CHAPTER 18
FOUNDATIONS AND RETAINING WALLS

SECTION 1801
GENERAL

1801.1 Scope. Provisions of this chapter shall govern the design, construction, and resistance to water intrusion of foundations for buildings and structures.

Exception: Buildings and structures located within the High Velocity Hurricane Zone shall comply with the provisions of Sections 1816 through 1834.

SECTION 1802
DEFINITIONS

For definitions, see Chapter 2.

SECTION 1803
EXCAVATIONS

1803.1 General

1803.1.1 When excavating for buildings or excavations accessory thereto, such excavations shall be made safe to prevent any danger to life and property, and shall be in accordance with Florida Statutes Section 553.60 Trench Safety Act.

1803.1.2 Permanent excavations shall have retaining walls of sufficient strength made of steel, masonry, or reinforced concrete to retain embankments, together with any surcharged loads.

1803.1.3 Excavations for any purpose shall not extend within 1 ft (305 mm) of the angle of repose or natural slope of the soil under any footing or foundation, unless such footing or foundation is first properly underpinned or protected against settlement.

1803.2 Support of adjoining buildings and structures

1803.2.1 Notice to adjoining structures. Notice to the owner of adjoining buildings or structures shall be served in writing by the one causing the excavation to be made at least ten days before an excavation is commenced. The notice shall state the depth and location of the proposed excavation.

1803.2.2 Excavation 10 ft (3048 mm) or less. When an excavation extends not more than 10 ft (3048 mm) below the established curb grade nearest the point of excavation under consideration, the owner of the adjoining structure or building shall be afforded the necessary license to enter the premises where the excavation is to be made, and at his own expense, shall provide the necessary underpinning or protection.

1803.2.3 Excavation greater than 10 ft (3048 mm)

1803.2.3.1 When an excavation extends more than 10 ft (3048 mm) below the established curb grade nearest the point of excavation under consideration, the one causing the excavation to be made, if given the necessary license to enter the adjoining premises, shall provide at his own expense one of the following:

1. Underpinning and protection required by that part of the excavation which extends to a depth greater than 10 ft (3048 mm) below the established curb grade nearest the point of excavation under consideration, whether or not the existing footings or foundations extend to the depth of 10 ft (3048 mm) or more below curb grade, or
2. Shoring and bracing of the sides of the excavation required to prevent any soil movement into the excavation. If permanent lateral support is provided, the method used must satisfy requirements of the building official.

1803.2.3.2 If the necessary license is not afforded the person causing the excavation to be made, it shall be the duty of the owner failing to afford such license to provide the required underpinning or protection for which purpose he shall be afforded the necessary license to enter the premises where such excavation is to be made.

1803.2.4 Unestablished curb grade. If there is not an established curb grade, the depth of excavation shall be referred to the level of the ground at the point under consideration.

1803.2.5 Difference in adjacent curb grades

1803.2.5.1 If an existing building or structure requiring underpinning or protection is so located that its curb grade or level is at a higher level than the level to which the excavation is properly referred, then such part of the required underpinning or protection that is necessary because of the difference in these levels shall be made and maintained at the joint expense of the owner of the building or structure and the person causing the excavation to be made.

1803.2.5.2 For the purpose of determining such part of the underpinning or protection that is necessary because of such difference in levels, the level to which a building more than 5 ft (1524 mm) back of the street line is properly referred shall be considered to be the level of the natural ground surface adjoining the building or structure.

1803.2.6 Party walls. A party wall, which is in good condition and otherwise suitable for continued use, shall be underpinned or protected as required at the expense of the person causing the excavation to be made.

1803.2.7 Adjoining structure protection. Where the necessary license has been given to the person making an excavation to enter any adjoining structure for the purpose of underpinning or protecting it, the person receiving such license shall provide for such adjoining structure adequate protection against injury from the elements resulting from such entry.

1803.2.8 Backfill. Only approved granular materials shall be used for backfill. It shall be properly compacted in order to prevent lateral displacements of the soil of the adjoining property after the removal of the shores or braces.

SECTION 1804
FOOTINGS AND FOUNDATIONS

1804.1 General

1804.1.1 Foundations shall be built on undisturbed soil or properly compacted fill material. Foundations shall be constructed of materials described in this chapter.

1804.1.2 Pile foundations shall be designed and constructed in accordance with 1805.

1804.1.3 The bottom of foundations shall extend no less than 12 inches (305 mm) below finish grade.

1804.1.4 Temporary buildings and buildings not exceeding one story in height and 400 sq ft (37 m^2) in area shall be exempt from these requirements.

1804.1.5 Excavations for foundations shall be backfilled with soil which is free of organic material, construction debris and large rocks.

1804.1.6 Where water impacts the ground from a roof valley, downspout, scupper or other rain water collection or diversion device, provisions shall be made to prevent soil erosion and direct the water away from the foundation.

1804.1.7 Finish grade shall be sloped away from the foundation for drainage.

1804.1.8 The area under footings, foundations and concrete slabs on grade shall have all vegetation, stumps, roots and foreign materials removed prior to their construction. Fill material shall be free of vegetation and foreign material.

1804.2 Soils investigation

1804.2.1 Plain concrete, masonry or timber footings. Footings shall be so designed that the allowable bearing capacity of the soil is not exceeded. If structural plain concrete, masonry or timber footings are used, they shall rest on undisturbed or compacted soil of uniform density and thickness. Compacted soils shall be tested to a minimum of 95% of Modified Proctor in accordance with ASTM D 1557 and compacted and tested in lifts not to exceed 12 inches (305 mm). If sufficient compactibilities exist, soils may be compacted and tested in greater lift thicknesses.

1804.2.2 Questionable soil. Where the bearing capacity of the soil is not definitely known or is in question, the building official may require load tests or other adequate proof as to the permissible safe bearing capacity at that particular location. To determine the safe bearing capacity of soil, it shall be tested at such locations and levels as conditions warrant, by loading an area not less than 4 sq ft (0.37 m^2) to not less than twice the maximum bearing capacity desired for use. Such double load shall be sustained by the soil for a period of not less than 48 hours with no additional settlement taking place, in order that such desired bearing capacity may be used. Subsoil conditions shall be examined at the expense of the owner, when deemed necessary by the building official.

1804.2.3 Natural solid ground or piles. Foundations shall be built upon natural solid ground. Where solid natural ground does not occur at the foundation depth, such foundations shall be extended down to natural solid ground or piles shall be used. Foundations may be built upon mechanically compacted earth or fill material subject to approval by the building official upon submittal of evidence that the proposed load will be adequately supported.

1804.2.4 Differential settlement. Where footings are supported by soils of widely different bearing capacity, the allowable bearing values of the more yielding soil shall be reduced or special provisions shall be made in the design to prevent serious differential settlements.

1804.2.5 Shifting or moving soils. When it is definitely known the top or subsoils are of a shifting or moving character, all footings shall be carried to a sufficient depth to insure stability. The excavation around piers shall be backfilled with soils or materials which are not subject to such expansion or contraction.

1804.2.6 Groundwater table investigation. A subsurface soil investigation shall be performed to determine the possibility of the groundwater table rising above the proposed elevation of the lowest floor when such floor is located below the finished ground level adjacent to the foundation for more than 75% of the perimeter of the building.

Exception: A subsurface soil investigation shall not be required when either of the following conditions is satisfied:

1. Waterproofing is provided in accordance with 1814.2.
2. Satisfactory data from adjacent areas is available which demonstrates that groundwater has not been a problem.

1804.3 Expansive soils

1804.3.1 General. Footings or foundations for buildings and structures founded on expansive soils shall be designed in accordance with this section. As an alternative to special design, the soil may be removed in accordance with 1804.3.4 or stabilized in accordance with 1804.3.5.

1804.3.2 Soil tests. In areas likely to have expansive soil, the building official may require soil tests to determine whether such soils do exist. 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% of the soil particles pass a #200 sieve (75 μm), determined in accordance with ASTM D 422.
3. More than 10% 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 SBCCI Standard for Expansive Soil Tests.

1804.3.3 Foundations

1804.3.3.1 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.

1804.3.3.2 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 by soil volume changes or be isolated from the expansive soil.

1804.3.3.3 Slab-on-ground, mat or raft foundations on expansive soils shall be designed and constructed in accordance with WRI/CRSI Design of Slab-on-Ground Foundations or PTI Design and Construction of Post-Tensioned Slabs-On-Ground.

Exception: Slab-on-ground systems which have performed adequately in soil conditions similar to those encountered at the building site may be used if approved by the building official.

1804.3.4 Removal of expansive soil. The expansive soil may be removed to a depth sufficient to assure a constant moisture content in the remaining soil. Fill material shall not contain expansive soils and shall be placed in accordance with the provisions of 1804.2.3.

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.

1804.3.5 Stabilization. The active zone of expansive soils may be stabilized when approved by the building official. Soils may be stabilized by chemical, dewatering, presaturation or equivalent techniques.

1804.4 Footing design

1804.4.1 The base area of the footings of all buildings shall be designed in the following manner: The area of the footing which has the largest percentage of live load to total load shall be determined by dividing the total load by the allowable soil load. From the area thus obtained, the dead load soil pressure of such footing is determined and the areas of all other footings of the building shall be determined on the basis of their respective dead loads only and such dead load soil pressure. In no case shall the load per sq ft under any portion of any footing, caused by the combined dead, live, wind and any other loads, exceed the safe sustaining power of the soil upon which the footing rests. The total reduced live load occurring in the column immediately above the footing shall be the live load used in the above computation.

