Module 1: Intro to site investigation

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COURSE CONTENTS AND SCHEDULE

Civil and Environmental Engineering

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Tentative schedule

Day	Date	Topic	Lab.
W	1/19/2022	Class introduction, syllabus, policies	Soil
F	1/21/2022	Invited speaker: Topic TBD	components
M	1/24/2022	Introduction: The geological cycle, soil origin	Grain size
W	1/26/2022	Introduction: Site investigation	dist.
F	1/28/2022	Index properties: Phase relationships	
M	1/31/2022	Index properties: Grain size distribution, Atterberg limits	Atterberg
W	2/2/2022	Index properties: Soil classification	limits
F	2/4/2022	Compaction	
M	2/7/2022	Quiz 1: Introduction, index properties, compaction, in-situ testing	Visual
W	2/9/2022	Water in soils: Groundawater table, pore pressure, total and effective stresses	classification
F	2/11/2022	Water in soils: Darcy's law	
M	2/14/2022	Water in soils: Permeability and hydraulic conductivity	Compaction
W	2/16/2022	Water in soils: One-dimensional seepage	
F	2/18/2022	Water in soils: 2D-3D seepage, flow nets, pore pressure, uplift force, seepage force	
M	2/21/2022	President's day: no class	In-situ
W	2/23/2022	Water in soils: piping	density
F	2/24/2022	Quiz 2: Water in soils	
M	2/28/2022	Induced stress: Approximations, Bousinesq's elastic solution	Permeability
W	3/2/2022	Induced stress: Bousinesq's elastic solution, superposition	
F	3/4/2022	Induced stress: Stress tensor, elastic deformations	
M	3/7/2022	Consolidation: Oedometer test, primary and secondary consolidation	Site
W	3/9/2022	Consolidation: Preconsolidation pressure, OCR	investigation
F	3/11/2022	Consolidation: Primary consolidation parameters	
M	3/14/2022	Spring break: no class	
W	3/16/2022	Spring break: no class	
F	3/18/2022	Spring break: no class	
M	3/21/2022	Consolidation: rate of consolidation	Bonus
W	3/23/2022	Consolidation: preloading, radial consolidation	
F	3/25/2022	Quiz 3: Induced stress and consolidaiton	
M	3/28/2022	State of stress: 2D stresses and Mohr's circle	Consolidation
W	3/30/2022	State of stress: principal stresses, stress invariants, rotations	
F	4/1/2022	State of stress:: Usage of Mohr's circle	
M	4/4/2022	State of stress: stress paths, simple shear, triaxial compression	Settlement
W	4/6/2022	Quiz 4: State of stress	estimates
F	4/8/2022	Shear strength: Mohr-Coulomb failure criteria	
M	4/11/2022	Shear strength: drained and undrained behavior	Unconfined
W	4/13/2022	Shear strength: Shear strength of clays	compression
F	4/15/2022	Shear strength: Shear strength of sands	test
M	4/18/2022	Quiz 5: Shear strength	Direct
W	4/20/2022	Lateral earth pressure: at-rest, passive, and active conditions [2]	shear
F	4/22/2022	Intro to slope stability [2]	
M	4/25/2022	Intro to bearing capacity [2]	Direct
W	4/27/2022	Maine's day: no class	shear
F	4/29/2022	Classes end: Q&A session	
M	5/2/2022	Final exam (1:30 PM- 3:30 PM) Williams Hall 110	

M: Monday - W: Wednesday - F: Friday

RECAP

- We learned about the rock cycle and how soils form.
- Soils are degraded rocks.
- Residual soils are formed by chemical reactions and remain in place.
- Soils are transported in various ways forming distinct formations.
- Soils become complex and heterogeneous as a result of these processes
- Soil behavior must be mapped and characterised on site.

CONTENTS

- Objectives of the site investigation
- Geotechnical surveying techniques
- Intact and disturbed samples
- In-situ testing
- Geophysical surveying techniques

These topics are covered in more detail in CIE-460

OBJECTIVES OF THE SITE INVESTIGATION

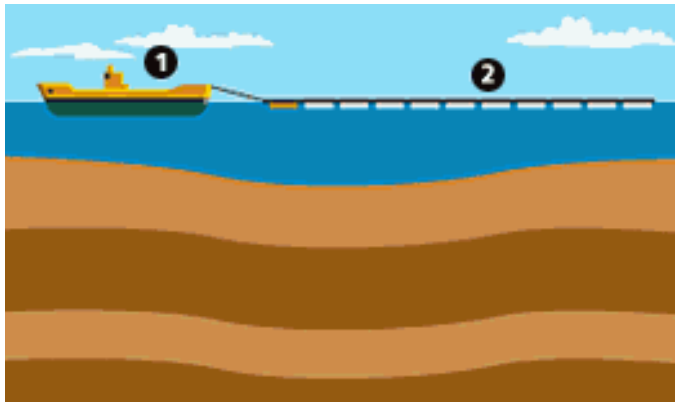
- Assess the site's suitability for the project.
- To asses the existing geohazards in the site.
- To supply the information needed for a cost-effective, resilient, and secure design.
- Identify potential issues that may arise during project development or execution.

