Mw 7.7 Super-shear Mandalay Earthquake Forum

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

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Date- 5.4.2026

Time- (10;15 – 10:30)

Venue- Central Training Center, Ministry of Construction

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.

2.1 Soil Investigation Report must be submitted to the Committee

- Site location plan
- Boring program (including bore hole location plan, equipment used, sampling, storage and transportation methods, standards used, environmental conditions)
- Description of Field Tests: Standard Penetration Test
- Description of Laboratory Tests: (**with registered design professionals)**
- Recommendations
- Appendices :Field data, Test results, Other data, Diagrams, Sources of literature, etc

- 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.
- To determine the site class value, it is necessary to consider not only the **shear wave velocity but also the SPT value.**

2.2 Number of Boreholes and Depth of Boring, Borehole Locations

Number of Boreholes

Minimum of 2 borings for every project.

One boring for every 2500 sq-ft (or 250 sq-m) for built-over area ≤ 10,000 sq-ft (or 1,000 sqm).

- 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).
- **For irregular soil and terrain conditions**, no of additional boreholes will be decided through consultation between structural engineer and geotechnical consultant.

Depth of Boring

For shallow foundations, minimum depth of boring shall be larger value of 1.5 times lesser dimension of the shallow foundation or 30ft (10m).

For deep foundations, minimum depth of boring shall be follows: $\llbracket 20S^{0.7}$" (ft) or $6S^{0.7}$ m) where S = number of storey including basements.

- 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.
- 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.

2.3 Minimum requirements of Soil Investigation Report for Deep Excavation Case

- Field Test, Laboratory Test, Remarks

Field Test

- 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.
- Standpipe or piezometers should be installed to determine and confirm the ground water conditions at site.

- 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.
- 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.

Remark

Borehole sample shall be taken 1.8m interval for up to 10m borehole depth and 3m interval from 10m to end of boring.

Laboratory Test

- Particles size distribution test, Atterberg limits
- Moisture content, unit weight, specific gravity shall be tested.
- Direct shear test or Triaxial Test shall be done according to soil nature to determine shear strength.
- 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.
- Unconfined Compression Strength Test (UCS) and Consolidation Test shall be done for **cohesive soil**.

2.5 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.

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

- 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**).
- **2.5.2 Requirements for Ultimate Pile Load Test**
- **2.5.3 Requirements for Working Pile Load Test**

2.6 Calculations of Bearing Capacity and Pile Capacity or Pile Group Capacity

2.6.1 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.

2.6.2 Pile Capacity or Pile Group Capacity Calculation for Pile Foundation Design

2.6.2.1 Pile Structural Capacity

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

2.6.2.2 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.

2.7 Minimum Reinforcement for Bored Pile

2.7.1 (a) For Category C

2.7.2 (b) For Category D, E, F

2.8 Liquefaction Analysis (MNBC)

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

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.
- 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.

- 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 $\mathbf{10}\ \boldsymbol{kN/m^2}$. **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.
		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