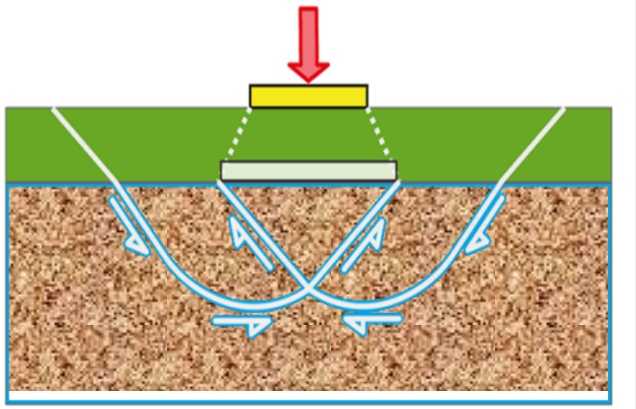
Foundation Engineering
CE 483



1. Introduction

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Contents

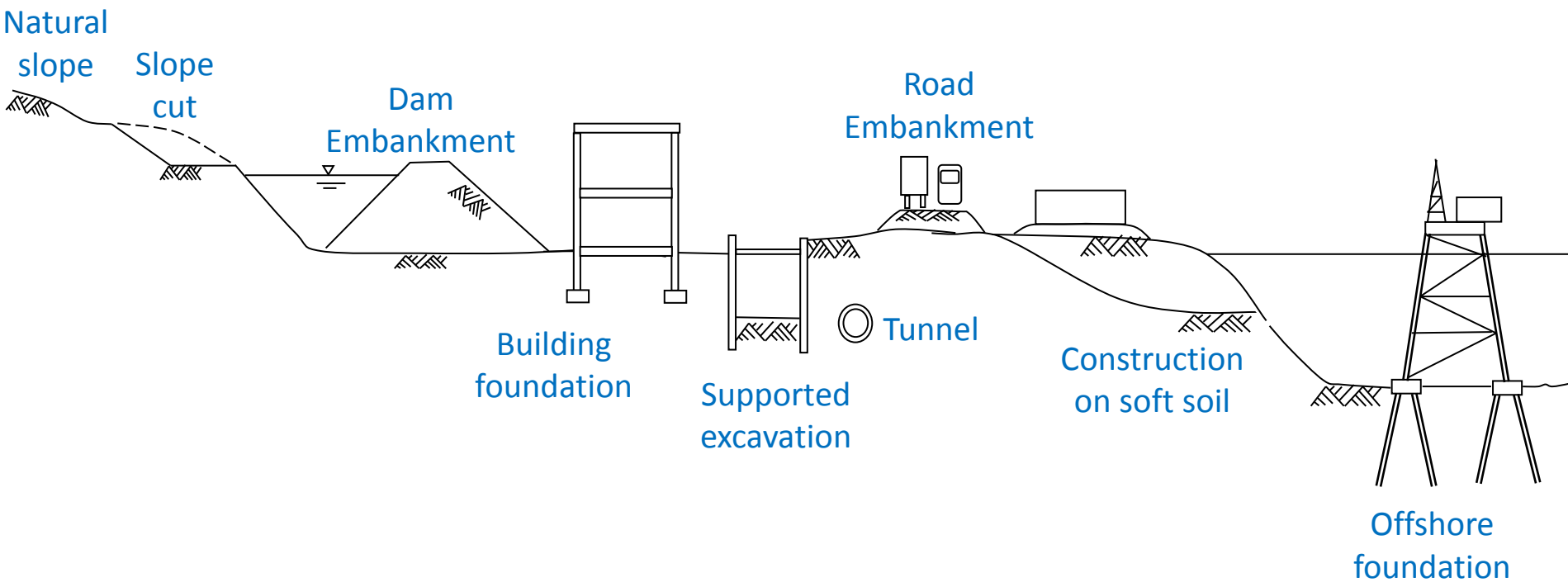
- Introduction
- Course General Information
- Prior Knowledge required for the course
- How to study the course?

Introduction

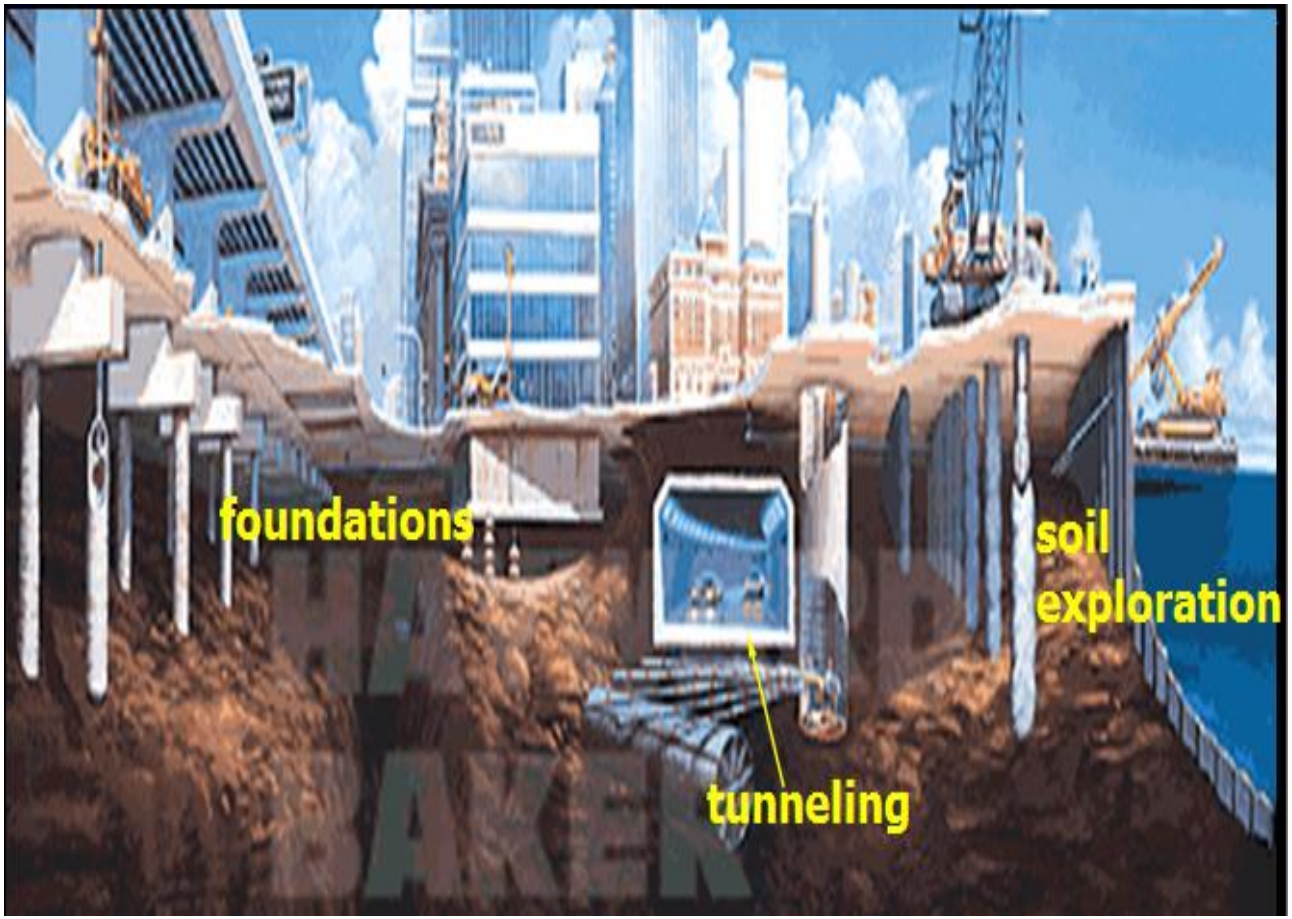
- Why Foundation Engineering?
- What is Foundation Engineering?

