Frost Protection For Slab Foundation

The question is often asked if a structure can be built on a slab without a frost wall. Per the State Building Code (the 2015 edition of The International Residential Code) which is currently in effect state wide. The answer is yes if done correctly. Section R 403.3.1.4.1 (attached), describes the frost protection requirements for one and two family dwellings and accessory buildings.

There are four ways to construct a slab without a frost wall.

1. If the slab is supported entirely on ledge.

2. If constructed per section R 403.3 of the code (attached). This method is only for buildings that will be heated to 64 degrees. Give our climate and frequent power outages, this generally doesn't apply here.

3. The slab is constructed per 2001 edition of ASCE Standard 32 (The American Society of Civil Engineers) standard for construction of frost protected shallow foundations, a portion of which is attached. This requires that structural insulation of at least R-6.8 be installed under the entire slab and extend at least 49 inches beyond the perimeter of the foundation. Due to the new 2015 energy code. Insulation must be upgraded to R-10.

4. If the foundation design is stamped by a Maine licensed Professional Engineer.

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Deputy Code Enforcement Officer
May 11, 2022

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 the undisturbed ground surface. Where applicable, the depth of footings shall also conform to Sections R403.1.4.1 through R403.1.4.2.

⇒ **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.(1).
2. Constructed in accordance with Section R403.3.
3. Constructed in accordance with ASCE 32.
4. Erected on solid rock.

Exceptions:

1. Protection of freestanding *accessory structures* with an area of 600 square feet (56 m^2) or less, of light-frame construction, with an eave height of 10 feet (3048 mm) or less shall not be required.
2. Protection of freestanding *accessory structures* with an area of 400 square feet (37 m^2) or less, of other than light-frame construction, with an eave height of 10 feet (3048 mm) or less shall not be required.
3. Decks not supported by a dwelling need not be provided with footings that extend below the frost line.

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

R403.1.5 Slope. The top surface of footings shall be level. The bottom surface of footings shall not have a slope exceeding one 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 one 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.

Cold-formed steel framing shall be anchored directly to the foundation or fastened to wood sill plates anchored to the foundation. Anchorage of cold-formed steel framing and sill plates supporting cold-formed steel framing shall be in accordance with this section and Section R505.3.1 or R603.3.1.

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 of 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 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 two bolts per plate section with one bolt located not more than 12 inches (305 mm) or less than seven bolt diameters from each end of the plate section. 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.

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 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 Categories C, D_0, D_1 and D_2. In addition to the requirements of Section R403.1.6, the following requirements shall apply to wood light-frame structures in Seismic Design Categories D_0, D_1 and D_2 and 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 within 12 inches (305 mm) of the

R403.1.8.1 Expansive soils classifications. Soils meeting all four of the following provisions shall be considered expansive, except that tests to show compliance with Items 1, 2 and 3 shall not be required if the test prescribed in Item 4 is conducted:

1. Plasticity Index (PI) of 15 or greater, determined in accordance with ASTM D 4318.
2. More than 10 percent of the soil particles pass a No. 200 sieve (75 µm), determined in accordance with ASTM D 422.
3. More than 10 percent of the soil particles are less than 5 micrometers in size, determined in accordance with ASTM D 422.
4. Expansion Index greater than 20, determined in accordance with ASTM D 4829.

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.** For buildings where the monthly mean temperature of the building is maintained at a minimum of 64°F (18°C), footings are not required to extend below the frost line when protected from frost by insulation in accordance with Figure R403.3(1) and Table R403.3(1). Foundations protected from frost in accordance with Figure R403.3(1) and Table R403.3(1) shall not be used for unheated spaces such as porches, utility rooms, garages and carports, and shall not be attached to basements or crawl spaces that are not maintained at a minimum monthly mean temperature of 64°F (18°C).

Materials used below *grade* for the purpose of insulating footings against frost shall be *labeled* as complying with ASTM C 578.

R403.3.1 Foundations adjoining frost-protected shallow foundations. Foundations that adjoin frost-protected shallow foundations shall be protected from frost in accordance with Section R403.1.4.

R403.3.1.1 Attachment to unheated slab-on-ground structure. Vertical wall insulation and horizontal insulation of frost-protected shallow foundations that adjoin a slab-on-ground foundation that does not have a monthly mean temperature maintained at a minimum of 64°F (18°C) shall be in accordance with Figure R403.3(3) and Table R403.3(1). Vertical wall insulation shall extend between the frost-protected shallow foundation and the adjoining slab foundation. Required horizontal insulation shall be continuous under the adjoining slab foundation and through any foundation walls adjoining the frost- protected shallow foundation. Where insulation passes through a foundation wall, it shall be either of a type complying with this section and having bearing capacity equal to or greater than the structural loads imposed by the building, or the building shall be designed and constructed using beams, lintels, cantilevers or other means of transferring building loads such that the structural loads of the building do not bear on the insulation.

