# CHAPTER 6

# BUILDING CODE

**Authority**

N.J.S.A. 13:17-1 et seq., specifically 13:17-6(i).

**Source and Effective Date**

R.2001 d.241, effective June 21, 2001.
See: 33 N.J.R. 385(a), 33 N.J.R. 2495(a).

**Executive Order No. 66(1978) Expiration Date**

Chapter 6, Building Code, expires on June 21, 2006.

**Chapter Historical Note**

Chapter 6, Building Code, was adopted as R.1970 d.46, effective May 1, 1970. See: 1 N.J.R. 17(b), 2 N.J.R. 52(a). Notice of routine program implementation. See: 25 N.J.R. 1010(a).

Subchapter 3, Uniform Construction Code; Uniform Procedure for Administration and Enforcement, was adopted as R.1977 d.457, effective on December 12, 1977. See: 9 N.J.R. 393(a), 10 N.J.R. 49(a).

Subchapter 1, General Provisions, and Subchapter 3, Uniform Construction Code; Uniform Procedure for Administration and Enforcement, were repealed, and a new Subchapter 1, General Provisions, was adopted by R.1991 d.233, effective May 6, 1991. See: 22 N.J.R. 2126(a), 23 N.J.R. 1451(a).

The expiration date of Chapter 6, Building Code, was extended by gubernatorial directive from May 6, 1996 to November 6, 1996. See: 28 N.J.R. 2566(c).

Pursuant to Executive Order No. 66(1978), Chapter 6, Building Code, was readopted as R.1996 d.399, effective July 26, 1996. See: 28 N.J.R. 2344(a), 28 N.J.R. 3969(d).

Pursuant to Executive Order No. 66(1978), Chapter 6, Building Code, was readopted as R.2001 d.241, effective June 21, 2001. See: Source and Effective Date.

**CHAPTER TABLE OF CONTENTS**

SUBCHAPTER 3. (RESERVED)

---

SUBCHAPTER 1. GENERAL PROVISIONS

**19:6–1.1 (Reserved)**

**19:6–1.2 Authority**

These rules are hereby adopted for the Hackensack Meadowlands District (HMD) pursuant to the Interagency Agreement between the Hackensack Meadowlands Development Commission (HMDC) and the Department of Community Affairs (DCA), and pursuant to N.J.S.A. 13:17–1 et seq.

**19:6–1.3 HMDC responsibility**

The HMDC, acting as agent for the Department of Community Affairs, shall have the responsibility, pursuant to N.J.S.A. 13:17–1 et seq., for the approval of all plans, for insuring compliance with the Uniform Construction Code (UCC) and for enforcement as outlined in this chapter.

**19:6–1.4 Enforcement**

(a) As per the Interagency Agreement between the Department of Community Affairs (DCA) and the Hackensack Meadowlands Development Commission (HMDC) dated February 27, 1991, the HMDC shall act as DCA's agent within the HMD.

(b) The Office of the Chief Engineer (OCE) shall have the responsibility for reviewing and approving plans for all work within the HMD, pursuant to N.J.S.A. 13:17–1 et seq., subject to the requirements of this chapter, in addition to the responsibilities cited in N.J.A.C. 19:6–1.3. The OCE shall reserve the right to perform any or all inspections conducted in accordance with N.J.A.C. 5:23–2.18.

(c) Each municipal construction official has the responsibility of enforcing the requirements of the UCC and of this chapter in that portion of the HMD within the boundaries of his or her municipality, except for the specific circumstances noted in these rules.

(d) At least one OCE inspector/plan examiner in each subcode shall hold a class I license in accordance with N.J.A.C. 5:23. At least one member of the OCE staff shall also be licensed as a construction official, in accordance with N.J.A.C. 5:23–5.6.

(e) In the event that a municipal code enforcement official fails to implement any provision of this chapter or the UCC in that portion of the HMD within his or her jurisdiction, and no immediate action is deemed necessary by the HMDC, then the OCE, with prior written approval by the DCA, shall act in the capacity of that official, as agent for the DCA, in order to insure compliance with this chapter and the UCC.

(f) Except for (g) below, when the OCE shall determine that a violation of this chapter or the UCC exists, the OCE shall notify the Municipal Construction Official in writing of such violation and request the municipal construction official and the appropriate subcode official to take action necessary to bring about compliance with this chapter or the UCC and to notify the OCE of his or her actions.

(g) When the OCE determines that work in progress is being done contrary to approved plans and there is not adequate time to follow the procedure outlined in (f) above, and/or the OCE believes that any delay may exacerbate the extent and nature of the violation, then the OCE may act immediately to prevent continuation of such violations, as a subcode official acting as the agent of the DCA. This designation is temporary in nature and the OCE will act in this capacity until the violation is resolved. The municipality, upon written notification by the OCE, of the emergency situation and of its resolution, shall resume compliance authority.

**19:6–1.5 Fees**

(a) Fees for plan review shall be in accordance with N.J.A.C. 19:3–1.3.

(b) In the event the OCE enters into an agreement with any or all municipalities within the District to perform required inspections, the OCE shall collect 100 percent of the HMDC's permit fee. Twenty percent of that fee, exclusive of plan review fees, will be returned to the municipality to cover administrative costs.

**19:6–1.6 Violations and penalties**

For any violation of this chapter or the UCC, notice of violation and penalty procedure shall be in accordance with N.J.A.C. 19:4–6.24 and the UCC N.J.A.C. 5:23–2.31. All penalties shall be in accordance with the Uniform Construction Code.

**19:6–1.7 Hackensack Meadowlands District uniform procedure**

(a) All applications shall be initiated at the office of the municipal construction official and be in accordance with N.J.A.C. 5:23–2.15.

(b) The municipal construction official shall advise applicants that all applications requiring plan review are to be approved by HMDC prior to the issuing of a construction permit.

(c) Submittals to the HMDC for purposes of plan review shall consist of three sets of plans, copies of the standard UCC application forms filed with the municipality and plan review fees required by N.J.A.C. 19:3–1.3.

(d) Following approval of construction plans, the OCE shall return two copies of the approved plans and a Certificate of Compliance to the municipal construction official. Providing all prior approvals and the UCC rules have been satisfied, the municipal construction official shall then issue a construction permit, a copy of which shall be sent to the OCE.

Next Page is 6-3

(e) Whenever the municipal construction official shall fail to issue a construction permit after the applicant has satisfied all provisions of this chapter and the UCC, the OCE shall issue such permit upon DCA's written authorization. The OCE will then assume all responsibility for the compliance of such project with this chapter.

(f) The inspection procedure shall be as follows:

1. The municipal code officials shall have the primary responsibility for all required inspections.

2. As per N.J.A.C. 19:6–1.4(b), the OCE reserves the right to perform all inspections pursuant to N.J.A.C. 5:23–2.18.

3. The OCE and Municipal Construction Official shall be notified by the owner or his or her agent at the various stages of construction when inspections are required.

4. If the municipal code official is temporarily unable to perform an inspection upon notification, he or she can request that the OCE perform the inspection without compensation.

5. When the municipal code official relinquishes his or her responsibility for the performance of subcode(s) inspection concerning specific projects, and the OCE agrees to perform the inspection, acting as DCA's agent, the HMDC shall receive fees for such subcode inspection in accordance with the municipality's fee schedule.

(g) Municipal construction officials and the OCE shall supply applicants with a list of all required inspections and apprise the applicant of his responsibility to notify the municipal construction official and the OCE when work is ready for inspection.

**19:6–1.8 Certificates of occupancy**

(a) No certificate of occupancy, temporary certificate of occupancy or certificate of continued occupancy, shall be issued by the municipal construction official without certification by the OCE that a final inspection has been performed by the OCE and that such occupancy meets all provisions of N.J.A.C. 19:4, 19:5 and this chapter, and the plans approved by the OCE.

(b) Whenever the municipal construction official fails to issue a certificate of occupancy for a structure or tenant space which is in compliance with all provisions of this chapter, the OCE, upon DCA's written authorization, will issue such certificate of occupancy and receive all fees associated with such certificates.

**19:6–1.9 Appeals**

(a) Whenever the OCE shall act as agent of the DCA in the capacity of a UCC enforcing official under these regulations, any appeal of a decision of the OCE shall be made directly to the Department of Community Affairs.

(b) Any appeal of a plan review determination shall be made directly to the Hackensack Meadowlands Development Commission in accordance with N.J.A.C. 19:4–6.25.

(c) Any appeals of a municipal decision within the HMD may be made in accordance with N.J.A.C. 5:23–2.35.

**19:6–1.10 Severability**

If any section or subsection of this chapter is invalidated by judicial decision, such decision shall not affect the remaining sections or subsections of these regulations.

**19:6–1.11 HMDC statutory authority**

Except as provided herein, nothing contained in this chapter shall be construed to affect the statutory authority of the Commission pursuant to N.J.S.A. 13:17–1 et seq.

---

## SUBCHAPTER 2. FOUNDATIONS

**19:6–2.1 Scope**

These regulations shall be known and may be cited as the "foundation supplement," and in the event of any inconsistency between the provisions of this foundation supplement and the provisions of the Standard Building Code of New Jersey, as modified under subchapter 1, General Provisions, of this chapter, the provisions of this foundation supplement shall be controlling.

**19:6–2.2 Foundations; generally**

The foundation of buildings, including retaining walls, shall bear on, or be carried down to, satisfactory bearing materials in such manner that the entire transmitted load will be distributed over the supporting soils of any depth beneath the foundation at unit intensities within the allowable bearing values established in this subchapter. In addition, foundations shall be proportioned to limit settlements to a magnitude that will not cause damage to the proposed construction or to existing adjacent or nearby buildings during or after construction.

**19:6–2.3 Depth of foundations**

(a) The bottom surface of any footing, pier pile cap, or other foundation construction, other than grade beams, shall be carried down sufficiently to avoid exposure to frost except for foundation elements in the interior of closed and heated buildings.

(b) The bottom surface of any grade beam shall be carried down at least 18 inches below the lowest level of the adjoining ground surface that is exposed to frost.

**19:6–2.4 Foundations at different levels**

Where footings are supported at different levels, or at different levels from the footings of adjacent structures, the influence of the pressures under the higher footings on the stability of the lower footings shall be considered. Consideration shall be given to the requirements for lateral support of the material supporting the higher footings, the additional load imposed on the lower footings and assessment of the effects of dragdown on adjacent pile-supporting buildings.

**19:6–2.5 Slabs on grade**

Slabs on grade within or adjacent to a building shall be so designed to limit settlement of such slabs to a magnitude that will not impair their usability or cause damage to the building or its foundations.

**19:6–2.6 Construction**

(a) No foundation shall be placed on frozen soil. No foundation shall be placed in freezing weather unless provision is made to maintain the underlying soil free of frost.

(b) In an excavation where soil and ground water conditions are such that an inward or upward seepage might be produced in soil material intended to provide vertical or lateral support for foundation elements or for adjacent foundations, excavating methods that will control or prevent the inflow of ground water shall be employed to prevent disturbance of the soil material in the excavation or beneath existing buildings. No foundation shall be laid on soil that has been disturbed by seepage unless remedial measures, as directed by an architect or engineer, are taken.

**19:6–2.7 Soil investigations; general**

Borings in earth or rock, recovery of samples, test of soil samples, load tests, or other investigations or exploratory procedures shall be performed as necessary for the design and construction of a safe foundation, subject to inspection in accordance with requirements of this subchapter.

**19:6–2.8 Borings**

(a) Except for one and two-family dwellings with plan dimension not exceeding 2,500 square feet and where soil conditions are essentially uniform, at least five borings shall be made for each building, one in each corner and one in the center. For one and two-family dwellings of a size not to exceed 2,500 square feet, one boring shall be made for each such building. For buildings supported on piling, one boring shall be made for every 4,000 square feet of building area or fraction thereof, but not less than five borings for each building. Additional borings may be necessary if soil conditions are not found to be uniform. The boring program shall be expanded by probes as described in section 10 of this subchapter.

1. Where foundations are to rest on rock of class 1–65, 2–65, or 3–65, and such rock is exposed prior to construction over a part or all of the area of the buildings, borings will not be required in those areas where rock is exposed and the area (within the limits of the building) of the exposed rock surface shall not be included in the area used to compute the required number of borings provided the following requirements are met:

i. The presence of defects or the inclination of bedding planes in the rock are of such size and location as to not affect the stability of the foundation;

ii. The foundation is designed for bearing pressures not exceeding those permitted in table 613.6 of this subchapter, without increase for embedment.

(b) At least two thirds of the required number of borings shall be located within the area under the building. Those outside of the area shall not be more than 25 feet from the limits of the building. Borings shall be uniformly distributed or distributed in accordance with the loading pattern imposed by the building.

(c) Rules concerning depth are:

1. Unless soil material of class 1–65 through 3–65 is encountered at shallower depth, borings shall extend below the deepest part of the excavation, or in the case of pile supported buildings, below anticipated tip elevations of piling as necessary to satisfy the more restrictive of the following requirements:

i. Borings shall extend deep enough into nominally satisfactory bearing material to establish its character and thickness, but not less than the following:

(1) Where the soil material is class 5–65: ten feet;

(2) For other classes: 25 feet.

ii. Except as noted in subparagraphs i, iii and iv of this subsection, in order to determine the full depth of the organic silt strata and the underlying depth of sand or desiccated clay, all borings shall penetrate to a depth of at least 25 feet below the top of the organic soil or to such depth that the penetration resistance to the sample spoon decreases significantly, whichever is deeper;

iii. Borings shall extend to the depth at which the vertical stress caused by the proposed construction is reduced to ten per cent or less of the original vertical stress at this depth due to the weight of the overburden, except that where strata of soil materials of class 9–65 or poorer are encountered within this depth, the borings shall penetrate such strata and be carried to a depth that shows penetration continuous of material of class 8–65 or better as required in subsection (a) of this section;

iv. At least one boring for each building or one boring for each 100,000 square feet of building area or fraction thereof, whichever is greater, shall extend as a minimum depth to the lower limit of the compressible material, defined as varved clay or silt, or material of classes 9–65 and 10–65. For buildings supported on piles, all borings shall be carried to the foregoing criteria;

v. For piling deriving their support in end bearing, the borings shall penetrate to at least ten feet into the compact glacial till that overlies bedrock.

2. Where rock is encountered in borings within the depth noted in paragraph 1 of this subsection, the borings shall be cored to a minimum of five feet into rock, or farther where necessary or required, to obtain at least a recovery of 35 per cent from five feet of penetration, but not to exceed the depth noted in paragraph 1 of this subsection. However, for foundations supported on piles bearing on the rock and having a capacity in excess of 80 tons per unit, the capacity of the rock to support the applied load shall be demonstrated by increasing the length of coring to ten feet.

(d) Rules concerning types are:

1. Soil borings: Soil samples shall be recovered at intervals not to exceed five feet and at every change of soil strata, except that sampling in the upper 25 feet shall be continuous. Such samples shall be recovered using a two-inch split spoon sampler having an inside diameter of 1–3/8 inches and a constant internal cross section. The sampler shall be at least 24 inches long and shall be tipped with a heat treated, sharp cutting shoe. It shall be straight and sound, with an undistorted cross section. The rods to which the sampler is attached shall be one-inch extra heavy pipe or 1–5/8– inch O.D. drill rods. The sampling tools shall be driven with a 140–pound hammer having a fall of 30 inches. The blows per foot so recorded shall be designated hereinafter by the symbol N. The fall of the hammer shall be free fall and the energy of impact shall not be mitigated by friction of the hoisting line on the drum, friction of the hammer against its guide or similar effects. All samples, except those of rock, shall be preserved in airtight bottles having a capacity of at least eight ounces.