Why Foundation Engineering?

- All civil engineering projects (buildings, roads, bridges, dams, tunnels and water tanks ..) is constructed **on** or **in** the **ground**.
- Civil engineers are required to identify and avoid the major **risks** posed by **ground conditions**. DO YOU THINK OF ANY RISK?



Why Foundation Engineering?



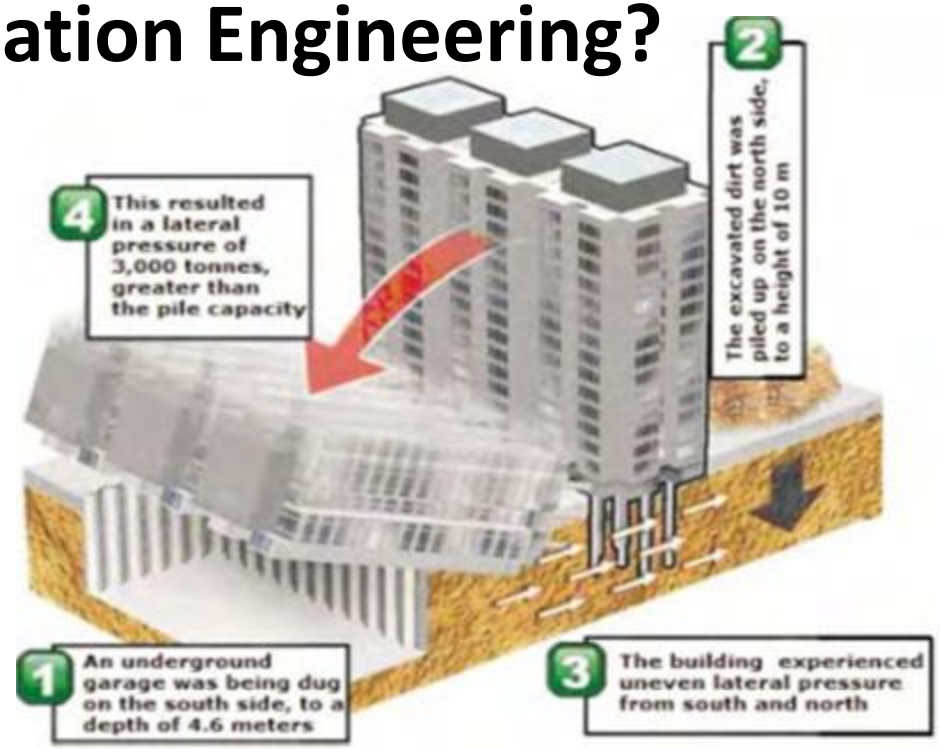
Why Foundation Engineering?

In the past several foundation-related engineering **problems**, such as the Leaning Tower of Pisa, prompted engineers to begin taking a more scientific-based approach to examining the subsurface.

Many engineering problems happened in the past because of poor understanding of the **behavior** of earth materials (soil & rock).

Why Foundation Engineering?

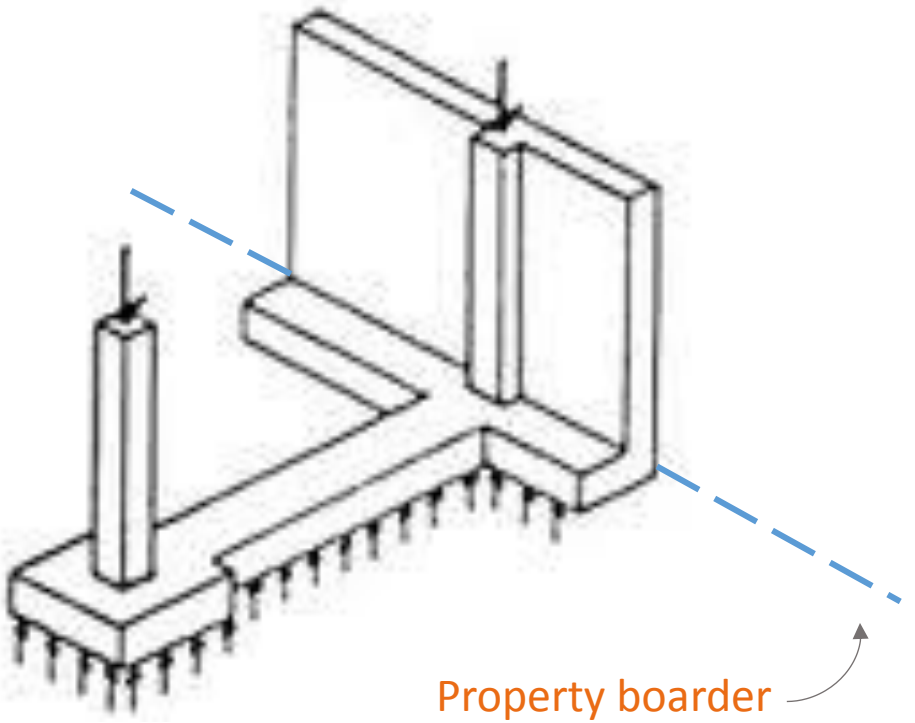
Why Foundation Engineering?



