Myanmar Engineering Society

Study on Updating the Myanmar National Building Code (MNBC- Geotechnical)

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PE-3165(Geotechnical)

Date- 14.11.2026

Time- (9:00am – 12:00 AM)

Venue-Functional Hall, MES

ABSTRACT

- The Mw 7.7 Mandalay earthquake highlights the critical role of **soil behavior in seismic performance**.
- Failures were not only structural but were also strongly controlled by **subsurface conditions**,
- Engineers need to study the updating of the geotechnical aspects of MNBC.

- GUIDELINE I : Geotechnical Investigations
- GUIDELINE II: Structural Design
- GUIDELINE III : Deep Excavation Design

GEOTECHNICAL INVESTIGATION

I. Soil Investigation Report must be submitted to the Committee.

- Section 1: Site location plan
- Section 2: Boring program (including bore hole location plan, equipment used, sampling, storage and transportation methods, standards used, environmental conditions)
- Section 3: Description of Field Tests: Standard Penetration Test

- Section 4: Description of Laboratory Tests:
  i. Natural Water Content Test
  ii. Liquid Limit and Plastic Limit Tests
  iii. Specific Gravity Test
  iv. Triaxial Test (Or Direct Shear Test if the test is compatible with the ground conditions at site)
  v. Unconfined Compressive Strength Test
  vi. Grain Size Distribution Test
  vii. Other relevant tests must also be performed if required.

- Section 5: Evaluation of test results consultation with registered design professionals (including all the detailed calculations mentioned in the Guideline and investigation of liquefaction potential)
- Section 6: Recommendations
- Appendices :Field data, Test results, Other data, Diagrams, Sources of literature, etc

- NOTE: 1. Geotechnical investigations shall be conducted in conformance with MNBC 2025 Sections **4.2.2 through 4.2.6.** Where required by the building official, the classification and investigation of the soil shall be made by a registered engineer (Refer to M.Eng C Professional Scope of Work).
- 2. If the Site Classification system is determined by Shear wave velocity method, it is required to investigate shear wave velocity test at pre-construction stage.
- 3. To determine the site class value, it is necessary to consider not only the shear wave velocity but also the SPT value.

4.2.2 INVESTIGATIONS REQUIRED

4.2.2.1 Questionable soil

4.2.2.2 Expansive soils

4.2.2.3 Ground-water table : existing ground-water table is above or within 5 feet (1524 mm) below the elevation of the lowest floor level

4.2.2.4 Pile and pier foundations: Sections **4.2.4 through 4.2.6** and Section **4.8.2.**

4.2.2.5 Rock strata : a sufficient number of borings shall be made to a depth of not less than 10 feet (3048 mm) below the level of the foundations

4.2.2.6 Seismic Design Category C

- Where a structure is determined to be in Seismic Design Category C in accordance with **Section 3.4**, an investigation shall be conducted and shall include an evaluation of the following potential hazards resulting from earthquake motions: **slope instability, liquefaction and surface rupture due to faulting or lateral spreading.**

4.2.2.7 Seismic Design Category D, E or F

The investigation shall include:(**addition**)

1. A determination of **lateral pressures** on basement and retaining walls due to earthquake motions.

2. An assessment of potential consequences of any **liquefaction and soil strength loss,** including estimation of differential settlement, lateral movement or reduction in foundation soil bearing capacity, and shall address mitigation measures.

4.2.3 SOIL CLASSIFICATION

- ASTM D 2487

4.2.3.2 Expansive soils

- **Soils meeting all four of the following provisions shall be considered expansive,** except that tests to show compliance with Items 1, 2 and 3 shall not be required if the test prescribed in Item 4 is conducted:
- 1. Plasticity index (PI) of 15 or greater, determined in accordance with ASTM D 4318.

- 2. More than 10 percent of the soil particles pass a No. 200 sieve (75 μm), determined in accordance with ASTMD 422.
- 3. More than 10 percent of the soil particles are less than 5 micrometers in size, determined in accordance with ASTM D 422.
- 4. Expansion index greater than 20, determined in accordance with ASTM D 4829.

3.4.1.4.2 Site Class Definitions

Based on the site soil properties, the site shall be classified as Site Class A, B, C, D, E, or F in accordance with **Table 3.4.2**.

Where the soil properties are not known in sufficient detail to determine the site class, **Site Class D** shall be used unless the authority having jurisdiction or geotechnical data determines Site Class E or F soils are present at the site.

