

CHAPTER 4

FOUNDATIONS

SECTION R401 GENERAL

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 the *floodplain administrator* 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 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 D₀, D₁ or D₂ shall be designed in accordance with Section R301.1.3.

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. Where a construction joint is created between a concrete footing and foundation wall, a means of restraint shall be provided to prevent lateral displacement. Such restraint shall be provided by forming a minimum 1½-inch (38 mm) wide by 1½-inch (38 mm) deep continuous keyway within the middle one-third of the wall, installing vertical bars in accordance with Section R403.1.3.1 or other *approved* method. Fill soils that support footings and foundations shall be designed, installed and tested in accordance with Section R301.1.3.

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 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, swales or other means shall be provided and shall be constructed to ensure drainage away from the structure. Impervious surfaces within 10 feet (3048 mm) of the building foundation shall be sloped not less than 2 percent away from the building.

R401.4 Soil tests. Where data 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. In lieu of a complete geotechnical evaluation, the load-bearing values in Table R401.4.1 shall be assumed.

**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	4,000
Sandy gravel and/or gravel (GW and GP)	3,000
Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000
Clay, sandy, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500 ^b

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 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. Lumber and plywood shall be pressure-preservative treated and dried after treatment in accordance with AWP A U1 (Commodity Specification A, 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 not less than 2-percent copper metal, by repeated brushing, dipping or soaking until the wood 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	
	Moderate	Severe
Basement walls, foundations and other concrete not exposed to the weather	2,500	2,500 ^c
Basement slabs and interior slabs on grade, except garage floor slabs	2,500	2,500 ^c
Basement walls, foundation walls, exterior walls and other vertical concrete work exposed to the weather	3,000 ^d	3,000 ^d
Porches, carport slabs and steps exposed to the weather, and garage floor slabs	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 $\frac{3}{4}$ 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 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 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 fill soils in accordance with Section R401.2. Concrete footings shall be designed and constructed in accordance with the provisions of Section R403 or in accordance with ACI 332.

R403.1.1 Minimum size. Concrete and masonry footings shall be in accordance with Table R403.1 and Figure R403.1(1) or R403.1.3, as applicable, 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 not less than 6 inches (152 mm) in thickness for foundation walls supporting one floor, 7 inches

(178 mm) in thickness for foundation walls supporting two floors, and 8 inches (203 mm) in thickness for foundation walls supporting three floors. 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 and allowable soil pressure in accordance with Table R401.4.1. For isolated footings, see Section R403.1.7. 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).

**TABLE R403.1
MINIMUM WIDTH OF CONCRETE,
PRECAST OR MASONRY FOOTINGS (inches)^a**

	LOAD-BEARING VALUE OF SOIL (psf)			
	1,000	1,500	2,000	≥ 3,000
Conventional light-frame construction				
1 story	18	12	12	12
2 story	23	15	12	12
3 story	35	23	17	12
4-inch brick veneer over light frame or 8-inch hollow concrete masonry				
1 story	18	12	12	12
2 story	32	21	16	12
3 story	48	32	24	16
8-inch solid concrete or masonry or fully grouted masonry				
1 story	24	16	12	12
2 story	44	29	21	14
3 story	63	42	32	21

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.

R403.1.2 Continuous footing in Seismic Design Categories D₀, D₁ and D₂. Exterior walls and required interior braced wall panels of buildings located in Seismic Design Categories D₀, D₁ and D₂ shall be supported by continuous (from beginning to end of braced wall line) solid or fully

grouted masonry or concrete footings in accordance with Table R403.1.2. Other footing materials or systems shall be designed in accordance with Section R301.1.3.

R403.1.3 Footing and stem wall reinforcing in Seismic Design Categories D₀, D₁ and D₂. Concrete footings and stem walls located in Seismic Design Categories D₀, D₁ and D₂, as established in Table R301.2, shall have minimum reinforcement in accordance with this section, Section R404 and Figure R403.1.3. Reinforcement shall be installed with support and cover in accordance with Section R403.1.3.5.