Why Foundation Engineering?

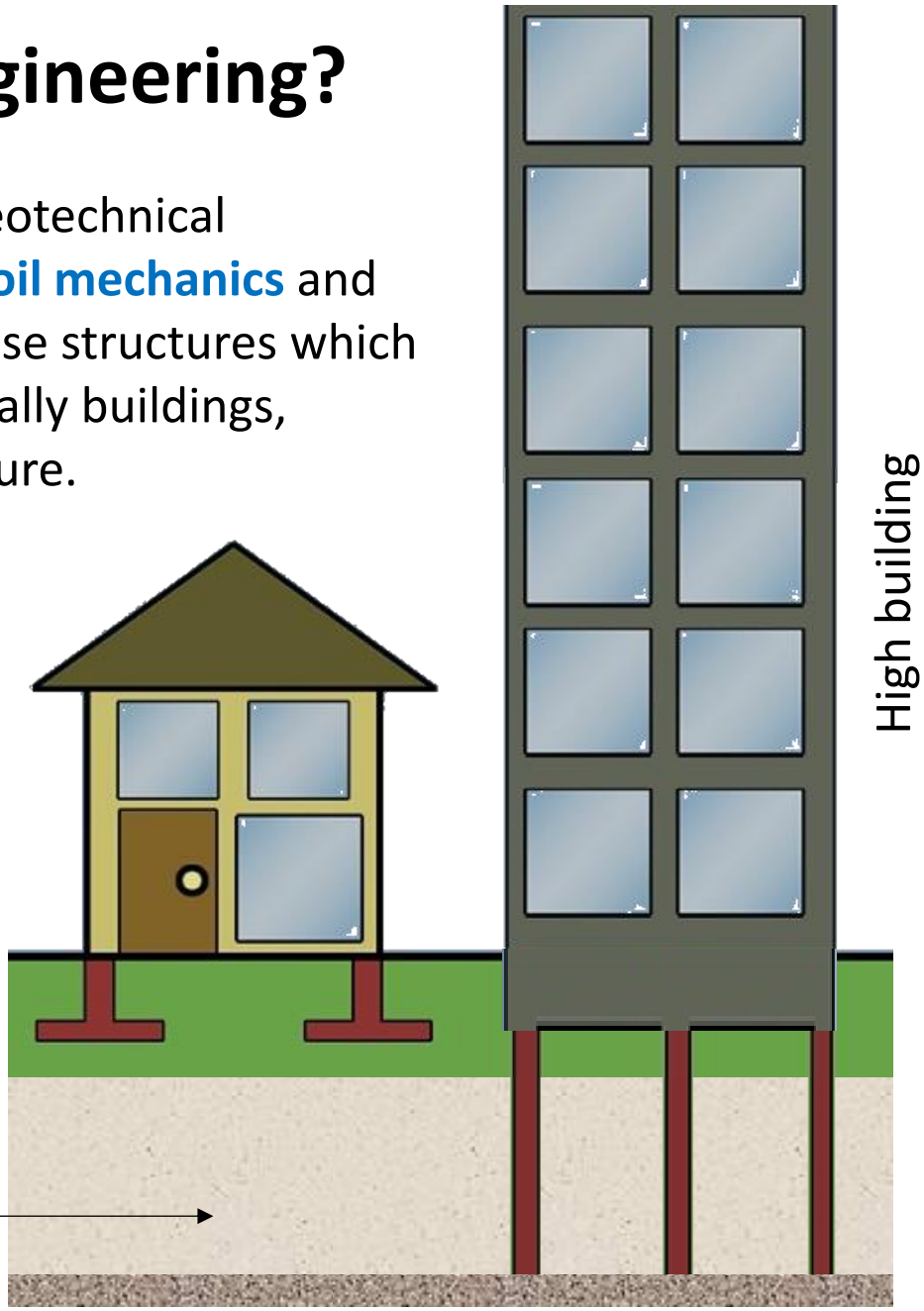
Why Foundation Engineering?

Combined footing is usually used when: one column is located at or near the



What is Foundation Engineering?

Foundation engineering is part of Geotechnical Engineering, uses the principles of **soil mechanics** and **rock mechanics** to the design of those structures which support other structures, most typically buildings, bridges or transportation infrastructure.



Why Foundation Engineering?

Avalon
Chrystie
Place
New York, NY

Course General Information

- Content of the course
- Course components
- Schedule of Assessment Tasks
- Learning Resources
- Course Delivery
- Course learning outcome assessment

Course contents

- Site Investigations
- Types of foundation and foundation materials
- Bearing capacity of shallow foundation
- Settlement of foundations
- Combined Foundation
- Mat Foundation
- Saudi Building Code for soils and foundations

