CHAPTER 18*A*

SOILS AND FOUNDATIONS

Adopt and/or codify chapter as amended below:

PROPOSED ADOPTION	DSA-SS	DSA-SS/CC	Comments
Adopt entire chapter WITHOUT AMENDMENTS			
Adopt entire chapter as amended	**X**	**X**	
Adopt only those sections listed below			

(All existing California amendments that are not revised below shall continue without change)

DRAFT INITIAL EXPRESS TERMS

SECTION 1801*A*
GENERAL

1801*A*.1 Scope. The provisions of this chapter shall apply to building and foundation systems.

~~*Refer to Appendix J, Grading, for requirements governing grading, excavation and earthwork construction, including fills and embankments.*~~

1801A.1.1 Application. *The scope of application of Chapter 18A is as follows:*

1. *Structures regulated by the Division of the State Architect—Structural Safety, which include those applications listed in Section 1.9.2.1 (DSA-SS), and 1.9.2.2 (DSA-SS/CC). These applications include public elementary and secondary schools, community colleges and state-owned or state-leased essential services buildings*

2. ***[Reserved for OSHPD]***

1801A.1.2 Amendments in this chapter. *DSA –SS & DSA –SS/CC adopt this chapter and all amendments.*

> ***Exception:*** *Amendments adopted by only one agency appear in this chapter preceded with the appropriate acronym of the adopting agency, as follows:*
>
> ***1.*** *Division of the State Architect-Structural Safety:*
> ***[DSA-SS]*** *For applications listed in Section 1.9.2.1.*
> ***[DSA-SS/CC]*** *For applications listed in Section 1.9.2.2.*
>
> ***2.*** ***[Reserved for OSHPD]***

1801A.1.3 Reference to other chapters.

1801A.1.3.1 ***[DSA-SS/CC]*** *Where reference within this chapter is made to sections in Chapters 16A,19A, 21A, and 22A, ~~and 34A~~, the provisions in Chapters 16, 19, 21, and 22, ~~and 34~~ respectively shall apply instead.*

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SECTION 1803*A*
GEOTECHNICAL INVESTIGATIONS

1803*A*.1 General. Geotechnical investigations shall be conducted in accordance with Section 1803*A*.2 and reported in accordance with Section ~~1803.6~~ *1803A.7*. ~~Where required by the *building official* or where geotechnical investigations involve in-situ testing, laboratory testing or engineering calculations, such investigations shall be conducted by a *registered design professional*.~~ *The classification and investigation of the soil shall be made under the responsible charge of a California registered geotechnical engineer. All recommendations contained in geotechnical and geohazard reports shall be subject to the approval of the enforcement agency. All reports shall be prepared and signed by a registered geotechnical engineer, certified engineering geologist, and a registered geophysicist, where applicable.*

1803*A*.2 Investigations required. Geotechnical investigations shall be conducted in accordance with Sections 1803*A*.3 through ~~1803*A*.5~~ *1803A.6*.

Exceptions: ~~The *building official* shall be permitted to waive the requirement for a geotechnical investigation where satisfactory data from adjacent areas is available that demonstrates an investigation is not necessary for any of the conditions in Sections 1803.5.1 through 1803.5.6 and Sections 1803.5.10 and 1803.5.11.~~

1. *Geotechnical reports are not required for one-story, wood-frame and light-steel-frame buildings of Type II or Type V construction and 4,000 square feet (371 m^2) or less in floor area, not located within Earthquake Fault Zones or Seismic Hazard Zones as shown in the most recently published maps from the California Geological Survey (CGS) or in seismic hazard zones as defined in the Safety Element of the local General Plan. Allowable foundation and lateral soil pressure values may be determined from Table 1806A.2.*

2. *A previous report for a specific site may be resubmitted, provided that a reevaluation is made and the report is found to be currently appropriate.*

…

1803*A*.3 Basis of investigation. Soil classification shall be based on observation and any necessary tests of the materials disclosed by borings, test pits or other subsurface exploration made in appropriate locations. Additional studies shall be made as necessary to evaluate slope stability, soil strength, position and adequacy of load-bearing soils, the effect of moisture variation on soil-bearing capacity, compressibility, liquefaction and expansiveness.

1803*A*.3.1 Scope of investigation. The scope of the geotechnical investigation including the number and types of borings or soundings, the equipment used to drill or sample, the in-situ testing equipment and the laboratory testing program shall be determined by a *registered design professional*.

There shall not be less than one boring or exploration shaft for each 5,000 square feet (465 m^2) of building area at the foundation level with a minimum of two provided for any one building. A boring may be considered to reflect subsurface conditions relevant to more than one building, subject to the approval of the enforcement agency.

Borings shall be of sufficient size to permit visual examination of the soil in place or, in lieu thereof, cores shall be taken.

Borings shall be of sufficient depth and size to adequately characterize sub-surface conditions.

…

1803*A*.5.4 Ground-water table. A subsurface soil investigation shall be performed to determine whether the existing ground-water table is above or within 5 feet (1524 mm) below the elevation of the lowest floor level where such floor is located below the finished ground level adjacent to the foundation.

~~**Exception:** A subsurface soil investigation to determine the location of the ground-water table shall not be required where waterproofing is provided in accordance with Section 1805.~~

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1803A.6. Geohazard Reports. *Geohazard reports shall be required for all proposed construction.*

Exceptions:

1. *Reports are not required for one-story, wood-frame and light-steel-frame buildings of Type II or Type V construction and 4,000 square feet (371m^2)*

or less in floor area, not located within Earthquake Fault Zones or Seismic Hazard Zones as shown in the most recently published maps from the California Geological Survey (CGS) or in seismic hazard zones as defined in the Safety Element of the local General Plan; nonstructural, associated structural or voluntary structural alterations, and incidental structural additions or alterations, and structural repairs for other than earthquake damage.*

2. *A previous report for a specific site may be resubmitted, provided that a reevaluation is made and the report is found to be currently appropriate.*

The purpose of the geohazard report shall be to identify geologic and seismic conditions that may require project mitigations. The reports shall contain data which provide an assessment of the nature of the site and potential for earthquake damage based on appropriate investigations of the regional and site geology, project foundation conditions and the potential seismic shaking at the site. The report shall be prepared by a California-certified engineering geologist in consultation with a California-registered geotechnical engineer.

The preparation of the geohazard report shall consider the most recent CGS Note 48: Checklist for the Review of Engineering Geology and Seismology Reports for California Public School, Hospitals, and Essential Services Buildings. In addition, the most recent version of CGS Special Publication 42, Fault Rupture Hazard Zones in California, shall be considered for project sites proposed within an Alquist-Priolo Earthquake Fault Zone. The most recent version of CGS Special Publication 117, Guidelines for Evaluating and Mitigating Seismic Hazards in California, shall be considered for project sites proposed within a Seismic Hazard Zone. All conclusions shall be ~~fully~~ supported by satisfactory data and analysis.

In addition to requirements in Sections 1803A.5.11 and 1803A.5.12, the report shall include, but shall not be limited to, the following:

1. *Site Geology.*

2. Evaluation of the known active and potentially active faults, both regional and local.

3. Ground-motion parameters, as required by Section<u>s</u> 1613A, 1616A, & ASCE 7.

The three Next Generation Attenuation (NGA) relations used for the 2008 USGS seismic hazards maps for Western United States (WUS) shall be utilized to determine the site-specific ground motion. When supported by data and analysis, other NGA <u>(NGA West 1)</u> relations, that were not used for the 2008 USGS maps, shall be permitted as additions or substitutions. No fewer than three NGA relations shall be utilized.

