

CHAPTER 18

SOILS AND FOUNDATIONS

SECTION 1801 GENERAL

1801.1 Scope. The provisions of this chapter shall apply to building and foundation systems in those areas not subject to scour or water pressure by wind and wave action. Buildings and foundations subject to such scour or water pressure loads shall be designed in accordance with Chapter 16.

Exception:

Buildings and structures located within the high-velocity hurricane zone shall comply with the provisions of Sections 1816 through 1834.

1801.2 Design. Allowable bearing pressures, allowable stresses and design formulas provided in this chapter shall be used with the allowable stress design load combinations specified in Section 1605.3. The quality and design of materials used structurally in excavations, footings and foundations shall conform to the requirements specified in Chapters 16, 19, 21, 22 and 23 of this code. Excavations and fills shall also comply with Chapter 33.

1801.2.1 Foundation design for seismic overturning. Reserved.

SECTION 1802 FOUNDATION AND SOILS INVESTIGATIONS

1802.1 General. Foundation and soils investigations shall be conducted in conformance with Sections 1802.2 through 1802.6. Where required by the building official, the classification and investigation of the soil shall be made by a registered design professional.

1802.2 Where required. The owner or applicant shall submit a foundation and soils investigation to the building official where required in Sections 1802.2.1 through 1802.2.7.

Exception: The building official need not require a foundation or soils investigation where satisfactory data from adjacent areas is available that demonstrates an investigation is not necessary for any of the conditions in Sections 1802.2.1 through 1802.2.6.

1802.2.1 Questionable soil. Where the classification, strength or compressibility of the soil are in doubt or where a load-bearing value superior to that specified in this code is claimed, the building official shall require that the necessary investigation be made. Such investigation shall comply with the provisions of Sections 1802.4 through 1802.6.

1802.2.2 Expansive soils. In areas likely to have expansive soil, the building official shall require soil tests to determine where such soils do exist.

1802.2.3 Ground-water table. A subsurface soil investigation shall be performed to determine whether the existing ground-water table is above or within 5 feet (1524 mm) below the elevation of the lowest floor level where such

floor is located below the finished ground level adjacent to the foundation.

Exception: A subsurface soil investigation shall not be required where waterproofing is provided in accordance with Section 1807.

1802.2.4 Pile and pier foundations. Pile and pier foundations shall be designed and installed on the basis of a foundation investigation and report as specified in Sections 1802.4 through 1802.6 and Section 1808.2.2.

1802.2.5 Rock strata. Where subsurface explorations at the project site indicate variations or doubtful characteristics in the structure of the rock upon which foundations are to be constructed, a sufficient number of borings shall be made to a depth of not less than 10 feet (3048 mm) below the level of the foundations to provide assurance of the soundness of the foundation bed and its load-bearing capacity.

1802.2.6 Seismic Design Category C. Reserved.

1802.2.7 Seismic Design Category D, E or F. Reserved.

1802.3 Soil classification. Where required, soils shall be classified in accordance with Section 1802.3.1 or 1802.3.2.

1802.3.1 General. For the purposes of this chapter, the definition and classification of soil materials for use in Table 1804.2 shall be in accordance with ASTM D 2487.

1802.3.2 Expansive soils. 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 μ m), 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.

1802.4 Investigation. Soil classification shall be based on observation and any necessary tests of the materials disclosed by borings, test pits or other subsurface exploration made in appropriate locations. Additional studies shall be made as necessary to evaluate slope stability, soil strength, position and adequacy of load-bearing soils, the effect of moisture variation on soil-bearing capacity, compressibility, liquefaction and expansiveness.

1802.4.1 Exploratory boring. The scope of the soil investigation including the number and types of borings or soundings, the equipment used to drill and sample, the

in-situ testing equipment and the laboratory testing program shall be determined by a registered design professional.

1802.5 Soil boring and sampling. The soil boring and sampling procedure and apparatus shall be in accordance with generally accepted engineering practice. The registered design professional shall have a fully qualified representative on the site during all boring and sampling operations.

1802.6 Reports. The soil classification and design load-bearing capacity shall be shown on the construction documents. Where required by the building official, a written report of the investigation shall be submitted that includes, but need not be limited to, the following information:

1. A plot showing the location of test borings and/or excavations.
2. A complete record of the soil samples.
3. A record of the soil profile.
4. Elevation of the water table, if encountered.
5. Recommendations for foundation type and design criteria, including but not limited to: bearing capacity of natural or compacted soil; provisions to mitigate the effects of expansive soils; mitigation of the effects of liquefaction, differential settlement and varying soil strength; and the effects of adjacent loads.
6. Expected total and differential settlement.
7. Pile and pier foundation information in accordance with Section 1808.2.2.
8. Special design and construction provisions for footings or foundations founded on expansive soils, as necessary.
9. Compacted fill material properties and testing in accordance with Section 1803.5.

SECTION 1803 EXCAVATION, GRADING AND FILL

1803.1 Excavations near footings or foundations. Excavations for any purpose shall not remove lateral support from any footing or foundation without first underpinning or protecting the footing or foundation against settlement or lateral translation.

1803.2 Placement of backfill. The excavation outside the foundation shall be backfilled with soil that is free of organic material, construction debris, cobbles and boulders or a controlled low-strength material (CLSM). The backfill shall be placed in lifts and compacted, in a manner that does not damage the foundation or the waterproofing or dampproofing material.

Exception: Controlled low-strength material need not be compacted.

1803.3 Site grading. The ground immediately adjacent to the foundation shall be sloped away from the building at a slope of not less than one unit vertical in 20 units horizontal (5-percent slope) for a minimum distance of 10 feet (3048 mm) measured perpendicular to the face of the wall. If physical obstructions or lot lines prohibit 10 feet (3048 mm) of horizontal distance, a 5-percent slope shall be provided to an approved alternative method of diverting water away from the foundation. Swales

used for this purpose shall be sloped a minimum of 2 percent where located within 10 feet (3048 mm) of the building foundation. Impervious surfaces within 10 feet (3048 mm) of the building foundation shall be sloped a minimum of 2 percent away from the building.

Exception: Where climatic or soil conditions warrant, the slope of the ground away from the building foundation is permitted to be reduced to not less than one unit vertical in 48 units horizontal (2-percent slope).

The procedure used to establish the final ground level adjacent to the foundation shall account for additional settlement of the backfill.

1803.4 Grading and fill in flood hazard areas. See Section 3110.

1803.5 Compacted fill material. Where footings will bear on compacted fill material, the compacted fill shall comply with the provisions of an approved report, which shall contain the following:

1. Specifications for the preparation of the site prior to placement of compacted fill material.
2. Specifications for material to be used as compacted fill.
3. Test method to be used to determine the maximum dry density and optimum moisture content of the material to be used as compacted fill.
4. Maximum allowable thickness of each lift of compacted fill material.
5. Field test method for determining the in-place dry density of the compacted fill.
6. Minimum acceptable in-place dry density expressed as a percentage of the maximum dry density determined in accordance with Item 3.
7. Number and frequency of field tests required to determine compliance with Item 6.

Exception: Compacted fill material less than 12 inches (305 mm) in depth need not comply with an approved report, provided it has been compacted to a minimum of 90 percent Modified Proctor in accordance with ASTM D 1557. The compaction shall be verified by a qualified inspector approved by the building official.

1803.6 Controlled low-strength material (CLSM). Where footings will bear on controlled low-strength material (CLSM), the CLSM shall comply with the provisions of an approved report, which shall contain the following:

1. Specifications for the preparation of the site prior to placement of the CLSM.
2. Specifications for the CLSM.
3. Laboratory or field test method(s) to be used to determine the compressive strength or bearing capacity of the CLSM.
4. Test methods for determining the acceptance of the CLSM in the field.
5. Number and frequency of field tests required to determine compliance with Item 4.

SECTION 1804 ALLOWABLE LOAD-BEARING VALUES OF SOILS

1804.1 Design. The presumptive load-bearing values provided in Table 1804.2 shall be used with the allowable stress design load combinations specified in Section 1605.3.

1804.2 Presumptive load-bearing values. The maximum allowable foundation pressure, lateral pressure or lateral sliding-resistance values for supporting soils near the surface shall not exceed the values specified in Table 1804.2 unless data to substantiate the use of a higher value are submitted and approved.

Presumptive load-bearing values shall apply to materials with similar physical characteristics and dispositions.

Mud, organic silt, organic clays, peat or unprepared fill shall not be assumed to have a presumptive load-bearing capacity unless data to substantiate the use of such a value are submitted.

Exception: A presumptive load-bearing capacity is permitted to be used where the building official deems the load-bearing capacity of mud, organic silt or unprepared fill is adequate for the support of lightweight and temporary structures.

1804.3 Lateral sliding resistance. The resistance of structural walls to lateral sliding shall be calculated by combining the values derived from the lateral bearing and the lateral sliding resistance shown in Table 1804.2 unless data to substantiate the use of higher values are submitted for approval.

For clay, sandy clay, silty clay and clayey silt, in no case shall the lateral sliding resistance exceed one-half the dead load.

1804.3.1 Increases in allowable lateral sliding resistance. The resistance values derived from the table are permitted to be increased by the tabular value for each additional foot (305 mm) of depth to a maximum of 15 times the tabular value.

Isolated poles for uses such as flagpoles or signs and poles used to support buildings that are not adversely affected by a 0.5 inch (12.7 mm) motion at the ground surface due to short-term lateral loads are permitted to be designed using lateral-bearing values equal to two times the tabular values.

SECTION 1805 FOOTINGS AND FOUNDATIONS

1805.1 General. Footings and foundations shall be designed and constructed in accordance with Sections 1805.1 through 1805.9. Footings and foundations shall be built on undisturbed soil, compacted fill material or CLSM. Compacted fill material shall be placed in accordance with Section 1803.5. CLSM shall be placed in accordance with Section 1803.6.

The top surface of footings shall be level. The bottom surface of footings is permitted to have a slope not 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 footing or where the surface of the ground slopes more than one unit vertical in 10 units horizontal (10-percent slope).

1805.2 Depth of footings. The minimum depth of footings below the undisturbed ground surface shall be 12 inches (305 mm). Where applicable, the depth of footings shall also conform to Sections 1805.2.1 through 1805.2.3.

1805.2.1 Frost protection. Except where otherwise protected from frost, foundation walls, piers and other permanent supports of buildings and structures shall be protected by one or more of the following methods:

1. Extending below the frost line of the locality;
2. Constructing in accordance with ASCE 32; or
3. Erecting on solid rock.

Exception: Free-standing buildings meeting all of the following conditions shall not be required to be protected:

1. Classified in Occupancy Category I, in accordance with Section 1604.5;
2. Area of 600 square feet (56 m²) or less for light-frame construction or 400 square feet (37 m²) or less for other than light-frame construction; and
3. Eave height of 10 feet (3048 mm) or less.

Footings shall not bear on frozen soil unless such frozen condition is of a permanent character.

1805.2.2 Isolated footings. Footings on granular soil shall be so located that the line drawn between the lower edges of adjoining footings shall not have a slope steeper than 30 degrees (0.52 rad) with the horizontal, unless the material supporting the higher footing is braced or retained or otherwise laterally supported in an approved manner or a greater slope has been properly established by engineering analysis.

1805.2.3 Shifting or moving soils. Where it is known that the shallow subsoils are of a shifting or moving character, footings shall be carried to a sufficient depth to ensure stability.

1805.3 Footings on or adjacent to slopes. The placement of buildings and structures on or adjacent to slopes steeper than one unit vertical in three units horizontal (33.3-percent slope) shall conform to Sections 1805.3.1 through 1805.3.5.

1805.3.1 Building clearance from ascending slopes. In general, buildings below slopes shall be set a sufficient distance from the slope to provide protection from slope drainage, erosion and shallow failures. Except as provided for in Section 1805.3.5 and Figure 1805.3.1, the following criteria will be assumed to provide this protection. Where the existing slope is steeper than one unit vertical in one unit horizontal (100-percent slope), the toe of the slope shall be assumed to be at the intersection of a horizontal plane drawn from the top of the foundation and a plane drawn tangent to the slope at an angle of 45 degrees (0.79 rad) to the horizontal. Where a retaining wall is constructed at the toe of the slope, the height of the slope shall be measured from the top of the wall to the top of the slope.

1805.3.2 Footing setback from descending slope surface. Footings on or adjacent to slope surfaces shall be founded in firm material with an embedment and set back

**TABLE 1804.2
ALLOWABLE FOUNDATION AND LATERAL PRESSURE**

CLASS OF MATERIALS	ALLOWABLE FOUNDATION PRESSURE (psf) ^d	LATERAL BEARING (psf/f below natural grade) ^d	LATERAL SLIDING	
			Coefficient of friction ^a	Resistance (psf) ^b
1. Crystalline bedrock	12,000	1,200	0.70	—
2. Sedimentary and foliated rock	4,000	400	0.35	—
3. Sandy gravel and/or gravel (GW and GP)	3,000	200	0.35	—
4. Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25	—
5. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500 ^c	100	—	130

For SI: 1 pound per square foot = 0.0479 kPa, 1 pound per square foot per foot = 0.157 kPa/m.

- a. Coefficient to be multiplied by the dead load.
- b. Lateral sliding resistance value to be multiplied by the contact area, as limited by Section 1804.3.
- c. Where the building official determines that in-place soils with an allowable bearing capacity of less than 1,500 psf (72 kPa) are likely to be present at the site, the allowable bearing capacity shall be determined by a soils investigation.
- d. An increase of one-third is permitted when using the alternate load combinations in Section 1605.3.2 that include **wind loads**.

from the slope surface sufficient to provide vertical and lateral support for the footing without detrimental settlement. Except as provided for in Section 1805.3.5 and Figure 1805.3.1, the following setback is deemed adequate to meet the criteria. Where the slope is steeper than 1 unit vertical in 1 unit horizontal (100-percent slope), the required setback shall be measured from an imaginary plane 45 degrees (0.79 rad) to the horizontal, projected upward from the toe of the slope.

1805.3.3 Pools. The setback between pools regulated by this code and slopes shall be equal to one-half the building footing setback distance required by this section. That portion of the pool wall within a horizontal distance of 7 feet (2134 mm) from the top of the slope shall be capable of supporting the water in the pool without soil support.

1805.3.4 Foundation elevation. On graded sites, the top of any exterior foundation shall extend above the elevation of the street gutter at point of discharge or the inlet of an approved drainage device a minimum of 12 inches (305 mm) plus 2 percent. Alternate elevations are permitted subject to the approval of the building official, provided it can be demonstrated that required drainage to the point of discharge and away from the structure is provided at all locations on the site.

1805.3.5 Alternate setback and clearance. Alternate setbacks and clearances are permitted, subject to the approval of the building official. The building official is permitted to require an investigation and recommendation of a registered design professional to demonstrate that the intent of this section has been satisfied. Such an investigation shall include consideration of material, height of slope, slope gradient, load intensity and erosion characteristics of slope material.

1805.4 Footings. Footings shall be designed and constructed in accordance with Sections 1805.4.1 through 1805.4.6.

1805.4.1 Design. Footings shall be so designed that the allowable bearing capacity of the soil is not exceeded, and

that differential settlement is minimized. The minimum width of footings shall be 12 inches (305 mm).

Footings in areas with expansive soils shall be designed in accordance with the provisions of Section 1805.8.

1805.4.1.1 Design loads. Footings shall be designed for the most unfavorable effects due to the combinations of loads specified in Section 1605.2 or 1605.3. The dead load is permitted to include the weight of foundations, footings and overlying fill. Reduced live loads, as specified in Sections 1607.9 and 1607.11, are permitted to be used in the design of footings.

1805.4.1.2 Vibratory loads. Where machinery operations or other vibrations are transmitted through the foundation, consideration shall be given in the footing design to prevent detrimental disturbances of the soil.

1805.4.2 Concrete footings. The design, materials and construction of concrete footings shall comply with Sections 1805.4.2.1 through 1805.4.2.6 and the provisions of Chapter 19.

Exception: Where a specific design is not provided, concrete footings supporting walls of light-frame construction are permitted to be designed in accordance with Table 1805.4.2.

1805.4.2.1 Concrete strength. Concrete in footings shall have a specified compressive strength (f'_c) of not less than 2,500 pounds per square inch (psi) (17 237 kPa) at 28 days.

1805.4.2.2 Footing seismic ties. **Reserved.**

1805.4.2.3 Plain concrete footings. The edge thickness of plain concrete footings supporting walls of other than light-frame construction shall not be less than 8 inches (203 mm) where placed on soil.

Exception: For plain concrete footings supporting Group R-3 occupancies, the edge thickness is permit-

ted to be 6 inches (152 mm), provided that the footing does not extend beyond a distance greater than the thickness of the footing on either side of the supported wall.

1805.4.2.4 Placement of concrete. Concrete footings shall not be placed through water unless a tremie or other method approved by the building official is used. Where placed under or in the presence of water, the concrete shall be deposited by approved means to ensure minimum segregation of the mix and negligible turbulence of the water.

1805.4.2.5 Protection of concrete. Concrete footings shall be protected from freezing during depositing and for a period of not less than five days thereafter. Water shall not be allowed to flow through the deposited concrete.

1805.4.2.6 Forming of concrete. Concrete footings are permitted to be cast against the earth where, in the opinion of the building official, soil conditions do not require forming. Where forming is required, it shall be in accordance with Chapter 6 of ACI 318.

1805.4.3 Masonry-unit footings. The design, materials and construction of masonry-unit footings shall comply

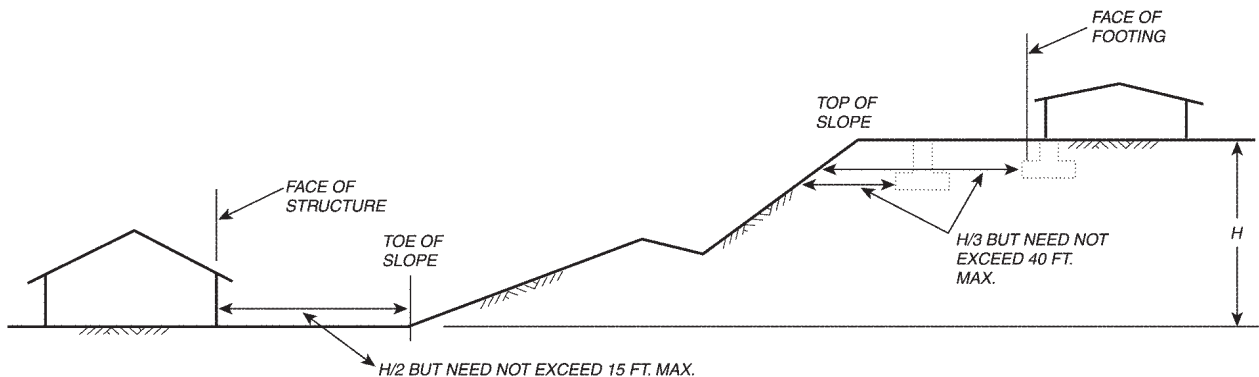
with Sections 1805.4.3.1 and 1805.4.3.2, and the provisions of Chapter 21.