Course components

Lectures — 30 hrs

- 2 hrs per week

Tutorial — 15 hrs

- 1 hr per week

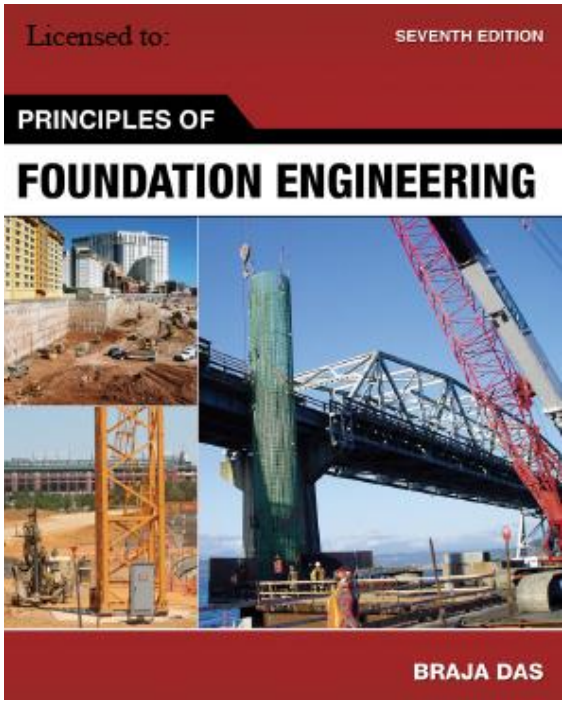
Assessment	Assessment task (eg. Essay, test, group project, examination etc.)	Week due	Proportion of Final Assessment
2	Quizzes and assignments	Bi-weekly basis	10%
3	Two Mid-term exams	The eighth and Therteenth week	40 %
4	Final Exam	As scheduled by the registrar	50 %

موعد الاختبار الفصلي الأول الاربعاء ٢٧ / ٥ /١٤٣٦ هـ الموافق ١٨/ ٣ /٢٠١٥م

موعد الاختبار الفصلي الثاني الاحد ٣٠ / ٦ /١٤٣٦ هـ الموافق ١٩/ ٤ /٢٠١٥م

الوقت: بعد صلاة المغرب ان شاء الله.

Learning Resources



Main reference test book:
Principles of Foundation Engineering,
Braja M Das, 7th ed, 2011 (or later ed)

Other useful references:

- Principle of Geotechnical Engineering , Braja M Das, 7th ed (or later ed).
- Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering, V. N. S. Murthy, 2003.
- GeotechniCAL on the web

Course Delivery

1 Coverage of Planned Program			
Topics	Planned Contact Hours	Actual Contact Hours	Reason for Variations if there is a difference of more than 25% of the hours planned
1. Introduction.	*2*		
2. Site Investigations	*4*		
3. Types of foundation and foundation materials.	*2*		
4. Bearing capacity of Spread footings	*6*		
5. Bearing capacity of Combined footings	*4*		
6. Bearing Capacity of Mat Foundation.	*4*		
7. Evaluate the settlement of the selected foundations.	*4*		
8. General overview of Saudi Building Code for soils and foundations	*4*		

Course learning outcome assessment

1. Understand the methods of site investigations and determine the site characteristics.
2. Understand the types of foundations.
3. Understand the types of loads to be applied to foundations.
4. Evaluate the bearing capacity of soils and rocks.
5. Select the proper type of foundation according to the site and structure characteristics.
6. Evaluate the settlement of the selected foundations.
7. Design of Spread footings, Combined footings, and Mat foundations
8. General overview of Saudi Building Code for soils and foundations

Prior Knowledge required for the course

CE 382 **Geotechnical Engineering-I**

CE 370 **Reinforced Concrete Design**

CE 481 **Geotechnical Engineering-II**

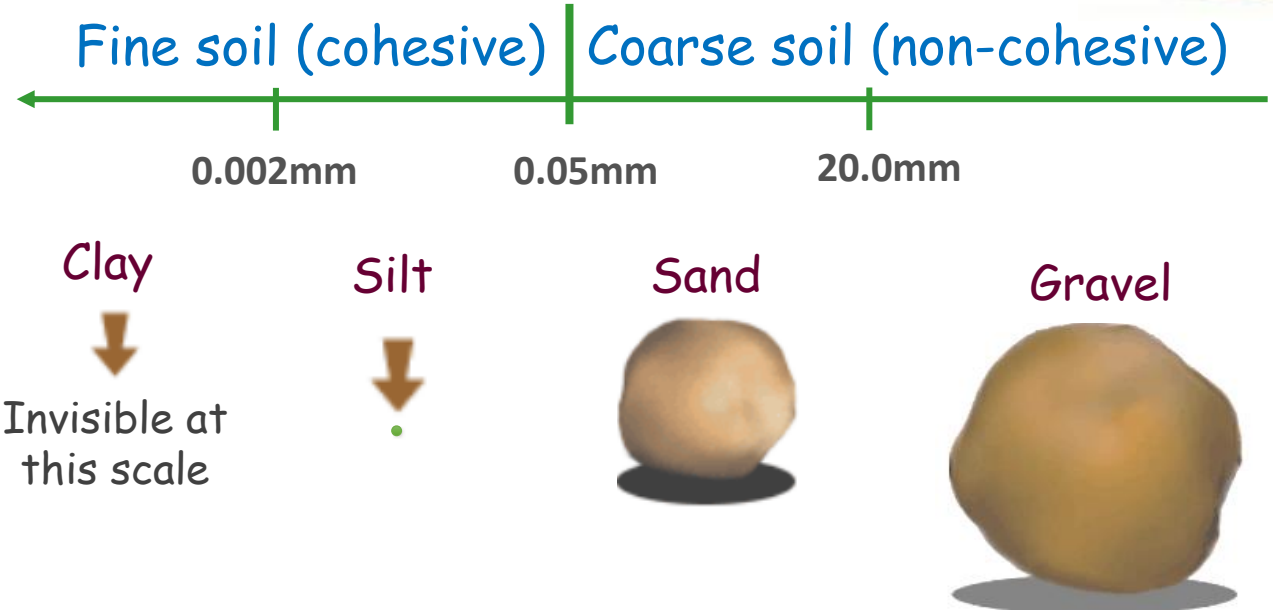
Prior Knowledge required for the course

- Classification of soil and rocks
- Physical Properties of soil
- In-situ stress: Total and effective stress principle
- Stress distribution in soil mass
- Basic mechanics of soil: stress and strain relationship
- Shear strength Parameters
- Compressibility Parameters
- Rates of loading and seepage

