CHAPTER 18 – SOILS & FOUNDATIONS - AMENDMENTS

The ninth edition building code became first effective on October 20, 2017 and, with a shortened concurrency period, the new code came into full force and effect on January 1, 2018.

The new, ninth edition code is based on modified versions of the following ***2015 International Codes as published by the International Code Council*** (ICC).

- The International Building Code (IBC);
- International Residential Code (IRC);
- International Existing Building Code (IEBC);
- International Mechanical Code (IMC);
- International Energy Conservation Code (IECC);
- International Swimming Pool and Spa Code (ISPSC);
- Portions of the International Fire Code (IFC).

Massachusetts amends these code fairly significantly to accommodate for unique issues in the commonwealth. This package of amendments revise the IBC, IEBC, IMC, and IECC.

Please remember that the Massachusetts amendments posted on-line are ***unofficial versions*** and are meant for convenience only. Official versions of the Massachusetts amendments may be purchased from the State House Bookstore @ **Shop the Bookstore** and any of the I-Codes may be purchased from the International Code Council (ICC) @ **iccsafe.org**.

Additionally, the ICC publishes transition documents that identify changes from the 2009 to the 2015 I-Codes for those who may have interest.

- **International Building Code (IBC) Transition**
- **International Residential Code (IRC) Transition.**

780 CMR: MASSACHUSETTS AMENDMENTS TO THE *INTERNATIONAL BUILDING CODE 2015*

CHAPTER 18: SOILS AND FOUNDATIONS

1801.3 Add section as follows:

> **1801.3 Foundation Types Not Covered by the Code.** Types of foundations not specifically covered by the provisions of 780 CMR 18.00, and ground modification treatments to improve soils with inadequate load bearing capacity or settlement characteristics, may be permitted subject to approval by the building official. A report shall be submitted to the building official that identifies the foundation as a type not covered by existing code provisions, and contains sufficient data and analyses to substantiate the adequacy of the proposed foundation. The report shall be prepared by a registered design professional knowledgeable in the design of the proposed type of foundation or ground modification. The building official may require that an independent peer review be performed to evaluate the adequacy of the proposed design.

1803.1 Revise section as follows:

> **1803.1 General.** Geotechnical investigations shall be conducted in accordance with section 1803.2 and reported in accordance with section 1803.6. Where required, such investigations shall be conducted by a registered design professional.

1803.2 Revise section as follows:

> **1803.2 Investigations Required.** Geotechnical investigations shall be conducted in accordance with sections 1803.3 through 1803.5.
>
> **Exceptions**: The building official shall be permitted to waive the requirement for a geotechnical investigation:
> 1. Where satisfactory data from adjacent areas is available that demonstrates an investigation is not necessary to meet the requirements of 780 CMR 18.00;
> 2. For unoccupied structures that do not pose a significant risk to public safety in the event of failure; or
> 3. For structures used for agricultural purposes.

1803.5.4 Delete the exception.

1803.5.11 In two locations replace "C" with "B, C."

1803.5.12 In two locations replace "D" with "B, C, D."

1803.6 Add item 11 as follows:

> 11. Magnitude and distribution of lateral soil and ground water pressures, including seismic loads, on foundation and retaining walls.

1805.1.2.1 Delete the exception.

1805.4.2 Add exception as follows:

> **Exception**: The foundation drain may be omitted if determined not to be necessary by a registered design professional.

1805.5 Add section as follows:

> **1805.5 Impacts on Groundwater Levels.** Below-grade structures, their appurtenances and foundation drains shall be designed and constructed so as not to cause changes to the temporary or permanent groundwater level if such changes could adversely impact nearby structures or facilities including deterioration of timber piles, settlement, flooding or other impacts.

18.00: continued

1806.2 Replace the text "Table 1806.2" with "Table 1806.2 or Table 1806.2a," and add Table 1806.2a as follows:

TABLE 1806.2a PRESUMPTIVE ALLOWABLE VERTICAL BEARING PRESSURES

Material Class	Description	Notes	Consistency in Place	Net Bearing Pressure (tons/ft^2)[1,2,3]
1a	Massive bedrock: Granite, diorite, gabbro, basalt, gneiss	4	Hard, sound rock, minor jointing	100
1b	Quartzite, well-cemented conglomerate	4	Hard, sound rock, moderate jointing	60
2	Foliated bedrock: slate, schist	4	Medium, hard rock, minor jointing	40
3	Sedimentary bedrock: cementation shale, siltstone, sandstone, limestone, dolomite, conglomerate	4	Soft rock, moderate jointing	20
4	Weakly-cemented sedimentary bedrock: compaction shale or other similar rock in sound condition	4	Very soft rock	10
5	Weathered bedrock: any of the above except shale.	5	Very soft rock, weathered and/or major jointing and fracturing	8
6	Slightly-cemented sand and/or gravel, glacial till (basal or lodgement), hardpan	6	Very dense	1 0
7	Gravel, widely-graded sand and gravel; and granular ablation till	6	Very dense Dense Medium dense Loose Very loose	8 6 4 2 NOTE 9
8	Sands and non-plastic silty sands with little or no gravel (except for Class 9 materials)	6, 7	Dense Medium dense Loose Very loose	4 3 1 NOTE 9
9	Fine sand, silty fine sand, and non-plastic inorganic silt	6, 7	Dense Medium dense Loose Very loose	3 2 1 NOTE 9
10	Inorganic sandy or silty clay, clayey sand, clayey silt, clay, or varved clay; low to high plasticity	8	Hard Stiff Medium Soft	4 2 1 NOTE 9
11	Organic soils: peat, organic silt, organic clay	8,9		NOTE 9