TABLE 3.4.2 SITE CLASS DEFINITIONS

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 FEET, SEE SECTION 3.4.1.3.4.2		
		Soil shear wave velocity $\bar{v}_s$ (ft/sec)	Standard penetration resistance $\bar{N}$	Soil undrained shear strength, $\bar{s}_u$(psf)
A	Hard Rock	$\bar{v}_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \bar{v}_s \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \bar{v}_s \leq 2{,}500$	$\bar{N} > 50$	$\bar{s}_u \geq 2{,}000$
D	Stiff soil profile	$600 \leq \bar{v}_s \leq 1{,}200$	$15 \leq \bar{N} \leq 50$	$1{,}000 \leq \bar{s}_u \leq 2{,}000$
E	Soft soil profile	$\bar{v}_s < 600$	$\bar{N} < 15$	$\bar{s}_u < 1{,}000$
E	-	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\bar{s}_u < 500$ psf		
F	-	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$). 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2, 1 pound per square foot = 0.0479 kPa.

N/A = Not applicable.

- The symbol i then refers to any one of the layers between 1 and n

where,

v_{si}= the shear wave velocity in feet per second (m/s).

d_i = the thickness of any layer between 0 and 100 feet (30,480 mm).

where,

$$\bar{v}_s = \frac{\Sigma_{i=1}^{n} d_i}{\Sigma_{i=1}^{n} \frac{d_i}{v_{si}}} \qquad \textit{Eq. (3.4.8)}$$

$$\sum_{i=1}^{n} d_i = 100\ ft\ (30{,}480\ mm)$$

N_i is the Standard Penetration Resistance (ASTM D1586) not to exceed 100 blows/foot (304.8 mm) as directly measured in the field without corrections. When refusal is met for a rock layer, N_i shall be taken as 100 blows/foot (304.8 mm).

$$\bar{N} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{N_i}} \qquad Eq.\ (3.4.9)$$

where,

N_i and d_i in Equation (3.4.9) are for cohesionless soil, cohesive soil and rock layers.

$$\bar{N}_{ch} = \frac{d_s}{\sum_{i=1}^{m} \frac{d_i}{N_i}} \qquad Eq.\ (3.4.10)$$

where,

$$\sum_{i=1}^{m} d_i = d_s$$

Use

d_i and N_i for cohesionless soil layers only in Equation (3.4.10)

d_s= total thickness of cohesionless soil layers in the top 100 feet (30,480 mm)

m = number of cohesionless soil layers in the top 100 feet (30,480 mm)

s_{ui} = the undrained shear strength in psf (kPa), not to exceed 5,000 psf (240 kPa), ASTM D2166 or D2850.

$$\bar{s}_u = \frac{d_c}{\sum_{i=1}^{k} \frac{d_i}{s_{ui}}} \qquad \textit{Eq. (3.4.11)}$$

where,

$$\sum_{i=1}^{k} d_i = d_c$$

d_c = the total thickness of cohesive soil layers in the top 100 feet (30,480 mm)

k = the number of cohesive soil layers in the top 100 feet (30,480 mm)

PI = the plasticity index, ASTM D 4318

w = the moisture content in percent, ASTM D 2216

TABLE 3.4.5 SITE CLASSIFICATION[a]

SITE CLASS	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
C	1,200 to 2,500 ft/s	>50	> 2,000
D	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E	< 600 ft/s	< 15	< 1,000 psf

Where a site does not qualify under the criteria for Site Class F and there is a **total thickness of soft clay greater than 10 feet (3048 mm) where a soft clay layer is defined by: su< 500 psf (24 kPa), w ≥ 40 percent, and PI > 20, it shall be classified as Site Class E.**

4.2.4 INVESTIGATION

Soil classification shall be based on observation and any necessary tests of the materials disclosed by borings, test pits or other subsurface exploration made in appropriate locations.

Additional studies shall be made as necessary to evaluate slope stability, soil strength, position and adequacy of load-bearing soil, the effect of moisture variation on soil bearing capacity, compressibility, liquefaction and expansiveness.

- 4.2.5 SOIL BORING AND SAMPLING
- 4.2.6 REPORTS

II. Number of Boreholes and Depth of Boring, Borehole Locations

A. Number of Boreholes

- 1. Minimum of 2 borings for every project.
- 2. One boring for every 2500 sq-ft (or 250 sq-m) for built-over area ≤ 10,000 sq-ft (or 1,000 sq m).
- 3. One additional boring for every extra 5,000 sq-ft (or 500 sq-m) for large area projects >10,000 sq-ft (or 1,000 sq-m).
- 4. For irregular soil and terrain conditions, no of additional boreholes will be decided through consultation between structural engineer and geotechnical consultant.

B. Depth of Boring

- 1. For shallow foundations, minimum depth of boring shall be larger value of 1.5 times lesser dimension of the shallow foundation or 30ft (10m).
- 2. For deep foundations, minimum depth of boring shall be follows: 20 $S^{0.7}$ (ft) or 6 $S^{0.7}$ (m) where S = number of storey including basements.
- 3. For any type of foundation in seismic design purposes (Seismic Design Categories A to F), minimum depth of boring shall be 100ft (or 30m) to enable proper determination of Site Class in the proposed project.
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- 4. In all cases, depth of boring shall be decided by the requirements **of design professional** and/or building authority to provide adequate information for design purposes.
- Boreholes should penetrate more than 5 meters into hard stratum with SPT blow counts of 100 or at least 5 times pile diameter beyond the intended foundation level for deep foundations.