1803A.7 ~~**1803.6**~~ ***Geotechnical* Reporting.** Where geotechnical investigations are required, a written report of the investigations shall be submitted to the *building official* by the permit applicant at the time of *permit* application. *The geotechnical report shall provide completed evaluations of the foundation conditions of the site and the potential geologic/seismic hazards affecting the site. The geotechnical report shall include, but shall not be limited to, site-specific evaluations of design criteria related to the nature and extent of foundation materials, groundwater conditions, liquefaction potential, settlement potential and slope stability. The report shall contain the results of the analyses of problem areas identified in the geohazard report. The geotechnical report shall incorporate estimates of the characteristics of site ground motion provided in the geohazard report.* This geotechnical report shall include, but need not be limited to, the following information:

1. A plot showing the location of the soil investigations.
2. A complete record of the soil boring and penetration test logs and soil samples.
3. A record of the soil profile.

4. Elevation of the water table, if encountered. *Historic high ground water elevations shall be addressed in the report to adequately evaluate liquefaction and settlement potential.*
5. Recommendations for foundation type and design criteria, including but not limited to: bearing capacity of natural or compacted soil; provisions to mitigate the effects of expansive soils; mitigation of the effects of liquefaction, differential settlement and varying soil strength; and the effects of adjacent loads.
6. Expected total and differential settlement.
7. Deep foundation information in accordance with Section 1803*A*.5.5.
8. Special design and construction provisions for foundations of structures founded on expansive soils, as necessary.
9. Compacted fill material properties and testing in accordance with Section 1803*A*.5.8.
10. Controlled low-strength material properties and testing in accordance with Section 1803*A*.5.9.
11. *The report shall consider the effects of stepped footings addressed in Section 1809A.3.*
12. *The report shall consider the effects of seismic hazards in accordance with Section 1803A.6 and shall incorporate the findings of the associated geohazard report.*

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1803A.8 Geotechnical peer review. [DSA-SS and DSA-SS/CC] *When alternate foundations designs or ground improvements are employed or where slope stabilization is required, a qualified peer review by a California-licensed geotechnical engineer, in accordance with Section 322 of Part 10, Title 24, C.C.R. ~~Section 3422~~, may be required by the enforcement agency. In Section 322 of Part 10, Title 24, C.C.R. ~~Section 3422~~, where reference is made to structural or seismic-resisting system, it shall be replaced with geotechnical, foundation, or ground improvement, as appropriate.*

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SECTION 1805*A*
DAMPPROOFING AND WATERPROOFING

1805*A*.1 General. Walls or portions thereof that retain earth and enclose interior spaces and floors below grade shall be waterproofed and damp proofed in accordance with this section, with the exception of those spaces containing groups other than residential and institutional where such omission is not detrimental
to the building or occupancy.

Ventilation for crawl spaces shall comply with Section 1203.4.

…

1805A.2 Dampproofing. Where hydrostatic pressure will not occur as determined by Section 1803*A*.5.4, floors and walls ~~for other than wood foundation systems~~ shall be dampproofed in accordance with this section. ~~Wood foundation systems shall be constructed in accordance with AF&PA PWF.~~

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SECTION 1807*A*
FOUNDATION WALLS, RETAINING WALLS AND EMBEDDED POSTS AND POLES

1807A.1 Foundation walls. Foundation walls shall be designed and constructed in accordance with Sections 1807*A*.1.1 through 1807*A*.1.6. Foundation walls shall be supported by foundations designed in accordance with Section 1808A.

1807*A*.1.1 Design lateral soil loads. Foundation walls shall be designed for the lateral soil loads ~~set forth in Section 1610*A*.~~ *determined by a geotechnical investigation in accordance with Section 1803A.*

1807*A*.1.2 Unbalanced backfill height. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground level. Where an interior concrete slab on grade is provided and is in contact with the interior surface of the foundation wall, the unbalanced backfill height shall be permitted to be measured from the exterior finish ground level to the top of the interior concrete slab.

1807*A*.1.3 Rubble stone foundation walls. *Not permitted by DSA –SS, DSA –SS/CC.* ~~Foundation walls of rough or random rubble stone shall not be less than 16 inches (406 mm) thick. Rubble stone shall not be used for foundation walls of structures assigned to *Seismic Design Category* C, D, E or F.~~

1807*A*.1.4 Permanent wood foundation systems. *Not permitted by DSA –SS, DSA –SS/CC.* ~~Permanent wood foundation systems shall be designed and installed in accordance with AF&PAPWF. Lumber and plywood shall be treated in accordance with AWPA U1 (Commodity Specification A, Use Category 4B and Section 5.2) and shall be identified in accordance with Section 2303*A*.1.8.1.~~

1807*A*.1.5 Concrete and masonry foundation walls. Concrete and masonry foundation walls shall be designed in accordance with Chapter 19*A* or 21*A*, as applicable.

~~**Exception:** Concrete and masonry foundation walls shall be permitted to be designed and constructed in accordance with Section 1807.1.6.~~

~~**1807.1.6 Prescriptive design of concrete and masonry foundation walls.** Concrete and masonry foundation walls that are laterally supported at the top and bottom shall be permitted to be designed and constructed in accordance with this section.~~

~~**1807.1.6.1 Foundation wall thickness.** The thickness of prescriptively designed foundation walls shall not be less than the thickness of the wall supported, except that foundation walls of at least 8-inch (203 mm) nominal width shall be permitted to support brick-veneered frame walls and 10-inch-wide (254 mm) cavity walls provided the requirements of Section 1807.1.6.2 or 1807.1.6.3 are met.~~

~~**1807.1.6.2 Concrete foundation walls**. Concrete foundation walls shall comply with the following:~~

~~1. The thickness shall comply with the requirements of Table 1807.1.6.2.~~

~~2. The size and spacing of vertical reinforcement shown in Table 1807.1.6.2 are based on the use of reinforcement with a minimum yield strength of 60,000 psi (414 Mpa). Vertical reinforcement with a minimum yield strength of 40,000 psi (276 Mpa) or 50,000 psi (345 Mpa) shall be permitted, provided the same size bar is used and the spacing shown in the table is reduced by multiplying the spacing by 0.67 or 0.83, respectively.~~

~~**TABLE 1807.1.6.2**~~

~~**CONCRETE FOUNDATION WALLS**~~[b, c]

~~(Deleted Table not shown for clarity)~~

~~3. Vertical reinforcement, when required, shall be placed nearest the inside face of the wall a distance, *d*, from the outside face (soil face) of the wall. The distance, *d*, is equal to the wall thickness,*t*, minus 1.25 inches (32 mm) plus one-half the bar diameter, *db*, [*d* = *t* – (1.25 + *db* / 2)]. The reinforcement shall be placed within a tolerance of ± 3/8 inch (9.5 mm) where *d* is less than or equal to 8 inches (203 mm)or ± 1/2 inch (12.7 mm)where *d* is greater than 8 inches (203 mm).~~

~~4. In lieu of the reinforcement shown in Table 1807.1.6.2, smaller reinforcing bar sizes with closer spacings that provide an equivalent cross-sectional area of reinforcement per unit length shall be permitted.~~

~~5. Concrete cover for reinforcement measured from the inside face of the wall shall not be less than ¾ inch (19.1 mm). Concrete cover for reinforcement measured from the outside face of the wall shall not be less than 11/2 inches (38 mm) for No. 5 bars and smaller, and not less than 2 inches (51 mm) for larger bars.~~

~~6. Concrete shall have a specified compressive strength, *fc'*, of not less than 2,500 psi (17.2 MPa).~~

~~7. The unfactored axial load per linear foot of wall shall not exceed 1.2 *t fc'* where *t* is the specified wall thickness in inches.~~

~~**1807.1.6.2.1 Seismic requirements.** Based on the *seismic design category* assigned to the structure in accordance with Section 1613, concrete foundation walls designed using Table 1905.1.7 shall be subject to the following limitations:~~

~~1. *Seismic Design Categories* A and B. No additional seismic requirements, except provide reinforcement around openings in accordance with Section 1909.6.3.~~
~~2. *Seismic Design Categories* C, D, E and F. Tables shall not be used except as allowed for plain concrete members in Section 1908.1.8.~~

~~**1807.1.6.3 Masonry foundation walls**. Masonry foundation walls shall comply with the following:~~