2. Rock borings: Where borings are required to penetrate rock, they shall be advanced by core drilling, and core samples shall be recovered using a double tube core barrel and diamond bits that provide cores at least 1–3/8 inches in diameter.

(e) Records of all borings required by the provisions of subsection (a) of this section shall accompany the application for approval of the building plans. Such records shall show, as a minimum, the size of casing and the number of blows per foot required to advance the casing (to the depth that the casing is used); the weight of the hammer and the distance of fall; a description of the sampler; a description of the drill tools and equipment including, where used, the size of diamond bits and type of core barrels; the number of blows required to drive the sampling spoon for each six-inch increment of penetration; the elevation of the ground surface referenced to an established datum that is not subject to subsidence or lateral movement; the location and depth of the boring and its relation to the proposed construction; the elevations at which samples were taken; the elevations at which core drilling was started and stopped for each "run"; the elevations of the boundaries of soil strata; per cent recovery for each "run" of core drilling; description of the soil strata encountered and geological classification of rock drilled (based on visual examination of cores); any particular, unusual, or special conditions such as loss of water in the earth and rock strata, boulders, cavities, and obstructions, use of special type of sampling traps, and so forth; and the level of ground water together with a description of how and when the ground water level was observed. All abandoned or unsuccessful attempts at borings or rock drilling shall be reported.

(f) Soil samples and rock cores shall be retained in an accessible location by the owner, or by the party making application for approval of the building plans for a period of one year after the date of issuance of a certificate of occupancy and shall be available upon reasonable notice for inspection.

**19:6–2.9 Test pits**

Test pits may be used to explore the depth and nature of existing fills and shall not be substituted for borings.

**19:6–2.10 Probings (or auger borings)**

Probes, obtaining soil samples, shall be performed as an expansion to the borings described in section 8 of this subchapter to determine the thickness of the surface organic soil. One probe shall be made for each 2,500 square feet of building area or fraction thereof. Probes may also be used to determine the thickness of existing fills.

**19:6–2.11 Boring methods**

(a) Borings shall be made by the continuous driving and clearing out of a pipe casing (including telescoping of smaller sizes inside of larger casing) except as permitted in this subsection. Where casing is used, it shall be cleaned out to undisturbed soil prior to sampling and the sample spoon driven into soil that has not been affected by chopping, washing or hydrostatic imbalance.

1. Uncased borings: Uncased borings, including borings where the casing is omitted for part of the depth, may be used if the mud slurry method is followed. The requirements for soil sampling and rock coring shall be the same for uncased borings as for borings made using casing, except that prior to each soil sampling operation the boring shall be substantially cleaned of disturbed material and the sample spoon shall be advanced through

any settled solids before counting the blows required to drive the spoon. Longer sample spoons, having a sludge chamber, shall be used where settled solids exceed six inches. In determining ground water levels, methods shall be used to reduce and replace the mud slurry so that the hydrostatic head may be measured. The procedures shall be described in detail in the records.

2. Auger borings: Borings may be made with augers except that short flight augers shall not be used in granular soils below the water level. Sampling procedures in auger borings for both soil and rock shall be the same as for cased borings. Full hydrostatic head shall be maintained in granular soils below the ground water level during the boring operation.

3. Maximum diameter: Where the bore hole, as drilled by any method, is in excess of four inches in diameter, sampling operations shall be performed through a temporary casing having a four-inch inside diameter or less.

**19:6–2.12 Probings and geophysical explorations**

(a) Where the foundations for a proposed building consist of footings or foundation piers or walls bearing on rock of class 1–65, 2–65, or 3–65, the use of probings (or auger borings) or geophysical methods without the recovery of soil samples or rock cores (except as hereinafter stipulated) may be substituted for up to one half of the number of borings required by the provisions of section 8 of this subchapter provided that such probings, borings, and so forth, are carried to adequate depth and are of a nature that will reasonably define the surface contours of the rock. The accuracy of such surface contour definition shall be confirmed by recovering rock cores at the locations of at least one fifth of the probings or auger borings, or in the case where geophysical methods are used, those borings which are made shall be so distributed as to permit confirmation of the accuracy of the geophysical investigations.

(b) Where the foundation for the proposed building consists of piling bearing on rock of class 1–65, 2–65, or 3–65, the provisions of subsection (a) of this section shall apply, provided that the borings consistently show that the soil overlying the rock consists solely of deposits of class 6–65 through 11–65 and it is free of boulders or other obstructions.

(c) Geophysical investigations shall be conducted by experienced and qualified personnel acceptable to the Chief Engineer, who may reject the results and require additional exploration by borings if the results of the geophysical explorations cannot be satisfactorily correlated to the logs of the borings.

**19:6–2.13 Existing borings**

(a) Existing boring data may be utilized subject to the following:

1. Borings, probings, and so forth, that have been made in accordance with all requirements of this section, but not necessarily for the investigation of the specific project for which application is being made, may be utilized in fulfillment of these provisions.

2. The logs of borings, probings, and so forth, that have been made in accordance with all requirements of this section, but wherein the soil samples and/or rock cores are not available for examination may be utilized in fulfillment of these provisions to an extent not to exceed one third of the required number of borings provided the logs of the new borings are in agreement with the logs of the former borings; otherwise, the existing boring logs shall not be utilized.

**19:6–2.14 Foundation loads**

Soil bearing pressures—the loads to be used in computing the bearing pressures on materials directly underlying footings shall be the total column, pier, or wall reactions on the basis of reduced live load; plus the weight of the foundations; plus the weight of the soil, fill, and slabs on grade that is included within vertical planes projected upward from the extreme limits of the footing to the final ground surface. Live load on grade, or on slabs on grade, within these limits shall also be included.

**19:6–2.15 Pile reactions**

The loads to be used in computing pile reactions shall be determined as provided in section 14 of this subchapter, except that where piles penetrate fill, clay, silt, peat or similar compressible strata, the pile loads shall be increased by the amount of drag exerted by such material, and by the overlying strata, during consolidation. Computation of the amount of drag shall consider the amount of added fill, the amount of shear strain between pile (or group) and the soil, the ratio of vertical to horizontal pressure in the soil, and the arrangement of the piles. The soil surrounding or underlying the pile cap shall not be considered as providing any vertical support for the cap.

**19:6–2.16 Lateral loads**

(a) Every foundation wall or other wall serving as a retaining structure shall be designed to resist, in addition to the vertical loads acting thereon, the incidental lateral earth pressures and surcharges, plus hydrostatic pressures corresponding to the maximum probable ground water level.

(b) Provisions shall be made to resist lateral loads imposed on the superstructure due to wind or other causes.

(c) Buildings shall not be constructed in areas where the soil is subject to lateral movements unless positive provision is made to prevent such movements.

## 19:6–2.17 Eccentricities

Eccentricity of loading in foundations, including eccentricity of loading or the basis of retaining walls, shall be investigated and the maximum soil pressure or pile load (considering eccentricity) shall be kept within the safe capacity thereof as established in sections 21 and 42 of this subchapter. Soil pressure and pile load due to eccentricity shall be computed on the basis of straight line distribution of foundation reaction. However, other modes of distribution of the foundation reaction may be assumed, subject to the approval of the chief engineer, if it can be demonstrated that the pile and/or soil is capable of sufficient plastic deformation or to develop such mode of distribution without failure.

## 19:6–2.18 Uplift forces

Uplift and overturning forces due to wind and hydrostatic pressure shall be considered.

## 19:6–2.19 Impact

Impact forces may be neglected in the design of foundations, except for foundations bearing on loose granular soils, or regardless of the type of soil material, for foundations supporting cranes, heavy machinery, or moving equipment, or where the ratio of the live load causing impact to the total of the reactions from live load applied without impact, plus dead load exceeds one third.

## 19:6–2.20 Stability

The provisions of sections 58 and 59 of this subchapter shall apply.

## 19:6–2.21 Classifications

(a) For the purpose of this subchapter, soil materials shall be classified and identified in accordance with table 613.6. In addition, the following supplementary definitions shall apply:

1. Rock:

i. Hard sound rock: Includes crystalline rocks such as gneiss, diabase, schist. Characteristics are: the rock rings when struck with pick or bar; does not disintegrate after exposure to air or water; breaks with sharp fresh fracture; cracks are unweathered and less than one-eighth inch wide, generally no closer than three feet apart; core recovery with a double tube, diamond core barrel is generally 85 per cent or greater for each five foot run;

ii. Medium hard rock: Includes crystalline rocks of subparagraph i of this paragraph, plus marble and serpentine. Characteristics are: all those listed in subparagraph i of this paragraph, except that cracks may be 1/4 inch wide and slightly weathered, generally spaced no closer than two feet apart; core recovery with a double tube, diamond core barrel is generally 50 per cent or greater for each five-foot run;

iii. Intermediate rock: Includes rocks of subparagraphs i and ii of this paragraph plus cemented shales and sandstones of Newark formation. Characteristics are: the rock gives dull sound when struck with pick or bar; may not disintegrate after exposure to air or water; broken pieces may show weathered surfaces; may contain fractured and weathered zones up to one inch wide spaced as close as one foot; core recovery with a double tube, diamond core barrel is generally 35 per cent or greater for each five foot run.

iv. Soft rock: Includes rocks of subparagraphs i, ii, and iii of this paragraph in partially weathered condition, plus uncemented shales and sandstones. Characteristics are: rock may soften on exposure to air or water, may contain thoroughly weathered zones up to three inches wide but filled with stiff soil; core recovery with a double tube, diamond core barrel is less than 35 per cent for each five foot run, but standard penetration resistance in soil sampling is more than 50 blows per foot. Where core recoveries are less than 20 per cent and the material is to be used for bearing, a minimum three-inch diameter core shall be recovered and the material recovered shall be classified in accordance with table 613.6.

(b) Special soil types rules are:

1. Fine sand: Soils of Group SM, containing more than 50 per cent (by weight) of particles passing a number 60 mesh sieve;

2. Hardpan: Soils of Groups GM, GC, and SW, generally directly overlying rock and which are sufficiently cemented to be difficult to remove by picking;

3. Clay soils: Soils of each Group SC, CL and CH shall be classified according to consistency as hard, medium or soft in accordance with the following:

i. Hard clay: A clay requiring picking for removal, a fresh sample of which cannot be molded by pressure of the fingers;

ii. Medium clay: A clay that can be removed by spading, a fresh sample of which can be molded by a substantial pressure of the fingers;

iii. Soft clay: A clay, a fresh sample of which can be molded with slight pressure of the fingers.

4. Silt soils: Soils of each group ML and MH shall be classified as dense, medium or loose depending on relative difficulties of removal as described for hard, medium and soft clays in paragraph 3 of this subsection.

5. Varved silt or varved clay: A natural soil deposit consisting of alternating thin layers of silt, clay and sand in which the silt (clay), or silt (plus clay), sand layers predominate.

## TABLE 613.6 UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

| Major Divisions 1 | | 2 | Group Symbols 3 | Typical Names 4 | Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights) 5 |
|---|---|---|---|---|---|
| Course-grained Soils<br>More than half of material is larger than Number 200 sieve size<br>The No.200 sieve size is about the smallest particle visible to the naked eye | Gravels<br>More than half of coarse fraction is larger than No. 4 sieve size<br>(For visual classification, the 1/4-in. size may be used as equivilent to the No. 4 sieve size) | Clean gravels (Little or no fines) | GW | Well-graded gravels, gravel-sand mixtures, little or no fines. | Wide range in grain sizes and substantial amounts of all intermediate particle sizes. |
| | | | CP | Poorly graded gravels or gravel-sand mixtures little or no fines. | Predominantly one size or a range of sizes with some intermediate sizes missing. |
| | | Gravels with Fines (Appreciable amount of fines) | GH | Silty gravels, gravel-sand-silt mixture. | Nonplastic fines or fines with low plasticity (for identification procedures see ML below). |
| | | | GC | Clayey gravels, gravel-sand-clay mixtures. | Plastic fines (for identification procedures see CL below). |
| | Sands<br>More than half of course fraction is smaller than No. 4 sieve size. | clean sands (little or no fines) | SW | Well-graded sands, gravelly sands, little or no fines. | Wide range in grain size and substantial amounts of all intermediate particle sizes. |
| | | | SP | Poorly graded sands or gravelly sands, little or no fines. | Predominantly one size or a range of sizes with some intermediate sizes missing. |
| | | Sands with fines (Appreciable amount of fines) | SM | Silty sands, sand-silt mixture. | Nonplastic fines or fines with low plasticity (for identification procedures see ML below). |
| | | | SC | Clayey sands, sand-clay mixtures. | Plastic fines (for identification procedures see CL below). |

## TABLE 613.6 UNIFIED SOIL CLASSIFICATION

### Information Required forDescribing Soils

6

For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions, and drainage characteristics.

Give typical name; indicate approximate percentages of sand and gravel, maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parenthesis.

Example:
Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. maximum size; rounded and subangular sand grains, coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).

### Laboratory Classification Criteria

7

Use grain-size curve in identifying the fractions as given under field identification.

Determine percentage of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows:

Less than 5% GW, GP, SW, SP,
More than 12% GM, GC, SM, SC.
5% to 12% Borderline cases requiring use of dual symbols.

$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4

$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3

Not meeting all gradation requirements for GW

Atterberg limits below "A" line or PI less than 4

Atterberg limits above "A" line with PI greater than 7

Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols.

$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6

$C_c = \frac{(D_{30})2}{D_{10} \times D_{60}}$ Between 1 and 3

Not meeting all gradation requirements for SW

Atterberg limits above "A" line or PI less than 4

Atterberg limits above "A" line with PI greater than 7

Limits a plotting in hatched zone with PI between 4 and 7 are borderline cases requiring use of dual symbols.

## TABLE 613.6 UNIFIED SOIL CLASSIFICATION

| Major Divisions 1 | Divisions 2 | Group Symbols 3 | Typical Names 4 | Identification Procedures on Fraction Smaller than No. 40 Sieve Size: Dry Strength (Crushing Characteristics) | Dilatancy (Reaction to shaking) | Toughness (Consistency near PL) |
|---|---|---|---|---|---|---|
| Fine-grained Soils<br>More than half of material is smaller than 200 sieve size<br>The NO. 200 sieve size is about the smallest particle visible to the naked eye | Silts and Clays<br>liquid limit is less than 50 | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. | None to slight | Quick to slow | None |
| | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. | Medium to high | None to very slow | Medium |
| | | OL | Organic silts and organic silty clays of low plasticity. | Slight to medium | Slow | Slight |
| | Silts and Clays<br>liquid limit is greater than 50 | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. | Slight to medium | Slow to none | Slight to medium |
| | | CH | Inorganic clays or high plasticity, fat clays. | High to very high | None | High |
| | | OH | Organic clays of medium to high plasticity, organic silts. | Medium to high | None to very slow | Slight to medium |
| Highly Organic Soils | | Pt | Peat and other highly organic soils. | Readily identified by color, odor, spongy feel and frequently by fibrous texture. | | |

TABLE 613.6 UNIFIED SOIL CLASSIFICATION

Information Required for Describing Soils

6

For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.