Classification of soil and rocks

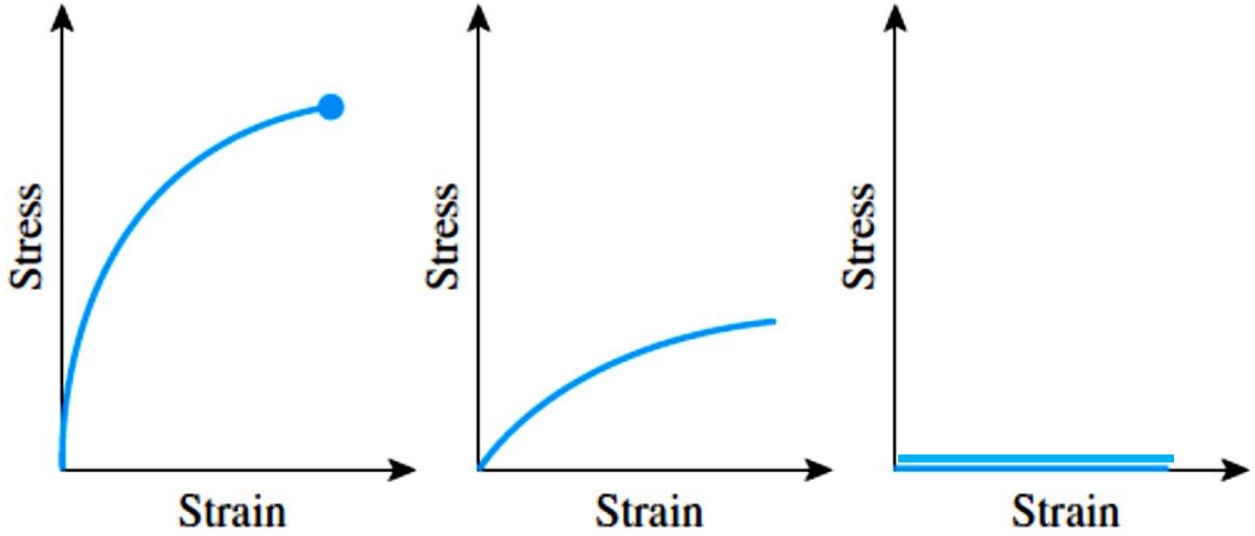
- Soil in nature is inhomogeneous and presents in **layers**.
- Soil types have geological names e.g. Alluvium, Marine sand, ..
- Soils are classified for engineering purpose.

