"EXPANSIVE SOILS CONDITIONS FOR HEAVY EARTHQUAKE AREA IN MYANMAR"

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Definition of Soil

Soil is the unconsolidated mineral and organic material on the Earth's surface, acting as a natural medium for plant growth. It's essentially the top layer of the Earth, formed through the weathering of rocks and the decomposition of organic matter, and is crucial for supporting terrestrial ecosystem.

- For Engineering purposes, soil is defined as an uncemented aggregate of mineral grains and decayed organic matter soil particles with liquid and gas in the empty spaces between the solid particles. Soil is used as a construction material in various Civil Engineering projects, and it supports structural foundations. Thus, Civil Engineers and Geotechnical Engineers must study the properties of soil, such as its origin, grain-size distribution, ability to drain water, compressibility, shear strength, the load-bearing capacity.
- Soil Mechanic is the branch of science that deals with the study to the physical properties of soil and the behavior of soil masses subjected to various types of forces.
- Soil Engineering is the application of the principles of soil mechanics to practical problems. Soils are of interest to many professionals. Soil chemists are interested in the chemical properties of soil. Geologists are interested in the origin and history of soil strata formation. Geotechnical Engineers are interested in the strength characteristics of soil.

Soil Type

- *Plastic soils (or Cohesive soils)*
  CLAY, Silty CLAY, Clayey SILT

- *Non Plastic soils*
  Silty SAND, SAND, Gravelly SAND, Sandy GRAVEL

- *Consistency of plastic soils*
  Very soft, Soft, Medium Stiff, Stiff, Very Stiff, Hard, Very Hard

- *Compactness of Non plastic soils*
  Very Loose, Loose, Medium Dense, Dense , Very Dense

Example: Medium Stiff Yellowish Brown Clayey SILT some Sand trace Gravel

Medium Dense Grey Silty SAND some Clay trace Gravel

❖***Expansive soil, other soil in Heavy Earthquake Area***

In Myanmar , we had to encounter many Residual soils (e.g : Laterite, Lateritic soils, Red tropical soils and Black cotton soils) and various types of transported soils (e.g : Alluvial soils, Aeolain deposits, Sand dunes, loess). Black cotton soils is the one of the foundation problem soil in Myanmar . In Middle Parts of Myanmar (including Mandalay Region), that Black cotton soils are finding most parts of area.

Black cotton soil also known as black soil in a mostly clayey soil, characterized by its

Expansive soils are those that significantly change volume in response to moisture content fluctuation , swelling when wet and shrinkage when dry.

The volume change can cause damage to structure built on or with those soil.

Expansive soils are composed mainly by kaolinite, montmorillonite and illite to group mineral.

❖ Swelling

Swelling an abnormal enlargement of a part of the body , typically as a result of an accumulation of fluid.

Becoming greater in intensity, number , amount or volume.

❖ Shrink

Become or make smaller in size or amount.

❖Kyatti Soil in Mandalay Region

Kyatti soil is one of the swelling soil and low to medium degree of expansive soil. At that soil clay percent is less than black cotton soil and fine sand percent is greater than black cotton soil.

The colors of that soil are mostly greyish yellow, greyish & brownish yellow and yellowish brown.

❖ Shrinkage

Shrinkage in a ground sense refers to a decrease in size amount or value. Fine-grained , clay-rich soils can absorb larger quantities at water after rainfall, becoming sticky and heavy. Conversely, they can also become very hard when dry, resulting in shrinking and cracking at the ground. The hardening end softening is known as ‘Shrink-swell behavior.

❖ Shrinkable for soft soil

Shrinkable in the context of soft soil refers to the tendency of certain soils, particularly those high in clay, to content and expand in volume due to changes in moisture content. This phenomenon, known as shrink-swell, can lead to significant issues with foundations and infrastructure built on such soils.

Soft soils, particularly those rich in clay, are known for their ability to shrink and swell in response to changes in moisture content. This shrink-swell behavior can cause significant issues for construction, particularly with foundations.

Soft rocks, in a geological context, are rocks with poor mechanical characteristics, meaning they are weaker and more easily eroded than hard rocks. They are generally sedimentary rocks, often composed of fine-grained materials like clay and shale, and can include materials like mudrocks and chalk. Essentially, soft rocks are those that are less resistant to weathering and erosion.


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Expansive Soil Area in Myanmar