R403.1.3.1 Concrete stem walls with concrete footings. In Seismic Design Categories D₀, D₁ and D₂ where a construction joint is created between a concrete footing and a concrete stem wall, not fewer than one No. 4 vertical bar shall be installed at not more than 4 feet (1219 mm) on center. The vertical bar shall have a standard hook and extend to the bottom of the footing and shall have support and cover as specified in Section R403.1.3.5.3 and extend not less than 14 inches (357 mm) into the stem wall. Standard hooks shall comply with Section R608.5.4.5. Not fewer than one No. 4 horizontal bar shall be installed within 12 inches (305 mm) of the top of the stem wall and one No. 4 horizontal bar shall be located 3 to 4 inches (76 mm to 102 mm) from the bottom of the footing.

R403.1.3.2 Masonry stem walls with concrete footings. In Seismic Design Categories D₀, D₁ and D₂ where a masonry stem wall is supported on a concrete footing, not fewer than one No. 4 vertical bar shall be installed at not more than 4 feet (1219 mm) on center. The vertical bar shall have a standard hook and extend to the bottom of the footing and shall have support and cover as specified in Section R403.1.3.5.3 and extend not less than 14 inches (357 mm) into the stem wall. Standard hooks shall comply with Section R608.5.4.5. Not fewer than one No. 4 horizontal bar shall be installed within 12 inches (305 mm) of the top of the wall and one No. 4 horizontal bar shall be located 3 to 4 inches (76 mm to 102 mm) from the bottom of the footing. Masonry stem walls shall be solid grouted.

**TABLE R403.1.2
CONTINUOUS FOOTING REQUIREMENTS IN SEISMIC DESIGN CATEGORIES D₀, D₁ AND D₂**

BUILDING PLAN DIMENSIONS	1-STORY						2-STORY						3-STORY	
	50 feet or less			> 50 feet			50 feet or less			> 50 feet			Any	
SDC	D ₀	D ₁	D ₂	D ₀	D ₁	D ₂	D ₀	D ₁	D ₂	D ₀	D ₁	D ₂	D ₀	D ₁
Continuous footings supporting exterior walls	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Continuous footings supporting required interior braced wall panels	NR	NR	NR	R ^a	R ^a	R ^a	NR	NR	R ^a	R ^a	R ^a	R ^a	R	R

R = Continuous solid or fully grouted masonry or concrete footings in accordance with Section R403.1.3.4 required.

NR = Continuous footings not required.

a. Buildings shall be permitted to have interior braced wall panels supported on continuous foundations at intervals not exceeding 50 feet, provided that the following conditions are met:

1. The height of cripple walls does not exceed 4 feet.
2. First-floor braced wall panels are supported on doubled floor joists, continuous blocking or floor beams.
3. The distance between bracing lines does not exceed twice the building width measured parallel to the braced wall line.

R403.1.3.3 Slabs-on-ground with turned-down footings. In *Seismic Design Categories D₀, D₁ and D₂*, slabs-on-ground cast monolithically with turned-down footings shall have not fewer than one No. 4 bar at the top and the bottom of the footing or one No. 5 bar or two No. 4 bars in the middle third of the footing depth.

Where the slab is not cast monolithically with the footing, No. 3 or larger vertical dowels with standard hooks on each end shall be installed at not more than 4 feet (1219 mm) on center in accordance with Figure R403.1.3, Detail 2. Standard hooks shall comply with Section R608.5.4.5.

R403.1.3.4 Interior bearing and braced wall panel footings in Seismic Design Categories D₀, D₁ and D₂. In *Seismic Design Categories D₀, D₁ and D₂*, interior footings supporting bearing walls or *braced wall panels*, and cast monolithically with a slab on *grade*, shall extend to a depth of not less than 12 inches (305 mm) below the top of the slab.

R403.1.3.5 Reinforcement. Footing and stem wall reinforcement shall comply with Sections R403.1.3.5.1 through R403.1.3.5.4.

R403.1.3.5.1 Steel reinforcement. Steel reinforcement shall comply with the requirements of ASTM A615, A706M or A996M. ASTM A996 bars produced from rail steel shall be Type R. The minimum yield strength of reinforcing steel shall be 40,000 psi (Grade 40) (276 MPa).

