

SECTION 13
EXCAVATIONS AND FOUNDATIONS

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SECTION 13

EXCAVATIONS AND FOUNDATIONS

1301 EXCAVATIONS

1301.1 General

Until provisions for permanent support have been made all excavations shall be properly guarded and protected so as to prevent the same from being dangerous to life and property. Such protection is to be provided by the person causing the excavation to be made. Excavations, for any purpose, shall not extend within one foot of the plane of the natural slope of the soil under any existing footing or foundation, unless such footing or foundation is first properly underpinned or protected against settlement.

1301.2 Permanent and Temporary Construction Excavations

No permanent excavations shall be made nor shall any construction excavations be left on any lot or lots which will endanger adjoining property or buildings or be a menace to public health or safety. Any such excavations made or maintained shall be properly drained and such drainage provisions shall function properly as long as the excavation exists.

Permanent excavations shall have retaining walls of steel, masonry, concrete or similar approved material of sufficient strength to retain the lateral thrust of the surrounding material together with any surcharged loads.

1301.3 Enforcement

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

1302 BEARING CAPACITY OF SOIL

1302.1 Soil Investigations

Plans for new buildings or additions shall bear a statement as to the nature and character of the soil under the structure. Where the bearing capacity of the soil is not known or is in question, the design engineer shall arrange for an examination of sub-soil conditions such as by borings and other tests. Plate load tests shall be used only to supplement other sub-soil investigations. The design capacity of the soil should be substantiated by recognised tests, analyses and procedures.

For the purposes of conceptual design only, Table 13-1 may be used as a guide in estimating the allowable bearing capacities of supporting soils.

Table 13-1

Maximum Safe Bearing Capacities for Horizontal Foundations at Depth 2 ft. under Vertical Static Loading. (Materials not listed in this Table shall be tested for bearing capacity).

Types of Rocks and Soils		Maximum Safe bearing Capacity - tons per sq.ft.	Remarks
1.	Massively-bedded limestones and hard sandstones.	40	To be determined
2.	Clay shales		
3.	Thinly-bedded limestones and sandstones	10	
		Dry	Submerged
4.	Compact well-graded sands and gravel sand mixtures	4	2
5.	Loose well graded sands mixtures	2	1
6.	Compact uniform sands	2	1
7.	Loose uniform sands	1	1/2
8.	Stiff clays and sandy clays	2	To be determined
9.	Firm clays and sandy clays	1	1
10.	Soft clays and silts	1/2	1/2
11.	Very soft clays and silts	-	-
12.	Made ground	-	To be determined after investigation

1302.2

Wind and Earthquake

- a) All allowable soil-bearing values specified in Table 13-1 may be increased by one-third in calculations for wind or earthquake loading when combined with vertical loads. No increase shall be allowed for vertical loads acting alone. Wind and earthquake loads need not be assumed to act simultaneously.
- b) It should be noted that in certain types of soils, for example, silty water-logged soils, liquefaction might occur under certain earthquake conditions. The possibility of the occurrence of liquefaction should be investigated.

1303.1 General

Footings shall be so designed that the soil pressure should be reasonably uniform to minimise differential settlement. The preferred material for the construction of footings is concrete.

1303.2 Continuous Footings

- (a) Footings under walls shall be continuous or continuity otherwise provided and shall not be less than required to keep the soil pressure within that set forth in Table 13-1 nor less than the minimum sizes set forth in Table 13-2.
- (b) All concrete footings shall be adequately reinforced, the minimum allowable amount of steel reinforcement being 0.15 percent of the gross cross-sectional area of the concrete in both horizontal directions. Reinforcing bars shall be provided with a minimum of 2" of concrete cover. (See Table 16-3)
- (c) Excavations for continuous footings shall be cut true to line and level and the sides of footings shall be shuttered, except where soil conditions are such that the sides of the excavation stand firm and square. Excavations shall be made to firm bearing.
- (d) Continuous footings shall be placed level and any changes in the level of such footings shall be made with a vertical tie of the same cross-section and design as the footings.
- (e) Continuous footings on which the centre of gravity of the loads falls outside of the middle one-third shall be considered eccentric, and provision shall be made to limit the soil pressure at the edges to allowable values by means of counter-balancing or by other approved methods.

1303.3 Isolated Footings

- (a) Isolated footings in soils having low lateral restraint shall be provided with adequate bracing to resist movement.
- (b) An isolated footing on which the centre of gravity of the load falls outside the middle one-third of any line passing through the centre of gravity of the footing shall be considered eccentric, and provision shall be made to limit the soil pressure at the edges by means of straps or other approved methods.
- (c) Where isolated footings support reinforced concrete columns, starter bars, equivalent in number and area to the column reinforcement, and having lengths not less than 30 diameters above and below the joints, shall be provided in the footing. Where

the footing depth does not allow straight bars, standard bends will be allowed. Such starter bars, or anchor bolts as are required for steel columns, shall be held to proper level and location during the concreting of the footing by templates or by other approved methods.