Give typical name, indicate degree and character of plasticity; amount and maximum size of coarse grains; color in wet condition; odor, if any; local or geologic name and other pertinent descriptive information; and symbol in parenthesis.

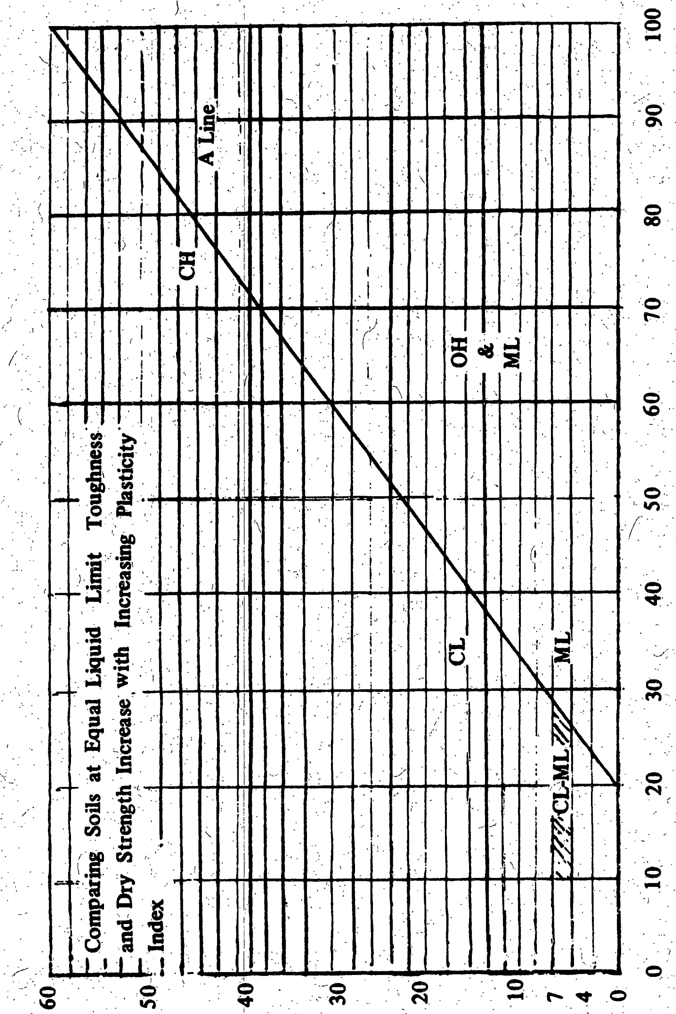
Example: Clayey silt, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML).

**TABLE 613.6 UNIFIED SOIL CLASSIFICATION**

**Laboratory Classification Criteria**
**7**

T

Use grain-size curve in identifying the fractions as given under field identification.




**LIQUID LIMIT**

**PLASTICITY CHART**

**for Laboratory classification of fine-grained soils**

TABLE 61 3.6 UNIFIED SOIL CLASSIFICATION

(1) Boundary classifications. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U.S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the course particles that interfere with the tests.

Dilatancy (reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pot which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pot stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (crushing characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air-drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (consistency near plastic limit)

After particles larger than the No. 40 sieve size are removed, a specimen of soil about one-half inch cube in size is molded to the consistency of putty. If too dry, water must be added and if too sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

**TABLE 613.6 UNIFIED SOIL CLASSIFICATION**

**After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.**

**The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.**

**Highly organic clays have a very weak spongy feel at the plastic limit.**

TABLE BA–613.7

ALLOWABLE SOIL BEARING PRESSURES

| Class of Material | Description (See Note 1) | Basic allowable Bearing Values (tons/sq. ft.)—see Notes 10, 11 |
|---|---|---|
| 1–65 | Hard Sound Rock | 60 See notes 2 and 8 |
| 2–65 | Medium Hard Rock | 40 See notes 2 and 8 |
| 3–65 | Intermediate Rock | 20 See notes 2 and 8 |
| 4–65 | Soft Rock | 8 |
| 5–65 | Hardpan | —See notes 3 and 8 |
| 6–65 | Gravel and Gravel Soils (Soil Groups GW, GP, GM and GC and soils of soil groups SW, SP, SM, containing more than ten per cent of material retained on a number 4 sieve) | —See notes 4, 8 and 9 |
| 7–65 | Sands (Other than fine sands) (Soil groups SW, SP, SM but containing not more than ten per cent of material retained in a number 4 sieve) | —See notes 5, 8 and 9 |
| 8–65 | Fine Sand | —See notes 6, 8 and 9 |
| 9–65 | Clays, and Clay Soils (Soil Groups SC, CL and CH) | |
| | Hard | 5 See note 7 |
| | Medium | 2 See note 7 |
| | Soft | —See BA–613.4 |
| 10–65 | Silts and Silt Soils (Soil Groups ML and MH) | |
| | Dense | 3 |
| | Medium | 1.5 |
| | Loose | —See BA–613.4 |
| 11–65 | Nominally Unsatisfactory Bearing Material | —See BA–613.4 |

NOTES TO TABLE BA–613.7

1. Classification—The soil classifications indicated in this table are those described in section 613.0. Where there is doubt as to the application classification of a soil stratum, the allowable bearing pressure applicable to the lower class of material to which the given stratum might conform shall apply unless conformance to the higher class of material can be proven by laboratory or field test procedures.

2. Allowable bearing pressure on rock—The tabulated values of basic allowable bearing values apply only for massive rocks, or for sedimentary or foliated rocks, where the strata are level or nearly so, and then only if the area has ample lateral support. Tilted strata with their relation to nearby slopes or excavations shall receive special consideration.

3. Allowable bearing pressure on hardpan—For hardpan consisting of well cemented material composed of a predominantly granular matrix and free of lenses of fine-grained material and inclusions of soft rock, the basic allowable bearing pressure shall be 12 tons per square foot. For hardpan consisting of poorly cemented material or containing lenses of fine-grained material, inclusions of soft rock or a fine-grained matrix, the basic allowable bearing pressure shall be eight tons per square foot.

4. Allowable bearing pressure on gravel and gravel soils—Basic allowable pressure shall be as follows:

(a) For soils of soil groups GW, GP, GM and GC;

—Compact, well graded material—ten tons per square foot.

—Loose, poorly graded material—six tons per square foot.

—Intermediate conditions—estimated by interpolation between indicated extremes.

(b) For soils of soil group SW, SP and SM, containing more than ten percent of material retained on a number four sieve:

—Compact, well graded material—eight tons per square foot.

—Loose, poorly graded material—four tons per square foot.

—Intermediate conditions—estimated by interpolation between indicated extremes.

5. Allowable bearing pressure on sands—The basic allowable bearing pressure shall be determined from the resistance to penetration of the standard sampling spoon. The basic allowable bearing pressure in tons per square foot shall equal 0.10 times the penetration resistance, the latter measured in blows per foot on the sample, but not greater than six tons per square foot nor less than three tons per square foot. The appropriate value for the penetration resistance at various areas of the site shall be made by averaging the measured resistance within a depth of soil below the proposed footing level equal to the width of the footing. Where the average values so obtained do not vary by more than 25 percent of the minimum of the average values over the site of the proposed building, the lowest average value shall be used for the design of the entire building. Where the variation exceeds 25 percent the allowable bearing pressure shall be predicated on the lowest average value, unless appropriate measures are taken to avoid detrimental amounts of differential settlements of the footings. Where the design bearing pressure on soils of class 7–65 exceeds three tons per square foot the embedment of the loaded area below the adjacent grade shall not be less than four feet and the width of the loaded area not less than three feet, unless analysis shall demonstrate the proposed construction to have a minimum factor of safety of 2.0 against shear failure of the soil.

6. Allowable bearing pressure on fine sand—The basic allowable bearing pressure shall be determined from the resistance to penetration of the standard sampling spoon. The basic allowable bearing pressure in tons per square foot shall equal 0.10 times the penetration resistance, the latter measured in blows per foot on the sampler, but not greater than four tons per square foot nor less than two tons per square foot, except that for loose materials (resistance to penetration of the standard sampling spoon ten blows per foot or less), where the foundation is subjected to vibratory loads from machinery or similar cause, the indicated basic values shall not apply. The allowable bearing pressure shall be established by analysis applying accepted principles of soil mechanics and a report on such analysis satisfactory to the chief engineer shall be submitted as part of the application for the acceptance of the plans.

7. Allowable bearing pressure on clays and clay soils—The bearing capacity of medium and hard clays and clay soils shall be established on the basis of the strength of such soils as determined by field or laboratory tests and shall provide a factor of safety against failure of the soil of not less than 2.0 computed on the basis of a recognized procedure of soils analysis, shall consider probable settlements of the building, and shall not exceed the tabulated maximum values.

8. Increases in allowable bearing pressure due to embedment of the foundation—

(a) The basic allowable bearing values of rock of classes 1–65, 2–65 and 3–65 shall apply where the loaded area is on the surface of sound rock. Where the loaded area is below the adjacent rock surface and is fully confined by the adjacent rock mass and provided that the rock mass has not been shattered by blasting or otherwise is or has been rendered unsound, these values may be increased ten percent of the base value for each foot of embedment below the surface of the adjacent rock surface in excess of one foot, but shall not exceed twice the basic values.

(b) The basic allowable bearing values for soils of classes 5–65 through 8–65, determined in accordance with notes 3, 4 and 5 above, shall apply where the loaded area is embedded four feet or less in the bearing stratum. Where the loaded area is embedded more than four feet below the adjacent surface of the bearing stratum, and is fully confined by the weight of the adjacent soil, these values may be increased five percent of the base value for each foot of additional embedment, but shall not exceed twice the basic values. Increases in allowable bearing pressure due to embedment shall not apply to soils of class 4–65, 9–65, 10–65, or 11–65.

9. Allowable increase in allowable bearing pressure for limited depth of bearing stratum—The allowable bearing values for soils of classes 6–65, 7–65 and 8–65 determined in accordance with this table and the notes thereto (including Note 8) may be increased up to one third where the density of the bearing stratum below the bottom of the footings or the tips of the piles increases with depth, provided that:

(a) The bearing stratum is not underlain by materials of a lower class.

(b) The allowable bearing value of the soil material underlying the bottom of the footings or the tips of the piles increases at least 50 percent within a depth below the footing or the tips of the piles which is not greater than the width of the footing or the width of the polygon circumscribing the pile group.

(c) It shall be demonstrated by a recognized means of analysis that the probable settlement of the foundation due to compression and/or consolidation do not exceed acceptable limits for the proposed building.

10. Correction for foundations bearing on materials of varying bearing capacities—Where it is shown by borings or otherwise that materials of varying bearing value will be used for support of a building: (1) Where the weakest material does not rank below class 5–65, no modification shall be required; (2) Where the weakest materials rank is classes 6–65 through 8–65, if the difference in basic allowable bearing values for the several materials does not exceed 30 percent of the allowable value for the poorest material which is to support the foundation, the foundations may be proportioned in direct conformance with the allowable bearing pressures. Where the difference in basic allowable bearing values exceeds 30 percent, appropriate measures shall be taken to limit the differential settlements of the

different portions of the structure to tolerable values; (3) For materials of classes 9–65 and 10–65, in all cases, appropriate measures shall be taken to equalize the settlements of the different portions of the structure.

11. Inundated footings—The provisions of this section relating to materials of classes 1–65 through 7–65 shall be deemed equally applicable both to the dry and to the inundated condition of the soil, provided:

(a) That the subgrade is undisturbed by the construction operations.

(b) The bearing area is in a confined condition. For such cases, no reduction in allowable bearing value will be required where the soil supporting the foundation is subject to a rising level of inundation. However, the effects on settlement of a falling level of inundation occurring after construction of the foundation shall be considered in the design.

### 19:6–2.22 Satisfactory bearing material

The following materials or any combination of them shall be considered as generally satisfactory bearing materials:

1. Hard sound, medium hard, intermediate, and soft rock, hardpan, granular soils and G and S groups;

2. Dense or medium silt soils of Groups ML and MH; and

3. Hard or medium clay soils of Groups CL and CH.

### 19:6–2.23 Nominally unsatisfactory bearing material

Controlled and uncontrolled fill material, peat (Group PC), organic silts and clays (Grouping OL and OH), soft or loose soils of Groups ML, CL, MH and CH, varved silt, or satisfactory bearing materials that contain lenses or are underlain by these materials shall be considered as nominally unsatisfactory bearing materials.

### 19:6–2.24 Allowable soil bearing pressures

(a) The allowable soil bearing pressures on satisfactory bearing materials shall be those established in table 613.7. The allowable bearing pressures on nominally unsatisfactory bearing materials shall be those established in accordance with section 25 of this subchapter. Allowable bearing pressures shall be considered to be the allowable pressure at a point in the soil mass in excess of the stabilized overburden pressure existing at the same point prior to construction operation. The stabilized overburden pressure existing at a point shall be defined as that portion of the weight of the overlying soil material that is supported by granular interaction rather than pore pressure. In general, the magnitude of the stabilized overburden pressure may be approximated as follows:

1. The overlying soil material shall have been in place for an adequate length of time to produce a stable condition of pore pressure in or below the foundation level. Where the bearing stratum consists of soils of classes 5–65 through 8–65, the bearing stratum shall be considered to be fully consolidated except with regard to the weight of that portion of the overlying soil material that consists of added fill material.

2. Where all or a portion of the overlying soil consists of fill material, the weight of the fill material shall not be included in the stabilized overburden pressure unless the magnitude of stabilized pressure is verified by an analysis acceptable by the chief engineer on the basis of laboratory or field tests on undisturbed material.

3. Bearing stratum: Where the bearing stratum consists of soils of classes 9–65 through 11–65, the stabilized overburden pressure shall be considered as zero unless the magnitude of the stabilized pressure is established by an analysis acceptable by the chief engineer on the basis of laboratory or field tests on undisturbed material.

4. The stabilized overburden pressure shall not include the weight of any soil removed by excavation and not replaced. For footings, the total stabilized overburden pressure shall not exceed the weight of a one square foot column of soil (considering submerged weight where the soil column is partly submerged) measured from the bottom of the footing to the lowest level of the final grade above the footing. For a box foundation, where the strength of the slab is adequate to stabilize the underlying soil, the stabilized overburden pressure shall not exceed the weight of a one square foot column of soil measured from the bottom of the box to the lowest level of the adjacent grade.

5. Where the bearing stratum consists of soils of classes 9–65 through 11–65, the allowable bearing pressure shall be adjusted for the effects of rebound due to excavation as determined from consolidation test data.

6. Where the bearing stratum consists of rock of classes 1–65 through 3–65, the stabilized overburden pressure shall be neglected.

### 19:6–2.25 Bearing capacity of nominally unsatisfactory bearing materials

(a) Whenever soils exploration shows that the proposed foundation would rest on, or be underlain by, nominally unsatisfactory bearing materials, a report based on soil tests and foundation analysis (including analysis of undisturbed samples) shall be submitted by an architect or engineer, demonstrating, subject to approval of the chief engineer, that the proposed construction under a condition of 100 percent overload is safe against failure of the soil materials. The report shall also show that the probable total magnitude and distribution of settlement to be expected under design conditions will not result in instability of the building or stresses in the structure in excess of the allowable values established in this subchapter. In addition, the following provisions shall apply:

1. Fill materials:

i. Controlled fills: Fills shall be considered as satisfactory bearing materials of class 6–65 or 7–65 when placed in accordance with the following procedures, under the provisions for controlled inspection:

(1) Before placement of fill, the existing ground surface shall be stripped of all organic growth, timber, rubbish, and debris. After stripping, the ground surface shall be compacted to the density described in item (4) below.