Exception: Where a specific design is not provided, masonry-unit footings supporting walls of light-frame construction are permitted to be designed in accordance with Table 1805.4.2.

1805.4.3.1 Dimensions. Masonry-unit footings shall be laid in Type M or S mortar complying with Section 2103.8 and the depth shall not be less than twice the projection beyond the wall, pier or column. The width shall not be less than 8 inches (203 mm) wider than the wall supported thereon.

1805.4.3.2 Offsets. The maximum offset of each course in brick foundation walls stepped up from the footings shall be 1.5 inches (38 mm) where laid in single courses, and 3 inches (76 mm) where laid in double courses.

1805.4.4 Steel grillage footings. Grillage footings of structural steel shapes shall be separated with approved steel spacers and be entirely encased in concrete with at least 6 inches (152 mm) on the bottom and at least 4 inches (102 mm) at all other points. The spaces between the shapes shall be completely filled with concrete or cement grout.



For SI: 1 foot = 304.8 mm.

FIGURE 1805.3.1
FOUNDATION CLEARANCES FROM SLOPES

TABLE 1805.4.2
FOOTINGS SUPPORTING WALLS OF LIGHT-FRAME CONSTRUCTION^{a, b, c, d, e}

NUMBER OF FLOORS SUPPORTED BY THE FOOTING ^f	WIDTH OF FOOTING (inches)	THICKNESS OF FOOTING (inches)
1	12	6
2	15	6
3	18	8 ^g

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

- a. Depth of footings shall be in accordance with Section 1805.2.
- b. The ground under the floor is permitted to be excavated to the elevation of the top of the footing.
- c. Interior-stud-bearing walls are permitted to be supported by isolated footings. The footing width and length shall be twice the width shown in this table, and footings shall be spaced not more than 6 feet on center.
- d. Reserved.
- e. For thickness of foundation walls, see Section 1805.5.
- f. Footings are permitted to support a roof in addition to the stipulated number of floors. Footings supporting roof only shall be as required for supporting one floor.
- g. Plain concrete footings for Group R-3 occupancies are permitted to be 6 inches thick.

1805.4.5 Timber footings. Timber footings are permitted for buildings of Type V construction and as otherwise approved by the building official. Such footings shall be treated in accordance with AWPA U1 (Commodity Specification A, Use Category 4B). Treated timbers are not required where placed entirely below permanent water level or where used as capping for wood piles that project above the water level over submerged or marsh lands. The compressive stresses perpendicular to the grain in untreated timber footings supported upon treated piles shall not exceed 70 percent of the allowable stresses for the species and grade of timber as specified in the AF&PA NDS.

1805.4.6 Wood foundations. Wood foundation systems shall be designed and installed in accordance with AF&PA Technical Report No. 7. Lumber and plywood shall be treated in accordance with AWPA U1 (Commodity Specification A, Use Category 4B and Section 5.2) and shall be identified in accordance with Section 2303.1.8.1.

1805.5 Foundation walls. Concrete and masonry foundation walls shall be designed in accordance with Chapter 19 or 21, respectively. Foundation walls that are laterally supported at the top and bottom and within the parameters of Tables 1805.5(1) through 1805.5(5) are permitted to be designed and constructed in accordance with Sections 1805.5.1 through 1805.5.5.

1805.5.1 Foundation wall thickness. The minimum thickness of concrete and masonry foundation walls shall comply with Sections 1805.5.1.1 through 1805.5.1.3.

1805.5.1.1 Thickness at top of foundation wall. The thickness of foundation walls shall not be less than the thickness of the wall supported, except that foundation walls of at least 8-inch (203 mm) nominal width are permitted to support brick-veneered frame walls and 10-inch-wide (254 mm) cavity walls provided the requirements of Section 1805.5.1.2 are met. Corbeling of masonry shall be in accordance with Section 2104.2. Where an 8-inch (203 mm) wall is corbeled, the top corbel shall not extend higher than the bottom of the floor framing and shall be a full course of headers at least 6 inches (152 mm) in length or the top course bed joint shall be tied to the vertical wall projection. The tie shall be W2.8 (4.8 mm) and spaced at a maximum horizontal distance of 36 inches (914 mm); the hollow space behind the corbelled masonry shall be filled with mortar or grout.

1805.5.1.2 Thickness based on soil loads, unbalanced backfill height and wall height. The thickness of foundation walls shall comply with the requirements of Table 1805.5(5) for concrete walls, Table 1805.5(1) for plain masonry walls or Table 1805.5(2), 1805.5(3) or 1805.5(4) for masonry walls with reinforcement. When using the tables, masonry shall be laid in running bond and the mortar shall be Type M or S.

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 founda-

tion 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, the unbalanced backfill height is permitted to be measured from the exterior finish ground level to the top of the interior concrete slab.

1805.5.1.3 Rubble stone. Foundation walls of rough or random rubble stone shall not be less than 16 inches (406 mm) thick.

1805.5.2 Foundation wall materials. Concrete foundation walls constructed in accordance with Table 1805.5(5) shall comply with Section 1805.5.2.1. Masonry foundation walls constructed in accordance with Table 1805.5(1), 1805.5(2), 1805.5(3) or 1805.5(4) shall comply with Section 1805.5.2.2.

1805.5.2.1 Concrete foundation walls. Concrete foundation walls shall comply with the following:

1. The size and spacing of vertical reinforcement shown in Table 1805.5(5) is based on the use of reinforcement with a minimum yield strength of 60,000 psi (414 MPa). Vertical reinforcement with a minimum yield strength of 40,000 psi (276 MPa) or 50,000 psi (345 MPa) is permitted, provided the same size bar is used and the spacing shown in the table is reduced by multiplying the spacing by 0.67 or 0.83, respectively.
2. Vertical reinforcement, when required, shall be placed nearest the inside face of the wall a distance, d , from the outside face (soil side) of the wall. The distance, d , is equal to the wall thickness, t , minus 1.25 inches (32 mm) plus one-half the bar diameter, d_b [$d = t - (1.25 + d_b/2)$]. The reinforcement shall be placed within a tolerance of $\pm 3/8$ inch (9.5 mm) where d is less than or equal to 8 inches (203 mm) or $\pm 1/2$ inch (2.7 mm) where d is greater than 8 inches (203 mm).
3. In lieu of the reinforcement shown in Table 1805.5(5), smaller reinforcing bar sizes with closer spacings that provide an equivalent cross-sectional area of reinforcement per unit length of wall are permitted.
4. Concrete cover for reinforcement measured from the inside face of the wall shall not be less than $3/4$ inch (19.1 mm). Concrete cover for reinforcement measured from the outside face of the wall shall not be less than 1.5 inches (38 mm) for No. 5 bars and smaller and not less than 2 inches (51 mm) for larger bars.
5. Concrete shall have a specified compressive strength, f'_c , of not less than 2,500 psi (17.2 MPa) at 28 days.
6. The unfactored axial load per linear foot of wall shall not exceed $1.2 tf'_c$, where t is the specified wall thickness in inches.

TABLE 1805.5(1)
PLAIN MASONRY FOUNDATION WALLS^{a, b, c}

MAXIMUM WALL HEIGHT (feet)	MAXIMUM UNBALANCED BACKFILL HEIGHT ^e (feet)	MINIMUM NOMINAL WALL THICKNESS (inches)		
		Soil classes and lateral soil load ³ (psf per foot below natural 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
7	4 (or less)	8	8	8
	5	8	10	10
	6	10	12	10 (solid ^c)
	7	12	10 (solid ^c)	10 (solid ^c)
8	4 (or less)	8	8	8
	5	8	10	12
	6	10	12	12 (solid ^c)
	7	12	12 (solid ^c)	Note d
9	8	10 (solid ^c)	12 (solid ^c)	Note d
	4 (or less)	8	8	8
	5	8	10	12
	6	12	12	12 (solid ^c)
9	7	12 (solid ^c)	12 (solid ^c)	Note d
	8	12 (solid ^c)	Note d	Note d
	9	Note d	Note d	Note d

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/m.

a. For design lateral soil loads, see Section 1610. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist soil conditions without hydrostatic pressure.

b. Provisions for this table are based on construction requirements specified in Section 1805.5.2.2.

c. Solid grouted hollow units or solid masonry units.

d. A design in compliance with Chapter 21 or reinforcement in accordance with Table 1805.5(2) is required.

e. For height of unbalanced backfill, see Section 1805.5.1.2.

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TABLE 1805.5(2)
8-INCH MASONRY FOUNDATION WALLS WITH REINFORCEMENT WHERE $d \geq 5$ INCHES^{a, b, c}

MAXIMUM WALL HEIGHT (feet-inches)	MAXIMUM UNBALANCED BACKFILL HEIGHT ^d (feet-inches)	VERTICAL REINFORCEMENT		
		Soil classes and lateral soil load ^a (psf per foot below natural 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
7-4	4-0 (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5-0	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	6-0	#4 at 48" o.c.	#5 at 48" o.c.	#5 at 48" o.c.
	7-4	#5 at 48" o.c.	#6 at 48" o.c.	#7 at 48" o.c.
8-0	4-0 (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5-0	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	6-0	#4 at 48" o.c.	#5 at 48" o.c.	#5 at 48" o.c.
	7-0	#5 at 48" o.c.	#6 at 48" o.c.	#7 at 48" o.c.
	8-0	#5 at 48" o.c.	#6 at 48" o.c.	#7 at 48" o.c.
8-8	4-0 (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5-0	#4 at 48" o.c.	#4 at 48" o.c.	#5 at 48" o.c.
	6-0	#4 at 48" o.c.	#5 at 48" o.c.	#6 at 48" o.c.
	7-0	#5 at 48" o.c.	#6 at 48" o.c.	#7 at 48" o.c.
	8-8	#6 at 48" o.c.	#7 at 48" o.c.	#8 at 48" o.c.
9-4	4-0 (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5-0	#4 at 48" o.c.	#4 at 48" o.c.	#5 at 48" o.c.
	6-0	#4 at 48" o.c.	#5 at 48" o.c.	#6 at 48" o.c.
	7-0	#5 at 48" o.c.	#6 at 48" o.c.	#7 at 48" o.c.
	8-0	#6 at 48" o.c.	#7 at 48" o.c.	#8 at 48" o.c.
	9-4	#7 at 48" o.c.	#8 at 48" o.c.	#9 at 48" o.c.
10-0	4-0 (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5-0	#4 at 48" o.c.	#4 at 48" o.c.	#5 at 48" o.c.
	6-0	#4 at 48" o.c.	#5 at 48" o.c.	#6 at 48" o.c.
	7-0	#5 at 48" o.c.	#6 at 48" o.c.	#7 at 48" o.c.
	8-0	#6 at 48" o.c.	#7 at 48" o.c.	#8 at 48" o.c.
	9-0	#7 at 48" o.c.	#8 at 48" o.c.	#9 at 48" o.c.
	10-0	#7 at 48" o.c.	#9 at 48" o.c.	#9 at 48" o.c.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/m.

a. For design lateral soil loads, see Section 1610. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist soil conditions without hydrostatic pressure.

b. Provisions for this table are based on construction requirements specified in Section 1805.5.2.2.

c. For alternative reinforcement, see Section 1805.5.3.

d. For height of unbalanced backfill, see Section 1805.5.1.2.

TABLE 1805.5(3)
10-INCH MASONRY FOUNDATION WALLS WITH REINFORCEMENT WHERE $d \geq 6.75$ INCHES^{a, b, c}

MAXIMUM WALL HEIGHT (feet-inches)	MAXIMUM UNBALANCED BACKFILL HEIGHT ^d (feet-inches)	VERTICAL REINFORCEMENT		
		Soil classes and lateral soil load ^a (psf per foot below natural 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
7-4	4-0 (or less)	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	5-0	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	6-0	#4 at 56" o.c.	#4 at 56" o.c.	#5 at 56" o.c.
	7-4	#4 at 56" o.c.	#5 at 56" o.c.	#6 at 56" o.c.
8-0	4-0 (or less)	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	5-0	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	6-0	#4 at 56" o.c.	#4 at 56" o.c.	#5 at 56" o.c.
	7-0	#4 at 56" o.c.	#5 at 56" o.c.	#6 at 56" o.c.
	8-0	#5 at 56" o.c.	#6 at 56" o.c.	#7 at 56" o.c.
8-8	4-0 (or less)	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	5-0	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	6-0	#4 at 56" o.c.	#4 at 56" o.c.	#5 at 56" o.c.
	7-0	#4 at 56" o.c.	#5 at 56" o.c.	#6 at 56" o.c.
	8-8	#5 at 56" o.c.	#7 at 56" o.c.	#8 at 56" o.c.
9-4	4-0 (or less)	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	5-0	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	6-0	#4 at 56" o.c.	#5 at 56" o.c.	#5 at 56" o.c.
	7-0	#4 at 56" o.c.	#5 at 56" o.c.	#6 at 56" o.c.
	8-0	#5 at 56" o.c.	#6 at 56" o.c.	#7 at 56" o.c.
	9-4	#6 at 56" o.c.	#7 at 56" o.c.	#8 at 56" o.c.
10-0	4-0 (or less)	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	5-0	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	6-0	#4 at 56" o.c.	#5 at 56" o.c.	#5 at 56" o.c.
	7-0	#5 at 56" o.c.	#6 at 56" o.c.	#7 at 56" o.c.
	8-0	#5 at 56" o.c.	#7 at 56" o.c.	#8 at 56" o.c.
	9-0	#6 at 56" o.c.	#7 at 56" o.c.	#9 at 56" o.c.
	10-0	#7 at 56" o.c.	#8 at 56" o.c.	#9 at 56" o.c.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/m.

a. For design lateral soil loads, see Section 1610. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist soil conditions without hydrostatic pressure.

b. Provisions for this table are based on construction requirements specified in Section 1805.5.2.2.

c. For alternative reinforcement, see Section 1805.5.3.

d. For height of unbalanced fill, see Section 1805.5.1.2.

TABLE 1805.5(4)
12-INCH MASONRY FOUNDATION WALLS WITH REINFORCEMENT WHERE $d \geq 8.75$ INCHES^{a, b, c}

MAXIMUM WALL HEIGHT (feet-inches)	MAXIMUM UNBALANCED BACKFILL HEIGHT ^d (feet-inches)	VERTICAL REINFORCEMENT		
		Soil classes and lateral soil load ^a (psf per foot below natural 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
7-4	4-0 (or less)	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	5-0	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	6-0	#4 at 72" o.c.	#4 at 72" o.c.	#5 at 72" o.c.
	7-4	#4 at 72" o.c.	#5 at 72" o.c.	#6 at 72" o.c.
8-0	4-0 (or less)	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	5-0	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	6-0	#4 at 72" o.c.	#4 at 72" o.c.	#5 at 72" o.c.
	7-0	#4 at 72" o.c.	#5 at 72" o.c.	#6 at 72" o.c.
	8-0	#5 at 72" o.c.	#6 at 72" o.c.	#7 at 72" o.c.
8-8	4-0 (or less)	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	5-0	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	6-0	#4 at 72" o.c.	#4 at 72" o.c.	#5 at 72" o.c.
	7-0	#4 at 72" o.c.	#5 at 72" o.c.	#6 at 72" o.c.
	8-8	#5 at 72" o.c.	#7 at 72" o.c.	#8 at 72" o.c.
9-4	4-0 (or less)	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	5-0	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	6-0	#4 at 72" o.c.	#5 at 72" o.c.	#5 at 72" o.c.
	7-0	#4 at 72" o.c.	#5 at 72" o.c.	#6 at 72" o.c.
	8-0	#5 at 72" o.c.	#6 at 72" o.c.	#7 at 72" o.c.
	9-4	#6 at 72" o.c.	#7 at 72" o.c.	#8 at 72" o.c.
10-0	4-0 (or less)	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	5-0	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	6-0	#4 at 72" o.c.	#5 at 72" o.c.	#5 at 72" o.c.
	7-0	#4 at 72" o.c.	#6 at 72" o.c.	#6 at 72" o.c.
	8-0	#5 at 72" o.c.	#6 at 72" o.c.	#7 at 72" o.c.
	9-0	#6 at 72" o.c.	#7 at 72" o.c.	#8 at 72" o.c.
	10-0	#7 at 72" o.c.	#8 at 72" o.c.	#9 at 72" o.c.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/m.

a. For design lateral soil loads, see Section 1610. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist soil conditions without hydrostatic pressure.

b. Provisions for this table are based on construction requirements specified in Section 1805.5.2.2.

c. For alternative reinforcement, see Section 1805.5.3.

d. For height of unbalanced backfill, see Section 1805.5.1.2.

**TABLE 1805.5(5)
CONCRETE FOUNDATION WALLS^{b, c}**

MAXIMUM WALL HEIGHT (feet)	MAXIMUM UNBALANCED BACKFILL HEIGHT ^e (feet)	VERTICAL REINFORCEMENT AND SPACING (inches)								
		Design lateral soil load ^a (psf per foot of depth)								
		30			45			60		
		Minimum wall thickness (inches)								
		7.5	9.5	11.5	7.5	9.5	11.5	7.5	9.5	11.5
5	4	PC	PC	PC	PC	PC	PC	PC	PC	PC
	5	PC	PC	PC	PC	PC	PC	PC	PC	PC
6	4	PC	PC	PC	PC	PC	PC	PC	PC	PC
	5	PC	PC	PC	PC	PC	PC	PC	PC	PC
	6	PC	PC	PC	PC	PC	PC	PC	PC	PC
7	4	PC	PC	PC	PC	PC	PC	PC	PC	PC
	5	PC	PC	PC	PC	PC	PC	PC	PC	PC
	6	PC	PC	PC	PC	PC	PC	#5 at 48"	PC	PC
	7	PC	PC	PC	#5 at 46"	PC	PC	#6 at 48"	PC	PC
8	4	PC	PC	PC	PC	PC	PC	PC	PC	PC
	5	PC	PC	PC	PC	PC	PC	PC	PC	PC
	6	PC	PC	PC	PC	PC	PC	#5 at 43"	PC	PC
	7	PC	PC	PC	#5 at 41"	PC	PC	#6 at 43"	PC	PC
	8	#5 at 47"	PC	PC	#6 at 43"	PC	PC	#6 at 32"	#6 at 44"	PC
9	4	PC	PC	PC	PC	PC	PC	PC	PC	PC
	5	PC	PC	PC	PC	PC	PC	PC	PC	PC
	6	PC	PC	PC	PC	PC	PC	#5 at 39"	PC	PC
	7	PC	PC	PC	#5 at 37"	PC	PC	#6 at 38"	#5 at 37"	PC
	8	#5 at 41"	PC	PC	#6 at 38"	#5 at 37"	PC	#7 at 39"	#6 at 39"	#4 at 48"
9 ^d	#6 at 46"	PC	PC	#7 at 41"	#6 at 41"	PC	#7 at 31"	#7 at 41"	#6 at 39"	
10	4	PC	PC	PC	PC	PC	PC	PC	PC	PC
	5	PC	PC	PC	PC	PC	PC	PC	PC	PC
	6	PC	PC	PC	PC	PC	PC	#5 at 37"	PC	PC
	7	PC	PC	PC	#6 at 48"	PC	PC	#6 at 35"	#6 at 48"	PC
	8	#5 at 38"	PC	PC	#7 at 47"	#6 at 47"	PC	#7 at 35"	#7 at 48"	#6 at 45"
	9 ^d	#6 at 41"	#4 at 48"	PC	#7 at 37"	#7 at 48"	#4 at 48"	#6 at 22"	#7 at 37"	#7 at 47"
	10 ^d	#7 at 45"	#6 at 45"	PC	#7 at 31"	#7 at 40"	#6 at 38"	#6 at 22"	#7 at 30"	#7 at 38"

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.157 kPa/m.

a. For design lateral soil loads for different classes of soil, see Section 1610.

b. Provisions for this table are based on construction requirements specified in Section 1805.5.2.1.

c. "PC" means plain concrete.

d. Where design lateral soil loads from Table 1610.1 are used, the requirements for 30 and 45 psf per foot of depth are not applicable. See Section 1610.

e. For height of unbalanced backfill, see Section 1805.5.1.2.