Table 13-2

Minimum Dimensions for Continuous Footings

Allowable bearing capacity (Tons per sq.ft.)	Number of storeys	Depth and width (ins)
Up to 1/2	1	12 x 30
	2	12 x 36
Over 1/2 but less than 1	1	9 x 24
	2	12 x 24
1 or more	1	9 x 16
	2	9 x 24

Note: The sizes given in the Table are to be used with caution as the characteristics of soils vary considerably and all soils should be analyzed before designing the foundation.

Based on soil investigations as set forth in 1302.1 the footing sizes may be changed when the allowable bearing values and loads are taken into account, but the minimum width of a footing under the main wall of a building shall not be less than 24" nor less than 8" more than the width of the foundation wall whichever is greater.

1304 CONCRETE SLABS ON FILL

- (a) Where it is proposed to place concrete slabs directly on the supporting soil, a sub-grade shall have first been prepared by removing all top soil, organic matter and debris, and the sub-grade and fill shall be thoroughly compacted by approved mechanical methods. All fill placed under slabs shall be clean, free of debris and other deleterious materials. The maximum size of rock in compacted fill shall be 4" in diameter. For cases of heavy loading special compaction tests may be required.
- (b) Concrete floor slabs placed directly on the supporting soil shall be of an appropriate thickness for the loads intended but in any case not less than 4", and shall be reinforced with steel reinforcement not less than 0.15 percent of the gross cross-sectional area of the concrete in the slab. The reinforcement shall be placed in the upper half of the slab.

1305.1

General

- (a) Piled foundations shall be designed and supervised by a professionally qualified engineer registered in the State, and suitably qualified and experienced in such design.
- (b) Piles used for the support of any building or structure shall be driven to a resistance and penetration in accordance with the plans and/or specifications and as set forth herein.
- (c) Piles may be jetted only if permitted by the engineer. Immediately after completion of jetting, the pile shall be driven below the depth jetted to the required resistance but not less than 1' 0". No jetting will be permitted that may be detrimental to existing adjacent structures or to piles that have been driven.
- (d) **Column action.** All piles standing unbraced in air, water, or in material not capable of providing lateral support, shall be designed as columns. Such piles driven into firm ground may be considered fixed and laterally supported at 5' 0" below the ground surface unless otherwise prescribed by the design engineer after a foundation investigation by a competent agency approved by the Authority.
- (e) When isolated columns and other loads are supported on piles a minimum of three piles shall be used for such support unless lateral bracing is provided at the pile cap to ensure stability. Should a pile be loaded eccentrically so as to produce an overload on any pile more than 10 per cent of the allowable load, footing straps or other approved methods shall be required to counteract the effect of eccentric loading.
- (f) The minimum centre-to-centre spacing of friction piles shall be not less than 3' 6" or the perimeter of the piles whichever is greater. For piles deriving their resistance from end bearing, the minimum centre spacing of the piles shall be not less than 2' 6" or twice the least width, whichever is greater. The spacing of piles shall be such that in no case the average load on the supporting stratum may exceed the safe bearing value of that stratum.
- (g) It is advisable that piles shall not be driven closer than 4' 0" to an existing building or structure, unless special consideration is given to the properties of the soil and to the structure of the existing building.
- (h) **Group action.** Consideration shall be given to the reduction of allowable pile load when piles are placed in groups. Where soil considerations make such load reductions advisable or

necessary, the allowable axial load determined for a single pile shall be reduced by any rational method or formula.

- (i) **Piles in subsiding areas.** Where piles are driven through subsiding fills or other subsiding strata and derive support from underlying firmer materials, consideration shall be given to the downward frictional forces which may be imposed on the piles by the subsiding upper strata
- (j) The engineer or other competent person approved by the Director supervising the pile-driving operations shall be required to keep an accurate record of the material and the principal dimensions of each pile; the weight and fall of the hammer, - if a single-acting or drop hammer; the size and make, operating pressure, length of hose, number of blows per minute and energy per blow - if a double-acting hammer; together with the average penetration of each pile for at least the last five blows, and the levels at tip and cut-off. A copy of these records shall be filed and kept with the plans.
- (k) All piles shall be designed so that lifting and handling stresses shall not exceed allowable working stresses, as specified. Stresses during driving may exceed these stresses by not more than 100 percent.