III. Minimum requirements of Soil Investigation Report for Deep Excavation Case

i. Field Test

1. Boreholes spacing may vary from site to site but generally be at intervals of 10m - 30m along the length of the wall. Borehole intervals should depend on soil condition.
2. Standpipe or piezometers should be installed to determine and confirm the ground water conditions at site.

3. SI report for structures with 3 basements and more (or) with total depth of basements 12m and above shall include the permeability test for dominant soil layers to consider the seasonal fluctuation of ground water.
4. Pressure meter or elastmeter measurement should be done on projects which include 3 basements and more (or) with total depth of basements 12m and above to determine of E value.

ii Laboratory Test

1. Particles size distribution shall be taken by sieve analysis and hydrometer test, etc.
2. Atterberg limits tests shall be done to determine liquid limit, plastic limit, plasticity index and if necessary (swell test).
3. Moisture content, unit weight, specific gravity shall be tested.
4. Direct shear test or Triaxial Test shall be done according to soil nature to determine shear strength.

5. Isotropic Consolidated Undrained Triaxial Test with pore water pressure measurements shall be done for structures with 3 basements and more (or) with total basements depth 12m and above.
6. Unconfined Compression Strength Test (UCS) and Consolidation Test shall be done for cohesive soil.

Remarks

- The above mentioned tests should be carried out at the boreholes along the wall.
- Determination of seepage pressure should be done case by case only.
- In-situ permeability test should be done for structures with 3 basements and more.
- Borehole sample shall be taken 1.8m interval for up to 10m borehole depth and 3m interval from 10m to end of boring.

IV. Special types of piles

The use of types of piles not specifically mentioned in MNBC 2025, the approval of the building official, upon the submission of acceptable test data, calculations and other information relating to the structural properties and load capacity of such piles is required to submit to HPBC.

The allowable stresses shall not in any case exceed the limitations specified MNBC.

V. Pile Load Test

- Pile load test must be performed with the approval of the Committee.
- The pile load test must be taken and follow according to ASTM D-1143 specification.

i. Minimum Number of Pile Load Tests

Bored Piles

- Instrumental / Ultimate Load Test – 1 No
- Working Load Test - 1 % of Total Number of Bored Piles
- Integrity Test - 50 % of Total Number of Bored Piles

Driven Piles

- Working Load Test - 1 % of Total Number of Piles
- Integrity Test - 50% of Total Number of Piles

Jacked-in Piles

- Working Load Test - 1% of Total Number of Pile for up to500 nos. If number of pile is more than 500 in one building, 0.5% shall be conducted for the rest of piles.
- Integrity Test - 50% of Total Number of Piles

Post Grouted Piles

- Ultimate Load Test (Grouted Pile)- 1 No
- Ultimate Load Test (Ungrouted Pile)- 1 No
- Working Load test – 3% to 5% of Total Number of Post grouted Piles
- Integrity Test- 50% of Total Number of Post Grouted Piles

- The location of test pile shall be based on soil profile and structural framing system.
- At least 50% of Working Load Test points shall be done by Static Load Test.

- And the remaining 50% of Working Load Test points can be done by Dynamic Load Test (ASTM D-4945).
- But the number of Dynamic Load Test Points shall be 3 times of the remaining 50% Working Load Test points. (1 static = 3 dynamic).
- Dynamic load test shall be performed at site where the adjacent buildings will not be affected and need to study the condition of adjacent buildings.

ii Requirements for Ultimate Pile Load Test

- The following requirements shall be submitted to HPBC in performing the pile load test.

1. Approval in Principle (From YCDC,MCDC,NCDC & other Municipalities)
2. Code of practice and design reference
3. Soil Report
4. Method statement of pile load test
5. Material properties

ii Requirements for Ultimate Pile Load Test

6. Pile design report by foundation designer

   (a) Design of test pile (structural capacity and geotechnical capacity)

   (b) Design of tension piles (if anchored piles are used)

7. Architectural conceptual drawings (Conceptual)
8. Site Location Plan with adjacent building and bore holes
9. Ultimate test pile location plan
10. Test pile details (Anchor pile details if anchor method)

iii Requirements for Working Pile Load Test

The following requirements shall be submitted to HPBC in performing the pile load test.