~~1. The thickness shall comply with the requirements of Table 1807.1.6.3(1) for plain masonry walls or Table 1807.1.6.3(2), 1807.1.6.3(3) or 1807.1.6.3(4) for masonry walls with reinforcement.~~
~~2. Vertical reinforcement shall have a minimum yield strength of 60,000 psi (414 Mpa).~~
~~3. The specified location of the reinforcement shall equal or exceed the effective depth distance, *d*, noted in Tables 1807.1.6.3(2), 1807.1.6.3(3) and 1807.1.6.3(4) and shall be measured from the face of the exterior (soil) side of the wall to the center of the vertical reinforcement. The reinforcement shall be placed within the tolerances specified in TMS 602/ACI 530.1/ASCE 6, Article 3.3.B.11 of the specified location.~~

~~TABLE 1807.1.6.3(1)~~

~~PLAIN MASONRY FOUNDATION WALLS~~~~[a,b,c]~~

~~(Deleted Table not shown for clarity)~~

~~4. Grout shall comply with Section 2103.12.~~

~~5. Concrete masonry units shall comply with ASTM C 90.~~

~~6. Clay masonry units shall comply with ASTM C 652 for hollow brick, except compliance with ASTM C 62 or ASTM C 216 shall be permitted where solid masonry units are installed in accordance with Table 1807.1.6.3(1) for plain masonry.~~

~~7. Masonry units shall be laid in running bond and installed with Type M or S mortar in accordance with Section 2103.2.1.~~

~~8. The unfactored axial load per linear foot of wall shall not exceed 1.2 $t f'_m$ where t is the specified wall thickness in inches and f'_m is the specified compressive strength of masonry in pounds per square inch.~~

~~9. At least 4 inches (102 mm) of solid masonry shall be provided at girder supports at the top of hollow masonry unit foundation walls.~~

~~10. Corbeling of masonry shall be in accordance with Section 2104.2. Where an 8-inch (203 mm) wall is corbeled, the top corbel shall not extend~~

~~TABLE 1807.1.6.3(2)~~

~~8-INCH MASONRY FOUNDATION WALLS WITH REINFORCEMENT WHERE d _ 5 INCHES[a,b,c]~~

~~(Deleted Table not shown for clarity)~~

~~higher than the bottom of the floor framing and shall be a full course of headers at least 6 inches (152 mm) in length or the top course bed joint shall be tied to the vertical wall projection. The tie shall be W2.8 (4.8 mm) and spaced at a maximum horizontal distance of 36 inches (914 mm). The hollow space behind the corbelled masonry shall be filled with mortar or grout.~~

~~**1807.1.6.3.1 Alternative foundation wall reinforcement.** In lieu of the reinforcement provisions for masonry foundation walls in Table 1807.1.6.3(2), 1807.1.6.3(3) or 1807.1.6.3(4), alternative reinforcing bar sizes and spacings having an equivalent cross-sectional area of reinforcement per linear foot (mm) of~~

~~wall shall be permitted to be used, provided the spacing of reinforcement does not exceed 72 inches (1829 mm) and reinforcing bar sizes do not exceed No. 11.~~

~~**1807.1.6.3.2 Seismic requirements.** Based on the *seismic design category* assigned to the structure in accordance with Section 1613, masonry foundation walls designed using Tables 1807.1.6.3(1) through 1807.1.6.3(4) shall be subject to the following limitations:~~

~~1. *Seismic Design Categories* A and B. No additional seismic requirements.~~
~~2. *Seismic Design Category* C. A design using Tables 1807.1.6.3(1) through 1807.1.6.3(4) is~~

~~TABLE 1807.1.6.3(3)~~

~~10-INCH MASONRY FOUNDATION WALLS WITH REINFORCEMENT WHERE d _ 6.75 INCHES~~ ~~[a, b, c]~~

~~(Deleted Table not shown for clarity)~~

~~subject to the seismic requirements of Section 7.4.3 of TMS 402/ACI 530/ASCE 5.~~

~~3. *Seismic Design Category* D. A design using Tables 1807.1.6.3(2) through 1807.1.6.3(4) is subject to the seismic requirements of Section 7.4.4 of TMS 402/ACI 530/ASCE 5.~~
~~4. *Seismic Design Categories* E and F. A design using Tables 1807.1.6.3(2) through 1807.1.6.3(4) is subject to the seismic requirements of Section 7.4.5 of TMS 402/ACI 530/ASCE 5.~~

~~TABLE 1807.1.6.3(4)~~

~~12-INCH MASONRY FOUNDATION WALLS WITH REINFORCEMENT WHERE d _ 8.75 INCHES~~~~[a,b,c]~~

~~(Deleted Table not shown for clarity)~~

1807*A*.2 Retaining walls. Retaining walls shall be designed in accordance with Sections 1807*A*.2.1 through 1807*A*.2.3. *Freestanding cantilever walls shall be design in accordance with Section 1807A.2.4.*

1807*A*.2.1 General. Retaining walls shall be designed to ensure stability against overturning, sliding, excessive foundation pressure and water uplift. Where a keyway is extended below the wall base with the intent to engage passive pressure and enhance sliding stability, lateral soil pressures on both sides of the keyway shall be considered in the sliding analysis.

1807*A*.2.2 Design lateral soil loads. Retaining walls shall be designed for the lateral soil loads ~~set forth in Section 1610.~~ *determined by a geotechnical investigation in accordance with Section 1803A and shall not be less than eighty percent of the lateral soil loads determined in accordance with Section 1610A.* <u>*For use with the load combinations, lateral soil loads due to gravity loads surcharge shall be considered gravity loads and seismic earth pressure increases due to earthquake shall be considered as seismic loads.*</u>

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1807A.2.4 Freestanding Cantilever Walls. *A stability check against the possibility of overturning shall be performed for isolated spread footings which support freestanding cantilever walls. The stability check shall be made by dividing R_p used for the wall by 2.0. The allowable soil pressure may be doubled for this evaluation.*

> ***Exception:*** *For overturning about the principal axis of rectangular footings with symmetrical vertical loading and the design lateral force applied, a triangular or trapezoidal soil pressure distribution which covers the full width of the footing will meet the stability requirement.*

…

SECTION 1808*A*
FOUNDATIONS

1808*A*.1 General. Foundations shall be designed and constructed in accordance with Sections 1808*A*.2 through 1808A.9. Shallow foundations shall also satisfy the requirements of Section 1809A. Deep foundations shall also satisfy the requirements of Section 1810*A*.

1808*A*.2 Design for capacity and settlement. Foundations shall be so designed that the allowable bearing capacity of the soil is not exceeded, and that differential settlement is minimized. Foundations in areas with expansive soils shall be designed in accordance with the provisions of Section 1808*A*.6.

The enforcing agency may require an analysis of foundation elements to determine subgrade deformations in order to evaluate their effect on the superstructure, including story drift.

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1808*A*.8 Concrete foundations. The design, materials and construction of concrete foundations shall comply with Sections1808*A*.8.1 through 1808*A*.8.6 and the provisions of Chapter 19*A*.

~~Exception: Where concrete footings supporting walls of light-frame construction are designed in accordance with Table 1809.7, a specific design in accordance with Chapter 19 is not required.~~

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TABLE 1808*A*.8.1

MINIMUM SPECIFIED COMPRESSIVE STRENGTH f'_c OF CONCRETE OR GROUT

FOUNDATION ELEMENT OR CONDITION	SPECIFIED COMPRESSIVE STRENGTH, f'_c
~~1. Foundations for structures assigned to Seismic Design Category A, B or C~~	~~2,500 psi~~
~~2a. Foundations for Group R or U occupancies of light-frame construction, two stories or less in height, assigned to Seismic Design Category D, E or F~~	~~2,500 psi~~
~~2b~~ *1.*Foundations for other structures assigned to Seismic Design Category D, E or F	3,000 psi
~~3~~ *2.* Precast nonprestressed driven piles	4,000 psi
~~4~~ *3.* Socketed drilled shafts	4,000 psi
~~5~~ *4.* Micropiles	4,000 psi
~~6~~ *5.* Precast prestressed driven piles	5,000 psi

For SI: 1 pound per square inch = 0.00689MPa.

