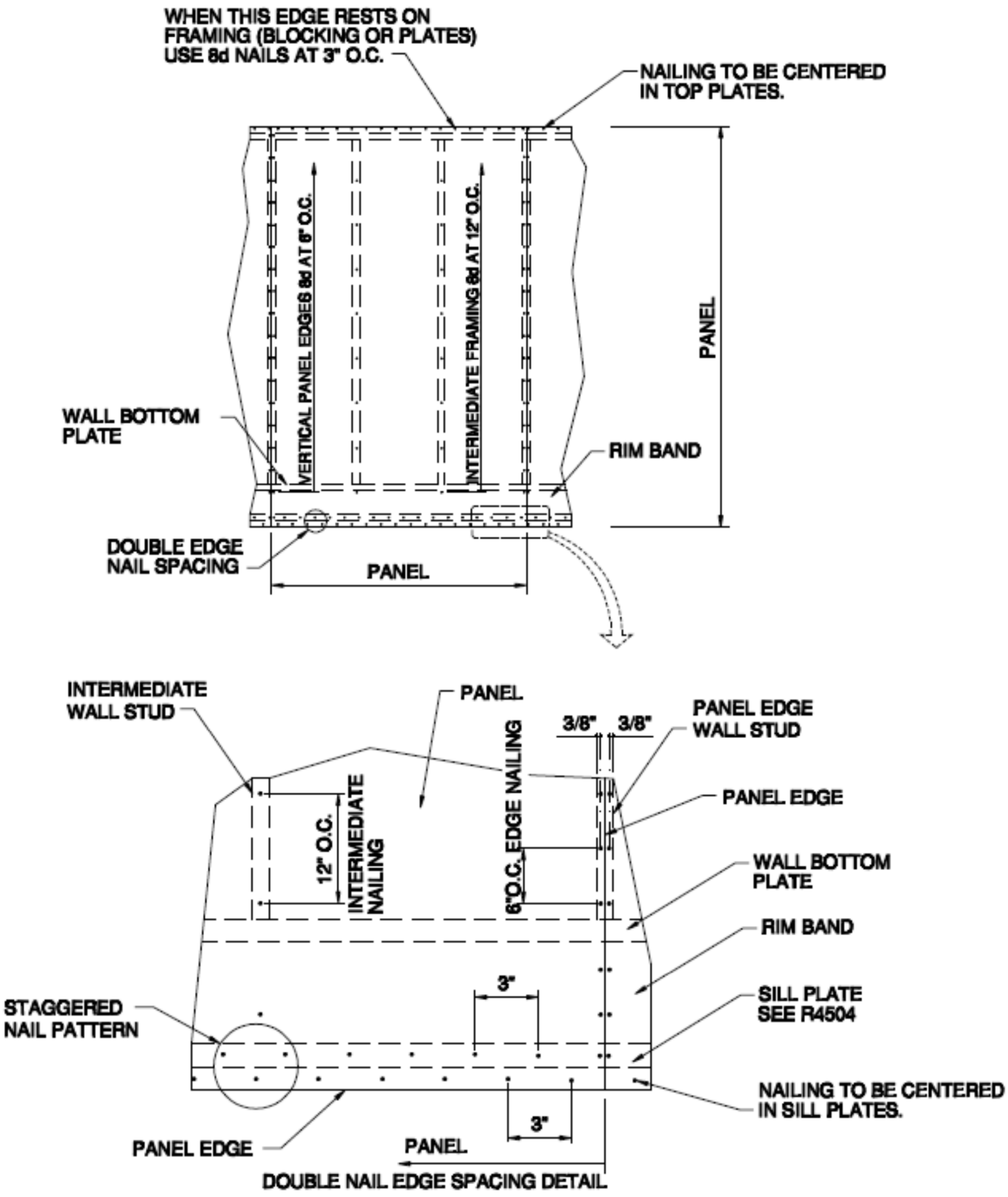



**FIGURE R4508.4(b)**
**PANEL ATTACHMENT TO COUNTER UPLIFT HORIZONTAL OR VERTICAL**

# CHAPTER 46
# COASTAL AND FLOOD PLAIN CONSTRUCTION STANDARDS

***This chapter is a North Carolina addition and not part of the 2021 International Residential Code. There will be no underlined text.***

## SECTION R4601
## PURPOSE, APPLICATION AND SCOPE

**R4601.1. General.**
The requirements set forth in this section shall apply to all construction located within areas identified by governmental agency (state and federal) as coastal high hazard areas, ocean hazard areas, the regulatory flood plain areas, and all areas designated as 150 mph (67 m/s) wind zone. See Table R301.2(1).

## SECTION R4602
## DEFINITIONS

**See Chapter 2 for definitions**

## SECTION R4603
## PILING STANDARDS

**R4603.1. General.**
All one- and two-family dwellings in areas identified as coastal high hazard areas or ocean hazard areas shall be constructed on a pile foundation of wood or concrete.

**R4603.2 Concrete piles.**
Concrete piles are permitted to be used if made and installed in accordance with the *North Carolina Building Code*, Chapter 18.

**R4603.3 Size of wood piles.**
Round timber piles shall not be less than 8 inches (203 mm) in diameter at building level and have a minimum tip diameter of 6 inches (152 mm). Square timber piles shall not be less than 8 inches square (0.005 m2), nominal. Piles supporting uncovered stairs, uncovered walkways and uncovered decks shall be 6 inches × 6 inches (153 mm × 153 mm) minimum, or if round, have a minimum tip diameter of 6 inches (153 mm). Piles supporting uncovered stairs, uncovered walkways and uncovered decks less than 5 feet (1524 mm) above grade are permitted to be 4 inches × 4 inches (102 mm × 102 mm) minimum.

**R4603.4 Required depth of piles.**
Pile tip shall extend to a depth of not less than 8 feet (2438 mm) below the natural grade or finished grade of the lot, whichever is lower. All pilings within the Ocean Hazard Area shall have a tip penetration of at least 5 feet (1524 mm) below mean sea level or 16 feet (4877 mm) below average original grade, whichever is least. Structures within Ocean Hazard Areas which are

placed upon the site behind a line 60 times the annual erosion rate away from the most seaward line of stable natural vegetation are exempt from this additional tip penetration requirement.

**R4603.5 Spacing of wood piles.**
The maximum center-to-center spacing of wood piles shall not be more than 8 feet (2438 mm) on center under load-bearing sills, beams, or girders. For dwellings having more than two stories above piles or where the piling spacing exceeds 8 feet (2438 mm) on center, the pile foundation shall be designed by a *registered design professional.* Pile spacing in the non-load bearing direction are permitted to be 12 feet (305 mm).

**R4603.6 Tying and bracing of wood piles.**
Beams and girders shall fully bear on pilings and butt joints shall occur over pilings. ~~If~~ Sills, beams or girders ~~are~~ shall be attached to the piling, ~~a minimum of two 5/8-inch (16 mm) galvanized steel bolts per beam member shall be through bolted at each piling connection in accordance with Figure R4503.6(a).~~ using either bolts or screws at each piling connection in accordance with Table 4603.6 and Figure R4603.6 (a). When the piling is notched so that the cross-section is reduced below 50 percent or the girder is top bearing, sills, beams or girders shall be attached using 3/16 × 4 × 18-inch (5 × 102 × 467 mm) hot dip galvanized straps, one each side, ~~bolted with two 5/8 inch (15.9 mm) galvanized through bolts in accordance with Figure R4603.6(b) and Figure R4603.6(c)~~fastened top and bottom with either bolts or screws in accordance with Table R4603.6 and Figure R4603.6(b) and Figure R4603.6(c). Where butt joints occur over the piling and screws are used, there shall be two straps on each side of the piling, having a minimum size of 3/16 × 2 × 18 inches (5 × 51 × 467 mm), with four self-drilling screws as described below in each end. ~~At corners, girders shall be connected to the pile with a minimum 3/16 × 4 × 18-inch (5 × 102 × 467 mm) hot dip galvanized strap bolted with two 5/8 inch (15.9 mm) galvanized through bolts on the exterior and a minimum L4 × 3/16 × 18 inches (102 × 5 × 467 mm) galvanized steel angle bolted with two 5/8 inch (15.9 mm) galvanized through bolts on the interior in accordance with Figure R4603.6(d).~~

~~Bracing of pile foundations is required where the clear height from ground to sill, beam or girder exceeds 10 feet (3048 mm) or the dwelling is more than one story above piles. A line of X-bracing is defined as a row of piles with X-bracing provided in at least two bays. A line of X-bracing shall be provided at all exterior pile lines. Where the perimeter lines of X-bracing exceed 40 feet (12 192 mm), an additional line of X-bracing shall be provided near the center of the building. See Figure R4603.6(e). X-bracing shall be with 2 × 10s through bolted with two 3/4-inch (19.1 mm) bolts at each end. The *code official* is permitted to accept alternate bracing designs if they bear the seal of a *registered design professional*~~

**R4603.6.1 Tying at corners.**
At corners, girders shall be connected to the pile with a minimum 3/16 × 4 × 18-inch (5 × 102 × 467 mm) hot dip galvanized strap bolted with two 5/8 inch (15.9 mm) galvanized through bolts on the exterior and a minimum L4 x 4 x 3/16 x 1'-6" (102 × 5 × 467 mm) galvanized steel angle bolted with two 5/8 inch (15.9 mm) galvanized through bolts on the interior in accordance with Figure R4603.6(d), or with a minimum of (2) 3/16" x 4" x 18" (5x102x467 mm) hot dip galvanized straps installed on the outside of the girders with fasteners per Table R4603.6.1 and in accordance with Figure R4603.6 (e).

**Table R4603.6**
**Minimum Fastening of Corner Beams and Girder to Pilings**

| Amount Piling is Notched | Beam/Girder Continuous | | Beam/Girder Butt joint | |
|---|---|---|---|---|
| | Bolts | Screws | Bolts | Screws |
| ≤ 50% | two 5/8” bolts[2] | four screws[3] | four 5/8” bolts[2] | eight screws[3] |
| > 50%[1] | two 5/8” bolts[2] | four screws[3] | four 5/8” bolts[2] | eight screws[3] |

1. Where piling is notched over 50%, use strap as required in Section 4603.6. Install the specified number of bolts or screws in each end of the strap.
2. Bolts shall be 5/8” diameter hot dipped galvanized through bolts with nuts and washers.
3. Screws shall be 0.270” (6.9 mm) minimum in diameter, hot dipped galvanized to a minimum of A153, Class C, and having a minimum length of 4”, and also shall be long enough to penetrate at least one inch through the remaining pile and into the girder.

**Table R4603.6.1**
**Minimum Fastening of Corner Beams and Girder to Pilings**

| Amount Piling is Notched | Associated Figure | Hardware | Fasteners |
|---|---|---|---|
| > 50%[1] | R4603.6(d) | one 3/16” x 4” x 18” | six 5/8" bolts[2] |
| | | one L 4 x 4 x 3/16 x 18” | |
| | R4603.6(e) | two 3/16” x 4” x 18” | eight 0.27"x4" each strap[3] |

1. Where piling is notched over 50%, use strap as required in Section 4603.6. Install the specified number of bolts or screws in each end of the strap.
2. Bolts shall be 5/8” diameter hot dipped galvanized through bolts with nuts and washers.
3. Screws shall be 0.270” (6.9 mm) minimum in diameter, hot dipped galvanized to a minimum of A153, Class C, and have a minimum length of 4” or shall be long enough to penetrate through the girder and a minimum of one inch into the remaining pile, whichever is greater.

**R4603.6.2 Bracing of Pilings**.
Bracing of pile foundations is required where the clear height from ground to sill, beam or girder exceeds 10 feet (3048 mm) or the dwelling is more than one story above piles. A line of X-bracing is defined as a row of piles with X-bracing provided in at least two bays. A line of X-bracing shall be provided at all exterior pile lines. Where the perimeter lines of X-bracing exceed 40 feet (12 192 mm), an additional line of X-bracing shall be provided near the center of the building. See Figure R4603.6(f). X-bracing shall be with 2 × 10s through bolted with two 3/4-inch (19.1 mm) bolts at each end. The code official is permitted to accept alternate bracing designs if they bear the seal of a registered design professional.

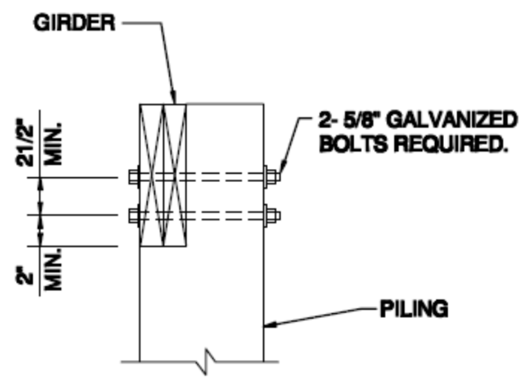



**FIGURE R4603.6(a)**
**PILING NOTCHED LESS THAN 50%**

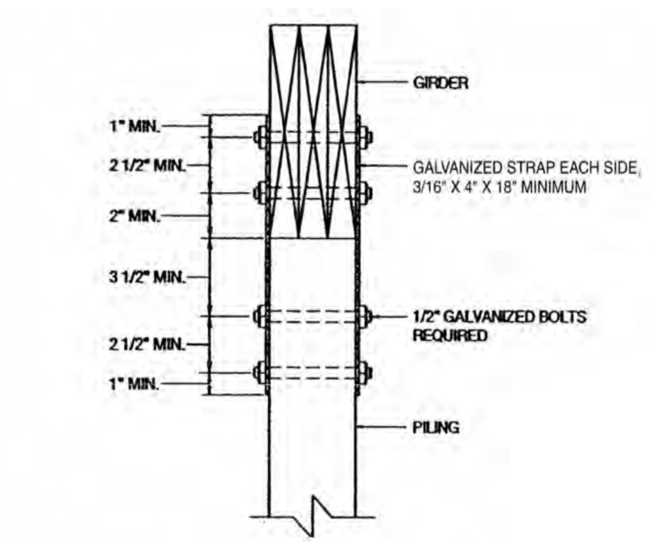



**FIGURE R4603.6(b)**
**TOP MOUNTED GIRDER**

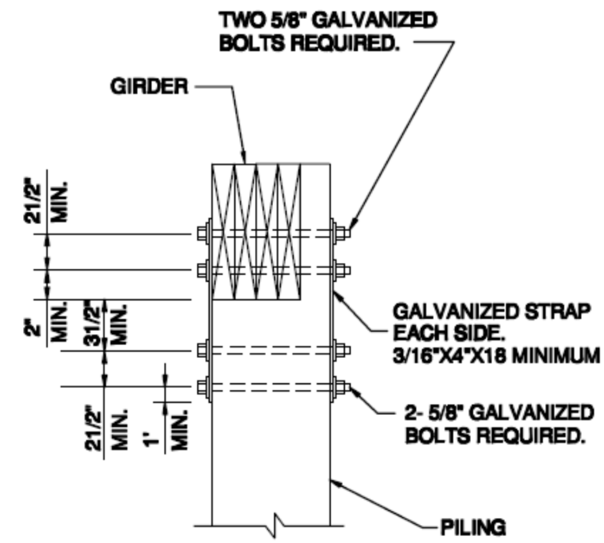



**FIGURE R4603.6(c)**
**PILING NOTCHED MORE THAN 50%**

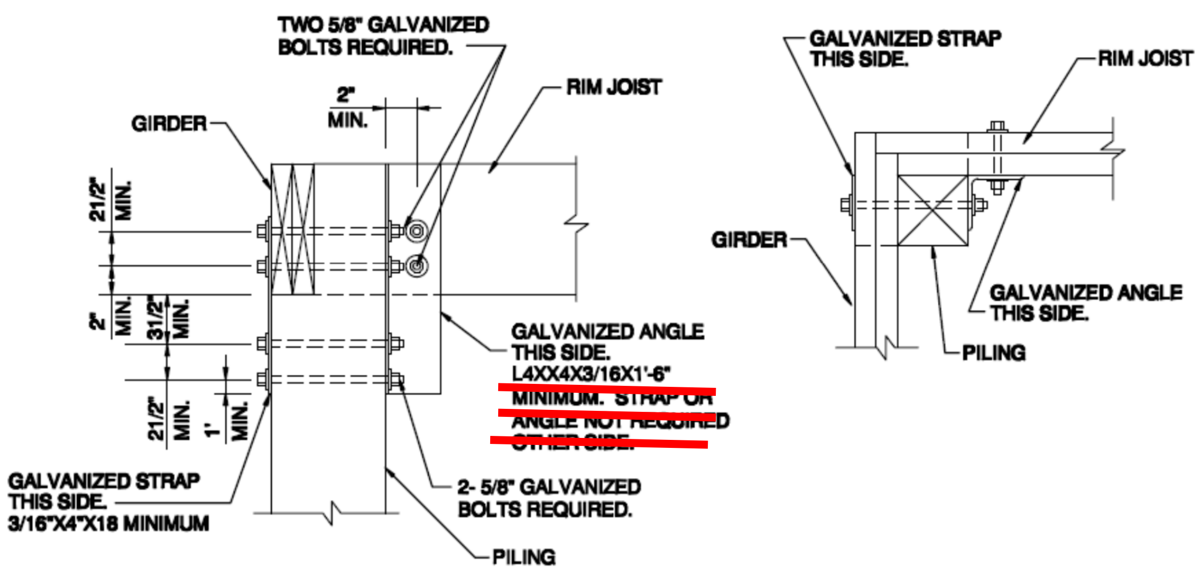



**FIGURE R4603.6(d)**
**CORNER PILE CONNECTION**

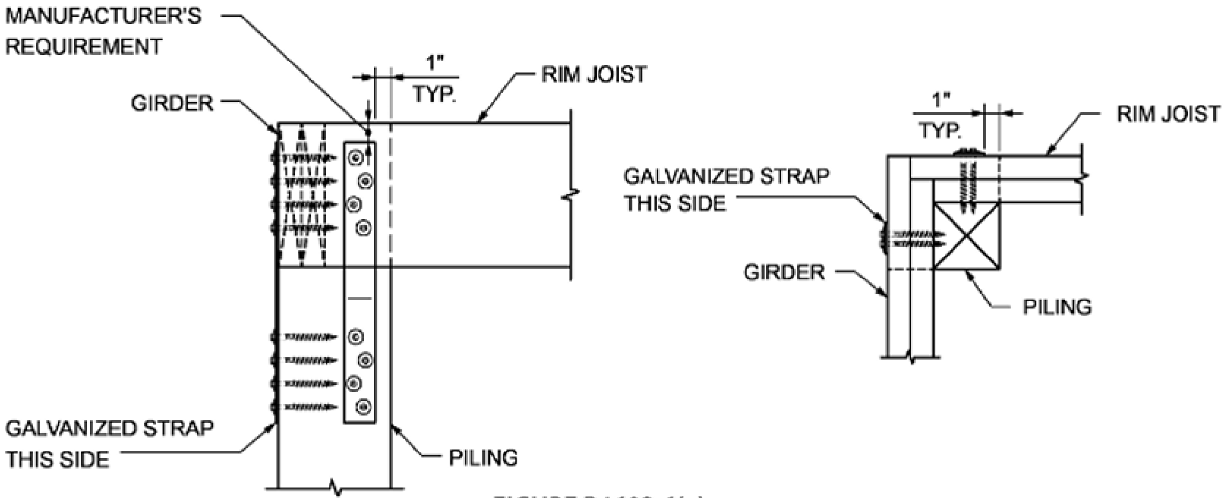



FIGURE R4603.6(e)
CORNER PILE CONNECTION

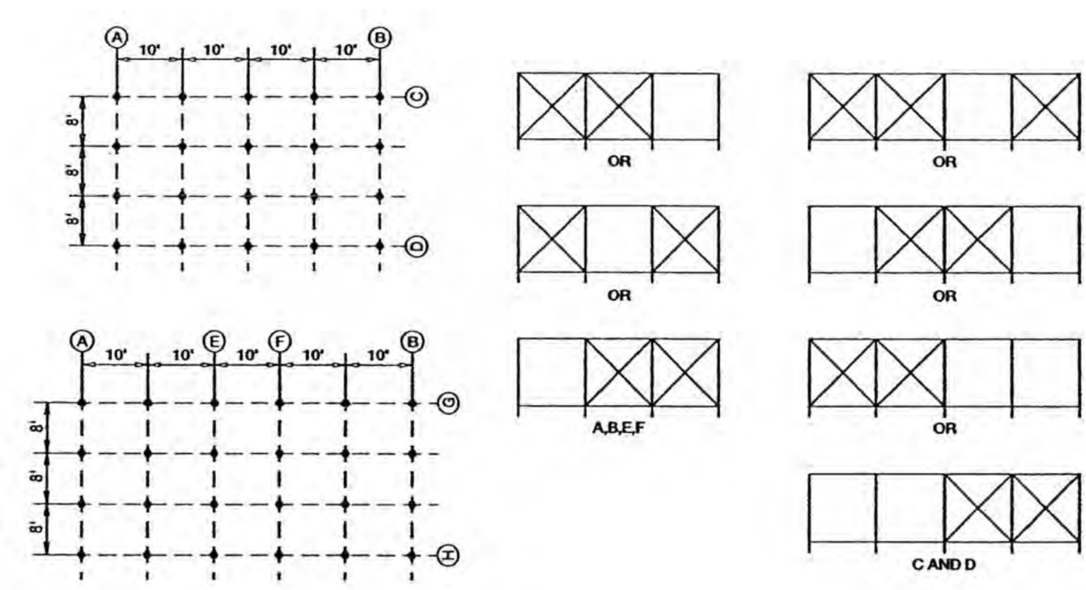



**FIGURE R4603.6**(f)

**ELEVATIONS**
**(SHOWING POSSIBLE ARRANGEMENT OF X-BRACING IN LINE) (G AND H SIMILAR)**

## SECTION R4604
## ELEVATION STANDARDS

**R4604.1. Lowest structural member.**
The lowest structural member, excluding pilings and bracing supporting the lowest habitable floor in the coastal high hazard area and ocean hazard area, shall be elevated above the base flood elevation.

**R4604.2. First habitable floor.**
The elevation of the first habitable floor of all structures in the regulatory flood plain except in the coastal high hazard areas shall be above the base flood elevation.

> **Exception:** This requirement does not apply to the addition, renovation or reconstruction to any building which was constructed prior to the initial Flood Insurance Study for that area if the addition, renovation or reconstruction does not exceed 50 percent of the present market value of the structure.

**R4604.3. Walls below flood elevation.**
Where walls are constructed below flood elevation in coastal high hazard area and ocean hazard area, they shall be constructed in a manner to eliminate wave forces on the piling.

## SECTION R4605
## CONSTRUCTION MATERIALS
## AND METHODS STANDARDS

**R4605.1. General.**
The requirements of Sections R4605.2 through R4605.8 are applicable in the coastal high-hazard area, the ocean hazard area, and all areas defined as 150 mph (~~57~~ m/s) wind zone.

**R4605.2. Roof anchorage.**
Every rafter or roof truss shall be anchored to the bearing wall as required by Section R4508. At the ridges, rafters shall have a minimum 1 × 6 or 2 × 4 collar or wind beam. Every third rafter not to exceed 4 feet (1219 mm) on center shall be anchored vertically with minimum 1 × 6 or 2 × 4 from its midpoint to ceiling joists below.

**R4605.3 Wood frame wall construction.**
Maximum stud spacing shall be 16 inches o.c. (406 mm) for 2 × 4s and 24 inches (610 mm) for 2 × 6s. See Section R4505 for wall construction requirements. See Section R4508 for uplift anchorage requirements.

**R4605.4. Design by registered design professional.**
Equal or better methods of tying structures together and to foundations designed for a specific building by a *registered design professional* shall be accepted by the *code official*.

~~**R4605.5 Fastener corrosion resistance**. In the coastal hazard area and the ocean hazard area, all metal connectors and~~

~~fasteners outside of conditioned spaces shall be hot-dip galvanized steel after fabrication and meet ASTM A153.~~
~~Exposed metal connectors, such as tie-down straps on porches, decks, and areas under the structure, shall be a minimum 3/16-inch (5 mm) thick, and shall be hot-dip galvanized after fabrication and meet ASTM A123 or ASTM A153.~~
~~Stainless steel light-gage metal connectors shall be permitted in exposed or partially exposed locations. Metal connectors of approved equivalent corrosion-resistant material are permitted to be accepted. See Table R4605.5.~~

**~~R4605.6~~ R4605.5 Building anchorage.**

1. For masonry buildings, the roof structure, including rafters and joists, shall be anchored to the wall in accordance with Section R606.11. All mortar used for masonry walls shall be Type M or S.

2. For masonry or wood frame buildings, all sills, beams or girders which resist uplift (including interior sills, beams, girders, and joists where the perimeter is unenclosed) shall be anchored to the footing in accordance with Section R4504. Footing dowel bars shall have an 8-inch (203 mm) hook.

3. Where wood partitions and masonry walls join, the stud abutting the masonry shall be double and bolted to the masonry with three 1/2-inch (13 mm) galvanized bolts.

4. Steel and wooden columns and posts, including porch columns, shall be anchored with metal ties and bolts to their foundations and to the members that they support.

**~~R4605.7~~ R4605.6 Insulation.**
Insulation installed in floors in exposed areas under buildings elevated on pilings shall be held in place with plywood with exterior glue or other material approved by the *code official*.

**~~R4605.8~~ R4605.7 Accessory structures.**
Detached accessory structures and out buildings shall be bolted to their foundation or otherwise constructed so as to prevent overturning.

## SECTION R4606
## FASTENER CORROSION RESISTANCE

**R4606.1 Fastener corrosion resistance.**
In the Coastal High Hazard Area, the Corrosion Resistance Area and the Ocean Hazard Area, all metal connectors and fasteners outside of conditioned spaces shall be hot-dip galvanized steel after fabrication and meet ASTM A 153. Exposed metal connectors, such as tie-down straps on porches, decks, and areas under the structure, shall be a minimum 3/16-inch (5 mm) thick, and shall be hot-dip galvanized after fabrication and meet ASTM A 123 or ASTM A 153.

Stainless steel light-gage metal connectors shall be permitted in exposed or partially exposed locations. Metal connectors of approved equivalent corrosion resistant material are permitted to be accepted. See Table R4606.1.

**TABLE R4606.1[a]**
**CORROSION RESISTANCE**

| | OPEN (exterior, porches, under house) | EXPOSURE LEVEL VENTED/ENCLOSED (attic, floor trusses, enclosed crawl spaces and stud cavity) | CONDITIONED (heated/cooled living areas) |
|---|---|---|---|
| Nails, staples, screws | Hot-dip galvanized | Hot-dip galvanized | - |
| Nuts, bolts, washers, tie rods | Hot-dip galvanized | Hot-dip galvanized | - |
| Steel angles, connection plates & straps (3/16″ minimum thickness) | Hot-dip galvanized after fabrication | Hot-dip galvanized | - |
| Sheet metal connectors, wind anchors, joists hangers, steel joists and beams | Stainless steel or hot-dipped galvanized after fabrication | Hot-dip galvanized after plate fabrication or triple galvanized[b] | Hot-dip galvanized or triple galvanized[b] |
| Truss plates | Stainless steel or hot-dipped galvanized after fabrication | Hot-dip galvanized after fabrication, stainless steel, triple galvanized[b] or in accordance with TPI-1 of the Truss Plate Institute within 6′-0″ of a gable louver, ridge or soffit vent. Otherwise, standard galvanized[b]. | Standard galvanized |

a. Applies only to structures located in Coastal High-Hazard Area, Corrosion Resistance Area and Ocean Hazard Area.
b. Triple galvanizing – G185, standard galvanizing – G60, both per ASTM A 653 / A 653M.

# CHAPTER 47
# WOOD DECKS
# (note to RRC: reformat from the previous 2018 NCRC Appendix M)

## SECTION 4701
## GENERAL

**4701.1 Decks.** Wood-framed decks shall be in accordance with this section. Decks shall be designed for the live load required in Section R301.

**4701.2 Deck design.** Computer deck design programs are permitted to be accepted by the *building official*.

## SECTION 4702
## MATERIALS

**4702.1 Wood materials.** Wood materials shall be No. 2 grade or better *pressure- preservative treated wood*, or *approved*, *naturally durable lumber*. Wood structural members shall be designed using the wet service factor defined in AWC NDS. All *pressure-preservative treated wood* products in contact with the ground shall be *labeled* for such usage.

**4702.2 Plastic composites.** *Plastic composite* exterior deck boards, stair treads, *guards* and *handrails* containing wood, cellulosic or other biodegradable materials shall comply with the requirements of ASTM D7032.

**4702.3 Flashing.** Flashing shall be corrosion-resistant metal of nominal thickness not less than 0.019 inch (0.48 mm) or *approved* nonmetallic material that is compatible with the substrate of the structure and the decking materials.

## SECTION 4703
## FASTENERS AND CONNECTORS

**4703.1 Fasteners and connectors in contact with pressure-preservative treated wood.** Fasteners, including nuts and washers, and connectors in contact with *pressure-preservative treated wood* shall be in accordance with this section. The coating weights for zinc-coated fasteners shall be in accordance with ASTM A153. Stainless steel driven fasteners shall be in accordance with the material requirements of ASTM F1667.

**4703.2 Fasteners for pressure-preservative treated wood.** Fasteners, including nuts and washers, for *pressure-preservative treated wood* shall be of hot-dipped, zinc-coated galvanized steel, stainless steel, silicon bronze or copper. Staples shall be of stainless steel. Coating types and weights for connectors in contact with preservative-treated wood shall be in accordance with the connector manufacturer's recommendations. In the absence of manufacturer's recommendations, not less than ASTM A653 type G185 zinc-coated galvanized steel, or equivalent, shall be used.

**Exceptions:**

1. $^{1}/_{2}$-inch-diameter (12.7 mm) or greater steel bolts.
2. Fasteners other than nails, staples and timber rivets shall be permitted to be of mechanically deposited zinc-coated steel with coating weights in accordance with ASTM B695, Class 55 minimum.

3. Plain carbon steel fasteners in SBX/DOT and zinc borate preservative-treated wood in an interior, dry environment shall be permitted.

**4703.3 Fastenings for wood foundations.** Fastenings, including nuts and washers, for wood foundations shall be as specified in this code and Table 4703.3.

**TABLE 4703.3**
**FASTENER AND CONNECTOR SPECIFICATIONS [a, b]**

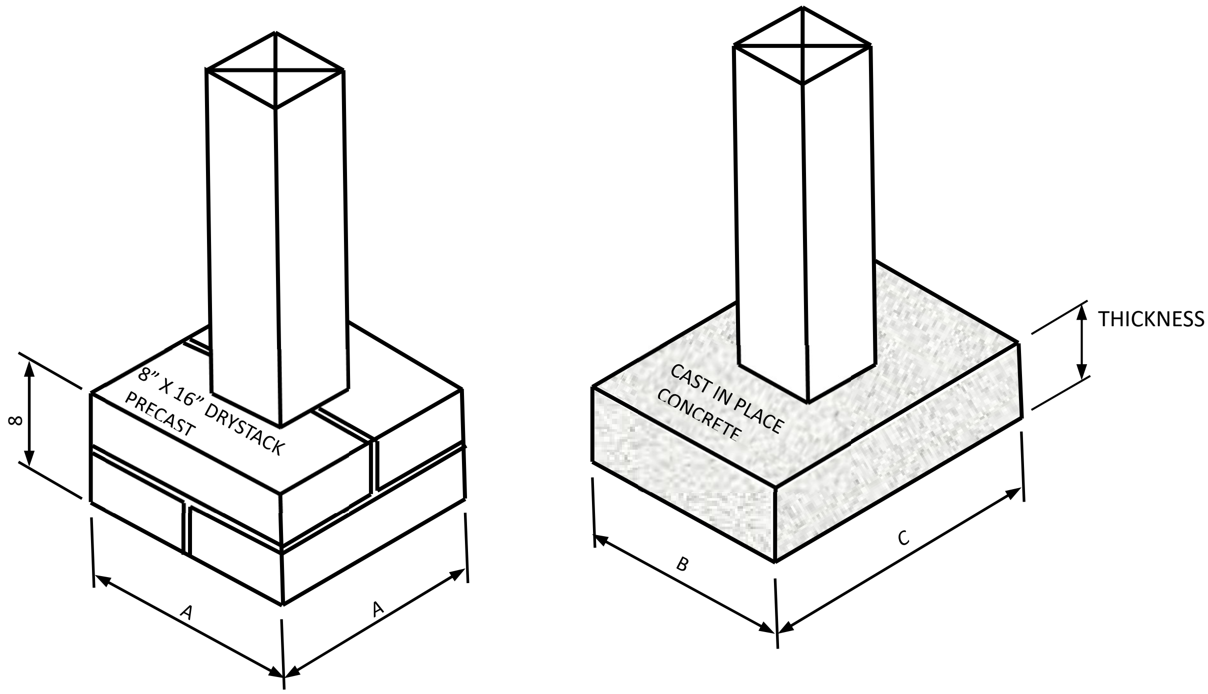
| ITEM | MATERIAL | MINIMUM FINISH/COATING | ALTERNATE FINISH/COATING[e] |
|---|---|---|---|
| Nails and **glulam** rivets | In accordance with ASTM F1667 | Hot-dipped galvanized per ASTM A153**, Class D for $^{3}/_{8}$-inch diameter and less** | Stainless steel, silicon bronze or copper |
| Bolts[c]<br>Lag screws[d] (including nuts and washers) | In accordance with ASTM A307 (bolts), ASTM A563 (nuts), ASTM F844 (washers) | Hot-dipped galvanized per ASTM A153, Class C (Class D for $^{3}/_{8}$-inch diameter and less) or mechanically galvanized per ASTM B695, Class 55 or 410 stainless steel | Stainless steel, silicon bronze or copper |
| Metal connectors | Per manufacturer's specification | ASTM A653 type G185 zinc-coated galvanized steel or post hot-dipped galvanized per ASTM A123 providing a minimum average coating weight of 2.0 oz./ft$^2$ (total both sides) | Stainless steel |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. Equivalent materials, coatings and finishes shall be permitted.
c. Holes for bolts shall be drilled a minimum $^{1}/_{32}$ inch and a maximum $^{1}/_{16}$ inch larger than the bolt.
e. Stainless-steel-driven fasteners shall be in accordance with ASTM F1667.

## SECTION 4704
## FOOTINGS

**4704.1 Minimum size.** Support posts shall be supported by a minimum concrete masonry or concrete footings in accordance with Figure 4704.1 and Table 4704.1. Tributary area is calculated as shown in Figure 4704.2. ~~Post footings in wind zones of 120 mph or higher shall be concrete.~~

**4704.2 Minimum depth.** The bottom of the footing shall be 12 inches (305 mm) below finished grade but not less than the frost line as determined by the local building official.




For SI: 1 inch = 25.4 mm, 1 square foot = 0.0929m$^2$

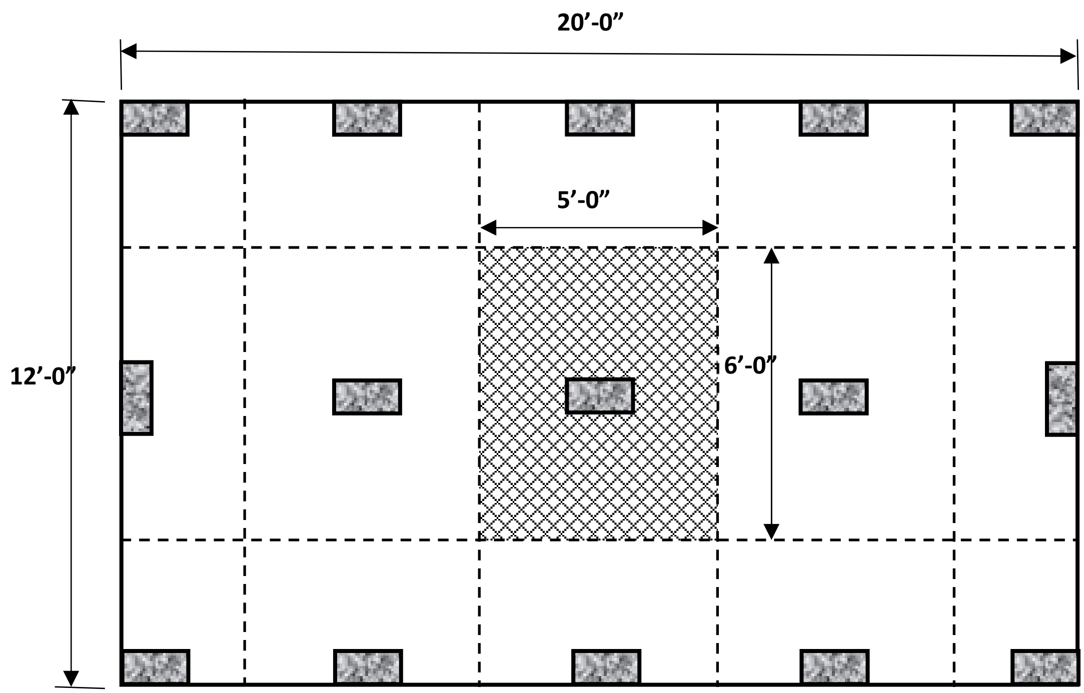
**FIGURE 4704.1**
**SUPPORT POST FOOTING**

**TABLE 4704.1**
**FOOTING TABLE[a,b,c]**

| SIZE (inches) | | TRIBUTARY AREA | THICKNESS (inches) | |
|---|---|---|---|---|
| A x A | B x C | (sq. ft.) | Precast | Cast-In-Place |
| 8 x 16 | 8 x 16 | 35 | 4 | 6 |
| 12 x 12 | 12 x 12 | 40 | 4 | 6 |
| 16 x 16 | 16 x 16 | 70 | 8 | 8 |
| - | 16 x 24 | 100 | - | 8 |
| - | 24 x 24 | 150 | - | 8 |

For SI: 1 inch = 25.4 mm, 1 square foot = 0.0929m$^2$.

a. Footing values are based on single floor loads.
b. Support post must rest in center 1/3 of footing.
c. Top of footing shall be level for full bearing support of post.




For SI: 1 inch = 25.4 mm, 1 square foot = $0.0929m^2$.

**Note:** Tributary area of shaded section on the free standing *deck* shown is 5’ x 6’ = 30 sq. ft.(2.79 $m^2$). Code will require a minimum footing of 8” x 16” (203 mm x 406 mm) in accordance with Table 401.1.

**FIGURE 4704.2**
**CALCULATED TRIBUTARY AREA**

## SECTION 4705
## POSTS

**4705.1 Height.** Maximum height of deck support posts shall be in accordance with Table 4705.1.

**TABLE 4705.1**
**DECK SUPPORT POST HEIGHT**

| POST SIZE[a] | MAXIMUM POST HEIGHT[b,c,d] |
|---|---|
| 4” x 4” | 8’-0” |
| 6” x 6” | 20’-0” |

For SI: 1 inch = 25.4, 1 foot = 304.8 mm

a. This table is based on No. 2 Southern Pine posts.
b. From top of footing to bottom of girder.

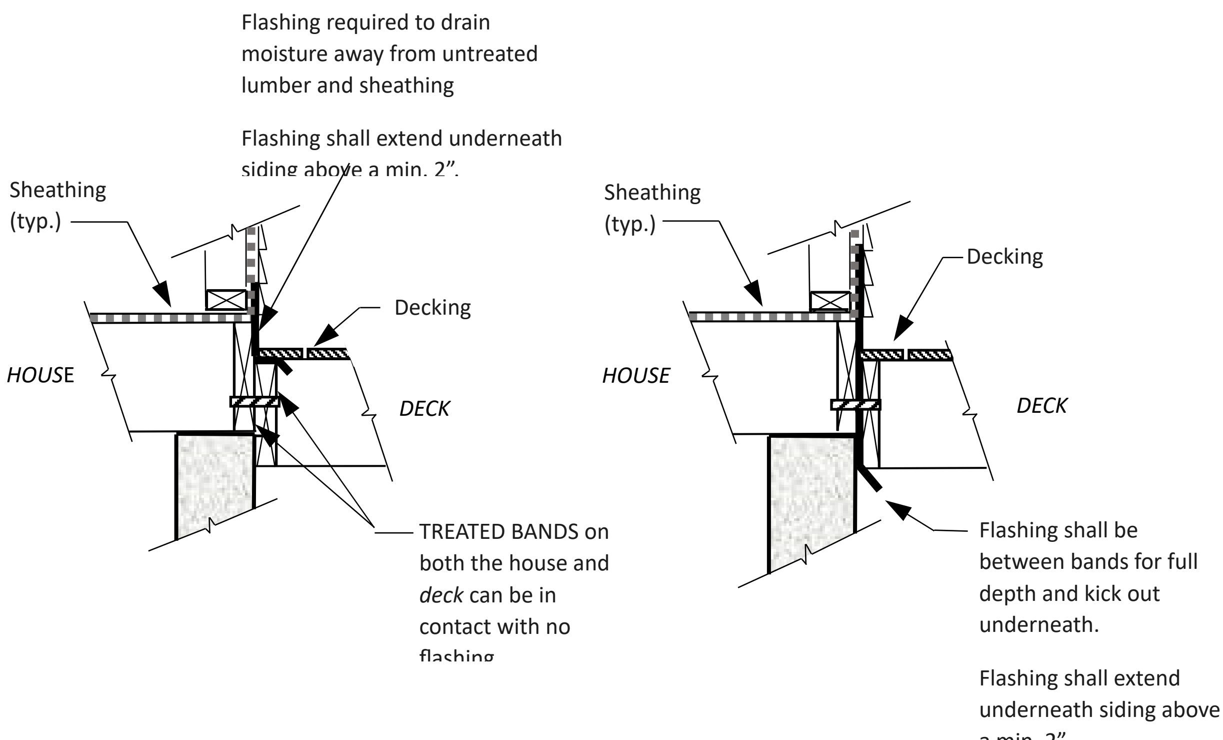
c. Decks with post heights exceeding these requirements shall be designed by a registered design professional.
d. Bracing shall be provided as required by Section 4711.

**4705.2 Anchorage.** Each post shall be anchored to the footing with one 1/2 inch galvanized anchor or equivalent in winds speeds of 120 mph and 130 mph. The center hole for the anchor shall be located in the center 1/3 of the post not less than 4 inches from the bottom end of the post and not less than 3-1/2 inches below the top of the footing. The anchor shall extend not less than 1/2 of the larger footing width. Anchors in 140 mph and 150 mph wind zones shall be designed by a NC design professional.

> **Exception:** Mechanical fasteners meeting the manufacturer's installation instructions for the applicable wind zone is acceptable.

## SECTION 4706
## DECK ATTACHMENT TO DWELLING

**4706.1 Weatherproofing.** When attached to a *dwelling* or accessory building, the building to which attached shall have a treated wood band for the length of the *deck*, or corrosion-resistant flashing shall be used to prevent moisture from coming in contact with the untreated framing of the *dwelling*. Aluminum flashing shall not be used in conjunction with *deck* construction. The *deck* band and the *dwelling* band shall be constructed in contact with each other except on brick veneer structures and where structural sheathing is required and properly flashed. Siding shall not be installed between the structure and the *deck* band. If attached to a brick structure, neither the flashing nor a treated band for brick structure is required. In addition, the treated *deck* band shall be constructed in contact with the brick veneer. Flashing shall be installed per Figure 4706.1.