Magwe Region

Ma Gwe, Min Bu, Aung Lan, Tha Yat, Pwint Phyu, Salingyi

Ayeyawady Region

Hin Tha Da, Nyaung Done, Za Lun

Sagaing Region

Sa Gaing, Mon Ywa, Shwe Bo, Ayadaw, Kalay, Kalaywa

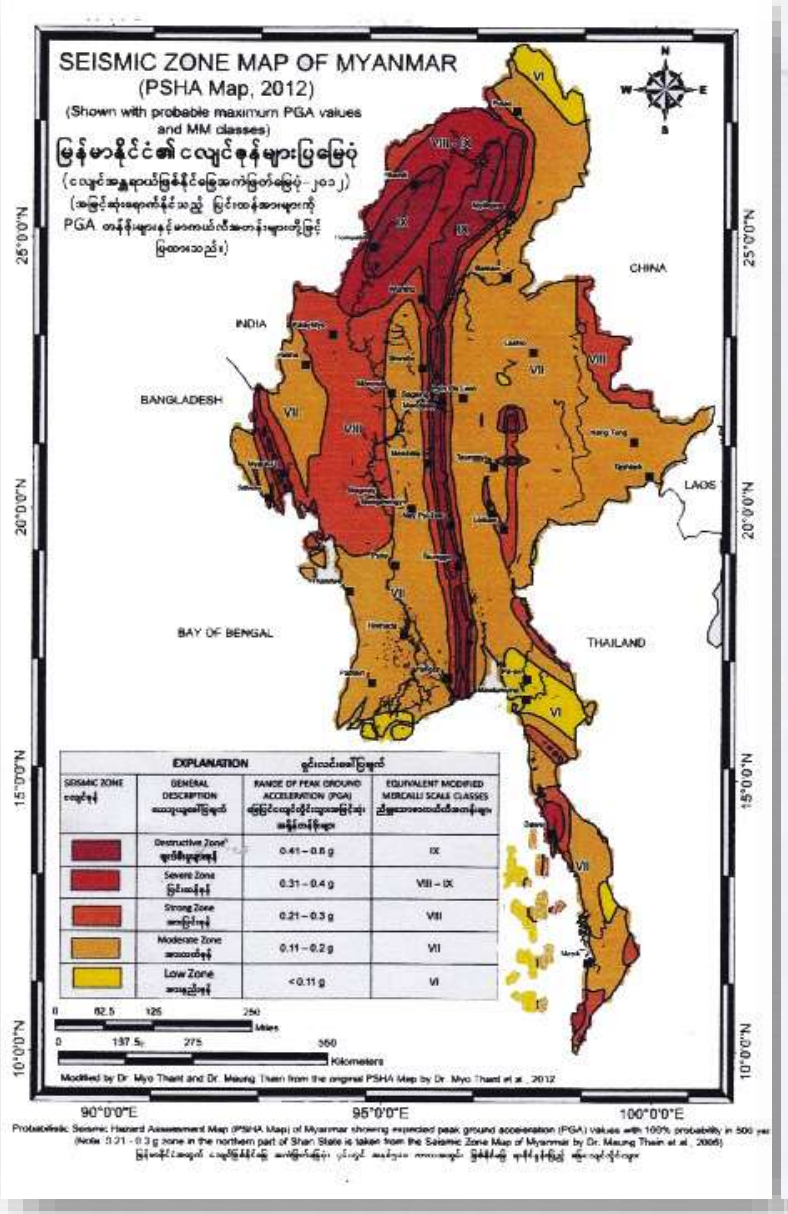
Mandalay Region

Mandalay, Amarapura

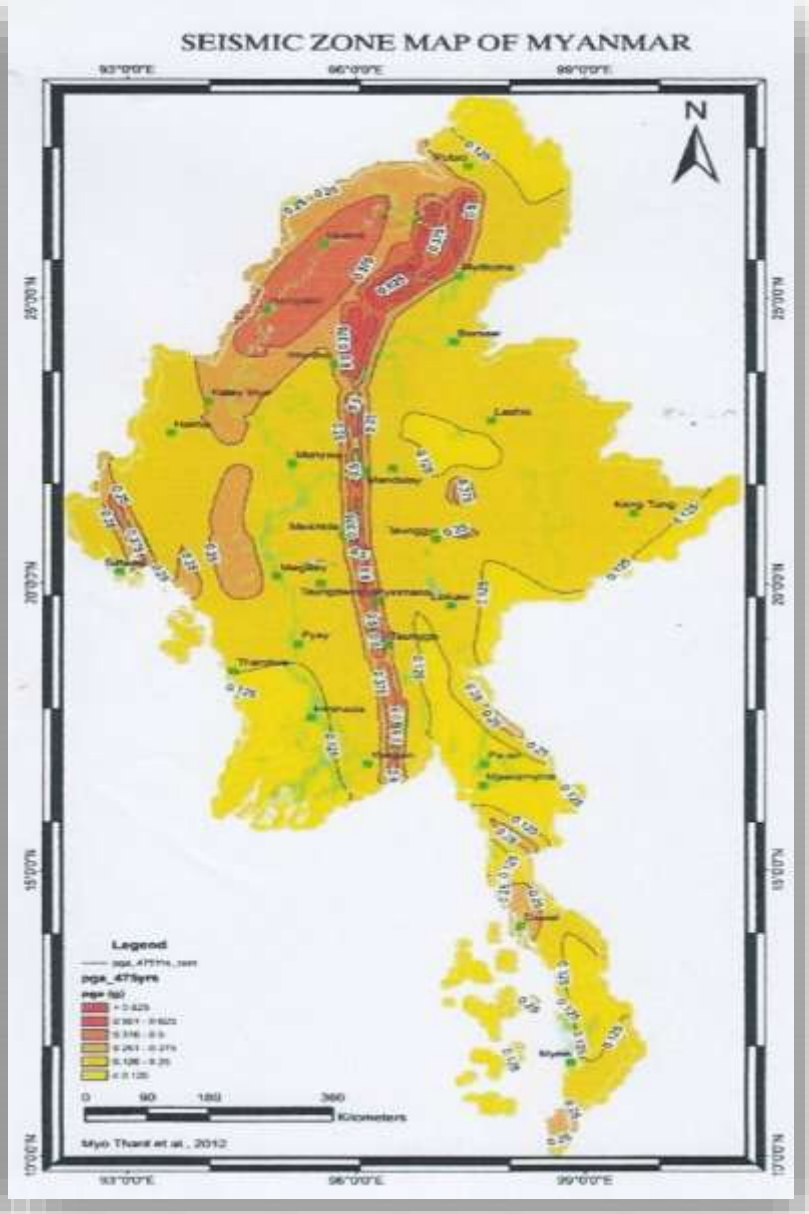
Bago Region

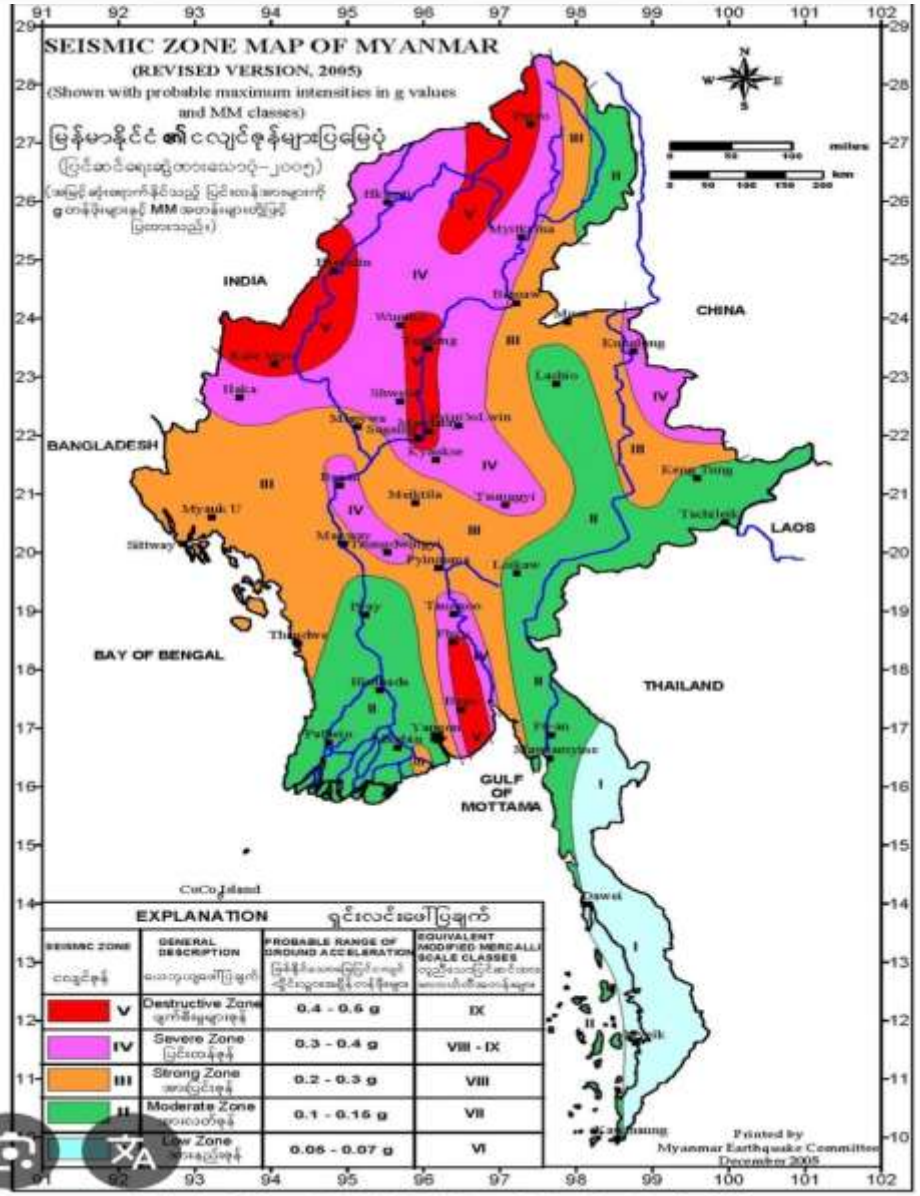
Bago, Pyay, Sintae

Black Cotton Soil Area