1804.4.2 Footings shall be proportioned to sustain the applied loads and induced reactions without exceeding the allowable stresses specified in this code.

1804.5 Concrete footings

1804.5.1 Compressive strength. Concrete in footings shall have a specified compressive strength of not less than 2,500 psi (17 238 kPa) at 28 days.

1804.5.2 Design. Design of footings shall be in accordance with Chapter 19.

1804.6 Foundation walls

1804.6.1 Concrete and masonry. Concrete and masonry foundation walls shall be designed and constructed in accordance with 1804.6.1.

1804.6.1.1 Plain concrete and plain masonry foundation walls shall be sized in accordance with Table 1804.6.1A, and reinforced concrete and reinforced masonry foundation walls shall be sized in accordance with Table 1804.6.1B, or such walls shall be designed in accordance with ACI 318, NCMA TR68-A, or ACI 530/ASCE 5/TMS 402, or other approved methods. Concrete foundation walls, constructed using insulated concrete forms (ICF), shall be sized in accordance with Table 1804.6.1C, 1804.6.1D, 1804.6.1E, 1804.6.1F or 1804.6.1G, or such walls shall be designed in accordance with ACI 318, or other approved methods. In addition, concrete foundation walls using insulated concrete forms (ICF), shall also be constructed in accordance 1804.6.2.

1804.6.1.2 The minimum thickness of concrete and masonry foundation walls shall be in accordance with 1804.6.1.1 but not less than the thickness of the wall being supported.

Exception: Foundation walls not less than 8 inches (203 mm) in thickness and conforming to the provisions of 1804.6.1.1 may be used as foundations for dwellings with walls of brick veneer on frame walls or 10-inch (254 mm) cavity walls, provided the dwelling is not more than two stories in height and the total height of the wall, including the gable, is not more than 28 ft (8.53 m). Foundation walls 8 inches (203 mm) thick supporting brick veneer or cavity walls shall be corbelled with solid units to provide a bearing the full thickness of the wall above. Corbeling of masonry shall be in accordance with 2111.2. The total projection shall not exceed 2 inches (51 mm) with individual corbels projecting not more than one-third the thickness of the unit nor one-half the height of the unit. The top corbel course shall not be higher than the bottom of floor joists and shall be a full header course.

1804.6.1.3 Concrete and masonry foundation walls shall extend above the finished grade a minimum of 4 inches (102 mm) where masonry veneer is used and a minimum of 6 inches (152 mm) elsewhere.

1804.6.1.4 Backfill adjacent to concrete and masonry foundation walls shall not be placed until the walls have sufficient strength and have been anchored to the floor above or have been braced to prevent damage by the backfill.

Exception: When approved by the building official, such bracing is not required for such walls supporting less than 4 ft (1.2 m) of unbalanced backfill.

1804.6.1.5 Curtain walls between solid piers and nonbearing perimeter walls shall be permitted for frame construction and masonry veneer frame construction in dwellings not more than two stories in height, subject to the following limitations:

1. Minimum thickness of the curtain wall shall be 4 inches nominal bonded into the piers and supported on a continuous concrete footing.
2. Masonry bearing piers shall comply with 2303.2. Pier spacing shall be governed by the beam or girder designed in accordance with 2307.2.
3. Unbalanced fill placed against a 4-inch (102 mm) curtain wall shall not exceed 24 inches (610 mm) for solid masonry or 16 inches (406 mm) for hollow masonry.
4. Maximum height of exterior, nonbearing curtain walls shall not exceed ten times the thickness of pier and properly bonded curtain wall.

1804.6.2 Insulated concrete form foundation walls

1804.6.2.1 Applicability limits. Buildings constructed with insulated concrete form (ICF) foundation walls in accordance with this section are subject to the following limitations:

1. Building plan dimensions do not exceed 60 ft (18.3 m).
2. Floor spans do not exceed 32 ft (9.7 m) and roof spans do not exceed 40 ft (12 m) clear.
3. Buildings are two stories or less in height above-grade with no story greater than 10 ft (3.0 m) high.
4. Building floor live loads do not exceed 40 psf (1915 Pa).

1804.6.2.2 Flat insulating concrete form wall systems. Flat ICF wall systems shall comply with Figure 1916.3 and shall have a minimum concrete thickness of 5.5 inches (140 mm).

1804.6.2.3 Waffle-grid insulating concrete form wall systems. Waffle-grid ICF wall systems shall have a minimum nominal concrete thickness of 6 inches (152 mm) for the horizontal and vertical concrete members (cores) and the minimum core dimension shall comply with Table 1916.4 and Figure 1916.4.

1804.6.2.4 Screen grid insulating concrete form wall systems. Screen-grid ICF wall systems shall have a minimum nominal concrete thickness of 6 inches for the horizontal and vertical concrete members (cores) and the minimum core dimensions shall comply with Table 1916.4 and Figure 1916.5.

1804.6.2.5 Concrete material. Concrete for insulating concrete form walls shall be in accordance with Chapter 19. The maximum slump shall not be greater than 6 inches (152 mm) as determined in accordance with ASTM C 143. The maximum aggregate size shall not be larger than 3/4 inch (19 mm).

Exception: Concrete mixes conforming to the ICF manufacturer's recommendations.

1804.6.2.6 Reinforcing Steel

1804.6.2.6.1 Reinforcing steel shall meet the requirements of 1903.5. The minimum yield strength of the reinforcing steel shall be 40,000 psi (Grade 40) (276 MPa). Vertical and horizontal wall reinforcements shall not be placed within the outside half of the wall. Steel reinforcement shall have concrete cover in accordance with 1908.6.

Exception: Where insulated concrete forms are used and the form remains in place as cover for the concrete, the minimum concrete cover for the reinforcing steel is permitted to be reduced to 3/4 inch (19 mm).

1804.6.2.6.2 ICF Foundation walls up to 8 ft (2.4 m) in height shall have a minimum of one continuous #4 horizontal reinforcing bar placed at 48 inches (1.2 m) on center with one bar located within 12 inches (305 mm) of the top of the wall story. ICF Foundation walls greater than 8 ft (2.4 m) in height shall have a minimum of one continuous #4 hori-

zontal reinforcing bar placed at 36 inches (914 mm) on center with one bar located within 12 inches (305 mm) of the top of the wall story.

1804.6.2.6.3 Vertical wall reinforcement required by 1804.6.2.2, 1804.6.2.3 or 1804.6.2.4 that is interrupted by wall openings shall have additional vertical reinforcement of the same size placed within 12 inches (305 mm) of each side of the opening.

1804.6.2.7 Foam Plastic Insulation

1804.6.2.7.1 Insulating concrete form material shall meet the surface burning characteristics of 2603.4. A thermal barrier shall be provided in accordance with 2603.5.

1804.6.2.7.2 In areas where hazard of termite damage is very heavy in accordance with Figure 2304.1.4, foam plastic insulation shall be permitted below grade on foundation walls in accordance with one of the following conditions:

1. When in addition to the requirements of 2304.1.2, an approved method of protecting the foam plastic and structure from subterranean termite damage is provided.
2. Within Types I, II and IV construction.
3. On the interior side of basement walls.

1804.6.2.8 Drainage and dampproofing/waterproofing. ICF foundation basements shall be dampproofed or waterproofed in accordance with 1814.

1804.6.3 Openings

1804.6.3.1 Ventilation. Crawl spaces under buildings without basements shall be ventilated by approved mechanical means or by openings in foundation walls. Openings shall be arranged to provide cross ventilation and shall be covered with corrosion-resistant wire mesh of not less than 1/4 inch (6.4 mm) nor more than 1/2 inch (12.7 mm) in any dimension. Openings in foundation walls shall be not less than the following:

1. Where wood floor systems are used, such openings shall have a net area of not less than 1 sq ft (0.093 m^2) for each 150 sq ft (14 m^2) of crawl space.
2. Where other than wood floor systems are used, such openings shall be not less than 1 1/2 sq ft (0.14 m^2) of net opening for each 15 linear feet (4572 mm) or major fraction thereof of exterior wall.
3. Where asphalt saturated felt weighing 55 lb (2.7 kg/m^2) per square, lapped at least 2 inches (51 mm) at joints, or 4 mil (0.102 mm) polyethylene lapped at least 4 inches (102 mm) at joints, or other approved vapor retarder is installed over the ground surface, the required net area of openings may be reduced to 10% of that required above. There shall be one ventilation opening within 3 ft (914 mm) of each corner, and these shall be of equal size totaling a minimum of 50% of required openings.
4. An operable vent louver shall be permitted only where an approved vapor barrier is installed over the ground surface.
5. Where combustion equipment is installed within a crawl space, air for combustion shall be provided in accordance with 705.1.1.4, 2810, and the *Florida Building Code, Mechanical.*

1804.6.3.2 Access. Usable crawl spaces under buildings without basements shall be provided with a minimum of one access opening not less than 18x24 inches (457x610 mm). Access openings shall be readily accessible and provided with a door or device that may be easily removed or operated. For access to mechanical equipment installed in underfloor areas of the *Florida Building Code, Mechanical.*

1804.6.4 Masonry with Type VI construction. Foundation walls of hollow masonry supporting Type VI construction shall be capped with 4 inches (102 mm) of solid masonry or concrete or shall have cavities of the top course filled with concrete or grout unless a sill plate of 2-inch (51 mm) nominal thickness bears on both face shells.