OBJECTIVES OF THE SITE INVESTIGATION

- We want to know soil stratigraphic composition.
- We're looking for soil "units" that behave mechanically similarly.
- As part of every project, we will create a geotechnical model.
- The figure shows a cut wall showing a complex stratigraphic profile.

GEOTECHNICAL SURVEYING TECHNIQUES

- There are many techniques to explore the subsurface.
- Can involve excavating or drilling.
- Can involve the use of in-situ tests.
- Usually combined with geophysics.

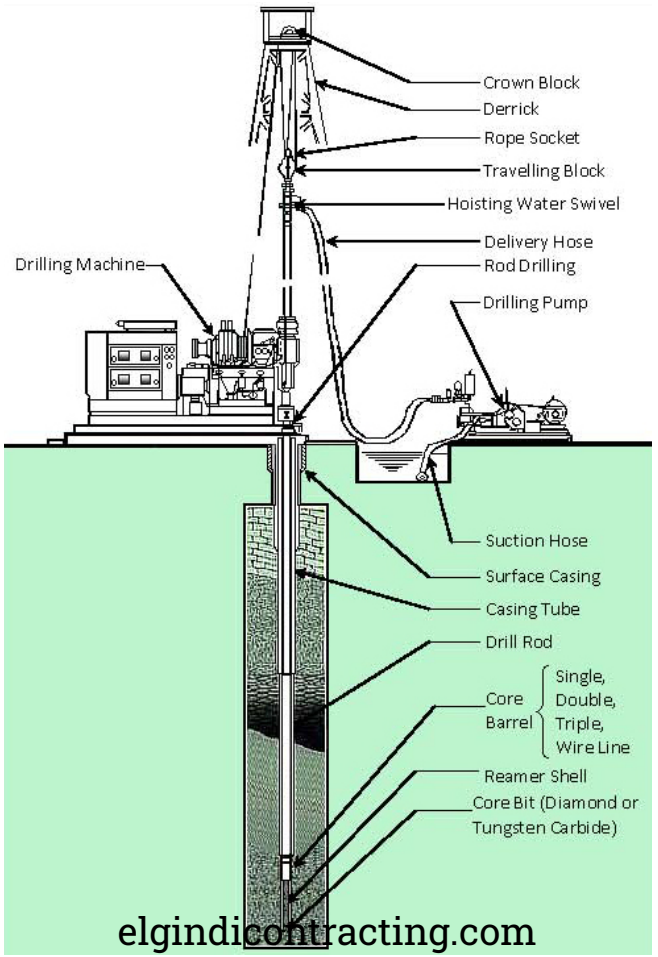


EXPLORATION TRENCHES

- Allows to determine a continuous shallow profile for small load projects (e.g., pavements).
- Hard to do in sandy soils with shallow groundwater.
- Wall samples are generally disturbed when taken.
- Intact samples are possible from blocks.

DRILLING BOREHOLES

- Information in a discrete point, but for deep exploration.
- Shelby tubes allow us to collect intact fine soil samples.
- Allows to perform some in-situ tests.
- Allows to determine the water table and bedrock elevation.
- Multiple boreholes are needed to construct a profile.



INTACT SAMPLES

- A sample that preserves the in-situ soil's properties and water content.
- Intact soil samples are used to assess mechanical parameters.
- Fine materials with cohesion allow intact sampling (e.g., rocks, clay, some silts).
- For coarse-grained soils, intact sampling is difficult and costly (e.g., sands, gravel, cobbles).

Intact box sampling in a trench.

Ayala et al. 2013

Shelby tube.

DISTURBED SAMPLES

- Disturbed samples are used to determine index properties (e.g., water content, grain size).
- Disturbed samples can't be used to obtain in-situ mechanical properties.
- They can be used to obtain "remolded" mechanical properties.