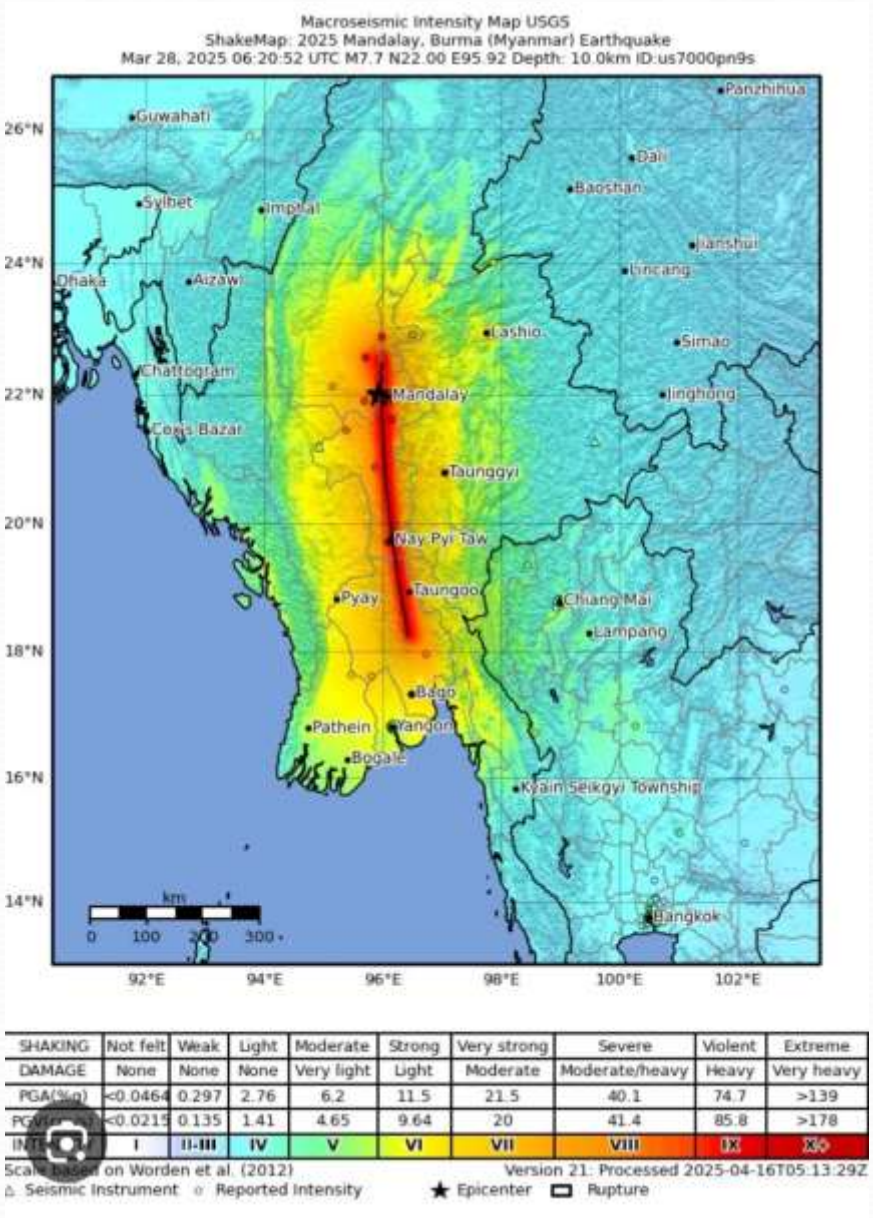


Probabilistic Seismic Hazard Assessment Map (PSHA Map) of Myanmar showing expected peak ground acceleration (PGA) values with 100% probability in 500 ye
(Note: 0.21 - 0.3 g zone in the northern part of Shan State is taken from the Seismic Zone Map of Myanmar by Dr. Maung Thein et al., 2005)





Revised by Dr. Maung Thein, U Tint Lwin Swe and Dr. Sone Han (December 2005)