(2) Materials for fill shall consist of sand, gravel, crushed stone, crushed gravel, or a mixture of these, and shall contain no organic matter. The fill materials shall contain no particles exceeding four inches in the largest dimension. No more than 30 percent of the material shall be retained on a 3/4 inch sieve. The material passing the 3/4 inch sieve shall contain, by weight, no more than 45 percent passing the 100 sieve, or 12 percent passing the 200 sieve.

(3) The grading of the fill shall be determined in accordance with the applicable procedures of Sec. MBA–611.0, National Standard for Foundations in the Manual for the Standard Building Code of New Jersey.

(4) Fill shall be placed and compacted at its optimum moisture content, in uniform layers not more than 12 inches thick (after compaction) and each layer shall be thoroughly compacted to a density of not less than 95 percent of the density prescribed in National Standard for Foundations. The field density shall be verified by in-place density tests made on each lift of the embankment. Fill shall not be placed when frozen or placed on a frozen or wet subgrade.

ii. Uncontrolled Fills: Fill material, other than controlled fill, may not be used for the support of buildings unless its use can be adequately demonstrated to the chief engineer.

2. Organic silts, organic clays, soft inorganic clay, loose inorganic silt and varved silt:

i. The allowable bearing pressure shall be determined independently of table 613.7, subject to the following:

(1) For varved silts, the average unit intensity of loading produced by the proposed building shall not exceed two tons per square foot, except that for desiccated or preconsolidated soils, higher bearing pressures will be allowed.

(2) Organic silts or clays (Groups OL and OH) or soft or loose soils of Groups ML, CL, MH and CH may not be assigned an allowable bearing pressure unless the procedures for their use have been clearly demonstrated to the satisfaction of the chief engineer.

ii. The report described in the introduction to this section shall contain, as a minimum, the following information:

(1) Subsurface profiles through the area defining the stratigraphy;

(2) Sufficient laboratory tests data on the compressible material to indicate the coefficient of consolidation, coefficient of compressibility permeability, secondary compression characteristics, and Atterberg limits;

(3) Where the design contemplates improvement of the natural bearing capacity and/or reduction in settlements by virtue of preloading, cross sections showing the amount of fill and surcharge to be placed and design details showing the required time for surcharging shall be indicated, and computations showing the settlement to be expected during surcharging. Records of settlement, plate elevations and pore-pressure readings, before, during and after surcharging shall be filed with the chief engineer.

(4) The estimated amount and rate of settlement expected to occur after the structure has been completed, including the influence of dead and live loads of the structure;

(5) A detailed analysis showing that the future settlement will not adversely affect the performance of the structure;

(6) Where sand drains are to be used, computations showing the diameter, spacing, and method of installation of such drains shall be provided.

3. Artificially treated soils: Nominally unsatisfactory soil materials that are artificially compacted, cemented, or preconsolidated (including soils compacted by vibration, cemented by chemical injection, or preconsolidated by use of electric current, but not including cases where preconsolidation consists solely of the use of surcharge with or without sand drains) may be used for the support of buildings, and nominally satisfactory soil materials that are similarly treated may be used to resist soil bearing pressures in excess of those indicated in table 613.7 for the soil in its natural state, subject to the following:

i. The vertical and lateral extent of the soil that is compacted, cemented or preconsolidated shall conform to the full extent of the distribution of loading that is assumed for purposes of computing the intensities of the soil bearing pressure. The actual soil bearing pressure shall not exceed the limitations of this section for nominally unsatisfactory bearing materials or, for satisfactory bearing materials, shall not exceed the limitations of table 613.7.

ii. After the treatment procedure, a minimum of one boring shall be made for every 1,600 square feet of that portion of the building area that is supported on treated soil, and a sufficient number of samples shall be recovered from the treated soil to demonstrate the efficacy of the treatment.

**19:6–2.26 Utility services**

(a) Where utility service lines are to be laid in soil materials of class 11–65, provision shall be made to prevent damage to such service lines, as follows:

1. Where the lines enter a structure, including a building, a manhole or junction chamber that is rigidly supported on piles or in firm bearing material, the services shall be supported on piles or bearing materials of adequate firmness to prevent differential settlement of the service lines with respect to the structure; otherwise, provisions such as oversized sleeves, flexible connections, utility tunnels, or other approved device, shall be made to permit the anticipated differential movement to occur without damage to the service lines.

2. Where the lines enter a structure that is supported on soil materials of class 11–65 or on soft clay or loose silt deposits, an engineering analysis shall be made of the probable differential settlement of the utility service line with respect to the structure, and provision shall be made to accommodate such displacement, as described in paragraph 1 of this section.

**19:6–2.27 Footings**

(a) Inspection of subgrade of footings, piers and walls shall comply with the requirements of section 46 of this subchapter:

1. Design:

i. Concrete footings: Concrete footings shall be proportioned in accordance with the requirements of this section. Reinforcement shall extend to within four inches of the edges of the footing.

ii. Masonry footings: Masonry used for construction of footings shall be solid units.

(1) Reinforced masonry footings shall meet the building code requirements for reinforced masonry—U.S.A.S.I.—A–41.2 (1960), and shall be proportioned similarly to the proportioning of reinforced concrete footings;

(2) Unreinforced masonry footings shall be of such dimension that a sloping plane extending downward from the top of the footing where it intersects the pier of wall, to the bottom of the footing, and measured at the angle with the horizontal that is indicated below, will be contained entirely within the footing:

(A) Soil bearing capacity of three tons per square foot or less—60 degrees;

(B) Soil bearing capacity between three tons per square foot and six tons per square foot—70 degrees;

(C) Soil bearing capacity greater than six tons per square foot shall be investigated;

(D) The compressive stress in the footing, based on the assumption that the vertical load is uniformed distributed over horizontal sections bounded by said planes, shall not exceed the values as required by design standards of this subchapter.

**19:6–2.28 Foundation piers**

(a) Foundation piers shall be designed as columns. Reinforced concrete, and reinforced and unreinforced masonry piers shall be designed in accordance with the requirements of this subchapter:

1. Lateral support: The equivalent unbraced length of a pier supported by lateral soil pressure may be determined by a recognized method of elastic analysis. Alternatively, such a pier may be assumed to be hinged, but laterally braced at intervals equal to the full height of the pier or eight times the least lateral dimension of the pier, whichever is the lesser value.

2. Unreinforced concrete piers: Where unreinforced concrete piers are used, the allowable compressive stress shall not exceed 0.25 c and the center of cross section of the pier at any level shall not deviate from the line of action of the resultant of all forces (which line of action shall consider the eccentricities due to all loads and moments acting on the pier) by an amount more than 1/60 of its height or 1/10 of its least lateral dimensions, or for greater eccentricities, piers shall be reinforced.

3. Metal shells: Where piers are encased by a metal shell, the shell may be considered as contributing to the structural strength of the pier provided that the thickness is 1/8 inch or greater, and subject to the following requirements:

i. Where boring records or site conditions indicate possible deleterious action on the shell, where any portion of the shell is embedded in ash, cinder fill or garbage fill, where the encased piers are used for support of chemical plants, piles of coal, or under other conditions conducive to chemical seepage or corrosive action, or where the encased piers are used for support of electrical generating plants, the metal shells shall be protected against deterioration by encasement, coating, or other device acceptable to the chief engineer.

ii. The area of the metal section of the shell multiplied by the efficiency of the horizontal joints shall be considered as equivalent vertical reinforcement of the pier. The area of the metal section of the shell multiplied by the efficiency of the vertical joints shall be considered as equivalent spiral reinforcement of the pier.

4. Minimum dimensions: The provisions of paragraph 5 below shall apply. In addition, the plan dimensions of the pier shall not be less than those of the column above.

5. Filling: The provisions of paragraphs 1 and 2 of this section shall apply only where the fill (or backfill) is placed around the pier as controlled fill in such a way that the level of the fill is raised uniformly around the entire perimeter of the pier. Where the fill operation is not raised uniformly, the least lateral dimension of a foundation pier shall be 24 inches and the pier shall be proportioned for lateral pressure equal to the pressure of a differential height of fill equal to five feet, applied simultaneously with the other loads on the pier specified in this subchapter.

**19:6–2.29 Foundation walls**

(a) Concrete foundation walls shall be designed in accordance with the requirements of this subchapter relating to bearing or retaining walls. The equivalent unbraced height of a wall supported by lateral soil pressure may be determined by a recognized method of elastic analysis. Alternatively, such a wall may be assumed to be laterally braced at intervals as follows:

1. Where fill is placed against both faces of the walls: the full height of the wall or eight times the thickness, whichever is the lesser value.

2. Where both faces of the wall are not in contact with the soil: the height of the unbraced section of the wall or eight times the thickness of the wall, whichever is greater, but not more than the full height of the wall.

(b) Masonry foundation walls shall conform to the requirements of this subchapter and the following:

1. Types: Masonary foundation walls may be of plain or reinforced masonry and shall be of solid units, except that load bearing hollow units shall be permitted for support of one and two-story buildings.

2. Wall thickness: Foundation walls of masonry shall be designed and constructed in accordance with the requirements of this subchapter supplemented by the provisions of this section relating to the unbraced height. The thickness shall be at least six inches.

**19:6–2.30 Construction of footings, foundation piers and foundation walls**

(a) Methods of installation and construction shall satisfy the following conditions:

1. Footings, piers or walls shall be founded on undisturbed soil or on satisfactorily compacted or prepared materials.

2. Accurate preparation and inspection of the bearing materials directly underlying the foundation shall be possible; and the bearing area shall be substantially level or suitably benched.

3. Excavation shall be kept substantially free of water during construction of the foundation except that the use of tremie or similar underwater construction will be permitted in the case of foundations bearing directly on rock, provided that the construction procedure will permit thorough cleaning and preparation of the rock surface, and that the surface of the rock is maintained in a clean condition, unfouled by the inflow of soil or settlement of the fluid suspension, until the concrete is in place.

**19:6–2.31 Pile foundations; general requirements**

(a) A plan showing clearly the designation of all piles by an identifying system shall be filed with the chief engineer prior to the installation of such piles. All detailed records for individual piles shall bear an identification corresponding to that shown on the plan. A copy of such plan shall be available at the site for inspection at all times.

(b) A record of penetration and behavior of each pile during installation shall be kept by the architect or engineer designated in this subchapter. Such records shall be prepared on forms furnished by, or satisfactory to, the chief engineer and, upon the completion of the installation, shall be filed with the chief engineer together with the records of any additional borings or subsurface information obtained during installation of the piles, and plans showing any deviations of the pile or related construction (including any corrective measures) from the details and locations shown on the approved plans. Inspection of piling and inspection of pile load tests shall conform to the requirements of this subchapter.

**19:6–2.32 Minimum pile penetrations**

(a) Rules concerning minimum pile penetrations are:

1. Required by soil bearing capacity. The provisions of section 42 of this subchapter shall apply.

2. Required for lateral restraint: The provisions of section 37 of this subchapter shall apply.

3. Piles located near a lot line: Piles located near a lot line shall be designed on the assumption that the adjacent lots will be excavated to a depth of ten feet below grade. Where such excavation would reduce the embedded length of the pile, the portion of the pile exposed shall be considered as providing no lateral or vertical support, and the load-carrying determination in accordance with the provisions of section 42 of this subchapter shall be made after the resistance offered by the soil that is subject to potential excavation has been discounted.

**19:6–2.33 Use of existing piles at demolished structures**

(a) Piles left in place where a structure has been demolished shall not be used for support of new construction unless satisfactory evidence, including load or hammer testing representative piles, can be produced indicating the capacity, length, and driving conditions of the piles. The load bearing value for such existing piles shall be the least of the values indicated by:

1. The load or hammer test;

2. The capacity of the pile as a structural member; and

3. The allowable bearing pressure on the soil underlying the pile tips, all in accordance with the provisions of section 42 of this subchapter.

**19:6–2.34 Tolerances and modification of design due to filed conditions**

(a) If the axis of any pile is installed out of plumb or deviates from the specified batter by more than four percent of the pile length, the design of the foundation shall be modified as may be necessary to resist the resulting vertical and lateral forces. In types of piles for which subsurface inspection is not possible, this determination shall be made on the exposed section of the pile, which section, at the time of checking axial alignment, shall not be less than five feet. In piles which can be checked for axial alignment below the ground surface, the sweep of the pile axis shall not exceed four percent of the embedded length.

(b) A tolerance of three inches from the designed location shall be permitted in the installation of each pile without reduction in load capacity. Where piles are installed out of position in excess of this amount, the true loading on such piles shall be analytically determined from a survey which defines the actual location of the piles as driven, and using the actual eccentricity in the pile group with respect to the line of action of the applied load. If the total load on any pile, so determined, is in excess of 110 percent of the allowable load bearing capacity, correction shall be made by installing additional piles or by other methods of load distribution, as required to reduce the maximum pile load to 110 percent of the capacity.

(c) Where piles have been bent during installation, and the amount of the bend exceeds the allowable tolerance for alignment of the pile axis as permitted in subsection (a) of this section, the condition shall be investigated and, where required, correction made by the installation of additional piles, by strengthening the bent piles, or by other means acceptable to the chief engineer.

**19:6–2.35 Minimum spacing of piles**

(a) Piles shall be spaced to meet the following requirements:

1. Spacing of piles shall provide for adequate distribution of the load on the pile group to the supporting soil, in accordance with the provisions of section 42 of this subchapter.

2. In no case shall the minimum center-to-center spacing of piles be less than 24 inches, nor less than the values for specific types of pilings as indicated in section 48 of this subchapter. Unless special measures are taken to assure that piles will penetrate sufficiently to meet the requirements of section 32 of this subchapter without interfering with, or intersecting each other, the minimum center-to-center spacing of piles shall be twice the average diameter of the butt for round piles; or, for taper piles, twice the diameter at a level 2/3 of the pile length measured up from the tip. In cases of practical difficulty, the spacing of new piles from existing piles under an adjacent building may be less than the above values provided that the requirements relating to minimum embedment and pile interference are satisfied and that the soil under the proposed and existing buildings is not overloaded by the closer pile grouping.

**19:6–2.36 Minimum section**

Except as provided in section 48 of this subchapter for timber piles, no tapered pile shall be less than six inches in diameter for any section, nor have less than an eight-inch diameter at cutoff. The taper of any tapered section may be uniform or may occur in steps. No pile of uniform section shall have a diameter of less than eight inches or, if not circular, a dimension of less than 7–1/2 inches. Tapered shoes or points of lesser dimensions may be attached to the tips of piles.

**19:6–2.37 Capping and bracing of piles**

(a) Capping of piles rules are:

1. Embedment: Tops of all piles shall be embedded at least three inches in concrete caps. Such concrete shall extend at least four inches beyond the edge of all piles. Cap plates will not be required for steel H piles embedded in a reinforced concrete cap.

2. Uplift: Where piles are subject to uplift, they shall be anchored into the cap to resist at least 1–1/2 times the amount of such uplift without exceeding the basic allowable stresses.