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1808*A*.8.6 Seismic requirements. See Section 1905*A* for additional requirements for foundations of structures assigned to *Seismic Design Category* ~~C,~~ D, E or F.

For structures assigned to *Seismic Design Category* D, E or F, provisions of Sections 18.13 of ACI 318 shall apply where not in conflict with the provisions of Sections 1808*A* through 1810*A*.

~~**Exceptions:**~~

~~1. Detached one- and two-family dwellings of light-frame construction and two stories or less above *grade plane* are not required to comply with the provisions of Section 18.13 od ACI 318.~~

~~2. Section 18.13.4.3(a) of ACI 318 shall not apply.~~

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SECTION 1809*A*
SHALLOW FOUNDATIONS

1809*A*.1 General. Shallow foundations shall be designed and constructed in accordance with Sections 1809*A*.2 through 1809*A*.13.

1809*A*.2 Supporting soils. Shallow foundations shall be built on undisturbed soil, compacted fill material or controlled low-strength material (CLSM). Compacted fill material shall be placed in accordance with Section 1804*A*.5. CLSM shall be placed in accordance with Section 1804*A*.6.

1809*A*.3 Stepped footings. The top surface of footings shall be level. The bottom surface of footings shall be permitted to have a slope not exceeding one unit vertical in 10 units horizontal (10-percent slope). Footings shall be stepped where it is necessary to change the elevation of the top surface of the footing or where the surface of the ground slopes more than one unit vertical in 10 units horizontal (10-percent slope).

Individual steps in continuous footings shall not exceed 18 inches (457 mm) in height and the slope of a series of such steps shall not exceed 1 unit vertical to 2 units horizontal (50% slope) unless otherwise recommended by a geotechnical report. The steps shall be detailed on the drawings. The local effects due to the discontinuity of the steps shall be considered in the design of the foundation.

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1809*A*.7 Prescriptive footings for light-frame construction. *Not permitted by DSA-SS, DSA-SS/CC.* ~~Where a specific design is not provided, concrete or masonry-unit footings supporting walls of light-frame construction shall be permitted to be designed in accordance with Table 1809.7.~~

~~TABLE 1809.7~~

~~PRESCRIPTIVE FOOTINGS SUPPORTING WALLS OFLIGHT-FRAME CONSTRUCTION~~$_{\text{a,b,c,d,e}}$

~~(Table not shown for clarity)~~

1809*A*.8 Plain concrete footings. *Not permitted by DSA-SS, DSA-SS/CC.* ~~The edge thickness of plain concrete footings supporting walls of other than light-frame construction shall not be less than 8 inches (203 mm) where placed on soil or rock.~~

~~**Exception:** For plain concrete footings supporting Group R-3 occupancies, the edge thickness is permitted to be 6 inches (152 mm), provided that the footing does not extend beyond a distance greater than the thickness of the footing on either side of the supported wall.~~

1809*A*.9 Masonry-unit footings. *Not permitted by DSA-SS, DSA-SS/CC.* ~~The design, materials and construction of masonry-unit footings shall comply with Sections 1809.9.1 and 1809.9.2, and the provisions of Chapter 21.~~

~~**Exception:** Where a specific design is not provided, masonry-unit footings supporting walls of light-frame construction shall be permitted to be designed in accordance with Table 1809.7.~~

~~**1809.9.1 Dimensions.** Mansonry-unit footings shall be laid in Type M or S mortar complying with Section 2103.8 and the depth shall not be less than twice the projection beyond the wall, pier or column. The width shall not be less than 8 inches (203 mm) wider than the wall supported thereon.~~

~~**1809.9.2 Offsets.** The maximum offset of each course in brick foundation walls stepped up from the footings shall be 11/2 inches (38 mm) where laid in single courses, and 3 inches (76 mm) where laid in double courses.~~

1809*A*.10 *Reserved.* ~~**Pier and curtain wall foundations.** Except in *Seismic Design Categories* D, E and F, pier and curtain wall foundations shall be permitted to be used to support light-frame construction not more than two *stories above grade plane*, provided the following requirements are met:~~

~~1. All load-bearing walls shall be placed on continuous concrete footings bonded integrally with the *exterior wall* footings.~~
~~2. The minimum actual thickness of a load-bearing masonry wall shall not be less than 4 inches (102 mm) nominal or 35/8 inches (92 mm) actual thickness, and shall be bonded integrally with piers spaced 6 feet (1829 mm) on center (o.c.).~~
~~3. Piers shall be constructed in accordance with Chapter 21 and the following:~~
~~3.1. The unsupported height of the masonry piers shall not exceed 10 times their least dimension.~~
~~3.2. Where structural clay tile or hollow concrete masonry units are used for piers supporting beams and girders, the cellular spaces shall be filled solidly with concrete or Type M or S mortar.~~

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

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

~~4. The maximum height of a 4-inch (102 mm) load-bearing masonry foundation wall supporting wood frame walls and floors shall not be more than 4 feet (1219 mm) in height.~~

~~5. The unbalanced fill for 4-inch (102 mm) foundation walls shall not exceed 24 inches (610 mm) for solid masonry, nor 12 inches (305 mm) for hollow masonry.~~

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1809*<u>A</u>*.12 Timber footings. *Not permitted by DSA-SS, DSA-SS/CC.* ~~Timber footings shall be permitted for buildings of Type V construction and as otherwise *approved* by the *building official*. Such footings shall be treated in accordance with AWPA U1 (Commodity Specification A, Use Category 4B). Treated timbers are not required where placed entirely below permanent water level, or where used as capping for wood piles that project above the water level over submerged or marsh lands. The compressive stresses perpendicular to grain in untreated timber footings supported upon treated piles shall not exceed 70 percent of the allowable stresses for the species and grade of timber as specified in the AF&PA NDS.~~

…

1809A.14 Pipes and Trenches. *Unless otherwise recommended by the soils report, open or backfilled trenches parallel with a footing shall not be below a plane having a downward slope of 1 unit vertical to 2 units horizontal (50% slope) from a line 9 inches (229 mm) above the bottom edge of the footing, and not closer than 18 inches (457 mm) from the face of such footing.*

Where pipes cross under footings, the footings shall be specially designed. Pipe sleeves shall be provided where pipes cross through footings or footing walls and sleeve clearances shall provide for possible footing settlement, but not less than 1 inch (25 mm) all around pipe.

> ***Exception:*** *Alternate trench locations and pipe clearances shall be permitted when approved by registered design professional in responsible charge and the enforcement agent.*

1809A.15 Grade beams: [DSA-SS, DSA-SS/CC] *For structures assigned to Seismic Design Category D, E or F, grade beams in shallow foundations shall comply with Section 1810A.3.12.*

SECTION 1810*A*
DEEP FOUNDATIONS

1810*A*.1 General. Deep foundations shall be analyzed, designed, detailed and installed in accordance with Sections 1810*A*.1 through 1810*A*.4.

…

1810*A*.3.1.5 Helical piles. Helical piles shall be designed and manufactured in accordance with accepted engineering practice to resist all stresses induced by installation into the ground and service loads.

1810A.3.1.5.1 Helical Piles Seismic Requirements. *For structures assigned to Seismic Design Category D, E or F, capacities of helical piles shall be determined in accordance with Section 1810A.3.3 by at least two project specific pre-production tests for each soil profile, size and depth of helical pile. At least two percent of all production piles shall be proof tested to the load determined in accordance with Section* <u>*1616A.1.16.*</u>~~*1615A.1.10.*~~

Helical piles shall satisfy corrosion resistance requirements of ICC-ES AC 358. In addition, all helical pile materials that are subject to corrosion shall include at least 1/16" corrosion allowance.