1804.7 Timber footings. Footings of wood may be used if they are entirely below permanent water level, or if they are pressure impregnated with an approved preservative in accordance with the AWPA Standards listed in Chapter 35.

1804.8 Wood foundation systems. The foundation system may be of wood when the engineering design is based on the bearing capacity of the soil (see 1804.2) and the design and construction comply with the provisions of AF&PA Technical Report No. 7. ☆

TABLE 1804.6.1A
PLAIN CONCRETE AND PLAIN MASONRY FOUNDATION WALLS[1,2]

MAXIMUM WALL HEIGHT, (ft)	MAXIMUM UNBALANCED BACKFILL HEIGHT, (ft)	SOIL CLASSES[4] AND LATERAL SOIL LOAD, PSF PER FOOT OF DEPTH					
		Plain Concrete Minimum Wall Thickness, (in)			Plain Masonry[3] Minimum Nominal Wall Thickness, (in)		
		GW, GP, SW and SP 30	GM, GC, SM, SM-SC and ML 45	SC, MH, ML-CL and Inorganic CL 60	GW, GP, SW and SP 30	GM, GC, SM, SM-SC and ML 45	SC, MH, ML-CL and Inorganic CL 60
4	2	6	6	6	6	6	6
5	4	8	8	8	8	8	8
	5	8	8	8	8	8	10
6	4	8	8	8	8	8	8
	5	8	8	8	8	8	10
	6	8	8	8	8	10	12
7	4	8	8	8	8	8	8
	5	8	8	8	8	10	10
	6	8	8	8	10	12	10 solid[5]
	7	8	8	10	12	10 solid[5]	12 solid[5]
8	4	8	8	8	8	8	8
	5	8	8	8	8	10	12
	6	8	8	10	10	12	12 solid[5]
	7	8	10	10	12	12 solid[5]	Note 6
	8	10	10	12	10 solid[5]	12 solid[5]	Note 6
9	4	8	8	8	8	8	8
	5	8	8	8	8	10	12
	6	8	8	10	10	12	12 solid[5]
	7	8	10	10	12	12 solid[5]	Note 6
	8	10	10	12	12 solid[5]	Note 6	Note 6
	9	10	12	Note 7	Note 6	Note 6	Note 6

For SI: 1 inch = 25.4 mm, 1 ft = 0.305 m, 1 psf - 47.8803 Pa.

Notes:

1. Foundation walls supporting more than 42 inches (1067 mm) of unbalanced backfill shall have permanent lateral support at the top and bottom.
2. Foundation walls subjected to surcharge loads shall be designed as prescribed in 1804.6.1.1.
3. Mortar shall be Type M or S and masonry shall be laid in running bond. Hollow, ungrouted masonry units are permitted except where otherwise indicated.
4. Soil classes are in accordance with the Unified Soil Classification System. See 1608.1.1.
5. Solid grouted hollow units or solid masonry units.
6. Reinforcement in accordance with Table 1804.6.1B or a design is required.
7. A design is required.

TABLE 1804.6.1B
REINFORCED CONCRETE AND REINFORCED MASONRY FOUNDATION WALLS[1,2,3]

MAXIMUM WALL HEIGHT, (ft)	MAXIMUM UNBALANCED BACKFILL HEIGHT, (ft)	SOIL CLASSES[6] AND LATERAL SOIL LOAD, PSF PER FOOT OF DEPTH		
		Minimum Vertical Reinforcement Size and Spacing[4,5] For 8-In Nominal Wall Thickness		
		GW, GP, SW and SP Soils 30	GM, GC, SM, SM-SC and ML Soils 45	SC, MH, ML-CL and Inorganic CL Soils 60
6	5	#4 @ 48" o.c.	#4 @ 48" o.c.	#4 @ 48" o.c.
	6	#4 @ 48" o.c.	#4 @ 40" o.c.	#5 @ 48" o.c.
7	4	#4 @ 48" o.c.	#4 @ 48" o.c.	#4 @ 48" o.c.
	5	#4 @ 48" o.c.	#4 @ 48" o.c.	#4 @ 40" o.c.
	6	#4 @ 48" o.c.	#5 @ 48" o.c	#5 @ 40" o.c.
	7	#4 @ 40" o.c.	#5 @ 40" o.c.	#6 @ 48" o.c.
8	5	#4 @ 48" o.c.	#4 @ 48" o.c.	#4 @ 40" o.c.
	6	#4 @ 48" o.c.	#5 @ 48" o.c.	#5 @ 40" o.c.
	7	#5 @ 48" o.c.	#6 @ 48" o.c.	#6 @ 40" o.c.
	8	#5 @ 40" o.c.	#6 @ 40" o.c.	#6 @ 24" o.c.
9	5	#4 @ 48" o.c.	#4 @ 48" o.c.	#5 @ 48" o.c.
	6	#4 @ 48" o.c.	#5 @ 48" o.c.	#6 @ 48" o.c.
	7	#5 @ 48" o.c.	#6 @ 48" o.c.	#6 @ 32" o.c.
	8	#5 @ 40" o.c.	#6 @ 32" o.c.	#6 @ 24" o.c.
	9	#6 @ 40" o.c.	#6 @ 24" o.c.	#6 @ 16" o.c.

For SI: 1 inch = 25.4 mm, 1 ft = 0.305 m, 1 psf = 47.8803 Pa.

Notes:

1. Foundation walls supporting more than 42 inches (1067 mm) of unbalanced backfill shall have permanent lateral support at the top and bottom.
2. Mortar shall be Type M or S and masonry shall be laid in running bond.
3. Foundation walls subjected to surcharge loads shall be designed as prescribed in 1804.6.1.1.
4. Alternative reinforcing bar sizes and spacings having an equivalent cross-sectional area of reinforcement per lineal foot of wall shall be permitted. Where the spacing of such alternative vertical reinforcement exceeds 48 inches (1219 mm) o.c., horizontal reinforcement shall be provided consisting of No. 9 gage wire joint reinforcement in every course or No. 4 bars spaced a maximum of 48 inches (1219 mm) o.c. The uppermost horizontal No. 4 bar shall be located in the top course of masonry and the lowermost horizontal No. 4 bar shall be located within 48 inches (1219 mm) of the top of the footing.
5. Vertical reinforcement shall be Grade 60 minimum. The distance from the face of the soil side of the wall to the center of vertical reinforcement shall be 5 inches (127 mm) minimum.
6. Soil classes are in accordance with the Unified Soil Classification System. See 1608.1.1.

TABLE 1804.6.1C
5.5 INCH THICK FLAT ICF FOUNDATION WALLS [1,2]

Maximum Wall Height (ft)	Maximum Unbalanced Backfill Height (ft)	SOIL CLASSES [2,3] AND LATERAL SOIL LOAD PSF PER FOOT OF DEPTH		
		Minimum Vertical Reinforcement Size and Spacing		
		GW, GP, SW and SP Soils	GM, GC, SM, SM-SC and ML Soils	SC, MH, ML-CL and Inorganic CL Soils
		30	45	60
8	4	#4@48"	#4@48"	#4@48"
	5	#4@48"	#3@12"; #4@22"; #5@32";	#3@8"; #4@14"; #5@20"; #6@26"
	6	#3@12"; #4@22"; #5@30"	3#@8"; #4@14"; #5@20"; #6@24"	#3@6"; #4@10"; #5@14"; #6@20"
	7	#3@8"; #4@14"; #5@22"; #6@26"	#3@5"; #4@10"; #5@14:; #6@18"	#3@4"; #4@6"; #5@10"; #6@14"
9	4	#4@48"	#4@48"	#4@48"
	5	#4@48"	#3@12"; #4@20"; #5@28"; #6@36"	#3@8"; #4@14"; #5@20"; #6@22"
	6	#3@10"; #4@20"; #5@28"; #6@34"	#3@6"; #4@12"; #5@18"; #6@20"	#4@8" #5@14"; #6@16"
	7	#3@8"; #4@14"; #5@20"; #6@22"	#4@8"; #5@12"; #6@16"	#4@6"; #5@10"; #6@12"
	8	#3@6"; #4@10"; #5@14"; #6@16"	#4@6"; #5@10"; #6@12"	#4@4"; #5@6"; #6@8"
10	4	#4@48"	#4@48"	#4@48"
	5	#4@48"	#3@10"; #4@18"; #5@26"; #6@30"	#3@6"; #4@14"; #5@18"; #6@20"
	6	#3@10"; #4@18"; #5@24"; #6@30"	#3@6"; #4@12"; #5@16"; #6@18"	#3@4"; #4@8" #5@12"; #6@14"
	7	#3@6"; #4@12"; #5@16"; #6@18"	#3@4"; #4@8"; #5@12"	#4@6" #5@8"; #6@10"
	8	#4@8"; #5@12"; #6@14"	#4@6"; #5@8"; #6@12"	#4@4" #5@6"; #6@8"
	9	#4@6"; #5@10"; #6@12"	#4@4"; #5@6"; #6@8"	#5@4"; #6@6"

For SI: 1 inch = 25.4 mm 1 psf = 0.0479 kN/m², 1 foot = 0.3 m

Notes:

1. Deflection criteria: L/240.
2. Interpolation between rebar sizes and spacing is not permitted.
3. Soil classes are in accordance with the Unified Soil Classification System. See 1608.1.1.