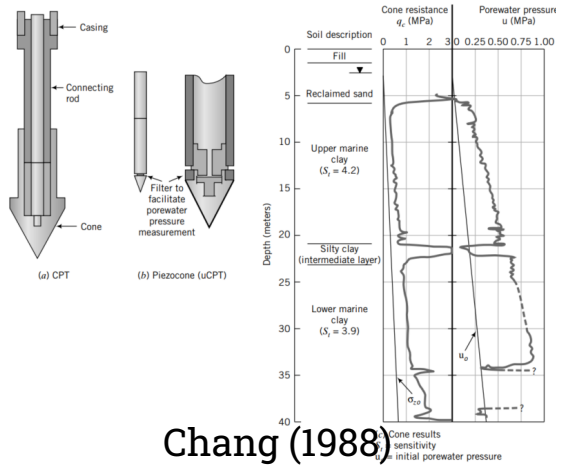
Sampling with a Van Veen sampler.

Sampling with an auger.

IN-SITU TESTING

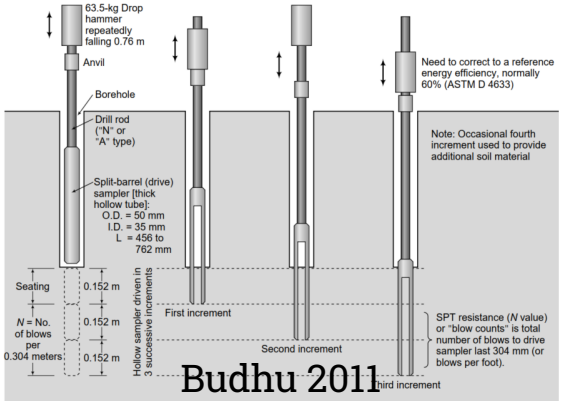
- Many in-situ tests exist. Selection based on availability, soil type, experience.
- Cone prenetration testing (CPT) is very versatile and popular. Not feaseable on gravels and cobbles.
- The Standard penetration test (SPT) is also popular. Counts the amount of blows to penetrate 1 ft.
- Others are available too. More is covered in CIE-460.

CPT



Chang (1988)

SPT

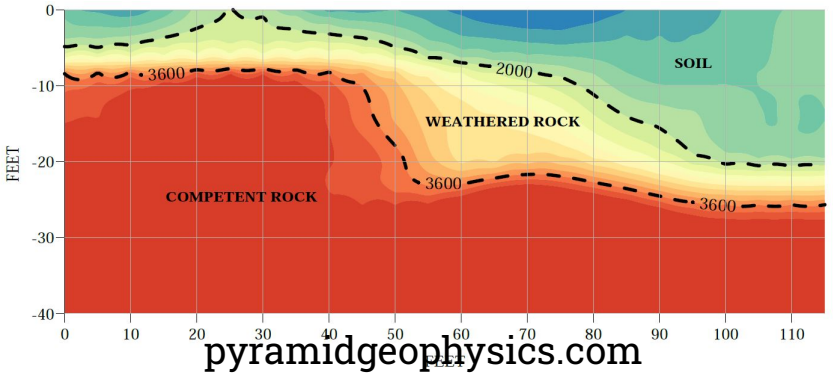


Budhu 2011

GEOPHYSICS

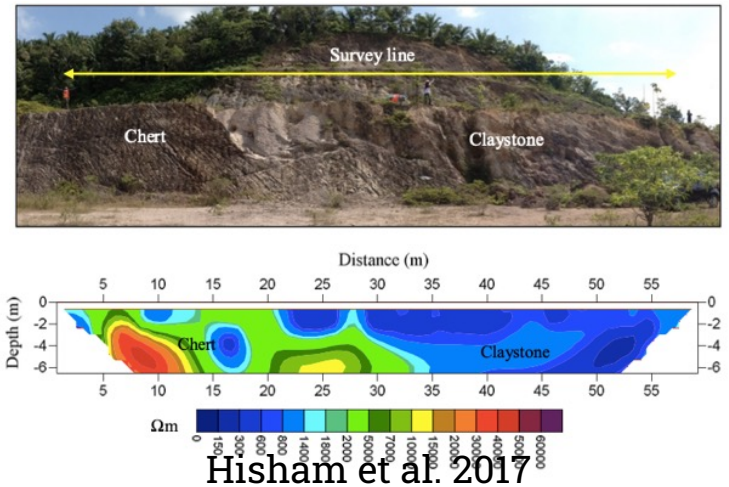
- Wave velocity, resistivity, gravity, and magnetism are used to identify geological structures.
- Important for offshore projects.
- Many techniques available. This is a field of its own.
- More frequent in geotechnical engineering are soil resistivity, seismic reflection, and shear wave velocity.

Seismic refraction profile



pyramidgeophysics.com

Electric resistivity tomography



Hisham et al. 2017

SOLVING THE PUZZLE