Helical piles shall not be considered as carrying any horizontal loads.

…

1810*A*.3.2 Materials. The materials used in deep foundation elements shall satisfy the requirements of Sections 1810*A*.3.2.1 through 1810*A*.3.2.8, as applicable.

…

~~**1810.3.2.1.2 ACI 318 Equation (25.8.3.3).** Where this chapter requires detailing of concrete deep foundation elements in accordance with Section 18.7.5.4 of ACI 318, compliance with Equation (25.8.3.3) of ACI 318 shall not be required.~~

…

1810*A*.3.2.4 Timber. *Not permitted by DSA-SS, DSASS/CC.* ~~Timber deep foundation elements shall be designed as piles or poles in accordance with AF&PA NDS. Round timber elements shall conform to ASTM D 25. Sawn timber elements shall conform to DOC PS-20.~~

~~**1810.3.2.4.1 Preservative treatment.** Timber deep foundation elements used to support permanent structures shall be treated in accordance with this section unless it is established that the tops of the untreated timber elements will be below the lowest ground-water level assumed to exist during the life of the structure. Preservative and minimum final retention shall be in accordance with AWPA U1 (Commodity Specification E, Use Category 4C) for round timber elements and AWPA U1 (Commodity Specification A, Use Category 4B) for sawn timber elements. Preservative-treated timber elements shall be subject to a quality control program administered by an *approved agency*. Element cutoffs shall be treated in accordance with AWPA M4.~~

…

1810A.3.3.1.2 Load tests. Where design compressive loads are greater than those determined using the allowable stresses specified in Section 1810A.3.2.6, where the design load for any deep foundation element is in doubt, <u>*where driven deep foundation elements are installed by means other than a pile hammer,*</u> or where cast-in-place deep foundation elements have an enlarged base formed either by compacting concrete or by driving a precast base, control test elements shall be tested in accordance with ASTM D 1143 *including Procedure G: Cyclic*

Loading Test or ASTM D 4945. At least one element shall be load tested in each area of uniform subsoil conditions. Where required by the building official, additional elements shall be load tested where necessary to establish the safe design capacity. The resulting allowable loads shall not be more than one-half of the ultimate axial load capacity of the test element as assessed by one of the published methods listed in Section 1810A.3.3.1.3 with consideration for the test type, duration and subsoil. The ultimate axial load capacity shall be determined by a registered design professional with consideration given to tolerable total and differential settlements at design load in accordance with Section 1810A.2.3. In subsequent installation of the balance of deep foundation elements, all elements shall be deemed to have a supporting capacity equal to that of the control element where such elements are of the same type, size and relative length as the test element; are installed using the same or comparable methods and equipment as the test element; are installed in similar subsoil conditions as the test element; and, for driven elements, where the rate of penetration (e.g., net displacement per blow) of such elements is equal to or less than that of the test element driven with the same hammer through a comparable driving distance, *or where the downward pressure and torque on such elements is greater than or equal to that applied to the test element that determined the ultimate axial load capacity at a comparable driving distance*.

...

1810A.3.3.1.5 Uplift capacity of a single deep foundation element. Where required by the design, the uplift capacity of a single deep foundation element shall be determined by an approved method of analysis based on a minimum factor of safety of three or by load tests conducted in accordance with ASTM D 3689. The maximum allowable uplift load shall not exceed the ultimate load capacity as determined in Section 1810A.3.3.1.2, using the results of load tests conducted in accordance with ASTM D3689 *including the Cyclic Loading Procedure*, divided by a factor of safety of two.

Exception: Where uplift is due to wind or seismic loading, the minimum factor of safety shall be two where capacity is determined by an analysis and one and a half where capacity is determined by load tests.

…

1810A.3.3.2 Allowable lateral load. Where required by the design, the lateral load capacity of a single deep foundation element or a group thereof shall be determined by an *approved* method of analysis or by lateral load tests *in accordance with ASTM D3966, including the Cyclic Loading Procedure,* to at least twice the proposed design working load. The resulting allowable load shall not be more than one-half of the load that produces a gross lateral movement of 1 inch (25 mm) at the lower of the top of foundation element and the ground surface, unless it can be shown that the predicted lateral movement shall cause neither harmful distortion of, nor instability in, the structure, nor cause any element to be loaded beyond its capacity.

…

1810*A*.3.5.3.3 Structural Steel Sheet Piling. Individual sections of structural steel sheet piling shall conform to the profile indicated by the manufacturer, and shall conform to general requirements specified by ASTM A6.

Installation of sheet piling shall satisfy inspection, monitoring, and observation requirements in Sections 1812A.6 and 1812A.7.

…

1810*A*.3.8.3 Precast prestressed piles. Precast prestressed concrete piles shall comply with the requirements of Sections 1810*A*.3.8.3.1 through 1810*A*.3.8.3.3.

…

1810*A*.3.8.3.2 Seismic reinforcement in Seismic Design Category C. *Not permitted by DSA-SS, DSA-SS/CC.* ~~For structures assigned to *Seismic Design Category* C in accordance with Section 1613, precast prestressed piles shall have transverse reinforcement in accordance with this section. The volumetric ratio of spiral reinforcement shall not be less than the amount required by the following formula for the upper 20 feet (6096 mm) of the pile.~~

~~$\rho_s = 0.12 f'_c / f_{yh}$ **(Equation 18-5)**~~

~~where:~~

~~f'_c = Specified compressive strength of concrete, psi (MPa).~~

~~f_{yh} = Yield strength of spiral reinforcement ≤ 85,000 psi (586 MPa).~~

~~ρ_s = Spiral reinforcement index (vol. spiral/vol. core).~~

~~At least one-half the volumetric ratio required by Equation 18-5 shall be provided below the upper 20 feet (6096 mm) of the pile.~~

1810*A*.3.8.3.3 Seismic reinforcement in Seismic Design Categories D through F. For structures assigned to *Seismic Design Category* D, E or F, ~~*in accordance with Section 1613A,*~~ precast prestressed piles shall have transverse reinforcement in accordance with the following:

…

5. Where the transverse reinforcement consists of circular spirals, the volumetric ratio of spiral transverse reinforcement in the ductile region shall comply with the following:

…

~~This required amount of spiral reinforcement is permitted to be obtained by providing an inner and outer spiral.~~

…

1810*A*.3.9.4.2.1 Site Classes A through D. For Site Class A, B, C or D sites, transverse confinement reinforcement shall be provided in the element in accordance with Sections 18.7.5.2, 18.7.5.3 and 18.7.5.4 of ACI 318 within three times the least element dimension *at* ~~of~~ the bottom of the pile cap. A transverse spiral reinforcement ratio of not less than one-half of that required in Section 18.7.5.4 ~~(a)~~ of ACI 318 shall be permitted *for concrete deep foundation elements.*

1810*A*.3.9.4.2.2 Site Classes E and F. For Site Class E or F sites, transverse confinement reinforcement shall be provided in the element in accordance with Sections 18.7.5.2, 18.7.5.3 and 18.7.5.4 of ACI 318 within seven times the least element dimension *at* ~~of~~ the *bottom of the* pile cap and within seven times the least element dimension *at* ~~of~~ the interfaces of strata that are hard or stiff and strata that are liquefiable or are composed of soft- to medium-stiff clay.

…

1810*A*.3.10 Micropiles. Micropiles shall be designed and detailed in accordance with Sections 1810*A*.3.10.1 through 1810*A*.3.10.4.