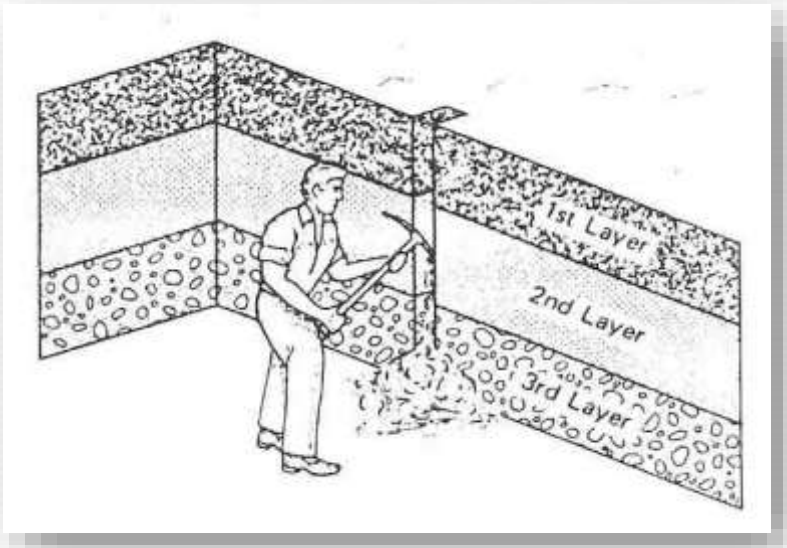


SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.0464	0.297	2.76	6.2	11.5	21.5	40.1	74.7	>139
PGV(cm/s)	<0.0215	0.135	1.41	4.65	9.64	20	41.4	85.8	>178
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Worden et al. (2012)
Version 21: Processed 2025-04-16T05:13:29Z
△ Seismic Instrument ○ Reported Intensity ★ Epicenter ▭ Rupture