**NO FLASHING BETWEEN TREATED BANDS** | **FLASHING FOR TREATED DECK BAND TO UNTREATED HOUSE BAND**

For SI: 1 inch = 25.4 mm

**FIGURE 4706.1**
**FLASHING FOR DECK ATTACHED TO STRUCTURE**

## SECTION 4707
## SUPPORT BY DWELLING

**4707.1 Attachment.** When a deck is supported at the structure by attaching the deck to the structure, Tables 4707.1(1) and 4707.1(2) shall apply for attaching the deck band to the structure.

## TABLE 4707.1(1)
## DECK ATTACHMENT FOR ALL STRUCTURES EXCEPT BRICK VENEER

| FASTENERS | 8' MAX JOIST SPAN[a] | 16' MAX JOIST SPAN[a] |
|---|---|---|
| 5/8" Hot dip galvanized bolts with nut and washer[b] **and** 12d Common hot dip galvanized nails[c] | 1 @ 3'-6" o.c. **and** 2 @ 8" o.c. | 1 @ 1'-8" o.c. **and** 3 @ 6" o.c. |
| **OR** | | |
| Self-Drilling Screw Fastener[d] | 12" o.c. staggered | 6" o.c. staggered |

For SI: 1 inch = 25.4, 1 foot = 304.8 mm

a. Attachment interpolation between 8 foot and 16 foot joists span is allowed.
b. Minimum edge distance for bolts is 2 ½ inches.
c. Nails must penetrate the supporting structure band a minimum of 1 ½ inches.
d. Self-drilling screw fastener having a minimum shank diameter of 0.195 inches and a length long enough to penetrate through the supporting structure band. The structure band shall have a minimum depth of 1-1/8 inches. Screw shall be evaluated by an approved testing agency for allowable shear load for Southern Pine to Southern Pine lumber of 250 pounds and shall have a corrosion resistant finish equivalent to hot dip galvanized. Minimum edge distance for screws is 1-7/16 inches. A maximum of ½ inch thick wood structural panel is permitted to be located between the deck ledger and the structure band.

## TABLE 4707.1(2)
## DECK ATTACHMENT FOR BRICK VENEER STRUCTURES

| FASTENERS | 8' MAX JOIST SPAN[a] | 16' MAX JOIST SPAN[a] |
|---|---|---|
| 5/8" Hot dip galvanized bolts with nut and washer[b] | 1 @ 2'-4" o.c. | 1 @ 1'-4" o.c. |

For SI: 1 inch = 25.4, 1 foot = 304.8 mm

a. Attachment interpolation between 8 foot and 16 foot joist span is allowed.
b. Minimum edge distance for bolts is 21/2 inches.

**4707.2 Masonry ledge support.** A deck band supported on a minimum 1/2 inch (13 mm) masonry ledge along the foundation wall attached with 5/8 inch (16 mm) hot dip galvanized bolts with washers spaced a maximum of 48 inches (1219 mm) o.c. shall be permitted.

**4707.3 Other means of support.** Joist hangers or other means of attachment are permitted to be connected to the dwelling band and shall be properly flashed.

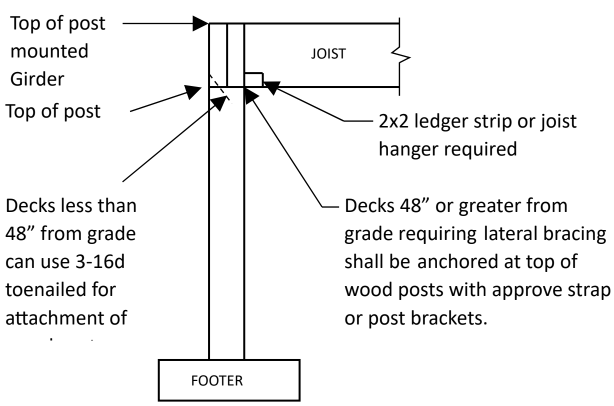
# SECTION 4708
# GIRDER SUPPORT AND SPAN

**4708.1 Girder to post bearing and connection.** Girders shall bear directly on the support post with the post attached at top to prevent lateral displacement or be connected to the side of the posts with one of the methods shown in Table 4708.1. Girder support is permitted to be installed in accordance with Figure 4708.1(1) for top mount, Figure 4708.1(2) for side mount, Figure 4708.1(3) for split girders, and Figure 4708.1(4) for cantilevered girders.

**Table 4708.1**
**Girder Connection to Side of Post[c]**

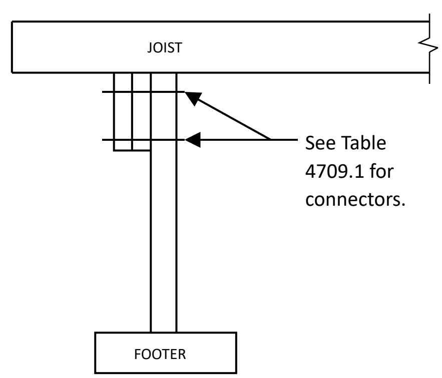
| Maximum Girder Thickness | | |
|---|---|---|
| Any | 3” (Double 2X) | 1-1/2” (Single 2X) |
| Two 5/8” diameter bolts[a] | Four 6” long screws[b] | Three 4” long screws[b] |

a. Bolts shall be hot dip galvanized through bolts and nuts.
b. Screws shall be hot dipped galvanized self-drilling screw fastener having a minimum diameter of 0.270”, staggered so that the screws are not in a line, and having a minimum edge distance of 1-1/2 inches.
c. Hot dipped galvanized washers shall be provided at the head and nut of each through bolt and the head of each screw.



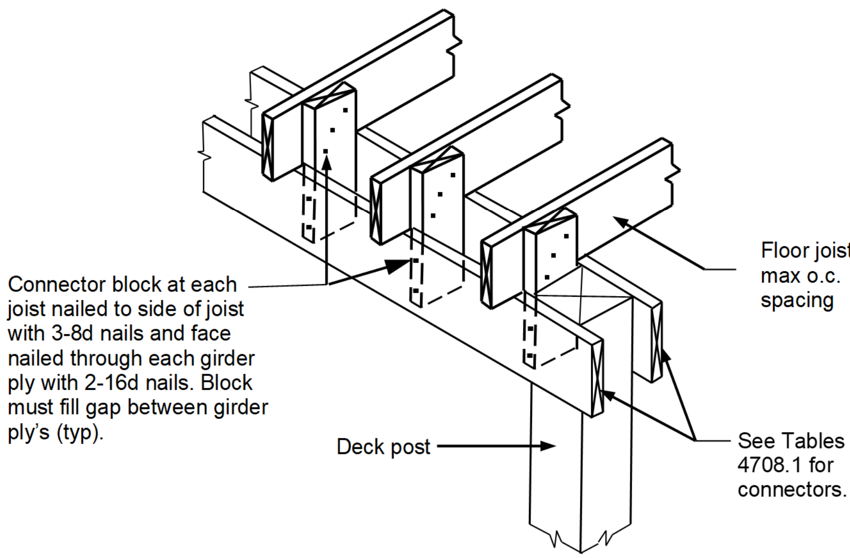

For SI: 1 inch = 25.4 mm.

**FIGURE 4708.1(1)**
**TOP MOUNT/FLUSH GIRDER**




For SI: 1 inch = 25.4 mm

**FIGURE 4708.1(2)**
**SIDE MOUNT DROPPED GIRDER**




Split girder limited to floor loads only and cantilever girder ends allowed per Figure 4708.1(4)

For SI: 1 inch = 25.4 mm.

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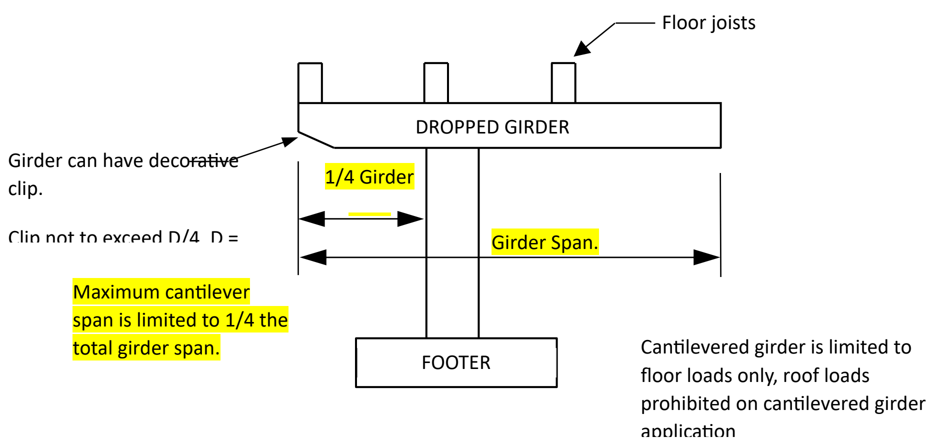
## FIGURE 701.1(3) SPLIT GIRDER




## FIGURE 701.1(4) CANTILIEVERED DROPPED GIRDER

**4708.2 Girder spans for uncovered decks.** Maximum allowable spans for wood deck girders, as shown in Figure 4708.2, shall be in accordance with Table 4708.2. Girder plies shall be fastened with two rows of 10d (3-inch × 0.128-inch) nails minimum at 16 inches (406 mm) on center along each edge. Girders shall be permitted to cantilever at each end up to one-fourth of the actual beam span. Splices of multi-span beams shall be located at interior post locations.

## TABLE 4708.2
## DECK GIRDER SPANS LENGTHS [a,b]
## (feet – inches)

| SPECIES[c] | SIZE[d] | DECK JOIST SPAN LESS THAN OR EQUAL TO: (feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **6** | **8** | **10** | **12** | **14** | **16** | **18** |
| Southern pine | 2 – 2 × 6 | 6-11 | 5-11 | 5-4 | 4-10 | 4-6 | 4-3 | 4-0 |
| | 2 – 2 × 8 | 8-9 | 7-7 | 6-9 | 6-2 | 5-9 | 5-4 | 5-0 |
| | 2 – 2 × 10 | 10-4 | 9-0 | 8-0 | 7-4 | 6-9 | 6-4 | 6-0 |
| | 2 – 2 × 12 | 12-2 | 10-7 | 9-5 | 8-7 | 8-0 | 7-6 | 7-0 |
| | 3 – 2 × 6 | 8-2 | 7-5 | 6-8 | 6-1 | 5-8 | 5-3 | 5-0 |
| | 3 – 2 × 8 | 10-10 | 9-6 | 8-6 | 7-9 | 7-2 | 6-8 | 6-4 |
| | 3 – 2 × 10 | 13-0 | 11-3 | 10-0 | 9-2 | 8-6 | 7-11 | 7-6 |
| | 3 – 2 × 12 | 15-3 | 13-3 | 11-10 | 10-9 | 10-0 | 9-4 | 8-10 |
| Douglas fir-larch[e], hem-fir[e], spruce-pine-fir[e], redwood, western cedars, ponderosa pine[f], red pine[f] | 3 × 6 or 2 – 2 x 6 | 5-5 | 4-8 | 4-2 | 3-10 | 3-6 | 3-1 | 2-9 |
| | 3 × 8 or 2 – 2 × 8 | 6-10 | 5-11 | 5-4 | 4-10 | 4-6 | 4-1 | 3-8 |
| | 3 × 10 or 2 – 2 × 10 | 8-4 | 7-3 | 6-6 | 5-11 | 5-6 | 5-1 | 4-8 |
| | 3 × 12 or 2 – 2 × 12 | 9-8 | 8-5 | 7-6 | 6-10 | 6-4 | 5-11 | 5-7 |
| | 4 × 6 | 6-5 | 5-6 | 4-11 | 4-6 | 4-2 | 3-11 | 3-8 |
| | 4 × 8 | 8-5 | 7-3 | 6-6 | 5-11 | 5-6 | 5-2 | 4-10 |
| | 4 × 10 | 9-11 | 8-7 | 7-8 | 7-0 | 6-6 | 6-1 | 5-8 |
| | 4 × 12 | 11-5 | 9-11 | 8-10 | 8-1 | 7-6 | 7-0 | 6-7 |
| | 3 – 2 × 6 | 7-4 | 6-8 | 6-0 | 5-6 | 5-1 | 4-9 | 4-6 |
| | 3 – 2 × 8 | 9-8 | 8-6 | 7-7 | 6-11 | 6-5 | 6-0 | 5-8 |
| | 3 – 2 × 10 | 12-0 | 10-5 | 9-4 | 8-6 | 7-10 | 7-4 | 6-11 |
| | 3 – 2 × 12 | 13-11 | 12-1 | 10-9 | 9-10 | 9-1 | 8-6 | 8-1 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound = 0.454 kg.

a. Ground snow load, live load = 40 psf, dead load = 10 psf, L/Δ = 360 at main span, L/Δ = 180 at cantilever with a 220-pound point load applied at the end.
b. Girders supporting deck joists from one side only.
c. No. 2 grade, wet service factor.
d. Girder depth shall be greater than or equal to depth of joists with a flush beam condition.
e. Includes incising factor.
f. Northern species. Incising factor not included.

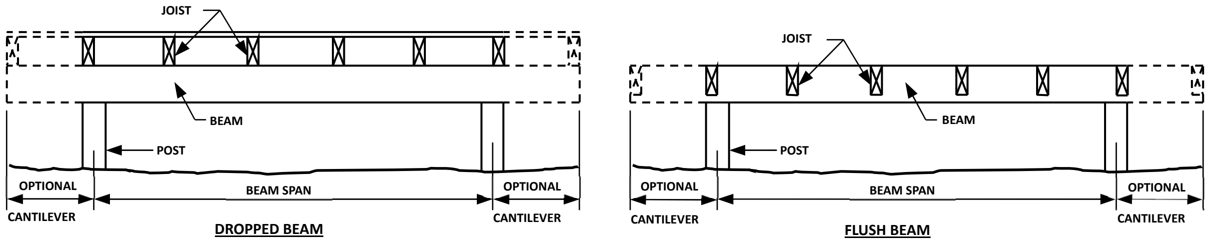



**FIGURE 4708.2**
**TYPICAL DECK GIRDER SPANS**

**4708.3 Girder span for roofed porches and decks.** Girder spans for covered *decks* shall be in accordance with Tables R602.7(1), (2) and (3).

## SECTION 4709
## ALLOWABLE JOIST SPANS AND CANTILEVERS~~, AND RAFTERS AND ROOFING~~

**4709.1 Joist spans for uncovered decks.** Maximum allowable spans for wood *deck* joists, as shown in Figure 4709.1, shall be in accordance with Table 4709.1or with the 2021 edition or later of American Wood Council online span calculator. *Deck* joists shall be permitted to cantilever not greater than one-fourth of the actual, adjacent joist span.

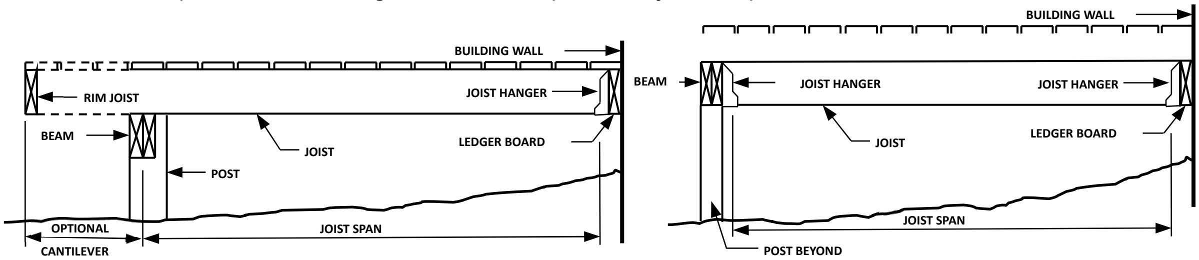
**TABLE 4709.1**
**JOIST SPANS FOR COMMON LUMBER SPECIES[f] (ft. - in.)**

| SPECIES[a] | SIZE | SPACING OF DECK JOISTS WITH NO CANTILEVER[b] (inches) | | | SPACING OF DECK JOISTS WITH CANTILEVERS[c] (inches) | | |
|---|---|---|---|---|---|---|---|
| | | 12 | 16 | 24 | 12 | 16 | 24 |
| Southern pine | 2 × 6 | 9-11 | 9-0 | 7-7 | 6-8 | 6-8 | 6-8 |
| | 2 × 8 | 13-1 | 11-10 | 9-8 | 10-1 | 10-1 | 9-8 |
| | 2 × 10 | 16-2 | 14-0 | 11-5 | 14-6 | 14-0 | 11-5 |
| | 2 × 12 | 18-0 | 16-6 | 13-6 | 18-0 | 16-6 | 13-6 |
| Douglas fir-larch[d], hem-fir[d] spruce-pine-fir[d] | 2 × 6 | 9-6 | 8-8 | 7-2 | 6-3 | 6-3 | 6-3 |
| | 2 × 8 | 12-6 | 11-1 | 9-1 | 9-5 | 9-5 | 9-1 |
| | 2 × 10 | 15-8 | 13-7 | 11-1 | 13-7 | 13-7 | 11-1 |
| | 2 × 12 | 18-0 | 15-9 | 12-10 | 18-0 | 15-9 | 12-10 |
| Redwood, western cedars, ponderosa pine[e], red pine[e] | 2 × 6 | 8-10 | 8-0 | 7-0 | 5-7 | 5-7 | 5-7 |
| | 2 × 8 | 11-8 | 10-7 | 8-8 | 8-6 | 8-6 | 8-6 |
| | 2 × 10 | 14-11 | 13-0 | 10-7 | 12-3 | 12-3 | 10-7 |
| | 2 × 12 | 17-5 | 15-1 | 12-4 | 16-5 | 15-1 | 12-4 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound = 0.454 kg.

a. No. 2 grade with wet service factor.
b. Ground snow load, live load = 40 psf, dead load = 10 psf, L/D = 360.
c. Ground snow load, live load = 40 psf, dead load = 10 psf, L/D = 360 at main span, L/D = 180 at cantilever with a 220-pound point load applied to end.
d. Includes incising factor.
e. Northern species with no incising factor

f. Cantilevered spans not exceeding the nominal depth of the joist are permitted.




JOIST WITH DROPPED BEAM JOIST WITH FLUSH BEAM

**FIGURE 4709.1**
**TYPICAL DECK JOIST SPANS**

~~**4709.2 Joist spans roofed porches and decks.** Joists spans shall be in accordance with Table R502.3.1(2) with 40 lbs per sq. ft. live load and 10 lbs per sq. ft. dead load. Cantilevered floor joists shall be in accordance with Table R502.3.3(1).~~

**4709.2 Lateral restraint at supports.** Joist ends and bearing locations shall be provided with lateral restraint to prevent rotation. Where lateral restraint is provided by joist hangers or blocking between joists, their depth shall equal not less than 60 percent of the joist depth. Where lateral restraint is provided by rim joists, they shall be secured to the end of each joist with not less than (3) 10d (3-inch × 0.128-inch) nails or (3) No. 10 × 3-inch (76 mm) long wood screws.

~~**4709.4 Rafters and roofing.** Rafters and roofing shall comply with R802. Fasteners shall comply with Tables R602.3(1) and R602.3(2).~~

## SECTION 4710
## FLOOR DECKING

**4710.1 Wood.** Floor decking shall be No. 2 grade pressure preservative treated Southern Pine or equivalent. The minimum floor decking thickness shall be in accordance with Table 4710.1.

**TABLE 4710.1**
**FLOOR DECKING THICKNESS**

| SUPPORT SPACING | DECKING (nominal) |
|---|---|
| 12” o.c. | 1” S4S |
| 16” o.c. | 1” T&G |
| 19.2” o.c. | 1 ¼” S4S |
| 24”-36” o.c. | 2” S4S |

For SI: 1 inch = 25.4, 1 foot = 304.8 mm

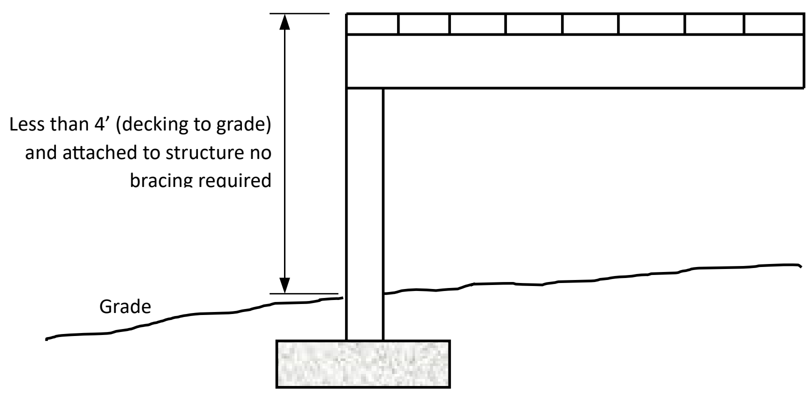
**4710.2 Plastic composites.** *Plastic composite* shall comply with Section 4702.2 and the manufacturer’s installation instructions.

## SECTION 4711
## BRACING

**4711.1 General.** Decks shall be braced to provide lateral stability. Lateral stability shall be provided in accordance with one of the methods in Sections 4711.2 through 4711.6.

**4711.2 Lateral bracing not required.** When any of the following apply additional lateral bracing is not required:

1. When the deck floor height is less than 4 feet (1219 mm) above finished grade as shown in Figure 4711.2 and the deck is attached to the structure in accordance with Chapter 6, lateral bracing is not required.
2. Lateral bracing is not required for freestanding decks with a deck floor height 30 inches (762 mm) or less above finished grade.
3. Lateral bracing is not required when the deck complies with Section 4711.5.
4. Lateral bracing is not required when the deck complies with Section 4711.6.




For SI:1 inch= 25.4 mm, 1 foot = 304.8 mm

**FIGURE 4711.2**
**NO LATERAL BRACING**

**4711.3 Knee bracing.**

4x4 wood knee braces are permitted to be provided on each column in both directions for freestanding decks or parallel to the structure at the exterior column line for attached decks. The knee braces shall attach to each post at a point not less than 1/3 of the post length from the top of the post, and the braces shall be angled between 45 degrees (0.79 rad) and 60 degrees (1.05 rad) from the horizontal. Knee braces shall be fastened to the post and the girder/double band in accordance with Table 4711.3 and Figures 4711.3(1), (2), and (3).

**TABLE 4711.3**
**FASTENING OF BRACE TO POST AND GIRDER/BAND (CHOOSE ONE)**

| Fastener | Installation | Minimum Distances |
|---|---|---|
| One 5/8” diameter hot dipped galvanized through bolt with nut and washer | Perpendicular to post or girder/band | 2-3/16” end distance |
| Two hot dipped galvanized (ASTM A153, Class C, minimum) screws having minimum diameter of 0.270” and long enough to achieve 3” penetration into the post or girder/band. | Perpendicular to post or girder/band | 1” edge distance, 1-1/2” horizontal spacing, minimum 3” end distance |

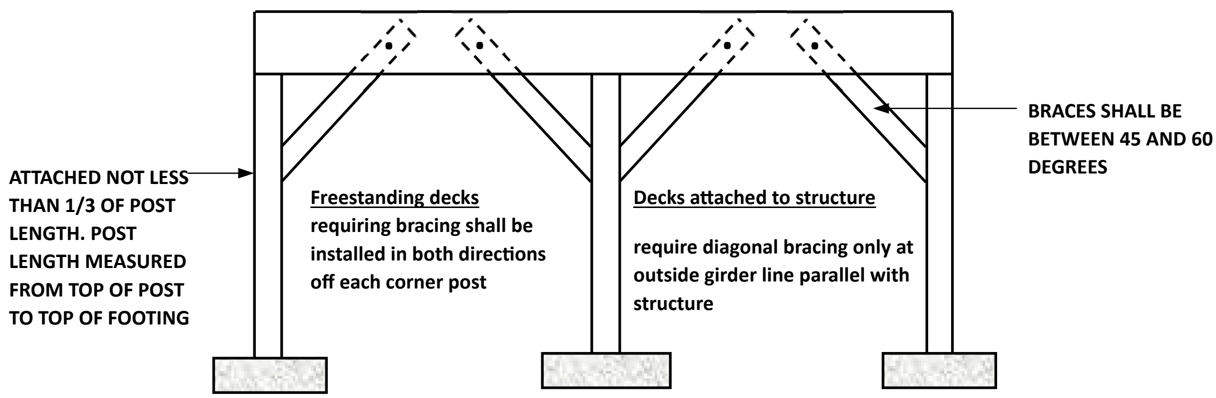



**FIGURE 4711.3(1)**
**KNEE BRACING**

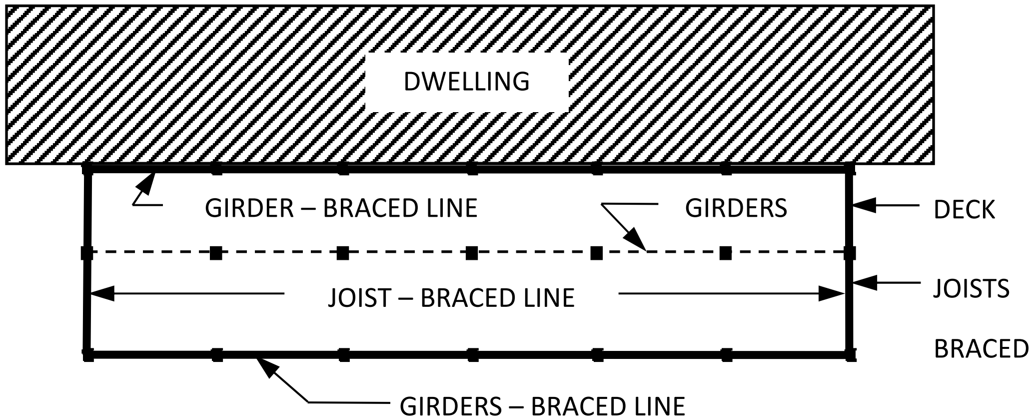



**FIGURE 4711.3(2)**
**FREESTANDING DECK KNEE BRACING LINE**
**(plan view)**

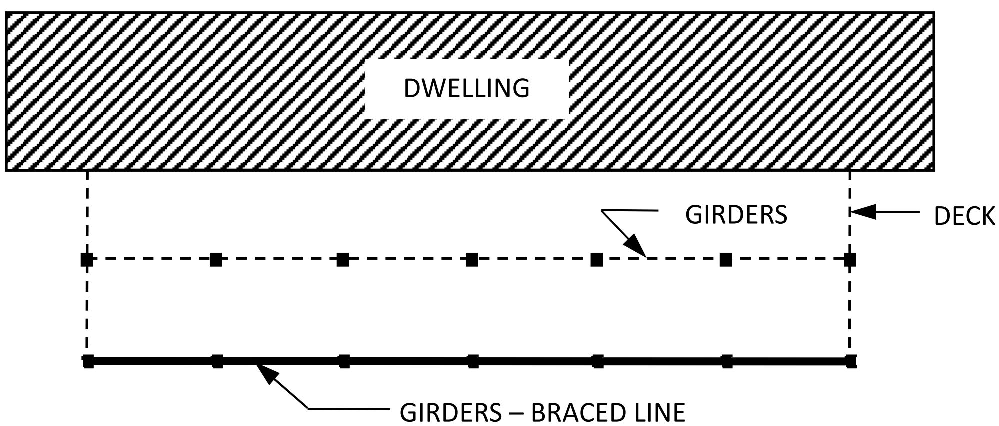


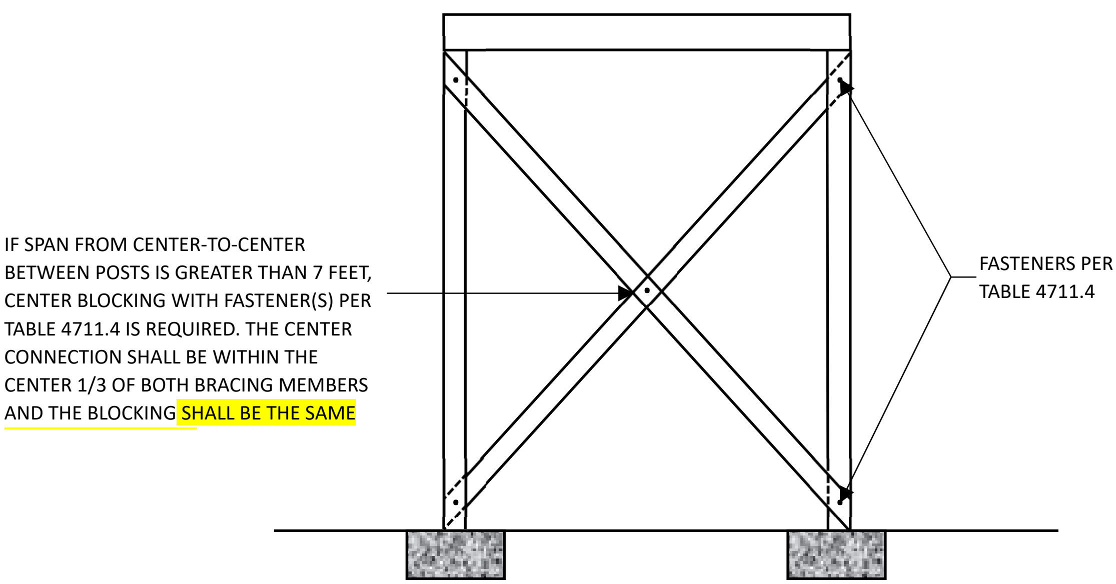

**FIGURE 4711.3(3)**
**DWELLING ATTACHED DECK KNEE BRACING LINE**
**(plan view)**

**4711.4 Cross bracing.** 2x6 diagonal vertical cross bracing is permitted to be provided in two perpendicular directions for free standing decks or parallel to the structure at the exterior column line for attached decks in accordance with Figures 4711.4 (3), and 4711.4 (4). The 2x6 bracing shall be attached to the posts with one of the methods in Table 4711.4 at each end of each bracing member in accordance with Figures 4711.4(1). Bracing members shall extend to within 6 inches of the top and bottom of the posts. Where more than one cross brace is installed between posts a 2x6 horizontal strut is required as shown in Figure 4711.4(2) and shall be fastened per Table 4711.4.

**Table 4711.4**
**FASTENING OF BRACE (CHOOSE ONE)**

| **Fastener Type** | **Diameter (inches)** | **QTY** | **Length** |
|---|---|---|---|
| Bolt | 5/8[a] | 1 | As required |
| Screws | 0.27[b] | 2 | Long enough to achieve a 1 ½" thread penetration of structural member opposite head of screw |

a. Bolts shall be hot dip galvanized through bolts with nut and washer
b. Screws shall be hot dip galvanized (ASTM A153, Class C, minimum) self drilling screw fastener having a minimum diameter of 0.27", and installed in the center of the post with a minimum of 1" space between screws.




For SI: 1 inch = 25.4, 1 foot = 304.8 mm.

**FIGURE 4711.4(1)**
**CROSS BRACING**

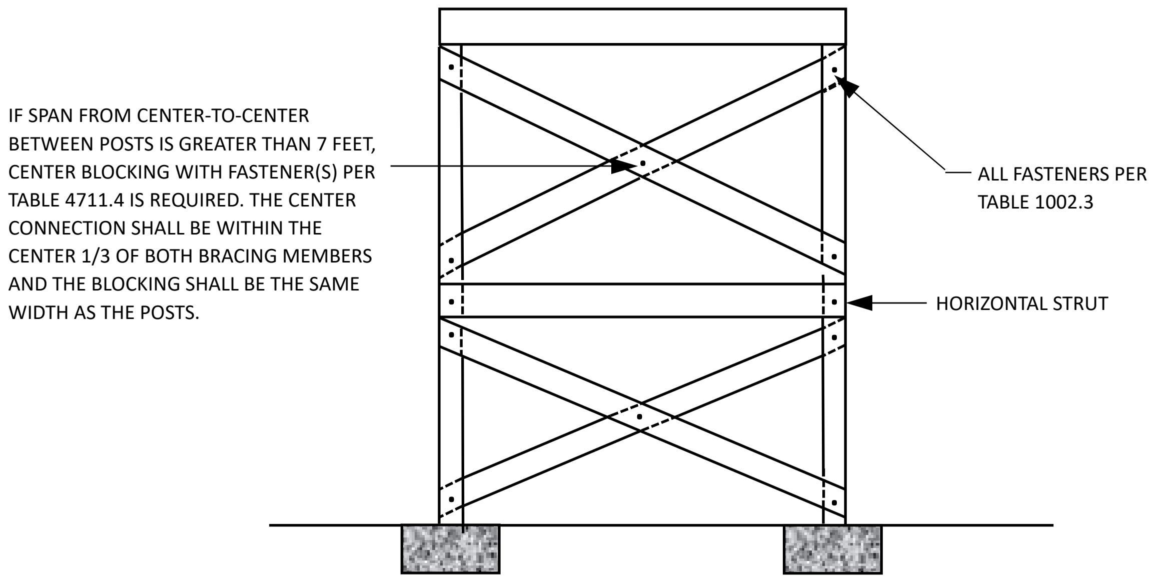
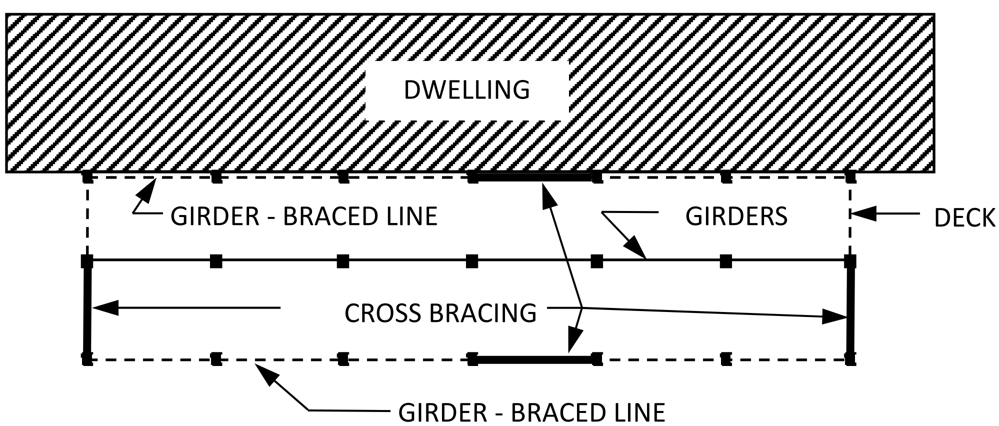



**FIGURE 4711.4(2)**

**CROSS BRACING**




**<u>FIGURE 4711.4(3)</u>**
**<u>FREESTANDING DECK CROSS BRACING LINE</u>**
**<u>(plan view)</u>**

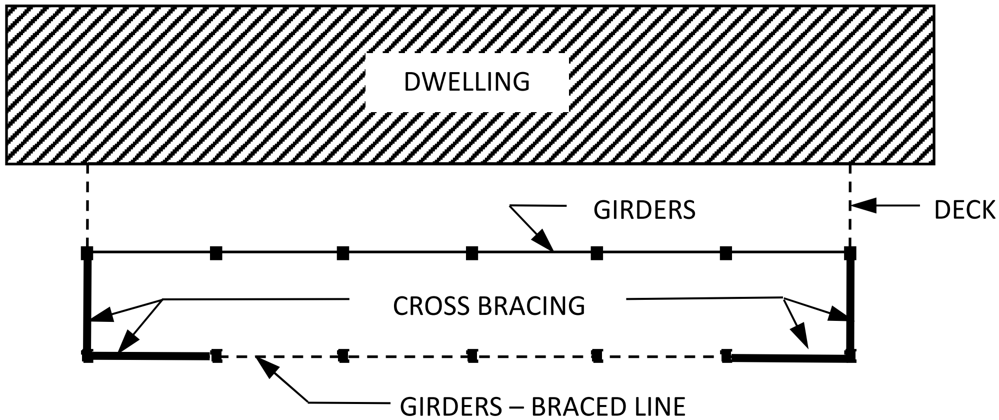
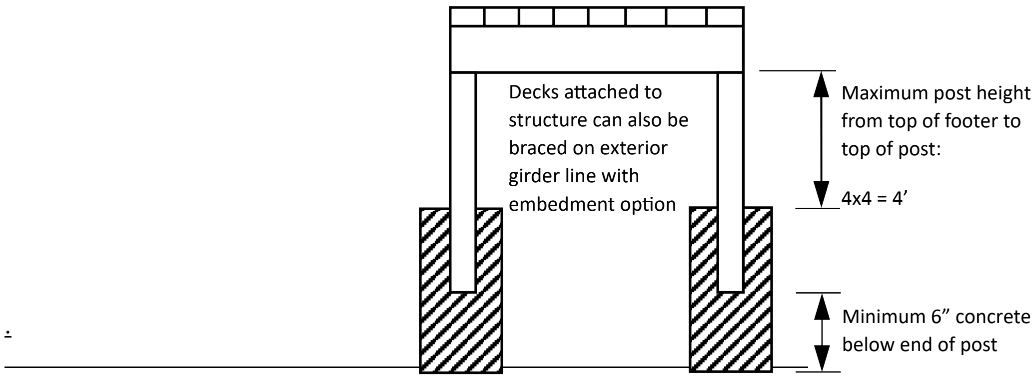



**FIGURE 4711.4(4)**
**DWELLING ATTACHED DECK CROSS BRACING LINE**
**(plan view)**

**4711.5 Post embedment bracing.** For free standing decks without knee braces or cross bracing, lateral stability is permitted to be provided by embedding the post in accordance with Figure 4711.5 and Table 4711.5.




For SI: 1 inch = 25.4, 1 foot = 304.8 mm

**FIGURE 1002.4**
**POST EMBEDMENT**

**TABLE 4711.5**
**POST EMBEDMENT FOR FREE STANDING DECKS**

| POST SIZE | MAXIMUM TRIBUTARY AREA | MAXIMUM POST HEIGHT | EMPEDMENT DEPTH | CONCRETE DIAMETER |
|---|---|---|---|---|
| 4" x 4" | 48 SF | 4'-0" | 2'-6" | 1'-0" |
| 6" x 6" | 120 SF | 6'-0" | 3'-6" | 1'-8" |

For SI: 1 inch = 25.4 mm, 1 square foot = 0.0929m$^2$.

**4711.6 Piles bracing in coastal regions.** Pile tip shall extend to a depth of not less than 8 feet (2438 mm) below the natural grade or finished grade of the lot, whichever is lower. All pilings within the *Ocean Hazard Area* shall have a tip penetration of at least 5 feet (1524 mm) below mean sea level or 16 feet (4877 mm) below average original grade, whichever is least. Structures within *Ocean Hazard Areas* which are placed upon the site behind a line 60 times the annual erosion rate away from the most seaward line of stable natural vegetation are exempt from this additional tip penetration requirement.

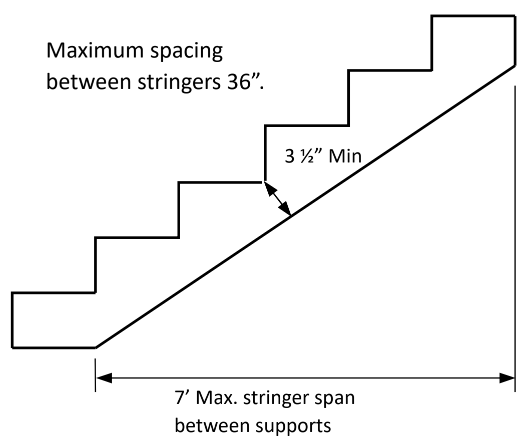
**4711.6 Pile bracing in coastal regions.** Additional bracing is not required where pile tips extend to a depth of not less than 8 feet (2438 mm) below the natural grade or finished grade of the lot, whichever is lower. All pilings within the *Ocean Hazard Area* shall have a tip penetration of at least 5 feet (1524 mm) below mean sea level or 16 feet (4877 mm) below average original grade, whichever is least.

**Exception:** Structures within *Ocean Hazard Areas* which are placed on a site behind a line 60 times the annual erosion rate away from the most seaward line of stable natural vegetation are allowed to comply with Table 4711.5.

## SECTION 4712
## STAIRS

**4712.1 Construction.** Stair shall comply with R311.7 and 4712.1.1

**4712.1.1 Stringers.** Stringer spans shall be no greater than 7 feet (2134 mm) between supports. Spacing between stringers shall be based upon decking material used in accordance with 4710. Each stringer shall have a minimum of 3 ½ inches (89 mm) between step cut and back of stringer. If used, suspended headers shall be attached with 3/8 inch (9.5 mm) galvanized bolts with nuts and washers to securely support stringers at the top. See Figure 4712.1.1.

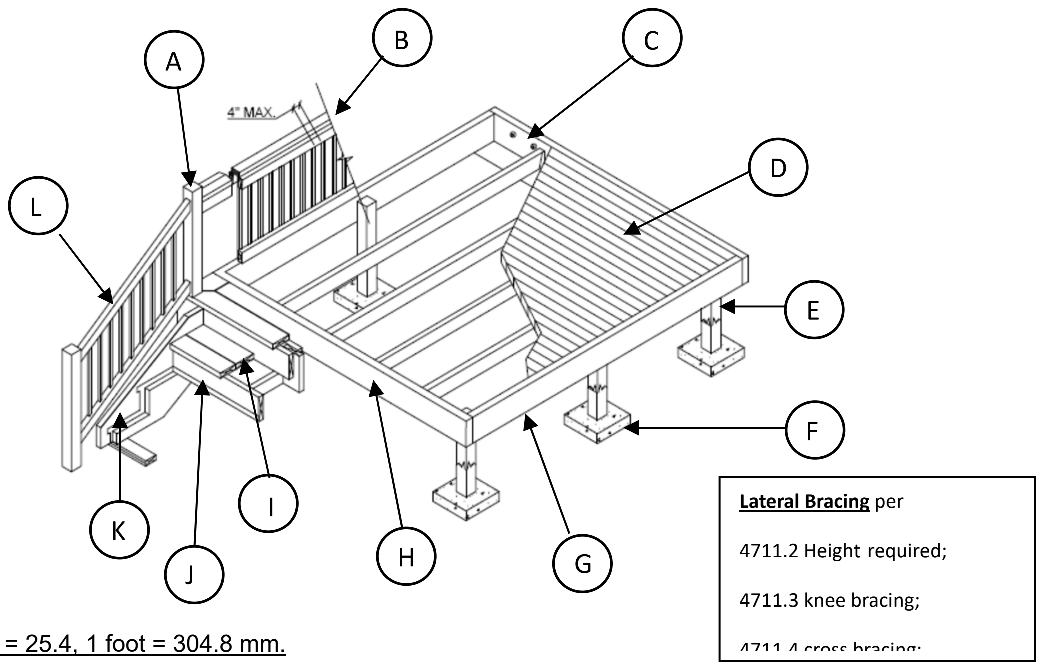



For SI: 1 inch = 25.4, 1 foot = 304.8 mm.