1805.5.2.2 Masonry foundation walls. Masonry foundation walls shall comply with the following:

1. Vertical reinforcement shall have a minimum yield strength of 60,000 psi (414 MPa).
2. The specified location of the reinforcement shall equal or exceed the effective depth distance, d , noted in Tables 1805.5(2), 1805.5(3) and 1805.5(4) and shall be measured from the face of the exterior (soil) side of the wall to the center of the vertical reinforcement. The reinforcement shall be placed within the tolerances specified in ACI 530.1/ASCE 6/TMS 402, Article 3.4 B7 of the specified location.
3. Grout shall comply with Section 2103.12.
4. Concrete masonry units shall comply with ASTM C 90.
5. Clay masonry units shall comply with ASTM C 652 for hollow brick, except compliance with ASTM C 62 or ASTM C 216 is permitted when solid masonry units are installed in accordance with Table 1805.5(1) for plain masonry.
6. Masonry units shall be installed with Type M or S mortar in accordance with Section 2103.8.
7. The unfactored axial load per linear foot of wall shall not exceed $1.2 t f'_m$ where t is the specified wall thickness in inches and f'_m is the specified compressive strength of masonry in pounds per square inch.

1805.5.3 Alternative foundation wall reinforcement. In lieu of the reinforcement provisions for masonry foundation walls in Table 1805.5(2), 1805.5(3) or 1805.5(4), alternative reinforcing bar sizes and spacings having an equivalent cross-sectional area of reinforcement per linear foot (mm) of wall are permitted to be used, provided the spacing of reinforcement does not exceed 72 inches (1829 mm) and reinforcing bar sizes do not exceed No. 11.

1805.5.4 Hollow masonry walls. At least 4 inches (102 mm) of solid masonry shall be provided at girder supports at the top of hollow masonry unit foundation walls.

1805.5.5 Seismic requirements. *Reserved.*

1805.5.6 Foundation wall drainage. Foundation walls shall be designed to support the weight of the full hydrostatic pressure of undrained backfill unless a drainage system is installed in accordance with Sections 1807.4.2 and 1807.4.3.

1805.5.7 Pier and curtain wall foundations. In regions where the basic wind speed is 100 mph or less. Pier and curtain wall foundations are permitted to be used to support light-frame construction not more than two stories in height, provided the following requirements are met:

1. All load-bearing walls shall be placed on continuous concrete footings bonded integrally with the exterior wall footings.
2. The minimum actual thickness of a load-bearing masonry wall shall not be less than 4 inches (102 mm)

nominal or 3.625 inches (92 mm) actual thickness, and shall be bonded integrally with piers spaced 6 feet (1829 mm) on center (o.c.).

3. Piers shall be constructed in accordance with Chapter 21 and the following:

- 3.1. The unsupported height of the masonry piers shall not exceed 10 times their least dimension.
- 3.2. Where structural clay tile or hollow concrete masonry units are used for piers supporting beams and girders, the cellular spaces shall be filled solidly with concrete or Type M or S mortar.

Exception: Unfilled hollow piers are permitted where the unsupported height of the pier is not more than four times its least dimension.

- 3.3. Hollow piers shall be capped with 4 inches (102 mm) of solid masonry or concrete or the cavities of the top course shall be filled with concrete or grout.

4. The maximum height of a 4-inch (102 mm) load-bearing masonry foundation wall supporting wood frame walls and floors shall not be more than 4 feet (1219 mm) in height.
5. The unbalanced fill for 4-inch (102 mm) foundation walls shall not exceed 24 inches (610 mm) for solid masonry, nor 12 inches (305 mm) for hollow masonry.

1805.6 Foundation plate or sill bolting. Wood foundation plates or sills shall be bolted or strapped to the foundation or foundation wall as provided in Chapter 23.

1805.7 Designs employing lateral bearing. Designs to resist both axial and lateral loads employing posts or poles as columns embedded in earth or embedded in concrete footings in the earth shall conform to the requirements of Sections 1805.7.1 through 1805.7.3.

1805.7.1 Limitations. The design procedures outlined in this section are subject to the following limitations:

1. The frictional resistance for structural walls and slabs on silts and clays shall be limited to one-half of the normal force imposed on the soil by the weight of the footing or slab.
2. Posts embedded in earth shall not be used to provide lateral support for structural or nonstructural materials such as plaster, masonry or concrete unless bracing is provided that develops the limited deflection required.

Wood poles shall be treated in accordance with AWWA U1 for sawn timber posts (Commodity Specification A, Use Category 4B) and for round timber posts (Commodity Specification B, Use Category 4B).

1805.7.2 Design criteria. The depth to resist lateral loads shall be determined by the design criteria established in Sec-

tions 1805.7.2.1 through 1805.7.2.3, or by other methods approved by the building official.

1805.7.2.1 Nonconstrained. The following formula shall be used in determining the depth of embedment required to resist lateral loads where no constraint is provided at the ground surface, such as rigid floor or rigid ground surface pavement, and where no lateral constraint is provided above the ground surface, such as a structural diaphragm.

$$d = 0.5A\{1 + [1 + (4.36h/A)]^{1/2}\} \quad \text{(Equation 18-1)}$$

where:

$$A = 2.34P/S_1 b.$$

b = Diameter of round post or footing or diagonal dimension of square post or footing, feet (m).

d = Depth of embedment in earth in feet (m) but not over 12 feet (3658 mm) for purpose of computing lateral pressure.

h = Distance in feet (m) from ground surface to point of application of "P."

P = Applied lateral force in pounds (kN).

S_1 = Allowable lateral soil-bearing pressure as set forth in Section 1804.3 based on a depth of one-third the depth of embedment in pounds per square foot (psf) (kPa).

1805.7.2.2 Constrained. The following formula shall be used to determine the depth of embedment required to resist lateral loads where constraint is provided at the ground surface, such as a rigid floor or pavement.

$$d^2 = 4.25(Ph/S_3 b) \quad \text{(Equation 18-2)}$$

or alternatively

$$d^2 = 4.25 (M_g/S_3 b) \quad \text{(Equation 18-3)}$$

where:

M_g = Moment in the post at grade, in foot-pounds (kN-m).

S_3 = Allowable lateral soil-bearing pressure as set forth in Section 1804.3 based on a depth equal to the depth of embedment in pounds per square foot (kPa).

1805.7.2.3 Vertical load. The resistance to vertical loads shall be determined by the allowable soil-bearing pressure set forth in Table 1804.2.

1805.7.3 Backfill. The backfill in the annular space around columns not embedded in poured footings shall be by one of the following methods:

1. Backfill shall be of concrete with an ultimate strength of 2,000 psi (13.8 MPa) at 28 days. The hole shall not be less than 4 inches (102 mm) larger than the diameter of the column at its bottom or 4 inches (102 mm)

larger than the diagonal dimension of a square or rectangular column.

2. Backfill shall be of clean sand. The sand shall be thoroughly compacted by tamping in layers not more than 8 inches (203 mm) in depth.
3. Backfill shall be of controlled low-strength material (CLSM).

1805.8 Design for expansive soils. Footings or foundations for buildings and structures founded on expansive soils shall be designed in accordance with Section 1805.8.1 or 1805.8.2.

Footing or foundation design need not comply with Section 1805.8.1 or 1805.8.2 where the soil is removed in accordance with Section 1805.8.3, nor where the building official approves stabilization of the soil in accordance with Section 1805.8.4.

1805.8.1 Foundations. Footings or foundations placed on or within the active zone of expansive soils shall be designed to resist differential volume changes and to prevent structural damage to the supported structure. Deflection and racking of the supported structure shall be limited to that which will not interfere with the usability and serviceability of the structure.

Foundations placed below where volume change occurs or below expansive soil shall comply with the following provisions:

1. Foundations extending into or penetrating expansive soils shall be designed to prevent uplift of the supported structure.
2. Foundations penetrating expansive soils shall be designed to resist forces exerted on the foundation due to soil volume changes or shall be isolated from the expansive soil.

1805.8.2 Slab-on-ground foundations. Moments, shears and deflections for use in designing slab-on-ground, mat or raft foundations on expansive soils shall be determined in accordance with *WRI/CRSI Design of Slab-on-Ground Foundations* or *PTI Standard Requirements for Analysis of Shallow Concrete Foundations on Expansive Soils*. Using the moments, shears and deflections determined above, nonprestressed slabs-on-ground, mat or raft foundations on expansive soils shall be designed in accordance with *WRI/CRSI Design of Slab-on-Ground Foundations* and post-tensioned slab-on-ground, mat or raft foundations on expansive soils shall be designed in accordance with *PTI Standard Requirements for Design of Shallow Post-Tensioned Concrete Foundations on Expansive Soils*. It shall be permitted to analyze and design such slabs by other methods that account for soil-structure interaction, the deformed shape of the soil support, the plate or stiffened plate action of the slab as well as both center lift and edge lift conditions. Such alternative methods shall be rational and the basis for all aspects and parameters of the method shall be available for peer review.

1805.8.3 Removal of expansive soil. Where expansive soil is removed in lieu of designing footings or foundations in accordance with Section 1805.8.1 or 1805.8.2, the soil shall be removed to a depth sufficient to ensure a constant mois-

ture content in the remaining soil. Fill material shall not contain expansive soils and shall comply with Section 1803.5 or 1803.6.

Exception: Expansive soil need not be removed to the depth of constant moisture, provided the confining pressure in the expansive soil created by the fill and supported structure exceeds the swell pressure.

1805.8.4 Stabilization. Where the active zone of expansive soils is stabilized in lieu of designing footings or foundations in accordance with Section 1805.8.1 or 1805.8.2, the soil shall be stabilized by chemical, dewatering, presaturation or equivalent techniques.

1805.9 Seismic requirements. *Reserved.*

SECTION 1806 RETAINING WALLS

1806.1 General. Walls built to retain or support the lateral pressure of earth or water or other superimposed loads shall be designed and constructed of masonry, concrete, steel sheet piling or other approved materials.

1806.2 Design. Retaining walls shall be designed to resist the design lateral soil loads in Section 1610, including both dead and live load surcharges to which such walls are subjected, and to ensure stability against overturning, sliding, excessive foundation pressure and water uplift.

1806.3 Hydrostatic pressure. Unless drainage is provided, the hydrostatic head of the water pressure shall be assumed to be equal to the height of the wall.

1806.4 Reinforced masonry retaining walls. Vertical reinforcement for masonry retaining walls shall comply with Table 1806.4 or shall be designed in accordance with ACI 530/ASCE 5/TMS 402. Masonry shall be fully grouted with a minimum f'_m of 1,500 psi (10 343 kPa). Mortar for masonry shall be Type M or S and laid in running bond. The specified location of the reinforcement shall equal or exceed the effective depth distance, d , noted in Table 1806.4 and shall be measured from the exposed side of the wall to the center of the vertical reinforcement. Footings for reinforced masonry retaining walls shall be designed in accordance with ACI 318.

1806.5 Segmental retaining walls. Segmental retaining walls shall be designed in accordance with NCMA Design Manual for Segmental Retaining Walls. ■

SECTION 1807 DAMPPOOFING AND WATERPROOFING

1807.1 Where required. Walls or portions thereof that retain earth and enclose interior spaces and floors below grade shall be waterproofed and dampproofed in accordance with this section, with the exception of those spaces containing groups other than residential and institutional where such omission is not detrimental to the building or occupancy.

Ventilation for crawl spaces shall comply with Section 1203.4.

1807.1.1 Story above grade plane. Where a basement is considered a story above grade plane and the finished ground level adjacent to the basement wall is below the basement floor elevation for 25 percent or more of the perimeter, the floor and walls shall be dampproofed in accordance with Section 1807.2 and a foundation drain shall be installed in accordance with Section 1807.4.2. The foundation drain shall be installed around the portion of the perimeter where the basement floor is below ground level. The provisions of Sections 1802.2.3, 1807.3 and 1807.4.1 shall not apply in this case.

1807.1.2 Under-floor space. The finished ground level of an under-floor space such as a crawl space shall not be located below the bottom of the footings. Where there is evidence that the ground-water table rises to within 6 inches (152 mm) of the ground level at the outside building perimeter, or that the surface water does not readily drain from the building site, the ground level of the under-floor space shall be as high as the outside finished ground level, unless an approved drainage system is provided. The provisions of Sections 1802.2.3, 1807.2, 1807.3 and 1807.4 shall not apply in this case.

1807.1.2.1 Flood hazard areas. *See Section 3110.*

1807.1.3 Ground-water control. Where the ground-water table is lowered and maintained at an elevation not less than 6 inches (152 mm) below the bottom of the lowest floor, the floor and walls shall be dampproofed in accordance with Section 1807.2. The design of the system to lower the ground-water table shall be based on accepted principles of engineering that shall consider, but not necessarily be limited to, permeability of the soil, rate at which water enters the drainage system, rated capacity of pumps, head against which pumps are to operate and the rated capacity of the disposal area of the system.

1807.2 Dampproofing required. Where hydrostatic pressure will not occur as determined by Section 1802.2.3, floors and walls for other than wood foundation systems shall be dampproofed in accordance with this section. Wood foundation systems shall be constructed in accordance with AF&PA Technical Report No. 7.

1807.2.1 Floors. Dampproofing materials for floors shall be installed between the floor and the base course required by Section 1807.4.1, except where a separate floor is provided above a concrete slab.

Where installed beneath the slab, dampproofing shall consist of not less than 6-mil (0.006 inch; 0.152 mm) polyethylene with joints lapped not less than 6 inches (152 mm), or other approved methods or materials. Where permitted to be installed on top of the slab, dampproofing shall consist of mopped-on bitumen, not less than 4-mil (0.004 inch; 0.102 mm) polyethylene, or other approved methods or materials. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's installation instructions.

1807.2.2 Walls. Dampproofing materials for walls shall be installed on the exterior surface of the wall, and shall extend from the top of the footing to above ground level.

**TABLE 1806.4
REINFORCEMENT FOR MASONRY RETAINING WALLS^a**

Nominal Wall thickness [(in.) (mm)]	Wall depth, H, ft (m)	Reinforcement size & spacing for equivalent fluid weight of soil, pcf (kN/m ³), of:		
		30 (4.7)	45 (7.1)	60 (9.4)
8 (203)	4.0 (1.2)	#4 at 64 in.	#4 at 40 in.	#4 at 32 in.
	4.7 (1.4)	#4 at 40 in.	#4 at 24 in.	#4 at 16 in.
	5.3 (1.6)	#4 at 24 in.	#4 at 16 in.	#5 at 16 in.
	6.0 (1.8)	#5 at 24 in.	#6 at 16 in.	#8 at 16 in.
	6.7 (2.0)	#5 at 16 in.	#6 at 8 in.	—
10 (254)	4.0 (1.2)	#4 at 72 in.	#4 at 64 in.	#4 at 48 in.
	4.7 (1.4)	#4 at 56 in.	#4 at 40 in.	#4 at 24 in.
	5.3 (1.6)	#4 at 40 in.	#4 at 24 in.	#4 at 16 in.
	6.0 (1.8)	#4 at 24 in.	#4 at 16 in.	#5 at 16 in.
	6.7 (2.0)	#4 at 16 in.	#5 at 16 in.	#6 at 16 in.
	7.3 (2.2)	#5 at 24 in.	#6 at 16 in.	#6 at 8 in.
12 (305)	8.0 (2.4)	#5 at 16 in.	#6 at 8 in.	—
	4.0 (1.2)	#4 at 72 in.	#4 at 72 in.	#4 at 64 in.
	4.7 (1.4)	#4 at 72 in.	#4 at 48 in.	#4 at 40 in.
	5.3 (1.6)	#4 at 48 in.	#4 at 32 in.	#4 at 24 in.
	6.0 (1.8)	#4 at 32 in.	#4 at 24 in.	#4 at 16 in.
	6.7 (2.0)	#4 at 24 in.	#4 at 16 in.	#5 at 16 in.
	7.3 (2.2)	#4 at 16 in.	#5 at 16 in.	#6 at 16 in.
	8.0 (2.4)	#5 at 24 in.	#5 at 16 in.	#7 at 16 in.
8.7 (2.7)	#5 at 16 in.	#7 at 16 in.	#7 at 8 in.	
9.3 (2.8)	#6 at 16 in.	#7 at 8 in.	—	

a. Based on fully grouted masonry; $f'_m = 1500$ psi (10.3 MPa); $d = 5$ in., 7 in. and 9 in. (127, 178 and 229 mm) for wall thicknesses of 8, 10, and 12 in. (203, 254, and 305 mm), respectively; level backfill to top of wall.

Dampproofing shall consist of a bituminous material, 3 pounds per square yard (16 N/m²) of acrylic modified cement, 0.125 inch (3.2 mm) coat of surface-bonding mortar complying with ASTM C 887, any of the materials permitted for waterproofing by Section 1807.3.2 or other approved methods or materials.

1807.2.2.1 Surface preparation of walls. Prior to application of dampproofing materials on concrete walls, holes and recesses resulting from the removal of form ties shall be sealed with a bituminous material or other approved methods or materials. Unit masonry walls shall be parged on the exterior surface below ground level with not less than 0.375 inch (9.5 mm) of portland cement mortar. The parging shall be coved at the footing.

Exception: Parging of unit masonry walls is not required where a material is approved for direct application to the masonry.

1807.3 Waterproofing required. Where the ground-water investigation required by Section 1802.2.3 indicates that a hydrostatic pressure condition exists, and the design does not include a ground-water control system as described in Section 1807.1.3, walls and floors shall be waterproofed in accordance with this section.

1807.3.1 Floors. Floors required to be waterproofed shall be of concrete and designed and constructed to withstand the hydrostatic pressures to which the floors will be subjected.

Waterproofing shall be accomplished by placing a membrane of rubberized asphalt, butyl rubber, fully adhered/fully bonded HDPE or polyolefin composite membrane or not less than 6-mil [0.006 inch (0.152 mm)] polyvinyl chloride with joints lapped not less than 6 inches (152 mm) or other approved materials under the slab. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's installation instructions.