❖ Trial Pits

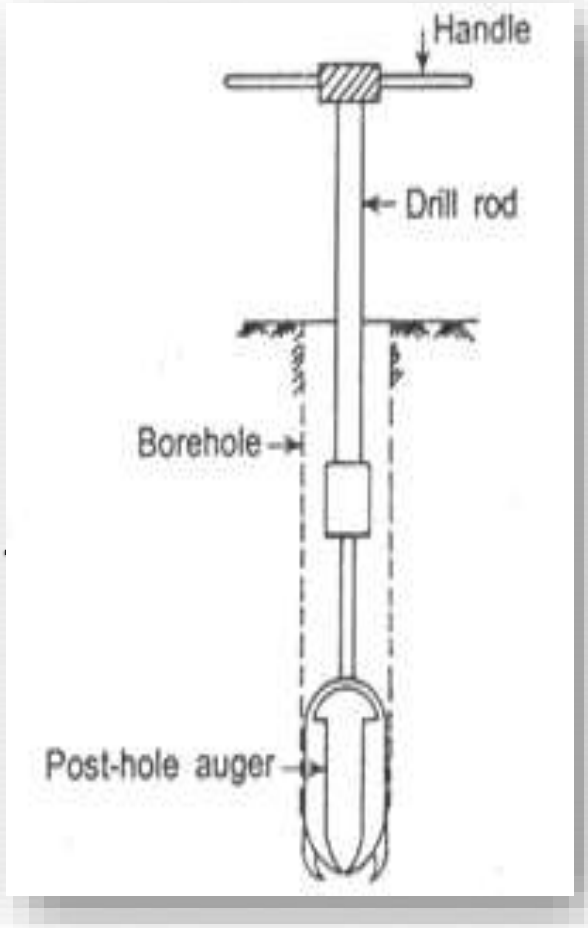
Excavation of trial pit (and trenches) is a simple and reliable method of exploration but it is limited to shallow depths, say about 3 meter. Pits and trenches have a great advantage over borings, in that state can be visually examined, large samples can be easily collected, and tests may be made insitu. Excavation is usually carried out manually. This method may apply good soils and expansive soils area of Myanmar to construct up to 2 storey building and warehouse.


1st Layer
2nd Layer
3rd Layer

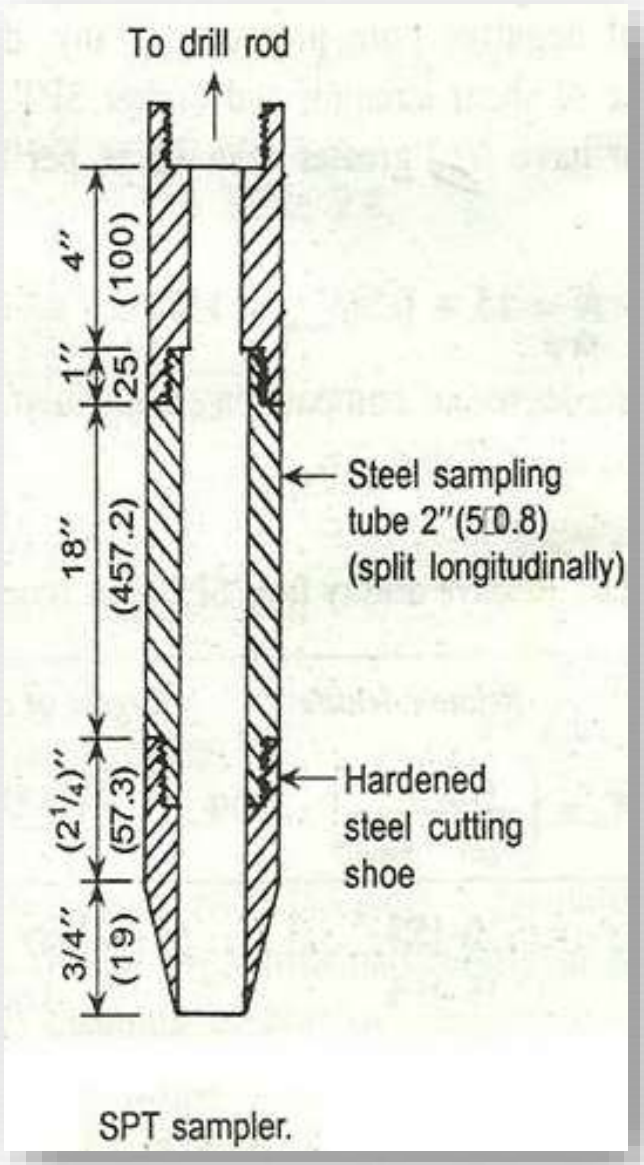

Test Pit-2R

❖ Hand and Power augers

In Myanmar, we mostly used various types of Hand Auger methods to construct up to 6 Storey buildings, factories and warehouse. Hand augers can be used to excavate boreholes to depths of around 10 meter in favorable types of which have sufficient cohesion to stand unsupported in an unlined borehole and are free from coarse gravel and other obstructions. The auger is rotated and pressed down into the soil by mean of a T handle on the upper rod. Undisturbed samples will be obtained by using cuts iron tube of 2.0 inch in inner diameter and 1 foot in length. Disturbed samples will be collected by using well prepared plastic bags.