**FIGURE 4712.1.1**
**STAIR STRINGER**

# SECTION 4713
# HANDRAILS, GUARDS AND GENERAL

**4713.1 Handrails, guards and general.** Deck handrails, guards and general construction shall be as shown in Figure 4713.1.



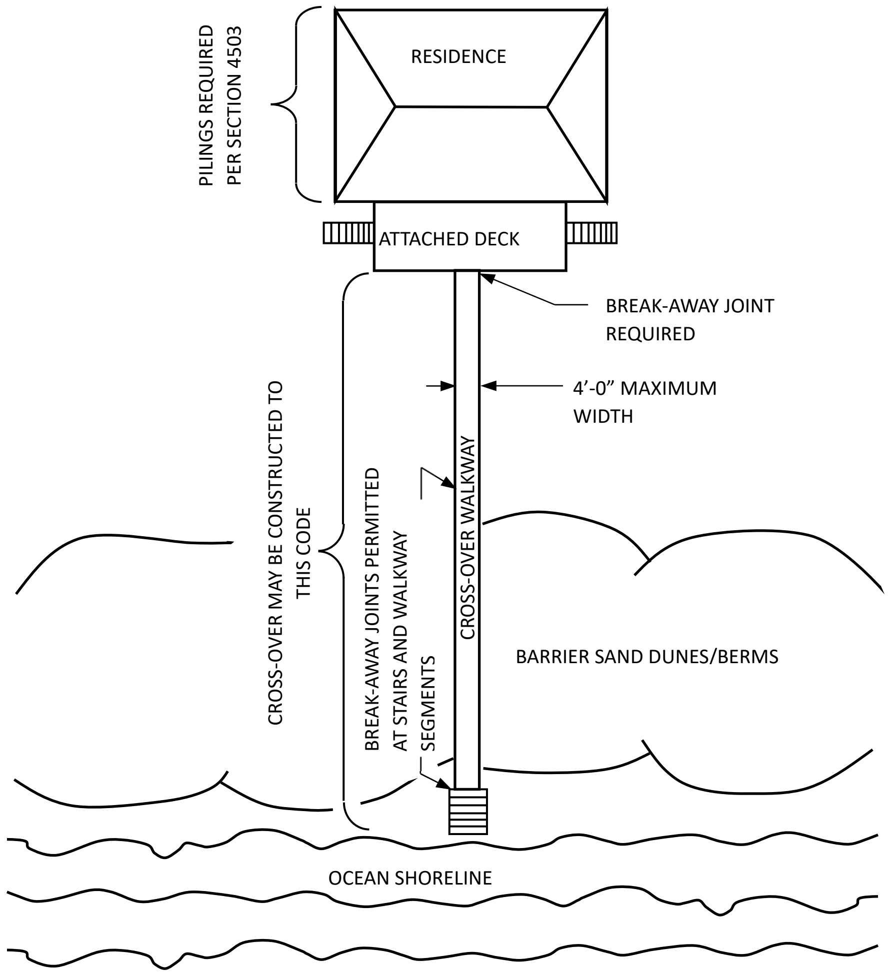

For SI: 1 inch = 25.4, 1 foot = 304.8 mm.

A. **Rail posts** shall be located a maximum of 8 feet o.c. Posts shall be attached to outer girder and joist bands with 2-3/8" galv. bolts with nut & washer to outer bands.
B. **Guards** at a minimum 36" height required with 30" drop and opening limits, top rail and post to support 200lbs with infill to meet 50lbs.
C. **Attachment** to structure shall comply with 4707.
D. **Decking** per 4710.
E. **Deck post** per 4705 and 4711.5.
F. **Shallow Footers** per 4704.
G. **Floor joist cantilevers** allowed per 4709.1 and 4709.2.
H. **Exterior Girder Clear Spans** per 4708.2 and 4708.3.
I. **Stairs treads and risers** per 4712.
J. **Riser openings** for stairs with a 30" or more vertical rise must have solid risers or opening restricted to prevent passage of a 4" sphere per R311.7.5.1.
K. **Stair Guard at Risers.** The triangle openings at the open side of stairs, formed by the riser, tread and bottom rail of a guard, shall not allow passage of a sphere 6 inches in diameter per R312.1.3.
L. **Stair handrail/Guard**. Height between 34"-38" per R312.1.2. Openings on side of stairs requiring guards shall not allow a sphere 4 3/8" to pass per R312.1.3.

**FIGURE 4713.1**
**DECK CONSTRUCTION**

## SECTION 4714
## WALKWAYS OVER DUNES IN OCEAN HAZARD AREAS

**4714.1 Construction.** Walkways over dunes in *ocean hazard areas* shall be constructed as shown in Figure 4714.1.




For SI: 1 inch = 25.4, 1 foot = 304.8 mm.

a. Posts for walkways over dunes or berms shall be embedded a minimum depth of 4′ - 0″ and post heights shall be limited to 5′- 0″ above grade for 4×4 and 10′ - 0″ above grade for 6 × 6. Walkways or portions of walkways over 4′ 0″ in width shall comply with the requirements of Chapters 45 and 46. Maximum walkway surface height is 30″ above grade without guard rails.
b. Walkway stair runs from walkway down to ocean shoreline grade are permitted to be greater than 12′ without a landing.
c. Open risers permitted on ocean shoreline stair.
d. Horizontal guards permitted to have maximum 18-inch opening on cross-over walkway and ocean shoreline stair.

**FIGURE 4714.1**
**WALKWAYS OVER DUNES OR BERMS IN OCEAN HAZARD AREAS**

# APPENDIX AA

# SIZING AND CAPACITIES OF GAS PIPING

This appendix is an excerpt from the 2021 International Fuel Gas Code® informative Appendix A. Table references in the text, other than AA tables, are as numbered in the International Fuel Gas Code (IFGC). For related table references in this code, you can find the IFGC table number in brackets adjacent to the table number in Chapter 24 of this code. For example, Table 402.4(2) in the IFGC is related to Table G2413.4(1) [402.4(2)] in this code.

## SECTION AA101
## GENERAL PIPING CONSIDERATIONS

The first goal of determining the pipe sizing for a fuel gas *piping* system is to make sure that there is sufficient gas pressure at the inlet to each *appliance*. The majority of systems are residential and the *appliances* will all have the same, or nearly the same, requirement for minimum gas pressure at the *appliance* inlet. This pressure will be about 5-inch water column (w.c.) (1.25 kPa), which is enough for proper operation of the *appliance* regulator to deliver about 3.5-inches water column (w.c.) (875 kPa) to the burner itself. The pressure drop in the *piping* is subtracted from the source delivery pressure to verify that the minimum is available at the *appliance*.

There are other systems, however, where the required inlet pressure to the different appliances is quite varied. In such cases, the greatest inlet pressure required must be satisfied, as well as the farthest *appliance*, which is almost always the critical *appliance* in small systems.

There is an additional requirement to be observed besides the capacity of the system at 100-percent flow. That requirement is that at minimum flow, the pressure at the inlet to any *appliance* does not exceed the pressure rating of the *appliance* regulator. This would seldom be of concern in small systems if the source pressure is $^{1}/_{2}$ psi (14-inch w.c.) (3.5 kPa) or less but it should be verified for systems with greater gas pressure at the point of supply.

To determine the size of *piping* used in a gas *piping* system, the following factors must be considered:

1. Allowable loss in pressure from *point of delivery* to *appliance*.
2. Maximum gas demand.
3. Length of *piping* and number of fittings.
4. Specific gravity of the gas.
5. Diversity factor.

For any gas *piping* system or special *appliance*, or for conditions other than those covered by the tables provided in this code such as longer runs, greater gas demands or greater pressure drops, the size of each gas *piping* system should be determined by standard engineering practices acceptable to the code official.

## SECTION AA102
## DESCRIPTION OF TABLES

**AA102.1 General.** The quantity of gas to be provided at each *outlet* should be determined, whenever possible, directly from the manufacturer's gas input Btu/h rating of the *appliance* that will be installed. In case the ratings of the *appliances* to be installed are not known, Table R402.2 shows the approximate consumption (in Btu per hour) of certain types of typical household *appliances*.

To obtain the cubic feet per hour of gas required, divide the total Btu/h input of all *appliances* by the average Btu heating value per cubic feet of the gas. The average Btu per cubic feet of the gas in the area of the installation can be obtained from the serving gas supplier.

**AA102.2 Low pressure natural gas tables.** Capacities for gas at low pressure [less than 2.0 psig (13.8 kPa gauge)] in cubic feet per hour of 0.60 specific gravity gas for different sizes and lengths are shown in Tables 402.4(1) and 402.4(2) for iron pipe or equivalent rigid pipe; in Tables 402.4(8) through 402.4(11) for smooth wall semirigid tubing; and in Tables 402.4(15) through 402.4(17) for corrugated stainless steel tubing. Tables 402.4(1) and 402.4(6) are based on a pressure drop of 0.3-inch w.c. (75 Pa), whereas Tables 402.4(2), 402.4(9) and 402.4(15) are based on a pressure drop of 0.5- inch w.c. (125 Pa). Tables 402.4(3), 402.4(4), 402.4(10), 402.4(11), 402.4(16) and 402.4(17) are special low-pressure applications based on pressure drops greater than 0.5-inch w.c. (125 Pa). In using these tables, an allowance (in equivalent length of pipe) should be considered for any *piping* run with four or more fittings (see Table AA102.2).

**AA102.3 Undiluted liquefied petroleum tables.** Capacities in thousands of Btu per hour of undiluted liquefied petroleum gases based on a pressure drop of 0.5-inch w.c. (125 Pa) for different sizes and lengths are shown in Table 402.4(28) for iron pipe or equivalent rigid pipe, in Table 402.4(30) for smooth wall semi-rigid tubing, in Table 402.4(32) for corrugated stainless steel tubing, and in Tables 402.4(35) and 402.4(37) for polyethylene plastic pipe and tubing. Tables 402.4(33) and 402.4(34) for corrugated stainless steel tubing and Table 402.4(36) for polyethylene plastic pipe are based on operating pressures greater than $1^{1}/_{2}$ pounds per square inch (psi) (3.5 kPa) and pressure drops greater than 0.5-inch w.c. (125 Pa). In using these tables, an allowance (in equivalent length of pipe) should be considered for any *piping* run with four or more fittings [see Table AA102.2.

**AA102.4 Natural gas specific gravity.** Gas *piping* systems that are to be supplied with gas of a specific gravity of 0.70 or less can be sized directly from the tables provided in this code, unless the code official specifies that a gravity factor be applied. Where the specific gravity of the gas is greater than 0.70, the gravity factor should be applied.

Application of the gravity factor converts the figures given in the tables provided in this code to capacities for another gas of different specific gravity. Such application is accomplished by multiplying the capacities given in the tables by the multipliers shown in Table AA102.4. In case the exact specific gravity does not appear in the table, choose the next higher value specific gravity shown.

**AA102.5 Higher pressure natural gas tables.** Capacities for gas at pressures 2.0 psig (13.8 kPa) or greater in cubic feet per hour of 0.60 specific gravity gas for different sizes and lengths are shown in Tables 402.4(5) through 402.4(7) for iron pipe or equivalent rigid pipe; Tables 402.4(12) to 402.4(14) for semirigid tubing; Tables 402.4(18) and 402.4(19) for corrugated stainless steel tubing; and Table 402.4(22) for polyethylene plastic pipe.

## SECTION AA103
## USE OF CAPACITY TABLES

**AA103.1 Longest length method.** This sizing method is conservative in its approach by applying the maximum operating conditions in the system as the norm for the system and by setting the length of pipe used to size any given part of the *piping* system to the maximum value.

To determine the size of each section of gas *piping* in a system within the range of the capacity tables, proceed as follows (also see sample calculations included in this Appendix):

1. Divide the *piping* system into appropriate segments consistent with the presence of tees, branch lines and main runs. For each segment, determine the gas load (assuming all *appliances* operate simultaneously) and its overall length. An allowance (in equivalent length of pipe) as determined from Table AA102.2 shall be considered for *piping* segments that include four or more fittings.
2. Determine the gas demand of each *appliance* to be attached to the *piping* system. Where Tables 402.4(1) through 402.4(24) are to be used to select the *piping* size, calculate the gas demand in terms of cubic feet per hour for each *piping* system *outlet*. Where Tables 402.4(25) through 402.4(37) are to be used to select the *piping* size, calculate the gas demand in terms of thousands of Btu per hour for each *piping* system *outlet*.
3. Where the *piping* system is for use with other than undiluted liquefied petroleum gases, determine the design system pressure, the allowable loss in pressure (pressure drop), and specific gravity of the gas to be used in the *piping* system.
4. Determine the length of *piping* from the *point of delivery* to the most remote *outlet* in the building/*piping* system.
5. In the appropriate capacity table, select the row showing the measured length or the next longer length if the table does not give the exact length. This is the only length used in determining the size of any section of gas *piping*. If the gravity factor is to be applied, the values in the selected row of the table are multiplied by the appropriate multiplier from Table AA102.4.
6. Use this horizontal row to locate ALL gas demand figures for this particular system of *piping*.
7. Starting at the most remote *outlet*, find the gas demand for that *outlet* in the horizontal row just selected. If the exact figure of demand is not shown, choose the next larger figure left in the row.
8. Opposite this demand figure, in the first row at the top, the correct size of gas *piping* will be found.

9. Proceed in a similar manner for each *outlet* and each section of gas *piping*. For each section of *piping*, determine the total gas demand supplied by that section.

Where a large number of *piping* components (such as elbows, tees and valves) are installed in a pipe run, additional pressure loss can be accounted for by the use of equivalent lengths. Pressure loss across any *piping* component can be equated to the pressure drop through a length of pipe. The equivalent length of a combination of only four elbows/tees can result in a jump to the next larger length row, resulting in a significant reduction in capacity. The equivalent lengths in feet shown in Table AA102.2 have been computed on a basis that the inside diameter corresponds to that of Schedule 40 (standard-weight) steel pipe, which is close enough for most purposes involving other schedules of pipe. Where a more specific solution for equivalent length is desired, this can be made by multiplying the actual inside diameter of the pipe in inches by *n*/12, or the actual inside diameter in feet by *n* (*n* can be read from the table heading). The equivalent length values can be used with reasonable accuracy for copper or brass fittings and bends although the resistance per foot of copper or brass pipe is less than that of steel. For copper or brass valves, however, the equivalent length of pipe should be taken as 45 percent longer than the values in the table, which are for steel pipe.

**AA103.2 Branch length method.** This sizing method reduces the amount of conservatism built into the traditional Longest Length Method. The longest length as measured from the meter to the farthest remote *appliance* is only used to size the initial parts of the overall *piping* system. The Branch Length Method is applied in the following manner:

1. Determine the gas load for each of the connected *appliances*.
2. Starting from the meter, divide the *piping* system into a number of connected segments, and determine the length and amount of gas that each segment would carry assuming that all *appliances* were operated simultaneously. An allowance (in equivalent length of pipe) as determined from Table AA102.2 should be considered for piping segments that include four or more fittings.
3. Determine the distance from the *outlet* of the gas meter to the *appliance* farthest removed from the meter.
4. Using the longest distance (found in Step 3), size each *piping* segment from the meter to the most remote *appliance outlet*.
5. For each of these *piping* segments, use the longest length and the calculated gas load for all of the connected *appliances* for the segment and begin the sizing process in Steps 6 through 8.
6. Referring to the appropriate sizing table (based on operating conditions and *piping* material), find the longest length distance in the first column or the next larger distance if the exact distance is not listed. The use of alternative operating pressures or pressure drops will require the use of a different sizing table, but will not alter the sizing methodology. In many cases, the use of alternative operating pressures or pressure drops will require the approval of both the code official and the local gas serving utility.
7. Trace across this row until the gas load is found or the closest larger capacity if the exact capacity is not listed.
8. Read up the table column and select the appropriate pipe size in the top row. Repeat Steps 6, 7 and 8 for each pipe segment in the longest run.
9. Size each remaining section of branch *piping* not previously sized by measuring the distance from the gas meter location to the most remote *outlet* in that branch, using the gas load of attached *appliances* and following the procedures of Steps 2 through 8.

**AA103.3 Hybrid pressure method.** The sizing of a 2 psi (13.8 kPa) gas *piping* system is performed using the traditional Longest Length Method but with modifications. The 2 psi (13.8 kPa) system consists of two independent pressure zones, and each zone is sized separately. The Hybrid Pressure Method is applied as follows:

The sizing of the 2 psi (13.8 kPa) section (from the meter to the line regulator) is as follows:

1. Calculate the gas load (by adding up the name plate ratings) from all connected *appliances*. (In certain circumstances the installed gas load can be increased up to 50 percent to accommodate future addition of *appliances*.) Ensure that the line regulator capacity is adequate for the calculated gas load and that the required pressure drop (across the regulator) for that capacity does not exceed $^3/_4$ psi (5.2 kPa) for a 2 psi (13.8 kPa) system. If the pressure drop across the regulator is too high (for the connected gas load), select a larger regulator.
2. Measure the distance from the meter to the line regulator located inside the building.
3. If there are multiple line regulators, measure the distance from the meter to the regulator farthest removed from the meter.

4. The maximum allowable pressure drop for the 2 psi (13.8 kPa) section is 1 psi (6.9 kPa).
5. Referring to the appropriate sizing table (based on piping material) for 2 psi (13.8 kPa) systems with a 1 psi (6.9 kPa) pressure drop, find this distance in the first column, or the closest larger distance if the exact distance is not listed.
6. Trace across this row until the gas load is found or the closest larger capacity if the exact capacity is not listed.
7. Read up the table column to the top row and select the appropriate pipe size.
8. If there are multiple regulators in this portion of the *piping* system, each line segment must be sized for its actual gas load, but using the longest length previously determined in steps 2 and 3.

The low pressure section (all *piping* downstream of the line regulator) is sized as follows:

1. Determine the gas load for each of the connected *appliances*.
2. Starting from the line regulator, divide the piping system into a number of connected segments or independent parallel piping segments, and determine the amount of gas that each segment would carry assuming that all *appliances* were operated simultaneously. An allowance (in equivalent length of pipe) as determined from Table AA102.2 should be considered for piping segments that include four or more fittings.
3. For each piping segment, use the actual length or longest length (if there are sub-branchlines) and the calculated gas load for that segment and begin the sizing process as follows:
   a. Referring to the appropriate sizing table (based on operating pressure and piping material), find the longest length distance in the first column or the closest larger distance if the exact distance is not listed. The use of alternative operating pressures or pressure drops will require the use of a different sizing table, but will not alter the sizing methodology. In many cases, the use of alternative operating pressures or pressure drops can require the approval of the code official.
   b. Trace across this row until the *appliance* gas load is found or the closest larger capacity if the exact capacity is not listed.
   c. Read up the table column to the top row and select the appropriate pipe size.
   d. Repeat this process for each segment of the piping system.

**AA103.4 Pressure drop per 100 feet method.** This sizing method is less conservative than the others, but it allows the designer to immediately see where the largest pressure drop occurs in the system. With this information, modifications can be made to bring the total drop to the critical *appliance* within the limitations that are presented to the designer.

Follow the procedures described in the Longest Length Method for Steps 1 through 4 and 9.

For each *piping* segment, calculate the pressure drop based on pipe size, length as a percentage of 100 feet (30 480 mm) and gas flow. Table AA103.4 shows pressure drop per 100 feet (30 480 mm) for pipe sizes from $^1/_2$ inch (12.7 mm) through 2 inches (51 mm). The sum of pressure drops to the critical *appliance* is subtracted from the supply pressure to verify that sufficient pressure will be available. If not, the layout can be examined to find the high drop section(s) and sizing selections modified.

**Note:** Other values can be obtained by using the following equation:

$$\text{Desired Value} = MBH \times \sqrt{\frac{\text{Desired Drop}}{\text{Table Drop}}}$$

For example, if it is desired to get flow through $^3/_4$-inch (19.1 mm) pipe at 2 inches/100 feet, multiply the capacity of $^3/_4$-inch (19.1 mm) pipe at 1 inch/100 feet by the square root of the pressure ratio:

$$147\ MBH \times \sqrt{\frac{2''\ \text{w.c.}}{1''\ \text{w.c.}}} = 147 \times 1.414 = 208\ MBH$$

($MBH$ = 1000 Btu/h)

## SECTION AA104
## USE OF SIZING EQUATIONS

Capacities of smooth wall pipe or tubing can be determined by using the following formulae:

1. High Pressure [1.5 psi (10.3 kPa) and above]:

$$Q = 181.6\sqrt{\frac{D^5 \times (P_1^2 - P_2^2) \times Y}{C_r \times fba \times L}}$$

$$= 2237\ D^{2.623}\left[\frac{(P_1^2 - P_2^2) \times Y}{C_r \times L}\right]^{0.541}$$

2. Low Pressure [Less than 1.5 psi (10.3 kPa)]:

$$Q = 187.3\sqrt{\frac{D^5 \times \Delta H}{C_r \times fba \times L}}$$

$$= 2313 D^{2.623}\left(\frac{\Delta H}{C_r \times L}\right)^{0.541}$$

where:

$Q$ = Rate, cubic feet per hour at 60°F and 30-inch mercury column

$D$ = Inside diameter of pipe, in.

$P_1$ = Upstream pressure, psia

$P_2$ = Downstream pressure, psia

$Y$ = Superexpansibility factor = 1/supercompressibility factor

$C_r$ = Factor for viscosity, density and temperature*

= $0.00354\ ST\left(\frac{Z}{S}\right)^{0.152}$

*Note: See Table 402.4 for $Y$ and $C_r$ for natural gas and propane.

$S$ = Specific gravity of gas at 60°F and 30-inch mercury column (0.60 for natural gas, 1.50 for propane), or = 1488μ

$T$ = Absolute temperature, °F or = $t$ + 460

$t$ = Temperature, °F

$Z$ = Viscosity of gas, centipoise (0.012 for natural gas, 0.008 for propane), or = 1488μ

$fba$ = Base friction factor for air at 60°F (CF = 1)

$L$ = Length of pipe, ft

$\Delta H$ = Pressure drop, in. w.c. (27.7 in. $H_2O$ = 1 psi)

(For SI, see Section 402.4)

## SECTION AA105
## PIPE AND TUBE DIAMETERS

Where the internal diameter is determined by the formulas in Section 402.4, Tables AA105.1 and AA105.2 can be used to select the nominal or standard pipe size based on the calculated internal diameter.

## SECTION AA106
## EXAMPLES OF PIPING
## SYSTEM DESIGN AND SIZING

**AA106.1 Example 1: Longest length method.** Determine the required pipe size of each section and *outlet* of the *piping* system shown in Figure AA106.1, with a designated pressure drop of 0.5-inch w.c. (125 Pa) using the Longest Length Method. The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/ft$^3$ (37.5 MJ/m$^3$).

**Solution:**

1. Maximum gas demand for *Outlet* A:

$$\frac{\text{Consumption (rating plate input) or Table 402.2 if necessary}}{\text{Btu of gas}} =$$

$$\frac{\text{35,000 Btu per hour rating}}{\text{1,000 Btu per cubic foot}} = \text{35 cubic feet per hour} = \text{35 cfh}$$

Maximum gas demand for *Outlet* B:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{75{,}000}{1{,}000} = \text{75 cfh}$$

Maximum gas demand for *Outlet* C:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{35{,}000}{1{,}000} = \text{35 cfh}$$

Maximum gas demand for *Outlet* D:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{100{,}000}{1{,}000} = \text{100 cfh}$$

2. The length of pipe from the *point of delivery* to the most remote *Outlet* (A) is 60 feet (18 288 mm). This is the only distance used.
3. Using the row marked 60 feet (18 288 mm) in Table 402.4(2):
   a. *Outlet* A, supplying 35 cfh (0.99 m$^3$/hr), requires $^1/_2$-inch pipe.
   b. *Outlet* B, supplying 75 cfh (2.12 m$^3$/hr), requires $^3/_4$-inch pipe.
   c. Section 1, supplying *Outlets* A and B, or 110 cfh (3.11 m$^3$/hr), requires $^3/_4$-inch pipe.
   d. Section 2, supplying *Outlets* C and D, or 135 cfh (3.82 m$^3$/hr), requires $^3/_4$-inch pipe.
   e. Section 3, supplying *Outlets* A, B, C and D, or 245 cfh (6.94 m$^3$/hr), requires 1-inch pipe.
4. If a different gravity factor is applied to this example, the values in the row marked 60 feet (18 288 mm) of Table 402.4(2) would be multiplied by the appropriate multiplier from Table AA102.4 and the resulting cubic feet per hour values would be used to size the *piping*.

**AA106.2 Example 2: Hybrid or dual pressure systems.** Determine the required CSST size of each section of the *piping* system shown in Figure AA106.2, with a designated pressure drop of 1 psi (6.9 kPa) for the 2 psi (13.8 kPa) section and 3-inch w.c. (0.75 kPa) pressure drop for the 13-inch w.c. (2.49 kPa) section. The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/ft$^3$ (37.5 MJ/ m$^3$).

**Solution:**

1. Size 2 psi (13.8 kPa) line using Table 402.4(18).
2. Size 10-inch w.c. (2.5 kPa) lines using Table 402.4(16).
3. Using the following, determine if sizing tables can be used.
    a. Total gas load shown in Figure AA106.2 equals 110 cfh (3.11 m$^3$/hr).
    b. Determine pressure drop across regulator [see notes in Table 402.4(18)].
    c. If pressure drop across regulator exceeds $^{3}/_{4}$ psig (5.2 kPa), Table 402.4(18) cannot be used. Note: If pressure drop exceeds $^{3}/_{4}$ psi (5.2 kPa), then a larger regulator must be selected or an alternative sizing method must be used.
    d. Pressure drop across the line regulator [for 110 cfh (3.11 m$^3$/hr)] is 4-inch w.c. (0.99 kPa) based on manufacturer's performance data.
    e. Assume the CSST manufacturer has tubing sizes or EHDs of 13, 18, 23 and 30.
4. Section A [2 psi (13.8 kPa) zone]
    a. Distance from meter to regulator = 100 feet (30 480 mm).
    b. Total load supplied by A = 110 cfh (3.11 m$^3$/ hr) (furnace + water heater + dryer).
    c. Table 402.4(18) shows that EHD size 18 should be used.

    Note: It is not unusual to oversize the supply line by 25 to 50 percent of the as-installed load. EHD size 18 has a capacity of 189 cfh (5.35 m$^3$/hr).
5. Section B (low pressure zone)
    a. Distance from regulator to furnace is 15 feet (4572 mm).
    b. Load is 60 cfh (1.70 m$^3$/hr).
    c. Table 402.4(16) shows that EHD size 13 should be used.
6. Section C (low pressure zone)
    a. Distance from regulator to water heater is 10 feet (3048 mm).
    b. Load is 30 cfh (0.85 m$^3$/hr).
    c. Table 402.4(16) shows that EHD size 13 should be used.
7. Section D (low pressure zone)
    a. Distance from regulator to dryer is 25 feet (7620 mm).
    b. Load is 20 cfh (0.57 m$^3$/hr).
    c. Table 402.4(16) shows that EHD size 13 should be used.

**AA106.3 Example 3: Branch length method.** Determine the required semirigid copper tubing size of each section of the *piping* system shown in Figure AA106.3, with a designated pressure drop of 1-inch w.c. (250 Pa) (using the Branch Length Method). The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/ft$^3$ (37.5 MJ/m$^3$).

**Solution:**

1. Section A
    a. The length of tubing from the *point of delivery* to the most remote *appliance* is 50 feet (15 240 mm), A + C.
    b. Use this longest length to size Sections A and C.
    c. Using the row marked 50 feet (15 240 mm) in Table 402.4(10), Section A, supplying 220 cfh (6.2 m$^3$/hr) for four *appliances* requires 1-inch tubing.
2. Section B
    a. The length of tubing from the *point of delivery* to the range/oven at the end of Section B is 30 feet (9144 mm), A + B.
    b. Use this branch length to size Section B only.

c. Using the row marked 30 feet (9144 mm) in Table 402.4(10), Section B, supplying 75 cfh (2.12 $m^3$/hr) for the range/oven requires $^1/_2$-inch tubing.

3. Section C

    a. The length of tubing from the *point of delivery* to the dryer at the end of Section C is 50 feet (15 240 mm), A + C.

    b. Use this branch length to size Section C.

    c. Using the row marked 50 feet (15 240 mm) in Table 402.4(10), Section C, supplying 30 cfh (0.85 $m^3$/hr) for the dryer requires $^3/_8$-inch tubing.

4. Section D

    a. The length of tubing from the *point of delivery* to the water heater at the end of Section D is 30 feet (9144 mm), A + D.

    b. Use this branch length to size Section D only.

    c. Using the row marked 30 feet (9144 mm) in Table 402.4(10), Section D, supplying 35 cfh (0.99 $m^3$/hr) for the water heater requires $^3/_8$-inch tubing.

5. Section E

    a. The length of tubing from the *point of delivery* to the furnace at the end of Section E is 30 feet (9144 mm), A + E.

    b. Use this branch length to size Section E only.

    c. Using the row marked 30 feet (9144 mm) in Table 402.4(10), Section E, supplying 80 cfh (2.26 $m^3$/hr) for the furnace requires $^1/_2$-inch tubing.

**AA106.4 Example 4: Modification to existing piping system.** Determine the required CSST size for Section G (retrofit application) of the *piping* system shown in Figure AA106.4, with a designated pressure drop of 0.5-inch w.c. (125 Pa) using the branch length method. The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/$ft^3$ (37.5 MJ/$m^3$).

**Solution:**

1. The length of pipe and CSST from the *point of delivery* to the retrofit *appliance* (barbecue) at the end of Section G is 40 feet (12 192 mm), A + B + G.
2. Use this branch length to size Section G.
3. Assume the CSST manufacturer has tubing sizes or EHDs of 13, 18, 23 and 30.
4. Using the row marked 40 feet (12 192 mm) in Table 402.4(15), Section G, supplying 40 cfh (1.13 $m^3$/hr) for the barbecue requires EHD 18 CSST.
5. The sizing of Sections A, B, F and E must be checked to ensure adequate gas carrying capacity since an *appliance* has been added to the *piping* system (see Section AA106.1 for details).

**AA106.5 Example 5: Calculating pressure drops due to temperature changes.** A test *piping* system is installed on a warm autumn afternoon when the temperature is 70°F (21°C). In accordance with local custom, the new *piping* system is subjected to an air pressure test at 20 psig (138 kPa). Overnight, the temperature drops and when the inspector shows up first thing in the morning the temperature is 40°F (4°C).

If the volume of the *piping* system is unchanged, then the formula based on Boyle's and Charles' law for determining the new pressure at a reduced temperature is as follows:

$$\frac{T_1}{T_2} = \frac{P_1}{P_2}$$

where:

$T_1$ = Initial temperature, absolute ($T_1$ + 459)

$T_2$ = Final temperature, absolute ($T_2$ + 459)

$P_1$ = Initial pressure, psia ($P_1$ + 14.7)

$P_2$ = Final pressure, psia ($P_2$ + 14.7)

$$\frac{(70+459)}{(40+459)} = \frac{(20+14.7)}{(P_2+14.7)}$$

$$\frac{529}{499} = \frac{34.7}{(P_2+14.7)}$$

$$(P_2+14.7)\times\frac{529}{499} = 34.7$$

$$(P_2+14.7)\times\frac{34.7}{1.060}$$

$P_2$ = 32.7 - 14.7

$P_2$ = 18 psig

Therefore, the gauge could be expected to register 18 psig (124 kPa) when the ambient temperature is 40°F (4°C).

**AA106.6 Example 6: Pressure drop per 100 feet of pipe method.** Using the layout shown in Figure AA106.1 and $\Delta H$ = pressure drop, in w.c. (27.7 in. $H_2O$ = 1 psi), proceed as follows:

1. Length to A = 20 feet, with 35,000 Btu/hr.

   For $^1/_2$-inch pipe, $\Delta H = {}^{20\text{ feet}}/_{100\text{ feet}}$ × 0.3 inch w.c. = 0.06 in w.c.

2. Length to B = 15 feet, with 75,000 Btu/hr.

   For $^3/_4$-inch pipe, $\Delta H = {}^{15\text{ feet}}/_{100\text{ feet}}$ × 0.3 inch w.c. = 0.045 in w.c.

3. Section 1 = 10 feet, with 110,000 Btu/hr. Here there is a choice:

   For 1-inch pipe: $\Delta H = {}^{10\text{ feet}}/_{100\text{ feet}}$ × 0.2 inch w.c. = 0.02 in w.c.

   For $^3/_4$-inch pipe: $\Delta H = {}^{10\text{ feet}}/_{100\text{ feet}}$ × [0.5 inch w.c. + $^{(110{,}000\text{ Btu/hr-}104{,}000\text{ Btu/hr})}/_{(147{,}000\text{ Btu/hr-}104{,}000\text{ Btu/hr})}$ × (1.0 inches w.c. - 0.5 inch w.c.)] = 0.1 × 0.57 inch w.c.≈ 0.06 inch w.c.

   *Note that the pressure drop between 104,000 Btu/hr and 147,000 Btu/hr has been interpolated as 110,000 Btu/hr.*

4. Section 2 = 20 feet, with 135,000 Btu/hr. Here there is a choice:

   For 1-inch pipe: $\Delta H = {}^{20\text{ feet}}/_{100\text{ feet}}$ × [0.2 inch w.c. + $^{(14{,}000\text{ Btu/hr})}/_{(27{,}000\text{ Btu/hr})}$ × 0.1 inch w.c.] = 0.05 inch w.c.

   For $^3/_4$-inch pipe: $\Delta H = {}^{20\text{ feet}}/_{100\text{ feet}}$ × 1.0 inch w.c. = 0.2 inch w.c.

   *Note that the pressure drop between 121,000 Btu/hr and 148,000 Btu/hr has been interpolated as 135,000 Btu/hr, but interpolation for the ¾-inch pipe (trivial for 104,000 Btu/hr to 147,000 Btu/hr) was not used.*

5. Section 3 = 30 feet, with 245,000 Btu/hr. Here there is a choice:

   For 1-inch pipe: $\Delta H = {}^{30\text{ feet}}/_{100\text{ feet}}$ × 1.0 inches w.c. = 0.3 inch w.c.

   For $1^1/_4$ -inch pipe: $\Delta H = {}^{30\text{ feet}}/_{100\text{ feet}}$ × 0.2 inch w.c. = 0.06 inch w.c.

   *Note that interpolation for these options is ignored since the table values are close to the 245,000 Btu/hr carried by that section.*

6. The total pressure drop is the sum of the section approaching A, Sections 1 and 3, or either of the following, depending on whether an absolute minimum is needed or the larger drop can be accommodated.

   Minimum pressure drop to farthest *appliance*:

   $\Delta H$ = 0.06 inch w.c. + 0.02 inch w.c. + 0.06 inch w.c. = 0.14 inch w.c.

Larger pressure drop to the farthest *appliance*:

$\Delta H$ = 0.06 inch w.c. + 0.06 inch w.c. + 0.3 inch w.c. = 0.42 inch w.c.

*Notice that Section 2 and the run to B do not enter into this calculation, provided that the appliances have similar input pressure requirements.*

For SI units: 1 Btu/hr = 0.293 W, 1 cubic foot = 0.028 m$^3$, 1 foot = 0.305 m, 1 inch w.c. = 249 Pa.

**TABLE AA102.2**
**EQUIVALENT LENGTHS OF PIPE FITTINGS AND VALVES**

| | | SCREWED FITTINGS[1] | | | | 90° WELDING ELBOWS AND SMOOTH BENDS[2] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 45°/Ell | 90°/Ell | 180° close return bends | Tee | R/d = 1 | R/d = 1 1/3 | R/d = 2 | R/d = 4 | R/d = 6 | R/d = 8 |
| k factor = | | 0.42 | 0.90 | 2.00 | 1.80 | 0.48 | 0.36 | 0.27 | 0.21 | 0.27 | 0.36 |
| L/d' ratio[4] ***n*** = | | 14 | 30 | 67 | 60 | 16 | 12 | 9 | 7 | 9 | 12 |
| Nominal pipe size, inches | Inside diameter ***d***, inches, Schedule 40[6] | ***L*** = Equivalent Length in Feet of Schedule 40 (Standard-weight) Straight Pipe[6] | | | | | | | | | |
| 1/2 | 0.622 | 0.73 | 1.55 | 3.47 | 3.10 | 0.83 | 0.62 | 0.47 | 0.36 | 0.47 | 0.62 |
| 3/4 | 0.824 | 0.96 | 2.06 | 4.60 | 4.12 | 1.10 | 0.82 | 0.62 | 0.48 | 0.62 | 0.82 |
| 1 | 1.049 | 1.22 | 2.62 | 5.82 | 5.24 | 1.40 | 1.05 | 0.79 | 0.61 | 0.79 | 1.05 |
| 1 1/4 | 1.380 | 1.61 | 3.45 | 7.66 | 6.90 | 1.84 | 1.38 | 1.03 | 0.81 | 1.03 | 1.38 |
| 1 1/2 | 1.610 | 1.88 | 4.02 | 8.95 | 8.04 | 2.14 | 1.61 | 1.21 | 0.94 | 1.21 | 1.61 |
| 2 | 2.067 | 2.41 | 5.17 | 11.5 | 10.3 | 2.76 | 2.07 | 1.55 | 1.21 | 1.55 | 2.07 |
| 2 1/2 | 2.469 | 2.88 | 6.16 | 13.7 | 12.3 | 3.29 | 2.47 | 1.85 | 1.44 | 1.85 | 2.47 |
| 3 | 3.068 | 3.58 | 7.67 | 17.1 | 15.3 | 4.09 | 3.07 | 2.30 | 1.79 | 2.30 | 3.07 |
| 4 | 4.026 | 4.70 | 10.1 | 22.4 | 20.2 | 5.37 | 4.03 | 3.02 | 2.35 | 3.02 | 4.03 |
| 5 | 5.047 | 5.88 | 12.6 | 28.0 | 25.2 | 6.72 | 5.05 | 3.78 | 2.94 | 3.78 | 5.05 |
| 6 | 6.065 | 7.07 | 15.2 | 33.8 | 30.4 | 8.09 | 6.07 | 4.55 | 3.54 | 4.55 | 6.07 |
| 8 | 7.981 | 9.31 | 20.0 | 44.6 | 40.0 | 10.6 | 7.98 | 5.98 | 4.65 | 5.98 | 7.98 |
| 10 | 10.02 | 11.7 | 25.0 | 55.7 | 50.0 | 13.3 | 10.0 | 7.51 | 5.85 | 7.51 | 10.0 |
| 12 | 11.94 | 13.9 | 29.8 | 66.3 | 59.6 | 15.9 | 11.9 | 8.95 | 6.96 | 8.95 | 11.9 |
| 14 | 13.13 | 15.3 | 32.8 | 73.0 | 65.6 | 17.5 | 13.1 | 9.85 | 7.65 | 9.85 | 13.1 |
| 16 | 15.00 | 17.5 | 37.5 | 83.5 | 75.0 | 20.0 | 15.0 | 11.2 | 8.75 | 11.2 | 15.0 |
| 18 | 16.88 | 19.7 | 42.1 | 93.8 | 84.2 | 22.5 | 16.9 | 12.7 | 9.85 | 12.7 | 16.9 |
| 20 | 18.81 | 22.0 | 47.0 | 105.0 | 94.0 | 25.1 | 18.8 | 14.1 | 11.0 | 14.1 | 18.8 |
| 24 | 22.63 | 26.4 | 56.6 | 126.0 | 113.0 | 30.2 | 22.6 | 17.0 | 13.2 | 17.0 | 22.6 |

*(continued)*

**TABLE AA102.4**

**MULTIPLIERS TO BE USED WITH TABLES 402.4(1) THROUGH 402.4(22) WHERE THE SPECIFIC GRAVITY OF THE GAS IS OTHER THAN 0.60**

| SPECIFIC GRAVITY | MULTIPLIER |
|---|---|
| 0.35 | 1.31 |
| 0.40 | 1.23 |
| 0.45 | 1.16 |
| 0.50 | 1.10 |
| 0.55 | 1.04 |
| 0.60 | 1.00 |
| 0.65 | 0.96 |
| 0.70 | 0.93 |
| 0.75 | 0.90 |
| 0.80 | 0.87 |
| 0.85 | 0.84 |
| 0.90 | 0.82 |
| 1.00 | 0.78 |
| 1.10 | 0.74 |
| 1.20 | 0.71 |
| 1.30 | 0.68 |
| 1.40 | 0.66 |
| 1.50 | 0.63 |
| 1.60 | 0.61 |
| 1.70 | 0.59 |
| 1.80 | 0.58 |
| 1.90 | 0.56 |
| 2.00 | 0.55 |
| 2.10 | 0.54 |

**TABLE AA102.2—continued**

**EQUIVALENT LENGTHS OF PIPE FITTINGS AND VALVES**

| | MITER ELBOWS[3] (No. of miters) | WELDING TEES | VALVES (screwed, flanged, or welded) |
|---|---|---|---|

| | | 1-45° | 1-60° | 1-90° | 2-90°[5] | 3-90°[5] | Forged | Miter[3] | Gate | Globe | Angle | Swing Check |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| k factor = | | 0.45 | 0.90 | 1.80 | 0.60 | 0.45 | 1.35 | 1.80 | 0.21 | 10 | 5.0 | 2.5 |
| L/d' ratio[4] *n* = | | 15 | 30 | 60 | 20 | 15 | 45 | 60 | 7 | 333 | 167 | 83 |
| Nominal pipe size, inches | Inside diameter *d*, inches, Schedule 40[6] | *L* = Equivalent Length in Feet of Schedule 40 (Standard-weight) Straight Pipe[6] | | | | | | | | | | |
| 1/2 | 0.622 | 0.78 | 1.55 | 3.10 | 1.04 | 0.78 | 2.33 | 3.10 | 0.36 | 17.3 | 8.65 | 4.32 |
| 3/4 | 0.824 | 1.03 | 2.06 | 4.12 | 1.37 | 1.03 | 3.09 | 4.12 | 0.48 | 22.9 | 11.4 | 5.72 |
| 1 | 1.049 | 1.31 | 2.62 | 5.24 | 1.75 | 1.31 | 3.93 | 5.24 | 0.61 | 29.1 | 14.6 | 7.27 |
| 1 1/4 | 1.380 | 1.72 | 3.45 | 6.90 | 2.30 | 1.72 | 5.17 | 6.90 | 0.81 | 38.3 | 19.1 | 9.58 |
| 1 1/2 | 1.610 | 2.01 | 4.02 | 8.04 | 2.68 | 2.01 | 6.04 | 8.04 | 0.94 | 44.7 | 22.4 | 11.2 |
| 2 | 2.067 | 2.58 | 5.17 | 10.3 | 3.45 | 2.58 | 7.75 | 10.3 | 1.21 | 57.4 | 28.7 | 14.4 |
| 2 1/2 | 2.469 | 3.08 | 6.16 | 12.3 | 4.11 | 3.08 | 9.25 | 12.3 | 1.44 | 68.5 | 34.3 | 17.1 |
| 3 | 3.068 | 3.84 | 7.67 | 15.3 | 5.11 | 3.84 | 11.5 | 15.3 | 1.79 | 85.2 | 42.6 | 21.3 |
| 4 | 4.026 | 5.04 | 10.1 | 20.2 | 6.71 | 5.04 | 15.1 | 20.2 | 2.35 | 112.0 | 56.0 | 28.0 |
| 5 | 5.047 | 6.30 | 12.6 | 25.2 | 8.40 | 6.30 | 18.9 | 25.2 | 2.94 | 140.0 | 70.0 | 35.0 |
| 6 | 6.065 | 7.58 | 15.2 | 30.4 | 10.1 | 7.58 | 22.8 | 30.4 | 3.54 | 168.0 | 84.1 | 42.1 |
| 8 | 7.981 | 9.97 | 20.0 | 40.0 | 13.3 | 9.97 | 29.9 | 40.0 | 4.65 | 222.0 | 111.0 | 55.5 |
| 10 | 10.02 | 12.5 | 25.0 | 50.0 | 16.7 | 12.5 | 37.6 | 50.0 | 5.85 | 278.0 | 139.0 | 69.5 |
| 12 | 11.94 | 14.9 | 29.8 | 59.6 | 19.9 | 14.9 | 44.8 | 59.6 | 6.96 | 332.0 | 166.0 | 83.0 |
| 14 | 13.13 | 16.4 | 32.8 | 65.6 | 21.9 | 16.4 | 49.2 | 65.6 | 7.65 | 364.0 | 182.0 | 91.0 |
| 16 | 15.00 | 18.8 | 37.5 | 75.0 | 25.0 | 18.8 | 56.2 | 75.0 | 8.75 | 417.0 | 208.0 | 104.0 |
| 18 | 16.88 | 21.1 | 42.1 | 84.2 | 28.1 | 21.1 | 63.2 | 84.2 | 9.85 | 469.0 | 234.0 | 117.0 |
| 20 | 18.81 | 23.5 | 47.0 | 94.0 | 31.4 | 23.5 | 70.6 | 94.0 | 11.0 | 522.0 | 261.0 | 131.0 |
| 24 | 22.63 | 28.3 | 56.6 | 113.0 | 37.8 | 28.3 | 85.0 | 113.0 | 13.2 | 629.0 | 314.0 | 157.0 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.01745 rad.