3. Reinforcement: Reinforcement shall be placed to provide at least three inches of clear cover, measured to the surface of the pile cap that is in contact with the ground. All reinforcement adjacent to timber or concrete piling shall have a minimum of one inch of concrete protection. Reinforcement shall extend to within four inches of the edges of the pile cap.

4. Design: Except as modified in this subsection, concrete pile caps shall be designed in accordance with the requirements of this subchapter.

(b) Except for short piles as described in subsection (c) of this section, every pile shall be laterally braced to conform with one or more of the following provisions:

1. Rigid cap: Three or more piles connected by a rigid cap shall be considered as being braced provided that the piles are located in radial directions from the centroid of the group not less than 60 degrees apart (within a tolerance of three inches in location of the pile). A two-pile group, in a rigid cap, shall be considered to be braced along the axis connecting the two piles.

2. Brace beams: Piles may be braced by use of brace beams or ties rigidly connecting to at least two other piles in radial directions not less than 60 degrees nor more than 120 degrees apart. Concrete brace beams shall have minimum dimensions of 1/20 of the clear distance between the pile caps, but not less than eight inches. All brace beams shall be proportioned to resist a maximum axial load equal to three percent of the total axial load capacity of the piles that are to be braced by that beam, plus the moment due to any eccentricity between the centroid of the pile group and the line action of the applied load. Where underlain by soil of class 9–65, 10–65 or 11–65, brace beams shall be proportioned to support the weight of soil, slab-on-ground, and live load on the slab-on-ground that is contained within vertical planes projected upward from the lateral limits of the brace beam. The design of brace beams to resist these loads shall conform to the provisions of this subchapter.

3. Concrete slab-on-grade: A continuous concrete slab or mat on grade, that is six inches or more in thickness and reinforced, and that extends at least three bays in each direction and is anchored to the pile caps (or in which the piles are embedded at least three inches), may be used in lieu of brace beams for bracing of pile caps providing that the slab is supported on material having an allowable bearing pressure of 1–11/2 tons per square foot or better and such material is not underlain by nominally unsatisfactory bearing materials.

4. Other means: Piles may be braced by anchors, anchor wall, or other means acceptable to the chief engineer.

5. Floor system: Single-pile or two-pile groups or a single line of piles may be considered to be adequately braced if connected to, and braced by, a self-supporting floor system provided:

i. That the details and dimensions of the floor and the wall or pier are of adequate strength to resist lateral displacement of the pile cap under conditions of maximum eccentricity of the applied load; and

ii. That the wall or pier is braced until connection of the floor framing is made and the flooring (or slab) is in place.

6. Special requirements for bracing batter piles: The provisions of paragraphs 1 to 5 of this subsection shall apply. In addition, provisions shall be made to oppose the lateral thrust resulting from the pile inclination.

(c) Rules concerning bracing of short piles are:

1. All pile caps supported by piles that penetrate less than ten feet below cutoff level or less than ten feet below ground level shall be braced against lateral movement. Such bracing may consist of connection to other pile caps that encompass piles embedded more than ten feet below those levels; the use of suitable anchors, connection to a slab-on-grade or the floor system as described in this section, or by other equivalent means. The heads of the piles shall be fixed in the cap.

2. Where the embedded length of piles located near a lot line would be reduced to less than ten feet by excavation of the adjacent site to a depth of ten feet below the nearest grade, the provisions of paragraph 1 of this subsection shall apply.

**19:6–2.38 Splicing of piles**

Splices shall be constructed so as to provide and maintain true alignment and position of the component parts of the pile during installation and subsequent thereto, and shall be of adequate strength to transmit the vertical and lateral loads (including tensions) and the moments occurring in the pile section at the location of the splice without exceeding the allowable stresses for such materials as established in section 42 of this subchapter. Except for piles which can be visually inspected after driving, splices shall develop at least 50 percent of the capacity of the pile in bending. In addition, all pile splices in the upper ten feet of the pile section shall be capable of resisting (at allowable working stresses) the moment and shear that would result from an assumed eccentricity of the pile load of three inches, or the pile shall be braced in accordance with the provisions of section 37 of this subchapter to other piles that do not have splices in the upper ten feet of embedment. For piles located near a lot line, the embedded length of such piles shall be determined on the basis that the adjacent site will be excavated to a depth of ten feet below the nearest grade.

**19:6–2.39 General requirements for installation of piles**

(a) Piles shall be installed with adequate provision for the protection of adjacent buildings and property.

(b) Piling shall be handled and installed to the required penetration and resistance by methods that leave their strength unimpaired and that develop and retain the required load bearing resistance. Any damaged pile shall be satisfactorily repaired or the pile shall be rejected. Subject to the approval of the chief engineer, damaged piles may be used at a fraction of the design load as determined by the architect or engineer in lieu of repair or rejection.

(c) Where boring records or site conditions indicate possible deleterious action on pile materials due to soil constituents, changing water levels, or other causes, such materials shall be adequately protected by preservatives or encasements that will not be rendered ineffective by driving and that will prevent deleterious action. The following specific provisions shall apply:

1. Untreated timber piles shall not be used unless the top level of the pile is below the permanent water table. The permanent water table level shall not be assumed higher than the invert level of any sewer, drain, or subsurface structure in the adjacent streets, nor higher than the water level at the site resulting from the lowest drawdown of wells or sumps, but in no case shall untreat-

ed timber piles be used where the cutoff level is less than ten feet below the adjacent legal grade. Where treated piles are required, preservation treatment shall consist of impregnation with creosote solution, or for piles entirely embedded below grade, a pentachlorophenal solution may be used. Treatment shall be in accordance with all requirements of this subchapter.

2. Piles installed in ash or garbage fills, cinder fills, or which are free-standing in or near a sea-water environment, shall be investigated regarding the need for special protective treatment and, where protection treatment is indicated, shall be protected against deterioration by encasement, coating, or other device acceptable to the chief engineer.

3. Equipment: Equipment and methods for installing piles shall be such that piles are installed in their proper position and alignment, without damage. Equipment shall be maintained in good repair.

**19:6–2.40 Use of uncased concrete pile shafts**

The use of uncased shafts (that is, where the concrete of the pile shaft is in direct contact with the surrounding soil) will not be permitted.

**19:6–2.41 Where more than one pile type, pile capacity or method of pile installation is used**

(a) Wherever it is proposed to construct a foundation for a building utilizing piles of more than one type or capacity, modifying an existing foundation by the addition of piles of a type or capacity other than those of the existing piling, construct or modify a foundation utilizing different methods or more than one method of installation, or using different types or capacities of equipment (such as different types of hammers having markedly different stricking energies or speeds), or support part of a building on piles and part on footings, the several parts of the building supported on the different types, capacities, or modes of pilings shall be separated by suitable joints providing for differential movement, or a report shall be submitted by an engineer qualified in soil mechanics, establishing to the satisfaction of the chief engineer that the proposed construction is adequate and safe, and showing that the probable settlements and differential settlements to be expected will not result in instability of the building or stresses in the structures in excess of the allowable values established in this subchapter. The provisions of section 42 of this subchapter relating to required load test shall apply separately and distinctly to each different type or capacity of piling method of installation, or type or capacity or equipment used, except where analysis of the probable, comparative behavior of the different types or capacities of the piles or the methods of installation indicates that data on one type of capacity of pile permits a reliable extrapolation of the probable behavior of the piles of other types and capacities.

TABLE BA–615.11
ALLOWABLE COMPRESSIVE STRENGTH
FOR PILE MATERIALS

| PILE MATERIAL | ALLOWABLE COMPRESSIVE STRESS |
|---|---|
| Concrete | Concrete 0.25f'c<br>Reinforcing steel—0.40 fy but not greater than 30,000 psi. |
| Timber | See Timber piles 618.1 |
| Steel | H piles—0.35 fy, with fy not to be taken as greater than 36,000 psi.<br>Minimum thickness of metal shall be 0.40. inches.<br>Pipe Piles, shells for cast-in-place concrete piles and shells of pipe sections used in casisson piles—0.35 fy (fy not to be taken as greater than 36,000 psi) for thickness of 1/8 inch or more. Metal thinner than 1/8 inch shall not be considered as contributing to the structural strength of the pile section. |

Note:
f'c = 28–day compressive strength of concrete.
fy = Minimum specified yield strength of steel.

**19:6–2.42 Pile foundations**

(a) The allowable axial load on a pile shall be the least value permitted by consideration of the following factors (for battered piles, the axial load shall be computed from the resultant of all vertical loads and lateral forces occurring simultaneously):

1. The capacity of the pile as a structural member.

2. The allowable bearing pressure on soil strata underlying the pile tips.

3. The resistance to penetration of the piles, including resistance to driving, resistance to jacking, the rate of penetration, or other equivalent criteria as established in this section.

4. The capacity as indicated by load test, where load tests are required.

5. The maximum loads prescribed in this section.

(b) Rules concerning the capacity of the pile as a structural member are:

1. Embedded portion of the pile: The compressive stress on any cross section of a pile produced by that portion of the design load that is considered to be transmitted to that section shall not exceed the allowable values for the construction materials as established in table 615.11. The tensile stress shall not exceed the values established in this article for like material.

2. Portion of the pile that is not embedded: That portion of any pile that is free standing in air or water shall be designed as a column in accordance with the provisions of this subchapter, fixed at a point five feet below the soil contact level in class 8–65 material or better and ten feet below in any other material. The conditions of lateral and rotational restraint offered by the pile cap shall be considered in determining the equivalent unbraced length.

3. Load distribution along embedded portion of the pile: The portion of the design load acting on any cross section of a pile may be determined by analysis, considering time dependent changes in distribution of the load. As an alternative method for the purposes of this section, it may be assumed that:

i. For piles embedded 40 feet or more in materials of class 10–65 or better, and bearing on or in materials of classes 1–65 to 5–65: 75 per cent of the load shall be assumed to be carried by the tip. For shorter piles, with similar conditions of embedment and bearing, 100 per cent of the load shall be assumed carried by the tip.

ii. For piles embedded in materials of class 10–65 or better and bearing on or in materials of classes 6–65 to 10–65, the full load shall be assumed to act as a cross section located at 2/3 of the embedded length of the pile measured up from the tip. Where tapered piles are used, the stress at all sections of the pile shall be determined on the basis that the full load acts at a location 2/3 of the embedded length of the pile measured up from the tip and that 1/3 of the full load acts at the tip. The stresses so computed shall not exceed the allowable values in table 615.11.

iii. For conditions not covered in subparagraphs i and ii of this subsection the provisions relating to analysis shall apply.

(c) Rules concerning allowable bearing pressure on soil strata underlying the pile tips are:

1. Bearing capacity: The allowable pile load shall be limited by the provision that the pressures in materials at and below the pile tips, produced by the loads on individual piles and by the aggregate of all piles in a group or foundation, shall not exceed the allowable bearing values established in section 21 of this subchapter. The provisions of sections 24 and 25 of this subchapter shall apply. The transfer of load from piles and soil shall be determined by the recognized method of analysis. As an alternative, for purposes of this section, piles or pile groups may be assumed to transfer their loads to the underlying materials by spreading the load uniformly at an angle of 60 degrees with the horizontal, starting at a polygon circumscribing the piles, located as follows:

i. For piles embedded entirely in materials of classes 4–65 to 8–65, the polygon shall be circumscribed at a level located 2/3 of the embedded length of the pile, measured up from the tip.

ii. For piles penetrating through soils of classes 9–65, 10–65, or 11–65 into bearing soils of class 8–65 or better, the polygon shall be circumscribed at the bottom of the strata of class 9–65, 10–65, or 11–65 materials.

iii. In the case of piles having enlarged bases, the lateral distribution of the load to the soil may be assumed to begin at the junction of the shaft and the enlarged base and to extend as follows:

(1) In the case where the enlarged base is formed in loose or medium compact (N value less than 30) soils in class 6–65 or 7–65 that extend 20 feet or more below the junction of the base and shaft, or that are of lesser extent but are directly underlain by soil of class 5–65 or better, the bearing area may be taken at the plane six feet below said junction but not lower than the bottom of the soils strata of class 6–65 or 7–65.

(2) Where the enlarged base is formed in compact (N value 30 to 60) soils of class 6–65 or 7–65 or in any soil of these classes that extends less than 20 feet below the junction of the base and the shaft and that is underlain by soil of class 8–65 or poorer, the bearing area shall be taken at planes less than six feet below said junction, with a lower limit of three feet where the material is very compact (N value 60, or greater) and the extent of the class 6–65 or 7–65 material is ten feet below the junction of shaft and base. (Provisions of section 48 of this subchapter relating to the minimum depth of bearing stratum below the junction of base and shaft shall apply.) For conditions intermediate between that described in item (1) above and the lower limit conditions described here, the location of the bearing area may be determined by linear interpolation between the indicated limits of N value and extent of bearing material below the junction of shaft and base, giving equal weight to both variables.

(3) Where the enlarged base is formed in or on soils of class 4–65 or 5–65, the bearing area shall be taken at a depth below the junction of the shaft and base consonant with the size and depth of the base formed, and as evaluated from the required test piles.

iv. For all piles bearing on soils of classes 1–65 to 3–65, analysis of load distribution will not be required if the requirements relating to capacity of the pile as a structural member, to resistance to penetration, to load test where required, and to maximum tabulated loads are satisfied.

v. For piles in soils of classes 9–65 and 10–65, for cases not described above, or for any case where the method of installing the pile utilizes a temporary casing, the provisions relating to analysis shall apply.

vi. In no case shall the area considered as supporting the load extend beyond the intersection of the 60 degrees planes of adjacent piles or pile groups.

2. Bearing stratum: The plans for the proposed work shall establish, in accordance with the requirements relating to allowable bearing pressure, the bearing strata to which the piles in the various sections of the building are to be penetrated and the approximate elevations of the top of such bearing strata. Where penetration of a given distance into the bearing strata is required for adequate distribution of the loads, such penetration shall be shown

on the plans. The indicated elevations of the top of the bearing strata shall be modified by such additional data as may be obtained during construction. All piles shall penetrate to or into the designated bearing strata.

(d) Where subsurface investigation, as described in this subchapter, or general experience in the area indicates that the soil must be penetrated by the pile, consists of glacial deposits containing boulders, or fills containing riprap, excavated detritus, masonry, concrete, or other obstructions in sufficient numbers to present a hazard to the installation of the piles, the selection of type of pile and penetration criteria shall be subject to the approval of the chief engineer, but in no case shall the minimum penetration resistance be less than that stipulated in tables 617.3 and 617.4.