TABLE 1804.6.1D
7.5 INCH THICK FLAT ICF FOUNDATION WALLS [1,2,3]

Maximum Wall Height (ft)	Maximum Unbalanced Backfill Height (ft)	SOIL CLASSES [4] AND LATERAL SOIL LOAD PSF PER FOOT OF SOIL DEPTH		
		Minimum Vertical Reinforcement Size and Spacing		
		GW, GP, SW and SP Soils	GM, GC, SM, SM-SC and ML Soils	SC, MH, ML-CL and Inorganic CL Soils
		30	45	60
8	6	N/R	N/R	N/R
	7	N/R	#3@8"; #4@14"; #5@20"; #6@28"	#3@6"; #4@10"; #5@16"; #6@20"
9	6	N/R	N/R	#3@8"; #4@14"; #5@20"; #6@28"
	7	N/R	#3@6"; #4@12"; #5@18; #6@26"	#3@4"; #4@8"; #5@14"; #6@18"
	8	#3@8"; #4@14"; #5@22"; #6@28"	#3@4"; #4@8"; #5@14"; #6@18"	#3@4"; #4@6"; #5@10"; #6@14"
10	6	N/R	N/R	#3@6"; #4@12"; #5@18"; #6@26"
	7	N/R	#3@6"; #4@12"; #5@18"; #6@24"	#3@4"; #4@8"; #5@12"; #6@18"
	8	#3@6"; #4@12"; #5@20"; #6@26"	#3@4"; #4@8"; #5@12"; #6@16"	#3@4"; #4@6"; #5@8"; #6@12"
	9	#3@6"; #4@10"; #5@14"; #6@20"	#3@4"; #4@6"; #5@10"; #6@12"	#4@4" #5@6"; #6@10"

For SI: 1 inch = 25.4 mm 1 psf = 0.0479 kN/m^2, 1 foot = 0.3 m

Notes:

1. N/R indicates no vertical reinforcement is required.
2. Deflection criteria: L/240.
3. Interpolation between rebar sizes and spacing is not permitted.
4. Soil classes are in accordance with the Unified Soil Classification System. See 1608.1.1.

TABLE 1804.6.1E
9.5 INCH THICK FLAT ICF FOUNDATION WALLS [1,2,3]

Maximum Wall Height (ft)	Maximum Unbalanced Backfill Height (ft)	SOIL CLASSES[4] AND LATERAL SOIL LOAD PSF PER FOOT OF DEPTH		
		Minimum Vertical Reinforcement Size and Spacing		
		GW, GP, SW and SP Soils	GM, GC, SM, SM-SC and ML Soils	SC, MH, ML-CL and Inorganic CL Soils
		30	45	60
8	7	N/R	N/R	N/R
9	6	N/R	N/R	N/R
	7	N/R	N/R	#3@6"; #6@12" #5@18"; #6@26"
	8	N/R	#3@6"; #4@12" #5@18"; #6@26"	#3@4"; #4@8" #5@14"; #6@18"
10	5	N/R	N/R	N/R
	6	N/R	N/R	#3@10" #4@18" #5@26"; #6@36"
	7	N/R	N/R	#3@6"; #4@10" #5@18"; #6@24"
	8	N/R	#3@6"; #4@12" #5@16"; #6@24"	3#@4"; #4@8" #5@12"; #6@16"
	9	N/R	#3@4"; #4@8" #5@12"; #6@18"	#3@4"; #4@6" #5@10"; #6@12"

For SI: 1 inch = 25.4 mm 1 psf = 0.0479 kN/m^2, 1 foot = 0.3 m

Notes:

1. N/R indicates no vertical reinforcement is required.
2. Deflection criteria: L/240.
3. Interpolation between rebar sizes and spacing is not permitted.
4. Soil classes are in accordance with the Unified Soil Classification System. See 1608.1.1.

TABLE 1804.6.1F
WAFFLE GRID ICF FOUNDATION WALLS[1,2,3]

Minimum Nominal Wall Thickness[4] (inches)	Maximum Wall Height (ft)	Maximum Unbalanced Backfill Height[5] (ft)	SOIL CLASSES [5] AND LATERAL SOIL LOADS, PSF PER F00T OF DEPTH		
			Minimum Vertical Reinforcement Size and Spacing		
			GW, GP, SW and SP Soils	GM, GC, SM, SM-SC and ML Soils	SC, MH, ML-CL and Inorganic CL Soils
			30	45	60
6	8	4	#4@48"	#3@12"; #4@24"	#3@12"
		5	#3@12"; #5@24"	#4@12"	#7@12"
		6	#4@12"	Design Required	Design Required
		7	#7@12"	Design Required	Design Required
	9	4	#4@48"	#3@12"; #5@24"	#3@12"
		5	#3@12"	#4@12"	Design Required
		6	#5@12"	Design Required	Design Required
		7	Design Required	Design Required	Design Required
	10	4	#4@48"	#4@12"	#5@12"
		5	#3@12"	Design Required	Design Required
		6	Design Required	Design Required	Design Required
		7	Design Required	Design Required	Design Required
8	8	4	N/R	N/R	N/R
		5	N/R	#3@12"; #4@24"l; #5@36"	#3@12" #5@24"
		6	#3@12"; #4@24" #5@36"	#4@12"; #5@24"	#4@12"
		7	#3@12"; #6@24"	#4@12"	#5@12"
	9	4	N/R	N/R	N/R
		5	N/R	#3@12"; #5@24"	#3@12" #5@24"
		6	#3@12"; #4@24"	#4@12"	#4@12"
		7	#4@12"; #5@24"	#5@12"	#5@12"
		8	#4@12"	#5@12"	#8@12"
	10	4	N/R	#3@12"; #4@24"; #6@36"	#3@12" #5@24"
		5	N/R	#3@12"; #4@24"; #6@36"	#4@12" #5@24"
		6	#3@12"; #5@24"	#4@12"	#5@12"
		7	#4@12"	#5@12"	#6@12"
		8	#4@12"	#6@12"	Design Required
		9	#5@12"	Design Required	Design Required

For SI: 1 inch = 25.4 mm 1 psf = 0.0479 kN/m^2, 1 ft = 0.3 m

Notes:

1. N/R indicates no vertical reinforcement is required.
2. Deflection criteria: L/240.
3. Interpolation between rebar sizes and spacing is not permitted.
4. Refer to Table 1916.4 for wall dimensions.
5. Soil classes are in accordance with the Unified Soil Classification System. See 1608.1.1.

TABLE 1804.6.1G
SCREEN-GRID ICF FOUNDATION WALLS [1,2]

Minimum Nominal Wall Thickness[3] (in)	Maximum Wall Height (ft)	Maximum Unbalanced Backfill Height[4] (ft)	SOIL CLASSES [4] AND LATERAL SOIL LOADS, PSF PER FOOT OF DEPTH		
			Minimum Vertical Reinforcement Size and Spacing		
			GW, GP, SW and SP Soils	GM, GC, SM, SM-SC and ML Soils	SC, MH, ML-CL and Inorganic CL Soils
			30	45	60
6	8	4	#4@48"	#3@12"; #4@24" #5@36"	#3@12" #5@24"
		5	#3@12"; #4@24"	#3@12"	#4@12"
		6	#4@12"	#5@12"	Design Required
		7	#4@12"	Design Required	Design Required
	9	4	#4@48"	#3@12"; #4@24"	#3@12" #6@24"
		5	#3@12"; #5@24"	#4@12"	#7@12"
		6	#4@12"	Design Required	Design Required
		7	Design Required	Design Required	Design Required
		8	Design Required	Design Required	Design Required
	10	4	#4@48"	#3@12"; #4@24"	#3@12"
		5	#3@12"	#4@12"	#7@12"
		6	#4@12"	Design Required	Design Required
		7	Design Required	Design Required	Design Required
		8	Design Required	Design Required	Design Required

For SI: 1 inch = 25.4 mm 1 psf = 0.0479 kN/m^2, 1 ft = 0.3 m

Notes:

1. Deflection criteria: L/240.
2. Interpolation between rebar sizes and spacing is not permitted.
3. Refer to Table 1916.4 for wall dimensions.
4. Soil classes are in accordance with the Unified Soil Classification System. See 1608.1.1.

SECTION 1805
PILES

1805.1 Investigation. Pile foundations shall be designed and installed on the basis of a foundation investigation and report which shall include borings, test pits or other subsurface exploration at locations and depths sufficient to determine the position and adequacy of the bearing soils except where sufficient data upon which to base the design and installation is available. The investigation and report shall include but not be limited to the following:

1. Recommended pile types and installed capacities.
2. Driving criteria.
3. Installation and field inspection procedures.
4. Pile load test requirements.
5. Durability of pile materials.
6. Designation of bearing stratum or strata.

1805.2 Special types of piles. The use of types of piles not specifically mentioned herein may be 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.

1805.3 Protection of pile materials. Where boring records or site conditions indicate possible deleterious action on pile materials because of soil constituents, changing water levels or other factors, the 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.

1805.4 Lateral support

1805.4.1 General. Any soil other than fluid soil shall be deemed to afford sufficient lateral support to the pile to prevent buckling and to permit the design of the pile in accordance with accepted engineering practice and the applicable provisions of this code.