Notes:

1. Net bearing pressure shall consist of the bearing pressure applied at the bottom of the foundation, including the weight of the foundation and any soil immediately overlying the foundation, minus the pressure calculated for a height of soil extending from the bottom of the foundation to the lowest ground surface level immediately adjacent to the foundation.
2. Where the load-bearing layer directly below the foundation is underlain by a weaker layer, the bearing pressure on the weaker layer shall be checked by assuming that the load is spread uniformly at an angle of 30° with the vertical, or by using another suitable method to determine the bearing pressure on the weaker layer.
3. The bearing strata shall be adequately protected against disturbance. If the bearing materials are disturbed from any cause, for example, by flow of water, freezing or construction activities, the extent of the disturbance shall be evaluated by a registered design professional to determine appropriate remedial measures or reduced allowable bearing pressures.
4. The allowable bearing pressures may be increased by an amount equal to 10% for each foot of depth below the surface of sound rock; however, the increase shall not exceed two times the value given in the table.

18.00: continued

5. Weathered shale and/or weathered compaction shale shall be included in Material Class 10. Other highly weathered rocks and/or residual soils shall be treated as soil under the appropriate description in Material Classes 6 to 10. Where the transition between residual soil and bedrock is gradual, a registered design professional shall make a judgment as to the appropriate bearing pressure.
6. Allowable bearing pressures may be increased by an amount equal to 5% for each foot of depth of the bearing area below the minimum required in section 1806.0; however, the bearing pressure shall not exceed two times the value given in the table. For foundation bearing areas having a least lateral dimension smaller than three feet, the allowable bearing pressure shall be ⅓ of the tabulated value times the least dimension in feet.
7. Evaluate susceptibility to liquefaction in accordance with section 1806.4.
8. Evaluate long-term settlement due to consolidation for these materials.
9. A registered design professional shall be engaged to provide recommendations for these special cases.

1806.3 Revise section as follows:

1806.3 Lateral Load. Where foundations are required to resist lateral loads, the allowable values of sliding friction, adhesion and passive pressure for design shall be determined by a registered design professional.

1806.3.1 through 1806.3.4 Delete subsections and replace with subsection 1806.3.1 as follows:

1806.3.1 Increase for Poles. Isolated poles for uses such as flagpoles or signs and poles used to support buildings that are not adversely affected by a ½-inch (12.7 mm) motion at the ground surface due to short-term lateral loads shall be permitted to be designed using lateral bearing pressures equal to two times the tabular values of Table 1806.2.

1806.4 Add sections 1806.4 through 1806.4.4 as follows:

1806.4 Liquefaction. The potential for liquefaction induced by the design earthquake in saturated clean to silty sands and non-plastic silts (Soil Classes 8 and 9 in Table 1806.2a) shall be evaluated as indicated in sections 1806.4.1 through 1806.4.4.

1806.4.1 Standard Penetration Test. For cases where lateral sliding cannot occur, the susceptibility to liquefaction can be evaluated on the basis of Standard Penetration Test ("SPT") blow counts, N (blows per foot), using Figures 1806.4(a) through (c). Figure 1806.4(a) shall be used if the N-values were determined using the standard 140-lb. donut drop weight, or if the type of hammer is not known. Figures 1806.4(b) and (c) shall be used only for cases where the specific type of hammer (safety hammer or automatic hammer) is known to have been used. Figures 1806.4(b) and (c) reflect the greater energy efficiency with these two specific types of hammer. Hammer type shall be as described in ASTM Standard Method D6066. N-values to be used with Figures 1806.4(a) through (c) are uncorrected field values.

Figures 1806.4(a) through (c) are intended to be a screening tool for Site Classes A through D, determined in accordance with section 1613.5.2. The figures are based on a rock spectral acceleration of SS = 0.35g, a soil amplification factor of Fa = 1.52 for Site Class D, and a factor of safety of 1.1. These figures are based on observed behavior of clean fine to medium sand and are conservative for other (more silty) materials in Soil Classes 8 and 9.

If the SPT N-values plot above or to the right of the applicable curve in Figures 1806.4(a) through (c), the soil shall be considered not susceptible to liquefaction. Liquefaction for soils below a depth of 60 feet (18 m) from final grade need not be considered for level ground. For pressure-injected footings, the ten-foot (3-m) thickness of soil immediately below the bottom of the driven shaft shall be considered not susceptible to liquefaction.