1. Code of practice and design reference
2. Method statement of pile load test
3. Material properties
4. Pile design report by foundation designer (a) Design of test pile (structural capacity and geotechnical capacity) (b) Design of tension piles (if anchored piles are used)
5. Site Location Plan with adjacent building and bore holes

6. Columns loading calculation
7. Piling plan and test pile locations.
8. Test pile details (Anchor pile details if anchor method is used)
9. Structural analysis and design software
10. Architectural drawings

Iv: Instructions for Performing the Pile Load Tests

1. The minimum C/C spacing of all working piles shall be 2.5 times of pile diameter.
2. In performing the ultimate pile load test, the minimum C/C spacing between test pile and anchor pile shall be 3 times of larger pile diameter.
3. In performing the working pile load test, the minimum C/C spacing between test pile and anchor pile shall be 2.5 times of larger pile diameter.

4. Structural tension capacity of anchor pile reinforcement shall be 0.6 fy.
5. Safety factor for geotechnical tension capacity of anchor pile shall be 3.
6. If the whole system is calibrated, the pile load test can be performed without load cell.

7. The calibrated time of load cell, hydraulic jack, pressure gauges & pressure transducers, dial gauge, level instrument and linear vibration displacement transducers (LVDT) shall be within 6 months.
8. Should there be any changes from the load test pile installation company and the remaining pile installation company, consulting with HPBC is necessary.

V. Guidelines on Pile Load Test

Any one of the following two methods on Pile Load Test can be selected and used, and duly submitted to the HPBC for approval.

Method (1)

- To conduct, first the Ultimate Load Test with the approval of HPBC and submit report of the test results for evaluation to the HPBC.
- The remaining working load test shall be continued following acceptance of the test result, and inspection on piling work to be made only after the pile capacity is fully attained.

Method (2)

- Both the Ultimate Load Test and the working load test can be conducted simultaneously with the approval of the HPBC.
- Upon completion, the ULT and WLT Reports shall be submitted to HPBC for review.
- HPBC will then issue the Pile Capacity Recommendation (ULT & WLT), after which the remaining Piling Works shall be executed under the responsibility of the Contractor and Designer.

Note

- The HPBC shall be duly informed of the method by which the piling test will be conducted before any work has begun on piling.
- When pile load test is required, pile integrity test must be carried out for anchor piles. After passing pile integrity test (PIT), the anchor piles can be used as working piles.

VI. Calculations of Bearing Capacity and Pile Capacity or Pile Group Capacity

i .**Allowable Bearing Capacity Calculation for Mat Foundation Design**

1. Nearest borehole data should be used for the bearing capacity calculation of mat foundation.
2. Bearing capacity can be determined by using minimum value from the calculation by (a) SPT value method and (b) C, ø value method.
3. State clearly the parameters considered in calculating bearing capacity for mat foundation design and explain how the parameters are found.

ii. Pile Capacity or Pile Group Capacity Calculation for Pile Foundation Design

a. Pile Structural Capacity

1. Cylinder strength of concrete shall be 30Mpa (f'c = 30 Mpa) for structural capacity calculation of **working pile**. Cylinder strength of concrete used in **pile construction** shall be increased from 30Mpa to 35Mpa.

2. Cylinder strength of concrete shall be 35Mpa (f'c = 35 Mpa) for structural capacity calculation of **ultimate pile**. Cylinder strength of concrete used in pile construction shall be increased from 35Mpa to 40Mpa.

- 3. Soil-pile structure interaction shall be considered in pile foundation design according to MNBC-2025 **part 4 (Section 4.8.24).**