R403.1.3.5.2 Location of reinforcement in wall. The center of vertical reinforcement in stem walls shall be located at the centerline of the wall. Horizontal and vertical reinforcement shall be located in footings and stem walls to provide the minimum cover required by Section R403.1.3.5.3.

R403.1.3.5.3 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 1½ 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 ¾ inch (19 mm).

R403.1.3.5.4 Lap splices. Vertical and horizontal 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)].

R403.1.3.6 Isolated concrete footings. In detached one- and two-family dwellings that are three *stories* or less in height and constructed with stud bearing walls, isolated plain concrete footings supporting columns or pedestals are permitted.

R403.1.4 Minimum depth. Exterior footings shall be placed not less than 12 inches (305 mm) below finished grade on the undisturbed ground surface. Where applicable, the depth of footings shall also conform to Section R403.1.4.1. Deck footings shall be in accordance with Section R507.3.

R403.1.4.1 Frost protection. Except where otherwise protected from frost, foundation walls, piers and other permanent supports of buildings and structures shall be protected from frost by one or more of the following methods:

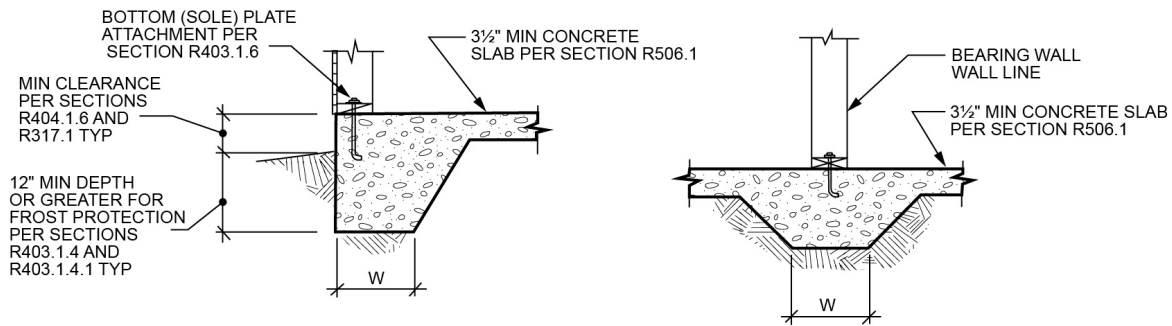
1. Extended below the frost line specified in Table R301.2.
2. Constructed in accordance with Section R403.3.
3. Constructed in accordance with ASCE 32.
4. Erected on solid rock.

Footings shall not bear on frozen soil unless the frozen condition is permanent.

Exceptions:

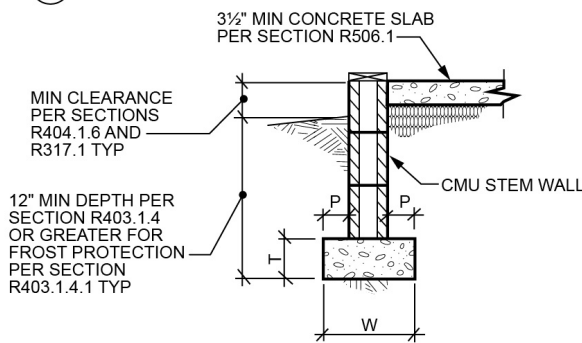
1. Protection of free-standing *accessory structures* with an area of 600 square feet (56 m²) or less, of *light-frame construction*, with an eave height of 10 feet (3048 mm) or less shall not be required.
2. Protection of free-standing *accessory structures* with an area of 400 square feet (37 m²) or less, of other than *light-frame construction*, with an eave height of 10 feet (3048 mm) or less shall not be required.

R403.1.5 Slope. The top surface of footings shall be level. 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).