**Note:** Values for welded fittings are for conditions where bore is not obstructed by weld spatter or backing rings. If appreciably obstructed, use values for "Screwed Fittings."

1. Flanged fittings have three-fourths the resistance of screwed elbows and tees.
2. Tabular figures give the extra resistance due to curvature alone to which should be added the full length of travel.
3. Small size socket-welding fittings are equivalent to miter elbows and miter tees.
4. Equivalent resistance in number of diameters of straight pipe computed for a value of ($f$ – 0.0075) from the relation ($n$ – $k/4f$).
5. For condition of minimum resistance where the centerline length of each miter is between d and 2 1/2*d.*
6. For pipe having other inside diameters, the equivalent resistance can be computed from the $n$ values.

Source: Crocker, S. *Piping Handbook*, 4th ed., Table XIV, pp. 100–101. Copyright 1945 by McGraw-Hill, Inc. Used by permission of McGraw-Hill Book Company.

**TABLE AA103.4**

**THOUSANDS OF BTU/H (MBH) OF NATURAL GAS PER 100 FEET OF PIPE AT VARIOUS PRESSURE DROPS AND PIPE DIAMETERS**

| PRESSURE DROP PER 100 FEET IN INCHES W.C. | PIPE SIZES (inch) | | | | | |
|---|---|---|---|---|---|---|
| | 1/2 | 3/4 | 1 | 1 1/4 | 1 1/2 | 2 |
| 0.2 | 31 | 64 | 121 | 248 | 372 | 716 |
| 0.3 | 38 | 79 | 148 | 304 | 455 | 877 |
| 0.5 | 50 | 104 | 195 | 400 | 600 | 1,160 |
| 1.0 | 71 | 147 | 276 | 566 | 848 | 1,640 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.293 W.

**TABLE AA105.2**
**COPPER TUBE STANDARD SIZES**

| TUBE TYPE | NOMINAL OR STANDARD SIZE (inches) | INTERNAL DIAMETER (inches) |
|---|---|---|
| K | 1/4 | 0.305 |
| L | 1/4 | 0.315 |
| ACR (D) | 3/8 | 0.315 |
| ACR (A) | 3/8 | 0.311 |
| K | 3/8 | 0.402 |
| L | 3/8 | 0.430 |
| ACR (D) | 1/2 | 0.430 |
| ACR (A) | 1/2 | 0.436 |
| K | 1/2 | 0.527 |
| L | 1/2 | 0.545 |
| ACR (D) | 5/8 | 0.545 |
| ACR (A) | 5/8 | 0.555 |
| K | 5/8 | 0.652 |
| L | 5/8 | 0.666 |
| ACR (D) | 3/4 | 0.666 |
| ACR (A) | 3/4 | 0.680 |
| K | 3/4 | 0.745 |
| L | 3/4 | 0.785 |
| ACR | 7/8 | 0.785 |
| K | 1 | 0.995 |
| L | 1 | 1.025 |
| ACR | 1 1/8 | 1.025 |
| K | 1 1/4 | 1.245 |
| L | 1 1/4 | 1.265 |
| ACR | 1 3/8 | 1.265 |
| K | 1 1/2 | 1.481 |

| | | |
|---|---|---|
| L | $1^1/_2$ | 1.505 |
| ACR | $1^5/_8$ | 1.505 |
| K | 2 | 1.959 |
| L | 2 | 1.985 |
| ACR | $2^1/_8$ | 1.985 |
| K | $2^1/_2$ | 2.435 |
| L | $2^1/_2$ | 2.465 |
| ACR | $2^5/_8$ | 2.465 |
| K | 3 | 2.907 |
| L | 3 | 2.945 |
| ACR | $3^1/_8$ | 2.945 |

For SI: 1 inch = 25.4 mm.

**TABLE AA105.1**
**SCHEDULE 40 STEEL PIPE STANDARD SIZES**

| NOMINAL SIZE (inch) | INTERNAL DIAMETER (inch) |
|---|---|
| $^1/_4$ | 0.364 |
| $^3/_8$ | 0.493 |
| $^1/_2$ | 0.622 |
| $^3/_4$ | 0.824 |
| 1 | 1.049 |
| $1^1/_4$ | 1.380 |
| $1^1/_2$ | 1.610 |
| 2 | 2.067 |
| $2^1/_2$ | 2.469 |
| 3 | 3.068 |
| $3^1/_2$ | 3.548 |
| 4 | 4.026 |

For SI: 1 inch = 25.4 mm.

# APPENDIX AB

# SIZING OF VENTING SYSTEMS SERVING APPLIANCES EQUIPPED WITH DRAFT HOODS, CATEGORY I APPLIANCES AND APPLIANCES LISTED FOR USE WITH TYPE B VENTS

This chapter submitted to Mechanical Code Ad-Hoc committee for review.

*This appendix is an excerpt from the 2021* **International Fuel Gas Code**® *informative Appendix B. Section and table references in the text, other than AB sections and tables, are as numbered in the* **International Fuel Gas Code** *(IFGC). For related table references in this code, you can find the IFGC table number in brackets adjacent to the table number in Chapter 24 of this code. For example, Table 504.2(2) in the IFGC is related to Table G2428.2(2) [504.2(2)] in this code.*

## SECTION AB101 EXAMPLES USING SINGLE-APPLIANCE VENTING TABLES

AB101.1 Example 1: Single draft hood-equipped appliance.

**An installer has a 120,000 British thermal unit (Btu) per hour input *appliance* with a 5-inch-diameter draft hood outlet that needs to be vented into a 10-foot-high Type B vent system. What size vent should be used assuming:**

1. *A 5-foot lateral single-wall metal vent connector is used with two 90-degree elbows, or*
2. *A 5-foot lateral single-wall metal vent connector is used with three 90-degree elbows in the vent system.*

**Solution:**

Table 504.2(2) of the *International Fuel Gas Code* should be used to solve this problem because single-wall metal vent connectors are being used with a Type B vent.

1. *Read down the first column in Table 504.2(2) of the International Fuel Gas Code until the row associated with a 10-foot height and 5-foot lateral is found. Read across this row until a vent capacity greater than 120,000 Btu per hour is located in the shaded columns labeled "NAT Max" for draft hood-equipped appliances. In this case, a 5-inch-diameter vent has a capacity of 122,000 Btu per hour and can be used for this application.*
2. *If three 90-degree elbows are used in the vent system, then the maximum vent capacity listed in the tables must be reduced by 10 percent (see Section 504.2.3 of the International Fuel Gas Code for single-appliance vents). This implies that the 5-inch-diameter vent has an adjusted capacity of only 110,000 Btu per hour. In this case, the vent system must be increased to 6 inches in diameter (see the following calculations).*

   *122,000(0.90) = 110,000 for 5-inch vent*

   *From Table 504.2(2) of the International Fuel Gas Code, select 6-inch vent.*

*186,000(0.90) = 167,000; This is greater than the required 120,000. Therefore, use a 6-inch vent and connector where three elbows are used.*

See Figure AB101.1 for an example.

AB101.2 **Example 2: Single fan-assisted appliance.** An installer has an 80,000 Btu per hour input fan-assisted *appliance* that must be installed using 10 feet of lateral connector attached to a 30-foot-high Type B vent. Two 90-degree elbows are needed for the installation. Can a single-wall metal vent connector be used for this application?

**Solution:**

Table 504.2(2) of the *International Fuel Gas Code* refers to the use of single-wall metal vent connectors with Type B vent. In the first column find the row associated with a 30-foot height and a 10-foot lateral. Read across this row, looking at the FAN Min and FAN Max columns, to find that a 3-inch-diameter single-wall metal vent connector is not recommended. Moving to the next larger size single wall connector (4 inches), note that a 4-inch-diameter single-wall metal connector has a recommended minimum vent capacity of 91,000 Btu per hour and a recommended maximum vent capacity of 144,000 Btu per hour. The 80,000 Btu per hour fan-assisted *appliance* is outside this range, so the conclusion is that a single-wall metal vent connector cannot be used to vent this *appliance* using 10 feet of lateral for the connector.

However, if the 80,000 Btu per hour input *appliance* could be moved to within 5 feet of the vertical vent, then a 4-inch single-wall metal connector could be used to vent the *appliance*. Table 504.2(2) of the *International Fuel Gas Code* shows the acceptable range of vent capacities for a 4-inch vent with 5 feet of lateral to be between 72,000 Btu per hour and 157,000 Btu per hour.

If the *appliance* cannot be moved closer to the vertical vent, then Type B vent could be used as the connector material. In this case, Table 504.2(1) of the *International Fuel Gas Code* shows that for a 30-foot-high vent with 10 feet of lateral, the acceptable range of vent capacities for a 4-inch-diameter vent attached to a fan-assisted *appliance* is between 37,000 Btu per hour and 150,000 Btu per hour.

See Figure AB101.2 for an example.

AB101.3 **Example 3: Interpolating between table values.** An installer has an 80,000 Btu per hour input *appliance* with a 4-inch-diameter draft hood outlet that needs to be vented into a 12-foot-high Type B vent. The vent connector has a 5-foot lateral length and is also Type B. Can this *appliance* be vented using a 4-inch-diameter vent?

**Solution:**

Table 504.2(1) of the *International Fuel Gas Code* is used in the case of an all Type B vent system. However, since there is no entry in Table 504.2(1) of the *International Fuel Gas Code* for a height of 12 feet, interpolation must be used. Read down the 4-inch diameter NAT Max column to the row associated with 10-foot height and 5-foot lateral to find the capacity value of 77,000 Btu per hour. Read further down to the 15-foot height, 5-foot lateral row to find the capacity value of 87,000 Btu per hour. The difference between the 15-foot height capacity value and the 10-foot height capacity value is 10,000 Btu per hour. The capacity for a vent system with a 12-foot height is equal to the capacity for a 10-foot height plus $^2/_5$ of the difference between the 10-foot and 15-foot height values, or 77,000 + $^2/_5$(10,000) = 81,000 Btu per hour. Therefore, a 4-inch-diameter vent can be used in the installation.

**AB101.4 Figures. See Figures AB101.4(1) through AB101.4(5) for examples of single-appliance venting.**

## SECTION AB102
## EXAMPLES USING COMMON VENTING TABLES

AB102.1 Example 4: Common venting two draft hood-equipped appliances. A 35,000 Btu per hour water heater is to be common vented with a 150,000 Btu per hour furnace using a common vent with a total height of 30 feet. The connector rise is 2 feet for the water heater with a horizontal length of 4 feet. The connector rise for the furnace is 3 feet with a horizontal length of 8 feet. Assume single-wall metal connectors will be used with Type B vent. What size connectors and combined vent should be used in this installation?

*Solution:*

**Table 504.3(2) of the *International Fuel Gas Code* should be used to size single-wall metal vent connectors attached to Type B vertical vents. In the vent connector capacity portion of Table 504.3(2) of the *International Fuel Gas Code*, find the row associated with a 30-foot vent height. For a 2-foot rise on the**

**vent connector for the water heater, read the shaded columns for draft hood-equipped appliances to find that a 3-inch-diameter vent connector has a capacity of 37,000 Btu per hour. Therefore, a 3-inch single-wall metal vent connector can be used with the water heater. For a draft hood-equipped furnace with a 3-foot rise, read across the appropriate row to find that a 5-inch-diameter vent connector has a maximum capacity of 120,000 Btu per hour (which is too small for the furnace) and a 6-inch-diameter vent connector has a maximum vent capacity of 172,000 Btu per hour. Therefore, a 6-inch-diameter vent connector should be used with the 150,000 Btu per hour furnace. Since both vent connector horizontal lengths are less than the maximum lengths listed in Section 504.3.2 of the *International Fuel Gas Code*, the table values can be used without adjustments.**

In the common vent capacity portion of Table 504.3(2) of the *International Fuel Gas Code*, find the row associated with a 30-foot vent height and read over to the NAT + NAT portion of the 6-inch-diameter column to find a maximum combined capacity of 257,000 Btu per hour. Since the two appliances total only 185,000 Btu per hour, a 6-inch common vent can be used.

See Figure AB102.1 for an example.

AB102.2 *Example 5a: Common venting a draft hood-equipped water heater with a fan-assisted furnace into a Type B vent.* In this case, a 35,000 Btu per hour input draft hood-equipped water heater with a 4-inch-diameter draft hood *outlet*, 2 feet of connector rise, and 4 feet of horizontal length is to be common vented with a 100,000 Btu per hour fan-assisted furnace with a 4-inch-diameter flue collar, 3 feet of connector rise, and 6 feet of horizontal length. The common vent consists of a 30-foot height of Type B vent. What are the recommended vent diameters for each connector and the common vent? The installer would like to use a single-wall metal vent connector.

*Solution:* [Table 504.3(2) of the *International Fuel Gas Code*].

Water Heater Vent Connector Diameter. Since the water heater vent connector horizontal length of 4 feet is less than the maximum value listed in Section 504.3.2 of the *International Fuel Gas Code*, the venting table values can be used without adjustments. Using the Vent Connector Capacity portion of Table 504.3(2), read down the Total Vent Height (*H*) column to 30 feet and read across the 2-foot Connector Rise (*R*) row to the first Btu per hour rating in the NAT Max column that is equal to or greater than the water heater input rating. The table shows that a 3-inch vent connector has a maximum input rating of 37,000 Btu per hour. Although this is greater than the water heater input rating, a 3-inch vent connector is prohibited by Section 504.3.21 of the *International Fuel Gas Code*. A 4-inch vent connector has a maximum input rating of not more than 67,000 Btu per hour and is equal to the draft hood *outlet* diameter. A 4-inch vent connector is selected. Since the water heater is equipped with a draft hood, there are no minimum input rating restrictions.

Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 504.3(2) of the *International Fuel Gas Code*, read down the Total Vent Height (*H*) column to 30 feet and across the 3-foot Connector Rise (*R*) row. Since the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu per hour rating greater than the furnace input rating. The 4-inch vent connector has a maximum input rating of 119,000 Btu per hour and a minimum input rating of 85,000 Btu per hour. The 100,000 Btu per hour furnace in this example falls within this range, so a 4-inch connector is adequate. Since the furnace vent connector horizontal length of 6 feet does not exceed the maximum value listed in Section 504.3.2 of the *International Fuel Gas Code*, the venting table values can be used without adjustment. If the furnace had an input rating of 80,000 Btu per hour, then a Type B vent connector [see Table 504.3(1) of the *International Fuel Gas Code*] would be needed in order to meet the minimum capacity limit.

Common Vent Diameter. The total input to the common vent is 135,000 Btu per hour. Using the Common Vent Capacity portion of Table 504.3(2) of the *International Fuel Gas Code*, read down the Total Vent Height (*H*) column to 30 feet and across this row to find the smallest vent diameter in the FAN + NAT column that has a Btu per hour rating equal to or greater than 135,000 Btu per hour. The 4-inch common vent has a capacity of 132,000 Btu per hour and the 5-inch common vent has a capacity of 202,000 Btu per hour. Therefore, the 5-inch common vent should be used in this example.

Summary. In this example, the installer can use a 4-inch-diameter, single-wall metal vent connector for the water heater and a 4-inch-diameter, single-wall metal vent connector for the furnace. The common vent should be a 5-inch-diameter Type B vent.

See Figure AB102.2 for an example.

**AB102.3 Example 5b: Common venting into a masonry chimney. In this case, the water heater and fan-assisted furnace of Example 5a are to be common vented into a clay tile-lined *masonry chimney* with a 30-foot height. The chimney is not exposed to the outdoors below the roof line. The internal dimensions of the clay tile liner are nominally 8 inches by 12 inches. Assuming the same vent connector heights, laterals and materials found in Example 5a, what are the recommended vent connector diameters, and is this an acceptable installation?**

***Solution:***

**Table 504.3(4) of the *International Fuel Gas Code* is used to size common venting installations involving single-wall connectors into masonry chimneys. Water Heater Vent Connector Diameter. Using Table 504.3(4) of the *International Fuel Gas Code*, Vent Connector Capacity, read down the Total Vent Height (H) column to 30 feet, and read across the 2-foot Connector Rise (R) row to the first Btu-per-hour rating in the NAT Max column that is equal to or greater than the water heater input rating. The table shows that a 3-inch vent connector has a maximum input of only 31,000 Btu per hour while a 4-inch vent connector has a maximum input of 57,000 Btu per hour. A 4-inch vent connector must therefore be used.**

Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 504.3(4) of the *International Fuel Gas Code*, read down the Total Vent Height (H) column to 30 feet and across the 3-foot Connector Rise (R) row. Since the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu-per-hour rating greater than the furnace input rating. The 4-inch vent connector has a maximum input rating of 127,000 Btu per hour and a minimum input rating of 95,000 Btu per hour. The 100,000 Btu-per-hour furnace in this example falls within this range, so a 4-inch connector is adequate.

Masonry Chimney. From Table AB102.3, the equivalent area for a nominal liner size of 8 inches by 12 inches is 63.6 square inches. Using Table 504.3(4) of the *International Fuel Gas Code*, Common Vent Capacity, read down the FAN + NAT column under the Minimum Internal Area of Chimney value of 63 to the row for 30-foot height to find a capacity value of 739,000 Btu per hour. The combined input rating of the furnace and water heater, 135,000 Btu per hour, is less than the table value, so this is an acceptable installation.

Section 504.3.17 of the *International Fuel Gas Code* requires the common vent area to be not greater than seven times the smallest *listed appliance* categorized vent area, flue collar area or draft hood outlet area. Both *appliances* in this installation have 4-inch-diameter outlets. From Table AB102.3, the equivalent area for an inside diameter of 4 inches is 12.2 square inches. Seven times 12.2 equals 85.4, which is greater than 63.6, so this configuration is acceptable.

AB102.4 *Example 5c: Common venting into an exterior* **masonry chimney**. In this case, the water heater and fan-assisted furnace of Examples 5a and 5b are to be common vented into an exterior *masonry chimney*. The chimney height, clay tile liner dimensions, and vent connector heights and laterals are the same as in Example 5b. This system is being installed in Charlotte, North Carolina. Does this exterior *masonry chimney* need to be relined? If so, what corrugated metallic liner size is recommended? What vent connector diameters are recommended?

*Solution:*

In accordance with Section 504.3.20 of the *International Fuel Gas Code*, Type B vent connectors are required to be used with exterior masonry chimneys. Use Tables 504.3(7a) and (7b) of the *International Fuel Gas Code* to size FAN+NAT common venting installations involving Type-B double wall connectors into exterior masonry chimneys.

The local 99-percent winter design temperature needed to use Table 504.3(7b) of the *International Fuel Gas Code* can be found in the ASHRAE *Handbook of Fundamentals.* For Charlotte, North Carolina, this design temperature is 19°F.

Chimney Liner Requirement. As in Example 5b, use the 63 square inch Internal Area columns for this size clay tile liner. Read down the 63 square inch column of Table 504.3(7a) of the *International Fuel Gas Code* to the 30-foot height row to find that the combined *appliance* maximum input is 747,000 Btu per hour. The combined input rating of the *appliances* in this installation, 135,000 Btu per hour, is less than the maximum value, so this criterion is satisfied. Table 504.3(7b) of the *International Fuel Gas Code*, at a 19°F design temperature, and at the same vent height and internal area used above, shows that the minimum allowable input rating of a space-heating *appliance* is 470,000 Btu per hour. The furnace input rating of 100,000 Btu per hour is less than this minimum value. So this criterion is not satisfied, and an alternative venting design needs to be used, such as a Type B vent shown in Example 5a or a *listed* chimney liner system shown in the remainder of the example.

In accordance with Section 504.3.19, Table 504.3(1) or Table 504.3(2) of the *International Fuel Gas Code* is used for sizing corrugated metallic liners in masonry chimneys, with the maximum common vent capacities reduced by 20 percent. This example will be continued assuming Type B vent connectors.

Water Heater Vent Connector Diameter. Using Table 504.3(1), Vent Connector Capacity, of the *International Fuel Gas Code* read down the Total Vent Height (*H*) column to 30 feet, and read across the 2-foot Connector Rise (*R*) row to the first Btu/h rating in the NAT Max column that is equal to or greater than the water heater input rating. The table shows that a 3-inch vent connector has a maximum capacity of 39,000 Btu/h. Although this rating is greater than the water heater input rating, a 3-inch vent connector is prohibited by Section 504.3.21 of the *International Fuel Gas*

*Code*. A 4-inch vent connector has a maximum input rating of 70,000 Btu/h and is equal to the draft hood outlet diameter. A 4-inch vent connector is selected.

Furnace Vent Connector Diameter. Using Table 504.3(1), Vent Connector Capacity, of the *International Fuel Gas Code* read down the Vent Height (*H*) column to 30 feet, and read across the 3-foot Connector Rise (*R*) row to the first Btu per hour rating in the FAN Max column that is equal to or greater than the furnace input rating. The 100,000 Btu per hour furnace in this example falls within this range, so a 4-inch connector is adequate.

Chimney Liner Diameter. The total input to the common vent is 135,000 Btu per hour. Using the Common Vent Capacity portion of Table 504.3(1) of the *International Fuel Gas Code*, read down the Vent Height (*H*) column to 30 feet and across this row to find the smallest vent diameter in the FAN+NAT column that has a Btu per hour rating greater than 135,000 Btu per hour. The 4-inch common vent has a capacity of 138,000 Btu per hour. Reducing the maximum capacity by 20 percent (Section 504.3.19 of the *International Fuel Gas Code*) results in a maximum capacity for a 4-inch corrugated liner of 110,000 Btu per hour, less than the total input of 135,000 Btu per hour. So a larger liner is needed. The 5-inch common vent capacity *listed* in Table 504.3(1) of the *International Fuel Gas Code* is 210,000 Btu per hour, and after reducing by 20 percent is 168,000 Btu per hour. Therefore, a 5-inch corrugated metal liner should be used in this example.

Single-Wall Connectors. Once it has been established that relining the chimney is necessary, Type B double-wall vent connectors are not specifically required. This example could be redone using Table 504.3(2) of the *International Fuel Gas Code* for single-wall vent connectors. For this case, the vent connector and liner diameters would be the same as found above with Type B double-wall connectors.

**AB102.5 Figures. See Figures AB102.5(1) through AB102.5(9) for examples of common venting. See Figure AB102.5(10) for the 99% Winter Design Temperatures for the Contiguous United States.**

**TABLE AB102.3**

**MASONRY CHIMNEY LINER DIMENSIONS WITH CIRCULAR EQUIVALENTS[a]**

| NOMINAL LINER SIZE (inches) | INSIDE DIMENSIONS OF LINER (inches) | INSIDE DIAMETER OR EQUIVALENT DIAMETER (inches) | EQUIVALENT AREA (square inches) |
|---|---|---|---|
| 4 × 8 | $2\frac{1}{2} \times 6\frac{1}{2}$ | 4 | 12.2 |
| | | 5 | 19.6 |
| | | 6 | 28.3 |
| | | 7 | 38.3 |
| 8 × 8 | $6\frac{3}{4} \times 6\frac{3}{4}$ | 7.4 | 42.7 |
| | | 8 | 50.3 |
| 8 × 12 | $6\frac{1}{2} \times 10\frac{1}{2}$ | 9 | 63.6 |
| | | 10 | 78.5 |
| 12 × 12 | $9\frac{3}{4} \times 9\frac{3}{4}$ | 10.4 | 83.3 |
| | | 11 | 95 |
| 12 × 16 | $9\frac{1}{2} \times 13\frac{1}{2}$ | 11.8 | 107.5 |
| | | 12 | 113.0 |
| | | 14 | 153.9 |
| 16 × 16 | $13\frac{1}{4} \times 13\frac{1}{4}$ | 14.5 | 162.9 |

| | | | |
|---|---|---|---|
| | | 15 | 176.7 |
| 16 × 20 | 13 × 17 | 16.2 | 206.1 |
| | | 18 | 254.4 |
| 20 × 20 | $16^3/_4 \times 16^3/_4$ | 18.2 | 260.2 |
| | | 20 | 314.1 |
| 20 × 24 | $16^1/_2 \times 20^1/_2$ | 20.1 | 314.2 |
| | | 22 | 380.1 |
| 24 × 24 | $20^1/_4 \times 20^1/_4$ | 22.1 | 380.1 |
| | | 24 | 452.3 |
| 24 × 28 | $20^1/_4 \times 20^1/_4$ | 24.1 | 456.2 |
| 28 × 28 | $24^1/_4 \times 24^1/_4$ | 26.4 | 543.3 |
| | | 27 | 572.5 |
| 30 × 30 | $25^1/_2 \times 25^1/_2$ | 27.9 | 607 |
| | | 30 | 706.8 |
| 30 × 36 | $25^1/_2 \times 31^1/_2$ | 30.9 | 749.9 |
| | | 33 | 855.3 |
| 36 × 36 | $31^1/_2 \times 31^1/_2$ | 34.4 | 929.4 |
| | | 36 | 1017.9 |

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 $m^2$.

a. Where liner sizes differ dimensionally from those shown in Table AB102.3, equivalent diameters can be determined from published tables for square and rectangular ducts of equivalent carrying capacity or by other engineering methods.

## APPENDIX AC

# EXIT TERMINALS OF MECHANICAL DRAFT AND DIRECT-VENT VENTING SYSTEMS

This appendix is informative and is not part of the code. This appendix is an excerpt from the *2018 International Fuel Gas Code®*, coordinated with the section numbering of the *International Residential Code*.

## SECTION AC101

## GENERAL

**AC101.1 Exit terminal locations.** Location requirements of exit terminals of mechanical draft and direct vent venting systems are provided in Figure AC101.1.

## APPENDIX AD

# RECOMMENDED PROCEDURE FOR SAFETY INSPECTION OF AN EXISTING APPLIANCE INSTALLATION

This appendix is an excerpt from the *2021* International Fuel Gas Code® informative Appendix D, coordinated with the section numbering of the International Residential Code.

### SECTION AD101
### GENERAL

The following procedure is intended as a guide to aid in determining that an appliance is properly installed and is in a safe condition for continued use. Where a gas supplier performs an inspection, their written procedures should be followed.

**AD101.1 Application.** This procedure is intended for existing residential installations of a furnace, boiler, room heater, water heater, cooking appliance, fireplace appliance and clothes dryer. This procedure should be performed prior to any attempt to modify the appliance installation or building envelope.

**AD101.2 Weatherization programs.** Before a building envelope is to be modified as part of a weatherization program, the existing appliance installation should be inspected in accordance with these procedures. After all unsafe conditions are repaired, and immediately after the weatherization is complete, the appliance inspections in Section AD105.2 are to be repeated.

**AD101.3 Inspection procedure.** The safety of the building occupant and inspector are to be determined as the first step as described in Section AD102. Only after the ambient environment is found to be safe should inspections of gas piping and appliances be undertaken. It is recommended that all inspections described in Sections AD103, AD104, and AD106, where the appliance is in the off mode, be completed and any unsafe conditions repaired or corrected before continuing with inspections of an operating appliance described in Sections AD105 and AD106.

**AD101.4 Manufacturer instructions.** Where available, the manufacturer's installation and operating instructions for the installed appliances should be used as part of these inspection procedures to determine if it is installed correctly and is operating properly.

**AD101.5 Instruments.** The inspection procedures include measuring for fuel gas and carbon monoxide (CO) and will require the use of a combustible gas detector (CGD) and a CO detector. It is recommended that both types of detectors be *listed*. Prior to any inspection, the detectors should be calibrated or tested in accordance with the manufacturer's instructions. In addition, it is recommended that the detectors have the following minimum specifications.

1. Gas Detector*:* The CGD should be capable of indicating the presence of the type of fuel gas for which it is to be used, for example, natural gas or propane. The combustible gas detector should be capable of the following:
    a. *PPM:* Numeric display with a parts per million (ppm) scale from 1ppm to 900 ppm in 1 ppm increments.
    b. *LEL:* Numeric display with a percent lower explosive limit (% LEL) scale from 0 percent to 100 percent in 1 percent increments.
    c. *Audio:* An audio sound feature to locate leaks.
2. CO Detector: The CO detector should be capable of the following functions and have a numeric display scale as follows:
    a. *PPM:* For measuring ambient room and appliance emissions a display scale in parts per million (ppm) from 0 to 1,000 ppm in 1 ppm increments.
    b. *Alarm:* A sound alarm function where hazardous levels of ambient CO is found (see AD102 for alarm levels)
    c. *Air Free:* Capable of converting CO measurements to an air free level in ppm. Where a CO detector is used without an air free conversion function, the CO air free can be calculated in accordance with Note 3 in Table AD106.

## SECTION AD102
## OCCUPANT AND INSPECTOR SAFETY

Prior to entering a building, the inspector should have both a combustible gas detector (CGD) and CO detector turned on, calibrated, and operating. Immediately upon entering the building, a sample of the ambient atmosphere should be taken. Based on CGD and CO detector readings, the inspector should take the following actions:

1. The CO detector indicates a carbon monoxide level of 70 ppm or greater.[1] The inspector should immediately notify the occupant of the need for themselves and any building occupant to evacuate; the inspector shall immediately evacuate and call 911.
2. Where the CO detector indicates a reading between 30 ppm and 70 ppm.[1] The inspector should advise the occupant that high CO levels have been found and recommend that all possible sources of CO should be turned off immediately and windows and doors opened. Where it appears that the source of CO is a permanently installed appliance, advise the occupant to keep the appliance off and have the appliance serviced by a qualified servicing agent.
3. Where CO detector indicates CO below 30 ppm[1] the inspection can continue.
4. The CGD indicates a combustible gas level of 20-percent LEL or greater. The inspector should immediately notify the occupant of the need for themselves and any building occupant to evacuate; the inspector shall immediately evacuate and call 911.
5. The CGD indicates a combustible gas level below 20-percent LEL, the inspection can continue.

If during the inspection process it is determined a condition exists that could result in unsafe appliance operation, shut off the appliance and advise the *owner* of the unsafe condition. Where a gas leak is found that could result in an unsafe condition, advise the owner of the unsafe condition and call the gas supplier to turn off the gas supply. The inspector should not continue a safety inspection on an operating appliance, venting system, and piping system until repairs have been made.

## SECTION AD103
## GAS PIPING AND CONNECTIONS INSPECTIONS

1. *Leak Checks*. Conduct a test for gas leakage using either a noncorrosive leak detection solution or a CGD confirmed with a leak detection solution.

   The preferred method for leak checking is by use of gas leak detection solution applied to all joints. This method provides a reliable visual indication of significant leaks.

   The use of a CGD in its audio sensing mode can quickly locate suspect leaks but can be overly sensitive indicating insignificant and false leaks. Suspect leaks found through the use of a CGD should be confirmed using a leak detection solution.

   Where gas leakage is confirmed, the *owner* should be notified that repairs must be made. The inspection should include the following components:

   a. Gas piping fittings located within the appliance space.
   b. Appliance connector fittings.
   c. Appliance gas valve/regulator housing and connections.
2. *Appliance Connector*. Verify that the appliance connection type is compliant with Section G2422. Inspect flexible appliance connections to determine if they are free of cracks, corrosion and signs of damage. Verify that there are no uncoated brass connectors. Where connectors are determined to be unsafe or where an uncoated brass connector is found, the appliance shutoff valve should be placed in the off position and the *owner* notified that the connector must be replaced.
3. *Piping Support*. Inspect piping to determine that it is adequately supported, that there is no undue stress on the piping, and if there are any improperly capped pipe openings.
4. *Bonding*. Verify that the electrical bonding of gas piping is compliant with Section G2411.

## SECTION AD104
## INSPECTIONS TO BE PERFORMED WITH THE APPLIANCE NOT OPERATING

The following safety inspection procedures are performed on appliances that are not operating. These inspections are applicable to all appliance installations.

1. *Preparing for Inspection*. Shut off all gas and electrical power to the appliances located in the same room being inspected. For gas supply, use the shutoff valve in the supply line or at the manifold serving each appliance. For electrical power, place the circuit breaker in the off position or remove the fuse that serves each appliance. A lock type device or tag should be installed on each gas shutoff valve and at the electrical panel to indicate that the service has been shut off for inspection purposes.
2. *Vent System Size and Installation*. Verify that the existing venting system size and installation are compliant with Chapter 5 of the *International Fuel Gas Code*. The size and installation of venting systems for other than natural draft and Category I appliances should be in compliance with the manufacturer's installation instructions. Inspect the venting system to determine that it is free of blockage, restriction, leakage, corrosion, and other deficiencies that could cause an unsafe condition. Inspect masonry chimneys to determine if they are lined. Inspect plastic venting system to determine that it is free of sagging and it is sloped in an upward direction to the outdoor vent termination.
3. *Combustion Air Supply*. Inspect provisions for *combustion air* as follows:
    a. *Nondirect-vent Appliances*. Determine that non-direct vent appliance installations are compliant with the *combustion air* requirements in Section G2407. Inspect any interior and exterior *combustion air* openings and any connected *combustion air* ducts to determine that there is no blockage, restriction, corrosion or damage. Inspect to determine that the upper horizontal *combustion air* duct is not sloped in a downward direction toward the air supply source.
    b. *Direct Vent Appliances*. Verify that the *combustion air* supply ducts and pipes are securely fastened to direct vent appliance and determine that there are no separations, blockage, restriction, corrosion or other damage. Determine that the combustion air source is located in the outdoors or to areas that freely communicate to the outdoors.
    c. *Unvented Appliances*. Verify that the total input of all unvented room heaters and gas-fired refrigerators installed in the same room or rooms that freely communicate with each other does not exceed 20 Btu/hr/$ft^3$.
4. *Flooded Appliances*. Inspect for flood damage to the appliance. Signs of flooding include a visible water submerge line on the appliance housing, excessive surface or component rust, deposited debris on internal components, and mildew-like odor. Inform the owner that any part of the appliance control system and any appliance gas control that has been under water must be replaced. Flood-damaged plumbing, heating, cooling and electrical appliances should be replaced.
5. *Flammable Vapors*. Inspect the room/space where the appliance is installed to determine if the area is free of the storage of gasoline or any flammable products such as oil-based solvents, varnishes or adhesives. Where the appliance is installed where flammable products will be stored or used, such as a garage, verify that the appliance burner(s) is not less than 18 inches above the floor unless the appliance is *listed* as flammable vapor ignition resistant.
6. *Clearances to Combustibles*. Inspect the immediate location where the appliance is installed to determine if the area is free of rags, paper or other combustibles. Verify that the appliance and venting system are compliant with clearances to combustible building components in accordance with Sections G2408.5, G2425.15.4, G2426.5, G2427.6.2, G2427.10.5 and other applicable sections of Section G2427.
7. *Appliance Components.* Inspect internal components by removing access panels or other components for the following:
    a. Inspect burners and crossovers for blockage and corrosion. The presence of soot, debris, and signs of excessive heating are potential indicators of incomplete combustion caused by blockage or improper burner adjustments.
    b. Metallic and nonmetallic hoses for signs of cracks, splitting, corrosion, and lose connections.
    c. Signs of improper or incomplete repairs.
    d. Modifications that override controls and safety systems.

e. Electrical wiring for loose connections; cracks, missing or worn electrical insulation; and indications of excessive heat or electrical shorting. Appliances requiring an external electrical supply should be inspected for proper electrical connection in accordance with the *National Electrical Code*.

8. *Placing Appliances Back in Operation*. Return all inspected appliances and systems to their preexisting state by reinstalling any removed access panels and components. Turn on the gas supply and electricity to each appliance found in safe condition. Proceed to the operating inspections in Sections AD105 through AD106.

## SECTION AD105
## INSPECTIONS TO BE PERFORMED WITH THE APPLIANCE OPERATING

The following safety inspection procedures are to be performed on appliances that are operating where there are no unsafe conditions or where corrective repairs have been completed.

**AD105.1 General appliance operation.**

1. *Initial Startup*. Adjust the thermostat or other control device to start the *appliance*. Verify that the *appliance* starts up normally and is operating properly.

**Determine that the pilot(s), where provided, is burning properly and that the main burner ignition is satisfactory, by interrupting and re-establishing the electrical supply to the *appliance* in any convenient manner. If the *appliance* is equipped with a continuous pilot(s), test all pilot safety devices to determine whether they are operating properly by extinguishing the pilot(s) when the main burner(s) is off and determining, after 3 minutes, that the main burner gas does not flow upon a call for heat. If the *appliance* is not provided with a pilot(s), test for proper operation of the ignition system in accordance with the *appliance* manufacturer's lighting and operating instructions.**

2. *Flame Appearance*. Visually inspect the flame appearance for proper color and appearance. Visually determine that the main burner gas is burning properly (i.e., without floating, lifting or flashback). Adjust the primary air shutter as required. If the *appliance* is equipped with high and low flame controlling or flame modulation, check for proper main burner operation at low flame.

3. *Appliance Shutdown*. Adjust the thermostat or other control device to shut down the *appliance*. Verify that the appliance shuts off properly.

**AD105.2 Test for combustion air and vent drafting for natural draft and Category I appliances.** *Combustion air* and vent draft procedures are for natural draft and Category I appliances equipped with a draft hood and connected to a natural draft venting system.

1. *Preparing for Inspection*. Close all exterior building doors and windows and all interior doors between the space in which the *appliance* is located and other spaces of the building that can be closed. Turn on any clothes dryer. Turn on any exhaust fans, such as range hoods and bathroom exhausts, so they will operate at maximum speed. Do not operate a summer exhaust fan. Close fireplace dampers and any fireplace doors.

2. *Placing the Appliance in Operation*. Place the *appliance* being inspected in operation. Adjust the thermostat or control so the *appliance* will operate continuously.

3. *Spillage Test*. Verify that all *appliances* located within the same room are in their standby mode and ready for operation. Follow lighting instructions for each *appliance* as necessary. Test for spillage at the draft hood relief opening as follows:

   a. After 5 minutes of main burner operation, check for spillage using smoke.

   b. Immediately after the first check, turn on all other fuel gas burning *appliances* within the same room so they will operate at their full inputs and repeat the spillage test.

   c. Shut down all *appliances* to their standby mode and wait for 15 minutes.

   d. Repeat the spillage test steps a through c on each *appliance* being inspected.

4. Additional Spillage Tests: Determine if the *appliance* venting is impacted by other door and air handler settings by performing the following tests.

   a. Set initial test condition in accordance with Section AD105.2, Item 1.

   b. Place the appliance(s) being inspected in operation. Adjust the thermostat or control so the appliance(s) will operate continuously.

c. Open the door between the space in which the appliance(s) is located and the rest of the building. After 5 minutes of main burner operation, check for spillage at each *appliance* using smoke.

d. Turn on any other central heating or cooling air handler fan that is located outside of the area where the *appliances* are being inspected. After 5 minutes of main burner operation, check for spillage at each *appliance* using smoke. The test should be conducted with the door between the space in which the appliance(s) is located and the rest of the building in the open and in the closed position.

5. Return doors, windows, exhaust fans, fireplace dampers, and any other fuel gas burning *appliance* to their previous conditions of use.

6. If, after completing the spillage test it is believed sufficient *combustion air* is not available, the *owner* should be notified that an alternative *combustion air* source is needed in accordance with Section G2407. Where it is believed that the venting system does not provide adequate natural draft, the *owner* should be notified that alternative vent sizing, design or configuration is needed in accordance with Chapter 24. If spillage occurs, the *owner* should be notified as to its cause, be instructed as to which position of the door (open or closed) would lessen its impact, and that corrective action by a HVAC professional should be taken.

## SECTION AD106
## APPLIANCE-SPECIFIC INSPECTIONS

The following *appliance*-specific inspections are to be performed as part of a complete inspection. These inspections are performed either with the *appliance* in the off or standby mode (indicated by "OFF") or on an *appliance* that is operating (indicated by "ON"). The CO measurements are to be undertaken only after the *appliance* is determined to be properly venting. The CO detector should be capable of calculating CO emissions in ppm air free.