Soil types:
according to
particle diameter



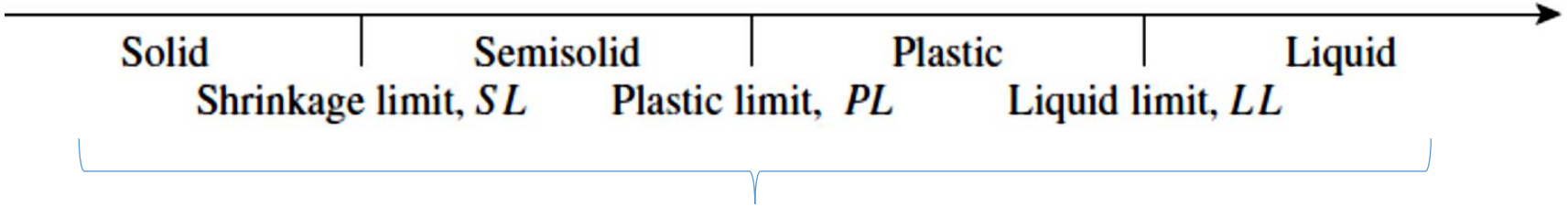
Physical Properties of soil

Plasticity of soil



Stress-strain diagrams at various states

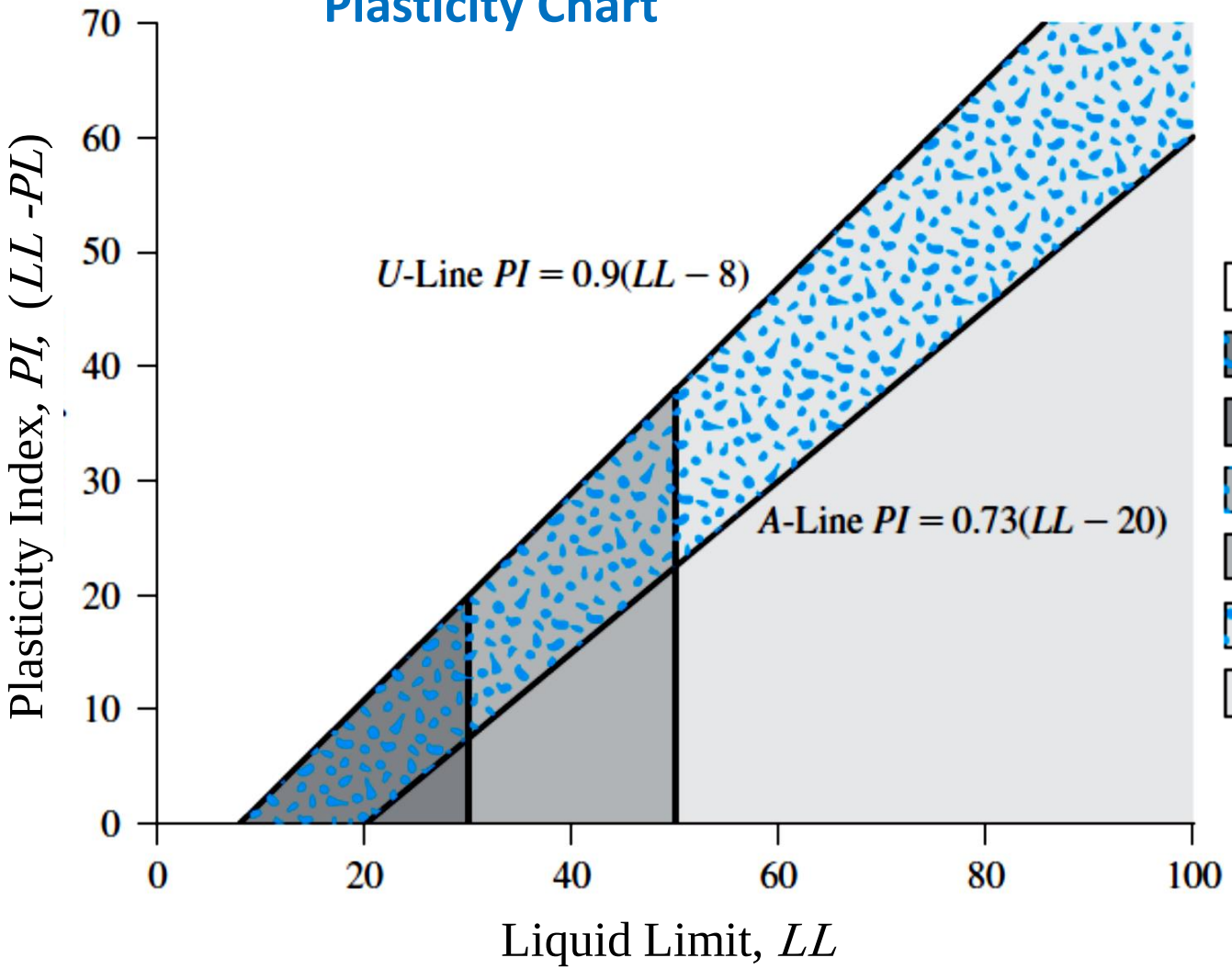
Moisture content increasing



Atterberg limits

Physical Properties of soil

Plasticity Chart



In-situ stress: Total and effective stress principle

In-situ stresses occur in all directions (vertical, horizontal,..).

The vertical stress is cased by the self-weight of soil and called overburden pressure.

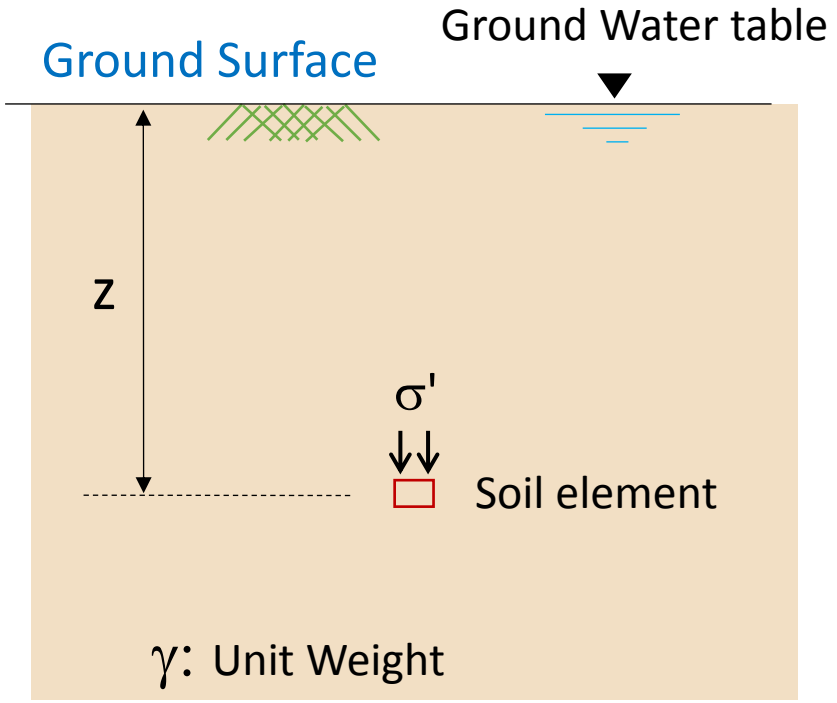
Vertical effective stress, σ' (at depth Z):

$$\sigma' = \sigma - u$$

Total stress, $\sigma = \gamma_{Sat\text{-}soil} \cdot z$

Pore water pressure, $u = \gamma_{water} \cdot z$

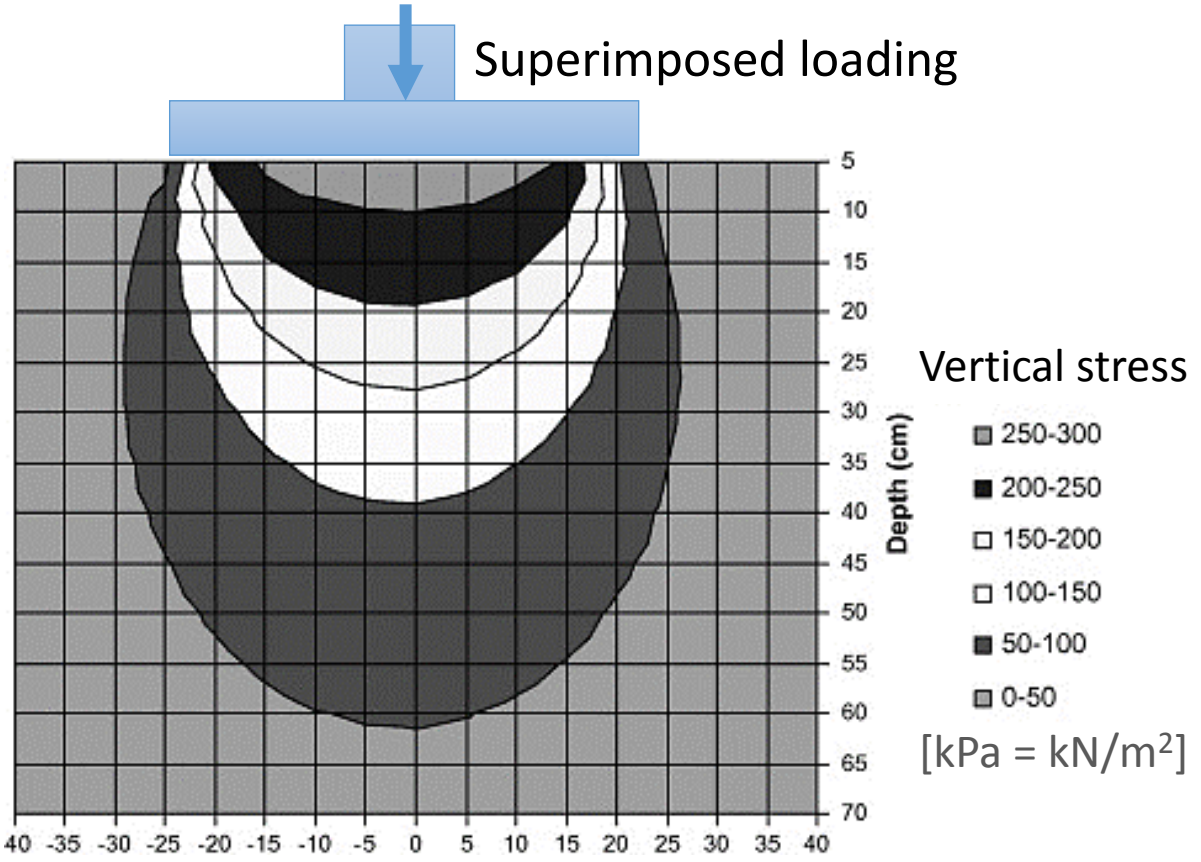
Question: what is the effective stress when the ground becomes dry (i.e. no water)?