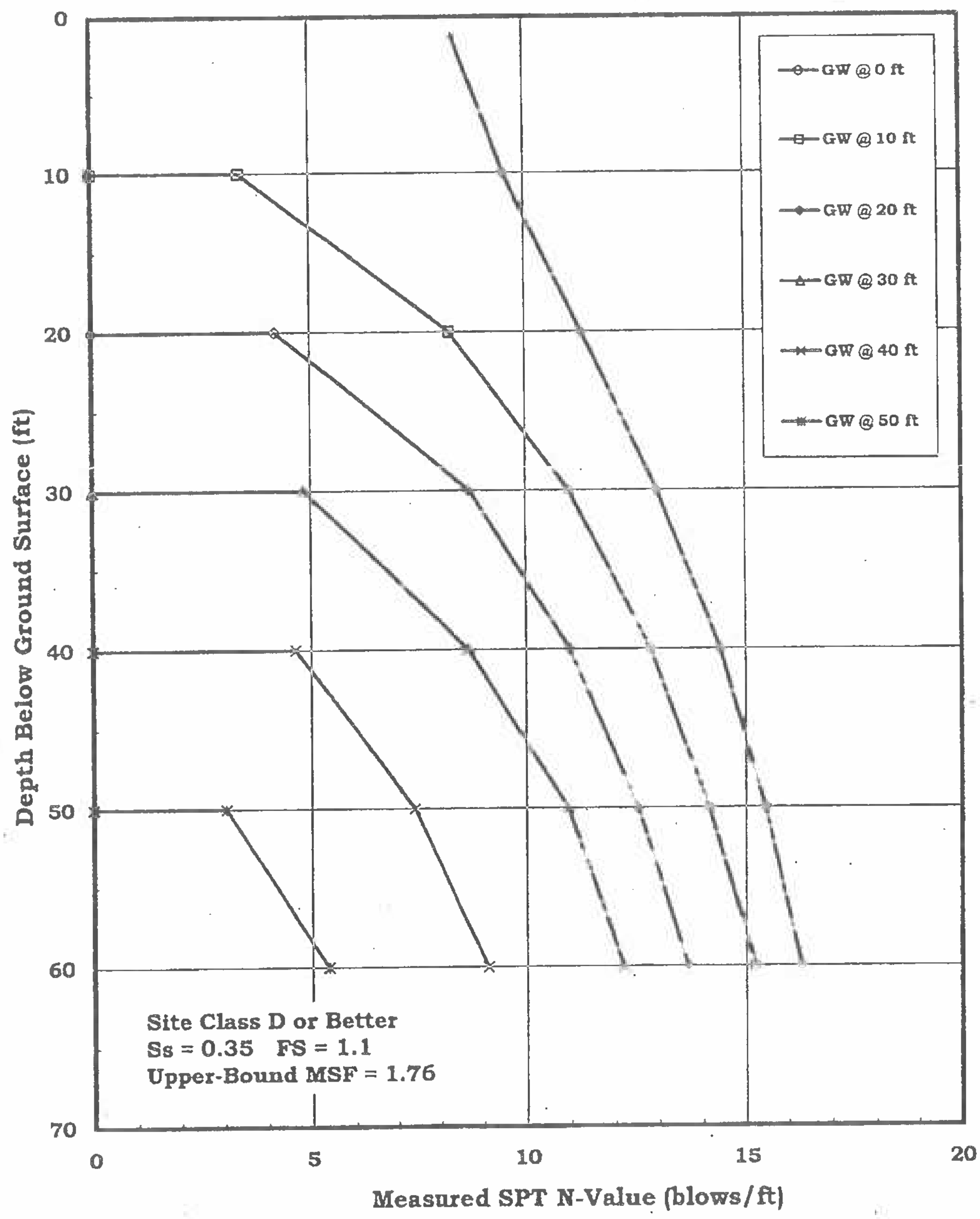
1806.4.2 Compacted Fills. Compacted granular fills shall be considered not susceptible to liquefaction provided that they are systematically compacted to at least 93% of the maximum dry density determined in accordance with ASTM Standard Method D1557.

18.00: continued

1806.4.3 Evaluation by a Registered Design Professional. Soils that do not meet the criteria in section 1806.4.1 or 1806.4.2 shall be considered potentially susceptible to liquefaction. For these cases, studies shall be performed by a registered design professional in accordance with section 1803.5.12.