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1805.4.2 Unbraced piles. All piles standing unbraced in air, water or soils not capable of providing lateral support shall be designed as columns in accordance with the provisions of this code.

1805.5 Group action. In cohesive soils, the compressive load capacity of a group of friction piles shall be analyzed by a rational method approved by the building official and where such analysis indicates, the individual allowable pile load shall be reduced accordingly.

1805.6 Stability

1805.6.1 All piles shall be braced to provide lateral stability in all directions. Three or more piles connected by a rigid cap shall be considered as being 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 piles shall be subject to the approval of the building official.

1805.6.2 Piles supporting walls shall be driven alternately in lines spaced at least 1 ft (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 may be used for one- and two-family dwellings and lightweight construction not exceeding two stories or 35 ft (11 m) in height provided the centers of the piles are located within the width of the foundation wall.

1805.7 Structural integrity. Piles shall be installed in such a manner and sequence as to prevent distortion or damage to piles being installed or already in place to the extent that such distortion or damage affects the structural integrity of the piles.

1805.8 Spacing. The minimum center-to-center spacing of piles shall be not less than twice the average diameter of a round pile, nor less than 1 3/4 times the diagonal dimension of a rectangular pile. When driven to or penetrating into rocks, the spacing shall be not less than 24 inches (610 mm). When receiving principal support from end bearing on materials other than rock, or through frictional resistance, the spacing shall be not less than 30 inches (762 mm) except for piles having enlarged bases formed either by compacting concrete or driving a precast base the minimum center-to-center spacing shall be 54 inches (1372 mm). The spacing of piles shall be such that the average load on the supporting strata will not exceed the safe bearing value of those strata as determined by test borings or other approved methods.

1805.9 Splices. Splices shall be constructed so as to provide and maintain true alignment and position of the component parts of the 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% of the least value of the pile in bending. In addition, all pile splices occurring in the upper 10 ft (3048 mm) of the embedded portion of the pile shall be capable of resisting at allowable working stresses the moment and shear that would result from an assumed eccentricity of the pile load of 3 inches (76 mm) or the pile shall be braced in accordance with 1805.6 to other piles that do not have splices in the upper 10 ft (3048 mm) of embedment.

1805.10 Pile caps

1805.10.1 All pile caps. Pile caps shall be of reinforced concrete. The soil immediately below the pile cap shall not be considered as carrying any vertical load. The tops of all 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 all piles. The tops of all piles shall be cut back to sound material before capping.

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1805.11 Pre-excavation. The use of jetting, augering, or other methods of pre-excavation shall be subject to the approval of the building official. When permitted, pre-excavation shall be carried out in the same manner as used for piles subject to load tests and in a manner that will not impair the carrying capacity of the piles already in place or damage adjacent structures. Pile tips shall be driven below the pre-excavated depth until the required resistance or penetration is obtained.

1805.12 Inspection. A qualified inspector approved by the building official shall be present when pile foundations are being installed and during tests. The inspector shall make and submit to the building official detailed records of the installation of each pile and the results of load tests. Records shall include the cutoff and tip elevation of each pile relative to a permanent reference.

1805.13 Identification. All 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.

1805.14 Pile location plan. A plan showing the location and designation of all piles by an identifying system shall be filed with the building official prior to installation of such piles. All detailed records for individual piles shall bear an identification corresponding to that shown on the plan.

1805.15 Use of existing piles. Piles left in place where a structure has been demolished shall not be used for the support for new construction unless satisfactory evidence is submitted to the building official indicating that the piles are sound and meet all the requirements of this code. Such piles shall be load tested or redriven to verify their capacity. The design load applied to such piles shall be the lowest allowable load as determined by tests or redriving data.

1805.16 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.

1805.17 Heaved piles. All piles that have heaved during the driving of adjacent piles shall be redriven as necessary to develop the required capacity and penetration or the capacity of the pile shall be verified by load test in accordance with 1806.4.

1805.18 Settlement analysis. The settlement of individual piles or groups of piles shall be estimated based upon accepted methods of analysis. The predicted settlement shall not cause harmful distortion of or instability in the structure nor shall it lead to any stresses exceeding allowable values.

1805.19 Use of vibratory drivers. Vibratory drivers may be used to install piles only if pile load capacity is verified by load tests in accordance with 1806.4. The installation of production piles shall be controlled according to power consumption and rate of penetration or other means acceptable to the building official that assures pile capacities equal or exceeding that of test piles.

1805.20 Installation sequence. Piles shall be installed in such sequence that the soil surrounding the piles is not compacted to the extent that other piles cannot be installed properly and that ground movements that could damage adjacent structures are prevented.

SECTION 1806
ALLOWABLE PILE LOAD

1806.1 Determination of allowable loads. The allowable axial and lateral loads on piles shall be determined by an approved formula, load tests or method of analysis.

1806.2 Piles in subsiding areas. Where piles are driven through subsiding fills or other subsiding strata and derive support from underlying firmer materials, the downward frictional forces which are imposed on piles by the subsiding upper strata shall be included in the design.

1806.3 Driving formula. The allowable compressive load on any pile when determined by the application of an approved driving formula shall not exceed 40 tons (356 kN). The formula 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 shall be permitted only with the approval of the building official. The introduction of fresh hammer cushion or pile cushion material just prior to final penetration shall not be permitted.

1806.4 Load tests. When greater compressive loads per pile than permitted by 1806.3 are desired or when the design load for any pile foundation is in doubt, control test piles shall be tested in accordance with ASTM D 1143. At least one pile shall be test loaded in each area of uniform subsoil conditions. When required by the building official, additional piles shall be load tested if necessary to establish the safe design capacity. The resulting allowable load shall be not more than one-half of that test load which produces a permanent net settlement per ton of test load of not more than 0.01 inch (0.25 mm), but in no case more than 3/4 inch (19 mm). In subsequent driving of the balance of foundation piles, all piles shall be deemed to have a supporting capacity equal to the control pile when 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 when the rate of penetration of such piles is equal to or less than that of the test pile through a comparable driving distance.

1806.5 Use of higher allowable stresses

1806.5.1 Allowable stresses greater than those specified for each pile type in 1807 through 1813 shall be permitted

1808.5 Placing concrete. Placing concrete shall conform to 1809.1.3.

SECTION 1809
CAST-IN-PLACE CONCRETE PILES

1809.1 General

1809.1.1 Material. All concrete shall have a 28-day specified compressive strength f'_c of not less than 2,500 psi (17 238 kPa). When 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). If concrete is to be pumped, the mix design including slump shall be adjusted to produce a pumpable concrete.

1809.1.2 Reinforcement. Except for steel dowels embedded 5 ft (1524 mm) or less in the pile and as provided in 1809.2, reinforcement when 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.

1809.1.3 Installation. Concrete shall be placed in such a manner as to insure the exclusion of any foreign matter and to secure a full-sized shaft. Concrete shall not be placed through water except when tremie methods are approved by the building official. 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.

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1809.2 Drilled or augered uncased piles

1809.2.1 Allowable stresses. The allowable design stress in the concrete of drilled uncased piles shall not exceed 0.33 f'_c. The allowable design stress in the concrete of augered cast-in-place piles shall not exceed 0.25 f'_c .

1809.2.2 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 piles shall be permitted to exceed 30 times the diameter, provided the design and installation of the pile foundation is under the direct supervision of a registered professional engineer knowledgeable in the field of soil mechanics and pile foundations. He shall certify to the building official that the piles as installed satisfy the design criteria.

1809.2.3 Installation

1809.2.3.1 If 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 concrete. If the steel liner is withdrawn during concreting, the level of concrete shall be maintained above the bottom of the liner a sufficient height to offset any hydrostatic or lateral soil pressure.

1809.2.3.2 If concrete is placed by pumping through a hollow-stem auger, the auger shall not be permitted to rotate during withdrawal and shall be withdrawn in a steady continuous motion. Concreting pumping pressures shall be measured and shall be maintained high enough at all times to offset hydrostatic and lateral earth pressures. Concrete volumes shall be measured to insure 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. If the installation process of any pile is interrupted or a loss of concreting pressure occurs, the pile shall be redrilled to original depth and reformed. Augered cast-in-place piles shall not be installed within 6 pile diameters center-to-center of a pile filled with concrete less than 24 hours old unless approved by the building official. If the concrete level in any completed pile drops, the pile shall be rejected and replaced.

1809.2.4 Reinforcement. For piles installed with a hollow stem auger, longitudinal steel reinforcement may be placed without lateral ties provided it is placed through ducts in the auger prior to filling the pile with concrete. All pile reinforcement shall have a concrete cover of not less than 2½ inches (64 mm).

1809.3 Driven uncased piles

1809.3.1 Allowable stress. The allowable design stress in the concrete shall not exceed 0.25 f'_c applied to a cross-sectional area not greater than the inside area of the drive casing or mandrel.

1809.3.2 Dimensions. The pile length shall not exceed 30 times the average diameter. The minimum diameter shall be 12 inches (305 mm).

1809.3.3 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 rejected and replaced. Piles shall not be installed in soils which could cause pile heave.

1809.3.4 Concrete cover. All pile reinforcement shall have a concrete cover of not less than 2½ inches (64 mm) measured from the inside face of the drive casing or mandrel.