R403.3.1.2 Attachment to heated structure. Where a frost-protected shallow foundation abuts a structure that has a monthly mean temperature maintained at a minimum of 64°F (18°C), horizontal insulation and vertical wall insulation shall not be required between the frost-protected shallow foundation and the adjoining structure. Where the frost-protected shallow foundation abuts the heated structure, the horizontal insulation and vertical wall insulation shall extend along the adjoining foundation in accordance with Figure R403.3(4) a distance of not less than Dimension A in Table R403.3(1).

Exception: Where the frost-protected shallow foundation abuts the heated structure to form an inside corner, vertical insulation extending along the adjoining foundation is not required.

R403.3.2 Protection of horizontal insulation below ground. Horizontal insulation placed less than 12 inches (305 mm) below the ground surface or that portion of horizontal insulation extending outward more than 24 inches (610 mm) from the foundation edge shall be protected against damage by use of a concrete slab or asphalt paving on the ground surface directly above the insulation or by cementitious board, plywood rated for below-ground use, or other *approved* materials placed below ground, directly above the top surface of the insulation.

R403.3.3 Drainage. Final *grade* shall be sloped in accordance with Section R401.3. In other than Group I Soils, as detailed in Table R405.1, gravel or crushed stone beneath horizontal insulation below ground shall drain to daylight or into an *approved* sewer system.

R403.3.4 Termite protection. The use of foam plastic in areas of "very heavy" termite infestation probability shall be in accordance with Section R318.4.

R403.4 Footings for precast concrete foundations. Footings for precast concrete foundations shall comply with Section R403.4.

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 C 33, 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 8-inch (203 mm) lifts. Crushed stone footings shall be limited to Seismic Design Categories A, B and C.

R403.4.2 Concrete footings. Concrete footings shall be installed in accordance with Section R403.1 and Figure R403.4(2).

SEI/ASCE 32-01

ASCE STANDARD

American Society of Civil Engineers

Design and Construction of Frost-Protected Shallow Foundations

ASCE

SEI Structural Engineering Institute

NAHB RESEARCH CENTER

Design and Construction of Frost-Protected Shallow Foundations

1. SCOPE AND LIMITATIONS

This Standard addresses the design and construction of frost-protected shallow foundations to prevent frost damage in cold climates with seasonal ground freezing. For the purpose of this Standard, a frost-protected shallow foundation is a foundation that does not extend below the design frost depth, but is protected against effects of frost. This Standard applies to buildings on potentially frost-susceptible ground with slab-on-ground or suspended floor foundations. This Standard does not apply to buildings on permafrost, to areas with mean annual outdoor air temperatures less than 32°F (0°C), or to areas with design air-freezing indexes greater than 4,500°F-days (60,000°C-hr).

This Standard addresses heated, unheated, and semi-heated structures, as classified by the minimum average monthly indoor temperature expected during the building's intended useful life. For the purpose of using this Standard, the building shall be classified in accordance with Table 1.

This Standard does not preclude the judgment and practice of those competent in foundation design and the prevention of frost damage, nor does it preclude compliance with other design considerations or local building code requirements. Structural requirements, other than frost protection, shall be in accordance with the building code or accepted design practices and are not included in this Standard.

TABLE 1. Classification of Building Based on Indoor Air Temperature

Minimum Average Monthly Indoor Temperature, T	Thermal Classification
$T \geq 63°F$ (17° C)	Heated
41° F(5° C) < T < 63°F (17° C)	Semi-heated
$T \leq 41°F$ (5° C)	Unheated

2. REFERENCES

American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). *Handbook of Fundamentals*, Atlanta, GA (1997).

American Society for Testing and Materials (ASTM). ASTM C578-95. *Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation*, West Conshohocken, PA (1995).

American Society for Testing and Materials. ASTM D422-63 (90). *Test Method for Particle-Size Analysis of Soils*, West Conshohocken, PA (1990).

American Society for Testing and Materials. ASTM D2487-93. *Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)*, West Conshohocken, PA (1993).

3. SYMBOLS, UNITS, AND DEFINITIONS

3.1 SYMBOLS AND UNITS

The symbols and units used throughout this Standard are found in Table 2. Conversion factors for units are found in Table 3. English units accompanied by soft conversions to SI units (shown in parentheses) are used throughout the Standard.