Stress distribution in soil mass

- The increase in the vertical stress in soil (caused by a load applied over a limited area) decreases with depth.

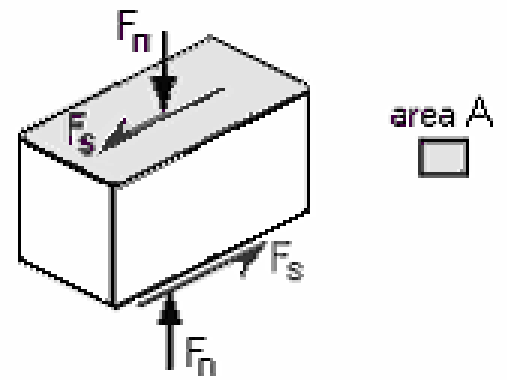
- The values can be determined by using the procedure described in Chapter 10 (Principle of Geotechnical Engineering, Das, 2010).



Basic mechanics of soil: stress & strain relationship

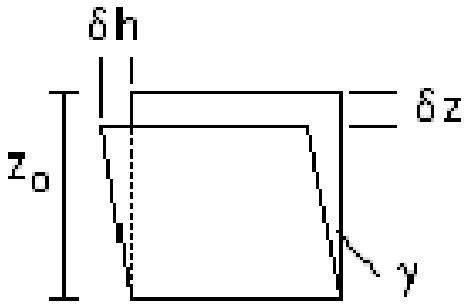
Loads on soil

Stresses



normal stress
$\sigma = F_n / A$
shear stress
$\tau = F_s / A$

Strains



normal strain
$\varepsilon = \delta z / z_o$
shear strain
$\gamma = \delta h / z_o$

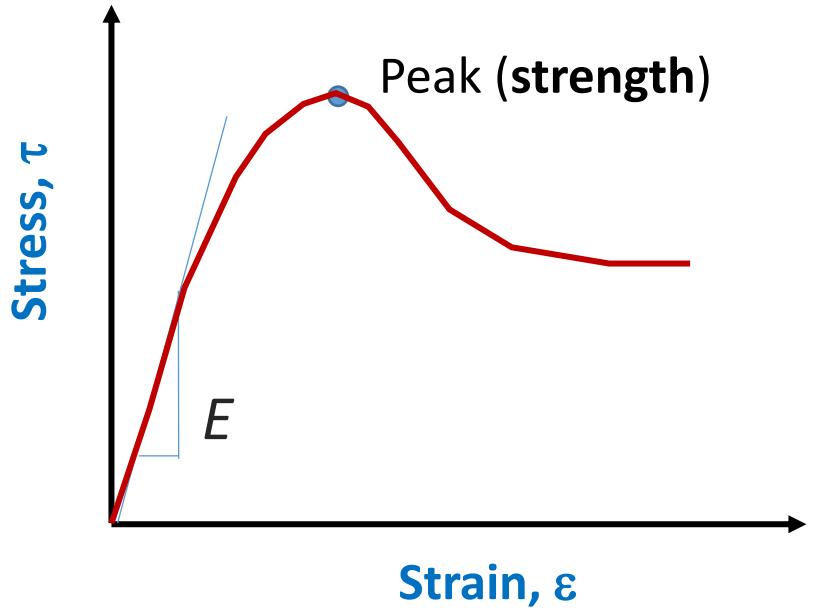
Instability & Settlements

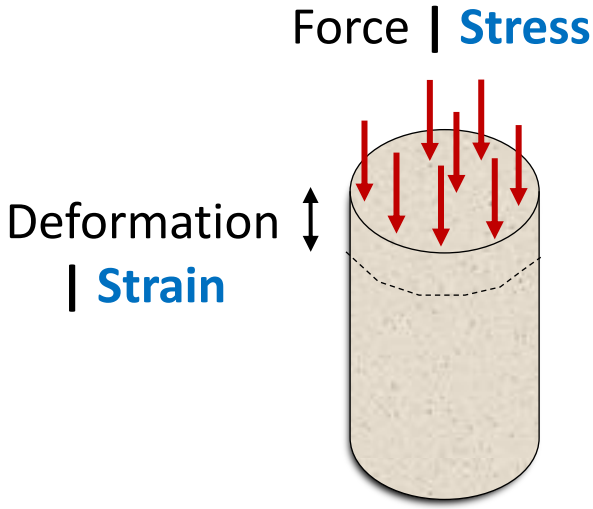
What is stress and strain?

Why is the relation between stress and strain so important?