1807.3.2 Walls. Walls required to be waterproofed shall be of concrete or masonry and shall be designed and constructed to withstand the hydrostatic pressures and other lateral loads to which the walls will be subjected.

Waterproofing shall be applied from the bottom of the wall to not less than 12 inches (305 mm) above the maximum elevation of the ground-water table. The remainder of the wall shall be dampproofed in accordance with Section 1807.2.2. Waterproofing shall consist of two-ply hot-mopped felts, not less than 6-mil (0.006 inch; 0.152 mm) polyvinyl chloride, 40-mil (0.040 inch; 1.02 mm) polymer-modified asphalt, 6-mil (0.006 inch; 0.152 mm) polyethylene or other approved methods or materials capable of bridging nonstructural cracks. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's installation instructions.

1807.3.2.1 Surface preparation of walls. Prior to the application of waterproofing materials on concrete or masonry walls, the walls shall be prepared in accordance with Section 1807.2.2.1.

1807.3.3 Joints and penetrations. Joints in walls and floors, joints between the wall and floor and penetrations of the wall and floor shall be made water-tight utilizing approved methods and materials.

1807.4 Subsoil drainage system. Where a hydrostatic pressure condition does not exist, dampproofing shall be provided and a base shall be installed under the floor and a drain installed around the foundation perimeter. A subsoil drainage system designed and constructed in accordance with Section 1807.1.3 shall be deemed adequate for lowering the ground-water table.

1807.4.1 Floor base course. Floors of basements, except as provided for in Section 1807.1.1, shall be placed over a floor base course not less than 4 inches (102 mm) in thickness that consists of gravel or crushed stone containing not more than 10 percent of material that passes through a No. 4 (4.75 mm) sieve.

Exception: Where a site is located in well-drained gravel or sand/gravel mixture soils, a floor base course is not required.

1807.4.2 Foundation drain. A drain shall be placed around the perimeter of a foundation that consists of gravel or crushed stone containing not more than 10-percent material that passes through a No. 4 (4.75 mm) sieve. The drain shall extend a minimum of 12 inches (305 mm) beyond the outside edge of the footing. The thickness shall be such that the bottom of the drain is not higher than the bottom of the base under the floor, and that the top of the drain is not less than 6 inches (152 mm) above the top of the footing. The top of the drain shall be covered with an approved filter membrane material. Where a drain tile or perforated pipe is used, the invert of the pipe or tile shall not be higher than the floor elevation. The top of joints or the top of perforations shall be protected with an approved filter membrane material. The pipe or tile shall be placed on not less than 2 inches (51 mm) of gravel or crushed stone complying with Section 1807.4.1, and shall be covered with not less than 6 inches (152 mm) of the same material.

1807.4.3 Drainage discharge. The floor base and foundation perimeter drain shall discharge by gravity or mechanical means into an approved drainage system that complies with the *Florida Building Code, Plumbing*.

Exception: Where a site is located in well-drained gravel or sand/gravel mixture soils, a dedicated drainage system is not required.

SECTION 1808 PIER AND PILE FOUNDATIONS

1808.1 Definitions. The following words and terms shall, for the purposes of this section, have the meanings shown herein.

FLEXURAL LENGTH. Flexural length is the length of the pile from the first point of zero lateral deflection to the underside of the pile cap or grade beam.

MICROPILES. Micropiles are 12-inch-diameter (305 mm) or less bored, grouted-in-place piles incorporating steel pipe (casing) and/or steel reinforcement.

PIER FOUNDATIONS. Pier foundations consist of isolated masonry or cast-in-place concrete structural elements extending into firm materials. Piers are relatively short in comparison to their width, with lengths less than or equal to 12 times the least horizontal dimension of the pier. Piers derive their load-carrying capacity through skin friction, through end bearing, or a combination of both.

Belled piers. Belled piers are cast-in-place concrete piers constructed with a base that is larger than the diameter of the remainder of the pier. The belled base is designed to increase the load-bearing area of the pier in end bearing.

PILE FOUNDATIONS. Pile foundations consist of concrete, wood or steel structural elements either driven into the ground or cast in place. Piles are relatively slender in comparison to their length, with lengths exceeding 12 times the least horizontal dimension. Piles derive their load-carrying capacity through skin friction, end bearing or a combination of both.

Augered uncased piles. Augered uncased piles are constructed by depositing concrete into an uncased augered hole, either during or after the withdrawal of the auger.

Caisson piles. Caisson piles are cast-in-place concrete piles extending into bedrock. The upper portion of a caisson pile consists of a cased pile that extends to the bedrock. The lower portion of the caisson pile consists of an uncased socket drilled into the bedrock.

Concrete-filled steel pipe and tube piles. Concrete-filled steel pipe and tube piles are constructed by driving a steel pipe or tube section into the soil and filling the pipe or tube section with concrete. The steel pipe or tube section is left in place during and after the deposition of the concrete.

Driven uncased piles. Driven uncased piles are constructed by driving a steel shell into the soil to shore an unexcavated hole that is later filled with concrete. The steel casing is lifted out of the hole during the deposition of the concrete.

Enlarged base piles. Enlarged base piles are cast-in-place concrete piles constructed with a base that is larger than the diameter of the remainder of the pile. The enlarged base is designed to increase the load-bearing area of the pile in end bearing.

Steel-cased piles. Steel-cased piles are constructed by driving a steel shell into the soil to shore an unexcavated hole. The steel casing is left permanently in place and filled with concrete.

Timber piles. Timber piles are round, tapered timbers with the small (tip) end embedded into the soil.

1808.2 Piers and piles—general requirements.

1808.2.1 Design. Piles are permitted to be designed in accordance with provisions for piers in Section 1808 and Sections 1812.3 through 1812.10 where either of the following conditions exists, subject to the approval of the building official:

1. Group R-3 and U occupancies not exceeding two stories of light-frame construction, or
2. Where the surrounding foundation materials furnish adequate lateral support for the pile.

1808.2.2 General. Pier and pile foundations shall be designed and installed on the basis of a foundation investigation as defined in Section 1802, unless sufficient data upon which to base the design and installation is available.

The investigation and report provisions of Section 1802 shall be expanded to include, but not be limited to, the following:

1. Recommended pier or pile types and installed capacities.
2. Recommended center-to-center spacing of piers or piles.
3. Driving criteria.
4. Installation procedures.
5. Field inspection and reporting procedures (to include procedures for verification of the installed bearing capacity where required).
6. Pier or pile load test requirements.
7. Durability of pier or pile materials.
8. Designation of bearing stratum or strata.
9. Reductions for group action, where necessary.

1808.2.3 Special types of piles. The use of types of piles not specifically mentioned herein is permitted, subject to the approval of the building official, upon the submission of acceptable test data, calculations and other information relating to the structural properties and load capacity of such piles. The allowable stresses shall not in any case exceed the limitations specified herein.

1808.2.4 Pile caps. Pile caps shall be of reinforced concrete, and shall include all elements to which piles are connected, including grade beams and mats. The soil immediately below the pile cap shall not be considered as carrying any vertical load. The tops of piles shall be embedded not less than 3 inches (76 mm) into pile caps and the caps shall extend at least 4 inches (102 mm) beyond the edges of piles. The tops of piles shall be cut back to sound material before capping.

1808.2.5 Stability. Piers or piles shall be braced to provide lateral stability in all directions. Three or more piles connected by a rigid cap shall be considered braced, provided that the piles are located in radial directions from the centroid of the group not less than 60 degrees (1 rad) apart. A two-pile group in a rigid cap shall be considered to be braced along the axis connecting the two piles. Methods used to brace piers or piles shall be subject to the approval of the building official.

Piles supporting walls shall be driven alternately in lines spaced at least 1 foot (305 mm) apart and located symmetrically under the center of gravity of the wall load carried, unless effective measures are taken to provide for eccentricity and lateral forces, or the wall piles are adequately braced to provide for lateral stability. A single row of piles without lateral bracing is permitted for one- and two-family dwellings and lightweight construction not exceeding two stories or 35 feet (10 668 mm) in height, provided the

centers of the piles are located within the width of the foundation wall.

1808.2.6 Structural integrity. Piers or piles shall be installed in such a manner and sequence as to prevent distortion or damage that may adversely affect the structural integrity of piles being installed or already in place.

1808.2.7 Splices. Splices shall be constructed so as to provide and maintain true alignment and position of the component parts of the pier or pile during installation and subsequent thereto and shall be of adequate strength to transmit the vertical and lateral loads and moments occurring at the location of the splice during driving and under service loading. Splices shall develop not less than 50 percent of the least capacity of the pier or pile in bending. In addition, splices occurring in the upper 10 feet (3048 mm) of the embedded portion of the pier or pile shall be capable of resisting at allowable working stresses the moment and shear that would result from an assumed eccentricity of the pier or pile load of 3 inches (76 mm), or the pier or pile shall be braced in accordance with Section 1808.2.5 to other piers or piles that do not have splices in the upper 10 feet (3048 mm) of embedment.

1808.2.8 Allowable pier or pile loads.

1808.2.8.1 Determination of allowable loads. The allowable axial and lateral loads on piers or piles shall be determined by an approved formula, load tests or method of analysis.

1808.2.8.2 Driving criteria. The allowable compressive load on any pile where determined by the application of an approved driving formula shall not exceed 40 tons (356 kN). For allowable loads above 40 tons (356 kN), the wave equation method of analysis shall be used to estimate pile driveability of both driving stresses and net displacement per blow at the ultimate load. Allowable loads shall be verified by load tests in accordance with Section 1808.2.8.3. The formula or wave equation load shall be determined for gravity-drop or power-actuated hammers and the hammer energy used shall be the maximum consistent with the size, strength and weight of the driven piles. The use of a follower is permitted only with the approval of the building official. The introduction of fresh hammer cushion or pile cushion material just prior to final penetration is not permitted.

1808.2.8.3 Load tests. Where design compressive loads per pier or pile are greater than those permitted by Section 1808.2.10 or where the design load for any pier or pile foundation is in doubt, control test piers or piles shall be tested in accordance with ASTM D 1143 or ASTM D 4945. At least one pier or pile shall be test loaded in each area of uniform subsoil conditions. Where required by the building official, additional piers or piles shall be load tested where necessary to establish the safe design capacity. The resulting allowable loads shall not be more than one-half of the ultimate axial load capacity of the test pier or pile as assessed by one of the published methods listed in Section 1808.2.8.3.1 with consideration for the test type, duration and subsoil. The ultimate axial load capacity shall be determined by a registered design

professional with consideration given to tolerable total and differential settlements at design load in accordance with Section 1808.2.12. In subsequent installation of the balance of foundation piles, all piles shall be deemed to have a supporting capacity equal to the control pile where such piles are of the same type, size and relative length as the test pile; are installed using the same or comparable methods and equipment as the test pile; are installed in similar subsoil conditions as the test pile; and, for driven piles, where the rate of penetration (e.g., net displacement per blow) of such piles is equal to or less than that of the test pile driven with the same hammer through a comparable driving distance.

1808.2.8.3.1 Load test evaluation. It shall be permitted to evaluate pile load tests with any of the following methods:

1. Davisson Offset Limit.
2. Brinch-Hansen 90% Criterion.
3. Butler-Hoy Criterion.
4. Other methods approved by the building official.

1808.2.8.4 Allowable frictional resistance. The assumed frictional resistance developed by any pier or uncased cast-in-place pile shall not exceed one-sixth of the bearing value of the soil material at minimum depth as set forth in Table 1804.2, up to a maximum of 500 psf (24 kPa), unless a greater value is allowed by the building official after a soil investigation, as specified in Section 1802, is submitted or a greater value is substantiated by a load test in accordance with Section 1808.2.8.3. Frictional resistance and bearing resistance shall not be assumed to act simultaneously unless recommended by a soil investigation as specified in Section 1802.

1808.2.8.5 Uplift capacity. Where required by the design, the uplift capacity of a single pier or pile shall be determined by an approved method of analysis based on a minimum factor of safety of three or by load tests conducted in accordance with ASTM D 3689. The maximum allowable uplift load shall not exceed the ultimate load capacity as determined in Section 1808.2.8.3 divided by a factor of safety of two. For pile groups subjected to uplift, the allowable working uplift load for the group shall be the lesser of:

1. The proposed individual pile uplift working load times the number of piles in the group.
2. Two-thirds of the effective weight of the pile group and the soil contained within a block defined by the perimeter of the group and the length of the pile.

1808.2.8.6 Load-bearing capacity. Piers, individual piles and groups of piles shall develop ultimate load capacities of at least twice the design working loads in the designated load-bearing layers. Analysis shall show that no soil layer underlying the designated load-bearing layers causes the load-bearing capacity safety factor to be less than two.

1808.2.8.7 Bent piers or piles. The load-bearing capacity of piers or piles discovered to have a sharp or sweeping bend shall be determined by an approved method of analysis or by load testing a representative pier or pile.

1808.2.8.8 Overloads on piers or piles. The maximum compressive load on any pier or pile due to mislocation shall not exceed 110 percent of the allowable design load.

1808.2.9 Lateral support.

1808.2.9.1 General. Any soil other than fluid soil shall be deemed to afford sufficient lateral support to the pier or pile to prevent buckling and to permit the design of the pier or pile in accordance with accepted engineering practice and the applicable provisions of this code.

1808.2.9.2 Unbraced piles. Piles standing unbraced in air, water or in fluid soils shall be designed as columns in accordance with the provisions of this code. Such piles driven into firm ground can be considered fixed and laterally supported at 5 feet (1524 mm) below the ground surface and in soft material at 10 feet (3048 mm) below the ground surface unless otherwise prescribed by the building official after a foundation investigation by an approved agency.

1808.2.9.3 Allowable lateral load. Where required by the design, the lateral load capacity of a pier, a single pile or a pile group shall be determined by an approved method of analysis or by lateral load tests to at least twice the proposed design working load. The resulting allowable load shall not be more than one-half of that test load that produces a gross lateral movement of 1 inch (25 mm) at the ground surface.

1808.2.10 Use of higher allowable pier or pile stresses. Allowable stresses greater than those specified for piers or for each pile type in Sections 1809 and 1810 are permitted where supporting data justifying such higher stresses is filed with the building official. Such substantiating data shall include:

1. A soils investigation in accordance with Section 1802.
2. Pier or pile load tests in accordance with Section 1808.2.8.3, regardless of the load supported by the pier or pile.

The design and installation of the pier or pile foundation shall be under the direct supervision of a registered design professional knowledgeable in the field of soil mechanics and pier or pile foundations who shall certify to the building official that the piers or piles as installed satisfy the design criteria.

1808.2.11 Piles in subsiding areas. Where piles are installed through subsiding fills or other subsiding strata and derive support from underlying firmer materials, consideration shall be given to the downward frictional forces that may be imposed on the piles by the subsiding upper strata.

Where the influence of subsiding fills is considered as imposing loads on the pile, the allowable stresses specified

in this chapter are permitted to be increased where satisfactory substantiating data are submitted.

1808.2.12 Settlement analysis. The settlement of piers, individual piles or groups of piles shall be estimated based on approved methods of analysis. The predicted settlement shall cause neither harmful distortion of, nor instability in, the structure, nor cause any stresses to exceed allowable values.

1808.2.13 Preexcavation. The use of jetting, augering or other methods of preexcavation shall be subject to the approval of the building official. Where permitted, preexcavation shall be carried out in the same manner as used for piers or piles subject to load tests and in such a manner that will not impair the carrying capacity of the piers or piles already in place or damage adjacent structures. Pile tips shall be driven below the preexcavated depth until the required resistance or penetration is obtained.

1808.2.14 Installation sequence. Piles shall be installed in such sequence as to avoid compacting the surrounding soil to the extent that other piles cannot be installed properly, and to prevent ground movements that are capable of damaging adjacent structures.

1808.2.15 Use of vibratory drivers. Vibratory drivers shall only be used to install piles where the pile load capacity is verified by load tests in accordance with Section 1808.2.8.3. The installation of production piles shall be controlled according to power consumption, rate of penetration or other approved means that ensure pile capacities equal or exceed those of the test piles.

1808.2.16 Pile driveability. Pile cross sections shall be of sufficient size and strength to withstand driving stresses without damage to the pile, and to provide sufficient stiffness to transmit the required driving forces.

1808.2.17 Protection of pile materials. Where boring records or site conditions indicate possible deleterious action on pier or pile materials because of soil constituents, changing water levels or other factors, the pier or pile materials shall be adequately protected by materials, methods or processes approved by the building official. Protective materials shall be applied to the piles so as not to be rendered ineffective by driving. The effectiveness of such protective measures for the particular purpose shall have been thoroughly established by satisfactory service records or other evidence.

1808.2.18 Use of existing piers or piles. Piers or piles left in place where a structure has been demolished shall not be used for the support of new construction unless satisfactory evidence is submitted to the building official, which indicates that the piers or piles are sound and meet the requirements of this code. Such piers or piles shall be load tested or redriven to verify their capacities. The design load applied to such piers or piles shall be the lowest allowable load as determined by tests or redriving data.

1808.2.19 Heaved piles. Piles that have heaved during the driving of adjacent piles shall be redriven as necessary to develop the required capacity and penetration, or the capac-

ity of the pile shall be verified by load tests in accordance with Section 1808.2.8.3.

1808.2.20 Identification. Pier or pile materials shall be identified for conformity to the specified grade with this identity maintained continuously from the point of manufacture to the point of installation or shall be tested by an approved agency to determine conformity to the specified grade. The approved agency shall furnish an affidavit of compliance to the building official.

1808.2.21 Pier or pile location plan. A plan showing the location and designation of piers or piles by an identification system shall be filed with the building official prior to installation of such piers or piles. Detailed records for piers or individual piles shall bear an identification corresponding to that shown on the plan.

1808.2.22 Special inspection. *Reserved.*

1808.2.23 Seismic design of piers or piles. *Reserved.*

SECTION 1809 DRIVEN PILE FOUNDATIONS

1809.1 Timber piles. Timber piles shall be designed in accordance with the AFPA NDS.

1809.1.1 Materials. Round timber piles shall conform to ASTM D 25. Sawn timber piles shall conform to DOC PS-20.

1809.1.2 Preservative treatment. Timber piles used to support permanent structures shall be treated in accordance with this section unless it is established that the tops of the untreated timber piles will be below the lowest ground-water level assumed to exist during the life of the structure. Preservative and minimum final retention shall be in accordance with AWPA U1 (Commodity Specification E, Use Category 4C) for round timber piles and AWPA U1 (Commodity Specification A, Use Category 4B) for sawn timber piles. Preservative-treated timber piles shall be subject to a quality control program administered by an approved agency. Pile cutoffs shall be treated in accordance with AWPA M4.

1809.1.3 Defective piles. Any substantial sudden increase in rate of penetration of a timber pile shall be investigated for possible damage. If the sudden increase in rate of penetration cannot be correlated to soil strata, the pile shall be removed for inspection or rejected.