1. Piles installed by use of steam-powered, air-powered, diesel-powered or hydraulic impact hammers:

i. The minimum required driving resistance and the requirements for hammer energies for various types and capacities of piles are given in tables 617.3 and 617.4. To obtain the required total driving resistance, the indicated driving resistances shall be added to any driving resistance experienced by the pile during installation, but which will be dissipated with time (resistance exerted by nonbearing materials or by materials which are to be excavated). For purposes of this section, the resistance exerted by nonbearing materials may be approximated as the resistance to penetration of the pile recorded when the pile has penetrated to the bottom of the lowest stratum of nominally unsatisfactory bearing material. (Class 11–65 or to the bottom of the lowest stratum of soft or loose deposits of class 9–65, but only where such strata are completely penetrated by the pile. The provisions of sections 44 through 48 of this subchapter shall also apply.)

ii. Alternate for similitude method: The requirement of piling to the penetration resistances given in tables 617.3 and 617.4 will be waived where the following five conditions prevail:

(1) The piles bear on, or in, soil of class 5–65 through class 10–65;

(2) The stratigraphy, as defined by not less than one boring for every 4,000 square feet of building area, shall be reasonably uniform or divisible into areas of uniform conditions;

(3) Regardless of pile type or capacity, one load test, as described in this section, shall be conducted in each area of uniform conditions, but not less than two typical piles for the entire foundation installation of the building or group of buildings on the site, nor less than one pile for every 15,000 square feet of building area, or one pile for every 100 piles installed, whichever is less, shall be load tested;

(4) Except as permitted by the provisions of item (6) below, all building piles within the area of influence of a given load-tested pile of satisfactory performance shall be installed to the same or greater driving resistance as the successful load-tested pile. The same equipment that was used to install the load-tested pile shall be used to install all other building piles, and the equipment shall be operated identically with respect to steam or air pressure, type and condition of cap block, length of hose, accessories, and all other variables. Also, all other piles shall be of same type, size and shape as the load-tested pile. All building piles within the area of influence represented by a given satisfactory load-tested pile shall bear in, or on, the same bearing stratum as the load-tested pile;

(5) A report by the architect or engineer shall be submitted establishing to the satisfaction of the chief engineer that the soil bearing pressures do not exceed the values permitted by the provisions of this subchapter and that the probable differential settlements will not cause stress conditions in the building in excess of those permitted by the provisions of this subchapter.

(6) Where the structure of the building or the spacing and length of the piling is such as to cause the building and its foundation to act as an essentially rigid body, the building piles may be driven to length and/or penetration into the bearing stratum without regard to penetration resistance, subject to the requirements of item (5) above relating to submission of report.

2. Piles installed by jacking or static forces: The carrying capacity of a pile installed by jacking or static forces shall be not more than 50 per cent of the load or force used to install the pile to the required penetration, except for piles jacked into position for underpinning. The working load of a temporary underpinning shall not exceed the total jacking force at final penetration. The working load of each permanent underpinning pile shall not exceed the larger of the following values: 2/3 of the total jacking force used to obtain the required penetration if the load is held constant for seven hours without measurable settlement; or 1/2 of the total jacking force at final penetration if the load is held for a period of one hour without measurable settlement. The jacking resistance used to determine the working load shall not include the resistance offered by nonbearing materials which will be dissipated with time.

3. Piles installed by use of vibratory hammer: The capacity of piles installed by vibratory hammers shall not exceed the value established by the principle of similitude as follows:

i. Comparison piles, as required by the provisions of subsection (e) of this section, shall be installed using an impact hammer and driving resistance corresponding to the proposed pile capacities as determined in subsection (d) of this section, or to tip elevations and driving resistances as determined by the architect or engineer.

ii. For each comparison pile, install an identical index pile by use of the vibratory hammer at a location at least four feet, but not more than six feet, from each comparison pile. The index piles shall be installed to the same tip elevation as the comparison pile, except that where the comparison piles bear on soils of classes 1–65 to 5–65, the index piles shall bear in, or on, similar material. All driving data for the index piles shall be recorded.

iii. The index piles shall be load tested in accordance with the provisions of subsection (e) of this section. Should the specified load test criteria indicate inadequate capacity of the index piles, steps i, ii and iii of this paragraph shall be repeated, using longer, larger, or other types of piles.

iv. All building piles within the area of influence of a given satisfactorily tested index pile shall be installed to the same or lesser rate of penetration (inches per minute) as the successful index pile. The same equipment that was used to install the index pile, identically operated as to rpm, manifold pressure, and so forth, shall be used to install the building piles. Also, all building piles shall be of the same type, size and shape as the index pile. All building piles within the area of influence as represented by a given satisfactory tested index pile bear in, or on, the same bearing stratum as the index pile.

(e) Load test of piling shall be required as follows:

1. Piles installed by static forces and piles installed by bored holes: The load bearing capacity of all types and capacities of piles installed by static forces or in bored holes (other than underpinning piles installed by jacking) shall be demonstrated by load test.

2. Piles driven by impact hammers: The load bearing capacity of piles installed by impact hammers shall be demonstrated by load test when the proposed pile capacity exceeds the following values.

i. Caisson piles: No load test required.

ii. Piles installed upon end to rock of class 1–65, 2–65 or 3–65—100 tons, except as provided in subparagraph iv of this paragraph, and except that no load tests will be required for piles up to 200 tons capacity wherein the pile load does not exceed 80 per cent of the load determined on the basis of limiting stresses in the pile materials and provided that the pipe or shell be driven to the resistance indicated in table 617.3;

iii. Piles bearing on rock or hardpan (soil classes 1–65 to 5–65) other than as described in subparagraph ii above and except as provided in subparagraph iv below.

iv. Piles bearing on materials of class 8 or better, wherein, on the assumption that 100 per cent of the load reaches the pile tip (or, in the case of piles having an enlarged base or other enlargement of the bearing area, the top of the enlargement), the bearing pressure on the soil underlying the tips or bases can be demonstrated to be equal to or less than the values of basic allowable pressure indicated in table 613.7, provided that the class and density of the bearing material supporting the piles be confirmed by not less than one boring at each column location, then the chief engineer may reduce the required number of load tests.

v. All other types of piles: 30 tons.

3. Piles installed by use of vibratory hammers: The load bearing capacity of all types and capacities of piles (other than caisson piles) shall be demonstrated by load test.

4. Load test procedures: Before any load test is made, the proposed apparatus and structure to be used in making the load test shall be satisfactory to the chief engineer and, when required by the chief engineer, all load tests shall be made under the surveillance of the chief engineer or his representative. A complete record of such tests shall be filed with the chief engineer:

i. Areas of the foundation site within which the subsurface soil conditions are substantially similar in character shall be established. In addition, for friction piles bearing on soil materials of class 6–65 or poorer, the uniformity of each such area shall be verified by installing at least three penetration test piles, distributed over the area. Continuous records of penetration resistance shall be made for such piles. If the records of penetration resistance are not similar or are not in reasonable agreement with the information obtained from the borings, the assumed areas of similar subsurface conditions shall be modified in accordance with the information derived from the penetration-test piles and additional penetration-test piles shall be installed as required to verify the uniformity of such areas.

ii. For piles installed by jacking or static forces or by impact hammers, one load test shall be conducted in each area of uniform conditions, but not less than two typical piles for the entire foundation installation of the building or group of buildings on the site, and not less than one pile for each 15,000 square feet of the area of the building wherein said piles are to be used shall be load tested. For piles installed by use of vibratory hammers, one comparison pile shall be installed and one index pile shall be load tested in each area of uniform conditions, but not less than two index piles shall be tested for the entire foundation installation of the building or group of buildings on the site, nor less than one index pile tested for every 7,500 square feet of the area of the building wherein said piles are to be used. For piles whose capacity is determined on the basis of similitude, the provisions of this subsection shall apply.

iii. The load test shall be conducted by a method that will maintain constant load under increasing settlement. Settlement observations shall be made by means of dial extensometers. The extensometers shall provide readings to the nearest 0.001 inch. In addition, settlement observations shall be taken using an engineer's level reading to 0.001 foot, properly referenced to a well established benchmark:

(1) Test loads shall be applied by direct weight or by means of a hydraulic jack acting against a deadweight or a reaction frame supported by anchor piles. The loading platform or box shall be carefully constructed to provide a concentric load on the pile. If direct weight is employed, the loading increments shall be applied without impact or jar. The weight of the loading platform or box shall be obtained prior to the test and this weight shall be considered as the first increment of load. If a hydraulic jack is employed, facilities for maintaining each increment of desired load constant under increasing settlement shall be provided. The gauge and the jack shall be calibrated as a unit for each project.

(2) The test load shall be twice the proposed working load of the pile. The test load shall be applied in seven increments at a load of 50 per cent, 75 per cent, 100 per cent, 125 per cent, 150 per cent, 175 per cent and 200 per cent of the proposed working load. After the proposed working load has been applied and for each increment thereafter, the test load shall remain in place until there is no measurable settlement in a two-hour period. The total test load shall remain in place until settlement does not exceed 0.001 foot in 48 hours. The total load shall be removed in decrements not exceeding 25 per cent of the total load at one-hour intervals or longer. The rebound shall be recorded after each decrement is removed, and the final rebound shall be recorded 24 hours after the entire test load has been removed.

(3) Under each load increment, settlement observations shall be made and recorded at one-half minute, one minute, two minutes, four minutes, and each four minutes thereafter after application of load increment, except in the instance of the total load, where, after the four minutes reading, the time interval shall be successively doubled until the final settlement limitation is reached and the load is removed.

(4) The allowable pile load shall be the lesser of the two values computed as follows:

(A) Fifty per cent of the applied load causing a net settlement of the pile of not more than 0.01 inch per ton of applied load. Net settlement in this paragraph means gross settlement due to the total test load minus the rebound after removing 100 per cent of the test load.

(B) Fifty per cent of the applied load causing a net settlement of the pile of 0.75 inch. Net settlement in this paragraph means gross settlement as defined in paragraph 1 of this subsection, less the amount of elastic shortening in the pile section due to total test load.

5. Foundation piles: Except as provided in subsection (d) of this section, all building piles within the area of influence of a given load-tested pile of satisfactory performances shall be installed to the same or greater penetration resistance (or static load) as the successful load-tested pile. The same equipment that was used to install the load-tested pile shall be used to install all other building piles, and the equipment shall be operated identically with respect to speed, height of fall, stroke, pressure, type and conditions of cap block, length of hose, accessories, and all other variables. Also all other piles shall be of the same type, size, and shape as the load-tested pile. All building piles within the area of influence represented by a given satisfactory load-tested pile shall bear in, or on, the same bearing stratum as the load-tested pile. For friction piles where the actual pile lengths vary more than 50 per cent from that of the test pile, the chief engineer may require investigation to determine the adequacy of the piles.

6. Pile groups: When the chief engineer has reason to doubt the safe load sustaining capacity of pile groups, he may require, at the expense of the owner, group load tests up to 150 per cent of the proposed group load.

7. "Casing off": Any temporary supporting capacity that the soil might provide to the pile during a load test, but which would be dissipated with time, shall be obviated by "casing off" or by other suitable means. For purposes of this section, temporary supporting capacity shall include the resistances offered by any strata of nominally unsatisfactory bearing materials (class 11–65) or of soft or loose deposits of class 9–65 or 10–65 that are completely penetrated by the pile, or any resistance offered by granular soils that will be dissipated by reason of vibration.

(f) Rules concerning maximum loads are:

1. Basic maximum loads: except as permitted by the provisions of paragraph 2 below, the maximum allowable pile load, determined in accordance with the provisions of this subchapter, shall not exceed the values specified in table 617.5

2. Substantiation of higher allowable loads: The pile capacities tabulated in table 617.5 may be exceeded where a higher value can be substantiated on the basis of test and analysis as follows:

i. Load tests: The provisions of subsection (e) of this section shall be supplemented as follows:

(1) Not less than one single-pile test shall be conducted for each 10,000 square feet of pile foundation area, or one such load test for every 100 piles installed, whichever is less;

(2) Final load increments shall remain in place for a total of not less than 96 hours;

(3) Single test piles shall be subjected to cyclical loading or suitably instrumented so that the movements of the pile tip and butt may be independently determined. Other alternate methods or devices, acceptable to the chief engineer, which will permit evaluation to the transfer of load from piles to soil may be used;

(4) If required, group load tests shall be performed in groups of numerically average size. Except where the proposed foundation is limited to a single and/or two-pile groups, each test group shall contain not less than three piles;

(5) Individual pile loadings shall not exceed those determined from a single-pile load test;

(6) The provisions of subsection (e) of this section shall apply.

ii. Analysis and report: A report shall be submitted by the architect or engineer establishing to the satisfaction of the chief engineer (on the basis of soil and load tests and foundation analysis, including analysis of the group action of the piles) that the proposed construction under a 100 per cent overload of the foundation is safe against failure of the pile and soil materials, and showing that the probable total magnitude and distribution of settlement to be expected under design conditions will not result in instability of the building or stresses in the structure in excess of the allowable values.

iii. Penetration resistance: The penetration resistance shall not be less than that required by the provisions of subsection (d) of this section or, where applicable values are not indicated therein, shall be determined from the required load tests. The pile material shall be capable of withstanding the driving stresses without being damaged.

**19:6–2.43 Allowable lateral load**

For plumb piles fully embedded in the ground the lateral load applied at the top of the pile shall not exceed one ton per pile unless it has been demonstrated by tests that the pile will resist a lateral load of 200 per cent of the proposed lateral load without lateral movement of more than one inch at the ground level and will resist the proposed working lateral load without a movement of more than 3/8 inch at the ground level. For piles projecting above the ground level, the shear and bending stresses computed on the basis of cantilever action to a level of five feet below grade in soils of class 8–65 or better and to ten feet below grade in poorer soils shall not exceed the allowable values for like materials established in this subchapter.

**19:6–2.44 Uplift capacity**

A minimum factor of safety against withdrawal of 2.0 shall be provided except that the factor of safety against withdrawal shall be greater than 2.0 when the piles are subjected to dynamic uplift loads. The uplift capacity shall be demonstrated by pull-out tests, except where a factor of safety of three or more based on analysis is used, pull-out tests need not be conducted.

**19:6–2.45 Pile driving operations**

The provisions of this section will not apply to piles driven with a vibratory hammer or other equipment wherein the energy of impact cannot be evaluated.

**19:6–2.46 Equipment**

(a) The hammer shall travel freely in the leads. The cushion or cap block shall be replaced, if crushed. The hammer shall deliver its rated energy, and measurement shall be made of the fall of the ram or other suitable data shall be observed at intervals as required to verify the actual energy delivered.

(b) The cushion or cap block shall be of solid block of hardwood with its grain parallel to the axis of the pile and enclosed in a tight-fitting steel housing, or shall be an equivalent assemblage. If laminated materials are used, the type and construction of these materials shall be such that their strength is equal to, or greater than, hardwood. Wood chips, pieces of rope, hose, shavings, or automobile tires and similar materials shall not be used. Cap blocks shall be replaced if burned, crushed or otherwise damaged.

(c) Followers shall not be used unless permitted in writing by the architect or engineer, and only when necessary to accomplish such installations. Where permitted, they shall be of steel or hardwood of such size, shape, length, and weight as to permit driving the pile in the desired location and to the required depth and resistance. The required driving resistance tabulated in tables BA–617.3 and BA–617.4 shall be increased to compensate for the loss of energy in the hammer blow. The follower shall be a single length section, shall be provided with a socket or hood carefully fitted to the top of the pile to minimize loss of energy and to prevent damage to the pile, and shall have sufficient rigidity to prevent "whip" during driving.