1809.4 Enlarged base piles

1809.4.1 Materials. The maximum size for coarse aggregate for all concrete shall be ¾ inch (19 mm). Compacted concrete shall have a zero slump.

1809.4.2 Allowable stress. The allowable design compressive stress in the concrete shall not exceed 0.25 f'_c except that where the concrete is placed in a permanent steel casing the allowable concrete stress may be increased to 0.33 f'_c.

when supporting data justifying such higher stresses is filed with the building official. Such substantiating data shall include:

1. A foundation investigation in accordance with 1805.1.
2. Pile load tests in accordance with 1806.4 regardless of the load supported by the pile.

1806.5.2 The design and installation of the pile foundation shall be under the direct supervision of a registered professional engineer knowledgeable in the field of soil mechanics and pile foundations who shall certify to the building official that the piles as installed satisfy the design criteria.

1806.6 Allowable lateral load. When required by the design, the lateral load capacity of 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 be not more than one-half of that test load which produces a gross lateral movement of 1 inch (25.4 mm) at the ground surface.

1806.7 Uplift capacity. When required by the design, the uplift capacity of a single pile shall be determined in accordance with ASTM D 3689 or an approved method of analysis based upon a minimum factor of safety of three. The maximum allowable uplift load shall be one-half that load which produces an upward movement of the pile but equal to the gross elastic extension of the pile plus 0.1 inch (2.5 mm). 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, or
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.

1806.8 Bearing capacity. Individual piles and groups of piles shall develop ultimate load capacities of at least twice the design working loads in the designated bearing layers. Analysis shall show that no soil layer underlying the designated bearing layers causes the bearing capacity safety factor to be less than two.

1806.9 Bent piles. The load-carrying capacity of piles discovered to have a sharp or sweeping bend may be determined by an approved method of analysis or by load testing a representative pile.

1806.10 Overloads on piles. The maximum compressive load on any pile caused by mislocation shall not exceed 110 percent of the allowable design load.

SECTION 1807
STRUCTURAL STEEL PILES

1807.1 Materials. Structural steel piles, steel pipe and fully welded steel piles fabricated from plates, shall conform to one of the following specifications: ASTM A 36, ASTM A 252, ASTM A 283, ASTM A 572, ASTM A 588, ASTM A 690.

1807.2 Allowable stresses. The allowable design compressive stress shall not exceed 0.35 of the minimum specified yield strength of the steel, except the allowable design stress may be increased up to 50 percent of the minimum specified yield strength of the steel where substantiated by 1806.5.

1807.3 Minimum dimensions

1807.3.1 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 be not less than 80% of the depth of the section.
2. The nominal depth in the direction of the web shall be not less than 8 inches (203 mm).
3. Flanges and web shall have a minimum nominal thickness of 3/8 inch (9.5 mm).

1807.3.2 Steel pipe piles. Steel pipe piles driven open ended shall have a nominal outside diameter of not less than 10 inches (254 mm) and a minimum wall thickness of 0.25 inch (6.4 mm) for diameters less than 14 inches (356 mm) and a minimum wall thickness of 0.375 inch (9.5 mm) for diameters 14 inches (356 mm) and over. Pipe of less wall thickness may be driven open ended if a suitable cutting shoe is provided. ☆

SECTION 1808
CONCRETE-FILLED STEEL PIPE AND TUBE PILES

1808.1 Material

1808.1.1 Steel pipe and tube piles shall conform to one of the following specifications: ASTM A 252, ASTM A 283.

1808.1.2 Concrete shall conform to 1809.1.1. The maximum size coarse aggregate shall be 3/4 inch (19 mm).

1808.2 Allowable stresses. The allowable design compressive stress in the concrete shall not exceed 0.33 f'_c. The allowable design compressive stress in the steel shall not exceed 0.35 of the minimum specified yield strength of the steel, except that the allowable design compressive stress may be increased up to 50% of the minimum specified yield strength of the steel where substantiated by 1806.5.

1808.3 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 1807.3.2 except that for mandrel-driven pipe piles the minimum wall thickness may be 0.10 inch (2.5 mm).

1808.4 Reinforcement

1808.4.1 Reinforcement steel shall conform to 1809.1.2. Reinforcement shall not be placed within 1 inch (25.4 mm) of the steel casing. ☆

1809.4.3 Installation. Enlarged bases formed either by compacting concrete or driving a precast base shall be formed in or driven into granular soils. All 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. If a case shaft is used, it shall be adequately reinforced to resist column action or the annular space around the pile shaft shall be filled sufficiently to reestablish the lateral support of the soil. If pile heave occurs, the pile shall be rejected unless it can be demonstrated that the pile is undamaged and capable of carrying twice its design load.

1809.4.4 Bearing capacity. Pile bearing capacity shall be verified by load tests in accordance with 1806.4.

1809.4.5 Concrete cover. The minimum concrete cover shall be 2 1/2 inches (64 mm) for uncased shafts and 1 inch (25.4 mm) for cased shafts.

1809.5 Steel cased piles

1809.5.1 Material. 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).

1809.5.2 Allowable stresses. The allowable design compressive stress in the concrete shall not exceed 0.33 f'_c except that the allowable concrete stress may be increased to a maximum value of 0.40 f'_c for that portion of the pile meeting the following conditions:

1. The thickness of the steel shell is not less than 0.075 inch (1.9 mm) minimum.
2. The shell is seamless or is provided with seams of strength equal to the basic material and is of a configuration which will provide confinement to the cast-in-place concrete.
3. The ratio of steel yield strength, f_y, to design f'_c shall be not less than six.
4. The nominal pile diameter is not greater than 16 inches (406 mm).

1809.5.3 Installation. Piles shall have steel shells mandrel-driven their full length in contact with the surrounding soil left permanently in place and filled with concrete. No pile shall be driven within 4 1/2 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.

1809.5.4 Reinforcement. Reinforcement shall not be placed within 1 inch (25.4 mm) of the steel shell. Reinforcing shall be considered necessary only for unsupported pile lengths or when the pile is designed to resist uplift or unbalanced lateral loads.

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SECTION 1810
PRECAST CONCRETE PILES

1810.1 General

1810.1.1 Design and manufacture. All piles shall be designed and manufactured in accordance with accepted practice and to resist all stresses induced by handling, driving and service loads. The minimum lateral dimension shall be 8 inches (203 mm). All corners of square piles shall be chamfered. Longitudinal steel shall be arranged in a symmetrical pattern and shall be laterally tied with steel ties or wire spiral spaced not more than 3 inches (76 mm) apart center-to-center for a distance of 2 ft (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 (25.4 mm) center-to-center.

1810.1.2 Installation. All piles shall be handled and driven so as not to cause injury or overstressing which will affect their durability or strength.

1810.2 Reinforced piles

1810.2.1 Design. The minimum amount of longitudinal reinforcement expressed as a percentage of the gross cross-sectional area of the pile shall be 1% for piles 40 ft (12 m) and shorter and 1 1/2% for piles longer than 40 ft (12 m) and shall consist of at least four bars.

1810.2.2 Material. All concrete shall have a 28 day specified strength f'_c of not less than 4,000 psi (28 MPa).

1810.2.3 Allowable stress. The allowable compressive stress in the concrete shall not exceed 0.33 f'_c applied to the gross cross-sectional area of the pile. The allowable compressive stress in the reinforcing steel shall not exceed 0.40 f_y or a maximum of 30,000 psi (207 MPa). The allowable tensile stress in the reinforcing steel shall not exceed 0.50 f_y or a maximum of 24,000 psi (165 MPa).

1810.2.4 Concrete cover

1810.2.4.1 Reinforcement for piles cast in the field shall have a concrete cover of not less than 2 inches (51 mm).

1810.2.4.2 Reinforcement for piles manufactured under plant control conditions shall have a concrete cover of not less than 1 1/4 inches (32 mm) for #5 bars and smaller, and not less than 1 1/2 inches (38 mm) for #6 through #11 bars except that longitudinal bars spaced less than 1 1/2 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.

1810.2.4.3 Reinforcement for piles not manufactured under plant control conditions shall have a concrete cover of not less than 2 inches (51 mm).

1810.2.4.4 Reinforcement for all piles exposed to sea water shall have a concrete cover of not less than 3 inches (76 mm).

1810.2.5 Installation. A precast concrete pile shall not be driven before the concrete has attained a compressive strength of at least 0.75 f'_c except that in all cases the concrete strength shall be sufficient to withstand handling and driving forces.

1810.3 Prestressed piles

1810.3.1 Design. The effective prestress in the pile shall be not less than 700 psi (4827 kPa).

1810.3.2 Material. Prestressing steel shall conform to ASTM A 416. All concrete shall have a 28 day specified compressive strength f'_c of not less than 5,000 psi (34 MPa).

1810.3.3 Allowable stress. The maximum allowable design compressive stress f'_c in concrete shall be determined as follows:

$$f_c = 0.33\, f'_c - 0.27 f_{pc}$$

Where:

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

1810.3.4 Installation. A prestressed pile shall not be driven before the concrete has attained a compressive strength of at least 0.75 f'_c except that in all cases the concrete shall be of sufficient strength to withstand handling and driving forces.

1810.3.5 Concrete cover. All prestressing steel and pile reinforcement shall have a concrete cover of not less than 1 1/4 inches (32 mm) for square piles of 12 inches (305 mm) or smaller size and 1½ inches (38 mm) for larger piles except that for piles exposed to sea water, the minimum protective concrete cover shall be not less than 2 1/2 inches (64 mm).