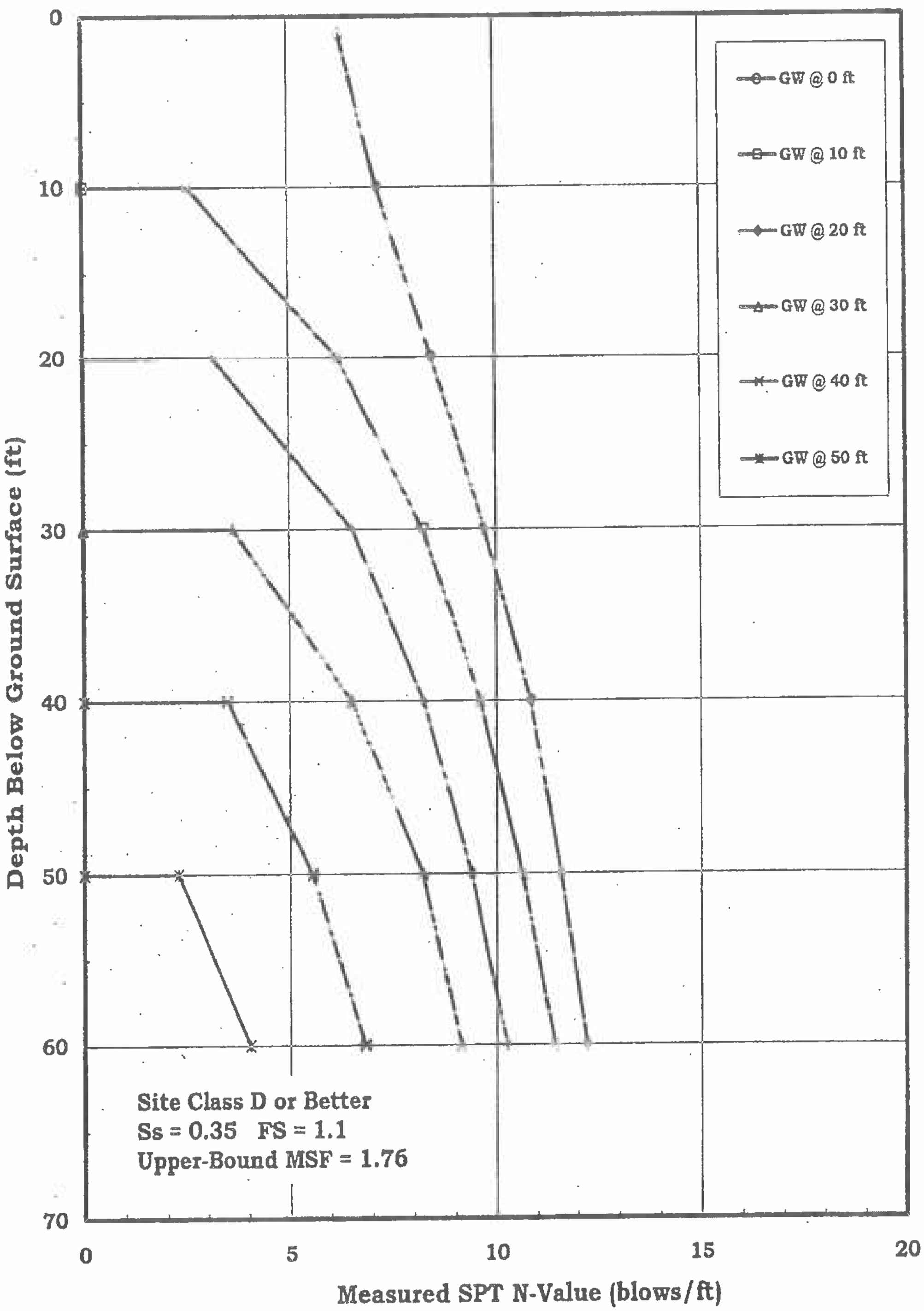
1806.4.4 Lateral Sliding. For sites underlain by the saturated soils identified in section 1806.4, and where the ground surface at the site or adjacent to the site is sloping such that lateral sliding (slope instability) may occur, studies by a registered design professional shall be made to establish the safety against sliding and lateral deformations as a result of the design earthquake.