Hand Augers Method



SPT sampler.

Figure of S.P.T Sampler

❖ Wash boring and Core boring

This Method is mostly applied to construct above 4 storey buildings, Bridges and High-rise Buildings (more than 9 storey) in Myanmar. This method can apply to get soil samples and rock samples up to 200 feet depth. It may depend of power of engine. Undisturbed samples can be collected by using standard Shelby tube sampler and disturbed samples may be obtained from standard split spoon sampler. By using 140lb hammer and 30 inch drop on split spoon sampler, we can obtain Standard Penetration Test (N) values. Higher S.P.T values can have higher bearing capacities of soils. S.P.T values are depending types of an Hammer, length of drill rocks, diameter of casing and other factors.

For that reason S.P.T values should be corrected by using proper formula. To take rock samples, rotary drilling method must be applied. Sizes of core samples may be depend on coring bit. Nx size is biggest size and A size is smallest size. According to the conditions of core samples we can calculate R.Q.D values of cores (Rock Quality Designation). Detailed sampling procedures are mostly based on A.S.T.M designation D.1586 method or other standard.

Site Investigation

Site Investigation

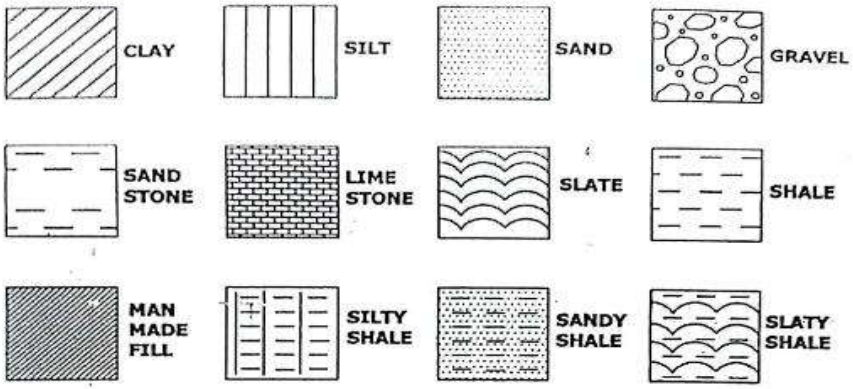
Consistency for Plastic Soils	Range of Unconfined Compression Test Results
Very Soft	>500 p.s.f (25 kPa)
Soft	500-1000 p.s.f (25 to 50 kPa)
Medium Stiff	1000-2000 p.s.f (50 to 100 kPa)
Stiff	2000-4000 p.s.f (100 to 200 kPa)
Very Stiff	4000-6000 p.s.f (200 to 300 kPa)
Hard	>6000 p.s.f (>300 kPa)

COMPACTNESS OF NON-PLASTIC SOIL	S.P.T VALUES (Uncorrected) BLOWS/Foot
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	>50

Classification system	Grain size (mm)
USCS	Gravel : 75 mm to 4.75 mm Sand: 4.75 mm to 0.075 mm Silt and clay (fines): <0.075 mm
AASHTO	Gravel : 75 mm to 2 mm Sand : 2 mm to 0.05 mm Silt: 0.05 mm to 0.002 mm Clay:<0.002 mm
BS	Gravel: 60 mm to 6 mm Sand: 2 mm to 0.2 mm Silt: 0.06 mm to 0.002 mm Clay: <0.002 mm

Sheet No.(1) LEGEND OF SYMBOLS AND TERMINOLOGY

LEGEND OF SYMBOLS TO INDICATED MATERIAL IN PROFILE OF BOREHOLE



TERMINOLOGY USED TO DENOTE THE PERCENTAGE BY WEIGHT OF EACH COMPONENT

DESCRIPTIVE TERM	RANGE OF PROPORTION
TRACE e.g trace Sand, trace Clay	1 - 9 %
SOME e.g some Silt, some Clay	10 - 19 %
ADJECTIVE e.g Sandy, Silty	20 - 34 %
AND (MAJOR SOIL) e.g SAND, CLAY, SILT	≥ 35 %

TERMINOLOGY USED TO INDICATE THE CONSISTENCY OF THE UNDISTURBED MATERIALS

DESCRIPTIVE TERM	RANGE OF UNCONFINED COMPRESSIVE STRENGTH	
	(KN/Sq.meter)	(Ton/Sq.ft)
VERY SOFT	< 25	< 0.25
SOFT	25 - 50	0.25 - 0.5
FIRM or MEDIUM STIFF	50 - 100	0.5 - 1.0
STIFF	100 - 200	1.0 - 2.0
VERY STIFF	200 - 400	2.0 - 4.0
HARD	> 400	> 4.0

HLAING

U.N.O GROUP

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BORE HOLE RECORD SHEET

JOB & LOCATION: Proposed (42-34) Storeyed Diamond Inya View Palace Project Site, No.2, U Hlaa Nyein Road, No.10 Ward, Mayangone Township, Yangon.