## TABLE BA–617.3

### MINIMUM DRIVING RESISTANCE AND MINIMUM HAMMER ENERGY FOR STEEL H PILES PRECAST AND CAST–IN–PLACE CONCRETE PILES AND COMPOSITE PILES (OTHER THAN TIMBERS)

Minimum Driving Resistance

| Pile Capacity (tons) | Hammer [b] Energy (ft. lbs.) | Friction Piles (blows/ft.) | Piles bearing on Hardpan (soil class 5–65) (blows/ft.) | Non–Displacement [a, c] Piles bearing on Decomposed Rock (soil class 4–65) (blows/ft.) | Displacement Piles Bearing on Decomposed Rock (soil class 4–65) (blows/ft.) | Piles Bearing on Rock (soil classes 1–65, 2–65, and 3–65) |
|---|---|---|---|---|---|---|
| | 15,000 | 19 | 19 | 48 | 48 | |
| Up to 20 | 19,000 | 15 | 15 | 27 | 27 | |
| | 24,000 | 11 | 11 | 16 | 16 | |
| | 15,000 | 30 | 30 | 72 | 72 | |
| 30 | 19,000 | 23 | 23 | 40 | 40 | |
| | 24,000 | 18 | 18 | 26 | 26 | |
| | 15,000 | 44 | 50 | 96 | 96 | |
| 40 | 19,000 | 32 | 36 | 53 | 53 | 5 blows per 1/4 inch (with minimum hammer energy of 15,000 ft. lbs.) |
| | 24,000 | 24 | 30 | 34 | 34 | |
| | 15,000 | 72 | 96 | 120 | 120 | |
| 50 | 19,000 | 49 | 54 | 80 | 80 | |
| | 24,000 | 35 | 37 | 60 | 60 | |
| | 32,000 | 24 | 25 | 40 | 40 | |
| | 15,000 | 96 | | 240 | 240 | |
| 60 | 19,000 | 63 | | 150 | 150 | |
| | 24,000 | 44 | | 100 | 100 | |
| | 32,000 | 30 | | 50 | 50 | |
| | 19,000 | ..... | 5 blows per 1/4 inch (minimum hammer energy of 15,000 ft. lbs.) | 5 blows per 1/4 inch (minimum hammer energy of 19,000 ft. lbs.) | ..... | |
| 70 to 80 | 24,000 | ..... | | | ..... | |
| | 32,000 | ..... | | | ..... | |
| | | | | | ..... | |
| | ..... | ..... | ..... | ..... | ..... | |
| 100 | ..... | ..... | ..... | ..... | ..... | |
| | ..... | ..... | ..... | ..... | ..... | |
| | ..... | ..... | ..... | ..... | ..... | |
| Over 100 | ..... | ..... | ..... | ..... | ..... | |
| | ..... | ..... | ..... | ..... | ..... | |

NOTES TO TABLE BA–617.3

a. Final driving resistance shall be the sum of tabulated values plus resistance exerted by nonbearing materials. The driving resistance of nonbearing materials shall be taken as the resistance experienced by the pile during driving, but which will be dissipated with time and may be approximated as described in section 616.0(c)(1)(i).

b. The hammer energy indicated is the rated energy.

c. Sustained driving resistance—Where piles are to bear in soil classes 4–65 and 5–65, the minimum driving resistance shall be maintained for the last 6 inches, unless a higher sustained driving resistance requirement is established by load test. Where piles are to bear in soil classes 6–65 through 10–65, the minimum driving resistance shall be maintained for the last 12 inches unless load testing demonstrates a requirement for higher sustained driving resistance. No pile need be driven to a resistance to penetration more than twice the resistance indicated on this table, nor beyond the point at which there is no measurable net penetration under the hammer blow.

d. The tabulated values assume that the ratio of total weight of pile to weight of striking part of hammer does not exceed three. If a larger ratio is used, or for other conditions for which no values are tabulated, the driving resistance shall be as approved by the chief engineer.

## TABLE BA–617.4

### MINIMUM DRIVING RESISTANCE AND HAMMER ENERGY FOR TIMBER PILES

| Pile Capacity (tons) a, b, d, | Minimum Driving Resistance (blows/in.) to be added to driving resistance exerted by nonbearing materials | Hammer Energy (ft.-lbs.)c |
|---|---|---|
| Up to 20 | | 7,500–12,000 |
| Over 20 to 25 | Formula in note d shall apply | 9,000–12,000 |
| | | 14,000–16,000 |
| Over 25 to 30 | | 12,000–16,000 (single-acting hammers) |
| | | 15,000–20,000 (double-acting hammers) |

NOTES:

a. The driving resistance exerted by nonbearing materials is the resistance experienced by the pile during driving, but which will be dissipated with time and may be approximated as described in section 616.0(c)(1)(a).

b. The hammer energy indicated is the rated energy.

c. Sustained driving resistance—Where piles are to bear in soil classes 4–65 to 5–65, the minimum driving, resistance measured in blows per inch shall be maintained for the last six inches, unless a higher sustained driving resistance requirement is established by load test. Where piles are to bear in soil classes 6–65 through 10–65, the minimum driving resistance measured in blows per inch shall be maintained for the last 12 inches, except that unless load testing demonstrates a requirement for higher sustained driving resistance, no pile need be driven to a resistance to penetration (in blows per inch) more than twice the resistance indicated in this table nor beyond the point at which there is no measurable net penetration under the hammer blow.

d. The minimum driving resistance shall be determined by the following formula:

$$P = \frac{2W_hH}{s+0.1} \quad \text{or} \quad P = \frac{2E}{s+0.1}$$

Where:

P = Allowable pile load in pounds.

$W_p$ = Weight driven in pounds.

$W_h$ = Weight of striking part of hammer in pounds.

H = Actual height of fall of striking part in hammer in feet.

E = Rated energy delivered by the hammer per blow in foot pounds.

s = Penetration of pile per blow, in inches, after the pile has been driven to a depth where successive blows produce approximately equal net penetration.

The value $\frac{W_p}{W_h}$ shall not exceed three.

TABLE BA–617.5
BASIC MAXIMUM PILE LOAD

| Type of Pile | Basic Maximum Pile Load—(tons) |
|---|---|
| Caisson Piles | No Upper Limit |
| Open-end pile (or tube) piles bearing on rock of classes 1–65, 2–65 and 3–65 | 18 inches O.D. and greater—250<br>Less than 18 inches O.D.—200 |
| Closed-end pipe (or tube) piles, H piles, cast-in-place concrete and compacted concrete piles bearing on rock of classes 1–65, 2–65 and 3–65 | 150 |
| Piles (other than timber or compacted concrete piles) bearing on soft rock (class 4–65) | |
| (1) Displacement piles such as pipe, cast-in-place concrete | 60 |
| (2) Non-displacement piles such as open-end pile and H piles | 80 |
| Compacted concrete piles bearing on soft rock (class 4–65) | 60 |
| Piles (other than timber or compacted concrete piles) bearing on hardpan (class 5–65) overlying rock | 100 |
| Compacted concrete piles bearing on hardpan (class 5–65) overlying rock | 100 |
| Piles (other than timber or compacted concrete piles) that receive their principal support other than by direct bearing on soils of classes 1–65 to 5–65 | 60 |
| Compacted concrete piles that receive their principal support other than by direct bearing on soils of classes 1–65 to 5–65 | 60 |
| Timber piles bearing in soils of classes 1–65 to 5–65 | 25 |
| Timber piles bearing in soils of classes 6–65 to 10–65 | 30 |

**19:6–2.47 Procedures**

(a) Driving of piles preliminary to final seating shall be continuous for an interval adequate to break or prevent the development of freeze. The hammer shall be operated at its rated speed during this interval.

(b) Jetting, augering and other methods of preexcavation shall not be used unless permitted in writing by the architect or engineer. When permitted, such procedures shall be carried out in a manner which will not impair the carrying capacity of the piles already in place or the safety of existing adjacent structures. Jetting or augering shall be stopped at least three feet above the final expected pile-tip elevation and at least three feet above the tip elevation of any pile previously driven within six feet of the jet or auger, except that where piles are to be end bearing on rock or hardpan, jetting or augering may be carried to the surface of the rock or hardpan. Piles shall be carried down beyond the depth of jetting, augering or other preexcavation until the required resistance is obtained. If there is evidence that jetting or other procedures have disturbed the load-bearing capacities of previously installed piles, those piles that have been disturbed shall be restored to conditions meeting the requirements of this article by redriving or by other methods acceptable to the architect or engineer. Redriving or other remedial measures shall be instituted after the jetting or other operations in the area have been completed.

(c) Individual piles and pile groups shall be installed in such sequence that the carrying capacity of previously installed piles is not reduced; the soil surrounding the piles is not compacted to the extent that other piles in the group cannot be installed properly; and ground movement that would damage adjacent buildings or utilities is prevented. In general in any group, driving shall start from one side and proceed progressively toward the other side of the group or shall start from the middle and proceed toward the edges of the group.

(d) In soils in which the installation of piles causes previously installed piles to heave, accurate level marks shall be put on all piles immediately after installation, and all piles that have been heaved by an amount in excess of 1/4 inch shall be redriven to the required resistance.

(e) Penetration measurements made for the purpose of determining resistance to driving shall not be made when pile heads are damaged to an extent that may affect measured penetration, nor shall they be made immediately after fresh cushion blocks have been inserted under the striking part of the hammer.

**19:6–2.48 Pile types; specific requirements**

Types of pile construction and installation that are not described in this section will be permitted for use only where acceptable to the chief engineer.

**19:6–2.49 Timber piles**

(a) Timber piles shall conform in quality to class A or B of ASTM D25 standard specifications for round-timber piles, current edition.

1. Size of piles: Piles shall be of adequate size to resist the applied loads without creating stresses in the pile materials in excess of 1,200 psi for piles of southern pine, Douglas fir, oak or other wood of comparable strength; or 850 psi for piles of cedar, Norway pine, spruce or other wood of comparable strength. Except as provided in paragraph 2 below, for piles 40 feet or more in length and of 30 tons capacity or less, the following sizes or classes of piles shall be deemed to be adequate for considerations of stress in the pile material:

i. Piles of 25 to 30 tons capacity: Class A or minimum eight-inch tip with uniform taper.

ii. Piles of less than 25 tons capacity: Class A or B or minimum six inches tip with uniform taper.

2. Piles driven to end bearing: All timber piles, regardless of capacity, driven to end bearing on soils of classes 1–65 through 5–65 shall be class A or shall have a minimum eight inches tip and a uniform taper.

3. Species of wood: Any species of wood may be used that conforms to the provisions of ASTM D25 and that will stand the driving stresses.

4. Peeling: Unless treated, piles need not be peeled.

(b) Where timber piles are to be driven to end bearing on soils of classes 1–65 through 5–65 by use of an impact hammer, the installation of each such pile shall be under the personal inspection of an architect or engineer, and the operations of driving such piles, the observations of penetrations resistance, and the operation of the equipment shall be so conducted as to terminate driving directly when the pile reaches bearing on the hard material. The upper portion above the water table shall be surrounded by a sand and gravel fill and shall not be in contact with any combustible material. A report, prepared by the architect or engineer, describing the procedures, equipment and precautions followed to prevent injury to the piling shall be submitted to the chief engineer.

(c) The use of lagged or inverted piles will be permitted. Double lagging shall be adequately connected to the basic pile material to transfer the full pile load from the basic pile material to the lagging without exceeding values of allowable stress as established in this article. The connection for single lagging shall be proportioned for half the pile load. The diameter of any inverted timber pile at any section shall be adequate to resist the applied load without exceeding the stresses indicated in subsection (a) of this section, but in no case shall it be less than eight inches.

(d) Rules on installation are:

1. All broomed, crushed, or otherwise damaged materials at the head of the pile shall be removed before capping.

2. Any sudden decrease in driving resistance shall be investigated with regard to the possibility of breakage of the pile, and if such sudden decrease in driving resistance cannot be correlated to boring data or some incident in the driving, and if the pile cannot be removed for inspection, it shall be considered as adequate cause for rejection of the pile.

**19:6–2.50 Precast concrete piles (including prestressed sections)**

(a) Materials for precast concrete piles shall conform to the requirements of this subchapter.

(b) Rules on construction are:

1. Handling: Precast concrete piles shall be proportioned, cast, cured, handled and driven so as to resist the stresses induced by handling and driving as well as by loads. Handling stresses shall be computed on the basis of 50 per cent of the weight of the pile as an allowance for impact. Handling equipment shall be constructed so as to equalize the reactions of the several lines of the pile pickups. The allowable stresses for the loading conditions induced by handling and driving shall be taken into consideration.

2. Dimensions: The minimum lateral dimension of the pile shall be ten inches except for the taper at the tip.

3. Structural design: Piles shall be proportioned in accordance with the provisions of section 42 of this subchapter to the following additional requirements:

i. For a length equal to at least three times the minimum lateral dimension at each end of the pile, lateral tie reinforcement consisting of 0.225 inch diameter rods or larger shall be spaced not more than three inches center-to-center, or an equivalent spiral shall be provided. Elsewhere, the spacing of the ties or the pitch of the spiral may be increased to 12 inches. The minimum amount of longitudinal reinforcement shall be two per cent of the concrete section placed in a symmetrical pattern of at least four bars. If prestressed piles are used, the minimum residual compression in the pile section shall be 700 psi. For piles designed with voids, the three inch spacing of the ties or spiral at each end of the pile shall be extended for a distance of 12 feet or one third the length of the pile, whichever is smaller.

ii. For piles designed with voids, the minimum wall thickness of the concrete in any section of the piles shall be four inches. Void may extend through either or both ends of the pile. If the voids extend through the lower end of the piles, the pile head shall be vented to prevent buildup of internal hydraulic pressure during driving.

iii. Reinforcing steel shall be covered with at least 1–½ inches of concrete on the surface against the ground.

4. Tolerances: Voids, when used, shall be located within ⅜ inch of the position shown in the plans. The maximum departure of the pile axis from a straight line, measured while the pile is not subject to bending forces, shall not exceed ⅛ inch in ten feet or ⅜ inch in 40 feet or 0.1 per cent of the pile length.

5. Installation: Precast concrete piles shall not be handled or driven until they have cured sufficiently to develop the necessary strength.

**19:6–2.51 Cast-in-place concrete piles**

(a) Cast-in-place concrete piles shall be cast in shells previously installed in the ground, or may be cast in an uncased hole. Cast-in-place piles may be tapered or cylindrical, or in combination of tapered and cylindrical shapes.

(b) Concrete for cast-in-place concrete piles shall conform to the requirements of this subchapter. Slump shall be five inches plus or minus one inch. Concrete of less slump may be used only if continuous vibration is provided and records of volumes placed vs. volume requirements indicate complete filling of piles. Where the pile shell is assumed to contribute to the capacity of the pile as a structural member, the shell shall be of metal and shall conform to the provisions of section 54 of this subchapter. Where the pile shell is not assumed to contribute to the capacity of the pile as a structural member, the shell may be of any material that will adequately resist the driving stresses and maintain an open well to receive the concrete. End closures for shells shall not project more than one-half inch beyond the outer limits of the pile when bearing in soils of class 6–65 or lower.

(c) Rules on installation are:

1. After installation to final depth and immediately before filling with concrete, the inside of the tube, shell or bore shall be thoroughly cleaned to the bottom and inspected by lowering a drop light or by means of a light beam. To be accepted the pile shall be free of collapsed sections of shell and the pile shell shall not show any tears; the pile shall be free of water except that a minor amount of water may be allowed to occur in the pile if it be absorbed by placing a suitable amount of dry cement-sand mixture in the tip end of the pile; and the alignment of the pile shall conform to the provisions of this subchapter. If the bottom of the casing is out of sight, the shape and alignment of the casing shall be surveyed with a suitable instrument, or the pile rejected.