1809.1.4 Allowable stresses. The allowable stresses shall be in accordance with the AF&PA NDS.

1809.2 Precast concrete piles.

1809.2.1 General. The materials, reinforcement and installation of precast concrete piles shall conform to Sections 1809.2.1.1 through 1809.2.1.4.

1809.2.1.1 Design and manufacture. Piles shall be designed and manufactured in accordance with accepted engineering practice to resist all stresses induced by handling, driving and service loads.

1809.2.1.2 Minimum dimension. The minimum lateral dimension shall be 8 inches (203 mm). Corners of square piles shall be chamfered.

1809.2.1.3 Reinforcement. Longitudinal steel shall be arranged in a symmetrical pattern and be laterally tied with steel ties or wire spiral spaced not more than 4 inches (102 mm) apart, center to center, for a distance of 2 feet (610 mm) from the ends of the pile; and not more than 6 inches (152 mm) elsewhere except that at the ends of each pile, the first five ties or spirals shall be spaced 1 inch (25 mm) center to center. The gage of ties and spirals shall be as follows:

For piles having a diameter of 16 inches (406 mm) or less, wire shall not be smaller than 0.22 inch (5.6 mm) (No. 5 gage).

For piles having a diameter of more than 16 inches (406 mm) and less than 20 inches (508 mm), wire shall not be smaller than 0.238 inch (6 mm) (No. 4 gage).

For piles having a diameter of 20 inches (508 mm) and larger, wire shall not be smaller than 0.25 inch (6.4 mm) round or 0.259 inch (6.6 mm) (No. 3 gage).

1809.2.1.4 Installation. Piles shall be handled and driven so as not to cause injury or overstressing, which affects durability or strength.

1809.2.2 Precast nonprestressed piles. Precast nonprestressed concrete piles shall conform to Sections 1809.2.2.1 through 1809.2.2.5.

1809.2.2.1 Materials. Concrete shall have a 28-day specified compressive strength (f'_c) of not less than 3,000 psi (20.68 MPa).

1809.2.2.2 Minimum reinforcement. The minimum amount of longitudinal reinforcement shall be 0.8 percent of the concrete section and shall consist of at least four bars.

1809.2.2.2.1 Seismic reinforcement in Seismic Design Category C. *Reserved.*

1809.2.2.2.2 Seismic reinforcement in Seismic Design Category D, E or F. *Reserved.*

1809.2.2.3 Allowable stresses. The allowable compressive stress in the concrete shall not exceed 33 percent of the 28-day specified compressive strength (f'_c) applied to the gross cross-sectional area of the pile. The allowable compressive stress in the reinforcing steel shall not exceed 40 percent of the yield strength of the steel (f_y) or a maximum of 30,000 psi (207 MPa). The allowable tensile stress in the reinforcing steel shall not exceed 50 percent of the yield strength of the steel (f_y) or a maximum of 24,000 psi (165 MPa).

1809.2.2.4 Installation. A precast concrete pile shall not be driven before the concrete has attained a compressive strength of at least 75 percent of the 28-day specified compressive strength (f'_c), but not less than the strength sufficient to withstand handling and driving forces.

1809.2.2.5 Concrete cover. Reinforcement for piles that are not manufactured under plant conditions shall have a concrete cover of not less than 2 inches (51 mm).

Reinforcement for piles manufactured under plant control conditions shall have a concrete cover of not less than 1.25 inches (32 mm) for No. 5 bars and smaller, and not less than 1.5 inches (38 mm) for No. 6 through No. 11 bars except that longitudinal bars spaced less than 1.5 inches (38 mm) clear distance apart shall be considered bundled bars for which the minimum concrete cover shall be equal to that for the equivalent diameter of the bundled bars.

Reinforcement for piles exposed to seawater shall have a concrete cover of not less than 3 inches (76 mm).

1809.2.3 Precast prestressed piles. Precast prestressed concrete piles shall conform to the requirements of Sections 1809.2.3.1 through 1809.2.3.5.

1809.2.3.1 Materials. Prestressing steel shall conform to ASTM A 416. Concrete shall have a 28-day specified compressive strength (f'_c) of not less than 5,000 psi (34.48 MPa).

1809.2.3.2 Design. Precast prestressed piles shall be designed to resist stresses induced by handling and driving as well as by loads. The effective prestress in the pile shall not be less than 400 psi (2.76 MPa) for piles up to 30 feet (9144 mm) in length, 550 psi (3.79 MPa) for piles up to 50 feet (15 240 mm) in length and 700 psi (4.83 MPa) for piles greater than 50 feet (15 240 mm) in length.

Effective prestress shall be based on an assumed loss of 30,000 psi (207 MPa) in the prestressing steel. The tensile stress in the prestressing steel shall not exceed the values specified in ACI 318.

1809.2.3.2.1 Design in Seismic Design Category C. *Reserved.*

1809.2.3.2.2 Design in Seismic Design Category D, E or F. *Reserved.*

1809.2.3.3 Allowable stresses. The allowable design compressive stress, f_c , in concrete shall be determined as follows:

$$f_c = 0.33f'_c - 0.27f_{pc} \quad (\text{Equation 18-10})$$

where:

f'_c = The 28-day specified compressive strength of the concrete.

f_{pc} = The effective prestress stress on the gross section.

1809.2.3.4 Installation. A prestressed pile shall not be driven before the concrete has attained a compressive strength of at least 75 percent of the 28-day specified compressive strength (f'_c), but not less than the strength sufficient to withstand handling and driving forces.

1809.2.3.5 Concrete cover. Prestressing steel and pile reinforcement shall have a concrete cover of not less than 1 $\frac{1}{4}$ inches (32 mm) for square piles of 12 inches (305 mm) or smaller size and 1 $\frac{1}{2}$ inches (38 mm) for larger

piles, except that for piles exposed to seawater, the minimum protective concrete cover shall not be less than 2½ inches (64 mm).

1809.3 Structural steel piles. Structural steel piles shall conform to the requirements of Sections 1809.3.1 through 1809.3.4.

1809.3.1 Materials. Structural steel piles, steel pipe and fully welded steel piles fabricated from plates shall conform to ASTM A 36, ASTM A 252, ASTM A 283, ASTM A 572, ASTM A 588, ASTM A 690, ASTM A 913 or ASTM A 992.

1809.3.2 Allowable stresses. The allowable axial stresses shall not exceed 35 percent of the minimum specified yield strength (F_y).

Exception: Where justified in accordance with Section 1808.2.10, the allowable axial stress is permitted to be increased above $0.35F_y$, but shall not exceed $0.5F_y$.

1809.3.3 Dimensions of H-piles. Sections of H-piles shall comply with the following:

1. The flange projections shall not exceed 14 times the minimum thickness of metal in either the flange or the web and the flange widths shall not be less than 80 percent of the depth of the section.
2. The nominal depth in the direction of the web shall not be less than 8 inches (203 mm).
3. Flanges and web shall have a minimum nominal thickness of ¾ inch (9.5 mm).

1809.3.4 Dimensions of steel pipe piles. Steel pipe piles driven open ended shall have a nominal outside diameter of not less than 8 inches (203 mm). The pipe shall have a minimum cross section of 0.34 square inch (219 mm²) to resist each 1,000 foot-pounds (1356 N-m) of pile hammer energy, or shall have the equivalent strength for steels having a yield strength greater than 35,000 psi (241 Mpa) or the wave equation analysis shall be permitted to be used to assess compression stresses induced by driving to evaluate if the pile section is appropriate for the selected hammer. Where pipe wall thickness less than 0.179 inch (4.6 mm) is driven open ended, a suitable cutting shoe shall be provided.

SECTION 1810

CAST-IN-PLACE CONCRETE PILE FOUNDATIONS

1810.1 General. The materials, reinforcement and installation of cast-in-place concrete piles shall conform to Sections 1810.1.1 through 1810.1.3.

1810.1.1 Materials. Concrete shall have a 28-day specified compressive strength (f'_c) of not less than 2,500 psi (17.24 MPa). Where concrete is placed through a funnel hopper at the top of the pile, the concrete mix shall be designed and proportioned so as to produce a cohesive workable mix having a slump of not less than 4 inches (102 mm) and not more than 6 inches (152 mm). Where concrete is to be pumped, the mix design including slump shall be adjusted to produce a pumpable concrete.

1810.1.2 Reinforcement. Except for steel dowels embedded 5 feet (1524 mm) or less in the pile and as provided in

Section 1810.3.4, reinforcement where required shall be assembled and tied together and shall be placed in the pile as a unit before the reinforced portion of the pile is filled with concrete except in augered uncased cast-in-place piles. Tied reinforcement in augered uncased cast-in-place piles shall be placed after piles are concreted, while the concrete is still in a semifluid state.

1810.1.2.1 Reinforcement in Seismic Design Category C. *Reserved.*

1810.1.2.2 Reinforcement in Seismic Design Category D, E or F. *Reserved.*

1810.1.3 Concrete placement. Concrete shall be placed in such a manner as to ensure the exclusion of any foreign matter and to secure a full-sized shaft. Concrete shall not be placed through water except where a tremie or other approved method is used. When depositing concrete from the top of the pile, the concrete shall not be chuted directly into the pile but shall be poured in a rapid and continuous operation through a funnel hopper centered at the top of the pile.

1810.2 Enlarged base piles. Enlarged base piles shall conform to the requirements of Sections 1810.2.1 through 1810.2.5.

1810.2.1 Materials. The maximum size for coarse aggregate for concrete shall be ¾ inch (19.1 mm). Concrete to be compacted shall have a zero slump.

1810.2.2 Allowable stresses. The maximum allowable design compressive stress for concrete not placed in a permanent steel casing shall be 25 percent of the 28-day specified compressive strength (f'_c). Where the concrete is placed in a permanent steel casing, the maximum allowable concrete stress shall be 33 percent of the 28-day specified compressive strength (f'_c).

1810.2.3 Installation. Enlarged bases formed either by compacting concrete or driving a precast base shall be formed in or driven into granular soils. Piles shall be constructed in the same manner as successful prototype test piles driven for the project. Pile shafts extending through peat or other organic soil shall be encased in a permanent steel casing. Where a cased shaft is used, the shaft shall be adequately reinforced to resist column action or the annular space around the pile shaft shall be filled sufficiently to reestablish lateral support by the soil. Where pile heave occurs, the pile shall be replaced unless it is demonstrated that the pile is undamaged and capable of carrying twice its design load.

1810.2.4 Load-bearing capacity. Pile load-bearing capacity shall be verified by load tests in accordance with Section 1808.2.8.3.

1810.2.5 Concrete cover. The minimum concrete cover shall be 2½ inches (64 mm) for uncased shafts and 1 inch (25 mm) for cased shafts.

1810.3 Drilled or augered uncased piles. Drilled or augered uncased piles shall conform to Sections 1810.3.1 through 1810.3.5.

1810.3.1 Allowable stresses. The allowable design stress in the concrete of drilled or augered uncased piles shall not exceed 33 percent of the 28-day specified compressive strength (f'_c). The allowable compressive stress of rein-

forcement shall not exceed 40 percent of the yield strength of the steel or 25,500 psi (175.8 MPa).

1810.3.2 Dimensions. The pile length shall not exceed 30 times the average diameter. The minimum diameter shall be 12 inches (305 mm).

Exception: The length of the pile is permitted to exceed 30 times the diameter, provided that the design and installation of the pile foundation are under the direct supervision of a registered design professional knowledgeable in the field of soil mechanics and pile foundations. The registered design professional shall certify to the building official that the piles were installed in compliance with the approved construction documents.

1810.3.3 Installation. Where pile shafts are formed through unstable soils and concrete is placed in an open-drilled hole, a steel liner shall be inserted in the hole prior to placing the concrete. Where the steel liner is withdrawn during concreting, the level of concrete shall be maintained above the bottom of the liner at a sufficient height to offset any hydrostatic or lateral soil pressure.

Where concrete is placed by pumping through a hollow-stem auger, the auger shall be permitted to rotate in a clockwise direction during withdrawal. The auger shall be withdrawn in continuous increments. Concreting pumping pressures shall be measured and maintained high enough at all times to offset hydrostatic and lateral earth pressures. Concrete volumes shall be measured to ensure that the volume of concrete placed in each pile is equal to or greater than the theoretical volume of the hole created by the auger. Where the installation process of any pile is interrupted or a loss of concreting pressure occurs, the pile shall be redrilled to 5 feet (1524 mm) below the elevation of the tip of the auger when the installation was interrupted or concrete pressure was lost and reformed. Augered cast-in-place piles shall not be installed within six pile diameters center to center of a pile filled with concrete less than 12 hours old, unless approved by the building official. If the concrete level in any completed pile drops due to installation of an adjacent pile, the pile shall be replaced.

1810.3.4 Reinforcement. For piles installed with a hollow-stem auger where full-length longitudinal steel reinforcement is placed without lateral ties, the reinforcement shall be placed through the hollow stem of the auger prior to filling the pile with concrete. All pile reinforcement shall have a concrete cover of not less than 2.5 inches (64 mm).

Exception: Where physical constraints do not allow the placement of the longitudinal reinforcement prior to filling the pile with concrete or where partial-length longitudinal reinforcement is placed without lateral ties, the reinforcement is allowed to be placed after the piles are completely concreted but while concrete is still in a semi-fluid state.

1810.3.5 Reinforcement in Seismic Design Category C, D, E or F. Reserved.

1810.4 Driven uncased piles. Driven uncased piles shall conform to Sections 1810.4.1 through 1810.4.4.

1810.4.1 Allowable stresses. The allowable design stress in the concrete shall not exceed 25 percent of the 28-day specified compressive strength (f'_c) applied to a cross-sectional area not greater than the inside area of the drive casing or mandrel.

1810.4.2 Dimensions. The pile length shall not exceed 30 times the average diameter. The minimum diameter shall be 12 inches (305 mm).

Exception: The length of the pile is permitted to exceed 30 times the diameter, provided that the design and installation of the pile foundation is under the direct supervision of a registered design professional knowledgeable in the field of soil mechanics and pile foundations. The registered design professional shall certify to the building official that the piles were installed in compliance with the approved design.

1810.4.3 Installation. Piles shall not be driven within six pile diameters center to center in granular soils or within one-half the pile length in cohesive soils of a pile filled with concrete less than 48 hours old unless approved by the building official. If the concrete surface in any completed pile rises or drops, the pile shall be replaced. Piles shall not be installed in soils that could cause pile heave.

1810.4.4 Concrete cover. Pile reinforcement shall have a concrete cover of not less than 2.5 inches (64 mm), measured from the inside face of the drive casing or mandrel.

1810.5 Steel-cased piles. Steel-cased piles shall comply with the requirements of Sections 1810.5.1 through 1810.5.4.

1810.5.1 Materials. Pile shells or casings shall be of steel and shall be sufficiently strong to resist collapse and sufficiently water tight to exclude any foreign materials during the placing of concrete. Steel shells shall have a sealed tip with a diameter of not less than 8 inches (203 mm).

1810.5.2 Allowable stresses. The allowable design compressive stress in the concrete shall not exceed 33 percent of the 28-day specified compressive strength (f'_c). The allowable concrete compressive stress shall be 0.40 (f'_c) for that portion of the pile meeting the conditions specified in Sections 1810.5.2.1 through 1810.5.2.4.

1810.5.2.1 Shell thickness. The thickness of the steel shell shall not be less than manufacturer's standard gage No. 14 gage (0.068 inch) (1.75 mm) minimum.

1810.5.2.2 Shell type. The shell shall be seamless or provided with seams of strength equal to the basic material and be of a configuration that will provide confinement to the cast-in-place concrete.

1810.5.2.3 Strength. The ratio of steel yield strength (f_y) to 28-day specified compressive strength (f'_c) shall not be less than six.

1810.5.2.4 Diameter. The nominal pile diameter shall not be greater than 16 inches (406 mm).

1810.5.3 Installation. Steel shells shall be mandrel driven their full length in contact with the surrounding soil.

The steel shells shall be driven in such order and with such spacing as to ensure against distortion of or injury to piles

already in place. A pile shall not be driven within four and one-half average pile diameters of a pile filled with concrete less than 24 hours old unless approved by the building official. Concrete shall not be placed in steel shells within heave range of driving.

1810.5.4 Reinforcement. Reinforcement shall not be placed within 1 inch (25 mm) of the steel shell. Reinforcing shall be required for unsupported pile lengths or where the pile is designed to resist uplift or unbalanced lateral loads.

1810.5.4.1 Reserved.

1810.6 Concrete-filled steel pipe and tube piles. Concrete-filled steel pipe and tube piles shall conform to the requirements of Sections 1810.6.1 through 1810.6.5.

1810.6.1 Materials. Steel pipe and tube sections used for piles shall conform to ASTM A 252 or ASTM A 283. Concrete shall conform to Section 1810.1.1. The maximum coarse aggregate size shall be $\frac{3}{4}$ inch (19.1 mm).

1810.6.2 Allowable stresses. The allowable design compressive stress in the concrete shall not exceed 33 percent of the 28-day specified compressive strength (f'_c). The allowable design compressive stress in the steel shall not exceed 35 percent of the minimum specified yield strength of the steel (F_y), provided F_y shall not be assumed greater than 36,000 psi (248 MPa) for computational purposes.

Exception: Where justified in accordance with Section 1808.2.10, the allowable stresses are permitted to be increased to $0.50 F_y$.

1810.6.3 Minimum dimensions. Piles shall have a nominal outside diameter of not less than 8 inches (203 mm) and a minimum wall thickness in accordance with Section 1809.3.4. For mandrel-driven pipe piles, the minimum wall thickness shall be $\frac{1}{10}$ inch (2.5 mm).

1810.6.4 Reinforcement. Reinforcement steel shall conform to Section 1810.1.2. Reinforcement shall not be placed within 1 inch (25 mm) of the steel casing.

1810.6.4.1 Seismic reinforcement. Reserved.

1810.6.5 Placing concrete. The placement of concrete shall conform to Section 1810.1.3, but is permitted to be chuted directly into smooth-sided pipes and tubes without a centering funnel hopper.

1810.7 Caisson piles. Caisson piles shall conform to the requirements of Sections 1810.7.1 through 1810.7.6.

1810.7.1 Construction. Caisson piles shall consist of a shaft section of concrete-filled pipe extending to bedrock with an uncased socket drilled into the bedrock and filled with concrete. The caisson pile shall have a full-length structural steel core or a stub core installed in the rock socket and extending into the pipe portion a distance equal to the socket depth.

1810.7.2 Materials. Pipe and steel cores shall conform to the material requirements in Section 1809.3. Pipes shall have a minimum wall thickness of $\frac{3}{8}$ inch (9.5 mm) and shall be fitted with a suitable steel-driving shoe welded to the bottom of the pipe. Concrete shall have a 28-day specified compressive strength (f'_c) of not less than 4,000 psi

(27.58 MPa). The concrete mix shall be designed and proportioned so as to produce a cohesive workable mix with a slump of 4 inches to 6 inches (102 mm to 152 mm).