Figure 1804.6a
Liquefaction Susceptibility - Donut Hammer Blow Counts



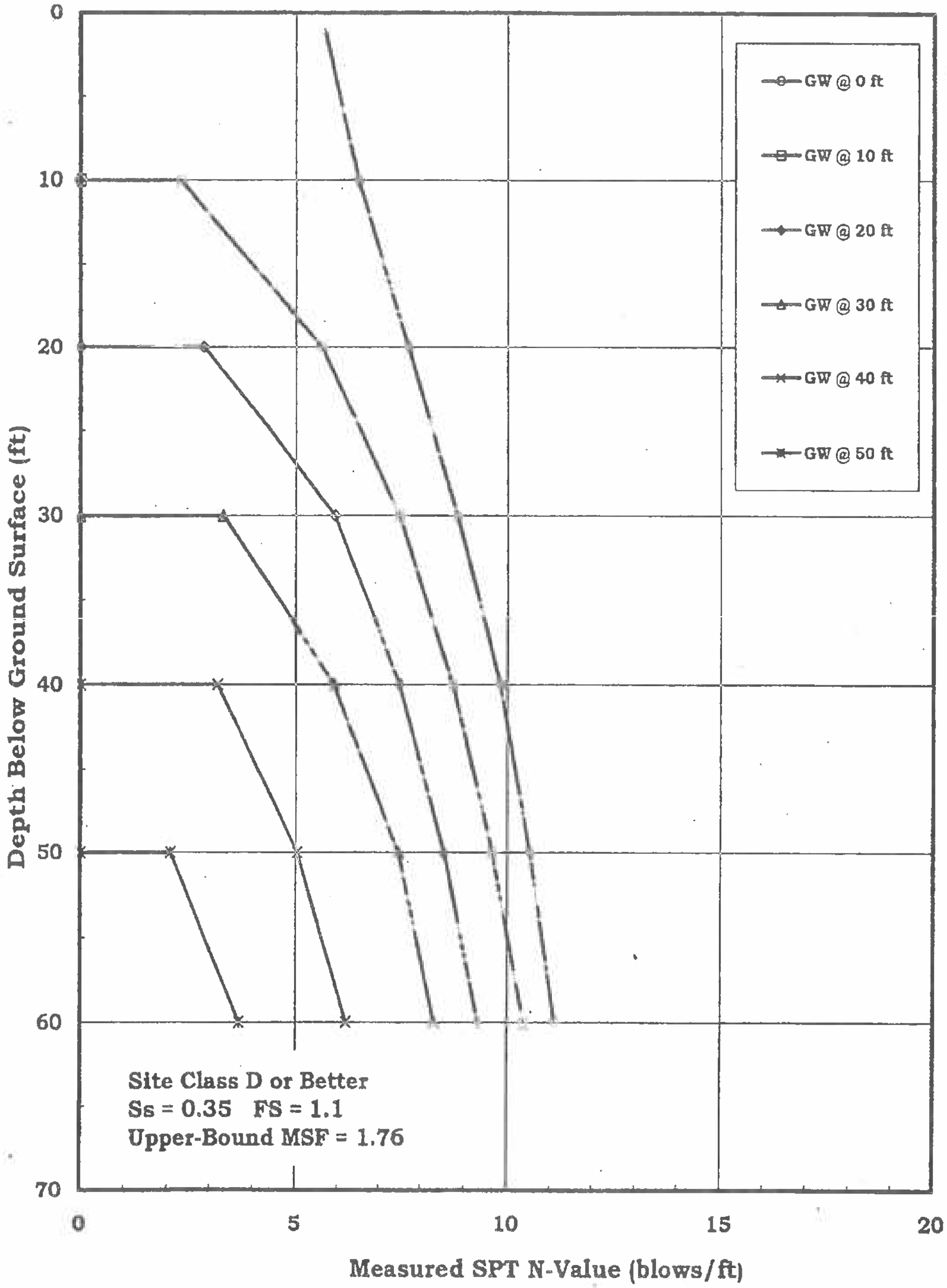
18.00: continued

Figure 1804.6b
Liquefaction Susceptibility - Safety Hammer Blow Counts



18.00: continued

Figure 1804.6c
Liquefaction Susceptibility - Automatic Hammer Blow Counts



18.00: continued

1807.1.6 Revise subsection as follows:

1807.1.6 Prescriptive Design of Concrete and Masonry Foundation Walls. Concrete and masonry foundation walls shall be permitted to be designed and constructed in accordance with this section, provided that they are laterally supported at the top and bottom, not subject to net hydrostatic pressures or surcharge loadings, and the backfill adjacent to the walls is not subjected to heavy compaction loads.

1807.2 through 1807.2.3 Replace section and subsections with 1807.2 through 1807.2.6 as follows:

1807.2 Retaining Walls. Retaining walls shall be designed in accordance with sections 1807.2.1 through 1807.2.6. The requirements of this section shall apply to any type of retaining structure or system that has any portion of its exposed face inclined steeper than one horizontal to one vertical, including conventional retaining walls, crib and bin wall systems, reinforced or mechanically stabilized earth systems, anchored walls, soil nail walls, multi-tiered systems, boulder walls or other types of retaining structures. The requirements of this section do not apply to slope facings, armor or riprap placed for the sole purpose of protection against surface erosion.

1807.2.1 Design. Retaining walls shall be designed to resist the static and seismic pressures of the retained materials, water pressures, and dead and live load surcharges to which such walls are subjected, and to ensure stability against excessive movements, overturning, sliding, excessive foundation pressure, and water uplift. Retaining walls that support an unbalanced height of retained material greater than six feet (1.83 m), and any retaining system or slope that could impact public safety or the stability of an adjacent structure shall be designed by a registered design professional.

1807.2.2 Design Lateral Soil Loads. Retaining walls shall be designed for the lateral soil loads set forth in section 1610, including seismic lateral pressure, or the lateral loads determined by a registered design professional based on a geotechnical investigation performed in accordance with section 1803.