…

~~**1810A.3.10.4 Seismic reinforcement.** For structures assigned to *Seismic Design Category* C, a permanent steel casing shall be provided from the top of the micropile down to the point of zero curvature. For structures assigned to *Seismic Design Category* D, E or F, the micropile shall be considered as an alternative system in accordance with Section 104.11. The alternative system design, supporting~~

~~documentation and test data shall be submitted to the *building official* for review and approval.~~

1810*A*.3.10.4 *Seismic requirements*. *For structures assigned to Seismic Design Category D, E, or F, a permanent steel casing having a minimum thickness of 3/8" shall be provided from the top of the micropile down to a minimum of 120 percent of the point of zero curvature. Capacity of micropiles shall be determined in accordance with Section 1810A.3.3 by at least two project specific pre-production tests for each soil profile, size and depth of micropile. At least two percent of all production piles shall be proof tested to the load determined in accordance with Section 1616A.1.16.~~1615A.1.10.~~*

Steel casing length in soil shall be considered as unbonded and shall not be considered as contributing to friction. Casing shall provide confinement at least equivalent to hoop reinforcing required by ACI 318 Section 18.13.4. ~~21.12.4~~.

Reinforcement shall have Class 1 corrosion protection in accordance with PTI Recommendations for Prestressed Rock and Soil Anchors. Steel casing design shall include at least 1/16" corrosion allowance.

Micropiles shall not be considered as carrying any horizontal loads.

…

1810*A*.4 Installation. Deep foundations shall be installed in accordance with Section 1810*A*.4. Where a single deep foundation element comprises two or more sections of different materials or different types spliced together, each section shall satisfy the applicable conditions of installation.

1810*A*.4.1 Structural integrity. Deep foundation elements shall be installed in such a manner and sequence as to prevent distortion or damage that may adversely affect the structural integrity of adjacent structures or of foundation elements being installed or already in place and as to avoid compacting the surrounding soil to the extent that other foundation elements cannot be installed properly.

…

1810*A*.4.1.5 Defective timber piles. *Not permitted by DSA-SS, DSA-SS/CC.* ~~Any substantial sudden increase in rate of penetration of a timber pile shall be investigated for possible damage. If the sudden increase in rate of penetration cannot be correlated to soil strata, the pile shall be removed for inspection or rejected.~~

…

SECTION 1811A
PRESTRESSED ROCK AND SOIL FOUNDATION ANCHORS

1811A.1 General. *The requirements of this section address the use of vertical rock and soil anchors in resisting seismic or wind overturning forces resulting in tension on shallow foundations.*

1811A.2 Adoption. *Except for the modifications as set forth in Sections 1811A.3 and 1811A.4, all Prestressed Rock and Soil Foundation Anchors shall ~~be designed~~ comply with ~~in accordance with~~ PTI Recommendations for Prestressed Rock and Soil Anchors.*

1811A.3 Geotechnical Requirements*. Geotechnical report for the Prestressed Rock & Soil Foundation Anchors shall address the following:*

1. *Minimum diameter and minimum spacing for the anchors including consideration of group effects.*
2. *Maximum unbonded length and minimum bonded length of the tendon.*
3. *Maximum recommended anchor tension capacity based upon the soil or rock strength / grout bond and anchor depth / spacing.*

4. *Allowable bond stress at the ground / grout interface and applicable factor of safety for ultimate bond stress.*

5. *Anchor axial tension stiffness recommendations at the anticipated anchor axial tension displacements, when required for structural analysis.*

6. *Minimum grout pressure for installation and post-grout pressure.*

7. *Class I Corrosion Protection is required for all permanent anchors. Geotechnical report shall specify the corrosion protection recommendations for temporary anchors.*

8. *Performance test shall be at a minimum of 1.6 times the design loads. There shall be a minimum of two preproduction test anchors. Preproduction test anchors shall be tested to ultimate load or 0.80 times the specified minimum tensile strength of the tendon. A Creep test is required for all prestressed anchors with greater than 10 kips of lock-off prestressing load.*

9. *Lock-off prestressing load requirements.*

10. *Acceptable Drilling methods.*

11. *Geotechnical observation and monitoring requirements.*

***1811A.4 Structural Requirements**.*

1. *Tendons shall be thread-bar anchors conforming to ASTM A722.*

2. *The anchors shall be placed vertical.*

3. *Design Loads shall be based upon the load combinations in Section 1605A.3.1 and shall not exceed 60 percent of the specified minimum tensile strength of the tendons.*

4. *Ultimate Load shall be based upon Section 1616A.1.16 ~~1615A.1.10~~ and shall not exceed 80 percent of the specified minimum tensile strength of the tendons.*

5. *The anchor shall be designed to fail in grout bond to the soil or rock before pullout of the soil wedge by group effect.*

6. *Foundation design shall incorporate the effect of lock-off loads.*

7. *Design shall account for as-built locations of soil anchors considering all the acceptable construction tolerances.*

8. *Design shall account for both short and long term deformation.*

9. *Enforcement agency may require consideration of anchor deformation in evaluating deformation compatibility or building drift where it may be significant.*

<u>*SECTION 1812A*</u>

<u>*EARTH RETAINING SHORING*</u>

(Relocated from Section J106.2) ***~~J106.2 Earth retaining shoring. [DSA-SS & DSA-SS/CC]~~***

<u>1812A.1</u> ***~~J106.2.1~~*** **General.** *The requirements of this section shall apply to temporary and permanent earth retaining shoring using soldier piles and lagging with or without tie-back anchors in soil or rock, only when existing or new ~~DSA-SS & DSA-SS/CC~~ facilities are affected. Shoring used as construction means and methods only, which does not affect existing or new ~~DSA-SS & DSA-SS/CC~~ facilities, are not regulated by <u>this section</u> ~~DSA~~ and shall satisfy the requirements of the authorities having jurisdiction.*

Design, construction, testing, and inspection shall satisfy the requirements of this code except as modified in Sections <u>1812A.2</u> ~~J106.2.2~~ through ~~J106.2.8~~ <u>1812A.8</u>.

<u>1812A.2</u> ***~~J106.2.2~~*** **Duration.** *Shoring shall be considered temporary when elements of the shoring will be exposed to site conditions for a period of less than one (1) year, and shall be considered permanent otherwise. Permanent shoring shall account for the increase in lateral soil pressure due to earthquake. At the end of the construction period,* *the existing and new structures shall not rely on the temporary shoring for support in anyway. Wood components shall not be used for permanent shoring lasting more than two (2) years. Wood components of the temporary shoring that may affect the performance of permanent structure shall be removed after the shoring is no longer required.*

All components of the shoring shall have corrosion protection or preservative treatment for their expected duration. Wood components of the temporary shoring that will not be removed shall be treated in accordance with AWPA U1 (Commodity Specification A, Use Category 4B and Section 5.2), and shall be identified in accordance with Section 2303.1.9.1 ~~2303.1.8.1~~.

1812A.3 ***~~J106.2.3~~*** ***Surcharge.*** *Surcharge pressure due to footings, traffic, or other sources shall be considered in design. If the footing surcharge is located within the semi-circular distribution or bulb of earth pressure (when shoring is located close to a footings), lagging shall be designed for lateral earth pressure due to footing surcharge. Soil arching effects may be considered in the design of lagging. Underpinning of the footing may be used in lieu of designing the shoring and lagging for surcharge pressure. Alternatively, continuously contacting drilled pier shafts near the footings shall be permitted. The lateral surcharge design pressure shall be derived using Boussinesq equations modified for the distribution of stresses in an elastic medium due to a uniform, concentrated or line surface load as appropriate and soil arching effects.*

1812A.4 ***~~J106.2.4~~*** ***Design and testing.*** *Except for the modifications as set forth in Sections 1812A.4.1 ~~J106.2.4.1 and J106.2.4.2~~ through 1812A.4.3 below, all Prestressed Rock and Soil Tie-back Anchors shall ~~be designed and tested in accordance~~ comply with PTI Recommendations for Prestressed Rock and Soil Anchors (PTI-2004).*

1812A.4.1 ***~~J106.2.4.1~~*** ***Geotechnical requirements.*** *The geotechnical report for the earth retaining shoring shall address the following:*

1. *Minimum diameter and minimum spacing for the anchors*

including consideration of group effects.

2. Maximum unbonded length and minimum bonded length of the tie-back anchors.

3. Maximum recommended anchor tension capacity based upon the soil or rock strength / grout bond and anchor depth / spacing.