Type of Drill Machine: KANO Myanmar (M-4)

Date of Drilling (Started Date): 10.7.2011 (2:30 PM) **(Finished Date):** 14.7.2011 (11:00 AM)

Bore Hole No: BH - 12

Name of Driller: U Aung Tun Kha **(Name of Recorder):** U Zaw Zaw Moe

Weather Condition: Fine

First Struck Ground Water Level depths and its Conditions: First Struck Ground Water at 15 feet. RL = -1.0 ft (Starting point is assumed to be zero.)

No.	Sampler type	Depths	S.P.T Values (N)				Visual Classification of Soils	Remarks
1.	SPLIT	0 - 5'		4	6	6	Yellowish & Greyish Brown Clayey &	Dry
							Sandy SILT trace Lat: Gravel.	
2.	SPLIT	5 - 10'		5	6	7	Greyish & Reddish Brown Sandy &	"
							Clayey SILT trace Lat: Gravel.	
3.	SHELBY	10 - 15'	7	8	12	13	Yellowish & Greyish Brown Silty SAND	"
	SPLIT			6	8	10	some Clay.	
4.	SHELBY	15 - 20'	8	10	13	15	Brownish & Greyish Yellow Silty SAND	"
	SPLIT			7	9	12	some Clay.	
5.	SPLIT	20 - 25'		12	15	15	Yellowish & Greyish Brown SAND &	Washing
							SILT some Clay.	
6.	"	25 - 30'		13	15	17	Grey SAND & SILT some Clay (Soil	"
							like Sandy SHALE to Silty SHALE).	
7.	"	30 - 35'		13	16	17	- do -	"
8.	"	35' - 40'		14	17	25	Light Grey SILT & SAND some Clay	
							(Soil like Silty SHALE to Sandy SHALE)	
9.	"	40' - 45'		20	25	-	Grey SAND & SILT some Clay (Soil	
							like Sandy SHALE to Silty SHALE)	
10.	CORING	45' - 50'	-	-	-	-	Light Grey Sandy SHALE to Silty	
							SHALE (R.Q.D - Nil)	
11.	"	50' - 55'	-	-	-	-	- do -	
							(R.Q.D - Nil)	

Remarks: All shale samples do not get R.Q.D value, Soil shale layers occurs to some depth. All shale samples are neither hard nor soft.

DRILLER SIGNATURE: Thukha (ေသးခ်ဳပ္ခ)

RECORDER SIGNATURE: Zaw Zaw Moe

❖*Atterberg limits*

Atterberg limits are critical water content boundaries that define the different state of consistency of fine-grained soils, including soil, semi-solid , plastic and liquid. These limits, specifically the limit (LL) , plastic limit (PL), and shrinkage limit (SL) are used to classify soils and predict their behavior in engineering applications.

❖*Liquid Limit (LL)*

The moisture content at which a soil transitions from a liquid state to plastic state, no longer following like a liquid.

❖*Plastic Limit (PL)*

The moisture content at which a soil can no longer be remolded without cracking.