1. Forced Air Furnaces:
   a. OFF. Verify that an air filter is installed and that it is not excessively blocked with dust.
   b. OFF. Inspect visible portions of the furnace combustion chamber for cracks, ruptures, holes, and corrosion. A heat exchanger leakage test should be conducted.
   c. ON. Verify both the limit control and the fan control are operating properly. Limit control operation can be checked by blocking the circulating air inlet or temporarily disconnecting the electrical supply to the blower motor and determining that the limit control acts to shut off the main burner gas.
   d. ON. Verify that the blower compartment door is properly installed and can be properly resecured if opened. Verify that the blower compartment door safety switch operates properly.
   e. ON. Check for flame disturbance before and after blower comes on which can indicate heat exchanger leaks.
   f. ON. Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table AD106.
2. Boilers:
   a. OFF and ON. Inspect for evidence of water leaks around boiler and connected piping.
   b. ON. Verify that the water pumps are in operating condition. Test low water cutoffs, automatic feed controls, pressure and temperature limit controls, and relief valves in accordance with the manufacturer's recommendations to determine that they are in operating condition.
   c. ON. Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table AD106.
3. Water Heaters:
   a. OFF. Verify that the pressure-temperature relief valve is in operating condition. Water in the heater should be at operating temperature.
   b. OFF. Verify that inspection covers, glass, and gaskets are intact and in place on a flammable vapor ignition resistant (FVIR) type water heater.
   c. ON. Verify that the thermostat is set in accordance with the manufacturer's operating instructions and measure the water temperature at the closest tub or sink to verify that it is not greater than 120°F.

d. OFF. Where required by the local building code in earthquake prone locations, inspect that the water heater is secured to the wall studs in two locations (high and low) using appropriate metal strapping and bolts.

e. ON. Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table AD106.

4. Cooking Appliances

a. OFF. Inspect oven cavity and range-top exhaust vent for blockage with aluminum foil or other materials.

b. OFF. Inspect cook top to verify that it is free from a build-up of grease.

c. ON. Measure the CO above each burner and at the oven exhaust vents after 5 minutes of burner operation. The CO should not exceed threshold in Table AD106.

5. Vented Room Heaters

a. OFF. For built-in room heaters and wall furnaces, inspect that the burner compartment is free of lint and debris.

b. OFF. Inspect that furnishings and combustible building components are not blocking the heater.

c. ON. Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table AD106.

6. Vent-Free (unvented) Heaters

a. OFF. Verify that the heater input is not more than 40,000 Btu input, but not more than 10,000 Btu where installed in a bedroom, and 6,000 Btu where installed in a bathroom.

b. OFF. Inspect the ceramic logs provided with gas log type vent free heaters that they are properly located and aligned.

c. OFF. Inspect the heater that it is free of excess lint build-up and debris.

d. OFF. Verify that the oxygen depletion safety shutoff system has not been altered or bypassed.

e. ON. Verify that the main burner shuts down within 3 minutes by extinguishing the pilot light. The test is meant to simulate the operation of the oxygen depletion system (ODS).

f. ON. Measure the CO after 5 minutes of main burner operation. The CO should not exceed threshold in Table AD106.

7. Gas Log Sets and Gas Fireplaces

a. OFF. For gas logs installed in wood burning fireplaces equipped with a damper, verify that the fireplace damper is in a fixed open position.

b. ON. Measure the CO in the firebox (log sets installed in wood burning fireplaces or in the vent (gas fireplace) after 5 minutes of main burner operation. The CO should not exceed threshold in Table AD106.

8. Gas Clothes Dryer

a. OFF. Where installed in a closet, verify that a source of make-up air is provided and inspect that any make-up air openings, louvers, and ducts are free of blockage.

b. OFF. Inspect for excess amounts of lint around the dryer and on dryer components. Inspect that there is a lint trap properly installed and it does not have holes or tears. Verify that it is in a clean condition.

c. OFF. Inspect visible portions of the exhaust duct and connections for loose fittings and connections, blockage, and signs of corrosion. Verify that the duct termination is not blocked and that it terminates in an outdoor location. Verify that only approved metal vent ducting material is installed (plastic and vinyl materials are not approved for gas dryers).

d. ON. Verify mechanical components including drum and blower are operating properly.

e. ON. Operate the clothes dryer and verify that exhaust system is intact and exhaust is exiting the termination.

f. ON. Measure the CO at the exhaust duct or termination after 5 minutes of main burner operation. The CO should not exceed threshold in Table AD106.

TABLE AD106

**CO THRESHOLDS**

| | |
|---|---|
| Boilers (all categories) | 400 ppm air free |
| Central Furnace (all categories) | 400 ppm[1] air free[2, 3] |
| Floor Furnace | 400 ppm air free |
| Gravity Furnace | 400 ppm air free |
| Wall Furnace (BIV) | 200 ppm air free |
| Wall Furnace (Direct Vent) | 400 ppm air free |
| Vented Room Heater | 200 ppm air free |
| Vent-Free Room Heater | 200 ppm air free |
| Water Heater | 200 ppm air free |
| Oven/Broiler | 225 ppm as measured |
| Top Burner | 25 ppm as measured (per burner) |
| Clothes Dryer | 400 ppm air free |
| Refrigerator | 25 ppm as measured |
| Gas Log (gas fireplace) | 25 ppm as measured in vent |
| Gas Log (installed in wood burning fireplace) | 400 ppm air free in firebox |

1. Parts per million.
2. Air-free emission levels are based on a mathematical equation (involving carbon monoxide and oxygen or carbon dioxide readings) to convert an actual diluted flue gas carbon monoxide testing sample to an undiluted air-free flue gas carbon monoxide level utilized in the appliance certification standards. For natural gas or propane, using as-measured CO ppm and $O_2$ percentage:

$$CO_{AFppm} = \left(\frac{20.9}{20.9 - O_2}\right) \times CO_{ppm}$$

where:

$CO_{AFppm}$ = Carbon monoxide, air-free ppm

$CO_{ppm}$ = As-measured combustion gas carbon monoxide ppm

$O_2$ = Percentage of oxygen in combustion gas, as a percentage

3. An alternate method of calculating the CO air-free when access to an oxygen meter is not available:

$$CO_{AFppm} = \left(\frac{UCO_2}{CO_2}\right) \times CO$$

where:

$UCO_2$ = Ultimate concentration of carbon dioxide for the fuel being burned in percent for natural gas (12.2 percent) and propane (14.0 percent)

$CO_2$ = Measured concentration of carbon dioxide in combustion products in percent

*CO* = Measured concentration of carbon monoxide in combustion products in percent

[1] US Consumer Product Safety Commission, *Responding to Residential Carbon Monoxide Incidents, Guidelines For Fire and Other Emergency Response Personnel*, Approved 7/23/02

# APPENDIX AE

# MANUFACTURED HOUSING USED AS DWELLINGS

**(DELETED)**

# APPENDIX AF

# RADON CONTROL METHODS

*If a sub-soil exhaust system is provided, the system shall conform to the requirements of this appendix.*

## SECTION AF101
## SCOPE

**AF101.1 General.** This appendix contains requirements for new construction where radon control systems are provided.

## SECTION AF102
## DEFINITIONS

**AF102.1 General.** For the purpose of these requirements, the terms used shall be defined as follows:

**DRAIN TILE LOOP.** A continuous length of drain tile or perforated pipe extending around all or part of the internal or external perimeter of a *basement* or *crawl space* footing.

**RADON GAS.** A naturally occurring, chemically inert, radioactive gas that is not detectable by human senses. As a gas, it can move readily through particles of soil and rock, and can accumulate under the slabs and foundations of homes where it can easily enter into the living space through construction cracks and openings.

**SOIL-GAS-RETARDER.** A continuous membrane of 6-mil (0.15 mm) polyethylene or other equivalent material used to retard the flow of soil gases into a building.

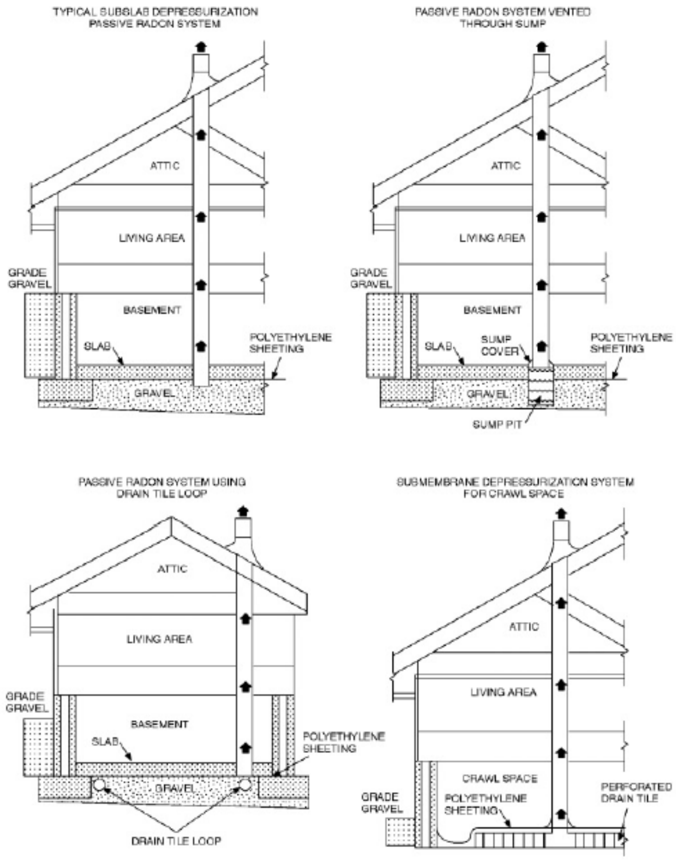
**SUBMEMBRANE DEPRESSURIZATION SYSTEM.** A system designed to achieve lower submembrane air pressure relative to *crawl space* air pressure by use of a vent drawing air from beneath the soil-gas-retarder membrane.

**SUBSLAB DEPRESSURIZATION SYSTEM (Active).** A system designed to achieve lower subslab air pressure relative to indoor air pressure by use of a fan-powered vent drawing air from beneath the slab.

**SUBSLAB DEPRESSURIZATION SYSTEM (Passive).** A system designed to achieve lower subslab air pressure relative to indoor air pressure by use of a vent pipe routed through the *conditioned space* of a building and connecting the subslab area with outdoor air, thereby relying on the convective flow of air upward in the vent to draw air from beneath the slab.

## SECTION AF103
## REQUIREMENTS

**AF103.1 General.** The following construction techniques are intended to resist radon entry and prepare the building for post-construction radon mitigation.




**~~FIGURE AF103~~FIGURE AF103.1**
**RADON-RESISTANT CONSTRUCTION DETAILS FOR FOUR FOUNDATION TYPES**

**AF103.2 Subfloor preparation.** A layer of gas-permeable material shall be placed under all concrete slabs and other floor systems that directly contact the ground and are within the walls of the living spaces of the building, to facilitate future installation of a subslab depressurization system, if needed. The gas-permeable layer shall consist of one of the following:

1. A uniform layer of clean aggregate, not less than 4 inches (102 mm) thick. The aggregate shall consist of material that will pass through a 2-inch (51 mm) sieve and be retained by a $^{1}/_{4}$-inch (6.4 mm) sieve.
2. A uniform layer of sand (native or fill), not less than 4 inches (102 mm) thick, overlain by a layer or strips of geotextile drainage matting designed to allow the lateral flow of soil gases.
3. Other materials, systems or floor designs with demonstrated capability to permit depressurization across the entire subfloor area.

**AF103.3 Soil-gas-retarder.** A minimum 6-mil (0.15 mm) [or 3-mil (0.075 mm) cross-laminated] polyethylene or equivalent flexible sheeting material shall be placed on top of the gas-permeable layer prior to casting the slab or placing the floor assembly to serve as a soil-gas-retarder by bridging any cracks that develop in the slab or floor assembly, and to prevent concrete from entering the void spaces in the aggregate base material. The sheeting shall cover the entire floor area with separate sections of sheeting lapped not less than 12 inches (305 mm). The sheeting shall fit closely around any pipe, wire or other penetrations of the material. Punctures or tears in the material shall be sealed or covered with additional sheeting.

**AF103.4 Entry routes.** Potential radon entry routes shall be closed in accordance with Sections AF103.4.1 through AF103.4.10.

**AF103.4.1 Floor openings.** Openings around bathtubs, showers, water closets, pipes, wires or other objects that penetrate concrete slabs, or other floor assemblies, shall be filled with a polyurethane caulk or equivalent sealant applied in accordance with the manufacturer's recommendations.

**AF103.4.2 Concrete joints.** Control joints, isolation joints, construction joints, and any other joints in concrete slabs or between slabs and foundation walls shall be sealed with a caulk or sealant. Gaps and joints shall be cleared of loose material and filled with polyurethane caulk or other elastomeric sealant applied in accordance with the manufacturer's recommendations.

**AF103.4.3 Condensate drains.** Condensate drains shall be trapped or routed through nonperforated pipe to daylight.

**AF103.4.4 Sumps.** Sump pits open to soil or serving as the termination point for subslab or exterior drain tile loops shall be covered with a gasketed or otherwise sealed lid. Sumps used as the suction point in a subslab depressurization system shall have a lid designed to accommodate the vent pipe. Sumps used as a floor drain shall have a lid equipped with a trapped inlet.

**AF103.4.5 Foundation walls.** Hollow block masonry foundation walls shall be constructed with either a continuous course of *solid masonry*, one course of masonry grouted solid, or a solid concrete beam at or above finished ground surface to prevent the passage of air from the interior of the wall into the living space. Where a brick veneer or other masonry ledge is installed, the course immediately below that ledge shall be sealed. Joints, cracks or other openings around all penetrations of both exterior and interior surfaces of masonry block or wood foundation walls below the ground surface shall be filled with polyurethane caulk or equivalent sealant. Penetrations of concrete walls shall be filled.

**AF103.4.6 Dampproofing.** The exterior surfaces of portions of concrete and masonry block walls below the ground surface shall be dampproofed in accordance with Section R406.

**AF103.4.7 Air-handling units.** Air-handling units in crawl spaces shall be sealed to prevent air from being drawn into the unit.

**Exception:** Units with gasketed seams or units that are otherwise sealed by the manufacturer to prevent leakage.

**AF103.4.8 Ducts.** Ductwork passing through or beneath a slab shall be of seamless material unless the air-handling system is designed to maintain continuous positive pressure within such ducting. Joints in such ductwork shall be sealed to prevent air leakage.

Ductwork located in crawl spaces shall have seams and joints sealed by closure systems in accordance with Section M1601.4.1.

**AF103.4.9 Crawl space floors.** Openings around all penetrations through floors above crawl spaces shall be caulked or otherwise filled to prevent air leakage.

**AF103.4.10 Crawl space access.** Access doors and other openings or penetrations between *basements* and adjoining crawl spaces shall be closed, gasketed or otherwise filled to prevent air leakage.

**AF103.5 Passive submembrane depressurization system.** In buildings with *crawl space* foundations, the following components of a passive submembrane depressurization system shall be installed during construction.

**Exception:** Buildings in which an *approved* mechanical *crawl space* ventilation system or other equivalent system is installed.

**AF103.5.1 Ventilation.** Crawl spaces shall be provided with vents to the exterior of the building. The minimum net area of ventilation openings shall comply with Section R408.1.

**AF103.5.2 Soil-gas-retarder.** The soil in crawl spaces shall be covered with a continuous layer of minimum 6-mil (0.15 mm) polyethylene soil-gas-retarder. The ground cover shall be lapped not less than 12 inches (305 mm) at joints and shall extend to all foundation walls enclosing the *crawl space* area.

**AF103.5.3 Vent pipe.** A plumbing tee or other *approved* connection shall be inserted horizontally beneath the sheeting and connected to a 3- or 4-inch-diameter (76 or 102 mm) fitting with a vertical vent pipe installed through the sheeting. The vent pipe shall be extended up through the building floors, and terminate not less than 12 inches (305 mm) above the roof in a location not less than 10 feet (3048 mm) away from any window or other opening into the *conditioned spaces* of the building that is less than 2 feet (610 mm) below the exhaust point, and 10 feet (3048 mm) from any window or other opening in adjoining or adjacent buildings.

**AF103.6 Passive subslab depressurization system.** In *basement* or slab-on-grade buildings, the following components of a passive subslab depressurization system shall be installed during construction.

**AF103.6.1 Vent pipe.** A minimum 3-inch-diameter (76 mm) ABS, PVC or equivalent gastight pipe shall be embedded vertically into the subslab aggregate or other permeable material before the slab is cast. A "T" fitting or equivalent method shall be used to ensure that the pipe opening remains within the subslab permeable material. Alternatively, the 3-inch (76 mm) pipe shall be inserted directly into an interior perimeter drain tile loop or through a sealed sump cover where the sump is exposed to the subslab aggregate or connected to it through a drainage system.

The pipe shall be extended up through the building floors, and terminate not less than 12 inches (305 mm) above the surface of the roof in a location not less than 10 feet (3048 mm) away from any window or other opening into the *conditioned spaces* of the building that is less than 2 feet (610 mm) below the exhaust point, and 10 feet (3048 mm) from any window or other opening in adjoining or adjacent buildings.

**AF103.6.2 Multiple vent pipes.** In buildings where interior footings or other barriers separate the subslab aggregate or other gas-permeable material, each area shall be fitted with an individual vent pipe. Vent pipes shall connect to a single vent that terminates above the roof or each individual vent pipe shall terminate separately above the roof.

**AF103.7 Vent pipe drainage.** Components of the radon vent pipe system shall be installed to provide positive drainage to the ground beneath the slab or soil-gas-retarder.

**AF103.8 Vent pipe accessibility.** Radon vent pipes shall be accessible for future fan installation through an attic or other area outside the *habitable space*.

**Exception:** The radon vent pipe need not be accessible in an attic space where an *approved* roof-top electrical supply is provided for future use.

**AF103.9 Vent pipe identification.** Exposed and visible interior radon vent pipes shall be identified with not less than one *label* on each floor and in accessible *attics*. The *label* shall read: “Radon Reduction System.”

**AF103.10 Combination foundations.** Combination *basement*/*crawl space* or slab-on-grade/*crawl space* foundations shall have separate radon vent pipes installed in each type of foundation area. Each radon vent pipe shall terminate above the roof or shall be connected to a single vent that terminates above the roof.

**AF103.11 Building depressurization.** Joints in air ducts and plenums in un*conditioned spaces* shall meet the requirements of Section M1601. Thermal envelope air infiltration requirements shall comply with the energy conservation provisions in Chapter 11. Fireblocking shall meet the requirements contained in Section R302.11.

**AF103.12 Power source.** To provide for future installation of an active submembrane or subslab depressurization system, an electrical circuit terminated in an *approved* box shall be installed during construction in the attic or other anticipated location of vent pipe fans. An electrical supply shall be accessible in anticipated locations of system failure alarms.

## SECTION AF104

## TESTING

**AF104.1 Testing.** Where radon-resistant construction is performed, radon testing shall be as specified in Items 1 through 11:

1. Testing shall be performed after the dwelling passes its air tightness test.
2. Testing shall be performed after the radon control system and HVAC installations are complete. The HVAC system shall be operating during the test. Where the radon system has an installed fan, the dwelling shall be tested with the radon fan operating.
3. Testing shall be performed at the lowest occupied floor level, whether or not that space is finished. Spaces that are physically separated and served by different HVAC systems shall be tested separately.
4. Testing shall not be performed in a closet, hallway, stairway, laundry room, furnace room, bathroom or kitchen.
5. Testing shall be performed with a commercially available radon test kit or testing shall be performed by an approved third party with a continuous radon monitor. Testing with test kits shall include two tests, and the test results shall be averaged. Testing shall be in accordance with this section and the testing laboratory kit manufacturer's instructions.
6. Testing shall be performed with the windows closed. Testing shall be performed with the exterior doors closed, except when being used for entrance or exit. Windows and doors shall be closed for not fewer than 12 hours prior to the testing.
7. Testing shall be performed by the builder, a registered design professional or an approved third party.
8. Testing shall be conducted over a period of not less than 48 hours or not less that the period specified by the testing device manufacturer, whichever is longer.
9. Written radon test results shall be provided by the test lab or testing party.
10. Where the radon test result is 4 pCi/L or greater, the fan for the radon vent pipe shall be installed as specified in Sections AF103.9 and AF103.12.
11. Where the radon test result is 4 pCi/L or greater, the system shall be modified and retested until the test result is less than 4 pCi/L.

Exception: Testing is not required where the occupied space is located above an unenclosed open space.

# APPENDIX AG

# PIPING STANDARDS FOR VARIOUS APPLICATIONS

*(The provisions contained in this appendix are adopted as part of this code.)*

## SECTION AG101
## PLASTIC PIPING STANDARDS

**AG101.1 Plastic piping.** Table AG101.1 provides a list of plastic piping product standards for various applications.

## SECTION AG102
## REFERENCED STANDARDS

**AG102.1 General.** See Table AG102.1 for standards that are referenced in this appendix. Standards are listed by the standard identification with the effective date, standard title, and the table that references the standard.

**TABLE AG101.1**
**PLASTIC PIPING STANDARDS FOR VARIOUS APPLICATIONS[a, b]**

| APPLICATION | LOCATION | TYPE OF PLASTIC PIPING | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ABS | CPVC | PE | PE-AL-PE | PE-RT | PEX | PEX-AL-PEX | PP | PVC |
| Central vacuum | System piping | — | — | — | — | — | — | — | — | ASTM F2158 |
| Foundation drainage | System piping | ASTM F628 | — | ASTM F405 | — | — | — | — | — | ASTM D2665; ASTM D2729; ASTM D3034 |
| Geothermal ground loop | System piping | — | ASTM D2846; ASTM F441; ASTM F442; ASTM F2855; CSA B137.6 | ASTM D2239; ASTM D2737; ASTM D3035 | ASTM F1282 | ASTM F2623; ASTM F2769; CSA B137.18 | ASTM F876; CSA B137.5 | ASTM F1281 | ASTM F2389; CSA B137.11 | ASTM D1785; ASTM D2241; CSA B137.3 |
| | Loop piping | — | — | ASTM D2239; ASTM D2737; ASTM D3035; NSF 358-1 | ASTM F1282 | ASTM F2623; ASTM F2769; CSA B137.18 | ASTM F876; CSA B137.5 | — | ASTM F2389; CSA B137.11 | — |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Graywater | Nonpressure distribution/ collection | ASTM F628 | — | ASTM D2239; ASTM D2737; ASTM D3035; ASTM F2306 | — | — | — | — | ASTM F2389; CSA B137.11 | ASTM D1785; ASTM D2729; ASTM D2949; ASTM D3034; ASTM F891; ASTM F1760; CSA B137.3 |
| | Pressure/ distribution | — | ASTM D2846; ASTM F441; ASTM F442; ASTM F2855; CSA B137.6 | ASTM D2239; ASTM D2737; ASTM D3035 | ASTM F1282 | ASTM F2623; ASTM F2769; CSA B137.18 | ASTM F876; CSA B137.5 | ASTM F1281 | ASTM F2389; CSA B137.11 | ASTM D1785; ASTM D2241; CSA B137.3 |
| Radiant cooling | Loop piping | — | ASTM D2846; ASTM F441; ASTM F442; ASTM F2855 | ASTM D2239; ASTM D2737; ASTM D3035 | ASTM F1282 | ASTM F2623; ASTM F2769; CSA B137.18 | ASTM F876; CSA B137.5 | ASTM F1281 | ASTM F2389; CSA B137.11 | — |

*(continued)*

**TABLE AG101.1—continued**

**PLASTIC PIPING STANDARDS FOR VARIOUS APPLICATIONS[a, b]**

| APPLICATION | LOCATION | TYPE OF PLASTIC PIPING | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ABS | CPVC | PE | PE-AL-PE | PE-RT | PEX | PEX-AL-PEX | PP | PVC |
| Radiant heating | Loop piping | — | ASTM D2846; ASTM F441; ASTM F442; ASTM F2855 | — | ASTM F1282 | ASTM F2623; ASTM F2769; CSA B137.18 | ASTM F876; CSA B137.5 | ASTM F1281 | ASTM F2389; CSA B137.11 | — |
| Rainwater harvesting | Nonpressure/ collection | ASTM F628 | — | ASTM F1901 | — | — | — | — | ASTM F2389; CSA B137.11 | ASTM D1785; ASTM D2729; ASTM D2949; ASTM F891; ASTM F1760; CSA B137.3 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pressure/ distribution | — | ASTM D2846/ D2846M; ASTM F441; ASTM F442; ASTM F2855; CSA B137.6 | ASTM D2239 ASTM D2737; ASTM D3035 | ASTM F1282 | ASTM F2623; ASTM F2769; CSA B137.18 | ASTM F876; CSA B137.5 | ASTM F1281 | ASTM F2389; CSA B137.11 | ASTM D1785; ASTM D2241; CSA B137.3 |
| Radon venting | System piping | ASTM F628 | — | — | — | — | — | — | — | ASTM D1785; ASTM F891; ASTM F1760 |
| Reclaimed water | Main to building service | — | ASTM D2846/ D2846M; ASTM F441; ASTM F442; ASTM F2855; CSA B137.6 | ASTM D3035; AWWA C901; CSA B137.1 | ASTM F1282 | ASTM F2623; ASTM F2769; CSA B137.18 | ASTM F876; AWWA C904; CSA B137.5 | — | ASTM F2389; CSA B137.11 | ASTM D1785; ASTM D2241; AWWA C905; CSA B137.3 |
| | Pressure/ distribution/ irrigation | — | ASTM D2846; ASTM F441; ASTM F442; ASTM F2855; CSA B137.6 | ASTM D2239; ASTM D2737; ASTM D3035 | ASTM F1282 | ASTM F2623; ASTM F2769; CSA B137.18 | ASTM F876; CSA B137.5 | ASTM F1281 | ASTM F2389; AWWA C900; CSA B137.11 | ASTM D1785; ASTM D2241; AWWA C900 |

*(continued)*

**TABLE AG101.1—continued**

**PLASTIC PIPING STANDARDS FOR VARIOUS APPLICATIONS[a, b]**

| APPLICATION | LOCATION | TYPE OF PLASTIC PIPING | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ABS | CPVC | PE | PE-AL-PE | PE-RT | PEX | PEX-AL-PEX | PP | PVC |
| Residential fire sprinklers[c] | Sprinkler piping | — | ASTM F441; ASTM F442; CSA B137.6; UL 1821 | — | — | ASTM F2769; CSA B137.18 | ASTM F876; CSA B137.5; UL 1821 | — | ASTM F2389; CSA B137.11 | — |
| Solar heating | Pressure/ distribution | — | ASTM D2846; ASTM F441; ASTM F442; ASTM F2855 | — | — | ASTM F2623; ASTM F2769; CSA B137.18 | ASTM F876; CSA B137.5 | ASTM F1281 | ASTM F2389; CSA B137.11 | — |

a. This table indicates manufacturing standards for plastic piping materials that are suitable for use in the applications indicated. Such applications support green and sustainable building practices. The system designer or the installer of piping shall verify that the piping chosen for an application complies with local codes and the recommendations of the manufacturer of the piping.
b. Fittings applicable for the piping shall be as recommended by the manufacturer of the piping.
c. Piping systems for fire sprinkler applications shall be listed for the application.

**TABLE AG102.1**
**REFERENCED STANDARDS**

| STANDARD ACRONYM | STANDARD NAME | TABLE HEREIN REFERENCED |
|---|---|---|
| ASTM D1785—15E1 | *Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120* | Table AG101.1 |
| ASTM D2239—12A | *Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter* | Table AG101.1 |
| ASTM D2241—15 | *Specification for Poly (Vinyl Chloride) (PVC) Pressure-rated Pipe (SDR-Series)* | Table AG101.1 |
| ASTM D2665—14 | *Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste and Vent Pipe and Fittings* | Table AG101.1 |
| ASTM D2729—17 | *Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings* | Table AG101.1 |
| ASTM D2737—2012A | *Specification for Polyethylene (PE) Plastic Tubing* | Table AG101.1 |
| ASTM D2846/ D2846M—2017BE1 | *Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot- and Cold-water Distribution Systems* | Table AG101.1 |
| ASTM D2949—10 | *Specification for 3.25-in. Outside Diameter Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste and Vent Pipe and Fittings* | Table AG101.1 |
| ASTM D3034—2016 | *Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings* | Table AG101.1 |
| ASTM D3035—15 | *Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter* | Table AG101.1 |
| ASTM F405—05 | *Specification for Corrugated Polyethylene (PE) Pipe and Fittings* | Table AG101.1 |
| ASTM F441/F441M—15 | *Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80* | Table AG101.1 |
| ASTM F442/F442M—13E1 | *Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)* | Table AG101.1 |
| ASTM F628—2012E2 | *Specification for Acrylonitrile-butadiene-styrene (ABS) Schedule 40 Plastic Drain, Waste and Vent Pipe with a Cellular Core* | Table AG101.1 |
| ASTM F876—2017 | *Specification for Cross-linked Polyethylene (PEX) Tubing* | Table AG101.1 |
| ASTM F891—2016 | *Specification for Coextruded Poly (Vinyl Chloride) (PVC) Plastic Pipe with a Cellular Core* | Table AG101.1 |
| ASTM F1281—2017 | *Specification for Cross-linked Polyethylene/Aluminum/ Cross-linked Polyethylene (PEX-AL-PEX) Pressure Pipe* | Table AG101.1 |
| ASTM F1282—2017 | *Specification for Polyethylene/Aluminum/Polyethylene (PE-AL-PE) Composite Pressure Pipe* | Table AG101.1 |
| ASTM F1760—01 (2011) | *Standard Specification for Coextruded Poly (Vinyl Chloride) (PVC) Non-Pressure Plastic Pipe Having Reprocessed-Recycled Content* | Table AG101.1 |
| ASTM F1901—10 | *Standard Specification for Polyethylene (PE) Pipe and Fittings for Roof Drain Systems* | Table AG101.1 |
| ASTM F2158—08 (2016) | *Standard for Residential Central-vacuum Tube and Fittings* | Table AG101.1 |
| ASTM F2306/ F2306M—2018 | *Standard Specification for 12" to 60" Annular Corrugated Profile-wall Polyethylene (PE) Pipe and Fittings for Gravity Flow Storm Sewer and Sub-surface Drainage Applications* | Table AG101.1 |
| ASTM F2389—2017A | *Standard for Pressure-rated Polypropylene (PP) Piping Systems* | Table AG101.1 |

| | | |
|---|---|---|
| ASTM F2623—14 | *Standard Specification for Polyethylene of Raised Temperature (PE-RT) SDRG Tubing* | Table AG101.1 |
| ASTM F2769—18 | *Polyethylene or Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems* | Table AG101.1 |
| ASTM F2855—12 | *Standard Specification for Chlorinated Poly (Vinyl Chloride)/ Aluminum/Chlorinated Poly (Vinyl Chloride) (CPVC AL CPVC) Composite Pressure Tubing* | Table AG101.1 |

(continued)

**TABLE AG102.1—continued**
**REFERENCED STANDARDS**

| STANDARD ACRONYM | STANDARD NAME | TABLE HEREIN REFERENCED |
|---|---|---|
| AWWA C900—07 | *Polyvinyl chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. through 12 in. (350 mm through 1200 mm), for Water Transmission and Distribution* | Table AG101.1 |
| AWWA C901—16 | *Polyethylene (PE) Pressure Pipe and Tubing $^{1}/_{2}$ in. (13 mm) through 3 in. (76 mm) for Water Service* | Table AG101.1 |
| AWWA C904—16 | *Cross-linked Polyethylene (PEX) Pressure Tubing, $^{1}/_{2}$ in. (13 mm) through 3 in. (76 mm) for Water Service* | Table AG101.1 |
| AWWA C905—10 | *Polyvinyl chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 in. through 48 in. (100 mm through 300 mm)* | Table AG101.1 |
| CSA B137.1—17 | *Polyethylene (PE) Pipe, Tubing and Fittings for Cold Water Pressure Services* | Table AG101.1 |
| CSA B137.3—17 | *Rigid Poly (Vinyl Chloride) (PVC) Pipe for Pressure Applications* | Table AG101.1 |
| CSA B137.5—17 | *Cross-linked Polyethylene (PEX) Tubing Systems for Pressure Applications* | Table AG101.1 |
| CSA B137.6—17 | *Chlorinated polyvinylchloride CPVC Pipe, Tubing and Fittings for Hot- and Cold-water Distribution Systems* | Table AG101.1 |
| CSA B137.11—17 | *Polypropylene (PP-R) Pipe and Fittings for Pressure Applications* | Table AG101.1 |
| CSA B137.18—17 | *Polyethylene of Raised Temperature (PE-RT) Tubing Systems for Pressure Applications* | Table AG101.1 |
| NSF 358-1—2017 | *Polyethylene Pipe and Fittings for Water-based Ground Source "Geothermal" Heat Pump Systems* | Table AG101.1 |
| UL 1821—2011 | *Standard for Thermoplastic Sprinkler Pipe and Fittings for Fire Protection Service—with revisions through August 2015* | Table AG101.1 |

# APPENDIX AH
# PATIO COVERS

*Deleted.*

## APPENDIX AI
# PRIVATE SEWAGE DISPOSAL

*Deleted*

## APPENDIX AJ

# EXISTING BUILDINGS AND STRUCTURES

***DELETED. See North Carolina Existing Building Code.***

# APPENDIX AK
# SOUND TRANSMISSION

## SECTION AK101
## GENERAL

**AK101.1 General.** Wall and floor-ceiling assemblies separating *dwelling units*, including those separating adjacent townhouse units, shall provide airborne sound insulation for walls, and both airborne and impact sound insulation for floor-ceiling assemblies.

**AK102.1 General.** Airborne sound insulation for wall and floor-ceiling assemblies shall meet a sound transmission class (STC) rating of 45 ~~when~~ where tested in accordance with ASTM E90 or a Normalized Noise Isolation Class (NNIC) rating of 42 where tested in accordance with ASTM E336. Penetrations or openings in construction assemblies for piping; electrical devices; recessed cabinets; bathtubs; soffits; or heating, ventilating or exhaust ducts shall be sealed, lined, insulated or otherwise treated to maintain the required ratings. *Dwelling unit* entrance doors, which share a common space, shall be tight fitting to the frame and sill.

**AK102.1.1 Masonry.** The sound transmission class of *concrete masonry* and *clay masonry* assemblies shall be calculated in accordance with TMS 0302 or determined through testing in accordance with ASTM E90.

## SECTION AK103
## STRUCTURAL-BORNE SOUND

**AK103.1 General.** Floor/ceiling assemblies between *dwelling units*, or between a *dwelling unit* and a public or service area within a structure, shall have an impact insulation class (IIC) rating of not less than 45 when tested in accordance with ASTM E492 or a Normalized Impact Sound Rating (NISR) of 42 where tested in accordance with ASTM E1007.

## SECTION AK104
## REFERENCED STANDARDS

**AK104.1 General.** See Table AK104.1 for standards that are referenced in various sections of this appendix. Standards are listed by the standard identification with the effective date, the standard title, and the section or sections of this appendix that references the standard.

~~**SECTION AK104**~~
~~**REFERENCED STANDARDS**~~
~~**ASTM**~~
~~ASTM E90—04 Test Method for Laboratory Measurement of Air-borne Sound Transmission Loss of Building Partitions and Elements . . . . . . . AK102~~
~~ASTM E492—09 Specification for Laboratory Measurement of Impact Sound Transmission through Floor-ceiling Assemblies Using the Tapping Machine. . . . . . . . . . . . . . . . . . . .AK103~~
~~**The Masonry Society**~~
~~TMS 0302—12 Standard for Determining the Sound Transmission Class Rating~~

~~for Masonry Walls . . . . . . . .AK102.1.1~~

**TABLE AK104.1**

**REFERENCED STANDARDS**

| STANDARD ACRONYM | STANDARD NAME | SECTIONS HEREIN REFERENCED |
|---|---|---|
| ASTM E90—09 | *Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements* | AK102.1, AK102.1.1 |
| ASTM E336—17a | *Standard Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings* | AK102.1 |
| ASTM E492—09 | *Specification for Laboratory Measurement of Impact Sound Transmission through Floor-ceiling Assemblies Using the Tapping Machine* | AK103.1 |
| ASTM E1007—16 | *Standard Test Method for Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures* | AK103.1 |
| TMS 0302—12 | *Standard for Determining the Sound Transmission Class Rating for Masonry Walls* | AK102.1.1 |

# APPENDIX AL
# PERMIT FEES

*Deleted*

## APPENDIX AM

# HOME DAY CARE—R-3 OCCUPANCY

Deleted.

# APPENDIX AN

# VENTING METHODS

*This appendix is informative and is not part of the code. This appendix provides examples of various venting methods.*

## SECTION AN101
## VENTING METHODS

**AN101.1 General.** Venting methods are illustrated in Figures AN101.1(1) through AN101.1(7).

# APPENDIX AO
# AUTOMATIC VEHICULAR GATES

*The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.*

## SECTION AO101
## GENERAL

**AO101.1 General.** The provisions of this appendix shall control the design and construction of automatic vehicular gates installed on the lot of a one- or two-family dwelling.

## SECTION AO102
## DEFINITION

**AO102.1 General.** The following term shall, for the purposes of this appendix, have the meaning shown herein.

**VEHICULAR GATE.** A gate that is intended for use at a vehicular entrance or exit to the lot of a one- or two-family dwelling, and that is not intended for use by pedestrian traffic.

## SECTION AO103
## AUTOMATIC VEHICULAR GATES

**AO103.1 Vehicular gates intended for automation.** Vehicular gates intended for automation shall be designed, constructed and installed to comply with the requirements of ASTM F2200.

**AO103.2 Vehicular gate openers.** Vehicular gate openers, where provided, shall be *listed* in accordance with UL 325.

## SECTION AO104
## REFERENCED STANDARDS

**AO104.1 General.** See Table AO104.1 for standards that are referenced in various sections of this appendix. Standards are listed by the standard identification with the effective date, the standard title, and the section or sections of this appendix that reference the standard.

**TABLE AO104.1**
**REFERENCED STANDARDS**

| STANDARD ACRONYM | STANDARD NAME | SECTIONS HEREIN REFERENCED |
|---|---|---|
| ASTM F2200—14 | *Standard Specification for Automated Vehicular Gate Construction* | AO103.1 |
| UL 325—02 | *Door, Drapery, Gate, Louver and Window Operations and Systems—with revisions through May 2015* | AO103.2 |

# APPENDIX AP

# SIZING OF WATER PIPING SYSTEM

## SECTION AP101
## GENERAL

**AP101.1 Scope.**

**AP101.1.1 Two procedures.** This appendix outlines two procedures for sizing a water piping system (see Sections AP103.3 and AP201.1). The design procedures are based on the minimum static pressure available from the supply source, the head changes in the system caused by friction and elevation, and the rates of flow necessary for operation of various fixtures.

**AP101.1.2 Variable conditions.** Because of the variable conditions encountered in hydraulic design, it is impractical to specify definite and detailed rules for sizing of the water piping system. Accordingly, other sizing or design methods conforming to good engineering practice standards are acceptable alternatives to those presented herein.

## SECTION AP102
## INFORMATION REQUIRED

**AP102.1 Preliminary.** Obtain the necessary information regarding the minimum daily static service pressure in the area where the building is to be located. If the building supply is to be metered, obtain information regarding friction loss relative to the rate of flow for meters in the range of sizes likely to be used. Friction loss data can be obtained from most manufacturers of water meters.

**AP102.2 Demand load.**

**AP102.2.1 Fixture demand.** Estimate the supply demand of the building main and the principal branches and risers of the system by totaling the corresponding demand from the applicable part of Table AP103.3(3).

**AP102.2.2 Continuous demand.** Estimate continuous supply demands, in gallons per minute (gpm) (L/m) such as for lawn sprinklers and air conditioners, and add the sum to the total demand for fixtures. The result is the estimated supply demand for the building supply.

## SECTION AP103
## SELECTION OF PIPE SIZE

**AP103.1 General.** Decide from Table P2903.1 what is the desirable minimum residual pressure that should be maintained at the highest fixture in the supply system. If the highest group of fixtures contains flushometer valves, the pressure for the group should be not less than 15 pounds per square inch (psi) (103.4 kPa) flowing. For flush tank supplies, the available pressure should be not less than 8 psi (55.2 kPa) flowing, except blowout action fixtures must not be less than 25 psi (172.4 kPa) flowing.

**AP103.2 Pipe sizing.**

**AP103.2.1 Pipe size selection.** Pipe sizes can be selected using the following procedure or by use of other design methods conforming to acceptable engineering practice that are *approved* by the *building official*. The sizes selected must not be less than the minimum required by this code.

**AP103.2.2 Pressures and losses.** Water pipe sizing procedures are based on a system of pressure requirements and losses, the sum of which must not exceed the minimum pressure available at the supply source. These pressures are as follows:

1. Pressure required at fixture to produce required flow. See Section P2903.1 of this code and Section 604.3 of the *International Plumbing Code*.
2. Static pressure loss or gain (due to head) is computed at 0.433 psi per foot (9.8 kPa/m) of elevation change.

**Example:** Assume that the highest fixture supply outlet is 20 feet (6096 mm) above or below the supply source. This produces a static pressure differential of 8.66 psi (59.8 kPa) loss [20 feet by 0.433 psi per foot (2096 mm by 9.8 kPa/m)].

3. Loss through water meter. The friction or pressure loss can be obtained from meter manufacturers.
4. Loss through taps in water main.
5. Loss through special devices, such as filters, softeners, backflow prevention devices and pressure regulators. These values must be obtained from the manufacturer.
6. Loss through valves and fittings. Losses for these items are calculated by converting to the *equivalent length* of piping and adding to the total pipe length.
7. Loss caused by pipe friction can be calculated where the pipe size, pipe length and flow through the pipe are known. With these three items, the friction loss can be determined. For piping flow charts not included, use manufacturers' tables and velocity recommendations.
8. For the purposes of all examples, the following metric conversions are applicable:

   1 cubic foot per minute = 0.4719 L/s.

   1 square foot = 0.0929 $m^2$.

   1 degree = 0.0175 rad.

   1 pound per square inch = 6.895 kPa.

   1 inch = 25.4 mm.

   1 foot = 304.8 mm.

   1 gallon per minute = 3.785 L/m.

**AP103.3 Segmented loss method.** The size of water service mains, branch mains and risers by the segmented loss method, must be determined by knowing the water supply demand [gpm (L/m)], available water pressure [psi (kPa)] and friction loss caused by the water meter and *developed length* of pipe [feet (m)], including the *equivalent length* of fittings. This design procedure is based on the following parameters:

- The calculated friction loss through each length of pipe.
- A system of pressure losses, the sum of which must not exceed the minimum pressure available at the street main or other source of supply.
- Pipe sizing based on estimated peak demand, total pressure losses caused by difference in elevation, equipment, *developed length* and pressure required at the most remote fixture; loss through taps in water main; losses through fittings, filters, backflow prevention devices, valves and pipe friction.

Because of the variable conditions encountered in hydraulic design, it is impractical to specify definite and detailed rules for the sizing of the water piping system. Current sizing methods do not address the differences in the probability of use and flow characteristics of fixtures between types of occupancies. Creating an exact model of predicting the demand for a building is impossible and final studies assessing the impact of water conservation on demand are not yet complete. The following steps are necessary for the segmented loss method.