4. Allowable bond stress at the ground / grout interface and applicable factor of safety for ultimate bond stress for the anchor. For permanent anchors, a minimum factor of safety of 2.0 shall be applied to ground soil interface as required by PTI-2004 Section 6.6.

5. Minimum grout pressure for installation and post-grout pressure for the anchor. The presumptive post grout pressure of 300 psi may be used for all soil type.

6. Class I Corrosion Protection is required for all permanent anchors. The geotechnical report shall specify the corrosion protection recommendations for temporary anchors.

7. Performance test for the anchors shall be at a minimum of two (2) times the design loads and shall not exceed 80% of the specified minimum tensile strength of the anchor rod. A creep test is required for all prestressed anchors that are performance tested. All production anchors shall be tested at 150% of design loads and shall not be greater than 70% of the specified minimum tensile strength of the anchor rod.

8. Earth pressure, surcharge pressure, and the seismic increment of earth pressure loading, when applicable.

9. Maximum recommended lateral deformation at the top of the soldier pile, at the tie-back anchor locations, and the drilled pier concrete shafts at the lowest grade level.

10. Allowable vertical soil bearing pressure, friction resistance, and lateral passive soil resistance for the drilled pier concrete shafts and associated factors of safety for these allowable capacities.

11. Soil-pier shaft / pile interaction assumptions and lateral soil stiffness to be used in design for drilled pier concrete shaft or pile lateral loads.

12. *Acceptable drilling methods.*
13. *Geotechnical observation and monitoring recommendations.*

1812A.4.2 ***~~J106.2.4.2~~*** ***Structural requirements****:*

1. *Tendons shall be thread-bar anchors conforming to ASTM A 722.*
2. *Anchor design loads shall be based upon the load combinations in Section 1605A.3.1 and shall not exceed 60 percent of the specified minimum tensile strength of the tendons.*
3. *The anchor shall be designed to fail in grout bond to the soil or rock before pullout of the soil wedge.*
4. *Design of shoring system shall account for as-built locations of soil anchors considering all specified construction tolerances in Section 1812A.8 ~~J106.2.8~~.*
5. *Design of shoring system shall account for both short and long term deformation.*

1812A.4.3 ***~~J106.2.4.3~~*** ***Testing of tie-back anchors****:*

1. *The geotechnical engineer shall keep a record at job site of all test loads, total anchor movement, and report their accuracy.*

2. *If a tie-back anchor initially fails the testing requirements, the anchor shall be permitted to be re-grouted and retested. If anchor continues to fail, the followings steps shall be taken:*

   a. *The contractor shall determine the cause of failure – variations of the soil conditions, installation methods, materials, etc.*
   b. *Contractor shall propose a solution to remedy the problem. The proposed solution will need to be reviewed and approved by geotechnical engineer, shoring design engineer, and the building official.*

3. *After a satisfactory test, each anchor shall be locked-off in accordance with Section 8.4 of PTI 2004.*

4. The shoring design engineer shall specify design loads for each anchor.

1812A.5 ~~*J106.2.5*~~ ***Construction:*** *The construction procedure shall address the following:*

1. *Holes drilled for piles / tie-back anchors shall be done without detrimental loss of ground, sloughing or caving of materials and without endangering previously installed shoring members or existing foundations.*
2. *Drilling of earth anchor shafts for tie-backs shall occur when the drill bench reaches two to three feet below the level of the tie-back pockets.*
3. *Casing or other methods shall be used where necessary to prevent loss of ground and collapse of the hole.*
4. *The drill cuttings from earth anchor shaft shall be removed prior to anchor installation.*
5. *Unless tremie methods are used, all water and loose materials shall be removed from the holes prior to installing piles / tie-backs.*
6. *Tie-back anchor rods with attached centralizing devices shall be installed into the shaft or through the drill casing. Centralizing device shall not restrict movement of the grout.*
7. *After lagging installation, voids between lagging and soil shall be backfilled immediately to the full height of lagging.*
8. *The soldier piles shall be placed within specified tolerances in the drilled hole and braced against displacement during grouting. Fill shafts with concrete up to top of footing elevation, rest of the shaft can generally be filled with lean concrete. Excavation for lagging shall not be started until concrete has achieved sufficient strength for all anticipated loads as determined by the shoring design engineer.*
9. *Where boulders and / or cobbles have been identified in the geotechnical reports, contractor shall be prepared to address boulders and / or cobbles that may be encountered during the drilling of soldier piles and Tie-back anchors.*
10. *The grouting equipment shall produce grout free of lumps and indispensed cement. The grouting equipment shall be sized to enable the grout to be pumped in continuous operation. The mixer shall be capable of continuously agitating the grout.*
11. *The quantity of grout and grout pressure shall be recorded. The grout pressure shall*

be controlled to prevent excessive heave in soils or fracturing rock formations.

12. *If post-grouting is required, post grouting operation shall be performed after initial grout has set for 24-hours in the bond length only. Tie-backs shall be grouted over a sufficient length (anchor bond length) to transfer the maximum anchor force to the anchor grout.*
13. *Testing of anchors may be performed after post-grouting operations provided grout has reached strength of 3,000 psi as required by PTI-2004 Section 6.11.*
14. *Anchor rods shall be tensioned straight and true. Excavation directly below the anchors shall not continue before those anchors are tested.*

1812A.6 ***~~J106.2.6~~*** ***Inspection, survey monitoring, and observation***

1. *The shoring design engineer or his designee shall make periodic inspections of the job site for the purpose of observing the installation of shoring system, testing of tie-back anchors, and monitoring of survey.*

2. *Testing, inspection, and observation shall be in accordance with testing, inspection and observation requirements approved by the building official. The following activities and materials shall be tested, inspected, or observed by the special inspector and geotechnical engineer:*
   a. *Sampling and testing of concrete in soldier pile and tie-back anchor shafts.*
   b. *Fabrication of tie-back anchor pockets on soldier beams*
   c. *Installation and testing of tie-back anchors.*
   d. *Survey monitoring of soldier pile and tie-back load cells.*
   e. *Survey Monitoring of existing buildings.*

3. *A complete and accurate record of all soldier pile locations, depths, concrete strengths, tie-back locations and lengths, tie-back grout strength, quantity of concrete per pile, quantity of grout per tie-back and applied tie-back loads shall be maintained by the special inspector and geotechnical engineer. The shoring design engineer shall be notified of any unusual conditions encountered during installation.*

4. *Calibration data for each test jack, pressure gauge, and master pressure gauge shall be verified by the special inspector and geotechnical engineer. The calibration tests shall be performed by an independent testing laboratory and within 120 calender days of the data submitted.*

5. *Monitoring points shall be established at the top and at the anchor heads of selected soldier piles and at intermediate intervals as considered appropriate by the geotechnical engineer.*

6. *Control points shall be established outside the area of influence of the shoring system to ensure the accuracy of the monitoring readings.*

7. *The periodic basis of shoring monitoring, as a minumum, shall be as follows:*

   a. *Intitial monitoring shall be performed prior to any excavation.*
   b. *Once excavation has begun, the periodic readings shall be taken weekly until excavation reaches the estimated subgrade elevation and the permanent foundation is complete.*
   c. *If performance of the shoring is within established guidelines, shoring design engineer may permit the periodic readings to be bi-weekly. Once initiated, bi-weekly readings shall continue until the building slab at ground floor level is completed and capable of transmitting lateral loads to the permanent structure. Thereafter, readings can be monthly.*
   d. *Where the building has been designed to resist lateral earth pressures, the periodic monitoring of the soldier piles and adjacent structure can be discontinued once the ground floor diaphragm and subterranean portion of the structure is capable of resisting lateral soil loads and approved by the shoring design engineer, geotechnical engineer, and the building official.*
   e. *Additional readings shall be taken when requested by special inspector, shoring design engineer, geotechnical engineer, or the building official.*

8. *Monitoring reading shall be submitted to shoring design engineer, engineer in responsible charge, and the building official within 3 working days after they are*

conducted. Monitoring readings shall be accurate to within 0.01 feet. Results are to be submitted in tabular form showing at least the intial date of monitoring and reading, current monitoring date and reading and difference between the two readings.