4.8.24 SEISMIC DESIGN OF PIERS OR PILES

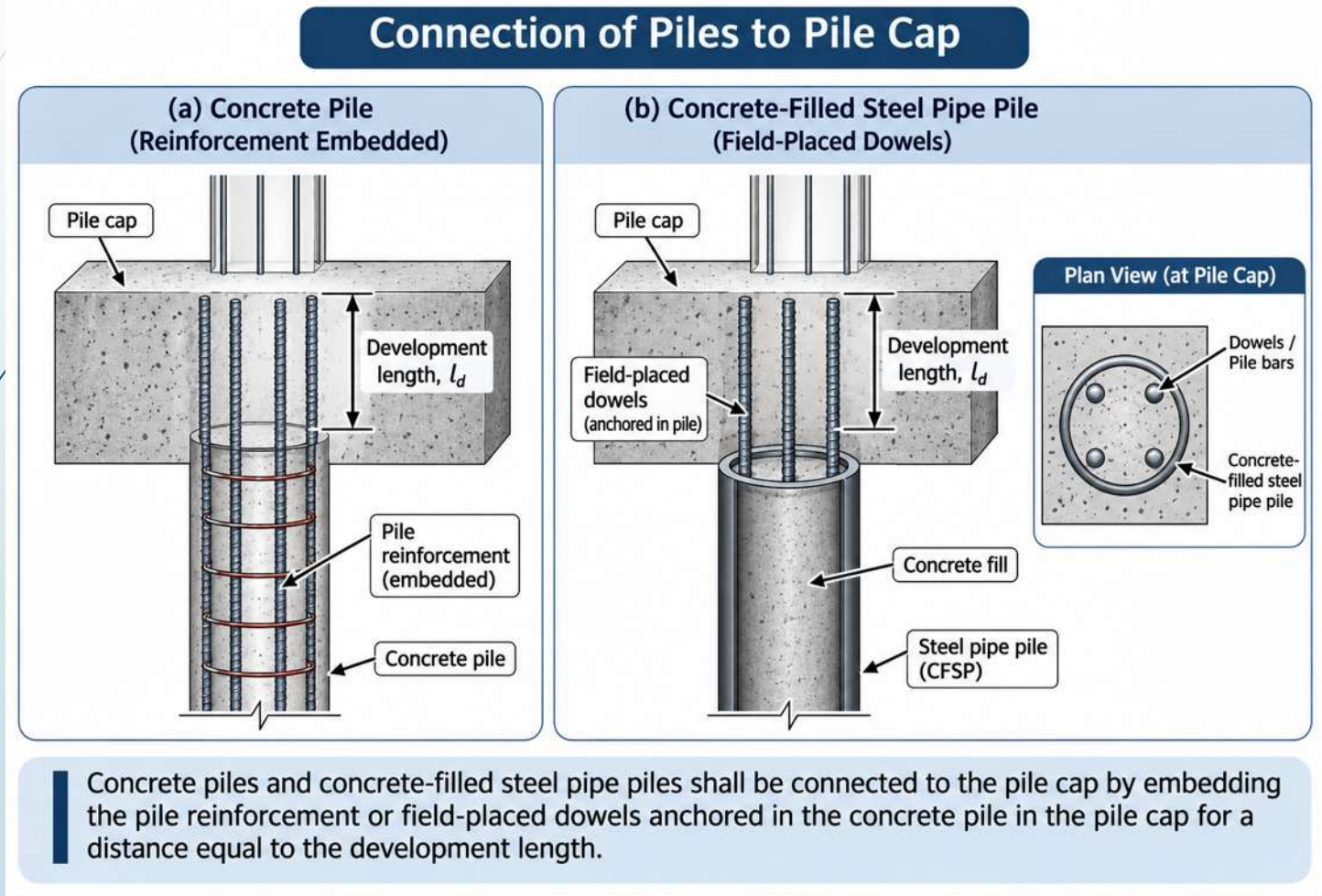
4.8.24.1 Seismic Design Category C

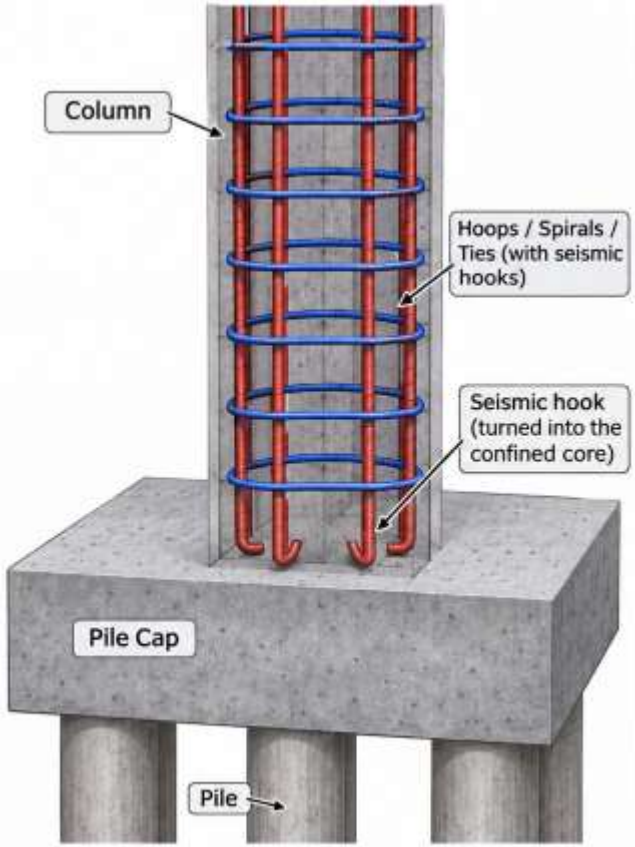
Where a structure is assigned to Seismic Design Category C in accordance with Section 3.4 of Part 3 (Structural Design), the following shall apply.

Individual pile caps, piers or piles shall be interconnected by ties.

4.8.24.1.1 Connection to pile cap

Ends of hoops, spirals and ties shall be terminated with seismic hooks, turned into the confined concrete core.