1. **Preliminary.** Obtain the necessary information regarding the minimum daily static service pressure in the area where the building is to be located. If the building supply is to be metered, obtain information regarding friction loss relative to the rate of flow for meters in the range of sizes to be used. Friction loss data can be obtained from manufacturers of water meters. Enough pressure must be available to overcome all system losses caused by friction and elevation so that plumbing fixtures operate properly. Section 604.6 of the *International Plumbing Code* requires that the water distribution system be designed for the minimum pressure available taking into consideration pressure fluctuations. The lowest pressure must be selected to guarantee a continuous, adequate supply of water. The lowest pressure in the public main usually occurs in the summer because of lawn sprinkling and supplying water for air-conditioning cooling towers. Future demands placed on the public

main as a result of large growth or expansion should be considered. The available pressure will decrease as additional loads are placed on the public system.

2. **Demand load.** Estimate the supply demand of the building main and the principal branches and risers of the system by totaling the corresponding demand from the applicable part of Table AP103.3(3). When estimating peak demand, sizing methods typically use water supply fixture units (w.s.f.u.) [see Table AP103.3(2)]. This numerical factor measures the load-producing effect of a single plumbing fixture of a given kind. The use of fixture units can be applied to a single basic probability curve (or table), found in the various sizing methods [see Table AP103.3(3)]. The fixture units are then converted into a gpm (L/m) flow rate for estimating demand.
    2.1. Estimate continuous supply demand in gpm (L/m) such as for lawn sprinklers, air conditioners, etc., and add the sum to the total demand for fixtures. The result is the estimated supply demand for the building supply. Fixture units cannot be applied to constant-use fixtures, such as hose bibbs, lawn sprinklers and air conditioners. These types of fixtures must be assigned the gpm (L/m) value.
3. **Selection of pipe size.** This water pipe sizing procedure is based on a system of pressure requirements and losses, the sum of which must not exceed the minimum pressure available at the supply source. These pressures are as follows:
    3.1. Pressure required at the fixture to produce required flow. See Section P2903.1 of this code and Section 604.3 of the *International Plumbing Code*.
    3.2. Static pressure loss or gain (because of head) is computed at 0.433 psi per foot (9.8 kPa/m) of elevation change.
    3.3. Loss through a water meter. The friction or pressure loss can be obtained from the manufacturer.
    3.4. Loss through taps in water main [see Table AP103.3(4)].
    3.5. Loss through special devices, such as filters, softeners, backflow prevention devices and pressure regulators. These values must be obtained from the manufacturers.
    3.6. Loss through valves and fittings [see Tables AP103.3(5) and AP103.3(6)]. Losses for these items are calculated by converting to the *equivalent length* of piping and adding to the total pipe length.
    3.7. Loss caused by pipe friction can be calculated where the pipe size, pipe length and flow through the pipe are known. With these three items, the friction loss can be determined using Figures AP103.3(2) through AP103.3(7). Where using charts, use pipe inside diameters. For piping flow charts not included, use manufacturers' tables and velocity recommendations. Before attempting to size any water supply system, it is necessary to gather preliminary information including available pressure, piping material, select design velocity, elevation differences and *developed length* to the most remote fixture. The water supply system is divided into sections at major changes in elevation or where branches lead to fixture groups. The peak demand must be determined in each part of the hot and cold water supply system. The expected flow through each section is determined in w.s.f.u. and converted to gpm (L/m) flow rate. Sizing methods require determination of the "most hydraulically remote" fixture to compute the pressure loss caused by pipe and fittings. The hydraulically remote fixture represents the most downstream fixture along the circuit of piping requiring the most available pressure to operate properly. Consideration must be given to all pressure demands and losses, such as friction caused by pipe, fittings and equipment; elevation; and the residual pressure required by Table P2903.1. The two most common and frequent complaints about water supply system operation are lack of adequate pressure and noise.

**TABLE AP103.3(1)**
**RECOMMENDED TABULAR ARRANGEMENT FOR USE IN SOLVING PIPE SIZING PROBLEMS**

| COLUMN | 1 | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Line | Description | | Pounds per square inch | Gallons per min through section | Length of section (feet) | Trial pipe size (inches) | Equivalent length of fittings and valves (feet) | Total equivalent length [(Col. 4 + Col. 6)/ 100 feet)] | Friction loss per 100 feet of trial size pipe (psi) | Friction loss in equivalent length Column 8 x Column 7 (psi) | Excess pressure over friction losses (psi) |
| A | | Minimum pressure available at main | 55.00 | — | — | — | — | — | — | — | — |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B | Service and cold water distribution piping[a] | Highest pressure required at a fixture (see Table P2903.1) | | 15.00 | | | | | | | |
| C | | Meter loss 2″ meter | | 11.00 | | | | | | | |
| D | | Tap in main loss 2″ tap [see Table AP103.3(4)] | | 1.61 | | | | | | | |
| E | | Static head loss 21 ft × 0.43 psi/ft | | 9.03 | | | | | | | |
| F | | Special fixture loss backflow preventer | | 9.00 | | | | | | | |
| G | | Special fixture loss—Filter | | 0.00 | | | | | | | |
| H | | Special fixture loss—Other | | 0.00 | | | | | | | |
| I | | Total overall losses and requirements (Sum of Lines B through H) | | 45.64 | | | | | | | |
| J | | Pressure available to overcome pipe friction (Line A minus Line I) | | 9.36 | | | | | | | |
| | Pipe section (from diagram) Cold water distribution piping | | A-B | 288 | 108.0 | 54 | $2^1/_2$ | 15.00 | 0.69 | 3.2 | 2.21 | — |
| | | | B-C | 264 | 104.5 | 8 | $2^1/_2$ | 0.5 | 0.085 | 3.1 | 0.26 | — |
| | | | C-D | 132 | 77.0 | 13 | $2^1/_2$ | 7.00 | 0.20 | 1.9 | 0.38 | — |
| | | | C-F[b] | 132 | 77.0 | 150 | $2^1/_2$ | 12.00 | 1.62 | 1.9 | 3.08 | — |
| | | | D-E[b] | 132 | 77.0 | 150 | $2^1/_2$ | 12.00 | 1.62 | 1.9 | 3.08 | — |
| K | Total pipe friction losses (cold) | | | | — | — | — | — | — | — | 5.93 | — |
| L | Difference (Line J minus Line K) | | | | — | — | — | — | — | — | — | 3.43 |
| | Pipe section (from diagram) Hot water distribution piping | | A′B′ | 288 | 108.0 | 54 | $2^1/_2$ | 12.00 | 0.69 | 3.3 | 2.21 | — |
| | | | B′C′ | 24 | 38.0 | 8 | 2 | 7.5 | 0.16 | 1.4 | 0.22 | — |
| | | | C′D′ | 12 | 28.6 | 13 | $1^1/_2$ | 4.0 | 0.17 | 3.2 | 0.54 | — |
| | | | C′F′[b] | 12 | 28.6 | 150 | $1^1/_2$ | 7.00 | 1.57 | 3.2 | 5.02 | — |
| | | | D′E′[b] | 12 | 28.6 | 150 | $1^1/_2$ | 7.00 | 1.57 | 3.2 | 5.02 | — |
| K | Total pipe friction losses (hot) | | | | — | — | — | — | — | — | 7.99 | — |
| L | Difference (Line J minus Line K) | | | | — | — | — | — | — | — | — | 1.37 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 3.785 L/m.

a. To be considered as pressure gain for fixtures below main (to consider separately, omit from "I" and add to "J").

b. To consider separately, in Line K use Section C-F only if greater loss than the loss in Section D-E.

**TABLE AP103.3(2)**

**LOAD VALUES ASSIGNED TO FIXTURES[a]**

| FIXTURE | OCCUPANCY | TYPE OF SUPPLY CONTROL | LOAD VALUES, IN WATER SUPPLY FIXTURE UNITS (w.s.f.u.) | | |
|---|---|---|---|---|---|
| | | | Cold | Hot | Total |
| Bathroom group | Private | Flush tank | 2.7 | 1.5 | 3.6 |
| Bathroom group | Private | Flushometer valve | 6.0 | 3.0 | 8.0 |

| | | | | | |
|---|---|---|---|---|---|
| Bathtub | Private | Faucet | 1.0 | 1.0 | 1.4 |
| Bathtub | Public | Faucet | 3.0 | 3.0 | 4.0 |
| Bidet | Private | Faucet | 1.5 | 1.5 | 2.0 |
| Combination fixture | Private | Faucet | 2.25 | 2.25 | 3.0 |
| Dishwashing machine | Private | Automatic | — | 1.4 | 1.4 |
| Drinking fountain | Offices, etc. | $^{3}/_{8}''$ valve | 0.25 | — | 0.25 |
| Kitchen sink | Private | Faucet | 1.0 | 1.0 | 1.4 |
| Kitchen sink | Hotel, restaurant | Faucet | 3.0 | 3.0 | 4.0 |
| Laundry trays (1 to 3) | Private | Faucet | 1.0 | 1.0 | 1.4 |
| Lavatory | Private | Faucet | 0.5 | 0.5 | 0.7 |
| Lavatory | Public | Faucet | 1.5 | 1.5 | 2.0 |
| Service sink | Offices, etc. | Faucet | 2.25 | 2.25 | 3.0 |
| Shower head | Public | Mixing valve | 3.0 | 3.0 | 4.0 |
| Shower head | Private | Mixing valve | 1.0 | 1.0 | 1.4 |
| Urinal | Public | 1″ flushometer valve | 10.0 | — | 10.0 |
| Urinal | Public | $^{3}/_{4}''$ flushometer valve | 5.0 | — | 5.0 |
| Urinal | Public | Flush tank | 3.0 | — | 3.0 |
| Washing machine (8 lb) | Private | Automatic | 1.0 | 1.0 | 1.4 |
| Washing machine (8 lb) | Public | Automatic | 2.25 | 2.25 | 3.0 |
| Washing machine (15 lb) | Public | Automatic | 3.0 | 3.0 | 4.0 |
| Water closet | Private | Flushometer valve | 6.0 | — | 6.0 |
| Water closet | Private | Flush tank | 2.2 | — | 2.2 |
| Water closet | Public | Flushometer valve | 10.0 | — | 10.0 |
| Water closet | Public | Flush tank | 5.0 | — | 5.0 |
| Water closet | Public or private | Flushometer tank | 2.0 | — | 2.0 |

For SI: 1 inch = 25.4 mm, 1 pound = 0.454 kg.

a. For fixtures not listed, loads should be assumed by comparing the fixture to one listed using water in similar quantities and at similar rates. The assigned loads for fixtures with both hot and cold water supplies are given for separate hot and cold water loads, and for total load. The separate hot and cold water loads are three-fourths of the total load for the fixture in each case.

### TABLE AP103.3(3)
### TABLE FOR ESTIMATING DEMAND

| SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH TANKS | | | SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSHOMETERS | | |
|---|---|---|---|---|---|
| Load | Demand | | Load | Demand | |
| (w.s.f.u.) | (gpm) | (cfm) | (w.s.f.u.) | (gpm) | (cfm) |

| | | | | | |
|---|---|---|---|---|---|
| 1 | 3.0 | 0.04104 | — | — | — |
| 2 | 5.0 | 0.0684 | — | — | — |
| 3 | 6.5 | 0.86892 | — | — | — |
| 4 | 8.0 | 1.06944 | — | — | — |
| 5 | 9.4 | 1.256592 | 5 | 15.0 | 2.0052 |
| 6 | 10.7 | 1.430376 | 6 | 17.4 | 2.326032 |
| 7 | 11.8 | 1.577424 | 7 | 19.8 | 2.646364 |
| 8 | 12.8 | 1.711104 | 8 | 22.2 | 2.967696 |
| 9 | 13.7 | 1.831416 | 9 | 24.6 | 3.288528 |
| 10 | 14.6 | 1.951728 | 10 | 27.0 | 3.60936 |
| 11 | 15.4 | 2.058672 | 11 | 27.8 | 3.716304 |
| 12 | 16.0 | 2.13888 | 12 | 28.6 | 3.823248 |
| 13 | 16.5 | 2.20572 | 13 | 29.4 | 3.930192 |
| 14 | 17.0 | 2.27256 | 14 | 30.2 | 4.037136 |
| 15 | 17.5 | 2.3394 | 15 | 31.0 | 4.14408 |
| 16 | 18.0 | 2.90624 | 16 | 31.8 | 4.241024 |
| 17 | 18.4 | 2.459712 | 17 | 32.6 | 4.357968 |
| 18 | 18.8 | 2.513184 | 18 | 33.4 | 4.464912 |
| 19 | 19.2 | 2.566656 | 19 | 34.2 | 4.571856 |
| 20 | 19.6 | 2.620128 | 20 | 35.0 | 4.6788 |
| 25 | 21.5 | 2.87412 | 25 | 38.0 | 5.07984 |
| 30 | 23.3 | 3.114744 | 30 | 42.0 | 5.61356 |
| 35 | 24.9 | 3.328632 | 35 | 44.0 | 5.88192 |
| 40 | 26.3 | 3.515784 | 40 | 46.0 | 6.14928 |
| 45 | 27.7 | 3.702936 | 45 | 48.0 | 6.41664 |
| 50 | 29.1 | 3.890088 | 50 | 50.0 | 6.684 |
| 60 | 32.0 | 4.27776 | 60 | 54.0 | 7.21872 |
| 70 | 35.0 | 4.6788 | 70 | 58.0 | 7.75344 |
| 80 | 38.0 | 5.07984 | 80 | 61.2 | 8.181216 |
| 90 | 41.0 | 5.48088 | 90 | 64.3 | 8.595624 |
| 100 | 43.5 | 5.81508 | 100 | 67.5 | 9.0234 |
| 120 | 48.0 | 6.41664 | 120 | 73.0 | 9.75864 |
| 140 | 52.5 | 7.0182 | 140 | 77.0 | 10.29336 |
| 160 | 57.0 | 7.61976 | 160 | 81.0 | 10.82808 |

| | | | | | |
|---|---|---|---|---|---|
| 180 | 61.0 | 8.15448 | 180 | 85.5 | 11.42964 |
| 200 | 65.0 | 8.6892 | 200 | 90.0 | 12.0312 |
| 225 | 70.0 | 9.3576 | 225 | 95.5 | 12.76644 |
| 250 | 75.0 | 10.026 | 250 | 101.0 | 13.50168 |
| 275 | 80.0 | 10.6944 | 275 | 104.5 | 13.96956 |
| 300 | 85.0 | 11.3628 | 300 | 108.0 | 14.43744 |
| 400 | 105.0 | 14.0364 | 400 | 127.0 | 16.97736 |
| 500 | 124.0 | 16.57632 | 500 | 143.0 | 19.11624 |

*(continued)*

**TABLE AP103.3(3)—continued**
**TABLE FOR ESTIMATING DEMAND**

| SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH TANKS | | | SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSHOMETERS | | |
|---|---|---|---|---|---|
| Load | Demand | | Load | Demand | |
| (w.s.f.u.) | (gpm) | (cfm) | (w.s.f.u.) | (gpm) | (cfm) |
| 750 | 170.0 | 22.7256 | 750 | 177.0 | 23.66136 |
| 1,000 | 208.0 | 27.80544 | 1,000 | 208.0 | 27.80544 |
| 1,250 | 239.0 | 31.94952 | 1,250 | 239.0 | 31.94952 |
| 1,500 | 269.0 | 35.95992 | 1,500 | 269.0 | 35.95992 |
| 1,750 | 297.0 | 39.70296 | 1,750 | 297.0 | 39.70296 |
| 2,000 | 325.0 | 43.446 | 2,000 | 325.0 | 43.446 |
| 2,500 | 380.0 | 50.7984 | 2,500 | 380.0 | 50.7984 |
| 3,000 | 433.0 | 57.88344 | 3,000 | 433.0 | 57.88344 |
| 4,000 | 535.0 | 70.182 | 4,000 | 525.0 | 70.182 |
| 5,000 | 593.0 | 79.27224 | 5,000 | 593.0 | 79.27224 |

For SI: 1 gallon per minute = 3.785 L/m, 1 cubic foot per minute = 0.000471 $m^3/s$.

**TABLE AP103.3(4)**
**LOSS OF PRESSURE THROUGH TAPS AND TEES IN POUNDS PER SQUARE INCH (psi)**

| GALLONS PER MINUTE | SIZE OF TAP OR TEE (inches) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 5/8 | 3/4 | 1 | 1 1/4 | 1 1/2 | 2 | 3 |
| 10 | 1.35 | 0.64 | 0.18 | 0.08 | — | — | — |
| 20 | 5.38 | 2.54 | 0.77 | 0.31 | 0.14 | — | — |
| 30 | 12.10 | 5.72 | 1.62 | 0.69 | 0.33 | 0.10 | — |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 40 | — | 10.20 | 3.07 | 1.23 | 0.58 | 0.18 | — |
| 50 | — | 15.90 | 4.49 | 1.92 | 0.91 | 0.28 | — |
| 60 | — | — | 6.46 | 2.76 | 1.31 | 0.40 | — |
| 70 | — | — | 8.79 | 3.76 | 1.78 | 0.55 | 0.10 |
| 80 | — | — | 11.50 | 4.90 | 2.32 | 0.72 | 0.13 |
| 90 | — | — | 14.50 | 6.21 | 2.94 | 0.91 | 0.16 |
| 100 | — | — | 17.94 | 7.67 | 3.63 | 1.12 | 0.21 |
| 120 | — | — | 25.80 | 11.00 | 5.23 | 1.61 | 0.30 |
| 140 | — | — | 35.20 | 15.00 | 7.12 | 2.20 | 0.41 |
| 150 | — | — | — | 17.20 | 8.16 | 2.52 | 0.47 |
| 160 | — | — | — | 19.60 | 9.30 | 2.92 | 0.54 |
| 180 | — | — | — | 24.80 | 11.80 | 3.62 | 0.68 |
| 200 | — | — | — | 30.70 | 14.50 | 4.48 | 0.84 |
| 225 | — | — | — | 38.80 | 18.40 | 5.60 | 1.06 |
| 250 | — | — | — | 47.90 | 22.70 | 7.00 | 1.31 |
| 275 | — | — | — | — | 27.40 | 7.70 | 1.59 |
| 300 | — | — | — | — | 32.60 | 10.10 | 1.88 |

For SI: 1 inch = 25.4 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 3.785 L/m.

**TABLE AP103.3(5)**
**ALLOWANCE IN EQUIVALENT LENGTHS OF PIPE FOR FRICTION LOSS IN VALVES AND THREADED FITTINGS (feet)**

| FITTING OR VALVE | PIPE SIZE (inches) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1/2 | 3/4 | 1 | 1 1/4 | 1 1/2 | 2 | 2 1/2 | 3 |
| 45-degree elbow | 1.2 | 1.5 | 1.8 | 2.4 | 3.0 | 4.0 | 5.0 | 6.0 |
| 90-degree elbow | 2.0 | 2.5 | 3.0 | 4.0 | 5.0 | 7.0 | 8.0 | 10.0 |
| Tee, run | 0.6 | 0.8 | 0.9 | 1.2 | 1.5 | 2.0 | 2.5 | 3.0 |
| Tee, branch | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 10.0 | 12.0 | 15.0 |
| Gate valve | 0.4 | 0.5 | 0.6 | 0.8 | 1.0 | 1.3 | 1.6 | 2.0 |
| Balancing valve | 0.8 | 1.1 | 1.5 | 1.9 | 2.2 | 3.0 | 3.7 | 4.5 |
| Plug-type cock | 0.8 | 1.1 | 1.5 | 1.9 | 2.2 | 3.0 | 3.7 | 4.5 |
| Check valve, swing | 5.6 | 8.4 | 11.2 | 14.0 | 16.8 | 22.4 | 28.0 | 33.6 |
| Globe valve | 15.0 | 20.0 | 25.0 | 35.0 | 45.0 | 55.0 | 65.0 | 80.0 |
| Angle valve | 8.0 | 12.0 | 15.0 | 18.0 | 22.0 | 28.0 | 34.0 | 40.0 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.

**TABLE AP103.3(6)**
**PRESSURE LOSS IN FITTINGS AND VALVES EXPRESSED AS EQUIVALENT LENGTH OF TUBE[a] (feet)**

| NOMINAL OR STANDARD SIZE (inches) | FITTINGS | | | | Coupling | VALVES | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Standard Ell | | 90-degree Tee | | | Ball | Gate | Butterfly | Check |
| | 90 Degree | 45 Degree | Side Branch | Straight Run | | | | | |
| 3/8 | 0.5 | — | 1.5 | — | — | — | — | — | 1.5 |
| 1/2 | 1 | 0.5 | 2 | — | — | — | — | — | 2 |
| 5/8 | 1.5 | 0.5 | 2 | — | — | — | — | — | 2.5 |
| 3/4 | 2 | 0.5 | 3 | — | — | — | — | — | 3 |
| 1 | 2.5 | 1 | 4.5 | — | — | 0.5 | — | — | 4.5 |
| 1 1/4 | 3 | 1 | 5.5 | 0.5 | 0.5 | 0.5 | — | — | 5.5 |
| 1 1/2 | 4 | 1.5 | 7 | 0.5 | 0.5 | 0.5 | — | — | 6.5 |
| 2 | 5.5 | 2 | 9 | 0.5 | 0.5 | 0.5 | 0.5 | 7.5 | 9 |
| 2 1/2 | 7 | 2.5 | 12 | 0.5 | 0.5 | — | 1 | 10 | 11.5 |
| 3 | 9 | 3.5 | 15 | 1 | 1 | — | 1.5 | 15.5 | 14.5 |
| 3 1/2 | 9 | 3.5 | 14 | 1 | 1 | — | 2 | — | 12.5 |
| 4 | 12.5 | 5 | 21 | 1 | 1 | — | 2 | 16 | 18.5 |
| 5 | 16 | 6 | 27 | 1.5 | 1.5 | — | 3 | 11.5 | 23.5 |
| 6 | 19 | 7 | 34 | 2 | 2 | — | 3.5 | 13.5 | 26.5 |
| 8 | 29 | 11 | 50 | 3 | 3 | — | 5 | 12.5 | 39 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.01745 rad.

a. Allowances are for streamlined soldered fittings and recessed threaded fittings. For threaded fittings, double the allowances shown in the table. The equivalent lengths presented in the table are based on a C factor of 150 in the Hazen-Williams friction loss formula. The lengths shown are rounded to the nearest half-foot.

~~**Problem**~~ **AP103.3.1 Sample problem.** What size Type L copper water pipe, service and distribution will be required to serve a two-story factory building having on each floor, back-to-back, two toilet rooms each equipped with hot and cold water? The highest fixture is 21 feet above the street main, which is tapped with a 2-inch corporation cock at which point the minimum pressure is 55 psi. In the building basement, a 2-inch meter with a ~~maximum~~ pressure drop of not more than 11 psi and 3-inch reduced pressure principle backflow preventer with a ~~maximum~~ pressure drop of not more than 9 psi are to be installed. The system is shown in Figure AP103.3(1). To be determined are the pipe sizes for the service main, and the cold and hot water distribution pipes.

**Problem solution:** A tabular arrangement such as shown in Table AP103.3(1) should first be constructed. The steps to be followed are indicated by the tabular arrangement itself as they are in sequence, Columns 1 through 10 and Lines A through L.

**Step 1**

**Columns 1 and 2:** Divide the system into sections breaking at major changes in elevation or where branches lead to fixture groups. After Point B [see Figure AP103.3(1)], separate consideration will be given to the hot and cold water piping. Enter the sections to be considered in the service and cold water piping in Column 1 of the tabular arrangement. Column 1 of Table AP103.3(1) provides a line-by-line, recommended tabular arrangement for use in solving pipe sizing.

The objective in designing the water supply system is to ensure an adequate water supply and pressure to all fixtures and equipment. Column 2 provides the psi (kPa) to be considered separately from the minimum pressure available at the main. Losses to take into consideration are the following: the differences in elevations between the water supply source and the highest water supply outlet; meter pressure losses; the tap in main loss; special fixture devices, such as water softeners and backflow prevention devices; and the pressure required at the most remote fixture outlet.

The difference in elevation can result in an increase or decrease in available pressure at the main. Where the water supply outlet is located above the source, this results in a loss in the available pressure and is subtracted from the pressure at the water source. Where the highest water supply outlet is located below the water supply source, there will be an increase in pressure that is added to the available pressure of the water source.

**Column 3:** Using Table AP103.3(3), determine the gpm (L/m) of flow to be expected in each section of the system. These flows range from 28.6 to 108 gpm. Load values for fixtures must be determined as w.s.f.u. and then converted to a gpm rating to determine peak demand. Where calculating peak demands, the w.s.f.u. are added and then converted to the gpm rating. For continuous flow fixtures, such as hose bibbs and lawn sprinkler systems, add the gpm demand to the intermittent demand of fixtures. For example, a total of 120 w.s.f.u. is converted to a demand of 48 gpm. Two hose bibbs × 5 gpm demand = 10 gpm. Total gpm rating = 48.0 gpm + 10 gpm = 58.0 gpm demand.

**Step 2**

**Line A:** Enter the minimum pressure available at the main source of supply in Column 2. This is 55 psi (379.2 kPa). The local water authorities generally keep records of pressures at different times of the day and year. The available pressure can ~~also~~ be checked from nearby buildings or from fire department hydrant checks.

**Line B:** Determine from Table P2903.1 the highest pressure required for the fixtures on the system, which is 15 psi (103.4 kPa), to operate a flushometer valve. The most remote fixture outlet is necessary to compute the pressure loss caused by pipe and fittings, and represents the most downstream fixture along the circuit of piping requiring the available pressure to operate properly as indicated by Table P2903.1.

**Line C:** Determine the pressure loss for the meter size given or assumed. The total water flow from the main through the service as determined in Step 1 will serve to aid in the meter selected. There are three common types of water meters; the pressure losses are determined by the American Water Works Association Standards for displacement type, compound type and turbine type. The maximum pressure loss of such devices takes into consideration the meter size, safe operating capacity [gpm (L/m)] and maximum rates for continuous operations [gpm (L/m)]. Typically, equipment imparts greater pressure losses than piping.

**Line D:** Select from Table AP103.3(4) and enter the pressure loss for the tap size given or assumed. The loss of pressure through taps and tees in psi (kPa) is based on the total gpm (L/m) flow rate and size of the tap.

**Line E:** Determine the difference in elevation between the main and source of supply and the highest fixture on the system. Multiply this figure, expressed in feet (mm), by 0.43 psi. Enter the resulting psi (kPa) loss on Line E. The difference in elevation between the water supply source and the highest water supply outlet has a significant impact on the sizing of the water supply system. The difference in elevation usually results in a loss in the available pressure because the water supply outlet is generally located above the water supply source. The loss is caused by the pressure required to lift the water to the outlet. The pressure loss is subtracted from the pressure at the water source. Where the highest water supply outlet is located below the water source, there will be an increase in pressure that is added to the available pressure of the water source.

**Lines F, G and H:** The pressure losses through filters, backflow prevention devices or other special fixtures must be obtained from the manufacturer or estimated and entered on these lines. Equipment, such as backflow prevention devices, check valves, water softeners, instantaneous, or tankless water heaters, filters and strainers, can impart a much greater pressure loss than the piping. The pressure losses can range from 8 to 30 psi.

**Step 3**

**Line I:** The sum of the pressure requirements and losses that affect the overall system (Lines B through H) is entered on this line. Summarizing the steps, all of the system losses are subtracted from the minimum water pressure. The remainder is the pressure available for friction, defined as the energy available to push the water through the pipes to each fixture. This force can be used as an average pressure loss, as long as the pressure available for friction is not exceeded. Saving a certain amount for available water supply pressures as an area incurs growth, or because of the aging of the pipe or equipment added to the system is recommended.

**Step 4**

**Line J:** Subtract Line I from Line A. This gives the pressure that remains available from overcoming friction losses in the system. This figure is a guide to the pipe size that is chosen for each section, incorporating the total friction losses to the most remote outlet (measured length is called *developed length*).

**Exception:** Where the main is above the highest fixture, the resulting psi (kPa) must be considered a pressure gain (static head gain) and omitted from the sums of Lines B through H and added to Line J.

The maximum friction head loss that can be tolerated in the system during peak demand is the difference between the static pressure at the highest and most remote outlet at no-flow conditions and the minimum flow pressure required at that outlet. If the losses are within the required limits, every run of pipe will be within the required friction head loss. Static pressure loss is at the most remote outlet in feet × 0.433 = loss in psi caused by elevation differences.

**Step 5**

**Column 4:** Enter the length of each section from the main to the most remote outlet (at Point E). Divide the water supply system into sections breaking at major changes in elevation or where branches lead to fixture groups.

**Step 6**

**Column 5:** Where selecting a trial pipe size, the length from the water service or meter to the most remote fixture outlet must be measured to determine the developed length. However, in systems having a flushometer valve or temperature-controlled shower at the topmost floors, the developed length would be from the water meter to the most remote flushometer valve on the system. A rule of thumb is that size will become progressively smaller as the system extends farther from the main source of supply. A trial pipe size can be arrived at by the following formula:

**Line J:** (Pressure available to overcome pipe friction) × 100/equivalent length of run total developed length to most remote fixture × percentage factor of 1.5 (Note: a percentage factor is used only as an estimate for friction losses imposed for fittings for initial trial pipe size) = psi (average pressure drop per 100 feet of pipe).

For trial pipe size, see Figure AP103.3(3) (Type L copper) based on 2.77 psi and 108 gpm = $2^{1}/_{2}$ inches. To determine the equivalent length of run to the most remote outlet, the developed length is determined and added to the friction losses for fittings and valves. The developed lengths of the designated pipe sections are shown in Table AP103.3.1(1).

The equivalent length of the friction loss in fittings and valves must be added to the developed length (most remote outlet). Where the size of fittings and valves is not known, the added friction loss should be approximated. A general rule that has been used is to add 50 percent of the developed length to allow for fittings and valves. For example, the equivalent length of run equals the developed length of run (225 feet × 1.5 = 338 feet). The total equivalent length of run for determining a trial pipe size is 338 feet.

**Example:** 9.36 (pressure available to overcome pipe friction) × 100/338 (equivalent length of run = 225 × 1.5) = 2.77 psi (average pressure drop per 100 feet of pipe).

**TABLE AP103.3.1(1)**

SUMMATION OF DEVELOPED PIPING LENGTHS

| SEGMENT | LENGTH[a] (feet) |
|---|---|
| A-B | 54 |
| B-C | 8 |
| C-D | 13 |
| D-E | 150 |

For SI: 1 foot = 304.8 mm.
a. Total developed length = 225 feet.

**Step 7**

**Column 6:** Select from Table AP103.3(6) the equivalent lengths for the trial pipe size of fittings and valves on each pipe section. Enter the sum for each section in Column 6. (The number of fittings to be used in this example must be an estimate). The equivalent length of piping is the developed length plus the equivalent lengths of pipe corresponding to the friction head losses for fittings and valves. Where the size of fittings and valves is not known, the added friction head losses must be approximated. An estimate for this example is found in Table AP103.3.1(2).

**Step 8**

**Column 7:** Add the figures from Columns 4 and 6, and enter in Column 7. Express the sum in hundreds of feet.

**Step 9**

**Column 8:** Select from Figure AP103.3(3) the friction loss per 100 feet of pipe for the gpm flow in a section (Column 3) and trial pipe size (Column 5). Maximum friction head loss per 100 feet is determined on the basis of the total pressure available for friction head loss and the longest equivalent length of run. The selection is based on the gpm demand, uniform friction head loss and maximum design velocity. Where the size indicated by the hydraulic table indicates a velocity in excess of the selected velocity, a size must be selected that produces the required velocity.

**Step 10**

**Column 9:** Multiply the figures in Columns 7 and 8 for each section and enter in Column 9.

Total friction loss is determined by multiplying the friction loss per 100 feet for each pipe section in the total developed length by the pressure loss in fittings expressed as equivalent length in feet (mm). Note: Section C-F should be considered in the total pipe friction losses only if greater loss occurs in Section C-F than in pipe Section D-E. Section C-F is not considered in the total developed length. Total friction loss in equivalent length is determined in Table AP103.3.1(3).

**Step 11**

**Line K:** Enter the sum of the values in Column 9. The value is the total friction loss in equivalent length for each designated pipe section.

**Step 12**

**Line L:** Subtract Line J from Line K and enter in Column 10.

The result should always be a positive or plus figure. If it is not, repeat the operation using Columns 5, 6, 8 and 9 until a balance or near balance is obtained. If the difference between Lines J and K is a high positive number, it is an indication that the pipe sizes are too large and should be reduced, thus saving materials. In such a case, the operations using Columns 5, 6, 8 and 9 should be repeated.

The total friction losses are determined and subtracted from the pressure available to overcome pipe friction for the trial pipe size. This number is critical because it provides a guide to whether the pipe size selected is too large and the process should be repeated to obtain an economically designed system.

**Answer:** The final figures entered in Column 5 become the design pipe size for the respective sections. Repeating this operation a second time using the same sketch but considering the demand for hot water, it is possible to size the hot water distribution piping. This has been worked up as a part of the overall problem in the tabular arrangement used for sizing the service and water distribution piping. Note that consideration must be given to the pressure losses from the street main to the water heater (Section A-B) in determining the hot water pipe sizes.

## SECTION AP201
## SELECTION OF PIPE SIZE

**AP201.1 Size of water-service mains, branch mains and risers.** The minimum size water service pipe shall be $^3/_4$ inch (19.1 mm). The size of water service mains, branch mains and risers shall be determined according to water supply demand [gpm (L/m)], available water pressure [psi (kPa)] and friction loss caused by the water meter and *developed length* of pipe [feet (m)], including the *equivalent length* of fittings. The size of each water distribution system shall be determined according to the procedure outlined in this section or by other design methods conforming to acceptable engineering practice and *approved* by the *building official*:

1. Supply load in the building water distribution system shall be determined by the total load on the pipe being sized, in terms of w.s.f.u., as shown in Table AP103.3(2). For fixtures not *listed*, choose a w.s.f.u. value of a fixture with similar flow characteristics.
2. Obtain the minimum daily static service pressure [psi (kPa)] available (as determined by the local water authority) at the water meter or other source of supply at the installation location. Adjust this minimum daily static pressure [psi (kPa)] for the following conditions:
   2.1. Determine the difference in elevation between the source of supply and the highest water supply outlet. Where the highest water supply outlet is located above the source of supply, deduct 0.5 psi (3.4 kPa) for each foot (0.3 m) of difference in elevation. Where the highest water supply outlet is located below the source of supply, add 0.5 psi (3.4 kPa) for each foot (0.3 m) of difference in elevation.
   2.2. Where a water pressure-reducing valve is installed in the water distribution system, the minimum daily static water pressure available is 80 percent of the minimum daily static water pressure at the source of supply or the set pressure downstream of the water pressure-reducing valve, whichever is smaller.
   2.3. Deduct all pressure losses caused by special equipment, such as a backflow preventer, water filter and water softener. Pressure loss data for each piece of equipment shall be obtained through the manufacturer of the device.
   2.4. Deduct the pressure in excess of 8 psi (55 kPa) resulting from the installation of the special plumbing fixture, such as temperature-controlled shower and flushometer tank water closet. Using the resulting minimum available pressure, find the corresponding pressure range in Table AP201.1.
3. The maximum *developed length* for water piping is the actual length of pipe between the source of supply and the most remote fixture, including either hot (through the water heater) or cold water branches multiplied by a factor of 1.2 to compensate for pressure loss through fittings. Select the appropriate column in Table AP201.1 equal to or greater than the calculated maximum *developed length*.
4. To determine the size of the water service pipe, meter and main distribution pipe to the building using the appropriate table, follow down the selected "maximum *developed length*" column to a fixture unit equal to or greater than the total installation demand calculated by using the "combined" w.s.f.u. column of Table AP201.1. Read the water service pipe and meter sizes in the first left-hand column and the main distribution pipe to the building in the second left-hand column on the same row.
5. To determine the size of each water distribution pipe, start at the most remote outlet on each branch (either hot or cold branch) and, working back toward the main distribution pipe to the building, add up the w.s.f.u. demand passing through each segment of the distribution system using the related hot or cold column of Table AP201.1. Knowing demand, the size of each segment shall be read from the second left-hand column of the same table and the maximum *developed length* column selected in Steps 1 and 2, under the same or next smaller size meter row. ~~In no case~~ The size of any branch or main need ~~to~~ <u>never</u> be larger than the size of the main distribution pipe to the building established in Step 4.

**TABLE AP103.3.1(2)**

**FITTING PRESSURE LOSSES EXPRESSED IN EQUIVALENT LENGTHS (formerly Table AP.1)**

| COLD WATER PIPE SECTION | FITTINGS/VALVES | PRESSURE LOSS EXPRESSED AS EQUIVALENT LENGTH OF TUBE (feet) | HOT WATER PIPE SECTION | FITTINGS/VALVES | PRESSURE LOSS EXPRESSED AS EQUIVALENT OF TUBE (feet) |
|---|---|---|---|---|---|
| A-B | 3 – $2\frac{1}{2}$″ Gate valves | 3 | A-B | 3 – $2\frac{1}{2}$″ Gate valves | 3 |
| | 1 – $2\frac{1}{2}$″ Side branch tee | 12 | — | 1 – $2\frac{1}{2}$″ Side branch tee | 12 |
| B-C | 1 – $2\frac{1}{2}$″ Straight run tee | 0.5 | B-C | 1 – 2″ Straight run tee | 7 |
| | — | — | — | 1 – 2″ 90-degree ell | 0.5 |
| C-F | 1 – $2\frac{1}{2}$″ Side branch tee | 12 | C-F | 1 – $1\frac{1}{2}$″ Side branch tee | 7 |

| | | | | | |
|---|---|---|---|---|---|
| C-D | 1 – $2^{1}/_{2}$″ 90-degree ell | 7 | C-D | 1 – $^{1}/_{2}$″ 90-degree ell | 4 |
| D-E | 1 – $2^{1}/_{2}$″ Side branch tee | 12 | D-E | 1 – $1^{1}/_{2}$″ Side branch tee | 7 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.01745 rad.

**TABLE AP201.1**

**MINIMUM SIZE OF WATER METERS, MAINS AND DISTRIBUTION PIPING BASED ON WATER SUPPLY FIXTURE UNIT VALUES (w.s.f.u.)**

| METER AND SERVICE PIPE (inches) | DISTRIBUTION PIPE (inches) | MAXIMUM DEVELOPMENT LENGTH (feet) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pressure Range 30 to 39 psi | | 40 | 60 | 80 | 100 | 150 | 200 | 250 | 300 | 400 | 500 |
| $^{3}/_{4}$ | $^{1}/_{2}$[a] | 2.5 | 2 | 1.5 | 1.5 | 1 | 1 | 0.5 | 0.5 | 0 | 0 |
| $^{3}/_{4}$ | $^{3}/_{4}$ | 9.5 | 7.5 | 6 | 5.5 | 4 | 3.5 | 3 | 2.5 | 2 | 1.5 |
| $^{3}/_{4}$ | 1 | 32 | 25 | 20 | 16.5 | 11 | 9 | 7.8 | 6.5 | 5.5 | 4.5 |
| 1 | 1 | 32 | 32 | 27 | 21 | 13.5 | 10 | 8 | 7 | 5.5 | 5 |
| $^{3}/_{4}$ | $1^{1}/_{4}$ | 32 | 32 | 32 | 32 | 30 | 24 | 20 | 17 | 13 | 10.5 |
| 1 | $1^{1}/_{4}$ | 80 | 80 | 70 | 61 | 45 | 34 | 27 | 22 | 16 | 12 |
| $1^{1}/_{2}$ | $1^{1}/_{4}$ | 80 | 80 | 80 | 75 | 54 | 40 | 31 | 25 | 17.5 | 13 |
| 1 | $1^{1}/_{2}$ | 87 | 87 | 87 | 87 | 84 | 73 | 64 | 56 | 45 | 36 |
| $1^{1}/_{2}$ | $1^{1}/_{2}$ | 151 | 151 | 151 | 151 | 117 | 92 | 79 | 69 | 54 | 43 |
| 2 | $1^{1}/_{2}$ | 151 | 151 | 151 | 151 | 128 | 99 | 83 | 72 | 56 | 45 |
| 1 | 2 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 86 |
| $1^{1}/_{2}$ | 2 | 275 | 275 | 275 | 275 | 258 | 223 | 196 | 174 | 144 | 122 |
| 2 | 2 | 365 | 365 | 365 | 365 | 318 | 266 | 229 | 201 | 160 | 134 |
| 2 | $2^{1}/_{2}$ | 533 | 533 | 533 | 533 | 533 | 495 | 448 | 409 | 353 | 311 |

| METER AND SERVICE PIPE (inches) | DISTRIBUTION PIPE (inches) | MAXIMUM DEVELOPMENT LENGTH (feet) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pressure Range 40 to 49 psi | | 40 | 60 | 80 | 100 | 150 | 200 | 250 | 300 | 400 | 500 |
| $^{3}/_{4}$ | $^{1}/_{2}$[a] | 3 | 2.5 | 2 | 1.5 | 1.5 | 1 | 1 | 0.5 | 0.5 | 0.5 |
| $^{3}/_{4}$ | $^{3}/_{4}$ | 9.5 | 9.5 | 8.5 | 7 | 5.5 | 4.5 | 3.5 | 3 | 2.5 | 2 |
| $^{3}/_{4}$ | 1 | 32 | 32 | 32 | 26 | 18 | 13.5 | 10.5 | 9 | 7.5 | 6 |
| 1 | 1 | 32 | 32 | 32 | 32 | 21 | 15 | 11.5 | 9.5 | 7.5 | 6.5 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3/4 | 1 1/4 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 27 | 21 | 16.5 |
| 1 | 1 1/4 | 80 | 80 | 80 | 80 | 65 | 52 | 42 | 35 | 26 | 20 |
| 1 1/2 | 1 1/4 | 80 | 80 | 80 | 80 | 75 | 59 | 48 | 39 | 28 | 21 |
| 1 | 1 1/2 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 78 | 65 | 55 |
| 1 1/2 | 1 1/2 | 151 | 151 | 151 | 151 | 151 | 130 | 109 | 93 | 75 | 63 |
| 2 | 1 1/2 | 151 | 151 | 151 | 151 | 151 | 139 | 115 | 98 | 77 | 64 |
| 1 | 2 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 |
| 1 1/2 | 2 | 275 | 275 | 275 | 275 | 275 | 275 | 264 | 238 | 198 | 169 |
| 2 | 2 | 365 | 365 | 365 | 365 | 365 | 349 | 304 | 270 | 220 | 185 |
| 2 | 2 1/2 | 533 | 533 | 533 | 533 | 533 | 533 | 533 | 528 | 456 | 403 |

*(continued)*

**TABLE AP201.1—continued**

**MINIMUM SIZE OF WATER METERS, MAINS AND DISTRIBUTION PIPING BASED ON WATER SUPPLY FIXTURE UNIT VALUES (w.s.f.u.)**

| METER AND SERVICE PIPE (inches) | DISTRIBUTION PIPE (inches) | MAXIMUM DEVELOPMENT LENGTH (feet) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pressure Range 50 to 60 psi | | 40 | 60 | 80 | 100 | 150 | 200 | 250 | 300 | 400 | 500 |
| 3/4 | 1/2[a] | 3 | 3 | 2.5 | 2 | 1.5 | 1 | 1 | 1 | 0.5 | 0.5 |
| 3/4 | 3/4 | 9.5 | 9.5 | 9.5 | 8.5 | 6.5 | 5 | 4.5 | 4 | 3 | 2.5 |
| 3/4 | 1 | 32 | 32 | 32 | 32 | 25 | 18.5 | 14.5 | 12 | 9.5 | 8 |
| 1 | 1 | 32 | 32 | 32 | 32 | 30 | 22 | 16.5 | 13 | 10 | 8 |
| 3/4 | 1 1/4 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 29 | 24 |
| 1 | 1 1/4 | 80 | 80 | 80 | 80 | 80 | 68 | 57 | 48 | 35 | 28 |
| 1 1/2 | 1 1/4 | 80 | 80 | 80 | 80 | 80 | 75 | 63 | 53 | 39 | 29 |
| 1 | 1 1/2 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 82 | 70 |
| 1 1/2 | 1 1/2 | 151 | 151 | 151 | 151 | 151 | 151 | 139 | 120 | 94 | 79 |
| 2 | 1 1/2 | 151 | 151 | 151 | 151 | 151 | 151 | 146 | 126 | 97 | 81 |
| 1 | 2 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 |
| 1 1/2 | 2 | 275 | 275 | 275 | 275 | 275 | 275 | 275 | 275 | 247 | 213 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 | 365 | 365 | 365 | 365 | 365 | 365 | 365 | 329 | 272 | 232 |
| 2 | $2^1/_2$ | 533 | 533 | 533 | 533 | 533 | 533 | 533 | 533 | 533 | 486 |

| METER AND SERVICE PIPE (inches) | DISTRIBUTION PIPE (inches) | MAXIMUM DEVELOPMENT LENGTH (feet) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pressure Range Over 60 | | 40 | 60 | 80 | 100 | 150 | 200 | 250 | 300 | 400 | 500 |
| $^3/_4$ | $^1/_2$[a] | 3 | 3 | 3 | 2.5 | 2 | 1.5 | 1.5 | 1 | 1 | 0.5 |
| $^3/_4$ | $^3/_4$ | 9.5 | 9.5 | 9.5 | 9.5 | 7.5 | 6 | 5 | 4.5 | 3.5 | 3 |
| $^3/_4$ | 1 | 32 | 32 | 32 | 32 | 32 | 24 | 19.5 | 15.5 | 11.5 | 9.5 |
| 1 | 1 | 32 | 32 | 32 | 32 | 32 | 28 | 28 | 17 | 12 | 9.5 |
| $^3/_4$ | $1^1/_4$ | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 30 |
| 1 | $1^1/_4$ | 80 | 80 | 80 | 80 | 80 | 80 | 69 | 60 | 46 | 36 |
| $1^1/_2$ | $1^1/_4$ | 80 | 80 | 80 | 80 | 80 | 80 | 76 | 65 | 50 | 38 |
| 1 | $1^1/_2$ | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 84 |
| $1^1/_2$ | $1^1/_2$ | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 144 | 114 | 94 |
| 2 | $1^1/_2$ | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 118 | 97 |
| 1 | 2 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 | 87 |
| $1^1/_2$ | 2 | 275 | 275 | 275 | 275 | 275 | 275 | 275 | 275 | 275 | 252 |
| 2 | 2 | 365 | 368 | 368 | 368 | 368 | 368 | 368 | 368 | 318 | 273 |
| 2 | $2^1/_2$ | 533 | 533 | 533 | 533 | 533 | 533 | 533 | 533 | 533 | 533 |

For SI: 1 inch = 25.4, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa.
a. Minimum size for building supply is a $^3/_4$-inch pipe.