1305.2

Allowable Loads

- (a) The allowable axial and lateral loads on piles shall be determined by an approved formula, by load tests, or by a foundation investigation by a competent agency.
- (b) Where a dynamic pile formula is used the ultimate resistance shall be calculated in accordance with the method given in BS 8004 or such other formula as the engineer shall consider suitable.
- (c) When the allowable axial load of a single pile is determined by a load test one of the following methods shall be used to determine the ultimate resistance.
- (d) The ultimate resistance shall be defined as:
 - (1) The load at which an increase in load produces a dramatic increase in settlement; or
 - (2) The maximum load which during a 48-hour period of continuous load application causes settlements at a rate not exceeding 0.01 in/hr.

In any event, the maximum settlement should not exceed 0.01 in/ton gross settlement or 0.025 in net settlement (where net settlement is the difference between gross and recovery).

- (e) Where the ultimate resistance of a friction pile is determined by soil tests, the soil investigation and laboratory tests shall be carried out by a competent agency.
- (f) Table 13-3 shall be used to determine the minimum factor of safety to be used in calculating the allowable axial load on a pile.

Table 13-3

Minimum Factor of Safety for Piles

Type of Ground	Test Load	Dynamic Formula Resistance not Reduced on Driving	Dynamic Formula Resistance Reduced on Re- driving	Soil Investigation and Soil tests
Rock	2.0	1.5	-	2.0
Non-cohesive soil	2.0	2.0	2.5	2.0
Hard cohesive soil	2.0	2.0	2.0 or more	2.0
Soft cohesive soil	2.0	N/A	N/A	2.0

* Test load should be used in the circumstances

1305.3

Timber Piles

- (a) Timber piles shall be of one piece of approved timber containing no evidence of decay, free from short kinks or reverse bends and having uniform taper from butt to tip. A straight line drawn from the centre of the butt to the centre of the tip shall lie wholly within the body of the pile. The diameter of round piles shall be not less than 6 inches at the tip and not less than 10 inches three feet from the butt, for piles which are 25'0" or less in length. For piles which exceed 25 feet in length, the diameter at the tip shall be not less than 8 inches; and at 3 feet from the butt, the diameter shall not be less than 12 inches.

- (b) No piles which have a spiral grain exceeding one complete turn in 40' 0" shall be used. Squared timber piles less than 8" square shall not be used.
- (c) Untreated wood piles shall not be used, except piles made of timber which has been shown to be resistant to termites and wood borers. The approval of the Director shall be sought for the use of all timbers for piling.
- (d) All other piles shall be pressure-treated in accordance with the requirements of Section 14 of this Code.
- (e) The allowable stress in compression parallel to the grain under maximum working load shall not exceed 60 percent of the basic stress as determined by the US National Forest Products Association or any other Agency approved by the Authority, and in no case shall stress exceed 700 lb. per sq.in.

1305.4

Precast Concrete Piles

- (a) The manufacture of precast concrete piles shall conform in all respects to Section 16 of this Code; concrete shall conform to not less than the requirements of standard mix ST4* for normal or easy driving and of mix ST5 for hard driving, and for all piles used in marine work.

***Note: Concrete grades are defined in Section 16.**

- (b) All piles shall be reinforced with not less than 4 longitudinal steel bars having an area of not less than 1.25 percent and not more than 4.0 percent of the gross cross-sectional area of the pile. All the main longitudinal bars shall be of uniform size and length. Joints in longitudinal bars, if unavoidable, shall be made by full-strength butt-welding.
- (c) Lateral reinforcement in the form of hoops or links shall be not less than 3/16" diameter. In the body of the pile the lateral reinforcement shall be not less than 2 percent of the gross volume spaced at not more than half the least width of the pile. For length of 3 times the least width of the pile at each end of the pile the volume of lateral reinforcement shall be not less than 6 percent of the gross volume. The transition between the close-spacing at the ends and the maximum spacing shall be made gradually over a length of 3 times the least width.
- (d) All reinforcement, including binding wire, shall be protected by at least 1-1/2" of concrete cover except that for piles subjected to the action of open water, waves or other severe exposure 2-1/2" cover shall be provided.

- (e) The compressive stress imposed on driven piles shall not exceed 750 lb. per sq.in. on the nominal minimum cross-sectional area of the pile.
- (f) Precast concrete piles shall be not less than 10" x 10" in section.
- (g) All precast concrete piles shall have their date of manufacture and the lifting points clearly marked on the pile. Concrete piles shall not be driven until they have attained their specified 28-day strength as verified by tests, nor shall the piles be removed from the forms until 50 percent of the specified 28-day strength has been attained. Piles shall not be transported nor driven until they have been cured not less than seven days.

1305.5 Prestressed Concrete Piles

- (a) Prestressed concrete piles shall conform to 1608 of this Code except as specifically detailed in 1305.5.
- (b) Longitudinal pre-stressing tendons shall have not less than 2" of cover except that for piles subject to open water or wave action, or other severe exposure the cover shall be 3".
- (c) Lateral reinforcement shall be as specified in 1305.4(c) for the precast concrete piles.
- (d) Piles shall have a minimum pre-stress of 600 lb. per sq.in. at time of driving.
- (e) No tension shall be allowed in the concrete under working load conditions.
- (f) The compressive stress in the pile under working load combined with the prestress in the pile at the time of loading shall not exceed one-third of the compressive strength of the pile.