1807.2.3 Safety Factor. Retaining walls shall be designed to resist the lateral action of soil to produce sliding and overturning with a minimum factor of safety of 1.5 in each case. The load combinations of section 1605 shall not apply to this requirement. Instead, design shall be based on 0.7 times nominal earthquake loads, 1.0 times other nominal loads, and investigation with one or more of the variable loads set to zero. The safety factor against lateral sliding shall be taken as the available soil resistance at the base of the retaining wall foundation divided by the net lateral force applied to the retaining wall.

Exception: Where earthquake loads are included, the minimum factor of safety for retaining wall sliding and overturning shall be 1.1.

1807.2.4 Overall Stability. The overall global stability of a retaining wall, considering potential failure surfaces extending through the materials located below, in front of and behind the wall shall be evaluated.

1807.2.5 Discrete Elements. For retaining walls constructed of discrete elements, such as unmortared masonry, rock, boulders, or stacked modular units, the elements shall be bonded or fastened together to prevent dislodgement under static and seismic loading conditions where dislodgement of the elements could pose a risk to public safety.

1807.2.6 Wall Drainage. Retaining walls shall be designed to support a hydrostatic head of water pressure equal to the full height of the wall, unless a drainage system is provided to reduce or eliminate hydrostatic pressure on the wall. Drainage systems shall be designed with sufficient permeability and discharge capacity, and shall be provided with appropriate filters and other design features to prevent blockage due to siltation, clogging, or freezing.

1808.2 Revise section as follows:

1808.2 Design for Capacity and Settlement. Foundations shall be designed to provide adequate load bearing capacity while limiting settlement, heave and lateral movement to tolerable levels. Foundations in areas with expansive soils shall be designed in accordance with the provisions of section 1808.6.

18.00: continued

1810.1.2 Revise subsection as follows:

1810.1.2 Use of Existing Deep Foundation Elements. Deep foundation elements left in place that have previously supported a partially or fully demolished structure may be used for support of new construction if satisfactory evidence is submitted by a registered design professional to the building official which indicates that the foundation elements have not been adversely impacted by the demolition, are structurally sound, have adequate load-bearing capacity to support the new design loads, and meet all of the requirements of 780 CMR. The load-bearing capacities of the deep foundation elements shall be determined by one of the following methods:

1. Analyses to determine the actual sustained load that the foundations supported satisfactorily in the previous structure.
2. Analyses based on documented foundation geometry and presumptive bearing value of the supporting soil, where applicable to the foundation type.
3. Load testing or re-driving performed on representative foundation elements. Records of previous pile-driving and load testing may be utilized where such records are deemed adequate by the registered design professional.

1810.3.2.6 Insert the following exceptions:

Exceptions:
1. Maximum allowable stress for concrete or grout in compression for elements that are cast in place without a permanent casing shall be 0.33 f c.
2. Maximum allowable stresses for timber foundation elements shall be 80% of the values determined in accordance with the AWC NDS.

1810.3.3.1 Replace subsection as follows:

1810.3.3.1 Allowable Axial Load. The allowable axial load on a deep foundation element shall be determined in accordance with sections 1810.3.3.1.1 through 1810.3.3.1.11. Where the allowable load capacity is not determined by using one of the formulas or analysis methods provided in sections 1810.3.3.1.1 through 1810.3.3.1.11, or the presumptive load- bearing values in section 1806, the allowable load capacity shall be verified by load tests. Dynamic load testing of instrumented driven piles performed in accordance with ASTM D4945 may be used in *lieu* of static load testing, where the testing program consists of a minimum of three instrumented piles tested to a minimum factor of safety of 2.5 using an analysis procedure that matches the force and velocity traces measured at the top of the pile. Load testing may be waived by the building official based upon submittal of substantiating data prepared by a registered design professional which include load test data or performance records for the proposed deep foundation elements under similar soil and loading conditions.

Exception: The allowable frictional resistance of cast-in-place elements greater than or equal to 12 inches in diameter obtaining capacity in Material Classes 1 through 6 in Table 1806.2a may be determined by a registered design professional based on analyses incorporating results of testing in similar bearing materials.

1810.3.3.1.1 through 1810.3.3.1.3 Replace as follows:

1810.3.3.1.1 Driving Criteria. For driven piles with a design load capacity not exceeding 50 tons (445 kN), the allowable load capacity may be determined based on final driving criteria (net displacement per hammer blow) obtained from an appropriate pile driving formula using a factor of safety not less than 3.5, or from wave equation analysis using a factor of safety not less than 2.75. The use of followers shall be allowed only as directed by a registered design professional.

The introduction of fresh hammer cushion material just prior to final penetration is not permitted.