**TABLE AP103.3.1(3)**
**TOTAL FRICTION LOSS EQUIVALENT PIPING LENGTH (formerly Table AP.2)**

| PIPE SECTIONS | FRICTION LOSS EQUIVALENT LENGTH (feet) | |
|---|---|---|
| | Cold Water | Hot Water |
| A-B | $0.69 \times 3.2 = 2.21$ | $0.69 \times 3.2 = 2.21$ |
| B-C | $0.085 \times 3.1 = 0.26$ | $0.16 \times 1.4 = 0.22$ |
| C-D | $0.20 \times 1.9 = 0.38$ | $0.17 \times 3.2 = 0.54$ |
| D-E | $1.62 \times 1.9 = 3.08$ | $1.57 \times 3.2 = 5.02$ |
| Total pipe friction losses (Line K) | 5.93 | 7.99 |

For SI: 1 foot = 304.8 mm.

# APPENDIX AQ
# TINY HOUSES

*The provisions contained in this appendix are adopted as part of this code.*

## SECTION AQ101
## GENERAL

**AQ101.1 Scope.** This appendix shall be applicable to *tiny houses* used as single *dwelling units*. *Tiny houses* shall comply with this code except as otherwise stated in this appendix.

## SECTION AQ102
## DEFINITIONS

**AQ102.1 General.** The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 of this code for general definitions.

**EGRESS ROOF ACCESS WINDOW.** A *skylight* or roof window designed and installed to satisfy the emergency escape and rescue opening requirements of Section R310.2.

**LANDING PLATFORM.** A landing provided as the top step of a stairway accessing a *loft*.

**LOFT.** A floor level located more than 30 inches (762 mm) above the main floor, open to the main floor on one or more sides with a ceiling height of less than 6 feet 8 inches (2032 mm) and used as a living or sleeping space.

**TINY HOUSE.** A *dwelling* that is 400 square feet (37 $m^2$) or less in floor area excluding *lofts*.

## SECTION AQ103
## CEILING HEIGHT

**AQ103.1 Minimum ceiling height.** *Habitable space* and hallways in *tiny houses* shall have a ceiling height of not less than 6 feet 8 inches (2032 mm). Bathrooms, toilet rooms and kitchens shall have a ceiling height of not less than 6 feet 4 inches (1930 mm). Obstructions including, but not limited to, beams, girders, ducts and lighting, shall not extend below these minimum ceiling heights.

**Exception:** Ceiling heights in *lofts* are permitted to be less than 6 feet 8 inches (2032 mm).

## SECTION AQ104
## LOFTS

**AQ104.1 Minimum loft area and dimensions.** *Lofts* used as a sleeping or living space shall meet the minimum area and dimension requirements of Sections AQ104.1.1 through AQ104.1.3.

**AQ104.1.1 Minimum area.** *Lofts* shall have a floor area of not less than 35 square feet (3.25 $m^2$).

**AQ104.1.2 Minimum horizontal dimensions.** *Lofts* shall be not less than 5 feet (1524 mm) in any horizontal dimension.

**AQ104.1.3 Height effect on loft area.** Portions of a *loft* with a sloped ceiling measuring less than 3 feet (914 mm) from the finished floor to the finished ceiling shall not be considered as contributing to the minimum required area for the loft. See Figure AQ104.1.3.

**Exception:** Under gable roofs with a minimum slope of 6 units vertical in 12 units horizontal (50-percent slope), portions of a *loft* with a sloped ceiling measuring less than 16 inches (406 mm) from the finished floor to the finished ceiling shall not be considered as contributing to the minimum required area for the *loft*.

**AQ104.2 Loft access and egress.** The access to and primary egress from *lofts* shall be of any type described in Sections AQ104.2.1 through AQ104.2.5. The loft access and egress element along its required minimum width shall meet the loft where its ceiling height is not less than 3 feet (914 mm).

**AQ104.2.1 Stairways.** Stairways accessing *lofts* shall comply with this code or with Sections AQ104.2.1.1 through AQ104.2.1.7.

**AQ104.2.1.1 Width.** Stairways accessing a *loft* shall not be less than 17 inches (432 mm) in clear width at or above the *handrail*. The width below the *handrail* shall be not less than 20 inches (508 mm).

**AQ104.2.1.2 Headroom.** The headroom above stairways accessing a *loft* shall be not less than 6 feet 2 inches (1880 mm), as measured vertically, from a sloped line connecting the tread, landing or landing platform *nosings* in the center of their width and vertically from the landing platform along the center of its width.

**AQ104.2.1.3 Treads and risers.** *Risers* for stairs accessing a *loft* shall be not less than 7 inches (178 mm) and not more than 12 inches (305 mm) in height. Tread depth and riser height shall be calculated in accordance with one of the following formulas:

1. The tread depth shall be 20 inches (508 mm) minus four-thirds of the riser height.
2. The riser height shall be 15 inches (381 mm) minus three-fourths of the tread depth.

**AQ104.2.1.4 Landings.** Intermediate landings and landings at the bottom of stairways shall comply with Section R311.7.6, except that the depth in the direction of travel shall be not less than 24 inches (610 mm).

**AQ104.2.1.5 Landing platforms.** The top tread and *riser* of stairways accessing *lofts* shall be constructed as a *landing platform* where the *loft* ceiling height is less than 6 feet 2 inches (1880 mm) where the stairway meets the *loft*. The *landing platform* shall be not less than 20 inches (508 mm) in width and in depth measured horizontally from and perpendicular to the *nosing* of the landing platform. The landing platform riser height to the loft floor shall be not less than 16 inches (406 mm) and not greater than 18 inches (457 mm).

**AQ104.2.1.6 Handrails.** *Handrails* shall comply with Section R311.7.8.

**AQ104.2.1.7 Stairway guards.** Guards at open sides of stairways, landings and landing platforms shall comply with Section R312.1.

**AQ104.2.2 Ladders.** Ladders accessing *lofts* shall comply with Sections AQ104.2.1 and AQ104.2.2.2.

**AQ104.2.2.1 Size and capacity.** Ladders accessing *lofts* shall have a rung width of not less than 12 inches (305 mm), and 10-inch (254 mm) to 14-inch (356 mm) spacing between rungs. Ladders shall be capable of supporting a 300-pound (136 kg) load on any rung. Rung spacing shall be uniform within $^3/_8$ inch (9.5 mm).

**AQ104.2.2.2 Incline.** Ladders shall be installed at 70 to 80 degrees from horizontal.

**AQ104.2.3 Alternating tread devices.** Alternating tread devices accessing *lofts* shall comply with Sections R311.7.11.1 and R311.7.11.2. The clear width at and below the *handrails* shall be not less than 20 inches (508 mm).

**AQ104.2.4 Ship's ladders.** Ship's ladders accessing *lofts* shall comply with Sections R311.7.12.1 and R311.7.12.2. The clear width at and below *handrails* shall be not less than 20 inches (508 mm).

**AQ104.2.5 Loft guards.** *Loft* guards shall be located along the open sides of *lofts*. *Loft* guards shall be not less than 36 inches (914 mm) in height or one-half of the clear height to the ceiling, whichever is less. Loft guards shall comply with Section R312.1.3 and Table R301.5 for their components.

## SECTION AQ105
## EMERGENCY ESCAPE AND RESCUE OPENINGS

**AQ105.1 General.** *Tiny houses* shall meet the requirements of Section R310 for emergency escape and rescue openings.

**Exception:** *Egress roof access windows* in *lofts* used as sleeping rooms shall be deemed to meet the requirements of Section R310 where installed such that the bottom of the opening is not more than 44 inches (1118 mm) above the *loft* floor, provided the egress roof access window complies with the minimum opening area requirements of Section R310.2.1.

## SECTION AQ106
## ENERGY CONSERVATION

**AQ106.1 Air leakage testing.** The air leakage rate for *tiny houses* shall not exceed 0.30 cubic feet per minute at 50 Pascals of pressure per square foot of the *dwelling unit* enclosure area. The air leakage testing shall be in accordance with the testing methods required in Section N1102.4.1.2. The *dwelling unit* enclosure area shall be the sum of the areas of ceilings, floors and walls that separate the conditioned space of a *dwelling unit* from the exterior, its adjacent unconditioned spaces and adjacent *dwelling units*.

**AQ106.1.1 Whole-house mechanical ventilation.** Where the air leakage rate is in accordance with Section AQ106.1, the *tiny house* shall be provided with whole-house mechanical ventilation in accordance with Section M1505.4.

**AQ106.2 Alternative compliance.** *Tiny houses* shall be deemed to be in compliance with Chapter 11 of this code and Chapter R4 of the *International Energy Conservation Code*, provided that the following conditions are met:

1. The insulation and fenestration meet the requirements of Table N1102.1.2.
2. The thermal envelope meets the requirements of Section N1102.4.1.1 and Table N1102.4.1.1.
3. Solar, wind or other renewable energy source supplies not less than 90 percent of the energy use for the structure.
4. Solar, wind or other renewable energy source supplies not less than 90 percent of the energy for service water heating.
5. Permanently installed lighting is in accordance with Section N1104.
6. Mechanical ventilation is provided in accordance with Section M1505 and operable fenestration is not used to meet ventilation requirements.

## SECTION AQ107
## SMOKE AND CARBON MONOXIDE DETECTORS

**AQ107.1 Smoke and Carbon monoxide detectors.** Smoke and carbon monoxide detectors shall be installed as required in Sections R314 and R315 and just below the highest point of any *loft*.

## SECTION AQ108 FOUNDATION

**AQ108.1 Foundation options.** *Tiny Houses* are permitted to be constructed without a masonry or concrete foundation per Section AQ108.1.1 and AQ108.1.2, except in *coastal high hazard, ocean hazard* and *flood hazard areas.*

**AQ108.1.1 Wood Foundation**. The building shall be supported on a wood foundation of minimum 4-inch by 4-inch or 6-inch by 6-inch mudsill or runner of approved wood in accordance with Section R317. Structural floor systems that include joists and subfloor material shall also comply with Section R317.1, item #1.

**AQ108.1.2. Anchorage**. *Tiny houses* with wood foundations per AQ108.1.1 shall be designed and anchored to resist overturning and sliding.

**Exc8ption:** *Tiny houses* with no more than 12’ vertical mean roof height shall be anchored to resist overturning and sliding by installing a minimum of one ground anchor at each corner of the building. The total resisting force of the anchors shall be equal to 20psf (958 Pa) times the plan area of the building.

## APPENDIX AR

# LIGHT STRAW-CLAY CONSTRUCTION

DELETED

# APPENDIX AS

# STRAWBALE CONSTRUCTION

*DELETED.*

# APPENDIX AT ~~[RE]~~

# SOLAR-READY PROVISIONS—DETACHED ONE- AND TWO-FAMILY DWELLINGS AND TOWNHOUSES

# Deleted.

~~*The provisions contained in this appendix are adopted as part of this code.not mandatory unless specifically referenced in the adopting ordinance.*~~

## ~~SECTION AT101 (RB101)~~
## ~~SCOPE~~

~~**AT101.1 (RB101.1) General.** These provisions shall be applicable for new construction where solar-ready provisions are required.~~

## ~~SECTION AT102 (RB102)~~
## ~~GENERAL DEFINITION~~

~~**AT102.1 (RB102.1) General.** The following term shall, for the purpose of this appendix, have the meaning shown herein.~~

~~**SOLAR-READY ZONE.** A section or sections of the roof or building overhang designated and reserved for the future installation of a solar photovoltaic or solar thermal system.~~

## ~~SECTION AT103 (RB103)~~
## ~~SOLAR-READY ZONE~~

~~**AT103.1 (RB103.2) General.** New detached one- and two-family dwellings, and townhouses with not less than 600 square feet (55.74 m$^2$) of roof area oriented between **110** degrees and 270 degrees of true north, shall comply with Sections AT103.2 through AT103.10.~~

~~**Exceptions:**~~

1. ~~New residential buildings with a permanently installed on-site renewable energy system.~~
2. ~~A building where all areas of the roof that would otherwise meet the requirements of Section AT103 are in full or partial shade for more than 70 percent of daylight hours annually.~~

~~**AT103.2 (RB103.2) Construction document requirements for solar-ready zone.** *Construction documents* shall indicate the solar-ready zone.~~

~~**AT103.3 (RB103.3) Solar-ready zone area.** The total solar-ready zone area shall be not less than 300 square feet (27.87 m$^2$) exclusive of mandatory access or setback areas as required by the *International Fire Code*. New townhouses three stories or less in height above *grade plane* and with a total floor area less than or equal to 2,000 square feet (185.8 m$^2$) per dwelling shall have a solar-ready zone area of not less than 150 square feet (13.94 m$^2$).~~

~~The solar-ready zone shall be composed of areas not less than 5 feet (1524 mm) in width and not less than 80 square feet (7.44 m²) exclusive of access or set-back areas as required by the *International Fire Code*.~~

~~**AT103.4 (RB103.4) Obstructions.** Solar-ready zones shall be free from obstructions, including but not limited to vents, chimneys, and roof-mounted equipment.~~

~~**AT103.5 (RB103.5) Shading.** The solar-ready zone shall be set back from any existing or new, permanently affixed object on the building or site that is located south, east or west of the solar zone a distance not less than two times the object's height above the nearest point on the roof surface. Such objects include, but are not limited to, taller portions of the building itself, parapets, chimneys, antennas, signage, rooftop equipment, trees and roof plantings.~~

~~**AT103.6 (RB103.6) Capped roof penetration sleeve.** A capped roof penetration sleeve shall be provided adjacent to a solar-ready zone located on a roof slope of not greater than 1 unit vertical in 12 units horizontal (8-percent slope). The capped roof penetration sleeve shall be sized to accommodate the future photovoltaic system conduit, but shall have an inside diameter of not less than 1¼ inches (32 mm).~~

~~**AT103.7 (RB103.7) Roof load documentation.** The structural design loads for roof dead load and roof *live load* shall be clearly indicated on the *construction documents*.~~

~~**AT103.8 (RB103.8) Interconnection pathway.** *Construction documents* shall indicate pathways for routing of conduit or plumbing from the solar-ready zone to the electrical service panel or service hot water system.~~

~~**AT103.9 (RB103.9) Electrical service reserved space.** The main electrical service panel shall have a reserved space to allow installation of a dual pole circuit breaker for future solar electric installation and shall be *labeled* "For Future Solar Electric." The reserved space shall be positioned at the opposite (load) end from the input feeder location or main circuit location.~~

~~**AT103.10 (RB103.10) Construction documentation certificate.** A permanent certificate, indicating the solar-ready zone and other requirements of this section, shall be posted near the electrical distribution panel, water heater or other conspicuous location by the builder or *registered design professional*.~~

# APPENDIX AU

# COB CONSTRUCTION (MONOLITHIC ADOBE)

DELETED.

# APPENDIX AV

## BOARD OF APPEALS

*DELETED.*

# APPENDIX AW
# 3D-PRINTED BUILDING CONSTRUCTION

The provisions contained in this appendix are *adopted as part of this code.*

## SECTION AW101
## GENERAL

**AW101.1 Scope.** Buildings, structures and building elements fabricated in whole or in part using 3D-printed construction techniques shall be designed, constructed and inspected in accordance with the provisions contained in this appendix and other applicable requirements in this code.

**AW101.2 Definitions.** The words and terms in Section AW102 shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 of this code for general definitions.

## SECTION AW102
## DEFINITIONS

**3D-PRINTED BUILDING CONSTRUCTION.** A process for fabricating buildings, structures and building elements from 3D model data using automated equipment that deposits construction material in a layer-upon-layer fashion.

**ADDITIVE MANUFACTURING MATERIALS.** Materials used by the 3D printer to produce the building structure or system components of the building.

**FABRICATION PROCESS.** Preparation of the job site and construction material, the deposition, curing, finishing, insertion of components and other methods used to construct building elements such as walls, partitions, *roof assemblies* and structural components, and the means used to connect assemblies together.

**PRODUCTION EQUIPMENT.** The equipment, including the 3D printer, its settings, nozzles and other accessories used in the fabrication process.

**SYSTEM COMPONENTS.** Devices, equipment and *appliances* that are installed in the building elements as part of the wiring, plumbing, HVAC and other systems. These include, but are not limited to, electrical outlet boxes, conduit, wiring, piping, tubing and HVAC ducts, each of which is covered by a product standard or installation code requirement.

## SECTION AW103
## BUILDING DESIGN

**AW103.1 Design organization.** 3D-printed buildings, structures and building elements shall be designed by an organization certified in accordance with UL 3401 by an *approved* agency and approved by the building official in accordance with this section.

**AW103.2 Design approval.** The structural design, *construction documents* and UL 3401 report of findings shall be submitted for review and approval in accordance with Section 104.11.

## SECTION AW104
## BUILDING CONSTRUCTION

**AW104.1 Construction.** 3D-printed buildings, structures and building elements shall be constructed in accordance with this section.

**AW104.2 Construction method.** The building construction method, consisting of the manufacturer's production equipment and fabrication process, shall be in accordance with the UL 3401 report of findings. The unique identifier of the construction method used shall match the identifier in the UL 3401 report of findings.

**AW104.3 Additive manufacturing materials.** Only the *listed* additive manufacturing materials identified in the UL 3401 report of findings shall be used to fabricate the building structure or system components. Containers of the additive manufacturing materials shall be *labeled*.

**AW104.4 Depositing of manufacturing materials.** Manufacturing materials shall only be deposited where ambient temperature and environmental conditions at the job site are within limits specified in the UL 3401 report of findings. The maximum number of layers permitted, specified curing time and any surface preparation or finishing shall be performed as specified in the UL 3401 report of findings.

## SECTION AW105
## SPECIAL INSPECTIONS

**AW105.1 Initial inspection.** An initial inspection of the production equipment, including 3D printer, and the fabrication process shall be performed after the production equipment is located on site and before building fabrication has begun. The inspection shall be conducted by representatives of the approved agency that evaluated the fabrication process for compliance with UL 3401. The inspection shall verify that the fabrication process, including production equipment, 3D-printing parameters and additive manufacturing materials, are in accordance with the UL 3401 report of findings and the proprietary information in the UL 3401 detailed report of findings.

**Exception:** Where approved by the building official, inspections of the production equipment, including 3D printer, and the fabrication process used in a single housing tract shall be conducted on the first building to be constructed, and on a selected number of subsequent buildings, where the same equipment, equipment operators and fabrication process are used on all buildings. The number of inspections to be performed shall be determined by the building official.

## SECTION AW106
## REFERENCED STANDARDS

**AW106.1 General.** See Table AW106.1 for standards that are referenced in various sections of this appendix. Standards are listed by the standard identification with the effective date, the standard title and the section or sections of this appendix that reference the standard.

**TABLE AW106.1**
**REFERENCED STANDARDS**

| STANDARD ACRONYM | STANDARD NAME | SECTIONS HEREIN REFERENCED |
|---|---|---|
| UL 3401—19 | Outline of Investigation for 3D Printed Building Construction | AW103.2, AW104.2, AW104.3, AW104.4, AW105.1 |

# APPENDIX NC-A
# SWIMMING POOLS, SPAS AND HOT TUBS

This appendix is a North Carolina addition and not part of the 2024 *International Residential Code*. There will be no underlined text.

*The provisions contained in this appendix are adopted as part of this code.*

## SECTION NCA101
## GENERAL

**NCA101.1 General.** The provisions of this appendix shall control the design and construction of swimming pools, spas and hot tubs installed in or on the *lot* of a one- or two-family dwelling.

**NCA101.2 Pools in flood hazard areas.** Pools that are located in flood hazard areas established by Table R301.2(1), including above-ground pools, on-ground pools and in-ground pools that involve placement of fill, shall comply with Section NCA101.2.1 or NCA101.2.2.

**Exception:** Pools located in riverine flood hazard areas that are outside of designated floodways.

**NCA101.2.1 Pools located in designated floodways.** Where pools are located in designated floodways, documentation shall be submitted to the *building official*, which demonstrates that the construction of the pool will not increase the design flood elevation at any point within the *jurisdiction*.

**NCA101.2.2 Pools located where floodways have not been designated.** Where pools are located where design flood elevations are specified but floodways have not been designated, the applicant shall provide a floodway analysis that demonstrates that the proposed pool will not increase the design flood elevation more than 1 foot (305 mm) at any point within the *jurisdiction*.

## SECTION NCA102
## DEFINITIONS

**NCA102.1 General.** For the purposes of these requirements, the terms used shall be defined as follows and as set forth in Chapter 2.

**ABOVE-GROUND/ON-GROUND POOL.** See "Swimming pool."

**BARRIER.** A permanent fence, wall, building wall or combination thereof that completely surrounds the swimming pool and
obstructs access to the swimming pool.

**HOT TUB.** See "Swimming pool."

**IN-GROUND POOL.** See "Swimming pool."

**RESIDENTIAL.** That which is situated on the premises of a detached one- or two-family dwelling or a one-family *townhouse* not more than three stories in height.

**SPA, NONPORTABLE.** See "Swimming pool."

**SPA, PORTABLE.** A nonpermanent structure intended for recreational bathing, in which all controls, water-heating and water-circulating *equipment* are an integral part of the product.

**SWIMMING POOL.** Any structure intended for swimming or recreational bathing that contains water over 24 inches (610 mm) deep. This includes in-ground, above-ground and on-ground swimming pools, hot tubs and spas.

**SWIMMING POOL, INDOOR.** A swimming pool which is totally contained within a structure and surrounded on all four sides by the walls of the enclosing structure.

**SWIMMING POOL, OUTDOOR.** Any swimming pool which is not an indoor pool.

## SECTION NCA103
## SWIMMING POOLS

**NCA103.1 In-ground pools.** In-ground pools shall be designed and constructed in conformance with ANSI/APSP/ICC 5 as listed in Section NCA107.

**NCA103.2 Above-ground and on-ground pools.** Aboveground and on-ground pools shall be designed and constructed in conformance with ANSI/APSP/ICC 4 as listed in Section NCA107.
**NCA103.3 Pools in flood hazard areas.** In flood hazard areas established by Table R301.2(1), pools in coastal high hazard areas shall be designed and constructed in conformance with ASCE 24.

## SECTION NCA104
## SPAS AND HOT TUBS

**NCA104.1 Permanently installed spas and hot tubs.** Permanently installed spas and hot tubs shall be designed and constructed in conformance with ANSI/APSP/ICC 3 as listed in Section NCA107.

**NCA104.2 Portable spas and hot tubs.** Portable spas and hot tubs shall be designed and constructed in conformance with ANSI/APSP/ICC 6 as listed in Section NCA107.

## SECTION NCA105
## BARRIER REQUIREMENTS

**NCA105.1 Application.** The provisions of this chapter shall control the design of barriers for residential swimming pools, spas and hot tubs. These design controls are intended to provide protection against potential drownings and near drownings by restricting access to swimming pools, spas and hot tubs.

**NCA105.2 Outdoor swimming pools and spas.** An outdoor swimming pool, including an in-ground, above-ground or on-ground pool, hot tub or spa shall be surrounded by a barrier that complies with **Sections NCA105.2.1** through **NCA105.7**.
**NCA105.2.1 Barrier height and clearances.** Barrier heights and clearances shall be in accordance with all of the following:

1. The top of the barrier shall be not less than 48 inches (1219 mm) above grade where measured on the side of the barrier that faces away from the pool or spa. Such height shall exist around the entire perimeter of the barrier and for a distance of 3 feet (914 mm) measured horizontally from the outside of the required barrier.
2. The vertical clearance between grade and the bottom of the barrier shall not exceed 2 inches (51 mm) for grade surfaces that are not solid, such as grass or gravel, where measured on the side of the barrier that faces away from the pool or spa.
3. The vertical clearance between a surface below the barrier to a solid surface, such as concrete, and the bottom of the required barrier shall not exceed 4 inches (102 mm) where measured on the side of the required barrier that faces away from the pool or spa.
4. Where the top of the pool or spa structure is above grade, the barrier shall be installed on grade or shall be mounted on top of the pool or spa structure. Where the barrier is mounted on the top of the pool or spa, the vertical clearance between the top of the pool or spa and the bottom of the barrier shall not exceed 4 inches (102 mm).

**NCA105.2.2 Openings.** Openings in the barrier shall not allow passage of a 4-inch-diameter (102 mm) sphere.

**NCA105.2.3 Solid barrier surfaces.** Solid barriers that do not have openings shall not contain indentations or protrusions that form handholds and footholds, except for normal construction tolerances and tooled masonry joints.

**NCA105.2.4 Mesh fence as a barrier.** Mesh fences, other than chain link fences in accordance with **Section NCA105.2.7**, shall be installed in accordance with the manufacturer's instructions and shall comply with the following:
1. The bottom of the mesh fence shall be not more than 1 inch (25 mm) above the deck or installed surface or grade.
2. The maximum vertical clearance from the bottom of the mesh fence and the solid surface shall not permit the fence to be lifted more than 4 inches (102 mm) from grade or decking.
3. The fence shall be designed and constructed so that it does not allow passage of a 4-inch (102 mm) sphere under any mesh panel. The maximum vertical clearance from the bottom of the mesh fence and the solid surface shall be not greater than 4 inches (102 mm) from grade or decking.

4. An attachment device shall attach each barrier section at a height not lower than 45 inches (1143 mm) above grade. Common attachment devices include, but are not limited to, devices that provide the security equal to or greater than that of a hook-and-eye-type latch incorporating a spring-actuated retaining lever such as a safety gate hook.
5. Where a hinged gate is used with a mesh fence, the gate shall comply with **Section NCA105.3**.
6. Patio deck sleeves such as vertical post receptacles that are placed inside the patio surface shall be of a nonconductive material.
7. Mesh fences shall not be installed on top of onground residential pools.

**NCA105.2.4.1 Setback for mesh fences. The inside of a mesh fence shall be not closer than 20 inches (508 mm) to the nearest edge of the water of a pool or spa.**

**NCA105.2.5 Closely spaced horizontal members.** Where the barrier is composed of horizontal and vertical members and the distance between the tops of the horizontal members is less than 45 inches (1143 mm), the horizontal members shall be located on the pool or spa side of the fence. Spacing between vertical members shall not exceed 13/4 inches (44 mm) in width. Where there are decorative cutouts within vertical members, spacing within the cutouts shall not exceed 13/4 inches (44 mm) in width.

**NCA105.2.6 Widely spaced horizontal members.** Where the barrier is composed of horizontal and vertical members and the distance between the tops of the horizontal members is 45 inches (1143 mm) or more, spacing between vertical members shall not exceed 4 inches (102 mm). Where there are decorative cutouts within vertical members, the interior width of the cutouts shall not exceed 1 3/4 inches (44 mm).

**NCA105.2.7 Chain link dimensions.** The maximum opening formed by a chain link fence shall be not more than 1 3/4 inches (44 mm). Where the fence is provided with slats fastened at the top and bottom that reduce the openings, such openings shall be not greater than 1 3/4 inches (44 mm).

**NCA105.2.8 Diagonal members.** Where the barrier is composed of diagonal members, the maximum opening formed by the diagonal members shall be not greater than 1 3/4 inches (44 mm). The angle of diagonal members shall be not greater than 45 degrees (0.79 rad) from vertical.

**NCA105.2.9 Clear zone.** Where equipment, including pool equipment such as pumps, filters and heaters, is on the same lot as a pool or spa and such equipment is located outside of the barrier protecting the pool or spa, such equipment shall be located not less than 36 inches (914 mm) from the outside of the barrier.

**NCA105.3 Doors and gates. Doors and** gates **in barriers** shall comply with the requirements of **Sections NCA105.3.1** through **NCA 105.3.3** and shall be equipped to accommodate a locking device. Pedestrian access **doors and** gates shall open outward away from the pool or spa, shall be self-closing and shall have a self-latching device.
**NCA105.3.1 Utility or service doors and gates.** Gates **Doors and gates** not intended for pedestrian use, such as utility or service **doors and** gates, shall remain locked when not in use.
**NCA105.3.2 Double or multiple doors and gates.** Double **doors and** gates or multiple **doors and** gates shall have not fewer than one leaf secured in place and the adjacent leaf shall be secured with a selflatching **device.**
**NCA105.3.3 Latches release.** For doors and gates in barrier, the door and gate latch release mechanisms shall be in accordance with the following**:**

1. Where door and gate latch release mechanisms are accessed from the outside of the barrier and are not of the self-locking type, such mechanism shall be located above the finished floor or ground surface not less 54 inches (1372 mm).

2. Where door and gate latch release mechanisms are of the self-locking type such as where the lock is operated by means of a key, an electronic opener or the entry of a combination into an integral combination lock, the lock operation control and the latch release mechanism shall be located above the finished floor or ground surface not greater than 54 inches (1372 mm).

3. Where the only latch release mechanism of a self-latching device for a gate is located on the pool and spa side of the barrier, the release mechanism shall be located at a point that is at least 3 inches (76 mm) below the top of the gate.

**NCA105.3.4 Barriers adjacent to latch release mechanisms.** Where a latch release mechanism is located on the inside of a barrier, openings in the door, gate and barrier within 18 inches (457 mm) of the latch shall not be greater than 1/2 inch (12.7 mm) in any dimension**.**

**NCA105.4 Structure wall as a barrier.** Where a wall of a dwelling or structure serves as part of the barrier and where doors**, gates** or windows provide direct access to the pool or spa through that wall, one of the following shall be required:

1. Operable windows having a sill height of less than 48 inches (1219 mm) above the indoor finished floor **, doors and** doors **gates** shall have an alarm that produces an audible warning when the window, door or their screens are opened. The alarm shall be listed and labeled as a water hazard entrance alarm in accordance with UL 2017.
2. The operable parts of the alarm deactivation switches shall be located **at not less than** 54 inches (1372 mm) above the finished floor.
3. A safety cover that is listed and labeled in accordance with **ASTM F1346** is installed for the pools and spas.
4. An approved means of protection, such as self-closing doors with self-latching devices, is provided. Such means of protection shall provide a degree of protection that is not less than the protection afforded by Item 1 or 2.

**NCA105.5 Onground residential pool structure as a barrier.** An onground residential pool wall structure or a barrier mounted on top of an onground residential pool wall structure shall serve as a barrier where all of the following conditions are present:

1. Where only the pool wall serves as the barrier, the bottom of the wall is on grade, the top of the wall is not less than 48 inches (1219 mm) above grade for the entire perimeter of the pool, the wall complies with the requirements of **Section NCA105.2** and the pool manufacturer allows the wall to serve as a barrier.
2. Where a barrier is mounted on top of the pool wall, the top of the barrier is not less than 48 inches (1219 mm) above grade for the entire perimeter of the pool, and the wall and the barrier on top of the wall comply with the requirements of **Section NCA105.2**.

3. Ladders or steps used as means of access to the pool are capable of being secured, locked or removed to prevent access except where the ladder or steps are surrounded by a barrier that meets the requirements of **Section NCA 105**.

4. Openings created by the securing, locking or removal of ladders and steps do not allow the passage of a 4-inch (102 mm) diameter sphere.

5. Barriers that are mounted on top of onground residential pool walls are installed in accordance with the pool manufacturer's instructions.

**NA105.6 Natural barriers.** In the case where the pool or spa area abuts the edge of a lake or other natural body of water, public access is not permitted or allowed along the shoreline, and required barriers extend to and beyond the water's edge not less than 18 inches (457 mm), a barrier is not required between the natural body of water shoreline and the pool or spa.

**NCA105.7 Natural topography.** Natural topography that prevents direct access to the pool or spa area shall include but not be limited to mountains and natural rock formations. A natural barrier approved by the governing body shall be acceptable provided that the degree of protection is not less than the protection afforded by the requirements of **Sections NCA105.2** through **NCA105.5**.

**NCA105.8 Indoor swimming pool.** Walls surrounding an indoor swimming pool shall comply with Section NCA105.2, Item 9.

**NCA105.9 Prohibited locations.** Barriers shall be located to prohibit permanent structures, equipment or similar objects from being used to climb them.

**NCA105.10 Barrier exceptions.** Spas or hot tubs with a safety cover that complies with ASTM F1346, as listed in Section NCA107, shall be exempt from the provisions of this appendix.

## SECTION NCA106
## ENTRAPMENT PROTECTION FOR SWIMMING POOL AND SPA SUCTION OUTLETS

**NCA106.1 General.** Suction outlets shall be designed and installed in accordance with APSP 7(ANSI/PHTA/ICC 7).

## SECTION NCA107
## REFERENCE STANDARDS

**APSP**
Pool & Hot Tub Alliance (formerly The Association of Pool &
Spa Professionals)
2111 Eisenhower Avenue, Suite 500
Alexandria, VA 22314

**ANSI/APSP/ICC 3—2014 American National Standard for Permanently Installed Residential Spas and Swim Spas**
**NCA104.1**

**ANSI/APSP/ICC 4—2012 American National Standard for Aboveground/Onground Residential Swimming Pools—Includes Addenda A Approved April 4, 2013**
**NCA103.2**

**ANSI/APSP/ICC 5—2011 American National Standard for Residential Inground Swimming Pools**
**NCA103.1**

**ANSI/APSP/ICC 6—2013 American National Standard for Residential Swimming Pool and Spa**
**NCA104.2**

**ANSI/PHTA/ICC 7—2020 American National Standard for Suction Entrapment Avoidance in Swimming Pools, Wading Pools, Spas, Hot Tubs, and Catch Basins**
**NCA106.1**

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**ASCE/SEI**

American Society of Civil Engineers Structural Engineering Institute
1801 Alexander Bell Drive
Reston, VA 20191-4400

**ASCE 24—14 Flood Resistant Design & Construction**
**NCA103.3**

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**ASTM**
ASTM International
100 Barr Harbor, P.O. Box C700
West Conshohocken, PA 19428-2959

**F1346—1991(2018) Standard Performance Specification for Safety Covers and Labeling Requirements for All Covers for Swimming Pools, Spas and Hot Tubs**
**NCA105.1, NCA105.4**

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ICC

International Code Council, Inc.
500 New Jersey Avenue, NW
6th Floor
Washington, DC 20001

ISPSC—21 International Swimming Pool and Spa Code

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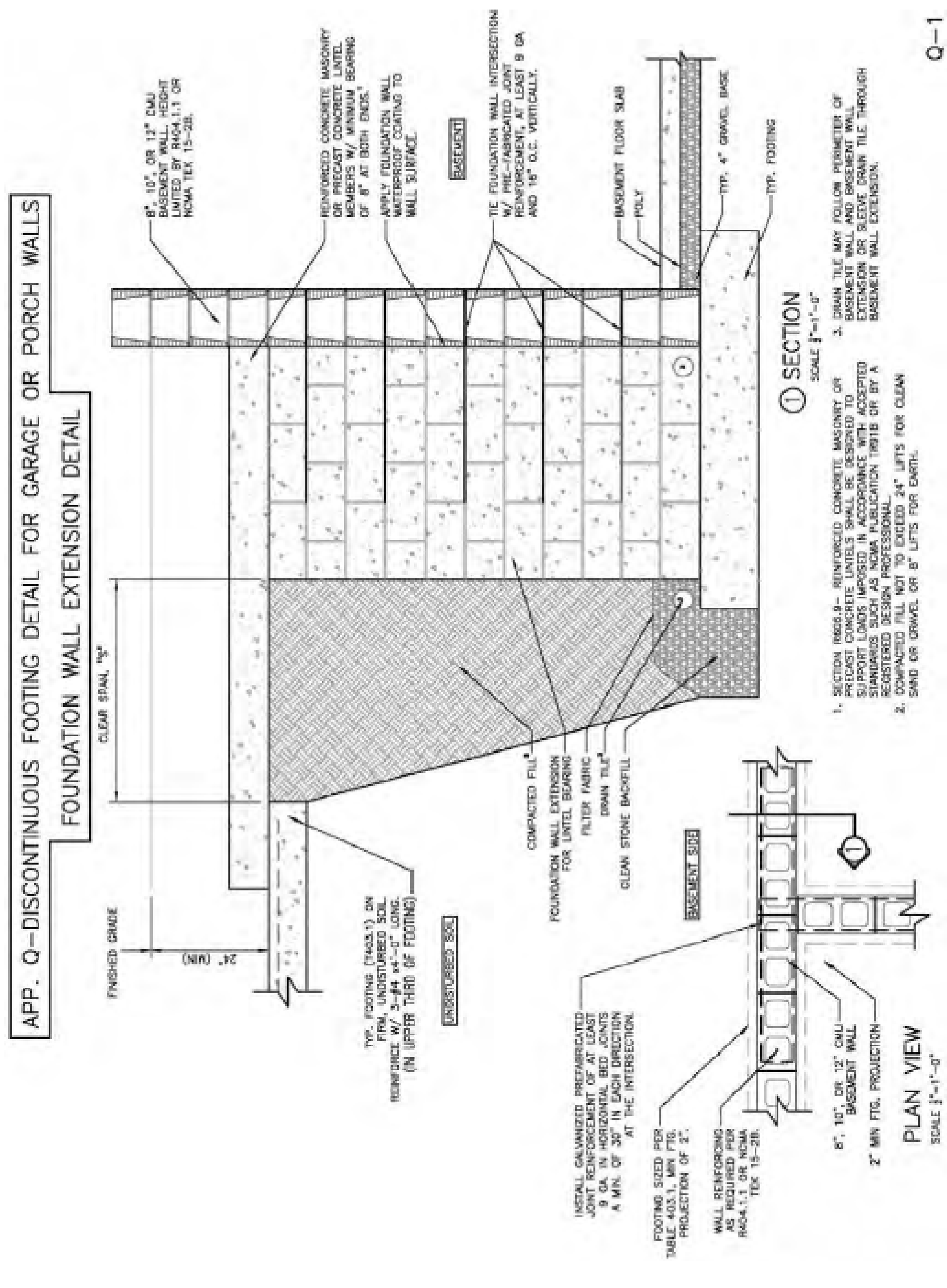
**UL**