3.2 DEFINITIONS

Approved: Accepted by the building official of the jurisdiction as the result of investigations, analysis, tests, or any combination of these evaluation approaches or by reason of accepted principles or local experience.

Air-Freezing Index (AFI): Determined from cumulative degree days above and below 32°F (0°C), recorded for an annual cycle. The AFI for a given winter is the largest difference between the maximum freezing degree day cumulative total reached at the start of the winter season and the minimum total reached during the winter.

Cold-Bridges: Discontinuities in insulation that create thermally conductive pathways and increase the potential for frost damage.

Design Air-Freezing Index (F_{100}): The 100-year mean return period AFI used in this Standard for protection of building foundations against frost damage.

Design Frost Depth: The minimum depth at which the soil temperature remains above freezing for an extreme winter event, based on analysis, local regulations, or experience.

Effective Thermal Resistivity (r_{eff}): An adjusted thermal resistivity to account for long-term use in a moist, below-ground condition. Commonly referred to in this Standard as an effective R per inch.

Effective Thermal Resistance (R_{eff}): An adjusted R-value to account for long-term use in a moist, below-ground condition.

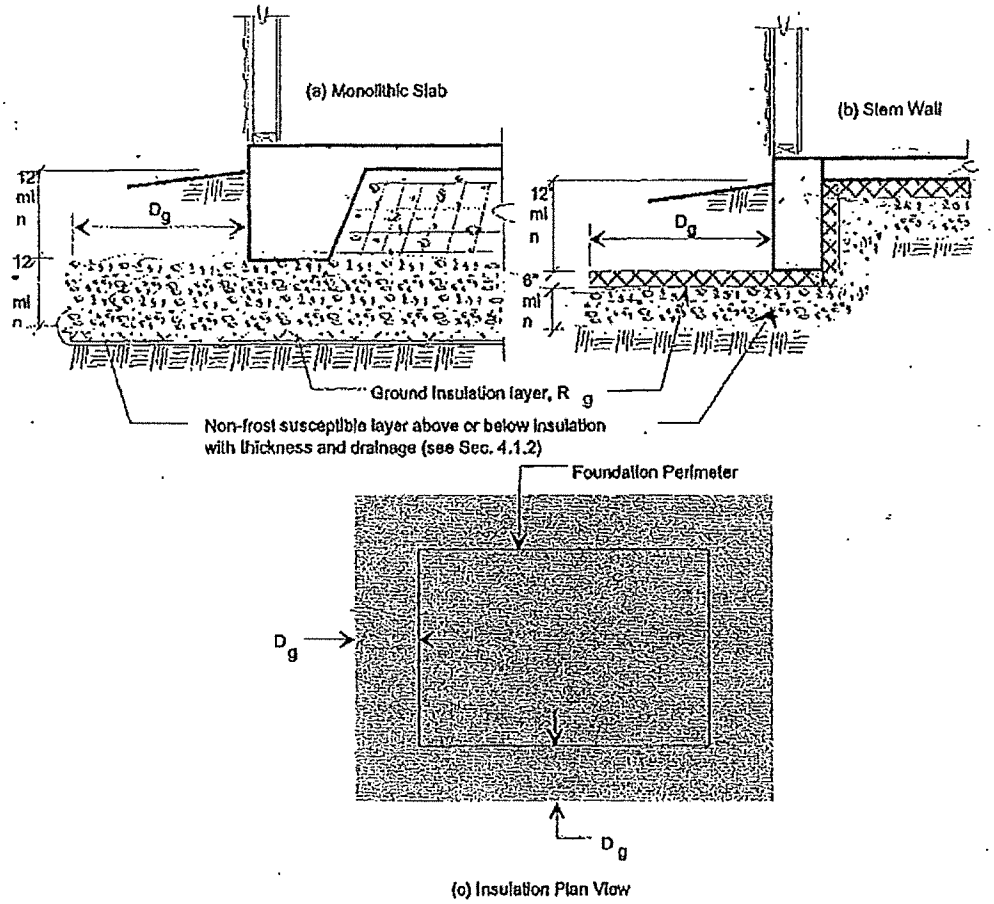

FIGURE 5. Slab-on-Ground Foundation for Unheated Buildings

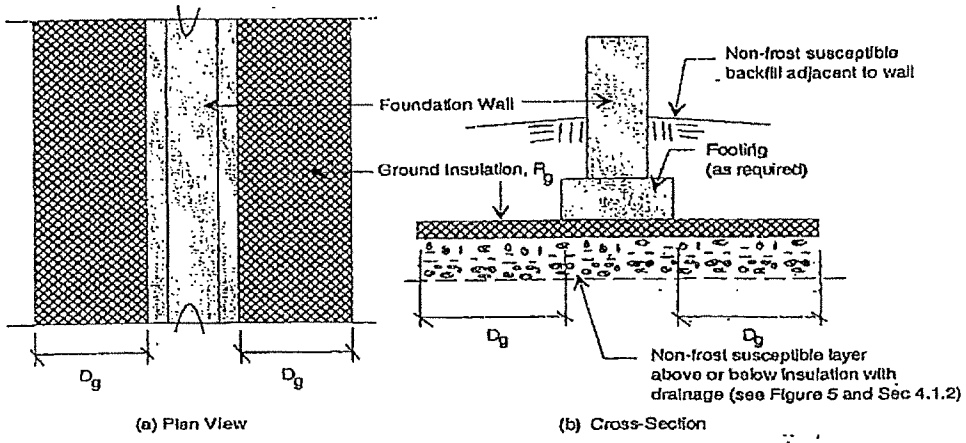

FIGURE 6. Continuous Foundation Wall (Unheated Buildings)

A.3 CLIMATE DATA

TABLE A3. Estimates of the Mean Annual Temperature (MAT) and the Design Air-Freezing Index (F_{100}) at Select Locations

Location	Mean Annual Temperature[1] (°F)	Design AFI Estimates[2] 100-Year Mean Return Period, F_{100} (°F-days)
Alaska, Anchorage (Elmendorf AFB)	35.0	3,430
Colorado, Denver	50.3	710
Connecticut, Hartford	49.7	940
Idaho, Idaho Falls	43.8	2,350
Illinois, Chicago	50.6	1,430
Indiana, South Bend	49.4	1,380
Iowa, Fort Dodge	47.4	2,130