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SECTION 1811
TIMBER PILES

1811.1 Materials. Timber piles shall conform ASTM D 25.

1811.2 Preservative treatment

1811.2.1 Timber piles used to support permanent structures shall be treated in accordance with this section unless it is established that the tops of untreated timber piles will be below lowest ground water level assumed to exist during the life of the structure.

1811.2.2 Preservative and minimum final retention shall be in accordance with AWPA Standard C 3.

1811.2.3 Preservative and minimum final retention for sawn timber piles shall be in accordance with AWPA Standard C 24.

1811.2.4 When timber piles are used in salt water, the treatment shall conform to AWPA C 18.

1811.2.5 Pile cutoffs shall be treated in accordance with AWPA M 4.

1811.3 Allowable stresses. The allowable stresses for treated round timber piles shall not exceed those set forth in Table 1811.3.

1811.4 End bearing piles. Any sudden decrease in driving resistance of an end bearing timber pile shall be investigated with regard to the possibility of damage and if the sudden decrease in driving resistance cannot be correlated to bearing data, the pile shall be removed for inspection or rejected.

SECTION 1812
COMPOSITE PILES

1812.1 Design. Composite piles consisting of two or more approved pile types shall be designed to meet the conditions of installation.

1812.2 Limitation of load. The maximum allowable load shall be limited by the capacity of the weakest section incorporated into the pile.

1812.3 Splices. Splices between concrete sections and steel or wood sections shall be designed to prevent separation of the sections both before and after the concrete portion has been set, and to insure the alignment and transmission of the total pile load. Splices shall be designed to resist uplift due to upheaval during driving of adjacent piles and shall develop the full compressive strength and not less than 50 percent of the strength in tension and bending of the weaker section.

SECTION 1813
CAISSON PILES

1813.1 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.

1813.2 Design. The depth of the rock socket shall be sufficient to develop the full loadbearing capacity of the caisson pile with a minimum factor of safety of two but the depth shall be not less than the outside diameter of the pipe. The design of the rock socket may be predicated on the sum of the allowable 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 pipe.

TABLE 1811.3
ALLOWABLE UNIT STRESSES FOR TREATED ROUND TIMBER PILES, NORMAL LOAD DURATION VALUES AT TIP OF PILE

SPECIES	COMPRESSION PARALLEL TO GRAIN, psi[4]	BENDING, psi[4]	SHEAR HORIZONTAL psi[4]	COMPRESSION PERPENDICULAR TO GRAIN, psi[4]	MODULUS OF ELASTICITY, psi
Pacific Coast Douglas Fir[1]	1,250	2,450	115	230	1,500,000
Southern Pine[1, 2]	1,200	2,400	110	250	1,500,000
Red Oak[3]	1,200	2,450	135	350	1,250,000
Red Pine[5]	900	1,900	85	155	1,280,000

For SI: 1 psi = 6.8948 kPa.

Notes:

1. The allowable unit stresses in compression parallel to grain for Pacific Coast Douglas Fir and Southern Pine may be increased 0.2% for each foot of length from the tip of the pile to the critical section. The increase shall not exceed 10% for any pile. The stress increase is cumulative with increase in section properties due to pile taper.
2. Southern Pine values apply to Longleaf, Slash, Loblolly and Shortleaf Pines.
3. Red Oak values apply to Northern and Southern Red Oak.
4. The working stresses in the above table have been adjusted to compensate for strength reductions caused by conditioning prior to treatment. Where piles are air dried or kiln dried prior to pressure treatment, or where untreated piles are to be used, the above working stresses shall be increased by multiplying the tabulated values by the following factors:
   Pacific Coast Douglas Fir, Red Oak, Red Pine 1.11
   Southern Pine 1.18
5. Red Pine values apply to Red Pine grown in the United States.

1813.3 Material. Pipe and steel cores shall conform to the material requirements in 1807. Pipe shall have a minimum wall thickness of 3/8 inch (9.5 mm) and shall be fitted with a suitable steel driving shoe welded to the bottom of the pipe. All concrete shall have a 28-day specified compressive strength f'_c of not less than 4,000 psi (28 MPa). The concrete mix shall be designed and proportioned so as to produce a cohesive workable mix with a slump of from 4 to 6 inches (102 to 152 mm).

1813.4 Structural core. The gross plan area of the structural steel core shall not exceed 25 percent of the gross caisson section. The minimum clearance between the structural core and the pipe shall be 2 inches (51 mm). If cores are to be spliced, the ends shall be milled or ground to provide full contact and shall be full depth welded.

1813.5 Allowable stresses. The allowable design compressive stresses shall not exceed the following: concrete, 0.33 f'_c; steel pipe, 0.35 f_y; structural steel core, 0.50 f_y.

1813.6 Installation. The rock socket and pipe shall be thoroughly cleaned of all foreign materials before filling with concrete. Steel cores shall be bedded to cement grout at the base of the rock socket. Concrete shall not be placed through water except when tremie methods are approved by the building official.

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SECTION 1814
WATERPROOFING AND DAMPPROOFING

1814.1 Where required. Where a groundwater table investigation indicates that hydrostatic pressure conditions exist, walls and floors retaining earth and enclosing spaces below finished ground level shall be waterproofed in accordance with 1814.2. Where hydrostatic pressure conditions do not exist, dampproofing and perimeter drainage shall be provided in accordance with 1814.3.

Exception: See 1804.8 for dampproofing of wood foundations.

1814.1.1 Organic-solvent-based products such as hydrocarbons, chlorinated hydrocarbons, ketones and esters shall not be used for ICF walls with expanded polystyrene form material.

1814.2 Waterproofing

1814.2.1 Surfaces to be waterproofed shall be prepared in accordance with the waterproofing manufacturer's recommendations.

1814.2.2 Waterproofing shall be applied from the top of the footing to not less than 6 inches (152 mm) above finish grade.

1814.2.3 Waterproofing shall consist of one of the following systems:

1. 3-ply hot mopped felts.
2. Bentonite clay layer at a minimum 0.75 lb/sq ft (3.7 kg/m^2).
3. 50 mil (1.3 mm) rubberized asphalt sheet or liquid.
4. 40 mil (1.0 mm) polymer modified asphalt.
5. 40 mil (1.0 mm) polyurethane rubber.
6. 20 mil (0.5 mm) single ply vulcanized rubber or thermoplastic sheet.
7. Other approved methods or materials capable of bridging nonstructural cracks.

1814.2.4 Wall and floor joints and penetrations shall be made water tight using approved methods and materials.

1814.2.5 Floor waterproofing shall consist of any material approved for waterproofing in 1814.2.3, with joints lapped and sealed in accordance with the waterproofing manufacturer's recommendations.

1814.3 Dampproofing

1814.3.1 Wall surfaces to be dampproofed shall have all holes and recesses, including those resulting from removal of form ties, sealed with a bituminous or other approved material.

1814.3.2 Dampproofing shall be applied to the exterior surface of walls from a point 12 inches (305 mm) below the top of the lowest slab to not less than 6 inches (152 mm) above finish grade.

1814.3.3 Dampproofing applied beneath the floor slab shall consist of 6 mil (0.15 mm) minimum polyethylene with joints lapped not less than 6 inches (152 mm) and taped, or other approved materials having a maximum perm rating of 0.5. Where installed below the finished walking surface, dampproofing shall consist of mopped-on bitumen, 4 mil (0.10 mm) minimum polyethylene, or other approved materials having a maximum perm rating of 0.5 [2.873 x 10^{-5} mg/(Pa • s • m^2)], with joints lapped and sealed in accordance with the dampproofing manufacturers recommendations.

1814.3.4 Wall dampproofing shall consist of one of the following systems:

1. 3/8-inch (9.5 mm) portland cement parging with a 1/16-inch (1.6 mm) bituminous coating
2. 1/8-inch (3.2 mm) bituminous coating
3. 1/8-inch (3.2 mm) cementitious coating
4. 1/8-inch (3.2 mm) surface bonding mortar
5. 40 mil (1.02 mm) acrylic latex coating
6. 1/16-inch (1.6 mm) bituminous coating over concrete
7. 6 mil (0.152 mm) polyethylene over 1/16 inch (1.6 mm) bituminous coating applied to masonry.
8. Acrylic modified cement base coating at a total minimum thickness of 3 lb per sq yd (1.6 kg/m^2).
9. Any material approved for waterproofing in 1814.2.3.

1814.3.5 When dampproofing is required, perimeter drainage shall be provided in accordance with either 1814.3.5.1 or 1814.3.5.2. The foundation perimeter drain shall have a minimum slope of 0.33 percent and discharge by gravity or mechanical means into an approved drainage system.

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

1814.3.5.1 Method 1. A drain, consisting of gravel or crushed stone containing not more than 10% material that passes a No. 4 sieve, shall be placed around the perimeter of the foundation. The drain shall extend 12 inches (305 mm) minimum 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 the top of the drain is not less than 12 inches (305 mm) above the top of the footing. The top of the gravel or crushed stone drain shall be covered with an approved filter membrane material.