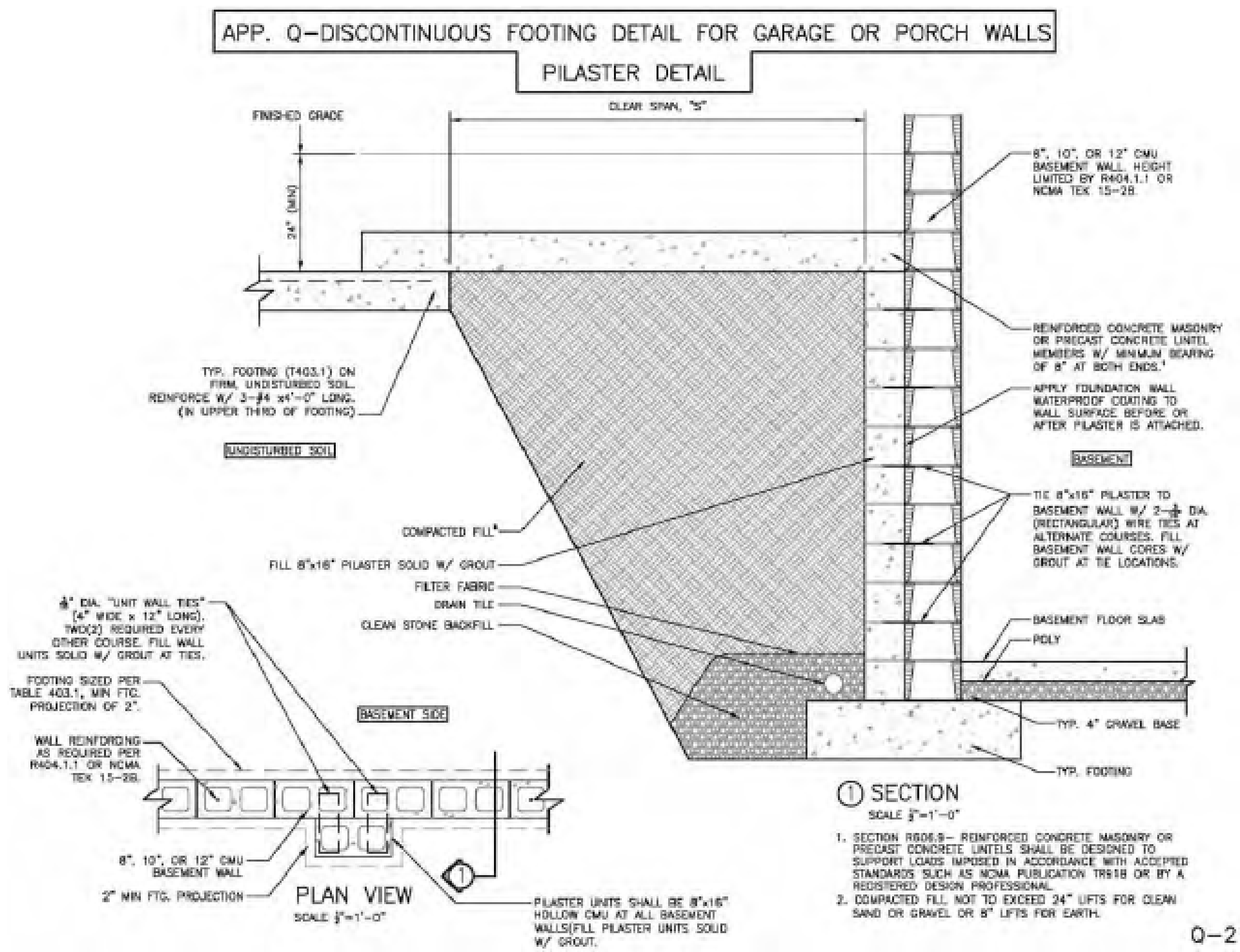
UL LLC
333 Pfingsten Road
Northbrook, IL 60062

**2017—2008 General-purpose Signaling Devices and Systems—with revisions through January 2018**
**NCA105.4**

# APPENDIX NC-B

***This appendix is a North Carolina addition to the 2021 International Residential Code.***
***There will be no underlined text.***
***(The provisions contained in this appendix are adopted as part of this code.)***

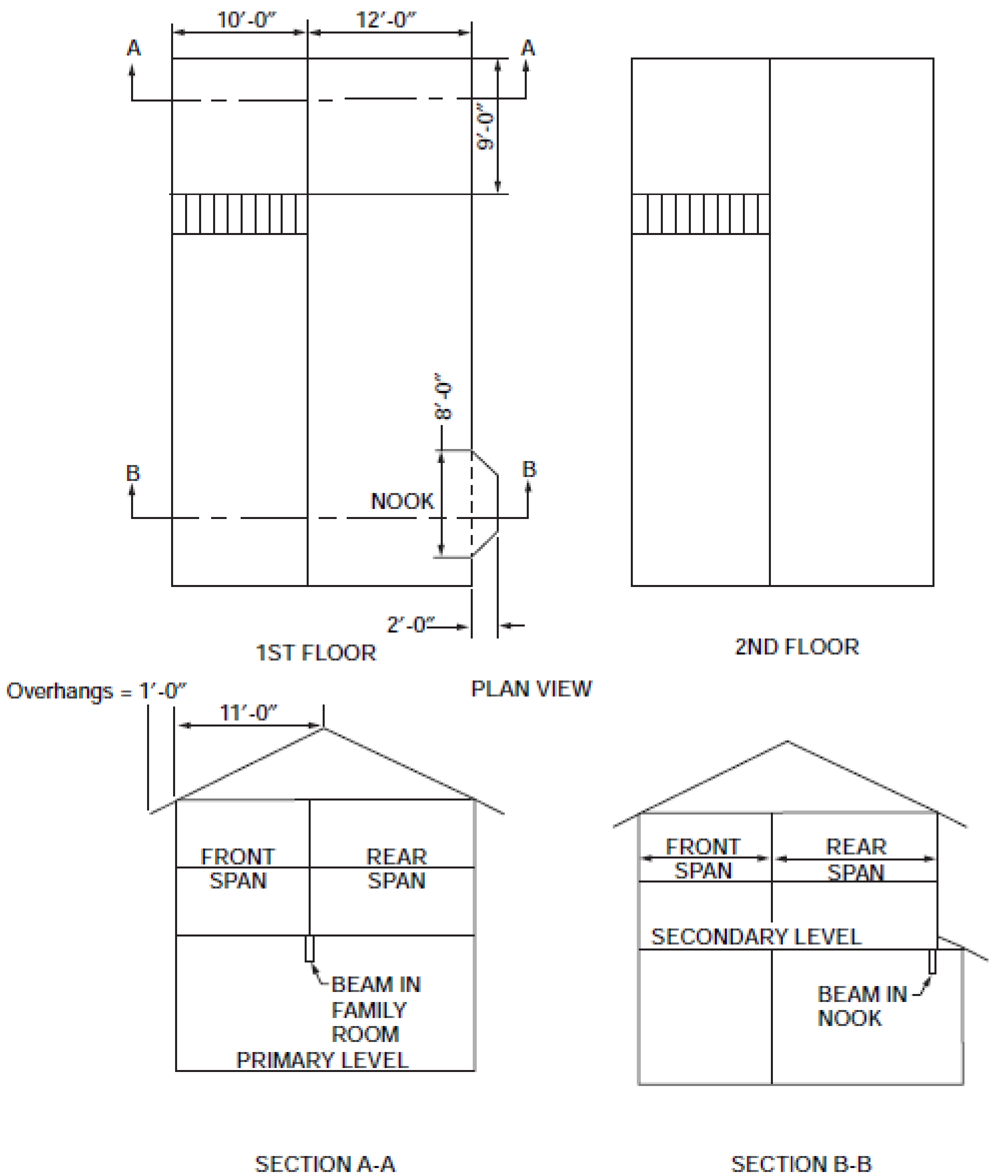



APP. Q-DISCONTINUOUS FOOTING DETAIL FOR GARAGE OR PORCH WALLS
PILASTER DETAIL
FINISHED GRADE
24" (MIN)
CLEAR SPAN, "S"
8", 10", OR 12" CMU BASEMENT WALL. HEIGHT LIMITED BY R404.1.1 OR NCMA TEK 15-28.
REINFORCED CONCRETE MASONRY OR PRECAST CONCRETE LINTEL MEMBERS W/ MINIMUM BEARING OF 8" AT BOTH ENDS.[1]
APPLY FOUNDATION WALL WATERPROOF COATING TO WALL SURFACE BEFORE OR AFTER PILASTER IS ATTACHED.
BASEMENT
TIE 8"x16" PILASTER TO BASEMENT WALL W/ 2-$\frac{3}{16}$ DIA. (RECTANGULAR) WIRE TIES AT ALTERNATE COURSES. FILL BASEMENT WALL CORES W/ GROUT AT TIE LOCATIONS.
BASEMENT FLOOR SLAB
POLY
TYP. 4" GRAVEL BASE
TYP. FOOTING
TYP. FOOTING (T403.1) ON FIRM, UNDISTURBED SOIL. REINFORCE W/ 3-#4 x4'-0" LONG. (IN UPPER THIRD OF FOOTING)
UNDISTURBED SOIL
COMPACTED FILL[2]
FILL 8"x16" PILASTER SOLID W/ GROUT
FILTER FABRIC
DRAIN TILE
CLEAN STONE BACKFILL
$\frac{3}{16}$" DIA. "UNIT WALL TIES" (4" WIDE x 12" LONG). TWO(2) REQUIRED EVERY OTHER COURSE. FILL WALL UNITS SOLID W/ GROUT AT TIES.
FOOTING SIZED PER TABLE 403.1, MIN FTG. PROJECTION OF 2".
BASEMENT SIDE
WALL REINFORCING AS REQUIRED PER R404.1.1 OR NCMA TEK 15-28.
8", 10", OR 12" CMU BASEMENT WALL
2" MIN FTG. PROJECTION
PLAN VIEW
SCALE $\frac{1}{2}$"=1'-0"
1
PILASTER UNITS SHALL BE 8"x16" HOLLOW CMU AT ALL BASEMENT WALLS(FILL PILASTER UNITS SOLID W/ GROUT.
1 SECTION
SCALE $\frac{1}{2}$"=1'-0"
1. SECTION R606.9- REINFORCED CONCRETE MASONRY OR PRECAST CONCRETE LINTELS SHALL BE DESIGNED TO SUPPORT LOADS IMPOSED IN ACCORDANCE WITH ACCEPTED STANDARDS SUCH AS NCMA PUBLICATION TR91B OR BY A REGISTERED DESIGN PROFESSIONAL.
2. COMPACTED FILL NOT TO EXCEED 24" LIFTS FOR CLEAN SAND OR GRAVEL OR 8" LIFTS FOR EARTH.
Q-2

# APPENDIX NC-C
# BASIC LOAD ESTIMATING

***This appendix is a North Carolina addition and not part of the 2021 International Residential Code. There will be no underlined text.***

***(The provisions contained in this appendix are adopted as part of this code.)***




For SI: 1 inch = 25.4, 1 foot = 304.8 mm, 1 square foot = 0.0929m2.

ASSUMPTIONS (sleeping area live load; roof or stick frame rafters with no interior bearing):

Loads

Secondary floor level is 30# L.L. + 10# D.L. = 40#/sq. ft.

Attic level is 20# live load + 10# dead load = 30#/sq. ft.
Nook ceiling is 10# dead load (No attic storage) = 10#/sq. ft.
Wall load
Studs @ 16", 1/2" gypsum = 8#/sq. ft.
Roof load
20# live load + 10# dead load = 30#/sq. ft.

## EXAMPLE OF LOAD ESTIMATING
## LOAD ON BEAM IN FAMILY ROOM

Loads in Section A - A as follows: **Total Loads**
(in pounds/linear foot)

$$\text{2nd floor load} = \frac{(\text{front joist span} + \text{rear joist span})}{2} \times \text{2nd floor (dead load + live load)} = \text{LOAD/linear ft}$$

$$= \frac{(10 + 12)}{2} \times (10 + 30) = \frac{(22)}{2} \times (40) = 11 \times 40 = \mathbf{440} \text{ pounds/linear ft}$$

Interior wall load = Wall Weight per Square foot x Wall Height = LOAD/linear foot

= 8 pounds/sq. ft. × 8ft. = = **64** pounds/linear ft
(Wall weight can vary. Verify actual weight of materials used)

$$\text{Attic load} = \frac{(\text{front joist span} + \text{rear joist span})}{2} \times \text{attic (dead load + live load)} = \text{LOAD/linear ft}$$

$$= \frac{(10 + 12)}{2} \times (10 + 20) = \frac{(22)}{2} \times (30) = 11 \times 30 = \underline{\mathbf{330}} \text{ pounds/linear ft}$$

Roof load: No roof load is transmitted to the beam in the family room. Roof Load = **0**

Total Load on Beam in Family Room = **834** pounds/1ft.

Beam span in family room is 9 feet and total estimated load is 834#/linear foot:

By using Table W-1, the required beam is 4 @ 2 × 12 ~~SYP or~~ SPF

OR

By using Table W-2, the required minimum flitch beam is 2@2 × 8 with ~~1/2~~5/8″×7″ steel plate bolted with 1/2″ bolts spaced at 2′ o.c.

## EXAMPLE OF LOAD ESTIMATING
## LOAD ON BEAM IN NOOK AREA

Loads in Section B - B as follows: **Total Loads**
(in pounds/linear foot)

2nd floor load = $\frac{\text{(front joist span + rear joist span)}}{2}$ x 2nd floor (dead load + live load) = LOAD/linear ft

$= \frac{(0 + 12)}{2} \times (10 + 30) = \frac{(12)}{2} \times (40) = 6 \times 40 =$ **240** pounds/linear ft

Exterior wall load = Wall Weight per Square foot x Wall Height = LOAD/linear foot

= 8 pounds/sq. ft. × 8ft. = = **64** pounds/linear ft
(Wall weight can vary. Verify actual weight of materials used)

Attic load = $\frac{\text{(front joist span + rear joist span)}}{2}$ x attic (dead load + live load) = LOAD/linear ft

$= \frac{(0 + 12)}{2} \times (10 + 20) = \frac{(12)}{2} \times (30) = 6 \times 30 =$ **180** pounds/linear ft

( front rear )
Roof load = $\frac{\text{(rafter span + rafter span)}}{2}$ + overhang x roof(dead load+live load)=LOAD/linear ft

$= (\frac{(11+11)}{2}+1) \times (10 + 20) = (\frac{(22)}{2}+1) \times (30) = 12 \times 30 =$ **360** pounds/linear ft

Nook Ceiling load = $\frac{\text{(joist span + joist span)}}{2}$ x ceiling(dead load+live load)=LOAD/linear ft

$= \frac{(0+2)}{2} \times (10 + 0) = \frac{(2)}{2} \times (10) = 1 \times 10 =$ **10** pounds/linear ft

Nook Roof load = $\frac{\text{(rafter span + rafter span)}}{2}$ x roof(dead load+live load)=LOAD/linear ft

$= \frac{(0+2)}{2} \times (10 + 20) = \frac{(2)}{2} \times (30) = 1 \times 30 =$ **30** pounds/linear ft

Total Load on Beam in Nook = **884** pounds/1ft.

Beam span in nook is 8 feet and total estimated load is 884#/linear foot:

By using Table W-1, the required beam is ~~3~~4 @ 2 × 12 Southern pine or 4 @ 2 × 12 Spruce-pine-fir

OR
By using Table W-2, the required minimum flitch beam is 2@2 × 8 with ~~3/8~~1/2″×7″ steel plate bolted with 1/2″ bolts spaced at 2′ o.c.

## TABLE W-1
## WOOD BEAMS AND GIRDERS ALLOWABLE LOADS IN POUNDS PER LINEAR FOOT [1, 2, 3, 4]

| **2X8 (1 ½" X 7 ¼")** | | | | | | |
|---|---|---|---|---|---|---|
| **Span L [6] (feet)** | **Spruce-Pine-Fir [5]** | | | **Southern Pine** | | |
| | **2 ply** | **3 ply** | **4 ply** | **2 ply** | **3 ply** | **4 ply** |
| 3 | 1305 | 1956 | 2610 | 1692 | 2538 | 3383 |
| 4 | 979 | 1468 | 1958 | 1013 | 1519 | 2026 |
| 5 | 736 | 1104 | 1472 | 648 | 972 | 1296 |
| 6 | 511 | 767 | 1022 | 450 | 675 | 900 |
| 7 | 375 | 563 | 751 | 331 | 496 | 661 |
| 8 | 287 | 431 | 575 | 253 | 380 | 506 |
| 9 | 227 | 341 | 454 | 200 | 300 | 400 |
| 10 | 184 | 276 | 368 | 162 | 243 | 324 |
| 12 | 114 | 172 | 228 | 113 | 169 | 225 |
| 14 | 72 | 108 | 144 | 72 | 108 | 144 |
| **2X10 (1 ½" X 9 ¼")** | | | | | | |
| **Span L [6] (feet)** | **Spruce-Pine-Fir [5]** | | | **Southern Pine** | | |
| | **2 ply** | **3 ply** | **4 ply** | **2 ply** | **3 ply** | **4 ply** |
| 3 | 1665 | 2498 | 3330 | 2158 | 3238 | 4317 |
| 4 | 1249 | 1873 | 2498 | 1426 | 2139 | 2852 |
| 5 | 999 | 1499 | 1998 | 913 | 1369 | 1825 |
| 6 | 763 | 1144 | 1525 | 634 | 951 | 1268 |
| 7 | 560 | 840 | 1120 | 466 | 698 | 931 |
| 8 | 429 | 643 | 858 | 357 | 535 | 713 |
| 9 | 339 | 508 | 678 | 282 | 423 | 563 |
| 10 | 275 | 412 | 549 | 228 | 342 | 456 |
| 12 | 191 | 286 | 381 | 158 | 238 | 317 |
| 14 | 140 | 210 | 280 | 116 | 175 | 233 |
| **2X12 (1 ½" X 11 ¼")** | | | | | | |
| **Span L [6] (feet)** | **Spruce-Pine-Fir [5]** | | | **Southern Pine** | | |
| | **2 ply** | **3 ply** | **4 ply** | **2 ply** | **3 ply** | **4 ply** |
| 3 | 2025 | 3038 | 4050 | 2625 | 3938 | 5250 |
| 4 | 1519 | 2278 | 3038 | 1969 | 2953 | 3938 |
| 5 | 1215 | 1823 | 2430 | 1266 | 1898 | 2531 |
| 6 | 1013 | 1519 | 2025 | 879 | 1318 | 1756 |
| 7 | 753 | 1130 | 1507 | 646 | 969 | 1291 |
| 8 | 577 | 856 | 1154 | 494 | 742 | 989 |
| 9 | 456 | 684 | 911 | 391 | 586 | 781 |
| 10 | 369 | 554 | 738 | 316 | 475 | 633 |
| 12 | 256 | 385 | 513 | 220 | 330 | 439 |
| 14 | 188 | 283 | 377 | 161 | 242 | 323 |

**Table W-1 Notes:**

1. Lumber grade is #2 intended for an in-service moisture content of 19% or less.
2. Deflection is limited to L/360.
3. Load duration factor used in calculations is 1.0.
4. Adequate bearing and lateral support for the member must be provided. Support for the member ends must provide a continuous load path from the bearing to the foundation.
5. Values tabulated are for Spruce-Pine-Fir, not Spruce-Pine-Fir (South). Values tabulated for Southern Pine are based on design values published by the American Wood Council in an addendum to NDS dated March 2013.
6. Span, L, is clear span. Effective span for bending and deflection is clear span plus 3 inches.

## Table W-2
## FLITCH PLATE BEAM ALLOWABLE LOADS IN POUNDS PER LINEAR FOOT [1,2,3,4,5]

| (2) 2x6 with Plate Indicated | | | | | |
|---|---|---|---|---|---|
| Span (ft.)[6] | Plate Size / (Beam Weight per Foot) | | | | |
| | ¼"x5" Plate (8 lb./ft.) | 3/8"x5" Plate (10 lb./ft.) | ½"x5" Plate (13 lb./ft.) | 5/8"x5" Plate (15 lb./ft.) | ¾"x5" Plate (17 lb./ft.) |
| 6'-0" | 643 | 825 | 1006 | 1188 | 1370 |
| 7'-0" | 473 | 606 | 739 | 873 | 1006 |
| 8'-0" | 362 | 464 | 566 | 668 | 771 |
| 9'-0" | 272 | 348 | 425 | 502 | 579 |
| 10'-0" | 198 | 254 | 310 | 366 | 422 |
| 11'-0" | 149 | 191 | 233 | 275 | 317 |
| 12'-0" | 115 | 147 | 179 | 212 | 244 |

| (2) 2x8 with Plate Indicated | | | | | |
|---|---|---|---|---|---|
| Span(ft.)[6] | Plate Size / (Beam Weight per Foot) | | | | |
| | ¼"x7" Plate (11 lb./ft.) | 3/8"x7" Plate (14 lb./ft.) | ½"x7" Plate (17 lb./ft.) | 5/8"x7" Plate (20 lb./ft.) | ¾"x7" Plate (23 lb./ft.) |
| 6'-0" | 1150 | 1499 | 1849 | 2199 | 2549 |
| 7'-0" | 845 | 1102 | 1359 | 1615 | 1872 |
| 8'-0" | 647 | 843 | 1040 | 1237 | 1434 |
| 9'-0" | 511 | 666 | 822 | 977 | 1133 |
| 10'-0" | 414 | 540 | 666 | 792 | 917 |
| 11'-0" | 342 | 446 | 550 | 654 | 758 |
| 12'-0" | 287 | 375 | 462 | 550 | 637 |
| 13'-0" | 230 | 300 | 369 | 439 | 509 |
| 14'-0" | 184 | 240 | 296 | 352 | 408 |
| 15'-0" | 150 | 195 | 240 | 286 | 331 |
| 16'-0" | 123 | 161 | 198 | 236 | 273 |

| (2) 2x10 with Plate Indicated | | | | | |
|---|---|---|---|---|---|
| Span (ft.) | Plate Size / (Beam Weight per Foot) | | | | |
| | ¼"x9" Plate (14 lb./ft.) | 3/8"x9" Plate (18 lb./ft.) | ½"x9" Plate (22 lb./ft.) | 5/8"x9" Plate (26 lb./ft.) | ¾"x9" Plate (30 lb./ft.) |
| 6'-0" | 1642 | 2145 | 2649 | 3153 | 3657 |
| 7'-0" | 1206 | 1576 | 1946 | 2317 | 2687 |

| | | | | | |
|---|---|---|---|---|---|
| 8’-0” | 923 | 1207 | 1490 | 1774 | 2057 |
| 9’-0” | 730 | 954 | 1177 | 1401 | 1625 |
| 10’-0” | 591 | 772 | 954 | 1135 | 1317 |
| 11’-0” | 488 | 638 | 788 | 938 | 1088 |
| 12’-0” | 410 | 536 | 662 | 788 | 914 |
| 13’-0” | 350 | 457 | 564 | 672 | 779 |
| 14’-0” | 302 | 394 | 487 | 579 | 672 |
| 15’-0” | 263 | 343 | 424 | 504 | 585 |
| 16’-0” | 231 | 302 | 373 | 443 | 514 |
| 17’-0” | 204 | 267 | 330 | 393 | 456 |
| 18’-0” | 182 | 238 | 294 | 350 | 406 |
| 19’-0” | 155 | 203 | 250 | 298 | 345 |
| 20’-0” | 133 | 174 | 214 | 255 | 296 |

| **(2) 2x12 with Plate Indicated** | | | | | |
|---|---|---|---|---|---|
| **Span (ft.)** | **Plate Size / (Beam Weight per Foot)** | | | | |
| | **¼”x11” Plate (18 lb./ft.)** | **3/8”x11” Plate (22 lb./ft.)** | **½”x11” Plate (27 lb./ft.)** | **5/8”x11” Plate (32 lb./ft.)** | **¾”x11” Plate (36 lb./ft.)** |
| 6’-0” | 2297 | 3006 | 3715 | 4425 | 5134 |
| 7’-0” | 1688 | 2209 | 2730 | 3251 | 3772 |
| 8’-0” | 1292 | 1691 | 2090 | 2489 | 2888 |
| 9’-0” | 1021 | 1336 | 1651 | 1966 | 2282 |
| 10’-0” | 827 | 1082 | 1338 | 1593 | 1848 |
| 11’-0” | 683 | 894 | 1105 | 1316 | 1527 |
| 12’-0” | 574 | 752 | 929 | 1106 | 1283 |
| 13’-0” | 489 | 640 | 791 | 943 | 1094 |
| 14’-0” | 422 | 552 | 682 | 813 | 943 |
| 15’-0” | 367 | 481 | 594 | 708 | 821 |
| 16’-0” | 323 | 423 | 522 | 622 | 722 |
| 17’-0” | 286 | 374 | 463 | 551 | 639 |
| 18’-0” | 255 | 334 | 413 | 492 | 570 |
| 19’-0” | 229 | 300 | 371 | 441 | 512 |
| 20’-0” | 207 | 271 | 334 | 398 | 462 |
| 21’-0” | 188 | 245 | 303 | 361 | 419 |
| 22’-0” | 171 | 224 | 276 | 329 | 382 |
| 23’-0” | 156 | 205 | 253 | 301 | 349 |
| 24’-0” | 140 | 183 | 226 | 269 | 312 |

**Table W-2 Notes**

1. Lumber species and grade is #2 Southern Pine intended for an in-service moisture content of 19% or less. Design values used were published by the American Wood Council in an addendum to NDS dated March 2013. For Spruce-Pine-Fir lumber using the tabulated flitch plate allowable loads will be slightly conservative.
2. Tabulated values are based on ASTM A36 structural steel plate.
3. Deflection is limited to L/360.
4. Load duration factor used in calculations is 1.0.
5. Adequate bearing and lateral support for the member must be provided. Support for the member ends must provide a continuous load path from the bearing to the foundation.

Span, L, is center to center of supports. Wood side plates and steel flitch plates shall be continuous throughout the span.

# APPENDIX NC-D

# FOAM PLASTIC DIAGRAMS

***This appendix is a North Carolina addition to the 2021 International Residential Code.***
***There will be no underlined text.***
***(The provisions contained in this appendix are adopted as part of this code.)***

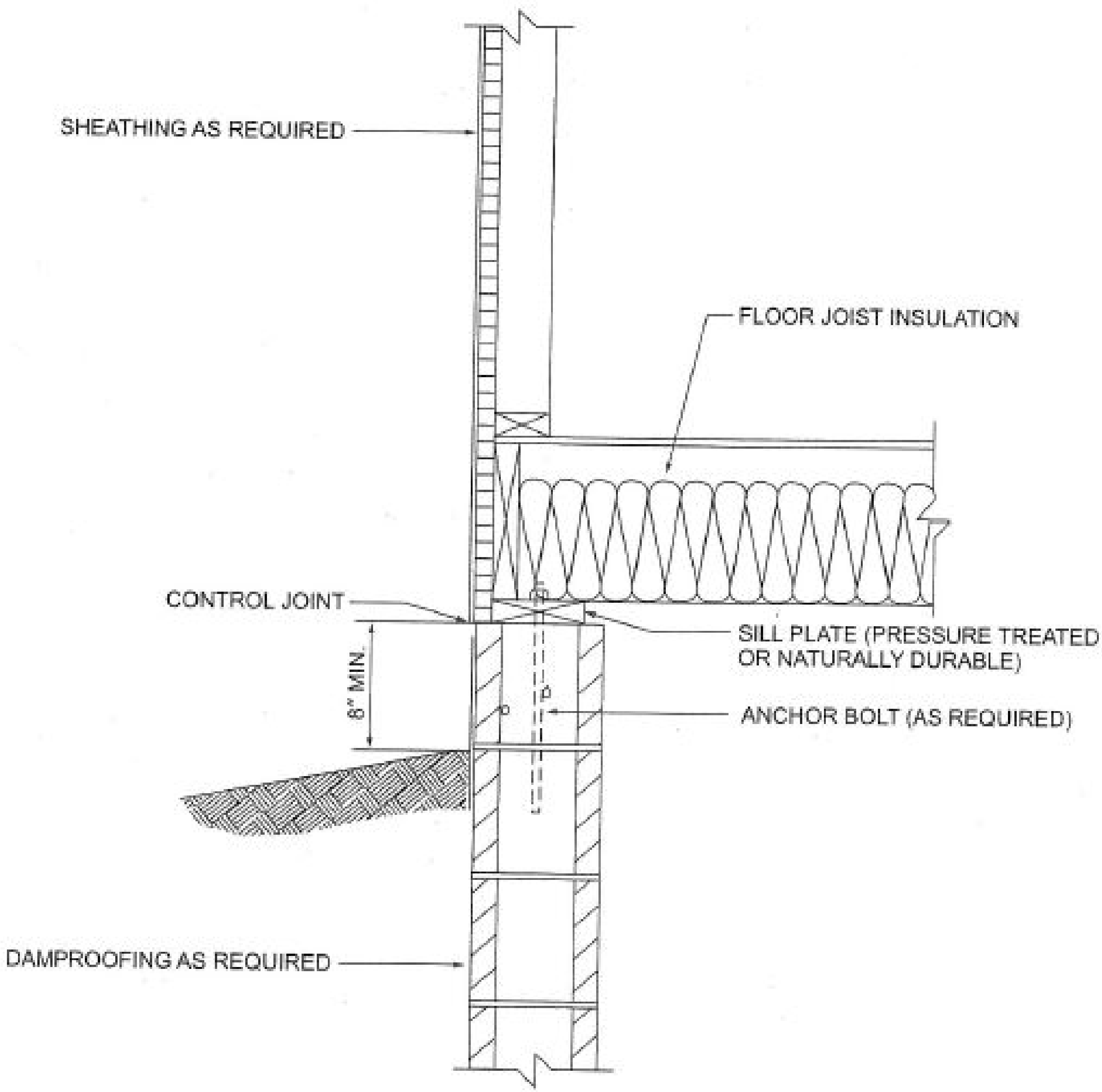


**FIGURE NCD-1**
**Foundation Wall**

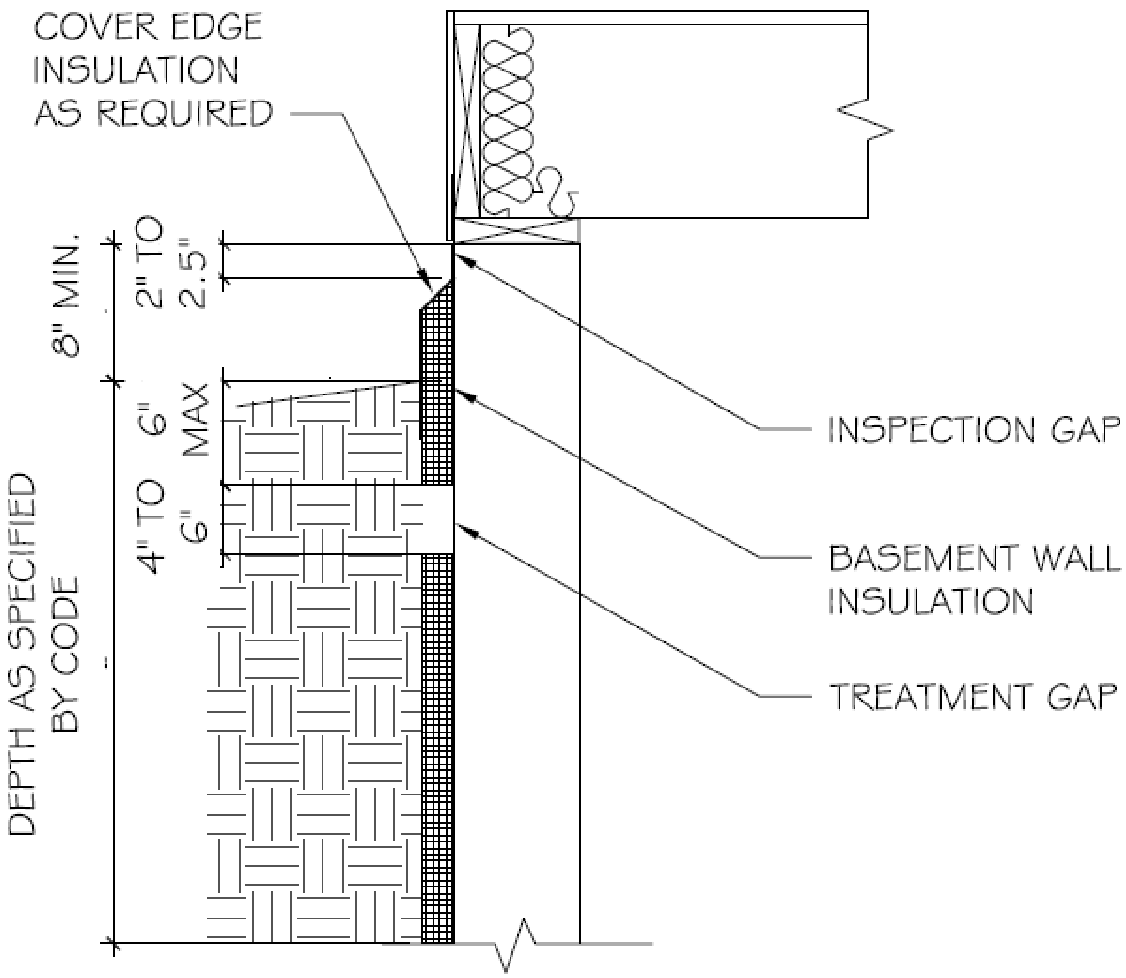
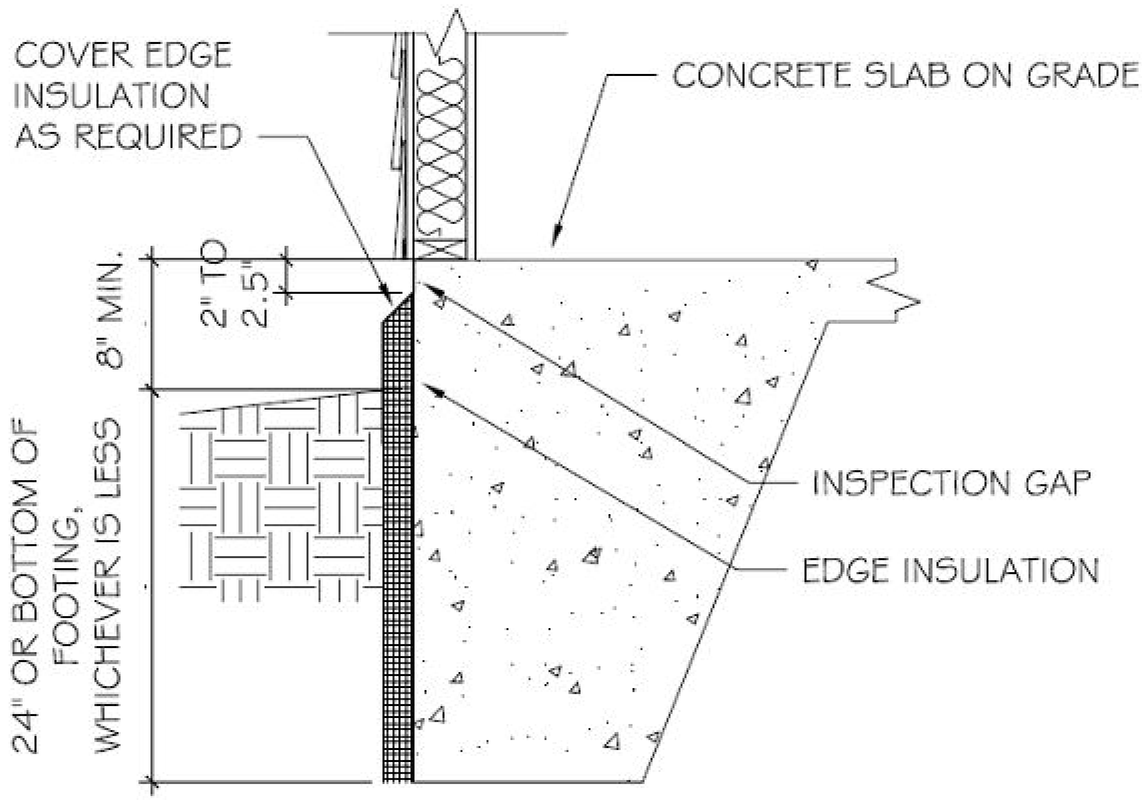


**FIGURE NCD-2**
**BASEMENT WALL**

**N1102.2.9 Basement walls with exterior foam insulation.** Insulation illustrations – Section view of exterior foam insulation location for basement walls (Includes detailing from N1102.2.11)




SECTION VIEW OF MONOLITHIC SLAB-ON-GRADE INSULATION

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**FIGURE NCD-3**
**FRAME WALL**

**N1102.2.10 Slab insulation details.** Insulation illustrations

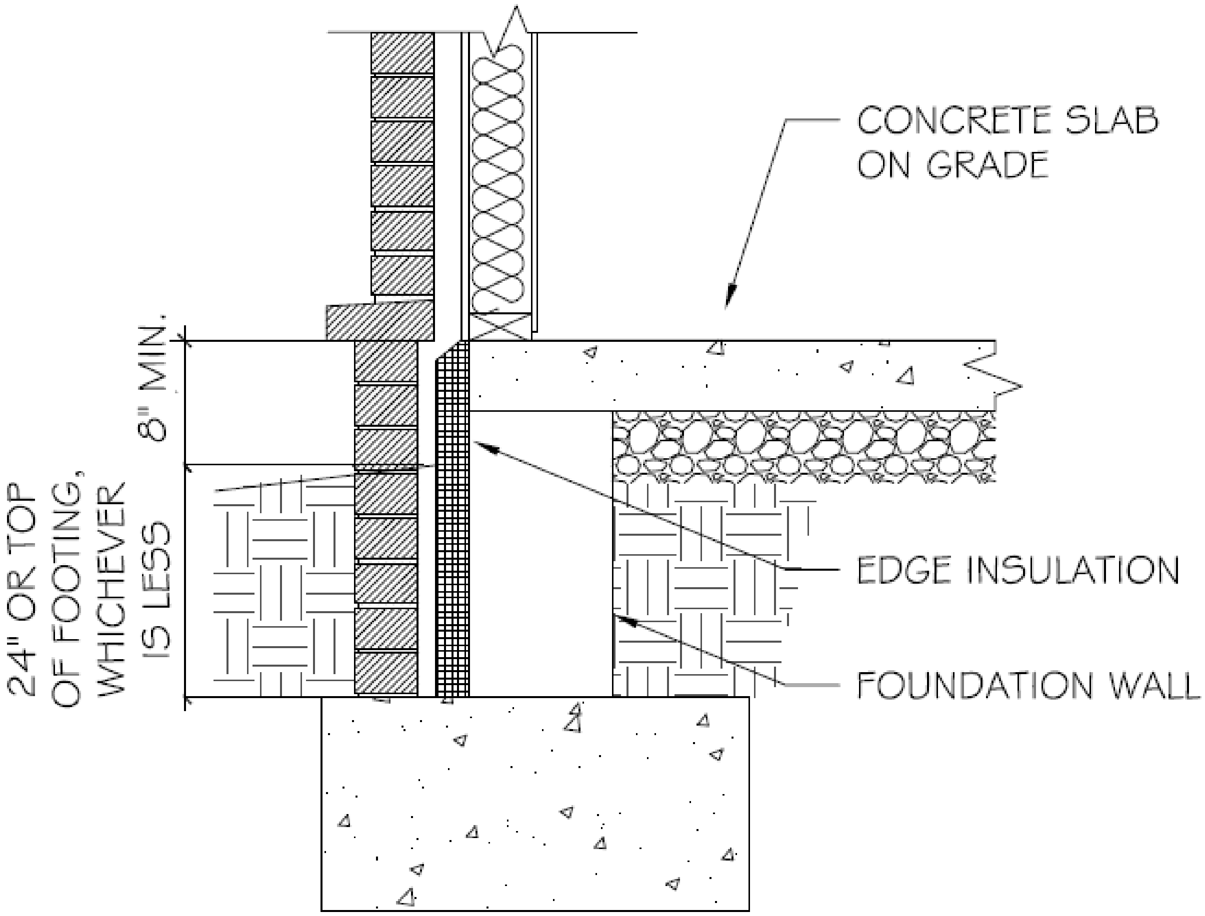


**FIGURE NCD-4**
**FRAME WALL**

**N1102.2.10 Slab insulation details.** Insulation illustrations - Example for slab edge insulation location behind brick, stone, or masonry facing (Other options may also compliant)

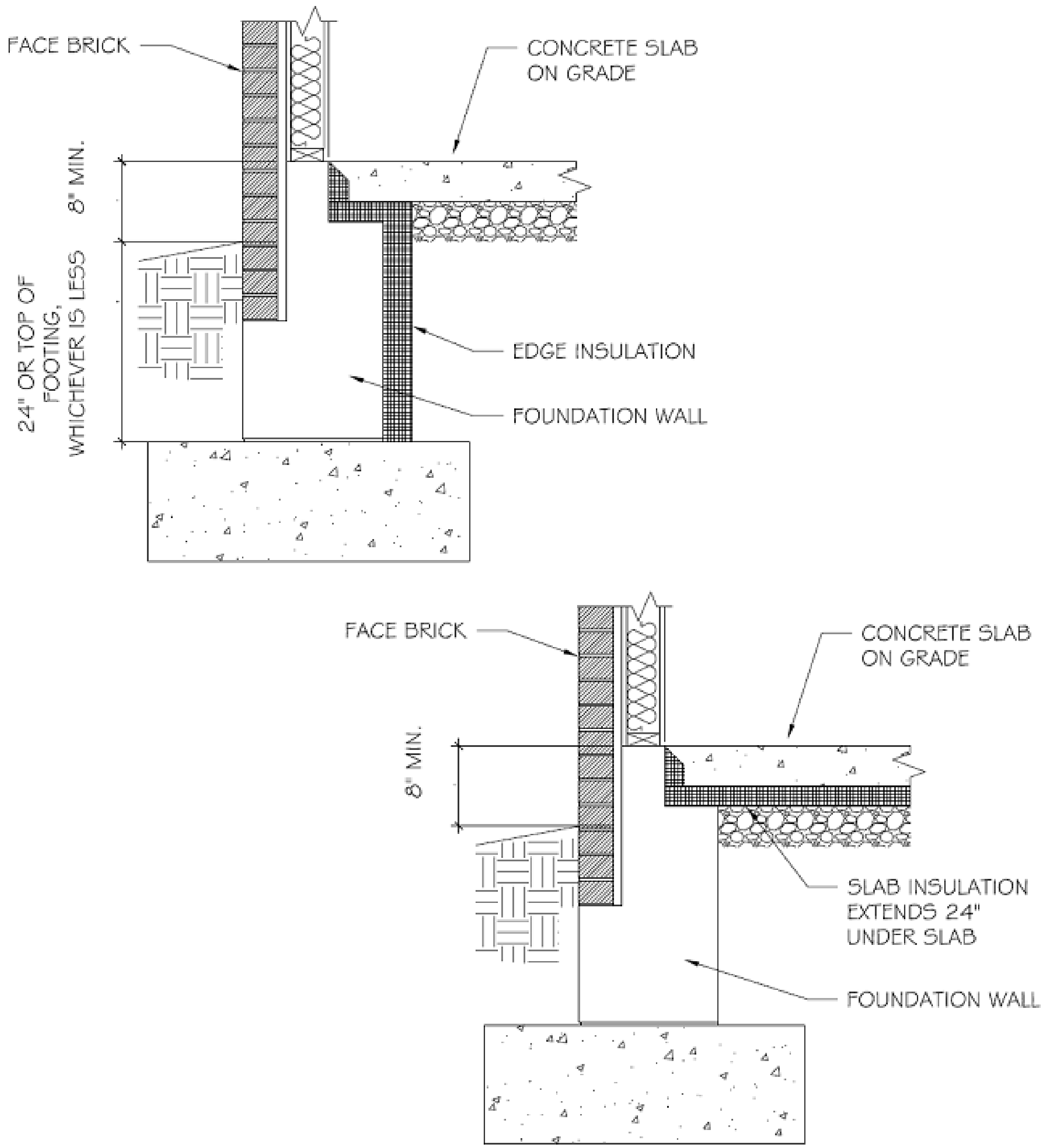


**Figure NCD-5**
**Frame Wall**

**N1102.2.10 Slab insulation details.** Insulation illustrations – Examples for slab insulation location for floating slab with stem wall