Kansas, Topeka	54.1	1,000
Kentucky, Lexington	54.9	720
Maine, Portland	45.0	1,410
Michigan, Lansing	47.2	1,530
Minnesota, Duluth	38.2	3,130
Missouri, Jefferson City	55.1	900
Montana, Lewistown	41.9	2,470
Nebraska, North Platte	48.1	1,690
Nevada, Elko	46.2	1,530
New Hampshire, Concord	45.3	1,600
New York, Syracuse	47.7	1,210
North Dakota, Bismarck	41.3	3,360
Ohio, Mansfield	48.2	1,370
Oregon, Baker	45.6	1,450
Pennsylvania, State College	49.3	1,170
South Dakota, Redfield	43.9	3,010
Utah, Ogden	50.8	1,080
Vermont, Burlington	44.1	2,050
Virginia, Big Meadows	47.2	1,150
Washington, Spokane	47.2	1,230
West Virginia, Elkins	49.4	1,050
Wisconsin, Wausau	42.4	2,490
Wyoming, Sheridan	44.6	2,280

[1] Climatography of the United States No. 81, Supplement No. 3, "Maps of Annual 1961–1990 Normal Temperature, Precipitation, and Degree Days" U.S. Dept of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center, Asheville NC.
[2] Steurer, Peter M. Methods Used to Create an Estimate of the 100-year Return Period of the Air-Freezing Index. U.S. Dept of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center, Asheville NC (1989).

TABLE A7. Minimum Thermal Resistance of Wing Insulation, R_{hc}, for Use at Corners with 16-inch (0.4-m) Footing Depth

		R-values for Various Wing Widths at Corners, D_{hc} (inches)					
F_{100} (°F-days)	L_c (in)	16	24	30	36	42	48
2,250 or fewer	0	0.0					
2,625	40	6.5	4.9	4.0			
3,000	40	9.6	8.6	8.0	7.4		
3,375	60		11.1	10.5	9.8	9.1	
3,750	60		13.1	12.5	12.0	11.2	10.8
4,125	60			14.5	13.7	13.0	12.5
4,500	80				15.9	15.1	14.8

Interpolation shall be permitted.

TABLE A8. Minimum Thermal Resistance (R-Value) of Ground Insulation, R_g, and Horizontal Extension, D_g, for Unheated Buildings

		Mean Annual Temperature (°F):				
F_{100} (°F-days)	D_g (inches)	≤32	36	38	40	≥41
750 or fewer	30	5.7	5.7	5.7	5.7	5.7
1,500	49	13.1	9.7	8.5	8.0	6.8
2,250	63	19.4	15.9	13.6	11.4	10.2
3,000	79	25.0	21.0	18.2	15.3	14.2
3,750	91	31.2	26.1	22.7	—	—
4,500	108	37.5	31.8	—	—	—

Interpolation shall be permitted.