1810.3.3.1.2 Load Tests. Where static load testing is required to determine the allowable load bearing capacity of deep foundation elements in vertical compression, the load tests shall be performed in accordance with ASTM D1143 and the following requirements:

18.00: continued

1. **Load in Bearing Stratum.** The load reaching the top of the bearing stratum under the maximum test load shall not be less than the following:
   a. For end-bearing elements: 100% of the allowable design load.
   b. For friction elements: 150% of the allowable design load.
   c. For foundation elements designed for a combination of end-bearing and friction, the required test load reaching the bearing stratum shall be based on the predominant support mode.
2. **Instrumentation.** The test element shall be instrumented using strain gauges, tell-tales, or similar methods to enable measurement or computation of the load in the element where it enters the bearing stratum. For foundation elements containing concrete, instrumentation shall be installed to permit direct measurement of the elastic modulus of the element during the test. Instrumentation of the test element is not required for the following cases:
   a. The test element is installed within a casing that extends to within ten feet above the bearing stratum.
   b. Load testing is performed on an existing foundation element, and appropriate consideration is given to potential frictional resistance developed above the bearing stratum during the load test.
   c. The foundation element length does not exceed 30 feet and no appreciable load will be supported above the bearing stratum.
3. **Loading Procedure.** The loading procedure shall be as follows:
   a. Apply 25% of the proposed allowable design load every 0.5 hour. Longer time increments may be used, but each time increment should be the same. In no case shall a load be changed if the rate of settlement is not decreasing with time.
   b. At 200% of the proposed allowable design load, maintain the load for a minimum of one hour and until the settlement (measured at the lowest point on the element at which measurements are made) over a one-hour period is not greater than 0.01 in.
   c. Remove 50% of the design load every 15 minutes until zero load is reached. Longer time increments may be used, but each should be the same.
   d. Measure rebound at zero load for a minimum of one hour.
   e, For each load increment or decrement, take readings at the top of the element and on the instrumentation at one, two, four, eight and 15 minutes and at 15-minute intervals thereafter.
   f. A load greater than 200% of the proposed allowable design load may be applied at the top of the test element, using the above loading procedure, to ensure that the requirement for minimum load reaching the bearing stratum is fulfilled. Other optional methods listed in ASTM D1143 may be approved by the building official upon submittal in advance of satisfactory justification prepared by a registered design professional.

1810.3.3.1.3 Load Test Evaluation Methods. Provided that the requirement for minimum load reaching the bearing stratum is satisfied, the allowable design load is permitted to be the greater of the following:

1. Allowable design load based on settlement during loading: 50% of the applied test load which causes a gross settlement at the top equal to the sum of:
   a. the theoretical elastic compression of the element in inches, assuming all the load at the top is transmitted to the tip, plus
   b. 0.15 inch (3.8 mm), plus
   c. 1% of the tip diameter or width in inches.
2. Allowable design load based on the net settlement after rebound: 50% of the applied test load which results in a net settlement at the top of 0.5 inch (13 mm) after rebound at zero load.

If the allowable design load is not governed by one of the above criteria, the allowable design load shall be equal to 50% of the maximum test load.

If the requirement for minimum test load reaching the bearing stratum is not satisfied, the allowable design load shall not exceed: a) the load reaching the bearing stratum for end-bearing elements and b) two-thirds of the load reaching the bearing stratum for friction elements.

18.00: continued

The allowable design load capacity determined from load tests can be applied to other foundation elements of the same type and size that are installed in similar subsurface conditions using the same installation methods and equipment. Where the design is based on a minimum embedment length, minimum penetration resistance, or friction over a minimum surface area, the applicable design value for the production elements shall equal or exceed the value used for the test element.

1810.3.3.1.10 Add subsection as follows:

1810.3.3.1.10 Enlarged Base Piles. For enlarged base piles with compacted concrete bases and design capacities up to 120 tons, that are formed on or in bearing materials of Classes 1 through 9 in Table 1806.2a, the allowable load may be computed by the following formula.

The Class 9 material (fine sand) shall have a maximum of 15% by weight finer than the No. 200 mesh sieve and the fines shall be non-plastic.

$$R = [(B \times E)/C]\, V^{2/3} \qquad \textbf{(Equation 18-12)}$$

Where:

R = allowable load in pounds.

B = average number of blows required to inject one cubic foot of concrete, during injection of the last batch.

E = energy per blow in foot-pounds.

C = constant.

V = total volume of base concrete in cubic feet.

The values of R, E, and C shall conform to Table 1810.3.3.1 unless other values are determined by load test, in which case the latter values shall control. The value of V shall include an allowance of one standard batch volume of concrete, if concrete is used in the tube during the driving process, plus the additional volume of concrete injected during formation of the base.

During injection of the last batch of concrete in the base, the height of concrete within the drive tube shall not be more than ⅓ of the drive-tube inside diameter.