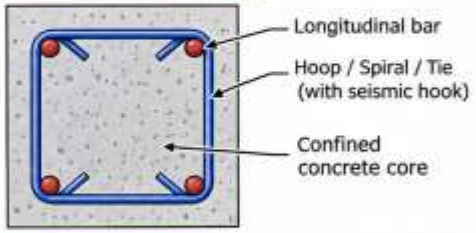




Detail of Seismic Hook (Typical)



Plan View (at Pile Cap Top)



Key Requirement

- ☑ Ends of hoops, spirals and ties shall be terminated with seismic hooks.
- ☑ Hooks shall be turned into the confined concrete core.
- ☑ Typical seismic hook: 135° (or 180°) with an extension length ≥ 6d_b (d_b = diameter of hoop/spiral/tie bar).

4.8.24.2 Seismic Design Category D, E or F

- Where a structure is assigned to Seismic Design Category D, E or F in accordance with Structural Design Section 3.4, the requirements for Seismic Design Category C given in Section 4.8.24.1 shall be met, in addition to the following.
- Provisions of ACI 318-08, Section 21.12.4, shall apply when not in conflict with the provisions of Sections 4.8, 4.9, 4.10, 4.11 and 4.12.
- Concrete shall have a specified compressive strength of not less than 3,000 psi (20.68 MPa) at 28 days.

4.8.24.2.1 Design details for piers, piles and grade beams

Piers or piles shall be designed and constructed to withstand maximum imposed curvatures from earthquake ground motions and structure response.

Curvatures shall include free-field soil strains modified for soil-pile-structure interaction coupled with pier or pile deformations induced by lateral pier or pile resistance to structure seismic forces. **

b. Pile Geotechnical Capacity

1. Pile geotechnical capacity shall be determined by using minimum value from the calculation by

(a) SPT value method and

(b) C, ø value method.

2. State clearly the parameters considered in calculating pile capacity for a pile or a pile- group design and explain how the parameters are found.

VII. Minimum Reinforcement for Bored Pile

i (a) For Category C

1. **Pile diameter (D) less than or equal 800 mm :**

- Longitudinal steel shall be provided for a length not less than 10 m from pile cap soffit level, with a minimum steel ratio of 1 % of pile cross sectional area.
- The longitudinal reinforcement beyond the top 10 m, steel shall be provided with a minimum steel ratio of 0.5 % of pile cross sectional area through the length of pile.

- If the soil is liquefied, reinforcement length shall extend 3D below the liquefiable strata, with minimum steel ratio of 1 % of pile cross sectional area.
- Beyond the liquefiable strata, the minimum steel ratio of 0.5% of pile cross sectional area through the length of pile shall be provided.

2. Pile diameter (D) greater than 800 mm :

- Longitudinal steel shall be provided for a length not less than 10 m from pile cap soffit level, with a minimum steel ratio of 0.8% of pile cross sectional area.

- The longitudinal reinforcement beyond the top 10 m, steel shall be provided with a minimum steel ratio of 0.4 % of pile cross sectional area through the length of pile.
- If the soil is liquefied, reinforcement length shall be extend 3D below the liquefiable strata, with minimum steel ratio of 0.8% of pile cross sectional area.
- Beyond the liquefiable strata, the minimum steel ratio of 0.4% of pile cross sectional area through the length of pile shall be provided.

ii (b) For Category D, E, F

1. Longitudinal steel shall be provided for a length not less than 10 m from pile cap soffit level, with a minimum steel ratio of 1 % of pile cross sectional area.

The longitudinal reinforcement beyond the top 10 m, steel shall be provided with a minimum steel ratio of 0.5 % of pile cross sectional area through the length of pile.

If the soil is liquefied, reinforcement length shall extend 3D below the liquefiable strata, with minimum steel ratio of 1% of pile cross sectional area.

Beyond the liquefiable strata, the minimum steel ratio of 0.5% of pile cross sectional area through the length of pile shall be provided.

2.For minimum yield strength of longitudinal reinforcement, (fy) shall be 50000 psi. For transverse reinforcement, (fy) shall be minimum of 40000 psi.

3. For bored piles less than 0.8 m diameter, minimum 16 mm diameter rebar shall be used.

4. For bored piles greater than or equal to 0.8 m diameter, minimum of 20 mm diameter rebar shall be used.

5. Minimum number of rebar shall be 6 Nos.

6. Minimum 10 mm diameter transverse reinforcement shall be provided at lesser spacing of 16-longitudinal-bar diameter or 12 inches.

7. Transverse confinement reinforcement with a maximum spacing of 6 inches (152 mm) or 8-longitudinal-bar diameters, whichever is less, shall be provided within a distance equal to three times the least pile dimension from the bottom of the pile cap.

VIII. Liquefaction Analysis (MNBC)

Geotechnical report shall include liquefaction analysis as stated in MNBC 2025.