1305.6 Cast-in-place Concrete Piles

- (a) Concrete piles cast in place against earth in drilled or bored holes shall be made in such a manner as to ensure the exclusion of any foreign matter and to secure a full-sized shaft.
- (b) **Allowable stresses.** The allowable compressive stress in the concrete shall not exceed 0.225 times the specified 28-day cube strength. The reinforcing steel shall conform to ASTM A706-82a - "Standard Specification for Low Alloy Steel Deformed Bars for Concrete Reinforcement" or to the equivalent British standard.
- (c) Cased cast-in-place concrete piles may consist of a steel or concrete shell driven in intimate contact with the surrounding

soil and left in place and filled with concrete. Steel shells may be uniformly tapered, step-tapered, cylindrical or a combination of such shapes and may be laterally corrugated, spirally corrugated, longitudinally fluted or plain.

- (d) Pile shells and end closures shall be of sufficient strength and rigidity to permit their driving in keeping with the driving method used, and to prevent harmful distortion caused by soil pressure or the driving of adjacent piles until filled with concrete. A reduction of cross-sectional area in excess of 15 percent shall be cause for rejection. The shells shall also be sufficiently water-tight to exclude water during the placing of concrete. The minimum diameter shall be 8".
- (e) Concrete for cast-in-place piles shall conform to not less than the requirements of Grade ST4, Table 16-2.
- (f) Reinforcement including binding wire shall have not less than 2" of concrete cover in uncased piles and 1" where piles are completely encased.
- (g) Where the shell has a thickness of 0.12" or more the shell may be considered as carrying part of the load.
- (h) Adequate allowance for corrosion shall be considered in the design but not less than the outer 1/16" of a steel shell shall be deducted before computing the area of the shell considered as carrying load. The load carried by the shell shall not exceed 9,000 lb. per sq.in. based on the net steel area deducting the allowance for corrosion.

1305.7

Steel Piles

- (a) The quality of the steel in joints, tubes, box piles and other plain or built up sections shall comply with the specification for structural steel in conformance with the relevant ASTM or British standard.
- (b) No section shall have a nominal thickness of metal of less than 3/8".
- (c) The allowable stress under working load shall not exceed 25 percent of the minimum guaranteed yield stress of the steel.
- (d) Where adequate corrosion prevention is not provided 1/16" shall be deducted from each surface in determining the area of the piles section.

1305.8 Special Piles or Special Conditions

The use of types of piles or conditions not specifically covered herein may be considered upon examination of acceptable test data, calculations or other information relating to the properties and load-carrying capacity of such piles.

1306 FOUNDATION BEAMS

- (a) Foundation beams, supporting loads between piles, shall be reinforced concrete, or structural steel protected by at least 2" of concrete cover.
- (b) The width of foundation beams shall be at least equal to the thickness of the wall they support but never less than 8".
- (c) Foundation beams shall be suitably designed and reinforced around access openings and vents.

1307 SEA WALLS AND BULKHEADS

1307.1 General

Sea walls, bulkheads, groynes and other retaining walls along an ocean front, bay, creek, canal, or water-way shall be designed by a professionally qualified and approved engineer.

1307.2 Design Criteria

- a) The structure shall retain the adjoining earth from the surface of the ground to a point sufficiently deep to retain the base against surcharge pressures, with due design considerations for wave action and currents.
- b) Timber shall not be used, other than where located below mean low water, except that bore-resistant or appropriately treated woods may be approved by the Director.
- c) Structures shall be classed as gravity types when the resultant of the acting forces falls within the middle third of the base. Boulder-type walls shall be considered as gravity type where the base width equals or exceeds the height of the wall. Structures which are not of gravity or cantilever type shall be secured to properly designed anchors.
- d) Where structures are constructed of a combination of lime rock boulders and concrete, the minimum percentage of cross-section area of the concrete to the total cross-section area of the structure shall be 40 percent, not including concrete used for copings or decorative purposes.

1308.1 General

The footings of any structure may be carried down to a firm foundation by isolated piers of reinforced concrete or by open or pneumatic caissons either with or without enlarged base or bell at the bottom.

1308.2 Design Criteria

- a) The safe-carrying capacity of such shafts or caissons shall not exceed the allowable unit bearing capacity of the soil multiplied by the area of the base or bell at the bottom, provided such bell shall have at least a 12" thickness of concrete at its edge and the sides shall slope at an angle of not less than 60 degrees with the horizontal.
- b) In no case shall such piers or caissons be of less than 2' 0" minimum horizontal dimension.