2. Concrete shall be placed by such methods that the entire volume of the tube, shell or bore is filled and in a manner that will preclude separation of the ingredients.

3. No concrete shall be placed in a cast-in-place pile until all piles within a radius of 15 feet or within the heave range have been driven.

4. Rejected pile shells shall be filled with concrete or sand.

5. The concrete cap shall not be placed until at least one hour after all piles within the cap group are completely filled.

**19:6–2.52 Compacted concrete piles**

(a) A "compacted concrete pile" shall denote a concrete pile formed with an enlarged base in which the concrete in the base is placed in small batches that are compacted prior to attaining an initial set. The concrete in the shaft of the pile shall be placed into a shell as specified in section 51 of this subchapter for cast-in-place concrete piles.

(b) Concrete for compacted concrete piles shall conform to the requirements of this subchapter. Concrete to be compacted shall have a minimum compressible strength at the age of 28 days of 4,000 psi and shall be mixed with sufficient water to permit hydration of the cement, but the slump shall be zero. The concrete shall be placed and compacted before initial set can occur. Non-compacted concrete, if used for the pile shafts, shall conform to the requirements of cast-in-place concrete piles.

(c) Minimum spacing between compacted concrete piles shall be four feet six inches center-to-center except that where the shafts of such piles are cased for their full length, this spacing may be reduced to three feet six inches. Where a question exists as to possible damage to adjacent previously driven piles, these minimums shall be increased.

(d) Rules on installation are:

1. The base shall be formed by ramming concrete in batches of approximately five cubic feet or less, from a drive casing and into the soil. Unless specifically otherwise permitted by the chief engineer, a minimum of 20 blows of at least 140,000 foot pounds per blow shall be required for extrusion of the last five cubic feet of concrete. The total quantity of concrete extruded from the drive casing to form the base shall be equal to or greater than the quantity so extruded in the case of the nearest successful application test pile, except that a compactive effort in excess of 30 blows, each of 140,000 foot pounds, will not be required for extrusion of the last five cubic feet.

2. After the expanded base has been formed, the shaft shall be constructed. Where a cased shaft is to be used, a steel shell shall be inserted into the drive casing and anchored to the expanded base by placing a fresh charge of concrete in the shell and driving it into the base. The shell may then be filled with concrete to cutoff elevation after the removal of the drive casing, in accordance with the provisions relating to cast-in-place concrete piles. Any annular space remaining between the shell and surrounding soil shall be suitably filled to assure proper lateral support of the shaft, unless there is sufficient recovery of the ground to provide the necessary support.

3. The outside diameter of the permanent shaft shall not be more than four inches less than the inside diameter of the drive casing.

4. No concrete shall be placed in the pile shafts until all piles within a radius of 15 feet or within the heave range have been driven.

(e) The enlarged base of the pile shall be formed in, or on, the same type of bearing material as is used to support the nearest applicable load-test and at a similar depth therein. In addition, the enlarged base shall be underlain by a minimum depth of ten feet (measured from the junction of the shaft and base) of soil materials of classes 1–65 to 7–65, except where installation of the base is permitted to be performed with blows of less energy than the 140,000 foot pounds indicated in subsection (d) of this section, the requirement for a ten foot depth of class 1–65 to 7–65 material may be reduced, subject to the approval of the architect or engineer and the approval of the chief engineer.

**19:6–2.53 Steel H sections**

(a) Steel H sections may be of any type of steel permitted by this subchapter. The use of built-up section or sections of other than "H" form will be permitted if the several components of the section are adequately connected to develop the strength of the adjacent components and if the ratio of width to thickness of the component parts does not exceed the values for conventional "H" sections.

(b) The tips of all steel H piles having a thickness of metal less than 0.5 inch, which are driven to end bearing rock of class 1–65 through 3–65 by an impact hammer, shall be reinforced. The installation of all steel H piles by impact hammer to end bearing on rock of classes 1–65 through 3–65 shall be under the personal inspection of an architect or engineer and the operations of driving such piles, the observations of penetration resistance, and the operation of the equipment shall be conducted so as to terminate driving directly when the pile reaches refusal on the rock surface.

**19:6–2.54 Concrete-filled pipe piles**

(a) The pipe shall conform to the requirements of ASTM A252 in this subchapter.

(b) Minimum dimensions are:

1. Pipe installed open-end and having a nominal outside diameter of less than 14 inches shall be at least 0.25 inch thick. For diameters from 14 to 18 inches the minimum thickness shall be 0.310 inch. For diameters over 18 inches the minimum thickness shall be 0.375 inch.

2. Steel pipe piles installed with ends closed shall have a minimum nominal wall thickness of at least 0.215 inch.

(c) Installation rules are:

1. Pipe shells driven open-end shall be cleaned to the bottom of the shell after driving.

2. After cleaning, open-end piles driven to end bearing on rock or hardpan shall be reseated to full bearing by redriving, applying at least 150 blows of the hammer. If the pipe shell shows two inches or more of penetration on redriving, the pipe shall be recleaned and redriven in successive cycles until the penetration or redriving is less than two inches.

3. Pipe shells shall be inspected before filling with concrete, shall be clean, and shall meet the requirements for alignment and condition of the shells as specified with regard to the soils of cast-in-place piles.

4. Placing of concrete fill in pipe shells shall conform to the requirements for placing concrete fill in cast-in-place piles.

**19:6–2.55 Caisson piles**

(a) Caisson piles shall denote concrete filled pipe piles that are socketed into bedrocks of classes 1–65, 2–65 or 3–65 and constructed with steel cores.

(b) Pipe or shell and concrete shall conform to the requirements for concrete filled pipe piles, except that the minimum compressive strength of the concrete at the age of 28 days shall be 3,500 psi. Steel cores shall conform to the requirements for steel H piles. Reinforcing steel cages shall be covered with at least 1–1/2 inches of concrete.

(c) The design of the rock socket shall be predicated on the sum of the allowable bearing pressures on the bottom of the socket plus bond along the sides of the socket. The allowable bearing pressure on the surface of the rock at the bottom of the socket may be increased for embedment in accordance with note 8 or table 613.7, provided that the strength of the concrete fill the socket, computed as 0.45f'c, is of comparable magnitude. The allowable bond stress between the concrete and the sides of the socket shall be taken as 200 psi.

(d) Spacing and minimum dimensions are:

1. Minimum diameter of a caisson shall be 18 inches with a minimum shell thickness of 3/8 inch. Minimum depth of the rock socket shall be equal to the diameter of the pipe.

2. The center-to-center spacing of caissons shall be at least 2–1/2 times the outside diameter of the shell.

(e) Installation rules are:

1. The steel shell shall be installed through overburden, the material within the shell shall be removed, and the shell seated in the rock sufficiently to stop the inflow of soil. Where required to extend the shells, splices are to be welded. A suitable steel driving shoe shall be welded to the bottom of each caisson.

2. A socket shall then be drilled in the rock to the required depth and shall be approximately of the same diameter as the inside diameter of the shell. Before placement of concrete, the socket and shell shall be thoroughly cleaned and the rock inspected to verify that the rock is of the class on which the design has been predicated, or of a better class. In case visual inspection cannot be made because of inability to unwater the caissons by standard pumping methods, drilling logs and screenings from the rock drilling operation may be utilized to determine the class of rock in the socket.

3. Where more than one section of steel core is required, the mating ends of the sections shall be spliced so as to safely withstand the handling stresses to which they may be subjected. The ends shall be milled or field ground to insure contact. The steel core shall be centrally installed in the caisson before grouting and concreting, shall not be more than one inch above the rock at the bottom of the socket, and shall be full length of the caisson or extend a sufficient distance up into the shaft to transmit the load in the steel core into the concrete of the caisson. A minimum-weight 36 pound stub core beam shall be installed in the socket for caissons not requiring steel cores in order to lock the caissons into the rock. In these cases, the length of the steel cores shall be twice the socket depth.

4. Concrete and grout shall be placed so that it completely fills the shell, the socket, and the space between the steel core and shell, and in a manner that will preclude separation of the ingredients.

5. If the leakage of water into the caisson is minor, the caisson shall be pumped out and one cubic yard of grout shall be placed in the caissons and then the balance of the concrete installed. If the leakage of water makes it inadvisable to attempt to place concrete in the dry, the shell shall be filled to its top with clean water, and the concrete placed by the tremie method to the top of the caisson in one continuous operation or by using a seal of grout of the same strength as the specified concrete. The grout seal, if used, shall be deposited by means of a grout pipe to an elevation of at least three feet above the cutting edge, and after a sufficient time has elapsed to allow the grout to set, the caisson shall be pumped dry and and the remaining space filled with concrete.

**19:6–2.56 Composite piles**

Composite piles include those consisting of two types of piles joined together. The maximum allowable load shall be that allowed for the component of lesser strength used to make up the full pile length. The connection or joint between the two components shall be constructed so as to prevent the separation of the upper and lower components during construction and thereafter. The details and methods of making joints shall be designed.

**19:6–2.57 Underpinning**

Where support of adjacent structures or properties is required, such support may be provided by underpinning, sheeting and bracing or by other means acceptable to the chief engineer. Except as specifically permitted otherwise, underpinning piers, walls, piles and footings shall be designed and installed in accordance with the applicable provisions of this subchapter relating to piers, walls, piles and footings used in new construction and shall be inspected as provided in section 61 of this subchapter.

**19:6–2.58 Use of rock support in lieu of underpinning**

Existing structures founded at a level above the level of adjacent new construction may be supported on hard rock in lieu of underpinning, the use of sheeting and bracing, or the construction of retaining walls, provided that a report by the architect or engineer is submitted substantiating the safety of the proposed construction and verifying that an "in-place" inspection has been made of the rock exposed and of the joining therein in the excavation.

**19:6–2.59 Stability**

The possibility of overturning and sliding of the building shall be considered.

**19:6–2.60 Factor of safety**

(a) The minimum factor of safety against overturning of the structure as a whole shall be 1–1/2. Stability against overturning shall be provided by the dead load of the building, by the allowable uplift capacity of piling, by anchors, by weight of soil directly overlying footings, provided that such soil cannot be excavated without recourse to major modifications of the building, or by any combination of these factors.

(b) The minimum factor of safety against sliding of the structure under lateral load shall be 1–1/2. Resistance to lateral loads shall be provided by friction between the foundation and the underlying soil, by passive earth pressure, by batter piles, or by plumb piles, subject to the following:

1. The resistance to the lateral loads due to passive earth pressure shall be discounted where the abutting soil could be removed inadvertently by excavation.

2. In the case of pile-supported structures, frictional resistance between the foundation and the underlying soil shall be discounted.

3. The available resistance to friction between the foundation and the underlying soil shall be predicated on an assumed friction factor of 0.5 for soils of classes 1–65 through 8–65. A greater value of coefficient of friction may be used subject to verification by analysis and test. For soils of poorer classes, the stability shall be analyzed by accepted procedures of soil mechanics.

**19:6–2.61 Boring operations**

(a) Boring operations shall be subject to controlled inspection, except that 50 per cent or less of the required number of borings may be inspected by an architect or engineer other than an architect or engineer designated for controlled inspection. The records of boring shall be attested to as follows:

1. The architect or engineer shall file a report stating which borings were performed under his inspection and whether such inspection was performed personally or otherwise. If the inspection was not made personally by the architect or engineer, the name and address of the inspector shall be noted. It shall be stated: that the borings so inspected were made and were carried to the depths indicated; that, to the best of the architect's or engineer's knowledge and belief, the description and classification of the soils are a true description of the samples recovered from the respective borings; that such samples were recovered at the levels indicated; and that the boring work progressed in such manner that the samples recovered are reasonably representative of the subsurface conditions.

2. The accuracy of the other data indicated on the boring records shall be attested to by the drilling contractor or by the driller making the borings.

**19:6–2.62 Piling**

The installation of all piling shall be subject to controlled inspection. Such inspection shall be performed only by an architect or engineer resident at the site, the inspection of the work may be performed by non-licensed or nonregistered personnel working under the resident architect or engineer who need act only in a supervisory capacity. This exception shall not apply, however, in cases of timber or steel piles driven to end bearing as described in this subchapter. In all cases, an inspector shall be assigned to observe the operations of each rig.

**19:6–2.63 Subgrade for footings, foundation piers and foundation walls**

The soil material directly underlying all footings, foundation piers, and foundation walls shall be inspected by an architect or engineer after excavation and immediately prior to construction of the footings. If such inspection indicates that the soils conditions do not conform to those assumed for purposes of design as described on the plans, or are unsatisfactory due to disturbance, then additional excavation, reduction in allowable bearing pressure, or other remedial measures shall be adopted, as required. A copy of a report or reports on such inspection or inspections describing the conditions found and any necessary modification of the design, and bearing the signature of the architect or engineer making the inspections, shall be filed with the chief engineer. In addition, notification shall be received by the chief engineer at least two working days prior to construction of the footing, pier, or foundation walls, that the subgrade is ready for inspection, if desired, and the subgrade shall be kept open for inspection by the chief engineer until the date and time specified in the notice.

**19:6–2.64 Constructions required for or affecting the support of adjacent properties or buildings**

Except in cases where a proposed excavation will extend less than ten feet below the legally established grade, all underpinning operations and the construction and excavation of temporary or permanent cofferdams, caissons, braced excavated surfaces, or other constructions or excavations required for or affecting the support of adjacent properties or buildings shall be subject to controlled inspection. The details of underpinning, cofferdams, caissons, bracing, or other constructions required for the support of adjacent properties or buildings shall be shown on the plans or prepared in the form of shop or detail drawings and shall be approved by the architect or engineer who prepared the plans.

**19:6–2.65 National standards for foundations**

(a) Replace SEC. MB–611.0 National Standard for Foundations in the Manual for the Standard Building Code of New Jersey with the following reference standards:

1. Accepted engineering practice:

i. Specifications and Dimensions for Wood Poles, 1963, USASI–05.1;

ii. Standard for the Preservative Treatment of all Timber Products by Pressure Processes, 1965, AWPA–C1;

iii. Standard for the Preservative Treatment of Piles by Pressure Processes, 1966, AWPA–C3;

iv. Standard for the Preservative Treatment of Poles by Pressure Processes, 1965, AWPA–C4;

v. Standard Instructions for the Inspection of Preservative Treatment of Wood, 1962, AWPA–M2;

vi. Standard for the Case of Pressure–Treated Wood Products, 1962, AWPA–M4;

vii. Standard Specification for Round Timber Piles, 1958; ASTM–D25;

viii. Specification for Welded and Seamless Steel Pipe Piles (Tentative), 1963, ASTM–A252;

ix. Test for Sieve or Screen Analysis of Fine and Coarse Aggregates, 1967, ASTM–C136;

x. Test for Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing, 1966, ASTM–C117;

xi. Method of Test for the Moisture–Density Relation of Soils Using a 10 pound Rammer and an 18 in. Drop (Tentative), 1966, ASTM–D1557;

xii. Test for Sieve or Linear Analysis of Fine and Coarse Aggregates, 1967, ASTM–C136;

xiii. Test for Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing, 1966, ASTM–C117;

xiv. Method of Test for the Moisture–Density Relation of Soils Using a 10 pound Rammer and an 18 inch Drop, 1966T, ASTM–D1557.

---

SUBCHAPTER 3. (RESERVED)