1810.7.3 Design. The depth of the rock socket shall be sufficient to develop the full load-bearing capacity of the caisson pile with a minimum safety factor of two, but the depth shall not be less than the outside diameter of the pipe. The design of the rock socket is permitted to be predicated on the sum of the allowable load-bearing pressure on the bottom of the socket plus bond along the sides of the socket. The minimum outside diameter of the caisson pile shall be 18 inches (457 mm), and the diameter of the rock socket shall be approximately equal to the inside diameter of the pile.

1810.7.4 Structural core. The gross cross-sectional area of the structural steel core shall not exceed 25 percent of the gross area of the caisson. The minimum clearance between the structural core and the pipe shall be 2 inches (51 mm). Where cores are to be spliced, the ends shall be milled or ground to provide full contact and shall be full-depth welded.

1810.7.5 Allowable stresses. The allowable design compressive stresses shall not exceed the following: concrete, $0.33 f'_c$; steel pipe, $0.35 F_y$, and structural steel core, $0.50 F_y$.

1810.7.6 Installation. The rock socket and pile shall be thoroughly cleaned of foreign materials before filling with concrete. Steel cores shall be bedded in cement grout at the base of the rock socket. Concrete shall not be placed through water except where a tremie or other approved method is used.

1810.8 Micropiles. Micropiles shall conform to the requirements of Sections 1810.8.1 through 1810.8.5.

1810.8.1 Construction. Micropiles shall consist of a grouted section reinforced with steel pipe or steel reinforcing. Micropiles shall develop their load-carrying capacity through a bond zone in soil, bedrock or a combination of soil and bedrock. The full length of the micropile shall contain either a steel pipe or steel reinforcement.

1810.8.2 Materials. Grout shall have a 28-day specified compressive strength (f'_c) of not less than 4,000 psi (27.58 MPa). The grout mix shall be designed and proportioned so as to produce a pumpable mixture. Reinforcement steel shall be deformed bars in accordance with ASTM A 615 Grade 60 or 75 or ASTM A 722 Grade 150.

Pipe/casing shall have a minimum wall thickness of $\frac{3}{16}$ inch (4.8 mm) and as required to meet Section 1808.2.7. Pipe/casing shall meet the tensile requirements of ASTM A 252 Grade 3, except the minimum yield strength shall be as used in the design submittal [typically 50,000 psi to 80,000 psi (345 MPa to 552 MPa)] and minimum elongation shall be 15 percent.

1810.8.3 Allowable stresses. The allowable design compressive stress on grout shall not exceed $0.33 f'_c$. The allowable design compressive stress on steel pipe and steel reinforcement shall not exceed the lesser of $0.4 F_y$, or 32,000 psi (220 MPa). The allowable design tensile stress for steel reinforcement shall not exceed $0.60 F_y$. The allowable design tensile stress for the cement grout shall be zero.

1810.8.4 Reinforcement. For piles or portions of piles grouted inside a temporary or permanent casing or inside a hole drilled into bedrock or a hole drilled with grout, the steel pipe or steel reinforcement shall be designed to carry at least 40 percent of the design compression load. Piles or portions of piles grouted in an open hole in soil without temporary or permanent casing and without suitable means of verifying the hole diameter during grouting shall be designed to carry the entire compression load in the reinforcing steel. Where a steel pipe is used for reinforcement, the portion of the cement grout enclosed within the pipe is permitted to be included at the allowable stress of the grout.

1810.8.4.1 Seismic reinforcement. Reserved.

1810.8.5 Installation. The pile shall be permitted to be formed in a hole advanced by rotary or percussive drilling methods, with or without casing. The pile shall be grouted with a fluid cement grout. The grout shall be pumped through a tremie pipe extending to the bottom of the pile until grout of suitable quality returns at the top of the pile. The following requirements apply to specific installation methods:

1. For piles grouted inside a temporary casing, the reinforcing steel shall be inserted prior to withdrawal of the casing. The casing shall be withdrawn in a controlled manner with the grout level maintained at the top of the pile to ensure that the grout completely fills the drill hole. During withdrawal of the casing, the grout level inside the casing shall be monitored to check that the flow of grout inside the casing is not obstructed.
2. For a pile or portion of a pile grouted in an open drill hole in soil without temporary casing, the minimum design diameter of the drill hole shall be verified by a suitable device during grouting.
3. For piles designed for end bearing, a suitable means shall be employed to verify that the bearing surface is properly cleaned prior to grouting.
4. Subsequent piles shall not be drilled near piles that have been grouted until the grout has had sufficient time to harden.
5. Piles shall be grouted as soon as possible after drilling is completed.
6. For piles designed with casing full length, the casing must be pulled back to the top of the bond zone and reinserted or some other suitable means shall be employed to verify grout coverage outside the casing.

SECTION 1811 COMPOSITE PILES

1811.1 General. Composite piles shall conform to the requirements of Sections 1811.2 through 1811.5.

1811.2 Design. Composite piles consisting of two or more approved pile types shall be designed to meet the conditions of installation.

1811.3 Limitation of load. The maximum allowable load shall be limited by the capacity of the weakest section incorporated in the pile.

1811.4 Splices. Splices between concrete and steel or wood sections shall be designed to prevent separation both before and after the concrete portion has set, and to ensure the alignment and transmission of the total pile load. Splices shall be designed to resist uplift caused by upheaval during driving of adjacent piles, and shall develop the full compressive strength and not less than 50 percent of the tension and bending strength of the weaker section.

1811.5 Seismic reinforcement. Reserved.

SECTION 1812 PIER FOUNDATIONS

1812.1 General. Isolated and multiple piers used as foundations shall conform to the requirements of Sections 1812.2 through 1812.10, as well as the applicable provisions of Section 1808.2.

1812.2 Lateral dimensions and height. The minimum dimension of isolated piers used as foundations shall be 2 feet (610 mm), and the height shall not exceed 12 times the least horizontal dimension.

1812.3 Materials. Concrete shall have a 28-day specified compressive strength (f'_c) of not less than 2,500 psi (17.24 MPa). Where concrete is placed through a funnel hopper at the top of the pier, the concrete mix shall be designed and proportioned so as to produce a cohesive workable mix having a slump of not less than 4 inches (102 mm) and not more than 6 inches (152 mm). Where concrete is to be pumped, the mix design including slump shall be adjusted to produce a pumpable concrete.

1812.4 Reinforcement. Except for steel dowels embedded 5 feet (1524 mm) or less in the pier, reinforcement where required shall be assembled and tied together and shall be placed in the pier hole as a unit before the reinforced portion of the pier is filled with concrete.

Exception: Reinforcement is permitted to be wet set and the 2¹/₂-inch (64 mm) concrete cover requirement be reduced to 2 inches (51 mm) for Group R-3 and U occupancies not exceeding two stories of light-frame construction, provided the construction method can be demonstrated to the satisfaction of the building official.

Reinforcement shall conform to the requirements of Sections 1810.1.2.1 and 1810.1.2.2.

Exceptions:

1. Isolated piers supporting posts of Group R-3 and U occupancies not exceeding two stories of light-frame construction are permitted to be reinforced as required by rational analysis but not less than a minimum of one No. 4 bar, without ties or spirals, when detailed so the pier is not subject to lateral loads and the soil is determined to be of adequate stiffness.
2. Isolated piers supporting posts and bracing from decks and patios appurtenant to Group R-3 and U

occupancies not exceeding two stories of light-frame construction are permitted to be reinforced as required by rational analysis but not less than one No. 4 bar, without ties or spirals, when the soil is determined to be of adequate stiffness.

3. Piers supporting the concrete foundation wall of Group R-3 and U occupancies not exceeding two stories of light-frame construction are permitted to be reinforced as required by rational analysis but not less than two No. 4 bars, without ties or spirals, when the soil is determined to be of adequate stiffness.

1812.5 Concrete placement. Concrete shall be placed in such a manner as to ensure the exclusion of any foreign matter and to secure a full-sized shaft. Concrete shall not be placed through water except where a tremie or other approved method is used. When depositing concrete from the top of the pier, the concrete shall not be chuted directly into the pier but shall be poured in a rapid and continuous operation through a funnel hopper centered at the top of the pier.

1812.6 Belled bottoms. Where pier foundations are belled at the bottom, the edge thickness of the bell shall not be less than that required for the edge of footings. Where the sides of the bell slope at an angle less than 60 degrees (1 rad) from the horizontal, the effects of vertical shear shall be considered.

1812.7 Masonry. Where the unsupported height of foundation piers exceeds six times the least dimension, the allowable working stress on piers of unit masonry shall be reduced in accordance with ACI 530/ASCE 5/TMS 402.

1812.8 Concrete. Where adequate lateral support is not provided, and the unsupported height to least lateral dimension does not exceed three, piers of plain concrete shall be designed and constructed as pilasters in accordance with ACI 318. Where the unsupported height to least lateral dimension exceeds three, piers shall be constructed of reinforced concrete, and shall conform to the requirements for columns in ACI 318.

Exception: Where adequate lateral support is furnished by the surrounding materials as defined in Section 1808.2.9, piers are permitted to be constructed of plain or reinforced concrete. The requirements of ACI 318 for bearing on concrete shall apply.

1812.9 Steel shell. Where concrete piers are entirely encased with a circular steel shell, and the area of the shell steel is considered reinforcing steel, the steel shall be protected under the conditions specified in Section 1808.2.17. Horizontal joints in the shell shall be spliced to comply with Section 1808.2.7.

1812.10 Dewatering. Where piers are carried to depths below water level, the piers shall be constructed by a method that will provide accurate preparation and inspection of the bottom, and the depositing or construction of sound concrete or other masonry in the dry.

SECTIONS 1813 – 1815 RESERVED

SECTION 1816 TERMITE PROTECTION

1816.1 Termite protection. Termite protection shall be provided by registered termiticides, including soil-applied pesticides, baiting systems and pesticides applied to wood, or other approved methods of termite protection labeled for use as a preventative treatment to new construction. See Section 202, Registered Termiticide. Upon completion of the application of the termite protective treatment, a certificate of compliance shall be issued to the building department by the licensed pest control company that contains the following statement: “The building has received a complete treatment for the prevention of subterranean termites. Treatment is in accordance with rules and laws established by the Florida Department of Agriculture and Consumer Services.”

1816.1.1 If soil treatment is used for subterranean termite prevention, the initial chemical soil treatment inside the foundation perimeter shall be done after all excavation, backfilling and compaction is complete.

1816.1.2 If soil treatment is used for subterranean termite prevention, soil area disturbed after initial chemical soil treatment shall be retreated with a chemical soil treatment, including spaces boxed or formed.

1816.1.3 If soil treatment is used for subterranean termite prevention, space in concrete floors boxed out or formed for the subsequent installation of plumbing traps, drains or any other purpose shall be created by using plastic or metal permanently placed forms of sufficient depth to eliminate any planned soil disturbance after initial chemical soil treatment.

1816.1.4 If soil treatment is used for subterranean termite prevention, chemically treated soil shall be protected with a minimum 6 millimeter vapor retarder to protect against rainfall dilution. If rainfall occurs before vapor retarder placement, retreatment is required. Any work, including placement of reinforcing steel, done after chemical treatment until the concrete floor is poured, shall be done in such manner as to avoid penetrating or disturbing treated soil.

1816.1.5 If soil treatment is used for subterranean termite prevention, concrete overpour or mortar accumulated along the exterior foundation perimeter shall be removed prior to exterior chemical soil treatment to enhance vertical penetration of the chemicals.

1816.1.6 If soil treatment is used for subterranean termite prevention, chemical soil treatments shall also be applied under all exterior concrete or grade within 1 foot (305 mm) of the primary structure sidewalls. Also, a vertical chemical barrier shall be applied promptly after construction is completed, including initial landscaping and irrigation/sprinkler installation. Any soil disturbed after the chemical vertical barrier is applied shall be promptly retreated.

1816.1.7 If a registered termiticide formulated and registered as a bait system is used for subterranean termite pre-

vention, Sections 1816.1.1 through 1816.1.6 do not apply; however, a signed contract assuring the installation, maintenance and monitoring of the baiting system for a minimum of 5 years from the issue of the certificate of occupancy shall be provided to the building official prior to the pouring of the slab, and the system must be installed prior to final building approval. If the baiting system directions for use require a monitoring phase prior to installation of the pesticide active ingredient, the installation of the monitoring phase components shall be deemed to constitute installation of the system.

1816.1.8 If a registered termiticide formulated and registered as a wood treatment is used for subterranean termite prevention, Sections 1816.1.1 through 1816.1.6 do not apply. Application of the wood-treatment termiticide shall be as required by label directions for use, and must be completed prior to final building approval. Changes in framing or additions to framing in areas of the structure requiring treatment that occur after the initial wood treatment must be treated prior to final building approval.

1816.2 Penetration. Protective sleeves around metallic piping penetrating concrete slab-on-grade floors shall not be of cellulose-containing materials and, if soil treatment is used for subterranean termite protection, shall receive application of a termiticide in annular space between sleeve and pipe.

**SECTION 1817
HIGH-VELOCITY HURRICANE ZONES –
EXCAVATIONS**

1817.1 General. Until provisions for permanent support have been made, all excavations shall be properly guarded and protected so as to prevent them from becoming dangerous to life and property and shall be sheet piled, braced and/or shored, where necessary, to prevent the adjoining earth from caving in; such protection to be provided by the person causing the excavation to be made. All excavations shall comply with the minimum requirements of Section 553.60, Florida Statute “Trench Safety Act,” and 29 CFR 1926-650 (P) “Occupational Safety and Health Administration Excavation Safety Act.” No excavation, for any purpose, shall extend within 1 foot (305 mm) of the angle of repose of any soil bearing footing or foundation unless such footing or foundation is first properly underpinned or protected against settlement.

1817.2 Permanent excavations. No permanent excavation shall be made nor shall any construction excavations be left on any lot that will endanger adjoining property or buildings or be a menace to public health or safety. Any such excavations made or maintained shall be properly drained and such drainage provisions shall function properly as long as the excavation exists. Permanent excavations shall have retaining walls of steel, masonry, concrete or similar approved material of sufficient strength to retain the embankment together with any surcharged loads.

1817.3 Enforcement. Where, in the opinion of the building official, an unsafe condition may result or damage may occur as the result of an excavation, he or she may order the work stopped or may approve the work of excavation subject to such limitations, as he or she may deem necessary.

**SECTION 1818
HIGH-VELOCITY HURRICANE ZONES—
BEARING CAPACITY OF SOIL**

1818.1 Design bearing capacity. Plans for new buildings, structures or additions shall clearly identify the nature of the soil under the structure and the allowable bearing capacity used in sizing the building foundation support system.

Exception: See Section 1822.1 for plans for new buildings, structures or additions that are to be supported on a piling foundation system.

1818.2 Allowable bearing capacity. Prior to the installation of any footing foundation system for new buildings, structures or additions, the building official shall be provided with a statement of allowable bearing capacity from an architect or professional engineer. Said statement shall clearly identify the allowable in-place bearing capacity of the building pad for the new building or addition and verify the existing soil conditions. The certified in-place bearing capacity shall have been determined using recognized tests or rational analysis and shall meet or exceed the design bearing capacity identified under Section 1818.1.

**SECTION 1819
HIGH-VELOCITY HURRICANE ZONES—
SOIL BEARING FOUNDATIONS**

1819.1 General. Footings shall be constructed of reinforced concrete, as set forth in Chapter 19 (High-Velocity Hurricane Zones) of this code and in this section, and shall, insofar as is practicable, be so designed that the soil pressure shall be reasonably uniform to minimize differential settlement.

1819.2 Continuous wall footings.

1819.2.1 Footings under walls shall be continuous or continuity otherwise provided and shall be not less than required to keep the soil pressure within that set forth in Section 1818 nor less than the following minimums:

Allowable bearing capacity pounds per square foot	No. of Stories	Minimum Depth and Width 2 (inches)
2000	1	12 × 161
2000	2	12 × 24

For SI: 1 inch = 25.4 mm; 1 pound per square foot 47.89 Pa.

Based on rational analysis and soil investigation as set forth in section Section 1818, the footing size or bearing capacity may vary, but the minimum width of a footing under the main walls of the building shall not be less than 16 inches nor less than 8 inches more than the width of the wall.

1. For single-story wood frame exterior walls, the minimum size continuous footing shall be 16 inches deep × 24 inches wide.
2. Any continuous wall footing acting as a shear wall foundation shall be specifically designed for that purpose.

1819.2.2 Masonry fences, flower bins, steps and similar decorative structures shall have reinforced concrete foundations designed for all live, dead and wind loads as set forth in Chapter 16 (High-Velocity Hurricane Zones) of this code. The minimum size of these foundations shall be as follows:

Allowable bearing capacity (pounds per square foot)	Unbraced Wall Above Grade (ft)	Minimum Depth and Width ² (inches)
2,000		12 x 16
2,000	≥ to 3 feet < 3 feet ≥ 6 feet < 6 feet	12 x 36
2,000		None Provided ¹

For SI: 1 inch = 25.4 mm; 1 foot = 304.8 mm; 1 pound per square foot = 47.88 kPa.

1. Foundations for masonry fences, flower bins, steps and similar decorative structures with unbraced heights in excess of six feet shall be based on rational analysis.
2. The minimum continuous footings specified in this section shall be reinforced in accordance with Section 1819.3.

1819.2.3 Based on rational analysis and soil investigation as set forth in Section 1818, the footing size or bearing capacity may vary, but the minimum width of a footing under masonry fences, flower bins, steps and similar decorative structures shall not be less than 16 inches (406 mm) nor less than 8 inches (203 mm) more than the width of the wall.

Exception: Masonry fences, wing walls and other similar walls that are exposed to lateral wind forces and do not have any lateral restraint above grade, shall have their continuous wall footings placed so the top of footing is no less than 16 inches (406 mm) below grade.

1819.3 The minimum continuous footings specified in this section shall be reinforced as follows:

Reinforcing	Foundation Width
2 # 5	16" and 20" wide
3 # 5	24" and 30" wide
4 # 5	36" wide

1819.3.1 Where footings are 30 inches (762 mm) or more in width, cross bars designed to resist bending at the face of the foundation wall shall be provided.

1819.3.1.1 Equivalent areas in #4 reinforcing bars may be substituted for the sizes as specified in Section 1819.3.

1819.3.1.2 Splices in reinforcing bars shall be not less than 36 bar diameters and reinforcement shall be continuous around all corners and changes in direction. Continuity shall be provided at corners or changes in direction by bending the longitudinal steel around the corner 48 bar diameters or by adding matching reinforcing steel, which shall extend 48 bar diameters from each corner or change in direction. When three or more bars are required, the bars shall be held in place and aligned by transverse bars spaced not more than 4 feet (1219 mm) apart.

1819.3.1.3 The reinforcement for footings and other principal structural members in which concrete is deposited against the ground shall have not less than 3 inches (76 mm) of concrete between the reinforcement and the ground contact surface. If concrete surfaces after

removal of the forms are to be exposed to the weather or be in contact with the ground, the reinforcement shall be protected with not less than 2 inches (51 mm) of concrete for bars larger than #5 and 1½ (38 mm) for #5 or smaller bars.