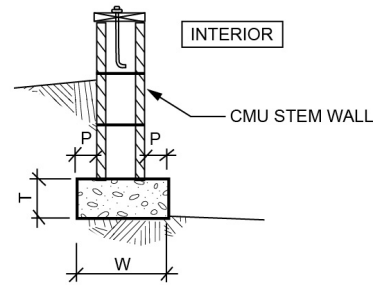


1 MONOLITHIC SLAB-ON-GROUND WITH TURNED-DOWN FOOTING
SCALE: NOT TO SCALE

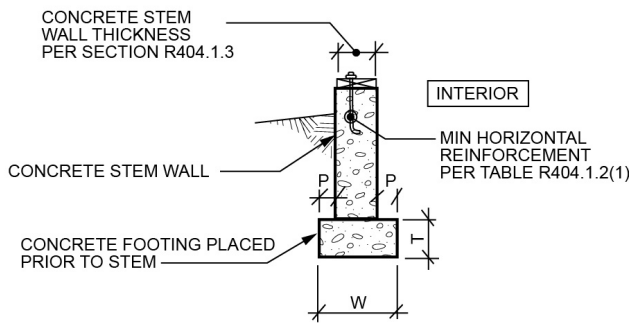
2 THICKENED SLAB-ON-GROUND FOOTING AT BEARING WALLS OR BRACED WALL LINES
SCALE: NOT TO SCALE



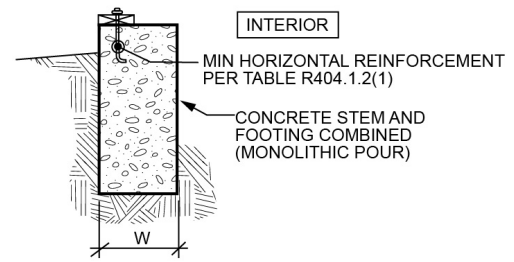
3 SLAB-ON-GROUND WITH MASONRY STEM WALL AND SPREAD FOOTING
SCALE: NOT TO SCALE



4 BASEMENT OR CRAWL SPACE WITH MASONRY WALL AND SPREAD FOOTING
SCALE: NOT TO SCALE



5 BASEMENT OR CRAWL SPACE WITH CONCRETE WALL AND SPREAD FOOTING
SCALE: NOT TO SCALE



6 BASEMENT OR CRAWL SPACE WITH FOUNDATION WALL BEARING DIRECTLY ON SOIL
SCALE: NOT TO SCALE

For SI: 1 inch = 25.4 mm.

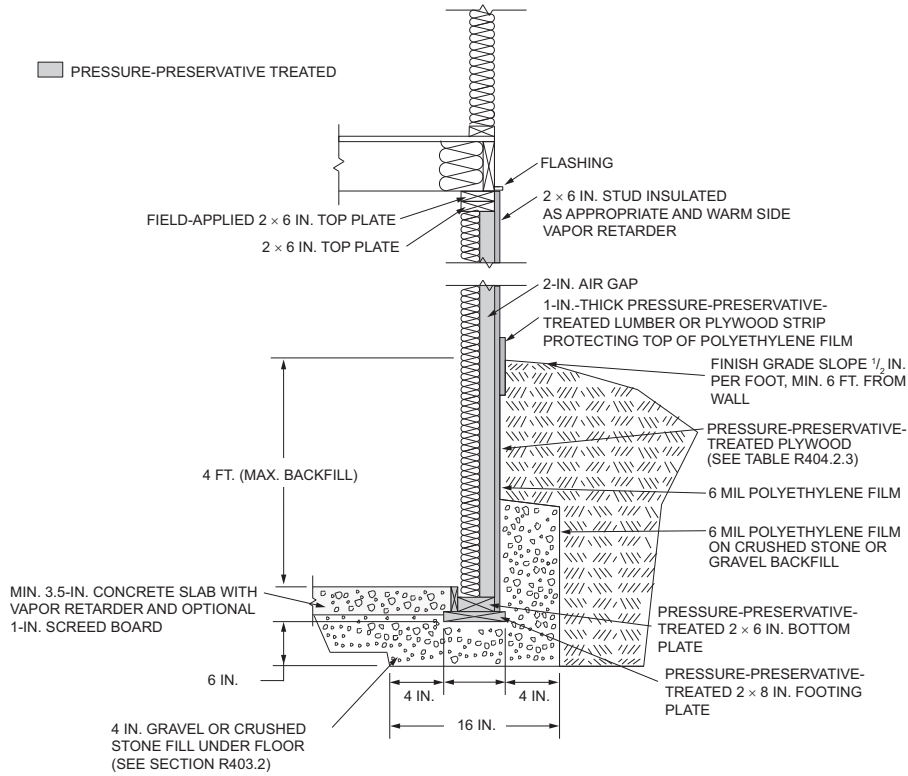
W = Width of footing per Table R403.1, T = Thickness of footing and P = Projection per Section R403.1.1.