TABLE 1810.3.3.1

R (tons)	Energy, E (foot-pounds)	C	Standard Batch Volume (ft^3)
over 100	140,000	18	5
51 to 100	100,000	18	5
25 to 50	60,000	30	2

1810.3.3.1.11 Add subsection as follows:

1810.3.3.1.11 Alternate Load Test Procedure for Micropiles. For micropiles designed as friction piles, the friction capacity in compression may be verified by load testing in tension in accordance with ASTM D3689 and the following requirements:

1. The test pile shall be cased or left ungrouted down to the top of the bearing stratum in a manner which will ensure that no friction resistance is developed above the bearing stratum.
2. The maximum design load shall be taken as 50% of the applied test load which results in a movement under load of 0.5 inch (13 mm) at the pile tip. The movement at the pile tip shall be:
   a. measured directly by a tell-tale; or
   b. computed by deducting the theoretical elastic elongation of the pile from the displacement measured at the top of the pile.

18.00: continued

1810.3.9.4.1 Insert, after the first sentence of the second paragraph, the following text:

> Where the actual cross-section area is greater than the minimum area required by design, the minimum reinforcement ratio can be applied to the minimum design area.

1810.3.9.4.2 Insert, after the first sentence of the second paragraph, the following text:

> Where the actual cross-section area is greater than the minimum area required by design, the minimum reinforcement ratio can be applied to the minimum design area.

1810.3.9.5 Revise subsection as follows:

> **1810.3.9.5 Belled Drilled Shafts.** Where drilled shafts are belled at the bottom, the edge thickness of the bell shall not be less than four inches (102 mm). Where the sides of the bell slope at an angle less than 60° (1 rad) from the horizontal, the effects of vertical shear shall be considered.

1810.3.14 Add subsection as follows:

> **1810.3.14 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 1.75 times the diagonal dimension of a rectangular pile. When driven to or penetrating into rock, 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, pile spacing shall be not less than 30 inches (762 mm). For enlarged base piles, the center-to-center spacing with uncased shafts shall be not less than 2.5 times the outside diameter of the drive tube and not less than 42 inches (1,067 mm). The center-to-center spacing of enlarged base piles with cased shafts shall be not less than three times the shaft diameter. For auger-cast piles, the minimum center-to-center spacing between adjacent piles shall not be less than 30 inches (760 mm) or two times the pile diameter, whichever is greater. The minimum center-to-center spacing between adjacent piers designed for friction support shall be not less than two times the shaft diameter.

1810.4.6 Revise subsection as follows:

> **1810.4.6 Heaved Elements.** Deep foundation elements in the vicinity of piles being driven shall be monitored to observe heave of the elements. Accurate reference points shall be established on each element immediately after its installation; for cast-in-place piles with unfilled casings or shells, the reference point shall be at the bottom of the pile. If, following the installation of piles in the vicinity, heaving of ½ inch (13 mm) or more occurs, the heaved element shall be re-driven to develop the required capacity and penetration, or the capacity of the element shall be verified by load testing in accordance with section 1810.3.3.1.2 or by analyses performed by a registered design professional.

1810.4.8 Replace as follows:

> **1810.4.8 Hollow-stem Augered, Cast-in-place Elements.** Where concrete or grout is placed by pumping through a hollow-stem auger, the element shall be formed by advancing a closed-end continuous-flight hollow-stem auger of uniform diameter into a satisfactory bearing material followed by removal of the tip closure and pumping cement grout or concrete through the hollow-stem while the hollow-stem auger is extracted. The installation shall conform to the following requirements:
>
> 1. During advancement, the hollow-stem auger shall be rotated at a higher rate than required for advancement, so that the material through which the auger is being advanced is removed by the auger flights and is not displaced laterally by the auger. During withdrawal, if the hollow-stem auger is rotated, it shall be rotated in a positive (advancing) direction.

18.00: continued

2. The grout or concrete shall be pumped under continuous pressure and in one continuous operation. Grout or concrete pump pressures shall be measured and maintained at all times sufficiently high to offset hydrostatic and lateral earth pressures. The rate of withdrawal of the auger shall be carefully controlled to exclude all foreign matter and ensure that the augered hole is completely filled with grout or concrete as the auger is withdrawn. The actual volume of grout or concrete pumped into each hole shall be equal to, or greater than, the theoretical volume of the augered hole.

3. If the grouting or concreting process of any element is interrupted, or a loss of concreting or grouting pressure occurs, the element shall be redrilled to five feet (1,524 mm) below the elevation of the tip of the auger when the installation was interrupted or concreting or grouting pressure was lost, or to the bottom of the element if less than five feet, and the installation shall resume from this point.

4. Elements shall not be installed within six diameters (center-to-center) of an element filled with grout or concrete less than 24 hours old except where approved by the registered design professional.

5. The continuous flight auger rig utilized to install augered uncased elements shall be equipped with data logging equipment that automatically monitors and produces a real-time printout of depth, grout or concrete pressure, grout or concrete flow, and rate of auger withdrawal. The automatic monitoring equipment shall immediately indicate to the equipment operator, and record on the printed record, any instance during the withdrawal of the hollow-stem auger where the rate of auger withdrawal times the theoretical element cross-sectional area exceeds the rate of grout or concrete placement. Printed instrumentation readout for each element shall be provided to the registered design professional's representative upon completion of each element.