1819.3.1.4 Excavations for continuous footings shall be cut true to line and grade and the sides of footings shall be formed, except where soil conditions are such that the sides of the excavation stand firm and square. Excavations shall be made to firm, clean bearing soil.

1819.4 Continuous footings shall be placed level and any changes in the grade of such footings shall be made with a vertical tie of the same cross section and design as the footings, or the smaller of the footings, so joined.

1819.4.1 Continuous footings with eccentric loading shall be designed to limit the soil pressure at the edges to within acceptable values by means of counterbalancing or by other approved methods.

1819.4.2 When foundation walls are to be poured separately from the footing, they shall be keyed and doweled to the footing with no less than #4 dowels, 20 diameters in length above and below the joint, spaced not more than 4 feet (1219 mm) apart. Where footing depth does not allow straight dowels, standard hooks will be allowable.

1819.4.3 Concrete footing and pads shall not receive superimposed loads until 12 hours or more after the concrete is placed.

1819.4.4 Excavations for footings and foundations, which are to serve as forms, shall be thoroughly wetted prior to the placement of concrete.

1819.4.5 The top of all continuous footings shall be a minimum of 8 inches (203 mm) below grade.

1819.5 Isolated footings. Dimensions for an isolated footing shall not be less than 12 inches (305 mm) deep and 24 inches square (.02 m²). Isolated footings in soil having low lateral restraint and isolated piers shall be provided with adequate bracing to resist lateral movement.

1819.5.1 Isolated footings with eccentric loading shall be designed to limit the soil pressure at the edges by means of footing straps or other approved methods.

1819.5.2 When isolated footings support reinforced concrete columns, dowels equivalent in number and area to the column reinforcement and having a length not less than 36 diameters above and below the joint shall be provided in the footing. Where the footing depth precludes straight dowels, standard ACI hooks will be allowable. Such dowels, or anchor bolts as required for steel columns, shall be held to proper grade and location during the pouring of the footing by means of templates or by other approved methods.

1819.5.3 The top of all isolated footings shall be a minimum of 8 inches (203 mm) below grade.

1819.5.4 Any isolated footing subjected to uplift and/or overturning forces shall be specifically designed for that purpose, as set forth in Section 1620.

1819.6 Lateral sliding resistance. The resistance of structural walls to lateral sliding shall be calculated by combining the values derived from the lateral bearing and the lateral sliding resistance shown in Table 1819.6 unless data to substantiate the use of higher values are submitted for approval. For clay, sandy clay and clayey silt, in no case shall the lateral sliding resistance exceed one-half the dead load.

1819.6.1 Increases in allowable lateral sliding resistance.

The resistance values derived from the table may be increased by the tabular value for each additional foot of depth to a maximum of 15 times the tabular value. Isolated poles for uses such as flagpoles or signs and poles used to support buildings which are not adversely affected by 1/2-inch (12.7 mm) motion at the ground surface because of short-term lateral loads may be designed using lateral bearing values equal to two times the tabular values.

1819.7 Designs employing lateral bearing. Designs to resist lateral loads employing posts or poles as columns embedded in earth or embedded in concrete footings in the earth shall conform to the requirements of Sections 1819.7.1 through 1819.7.2.1.

1819.7.1 Limitation. Posts embedded in earth shall not be used to provide lateral support for structural or non structural materials such as plaster, masonry or concrete unless bracing is provided that develops the limited deflection required.

1819.7.2 Design criteria. The depth to resist lateral loads shall be determined by the design criteria in Sections 1819.7.2.1 through 1819.7.2.2 or by other methods approved by the building official.

1819.7.2.1 Unconstrained. The following formula shall be used in determining the depth of embedment required to resist the lateral loads where no constraint is provided at the ground surface, such as a structural diaphragm.

$$d = 0.5A \{ 1 + [1 + (4.36h/A)]^{1/2} \}$$

Where:

$$A = 2.34P / (S_1 b)$$

b = diameter of round post or diagonal dimension of square post or footing, feet.

d = depth of embedment in earth in feet but not over 12 feet (3658 mm) for purpose of computing lateral pressure.

h = distance in feet from ground surface to point of application of P.

P = applied lateral force, pounds.

S1 = Allowable lateral soil-bearing pressure as set forth in Table 1819.6 based on a depth of one-third the depth of embedment, pounds per square foot.

S3 = Allowable lateral soil-bearing pressure as set forth in Table 1819.6 based on a depth equal to the depth of embedment, pounds per square foot.

1819.7.2.2 Constrained. The following formula shall be used in determining the depth of embedment required to resist the lateral loads where constraint is provided at the ground surface, such as a rigid floor or rigid ground surface pavement.

$$d_2 = 4.25(P_h / S_3 b)$$

or alternately

$$d_2 = 4.25(M_g / S_3 b)$$

Where:

M_g = Moment in the post at grade, foot-pounds.

**SECTION 1820
HIGH-VELOCITY HURRICANE ZONES—
CONCRETE SLABS ON FILL**

1820.1 Concrete floors placed directly on the supporting soil shall comply with this section.

1820.2 Where it is proposed to place concrete slabs directly on the supporting soil, a subgrade shall be thoroughly compacted by approved methods. All fill placed under slabs shall be clean sand or rock, free of debris and other deleterious materials. The maximum size of rock within 12 inches (305 mm) below the floor slab in compacted fill shall be 3 inches (76 mm) in diameter. Where fill material includes rock, large rocks shall not be allowed to nest and all voids shall be carefully filled with small stones or sand, and properly compacted.

1820.3. Concrete floor slabs placed directly on the supporting soil shall be a minimum of 4 inches (102 mm) in thickness, reinforced with not less than 0.028 square inches (18 mm²) of reinforcing per linear foot of slab in each direction.

1820.3.1 Fill supporting such slabs shall be compacted under the supervision of a special inspector to a minimum of

**TABLE 1819.6
ALLOWABLE LATERAL PRESSURE**

CLASS OF MATERIALS	LATERAL BEARING (psf/ft BELOW NATURAL GRADE)	LATERAL SLIDING	
		Coefficient of Friction (a)	Resistance (psf)(b)
1. Sedimentary and foliated rock	400	0.35	130
2. Sandy gravel and/or gravel	200	0.35	
3. Sand, silty sand, clayey sand, silty gravel and clayey gravel	150	0.25	
4. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt	100		

For SI: 1 pound per square foot = 47.88 Pa.

NOTES:

- a. Coefficient to be multiplied by the dead load.
- b. Lateral sliding resistance to be multiplied by the contact area, as limited by Section 1819.6.

95 percent of maximum dry density for all layers, as verified by field density tests specified in Section 1820.3.2.

1820.3.2 Tests shall be made in accordance with Methods of Test for Moisture Density Relations of Soils, ASTM D 1557 modified to use 25 blows on five layers with a 10-pound (5 kg) hammer dropping 18 inches (457 mm). In addition, a minimum of one in-place field density test shall be performed for each 2,500 square feet (232 m²), or fraction thereof, for each lift of compacted soil, and such testing shall be performed in accordance with either ASTM D 1556, Standard Test Method for Density of Soil In-Place by the Sandcone; or ASTM D 2922, Standard Test Methods for Density of Soil and Soil Aggregate in-place by Nuclear Methods (Shallow Depth), or other approved methods.

1820.3.3 Where a concrete slab is supported by a foundation wall or continuous footing, the effect of the support shall be considered in the design.

1820.3.4 All concrete slab edges and concrete beams supporting exterior walls shall be recessed a minimum of 3/4 inch (19 mm) below top of slab for a width of the exterior wall, or provided with an alternate water-stop method approved by the building official.

1820.3.5 The discontinuous edges of all slabs surrounding swimming pools and floor slabs for screen patios and utility sheds shall be at least a minimum of 8 inches (203 mm) deep and 8 inches (203 mm) wide and shall be reinforced with one continuous #5 bar.

1820.3.6 Reinforced concrete slabs on fill for garbage containers shall be a minimum of 1 foot (305 mm) larger on all sides than the garbage receptacle (dumpster) and a minimum thickness of 6 inches (152 mm).

1820.4 When polyethylene sheets are used as a vapor barrier beneath a ground floor slab, the subgrade for that slab shall be considered a formed surface for the purpose of reinforcing steel coverage.

1820.5 Concrete slabs outside of buildings, other than patios and pool slabs, where placed directly on the supporting soil, for minor accessory uses such as, but not limited to, walkways, driveways, minor equipment pads, etc, shall be not less than 4 inches (102 mm) thick. Such slabs shall be placed on clean, thoroughly compacted sand or crushed rock free from organics, debris or other deleterious materials.

**SECTION 1821
HIGH-VELOCITY HURRICANE ZONES—
MONOLITHIC FOOTINGS**

1821.1 Monolithic footings under walls shall be continuous or continuity otherwise provided and shall be not less than required to keep the soil pressure within that set forth in Section 1818 nor less than the following minimums:

Allowable bearing capacity (Pounds per square foot)	No. of Stories	Minimum Depth and Width(2) (inches)
2000	1	12 x 16 ¹
2000	2	12 x 24

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 47.88 Pa.
Based on rational analysis and soil investigation as set forth in Section 1818, the footing size or bearing capacity may vary, but the minimum width of a

footing under the main walls of the buildings shall not be less than 16 inches nor less than 8 inches more than the width of the foundation wall.

NOTES:

- (1) For single story wood frame exterior walls, the minimum size continuous footing shall be 16 inches deep x 24 inches wide.
- (2) Any continuous wall footing acting as a shear wall foundation shall be specifically designed for that purpose.

1821.1.1 A minimum outside finish grade of 8 inches (203 mm) above the bottom of the exterior monolithic footing shall be required, but in no case shall the outside finish grade be above the top of the finish slab surface unless sufficient means to minimize moisture intrusion into the structure have been provided to the satisfaction of the building official.

1821.1.2 Continuous monolithic footings shall be placed level and any change in the grade of such footings shall be made with a step of the same cross section and design as the monolithic footings, or the smaller of the monolithic footings, so joined.

1821.1.3 Continuous monolithic footings with eccentric loading shall be designed to limit the soil pressure at the edges to within acceptable values by means of counterbalancing or by other approved methods.

1821.1.4 Concrete monolithic footings and pads shall not receive superimposed loads until 12 hours or more after the concrete is placed.

1821.1.5 Excavations for monolithic footings and foundations, which are to serve as forms, shall be thoroughly wet prior to placing concrete.

1821.1.6 Monolithic foundation systems shall be limited for the support of a maximum of two stories and/or floors or a maximum mean roof height of 25 feet (7620 mm) above grade unless the monolithic foundation system has been designed by a professional engineer and ample consideration has been given to the eccentric loading, foundation rotation and shear cracking at the slab/foundation interface.

1821.1.7 The minimum continuous monolithic footings specified in this section shall be reinforced as follows:

Reinforcing	Minimum Width Foundation (in.)
2 # 5	16" and 20" wide
3 # 5	24" and 30" wide
4 # 5	36" wide

For SI: 1 inch = 25.4 mm.

1821.1.8 Where footings are 30 inches (762 mm) or more in width, cross bars designed to resist bending at the face of the foundation wall shall be provided.

1821.1.9 Equivalent areas in #4 reinforcing bars may be substituted for the sizes as specified in Section 1821.1.7.

1821.1.10 Splices in reinforcing bars shall be not less than 36 bar diameters and reinforcement shall be continuous around all corners and changes in direction. Continuity shall be provided at corners or changes in direction by bending the longitudinal steel around the corner 48 bar diameters or by adding matching reinforcing steel, which shall extend 48

bar diameters from each corner or change in direction. When three or more bars are required, the bars shall be held in place and alignment by transverse bars spaced not more than 4 feet (1219 mm) apart.

1821.1.11 The reinforcement for monolithic footings and other principal structural members in which concrete is deposited against the ground shall have not less than 3 inches (76 mm) of concrete between the reinforcement and the ground contact surface. If concrete surfaces after removal of the forms are to be exposed to the weather or be in contact with the ground, the reinforcement shall be protected with not less than 2 inches (51 mm) of concrete for bars larger than #5 and 1 1/2 inches (38 mm) for #5 or smaller bars.

1821.1.12 Excavations for continuous monolithic footings shall be cut true to line and grade and the sides of footings shall be formed, except where soil conditions are such that the sides of the excavation stand firm and square. Excavations shall be made to firm, clean bearing soil.

1821.1.13 Unless otherwise determined by rational analysis, monolithic footings shall have transfer reinforcement along the perimeter of the foundation. Said reinforcement shall be no less than #4 reinforcing steel bars spaced no greater than 12 inches (305 mm) on center and shall be no less than 5 feet (1524 mm) in length plus a standard ACI hook and shall be placed to transfer into the slab section commencing at a point no less than 3 inches (76 mm) from the edge form.

SECTION 1822 HIGH-VELOCITY HURRICANE ZONES— PILE FOUNDATIONS

1822.1 Pile foundations shall be designed and installed on the basis of a geotechnical exploration which shall include field and/or laboratory tests.

1822.1.1 Piles used for the support of any building or structure shall be driven to a resistance and penetration in accordance with the plans and/or specifications as set forth herein.

1822.1.2 Piles may be jetted under the supervision of a professional engineer. Immediately after completion of jetting, piles shall be driven below the depth jetted to the required resistance, but not less than 1 foot (305 mm), or to nominal refusal whichever comes first. No jetting will be permitted that may be detrimental to existing adjacent structures or piles that have been driven.

1822.1.3 When isolated columns, piers and other loads are supported on piles, a minimum of three piles shall be used for such support unless lateral bracing is provided at the pile cap to insure stability. Should a pile group be loaded eccentrically so as to produce an overload on any pile more than 10 percent of the allowable load, footing straps or other approved methods shall be required to counteract the effect of eccentric loading.

1822.1.4 The minimum center-to-center spacing of piles shall be not less than twice the average diameter of round

piles or $1\frac{3}{4}$ times the diagonal dimensions of rectangular piles but in no case less than 30 inches (762 mm). Piles supporting structural walls shall have dowels installed to offer sufficient resistance for lateral restraint of a grade beam.

1822.1.5 Nonfluid soil shall be considered as providing full lateral support against column action. The portion of a pile that extends through air, water, fluid soil or other unstable material shall be designed as a structural column. Soils having a consistency stiffer than fluid soil may be considered as capable of providing lateral support. Where cast-in-place piles are used reinforcement shall extend 10 feet (3048 mm) below the plane where the soil provides lateral restraint. Sufficient reinforcement for all types of piles shall be provided at the junction of the pile and pile cap or grade beam to make a suitable connection. Shells conforming to Section 1826.1 may be considered as reinforcement.

1822.1.6 Reinforced concrete caps shall be provided for all pile clusters and such caps shall extend laterally not less than 6 inches (152 mm) beyond the extreme pile surface and vertically not less than 4 inches (102 mm) below the pile butt. Pile caps may be omitted when piles are used to support grade beams, provided that the spacing of Section 1822.1.4 is complied with, and provided that the portions of the grade beams acting in place of the pile cap shall be computed by a recognized method of analysis to properly carry the loads.

1822.1.7 Piles shall be driven using an approved cushion block consisting of material arranged to provide transmission of hammer energy equivalent to one-piece hardwood with the grain parallel to the axis of the pile and enclosed in a metal housing to prevent its lateral deformation between the hammer ram and the top of the pile.

1822.1.8 Friction piles shall be driven to a minimum penetration of 12 feet (3658 mm) below the cutoff or the existing ground, whichever is the lower.

1822.1.9 Diesel hammers may be used for driving piles if provided with one of the following means of determining the energy of the hammer's blow.

1822.1.10 Closed-top diesel hammers shall be used with a rating instrument and charts to measure the equivalent WH energy per blow of the hammer. The equivalent WH energy as measured by the instrument shall be the ram's weight times the equivalent ram plus an added value obtained from the energy stored in the bounce chamber. The energy per blow shall be the equivalent WH energy for the closed-top diesel.

1822.1.11 Open-top diesel hammers shall be equipped with a ram stroke indicator rod that is striped in increments above the hammer body and fastened to the body of the hammer. The energy per blow for the open top diesel shall be computed as the ram's working stroke times the ram's weight.

1822.1.12 The load-bearing formula applicable for single-acting pile hammers shall be used to compute the bearing capacity of the driven pile.

1822.1.13 Followers shall be used only upon permission of the special inspector or engineer and only where necessary to effect installation of piles. A follower shall be of a size,

shape, length, material and weight to permit driving the pile in the desired location and to the required depth and resistance without loss of hammer energy in the follower.

1822.1.14 Splices shall be avoided as far as practicable. Splices shall be constructed to provide and maintain true alignment and position of the component parts of the pile during installation and subsequent thereto. Splices shall develop the required strength of the pile.

1822.1.15 The safe capacity of a group of friction piles in plastic material may be determined by load testing the group to 150 percent of the proposed group load or by the formula given in Section 1822.2. When computed by formula, the allowable load for such a group shall be the allowable load for one pile times the number of piles in the group times the efficiency of the pile group determined as follows:

$$E = 1 - 0 \frac{(N-1)M + (M-1)N}{90MN}$$

Where:

E=is the efficiency

S=the average spacing of the piles, inches

M=the number of rows

N=the number of piles in one row

D=the average diameter of the pile, inches

O=arc tan $\frac{D}{S}$, in degrees

1822.1.16 Types of piles that are not provided for in this section shall conform to the requirements herein for the type that it most nearly approximates, subject to such additional requirements as may be made by the building official.

1822.1.17 Pile driving hammers shall develop a minimum of 1 foot-pound of energy per pound of pile or mandrel, but not less than 7,000 foot-pounds of energy per blow.

1822.1.18 Piles may be driven with drop or gravity hammers provided the hammer shall weigh not less than 3,000 pounds (1362 kg) and the fall of the hammer shall not exceed 6 feet (1829 mm).

1822.1.19 Piles shall be driven with a variation of not more than 1/4 (6 mm) inch per foot from the vertical, or from the batter line indicated, with a maximum variation of the head of the pile from the position shown on the plans of not more than 3 inches (76 mm), subject to the provisions of Section 1822.1.3.

1822.1.20 The special inspector or engineer supervising the pile driving operations shall be required to keep an accurate record of the material and the principal dimensions of each pile; of the weight and fall of the hammer, if a single-acting hammer or drop hammer; the size and make, operating pressure, length of hose, number of blows per minute and energy per blow, if a double-acting hammer; together with the average penetration of each pile for at least the last five blows, and the grades at tip and cut-off. A copy of these records shall be filed with the building official and kept with the plans.

1822.1.21 Where piling must penetrate strata offering high resistance to driving or where jetting could cause damage,

the inspector or supervising engineer may require that the piles be set in predrilled or punched holes. The equipment used for drilling or punching must be approved by the special inspector or engineer, and provided that all piles shall reach their final penetration by driving.

1822.1.22 The maximum load permitted on any driven pile shall not exceed 36 tons unless substantiated by a load test performed at the site, as set forth in Section 1829.