NOTES:

- a. See Section R404.3 for sill requirements.
- b. See Section R403.1.6 for sill attachment.
- c. See Section R506.2.3 for vapor retarder requirements.
- d. See Section R403.1 for base.
- e. See Figure R403.1.3 for additional footing requirements for structures in Seismic Design Categories D₀, D₁ and D₂ and townhouses in Seismic Design Category C.
- f. See Section R408 for underfloor ventilation and access requirements.
- g. See Section R401.2 for foundation wall to footing restraint requirements.

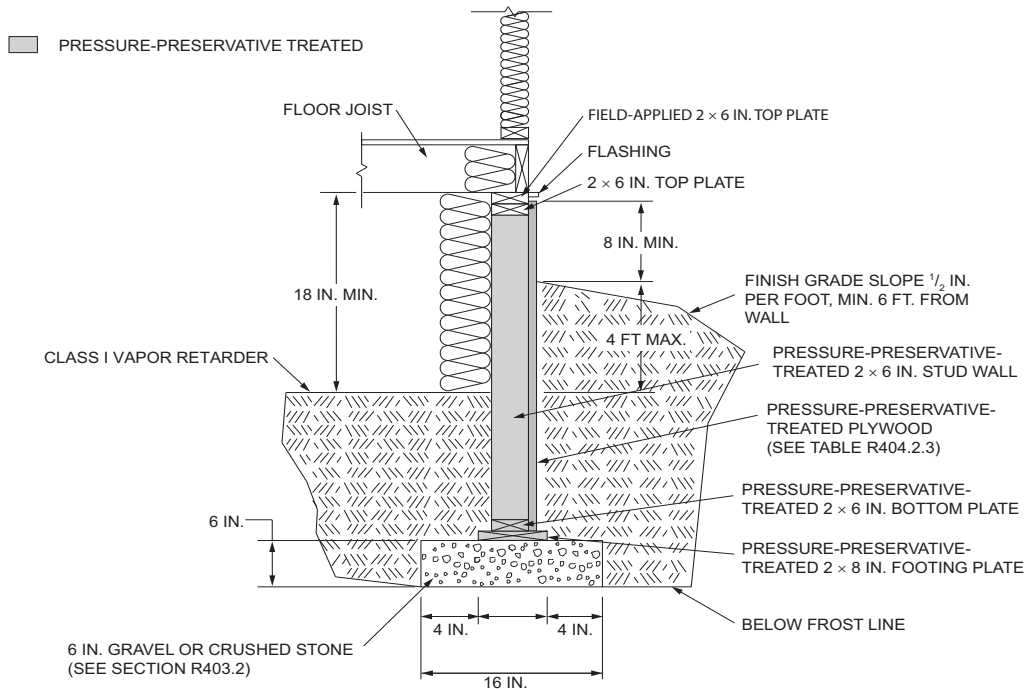
FIGURE R403.1(1)
PLAIN CONCRETE FOOTINGS WITH MASONRY AND CONCRETE STEM WALLS IN SEISMIC DESIGN CATEGORIES A, B AND C^{a, b, c, d, e, f}

FOUNDATIONS



For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm.

**FIGURE R403.1(2)
PERMANENT WOOD FOUNDATION BASEMENT WALL SECTION**



For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm.

**FIGURE R403.1(3)
PERMANENT WOOD FOUNDATION CRAWL SPACE SECTION**