IX. Soil Improvement

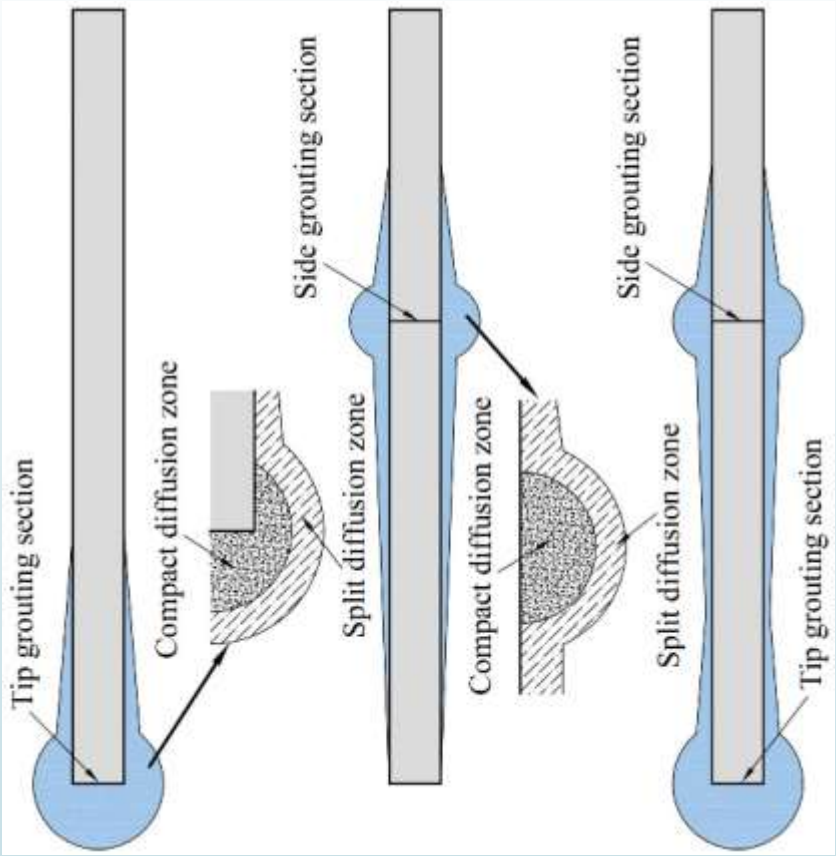
Criteria for Soil Improvement of Shallow foundation: Required specifications shall be tested as per design requirements.

i. **Criteria for Soil Improvement of Pile foundation: (Post grouted Pile)**

For post-grouted piles, design and construction shall be carried out in accordance with internationally recognized codes and standards.

(a) Base (Tip) Grouting

Grout is injected beneath the pile toe to improve end-bearing resistance.



The criteria to be determined during post-grouting are:

1. Grout pressure,
2. Bore pile uplift (vertical displacement of pile top, 3 mm – 6 mm or according to results PLT test), and
3. Grout volume

- **Remark:** -Multi-axial plots shall be used for the real time monitoring of grout volume and grout pressure, and the parameters monitoring must be stable during post grouting.

1. The practical limit of grout pressure is according to the limitations of pump and pipe during the testing pile.

2. Pile uplift measuring shall be carried out by using automatic optical survey equipment according to ASTM D1143.
3. Two grout volume thresholds shall be specified as part of grouting termination criteria (Minimum and maximum net grout volume) for the project.

ii. **Criteria for Soil Improvement of Deep Excavation**

- Required specifications shall be tested as per design requirements.

Coffee Break

FORMAT FOR DESIGN CALCULATIONS REPORT

PART (A) FOUNDATION

Section 1 : Design Parameters and Assumptions

Section 2 : Loadings and load Combinations

Section 3 : Structural Systems

All plans and sections in both directions (including assumed member sizes for the final run)

Section 4 : Input Data

Section 5 : Output Data (Important or significant results only)

Section 6 : Detailing of Foundation Reinforcement

Note All the details involved in the analysis and design processes must be submitted.

DEEP EXCAVATION DESIGN

Basement Construction:

General Requirements for Excavation and Lateral Support (ELS)

1. ELS plans submission document shall include the geotechnical assessment, geotechnical details and calculations, site investigation reports.

2. Designer shall prepare and sign the plans and structural design as well as the structural assessment report of the effects of the excavation and dewatering on adjoining structures.

3. ELS design report shall explain the references for recognized specifications and code of practice for design calculation.

Construction methodology shall explain, for example, detail excavation and support installation sequence and then removal of temporary support, construction of permanent structure for each stage.

3. ELS design report shall explain the references for recognized specifications and code of practice for design calculation.

4. Construction methodology shall explain, for example, detail excavation and support installation sequence and then removal of temporary support, construction of permanent structure for each stage.

5. Designer shall prepare the impact assessment of surrounding building and facilities, monitoring plan and instrumentation.