9. *If the total cummulative horizontal or vertical movement (from start of construction) of the existing buildings reaches ½" or soldier piles reaches 1" all excavation activities shall be suspended. The geotechnical and shoring design engineer shall determine the cause of movement, if any, and recommend corrective measures, if necessary, before excavation continues.*

10. *If the total cummulative horizontal or vertical movement (from start of construction) of the existing buildings reaches 3/4" or soldier piles reaches 1 ½" all excavation activities shall be suspended until the causes, if any, can be determined. Supplemental shoring shall be devised to eliminate further movement and the building official shall review and approve the supplemental shoring before excavation continues.*

11. *Monitoring of Tie-back Anchor Loads:*

    a. *Load cells shall be installed at the tie-back heads adjacent to buildings at maximum interval of 50', with a minimum of one load cells per wall.*
    b. *Load cell readings shall be taken once a day during excavation and once a week during the remainder of construction.*
    c. *Load cell readings shall be submitted to the geotechnical engineer, shoring design engineer, engineer in responsible charge, and the building official.*
    d. *Load cell readings can be terminated once the temporary shoring no longer provides support for the buildings.*

<u>1812A.7</u> ~~J106.2.7~~ Monitoring of existing DSA-SS and DSA-SS/CC structures

1. *The contractor shall complete a written and photographic log of all existing DSA-*

SS, DSA-SS/CC and structures within 100 ft or three times depth of shoring, prior to construction. A licensed surveyor shall document all existing substantial cracks in adjacent existing structures.

2. *Contractor shall document existing condition of wall cracks adjacent to shoring walls prior to start of construction.*
3. *Contractor shall monitor existing walls for movement or cracking that may result from adjacent shoring.*
4. *If excessive movement or visible cracking occurs, contractor shall stop work and shore / reinforce excavation and contact shoring design engineer and the building official.*
5. *Monitoring of the existing structure shall be at reasonable intervals as required by the registered design professional subject to approval of the building official. Monitoring shall be performed by a licensed surveyor and shall consist of vertical and lateral movement of the existing structures. Prior to starting shoring installation a pre-construction meeting shall take place between the contractor, shoring design engineer, surveyor, geotechnical engineer, and the building official to identify monitoring locations on existing buildings.*
6. *If in the opinion of the building official or shoring design engineer, monitoring data indicate excessive movement or other distress, all excavation shall cease until the geotechnical engineer and shoring design engineer investigates the situation and makes recommendations for remediation or continuing.*
7. *All reading and measurements shall be submitted to the building official and shoring design engineer.*

1812A.8 ***~~J106.2.8~~*** ***Tolerances.*** *Following tolerances shall be specified on the construction documents.*

1. *Soldier Piles:*

    i. *Horizontal and vertical construction tolerances for the soldier pile locations.*
    ii. *Soldier pile plumbness requirements (angle with vertical line).*

2. *Tie-back Anchors:*

   i. *Allowable deviation of anchor projected angle from specified vertical and horizontal design projected angle.*
   ii. *Anchor clearance to the existing/new utilities and structures.*

(Relocated from Section J112)

Section <u>1813A</u> ~~J112~~

Vibro Stone Columns for Ground Improvement

<u>1813A.1</u> ~~J112.1~~ General. ~~[DSA-SS & DSA-SS/CC]~~ *This section shall apply to Vibro Stone Columns (VSCs) for ground improvement using unbounded aggregate materials. Vibro stone column provisions in this section are intended to increase bearing capacity, reduce settlements, and mitigate liquefaction for shallow foundations. These requirements shall not be used for grouted or bonded stone columns, ground improvement for deep foundation elements, or changing site class. VSCs shall not be considered as a deep foundation element.*

Ground improvement shall be installed under the entire building/structure footprint and not under isolated foundation elements only.

Design, construction, testing, and inspection shall satisfy the requirements of this code except as modified in Sections <u>1813A.2</u> ~~J112.2~~ through ~~J112.5~~ <u>1813A.5</u>.

<u>1813A.2</u> ~~J112.2~~ Geotechnical Report. *The geotechnical report shall specify vibro stone column requirements to ensure uniformity in total and differential immediate settlement, long term settlement, and earthquake induced settlement.*

1. *Soil compaction shall be sufficient to mitigate potential for liquefaction as described in California Geological Survey (CGS) Special Publication 117A (SP-117A): Guidelines for Evaluating and Mitigating Seismic Hazard in California.*

2. *Area replacement ratio for the compaction elements and the basis of its determination shall be explained. Minimum factor of safety for soil compaction shall be in accordance with SP-117A.*

3. *Depth of soil compaction elements and extent beyond the footprint of structures/foundation shall be defined. Extent beyond the foundation shall be half the depth of the VSCs with a minimum of 10' or an approved alternative.*

4. *Minimum diameter and maximum spacing of soil compaction elements shall be specified. VSC's shall not be less than 2 feet in diameter and center to center spacing shall not exceed 8 feet.*

5. *The modulus of subgrade reactions for shallow foundations shall account for the presence of compaction elements.*

6. *The modulus of subgrade reactions, long-term settlement, and post-earthquake settlement shall be specified along with expected total and differential settlements for design.*

7. *The acceptance criteria for <u>Friction Cone and Piezocone Penetration Testing</u> ~~Cone Penetration Test (CPT)~~ in accordance with ASTM D <u>5778</u> ~~3441~~ complemented by Standard Penetration Test (SPT) in accordance with ASTM D 1586, if necessary, to verify soil improvement shall be specified*

8. *The requirements for special inspection and observation by the Geotechnical engineer shall be specified.*

9. *A Final Verified Report (FVR) documenting the installation of the ground improvement system and confirming that the ground improvement acceptance criteria have been met shall be prepared by the Geotechnical Engineer and submitted to the enforcement agency for review and approval.*

<u>1813A.3</u> ~~***J112.3***~~ ***Shallow Foundations.*** *VSCs under the shallow foundation shall be located symmetrically around the centroid of the footing or load.*

1. *There shall be a minimum of four stone columns under each isolated or continuous/combined footing or approved equivalent.*

2. *The VSCs or deep foundation elements shall not be used to resist tension or overturning uplift from the shallow foundations.*

3. *The foundation design for the shallow foundation shall consider the increased vertical stiffness of the VSCs as point supports for analysis, unless it is substantiated that the installation of the VSCs result in improvement of the surrounding soils such that the modulus of subgrade reaction, long term settlement, and post-earthquake settlement can be considered uniform throughout.*

<u>1813A.4</u> ~~***J112.4***~~ ***Installation.*** *VSCs shall be installed with vibratory probes. Vertical columns of compacted unbounded aggregate shall be formed through the soils to be improved by adding gravel near the tip of the vibrator and progressively raising and re-penetrating the vibrator which will results in the gravel being pushed into the surrounding soil.*

Gravel aggregate for VSCs shall be well graded with a maximum size of 6" and not more than 10% smaller than 3/8" after compaction.

<u>1813A.5</u> ~~***J112.5***~~ ***Construction Documents.*** *Construction documents for VSCs, as a minimum, shall include the following:*

1. *Size, depth, and location of VSCs.*
2. *Extent of soil improvements along with building/structure foundation outlines.*
3. *Field verification requirements and acceptance criteria using CPT/SPT.*
4. *The locations where CPT/SPT shall be performed.*
5. *The Testing, Inspection and Observation (TIO) program shall indicate the inspection and observation required for the VSCs.*

(All existing amendments that are not revised above shall continue without any change)

Notation:

Authority: Health and Safety Code Section 129850

Reference: Health and Safety Code Sections 1275, 129850 and 129790