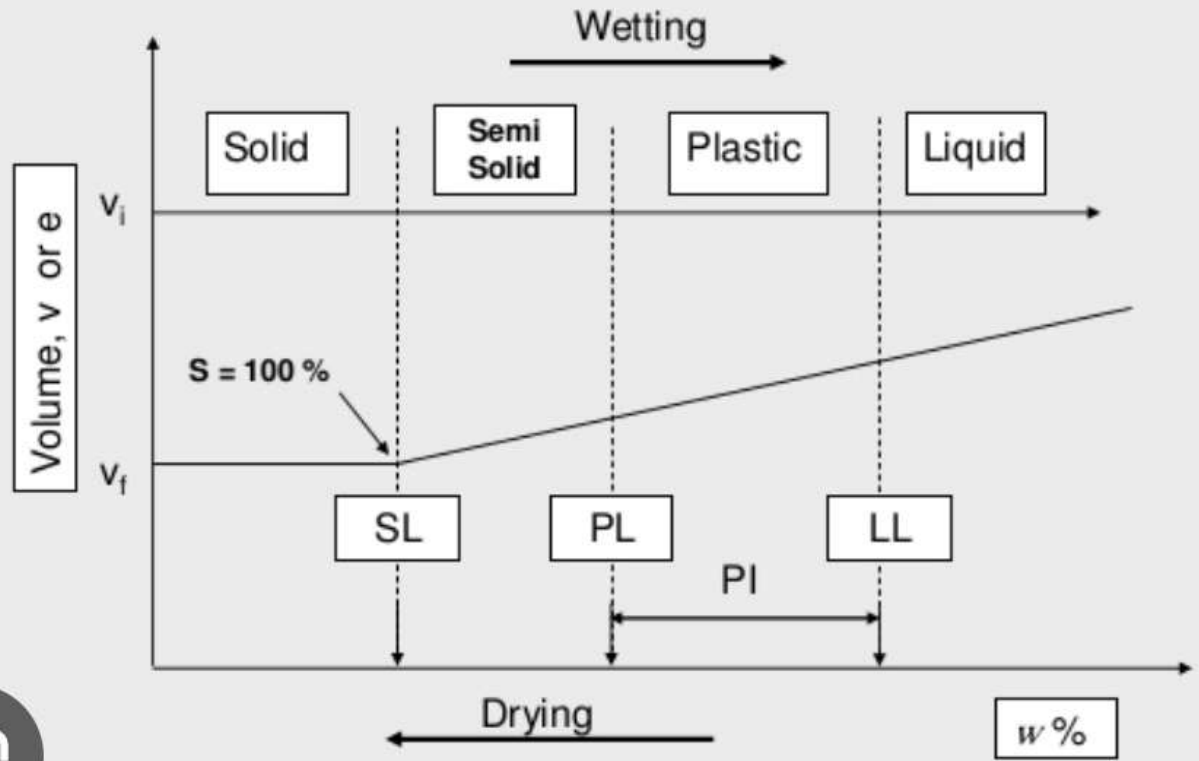
❖ *Shrinkage Limit (SL)*

The moisture content below which a soil will no longer shrink in volume upon drying.

❖ *Plasticity Index(PI)*

The difference between the liquid limit and the plastic limit (PI=LL-PL) , indicating the range of moisture content over which a soil behaves plastically.

Atterberg Limits (cont.)



❖Granular soils

Granular soils are clayey soils formed from material derived by strong weathering of volcanic rocks or ash. Dry or moist soil samples may be easily parted into small hard fragments. When wetted and rubbed between the fingers the clay becomes sticky and may be easily remolded with little cracking.

❖Laterite soil

Laterite soil is a type of highly weathered soil, rich in iron and aluminum oxides, typically found in tropical and subtropical regions. It's characterized by a reddish brown color and a hardened, sometime blocky texture.

❖Transported soil

Soil transport refers to the movement of soil particles from one location to another . This occur naturally through various forces like wind, water , and gravity, or it can be included by human activities like construction or farming.

❖Wind:

Aeolian soil, also known as wind-blown soil, is a type of soil that is transported by wind. Wind can move soil particles across long distances, creating deposits like sand dunes and loess.

❖Water :

Alluvial soil is a type of soil transported by water. Water erosion can carry soil particles and sediments, which are than deposited in new locations, often forming river deltas and floodplains.

❖Gravity:

Soil can also be transported by gravity, particularly on slope. This can lead to erosion and mass movements like landslide.

❖Human Activities:

Excavation and Construction:

Activities like construction and mining involve the movement of large quantities of soil, often transported by trucks or other machinery.

❖Alluvial soil

Alluvial soil is soil deposited by the movement of surface water , typically rivers and streams. It’s often found in riverbeds, floodplains and deltas and is known for being nutrient-rich and fertile. Alluvial deposit can be composed of various materials like clay, silt, sand and gravel.

❖Residual soil

Residual soil refers to soil formed in place through the weathering of parent rock materials. This process, primarity chemical weathering, occurs in situ, meaning the soil remain at the location of its formation. Residual soils are not transported from one location to another.

❖Bearing Capacity

Bearing Capacity refers to the ability of soil to support loads without failing in shear. It’s the maximum pressure as a soil can withstand before it starts to fail or settle excessively. This capacity depends on various factors like soil type, density, shear strength, and depth of the foundation.

❖Soil Bearing Capacity

Ultimate bearing capacity: The minimum pressure that would cause the shear failure of the supporting soil immediately below and adjacent to the foundation.

❖Soil Bearing Capacity: Terzaghi and Meyerhof

The ultimate bearing capacity refers to the maximum pressure that the soil can sustain before failure, where the applied loads exceed the soil's supporting.

❖Soil settlement

Soil settlement refers to the downward movement of the soil due to change in stress, often caused by loads applied to the ground. This process can lead to various types of settlement, including uniform, differential, and curvature settlements. The amount of settlement depends on factors like soil type, moisture content and the applied load.

The settlement of soils in response to loading can be broadly divided into two types: ***elastic and time dependent settlement.*** Elastic settlements are the simplest to deal with; they are instantaneous, recoverable, and can be calculated from linear elastic theory.

❖Which soil is best for settlement

The findings conclude that ***sandy soils***, with their higher strength and lower compressibility, are more suitable for supporting foundation loads compared to….

❖ Soil Stabilization

Soil stabilization refers to any method used to improve the physical, chemical, or biological properties of soil to enhance its stability and strength for engineering purposes. This can involve adding stabilizing agents like lime or cement, using mechanical methods like geogrids or even employing biological techniques like panting to stabilize the soil.

Method of Soil Stabilization

- **Chemical Stabilization:**

This involves adding chemicals like lime or cement to bind soil particles together, increasing strength and durability.

- **Mechanical Stabilization:**

This uses materials like geogrids or aggregates to reinforce the soil structure and distribute loads, particularly in road construction.

Benefits of Soil Stabilization

- **Increased Strength and BearingCapacity:** Stabilized soil can support heavier loads and resist deformation.
- **Reduced Erosion:** Stabilization helps prevent soil from being washed away by water or wind.
- **Improved Drainage:** Some stabilization methods can enhance soil's ability to drain water.
- **Dust Control:** Stabilization can help reduce dust, especially in areas with dry or windy conditions.

THANK YOU

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Consultant Geotechnical Engineering Group