1822.1.23 The building official may require tests on any pile where performance is questionable.

1822.1.24 Piles shall be designed and driven to develop not less than 10 tons safe bearing capacity.

1822.1.25 In soils in which the installation of piles causes previously installed piles to heave, accurate level marks shall be put on all piles immediately after installation and all heaved piles shall be reinstalled to the required resistance.

1822.1.26 Piles shall not be driven closer than 2 feet (610 mm) nor jetted closer than 10 feet (3048 mm) to an existing building or structure unless approved by a special inspector or engineer.

1822.2 Driving formula load. Subject to pile load limitations contained in Sections 1823.1.8 and 1824.1.2 and in the absence of pile load test data satisfactory to the building official, the load on a pile shall not exceed that computed from the following driving formula:

Drop Hammer:
$$P = \frac{2Wh}{S + 1}$$

Single Acting Hammers:
$$P = \frac{2Wh}{S + 0.1}$$

Double Acting Hammers:
$$P = \frac{2(W + Ap)^h}{S + 0.1}$$

Or differential in which:

A = area of piston, square inches

p = pressure at the hammer, pounds per square inch

P = allowable total load, pounds

W = weight of striking part of hammer, pounds

H = height of fall of striking part of hammer, feet, or stroke, feet

S = average penetration per blow of not less than the five final blows

SECTION 1823 HIGH-VELOCITY HURRICANE ZONES— WOOD PILES

1823.1 Woodpiles shall conform to ASTM D 25, Round Timber Piles.

1823.1.1 Untreated wood piles in all cases shall be cut off not higher than mean low water table and shall be capped with concrete.

1823.1.2 Timber piles used to support permanent structures shall be treated in accordance with this section unless it is established that the top of the untreated timber piles will be below lowest ground water level assumed to exist during the life of the structure.

1823.1.3 Preservative and minimum final retention shall be in accordance with AWPA C3.

1823.1.4 When timber piles are used in salt water, the treatment shall conform to AWPA MP-1, MP-2 or MP-4. Pile cutoffs shall be treated in accordance with AWPA M-4.

1823.1.4.1 All preservative-treated wood piles shall have a metal tag, brand or other preservative treatment identification mark.

1823.1.4.2 Such mark shall identify the producer, and/or the appropriate inspection agency, and treatment specifications or quality mark.

1823.1.5 Wood piles which support a structure over water may project above the water to such height as may be necessary for structural purposes, provided that such piles used to support structures other than open wharves, boat landings, and other similar light structures shall have been treated in accordance with Section 1823.1.2

1823.1.6 Wood piles shall be driven with a protective driving cap or ring when necessary to prevent brooming or splitting of the butt. When brooming or splitting occurs, such piles shall be cut back to solid wood before the final resistance to penetrations is measured.

1823.1.7 If required, when driving through or to hard material or to rock, wood piles shall be fitted with a metal protective driving cap shown satisfactory to the building official.

1823.1.8 The maximum allowable load on a round timber pile shall be determined in accordance with Section 1822.1.22, provided the maximum allowable stresses of timber are not exceeded.

1823.1.8.1 The allowable stresses for timber piles shall not exceed the values in Table 1823 except as modified by Part 6 of the National Design Specification for Wood Construction.

**SECTION 1824
HIGH-VELOCITY HURRICANE ZONES—
PRECAST CONCRETE PILES**

1824.1 Precast concrete piles shall be cast of concrete having a compressive strength of not less than 3,000 pounds per square inch (psi) (21 MPa) at the time of driving, and shall be reinforced with a minimum of four longitudinal steel bars having an area of not less than 1 percent nor more than 4 percent of the gross concrete area. All longitudinal bars shall be of uniform size and shall be tied by not less than #2 hoops spaced 8 inches (203 mm) in the body of the pile and not over 3 inches (76 mm) for the first 18 inches (437 mm) from both the butt and the tip. All reinforcement shall be protected by 2 inches (51 mm) or more of concrete, except that for piles subjected to the action of open water, waves or other severe exposure, a 3-inch (76 mm) protective covering shall be furnished in the zone of such exposure. For point bearing piles, the concrete area of the tip shall be not less than 75 percent of the area of the butt.

1824.1.1 All precast concrete piles shall have their date of manufacture and the lifting points clearly marked on the pile. Concrete piles shall not be driven until they have attained their full specification strength as verified by tests, nor shall the piles be removed from the forms until 50 percent of the specification strength has been attained. Piles shall not be transported nor driven until they have been cured not less than seven days for Type I cement and three days for Type III cement.

1824.1.2 In the absence of load tests, the maximum allowable load per pile shall not exceed the values set forth in Table 1824.

TABLE 1823

SPECIES	COMPRESSION PARALLEL TO GRADE (psi) ⁴	BENDING (psi) ⁴	SHEAR HORIZ (psi) ⁴	COMP PERP TO GRAIN (psi) ⁴	MODULUS OF ELASTICITY
Pacific Coast					
Douglas Fir ¹	1,250	2,450	115	230	1,500,000
Southern Pine ²	1,200	2,400	110	250	1,500,000
Red Oak ³	1,100	2,450	135	350	1,250,000
Red Pine ⁴	900	1,900	85	155	1,280,000

For SI: 1 pound per square inch = 0.0068 MPa.

1. Pacific Douglas Coast Fir values apply only to species as defined in ASTM Designation 01760-76, Standard Specification for Pressure Treatment of Timber Products. For faster design, use Douglas Fir-Larch design values.
2. Southern Pine values apply to Longleaf, Slash, Loblolly and Short Leaf Pines.
3. Red Oak values apply to Northern and Southern Red Oak.
4. Red Pine values apply to Red Pine grown in the United States.

TABLE 1824

SIZE (INCHES)	MAXIMUM LOAD (TONS)
10 x 10	17
12 x 12	25
14 x 14	35

For SI: 1 inch = 25.4 mm.

SECTION 1825 HIGH-VELOCITY HURRICANE ZONES — PRESTRESSED PRECAST CONCRETE PILES

1825.1 Prestressed precast concrete piles shall conform to Chapter 19 (High-Velocity Hurricane Zones) and to Sections 1822.1.1, 1822.2, 1824 and 1828 except as specifically detailed in this section.

1825.1.1 Prestressed concrete piles shall be cast of concrete having a compressive strength of not less than 5,000 psi (34 MPa) at time of driving and 3,000 psi (21 MPa) before transfer of the prestressing force. The prestressing elements shall not be stressed initially in excess of 75 percent of ultimate strength. The elements shall transfer a compressive stress to the concrete, after losses, of not less than 0.08 percent of the specified strength at driving. Under loads other than handling no tension will be permitted in the concrete.

1825.1.2 Longitudinal reinforcing shall be protected by 2 inches (51 mm) of concrete and shall be tied by #2 hoops or #5 AS&W gauge spirals spaced at 8 inches (203 mm) in the body of piling 14 inches (356 mm) or smaller or 9 inches (22 mm) in the body of piling 16 inches (76 mm) or larger and not over 3 inches (76 mm) for the first 18 inches (457 mm) from both the butt and the tip.

SECTION 1826 HIGH-VELOCITY HURRICANE ZONES— CAST-IN-PLACE

1826.1 Cast-in place concrete piles shall consist of a steel shell driven in intimate contact with the surrounding soil and left in place and filled with concrete. Steel shells may be uniformly tapered, step-tapered, cylindrical or a combination of such shapes and may be laterally corrugated, spirally corrugated, longitudinally fluted or plain.

1826.1.1 Pile shells and end closures shall be of sufficient strength and rigidity to permit their driving in keeping with the driving method used, and to prevent harmful distortion caused by soil pressures or the driving of adjacent piles until filled with concrete. A reduction of cross sectional area in excess of 15 percent shall be cause for rejection. The shells shall also be sufficiently water tight to exclude water during the placing of concrete.

1826.1.2 The minimum diameter shall be 8 inches.

1826.1.3 Concrete for cast-in-place piles shall develop a compressive strength of not less than 3,000 psi (21 MPa) in 28 days. The concrete shall be deposited in a continuous operation to insure a full-sized pile without voids or separation. Concrete shall be placed in the dry. The pile may be

sealed by depositing concrete by tremie or other approved method.

1826.1.4 Splices of shell sections shall be designed to insure the alignment of the shells and develop the full strength of the shell station.

1826.1.5 The load on the shell shall not exceed 25 percent of the minimum average tensile yield strength of the steel multiplied by the area of the shell.

1826.1.5.1 Shells having a wall thickness of 0.119 inch (3 mm) or more may be considered as carrying part of the load.

1826.1.5.2 Adequate allowance for corrosion shall be considered in the design but not less than the outer inch of the shell thickness shall be deducted before computing the area of the shell considered as carrying load.

1826.1.5.3 The metal for the shells shall conform to the Standards of Welded and Seamless Steel Pipe Piles, Grade 2, ASTM A 252, for Hot-Rolled Carbon Steel Sheets and Strip of Structural Quality, ASTM A 570 and Carbon Structural Steel, Cold-Rolled Sheet, ASTM A 611.

1826.1.5.4 The yield strength used in design shall be that of the material in the fabricated shell.

1826.1.6 For friction piles, the allowable load shall be computed at the cross section located at a point two-thirds of the embedded length of the pile, in material providing suitable lateral support, measured upward from the tip. The load on the concrete shall not exceed 25 percent of the 28-day strength of the concrete multiplied by the concrete area.

1826.1.7 For end-bearing piles, the concrete area of the critical section shall be such that the unit stress on the concrete does not exceed $0.25 f_{c'}$ under the pile load. The area of the shell and the critical section of the concrete shall be taken at the elevation where the pile enters the stratum furnishing and bearing.

SECTION 1827 HIGH-VELOCITY HURRICANE ZONES — ROLLED STRUCTURAL SHAPES

1827.1 Rolled structural steel piles shall conform to the Standards for general requirements for Hot-Rolled and Cold-Finished Carbon and Alloy Steel Bars, ASTM A 29, and Carbon Steel Bars Subject to Mechanical Property Requirements, ASTM A 306, except that copper may be added to increase the corrosion-resistant properties of the material.

1827.1.1 Sections of such pile of H form shall have flange projections not exceeding 14 times the thickness of web or flange and total flange width not less than 85 percent of the depth of the section.

1827.1.2 No section shall have a nominal thickness of metal less than 3/8 inch (10 mm).

1827.1.3 For end-bearing piles, the allowable stress may be determined on the basis of an allowable stress of 25 percent of the yield value of the steel.

1827.1.4 In the absence of adequate corrosion protection, 1/16 inch (1.6 mm) shall be deducted from each face in determining the area of the pile section.

1827.1.5 The allowable load, when used as friction piles, shall be determined by load tests at the site.

SECTION 1828 HIGH-VELOCITY HURRICANE ZONES — SPECIAL PILES OR SPECIAL CONDITIONS

1828.1 The use of types of piles or conditions not specifically covered herein may be permitted, subject to the approval of the building official, upon submission of acceptable test data, calculations or other information relating to the properties and load-carrying capacity of such piles.

SECTION 1829 HIGH-VELOCITY HURRICANE ZONES— LOAD TESTS ON PILES

1829.1 Single piles tested shall be loaded to at least twice the desired design load and should pile groups be tested, the test load shall be not less than 1 1/2 times the total desired load for the group.

1829.1.1 The apparatus for applying known vertical loads to the top of the pile shall maintain constant load under increasing settlement, and shall apply the loads in such a way that no lateral forces or impact will occur. Hydraulic jacks when used shall be equipped with a calibrated pressure gauge. Uplift piles used to provide the jacking resistance shall be a sufficient distance from the test pile so as not to influence its behavior under test.

1829.1.2 The test load shall be applied in increments of not more than 25 percent of the design load until the total test load has been applied.

1829.1.3 The method for determining vertical movement shall be subject to the approval of the building official. Readings shall be sufficient in number to define the time settlement and rebound curve.

1829.1.4 Each load increment shall be maintained for a minimum of 1 hour, and until the rate of settlement is less than 0.01 inch (.25 mm) per hour. The total load shall be maintained until settlement does not exceed 0.01 (.25 mm) inch in 24 hours. Settlement readings shall be taken at regular intervals during the test period.

1829.1.5 After the maximum load has remained on the pile for 24 hours and final settlement readings have been taken, the pile shall be unloaded in 50-percent decrements of design load. Rebound readings shall be taken at regular intervals during the unloading period, and final reading taken approximately 12 hours after the entire load has been removed.

1829.1.6 The maximum allowable pile load shall be one-half of that load which causes a net settlement of not more than 0.005 inch (.13 mm) per ton of test load, a gross settlement of 1 inch (25 mm) (whichever is less) or a disproportionate increase in settlement.

1829.1.7 Control test piles shall be tested in accordance with ASTM D 1143, Method of Testing Piles Under Axial Compressive Load. If quick load test procedures are used, the applied test load shall be not less than three times the working pile capacity and in accordance with the standard.

SECTION 1830 HIGH-VELOCITY HURRICANE ZONES — FOUNDATION WALLS AND GRADE BEAMS

1830.1 Exterior foundation walls of buildings, where the character of the soil is such that allowable soil loads of 1,500 pounds per square foot (psf) (81 kN/m²) or less are used for design, shall be poured-in-place reinforced concrete from the footing to the bottom of the first or ground floor construction.

1830.1.1 Exterior foundation walls of building, where the character of the soil is such that allowable soil loads of more than 1,500 psf (71 kN/m²) are used for design, may be of unit masonry or concrete on continuous concrete footings.

1830.1.2 Under the exterior walls of buildings of Type V construction, in locations where extreme dampness exists, the building official may approve isolated piers, provided such piers are as otherwise set forth in Section 1823.1.1.

1830.2 Detailed requirements.

1830.2.1 The thickness of the foundation wall shall be not less than 8 inches (203 mm).

1830.2.2 Where wood joist construction is used for the first or ground floor, the thickness of the exterior foundation walls shall be not less than 8 inches (203 mm), plus 4 inches (102 mm) for the bearing of joists.

1830.2.3 Foundations of unit masonry supporting joists shall be capped with 4 inches (102 mm) of concrete.

1830.3 Interior bearing walls. Interior foundation walls shall be of the material and design as specified in Section 1830.1 except as follows.

1830.3.1 Interior foundation walls that support stud walls shall be exempted from the additional 4 inches (102 mm) of width required for the bearing of joists.

1830.3.2 The use of isolated piers, girders and beams may be substituted for interior foundation walls when designed by a registered architect and/or engineer.

1830.4 Grade beams.

1830.4.1 Grade beams supporting loads between piles or piers shall be reinforced concrete or structural steel protected by 2 inches (51 mm) of concrete cover.

1830.4.2 Grade beams shall be the thickness of the wall they support but never less than 8 inches (203 mm) nor less than set forth for foundation walls herein.

1830.4.3 Grade beams shall be suitably designed and reinforced around access openings and vents.

**SECTION 1831
HIGH-VELOCITY HURRICANE ZONES —
GRADES UNDER BUILDINGS**

1831.1 The grade of the ground under buildings of joist or suspended slab construction having no basements shall not be lower than the lowest surrounding finished lot area grade in order to prevent the accumulation and standing of ground, storm or tide water under such buildings unless provided with other approved means of drainage.

1831.1.1 Plans for future raising of lots shall be taken into account in planning the grade of the ground under such buildings.

1831.1.2 The building official may establish grades under such buildings based on present or future street or sidewalk grades abutting the property.

**SECTION 1832
HIGH-VELOCITY HURRICANE ZONES—
RETAINING WALLS**

1832.1 All walls exceeding 24 inches (610 mm) in height built to retain or support earth, or subject to pressure from adjoining earth, and any surcharge shall be designed to resist the pressure to which they are subjected, including water pressure that may exist.

**SECTION 1833
HIGH-VELOCITY HURRICANE ZONES—
SEAWALLS AND BULKHEADS**

1833.1 All dredging, filling, excavation and waterfront construction such as docks, piers, wharves, bridges, groins, jetties, moles, breakwaters, seawalls, revetments, causeways, artificial nourishment of beaches or other deposition or removal of material in all water areas within the area of jurisdiction of this code shall be planned and designed by a professional engineer, except as noted in Section 1833.2, in accordance with this code and the applicable standards and requirements of the administrative authority.

1833.2 The requirement for professional design will not be required by the building official for bulkheads, docks, piers and similar structures constructed in conjunction with private residences on lakes, private canals and similar water frontage not subject to wind, wave or tidal action; do not involve unusual soil conditions, slopes or unstable soil and are not part of a foundation or support for an above-grade structure.

**SECTION 1834
HIGH-VELOCITY HURRICANE ZONES—
SOIL IMPROVEMENT**

1834.1 The application of soil improvement techniques shall comply with this section.

1834.1.1 Methods of soil improvement for a specific site shall be determined by a registered professional engineer, hereinafter referred to as the geotechnical engineer, and such methods shall provide for field testing as required herein.

1834.1.2 A permit shall be required prior to the commencement of any soil improvement, and no building permit shall be issued until it has been determined that adequate bearing capacity has been obtained for the foundation, and the requirements of this section have been satisfied.

1834.2 Limits on application.

1834.2.1 Soil improvement shall not be permitted where subsurface conditions consist of zones of organic materials of sufficient quality above or below the ground water table which cannot be dispersed or displaced to levels not exceeding 5-percent dry weight of organic content in any undisturbed sample.

1834.2.2 Dynamic compaction, vibrocompaction, preloading, surcharging or other similar methods of soil improvements shall not be permitted near or within coastal areas subject to storm surge, scour or other forms of water erosion without suitable protection provided for the building foundation.

1834.3 Required testing.

1834.3.1 A rational program of field tests and soil analyses shall be part of the soil improvement treatment.

1834.3.2 Such tests shall determine the soil characteristics after treatment, and the results of the tests shall demonstrate whether the subsurface improvement has increased the bearing capacity of the soil to that which is capable of safely supporting the proposed construction.

1834.3.3 The testing shall be performed in accordance with the provisions of ASTM D 1586, Standard Penetration Test; ASTM D 3441, Static Cone Soundings; or by Menard Pressuremeter; Dilatometer or other on-site tests recognized by the industry.

1834.3.4 The test results shall be used to determine the achieved bearing capacity and the anticipated settlement.

1834.4 Requirements for acceptance. The efficacy of any application of soil improvement techniques shall be verified by appropriate calculations, testing and documentation as required in this section.

1834.4.1 All organics, including any organic lens, shall be displaced by the injection of sand or other suitable fill material, or otherwise dispersed in accordance with the provisions of this section, to levels not exceeding 5 percent by weight of organic content in any undisturbed sample.

1834.4.2 Complete documentation of required tests shall be required, and shall included as a minimum, but shall not be limited to:

1. A description of the stratigraphy and densification required and
2. Foundation bearing capacity and settlement analysis performed by an independent testing laboratory.
3. The anticipated settlement potential under superimposed loads shall be acknowledged and accepted by the engineer of record in writing prior to issuance of a building permit.

4. The results of testing to determine subsurface conditions shall be retained by the geotechnical engineer and submitted to the building official upon request.

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