The impact assessment shall include hydrological assessment including surface and subsurface ground water flow, ground movement during and/after construction, vibration due to construction and mitigation of impacts on surrounding buildings and facilities.

6. The followings shall be included in detail drawings of basement:

a) Detail drawings of all structural elements, joint connection, reinforcement and technical notes.

b) Detail site layout plan with adjacent buildings and bored hole location.

c) The construction structural details of the lateral support system, including detailing of the structural supports (struts, anchorage etc.) for each stage of excavation.

d) Detail excavation depth including localized pits and sloping ground.

7. Adjacent building survey shall be done according to the survey form in the guideline.

8. All calculations shall be carried out in compliance with MNBC 2025.

Technical Requirements:

Consideration shall be given in geotechnical design as below.

1. Restricted Area
2. Protection to adjacent structures (road, building, underground related facilities etc.)
3. Construction hazards

Geotechnical Design Requirement

1. The surcharge load shall be considered a minimum value of 10 kN/m2. Additional surcharge loading shall be used in the design to take account of incidental loading arising from adjacent buildings, working area, construction plant and stacking of materials.
2. Dynamic load factor of traffic shall be considered due to the movement of vehicles during construction.
3. The ground-water pressure, ground water flow into excavation and its influence on the wall stability and impact on the adjacent building shall be considered in design.

4. The Ultimate Limit States (ULS) of the wall shall be checked by using the global safety factor of 2 for temporary work. Unfactored soil strength parameters and loads are used in the stability checks.
5. Serviceability Limit States (SLS) checks shall be carried out to assess the impacts on adjoining buildings, structures, services and land that require the use of deformation parameters in given the attached Tables (2A, 2B and 2C).

Wall deflection and ground settlement behind the basement wall shall be computed and submitted for critical sections.

6. Analytical method is allowed for single excavation stage.

7. For the analysis of interaction of soil and support, recognized finite element computer program shall be used where the excavation is multilayer excavation and supporting.

8. The program used, soil model used, other specifications and design assumptions shall be clearly stated in calculation report.

9. For multi layers of excavation and supporting, consideration shall be given the interaction between the removal of temporary support and performance of permanent support.

10. Over excavation depth shall be considered in the design.

11. The accidental load (minimum 50 kN), temperature load (minimum 20 C) and live load (Construction Activity load) shall be properly designed in structural design. AISC specifications are recommended for the design of steel members.

12. The axial force, bending moment and shear force of all structural members shall be computed and submitted.

13. All geotechnical capacities of structural members (ground anchor, soil nail etc.) in compliance with relevant design codes of practices can be taken into account. (Minimum 1 % for proving test and 8% for acceptance test shall be performed as per code requirement.)

14. As built drawings endorsed by PE (Construction) shall be submitted after completion of retaining wall and piling works.

15. Any changes on the basement depth or number of basements is not permitted after recommendation of Deep Excavation Design.

Appendices for Geotechnical Design

1	Overall Stability	To check the sufficient embedment depth to prevent overturning of the wall and overall slope stability
2	Basal Failure	To check the wall penetration depth to prevent basal failure in front of the wall after excavation to formation level
3	Hydraulic Failure	To check the penetration of the wall to avoid piping or 'blow out' in front of the wall after excavation to formation level.
1	Overall Stability	To check the sufficient embedment depth to prevent overturning of the wall and overall slope stability
Note: The design check methods or formula shall match with application of predetermined design concept.		

Table (2A) Allowable Wall Deflection Limits

No.	Distance	Zone	Allowable maximum wall deflection limits, δ_w /H
1	H>d	Zone 1	< 0.5 % H
2	2H>d>H	Zone 2	< 0.7 % H
3	D> 2H	Zone 3	0.7 % H for ground type A 1.0 % H for ground type B

Where, δ_w = maximum wall deflection
H = Excavation depth,
d = distance between existing structure and the edge of the excavation
Ground Type A = over-consolidated stiff clays and silts, residual soils, and medium to dense sands
Ground Type B = soft clays, silts or organic soils.
Allowable displacement: Near existing building with allowable displacement shall be < 0.5 H%

Table (2B) Control of Wall Deflection during Construction

	Allowable Limit	
Check level	Alert level	Work suspension level
50% of WSL	70% of WSL	Allowable wall deflection limit
Note: Work Suspension Level is equivalent to the maximum analysis results.		

Table (2C) Control of Angular Distortion during Construction

	Allowable Limit	
Check level	Alert level	Work suspension level
1/1000	1/750	1/500

Control of Vertical Settlement during Construction

- 1. For nonstructural building, the allowable vertical settlement shall be considered by the recognized criteria.
- 2. Based on the types of foundation of adjacent buildings, the allowable differential settlement shall be estimated by the recognized criteria.
- 3. The safety factor shall be considered for sensitive building.

Thank you for your kind attention