1814.3.5.2 Method 2. A drain tile or perforated pipe shall be placed around the perimeter of a foundation. The invert of the pipe or tile shall be no 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 containing not more than 10 percent material that passes a No. 4 sieve and covered with not less than 6 inches (152 mm) of the same material. The gravel or crushed stone shall extend 12 inches (305 mm) minimum beyond the outside edge of the footing. The top of the gravel or crushed stone shall be covered with an approved filter membrane.

1814.4 Backfilling. Backfill shall be placed in lifts and compacted in a manner which does not damage the waterproofing or dampproofing material, or the foundation wall.

SECTION 1815
RETAINING WALLS

1815.1 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.

1815.2 Design. Retaining walls shall be designed to resist the design lateral soil loads in 1608.1, 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.

1815.3 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.

1815.4 Reinforced masonry retaining walls. Vertical reinforcement for masonry retaining walls shall comply with Table 1815.4 or shall be designed in accordance with ACI 530/ASCE 5/TMS 402. Masonry shall be fully grouted with a minimum f'm of 1500 psi. 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 1815.4 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.

1815.5 Segmental Retaining Walls. Segmental retaining walls shall be designed in accordance with NCMA Design Manual for Segmental Retaining Walls.

SECTION 1816
TERMITE PROTECTION

1816.1 Termite Protection. Termite protection shall be provided by registered termiticides or other approved methods of termite protection labeled for use as a preventative treatment to new construction.

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 mil 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 distubing 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.

TABLE 1815.4
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/m³), of:		
		30 (4.7)	45 (7.1)	60 (9.4)
8 (203)	4.0 (1.2)	#4 @ 64 in.	#4 @ 40 in.	#4 @ 32 in.
	4.7 (1.4)	#4 @ 40 in.	#4 @ 24 in.	#4 @ 16 in.
	5.3 (1.6)	#4 @ 24 in.	#4 @ 16 in.	#5 @ 16 in.
	6.0 (1.8)	#5 @ 24 in.	#6 @ 16 in.	#8 @ 16 in.
	6.7 (2.0)	#5 @ 16 in.	#6 @ 8 in.	=
10 (254)	4.0 (1.2)	#4 @ 72 in.	#4 @ 64 in.	#4 @ 48 in.
	4.7 (1.4)	#4 @ 56 in.	#4 @ 40 in.	#4 @ 24 in.
	5.3 (1.6)	#4 @ 40 in.	#4 @ 24 in.	#4 @ 16 in.
	6.0 (1.8)	#4 @ 24 in.	#4 @ 16 in.	#5 @ 16 in.
	6.7 (2.0)	#4 @ 16 in.	#5 @ 16 in.	#6 @ 16 in.
	7.3 (2.2)	#5 @ 24 in.	#6 @ 16 in.	#6 @ 8 in.
	8.0 (2.4)	#5 @ 16 in.	#6 @ 8 in.	=
12 (305)	4.0 (1.2)	#4 @ 72 in.	#4 @ 72 in.	#4 @ 64 in.
	4.7 (1.4)	#4 @ 72 in.	#4 @ 48 in.	#4 @ 40 in.
	5.3 (1.6)	#4 @ 48 in.	#4 @ 32 in.	#4 @ 24 in.
	6.0 (1.8)	#4 @ 32 in.	#4 @ 24 in.	#4 @ 16 in.
	6.7 (2.0)	#4 @ 24 in.	#4 @ 16 in.	#5 @ 16 in.
	7.3 (2.2)	#4 @ 16 in.	#5 @ 16 in.	#6 @ 16 in.
	8.0 (2.4)	#5 @ 24 in.	#5 @ 16 in.	#7 @ 16 in.
	8.7 (2.7)	#5 @ 16 in.	#7 @ 16 in.	#7 @ 8 in.
	9.3 (2.8)	#6 @ 16 in.	#7 @ 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.

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 Termite protection. All buildings shall have pre-construction treatment protection against subterranean termites. The rules and laws as established by the Florida Department of Agriculture and Consumer Services shall be deemed as approved with respect to pre-construction soil treatment for protection against subterranean termites. 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."

1816.2 Penetration. Protective sleeves around metallic piping penetrating concrete slab-on-grade floors shall not be of cellulose-containing materials and 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 Florida Statute 553.60, "Trench Safety Act," and 29-CFR1926-650 (P) "Occupational Safety and Health Administration Excavation Safety Act." No excavation, for any purpose, shall extend within 1'-0" 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 may order the work stopped or may approve the work of excavation subject to such limitations, as he 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 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 by way of recognized tests or rational analysis and shall meet or exceed the design bearing capacity identified under 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 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

Based on rational analysis and soil investigation as set forth in section 2402, 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 than16 inches nor less than 8 inches more than the width of the 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.

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)
2000	Less than or equal to 3 feet	12 x 16
2000	Greater than 3 feet but less than and including 6 feet	12 x 36
2000	Greater than 6 feet	None Provided[1]

Notes:

(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 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 than16 inches nor less than 8 inches 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 below grade.

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

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

1819.3.1 Where footings are 30 inches 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 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 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 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 of concrete for bars larger than #5 and 1 1/2 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 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 below grade.

1819.5 Isolated footings. Dimensions for an isolated footing shall not be less than 12 inches deep and 24 inches square. 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 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 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 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 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 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 for purpose of computing lateral pressure.

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

P = applied lateral force, pounds.

S_1 = 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.

S_3 = 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.

$$d^2 = 4.25(Ph/S_3 b)$$

or alternately

$$d^2 = 4.25(M_g/S_3 b)$$

Where:

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

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	
2. Sandy gravel and/or gravel	200	0.35	
3. Sand, silty sand, clayey sand, silty grave land clayey gravel	150	0.25	
4. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt	100		130

NOTES

a. Coefficient to be multiplied by the dead load

b. Lateral sliding resistance to be multiplied by the contact area, as limited by 1819.6.

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 below the floor slab in compacted fill shall be 3 inches 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 in thickness, reinforced with not less than 0.028 square inches 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 95 percent of maximum dry density for all layers, as verified by field density tests specified in 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 hammer dropping 18 inches. In addition, a minimum of one in-place field density test shall be performed for each 2500 sq ft, 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 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 in. (203 mm) deep and 8 in. (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 larger on all sides than the garbage receptacle (Dumpster) and a minimum thickness of 6 inches.

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 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 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	16 x 16 (1)
2000	2	16 x 24

Based on rational analysis and soil investigation as set forth in 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 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 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

1821.1.8 Where footings are 30 inches 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 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 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 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 of concrete for bars larger than #5 and 1 1/2 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 on center and shall be no less than 5 feet 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 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, 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 3/4 times the diagonal dimensions of rectangular piles but in no case less than 30 inches. 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 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 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 beyond the extreme pile surface and vertically not less than 4 inches below the pile butt. Pile caps may be omitted when piles are used to support grade beams, provided that the spacing of 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 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 indictor 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 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:

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

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 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 7000 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 3000 pounds and the fall of the hammer shall not exceed 6 feet.

1822.1.19 Piles shall be driven with a variation of not more than 1/4 inch per foot from the vertical, or from the batter line indicted, with a maximum variation of the head of the pile from the position shown on the plans of not more than 3 inches, subject to the provisions of 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 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 nor jetted closer than 10 feet 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 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: $$P = \frac{2(W + Ap)^h}{S + 0.1}$$

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

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 the Standard, Round Timber Piles, ASTM D 25.

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 AWPB Standard C3.

1823.1.4 When timber piles are used in salt water, the treatment shall conform to AWPB Standard MP-1, MP-2 or MP-4. Pile cutoffs shall be treated in accordance with AWPB Standard 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 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 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 3000 pounds per square inch 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 in the body of the pile and not over 3 inches for the first 18 inches from both the butt and the tip. All reinforcement shall be protected by 2 inches or more of concrete, except that for piles subjected to the action of open water, waves or other severe exposure, a 3-inch 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 7 days for Type I cement and 3 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 1824

Size (Inches)	Maximum Load (tons)
10 x 10	17
12 x 12	25
14 x 14	35

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 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 5000 psi at time of driving and 3000 psi 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 of concrete and shall be tied by #2 hoops or #5 AS&W gage spirals spaced at 8 inches in the body of piling 14 inches or smaller or 9 inches in the body of piling 16 inches or larger and not over 3 inches for the first 18 inches from both the butt and the tip.

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]	1250	2450	115	230	1,500,000
Southern Pine [2]	1200	2400	110	250	1,500,000
Red Oak [3]	1100	2450	135	350	1,250,000
Red Pine [4]	900	1900	85	155	1,280,000

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.

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 3000 pounds per square inch 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 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 $0.25f'_c$ 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.

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 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 per hour. The total load shall be maintained until settlement does not exceed 0.01 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 per ton of test load, a gross settlement of 1 inch (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 3 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 1500 pounds per square foot 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 1500 pounds per square foot 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 1823.1.1.

1830.2 Detailed requirements.

1830.2.1 The thickness of the foundation wall shall be not less than 8 inches.

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, plus 4 inches for the bearing of joists.

1830.2.3 Foundations of unit masonry supporting joists *shall be capped with 4 inches of concrete.*

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

1830.3.1 Interior foundation walls that support stud walls shall be exempted from the additional 4 inches 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 of concrete cover.

1830.4.2 Grade beams shall be the thickness of the wall they support but never less than 8 inches 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 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 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% dry weight of organic content in any undisturbed sample.

1834.2.2 Dynamic compaction, vibro-compaction, 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.