Basic mechanics of soil: stress & strain relationship

Stress ← (soil parameters: E, G, μ, ..) → Strain





Soil specimen in experiment

Typical stress strain curve – from compression test

Shear strength Parameters

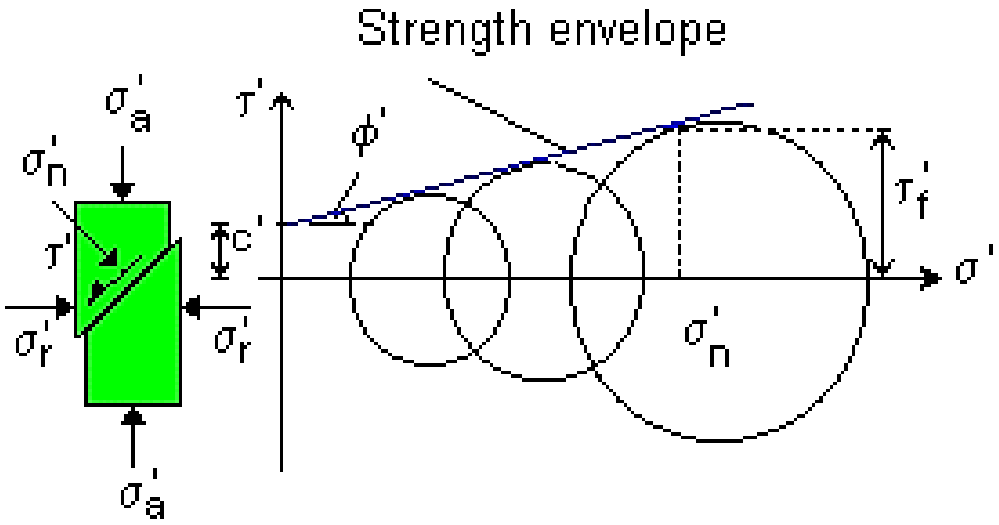
Mohr-Coulomb criterion

- Based on the general relationship between the shear stress and normal stress, soil is considered to have two shear strength parameters at the ultimate condition (failure):

$$\tau'_f = c' + \sigma'_n \tan\phi'$$

ϕ' = **Internal friction angle**

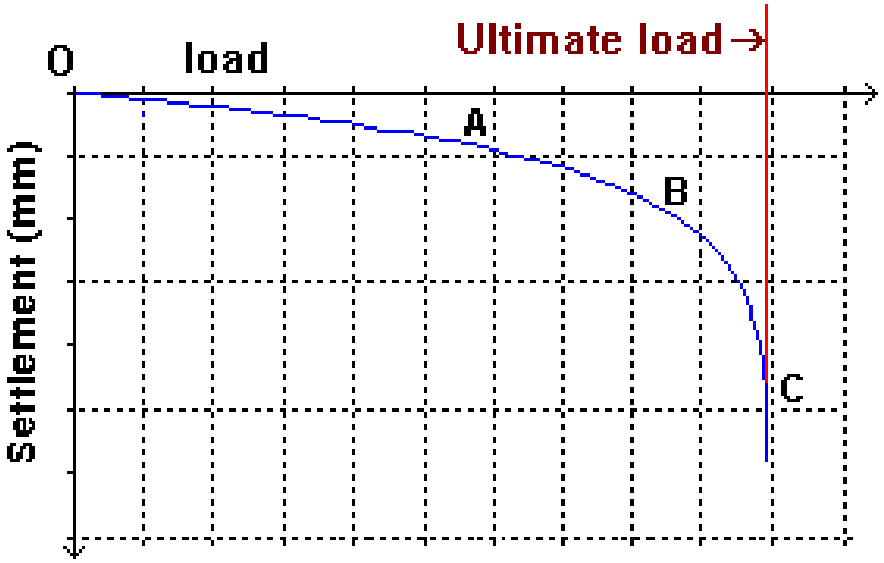
c' = **Cohesion**

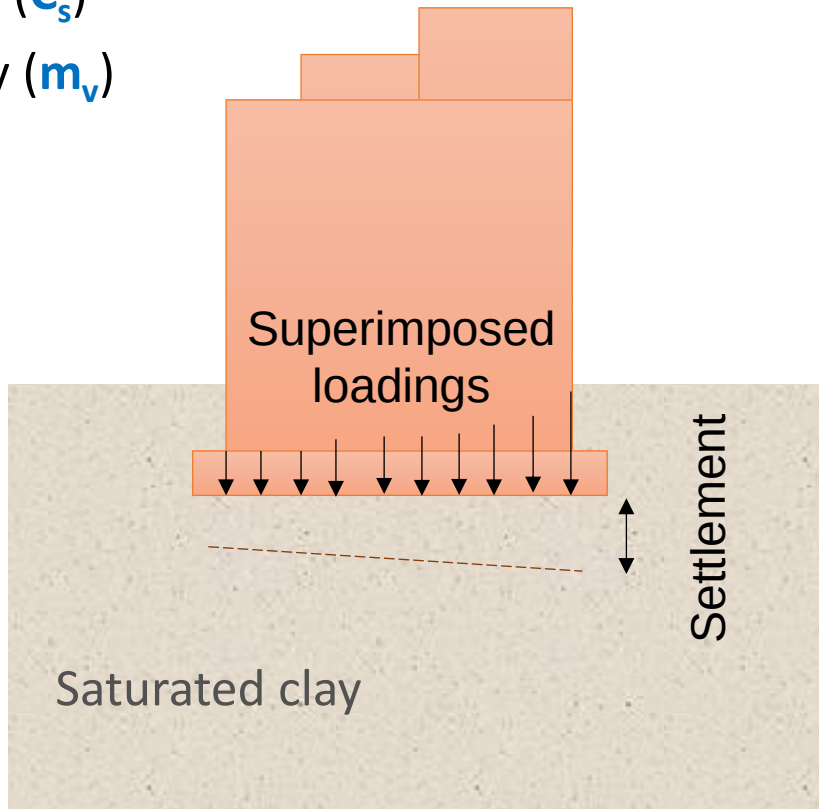


- These soil parameters varies depending on type of loading (drained or untrained) and type of soil (coarse or fine).
- Usually, coarse soils (such as sand and gravel) have mainly internal friction angle ϕ' and no cohesion ($c' = 0$), therefore they are called frictional soils or non-cohesive soils.

Compressibility Parameters

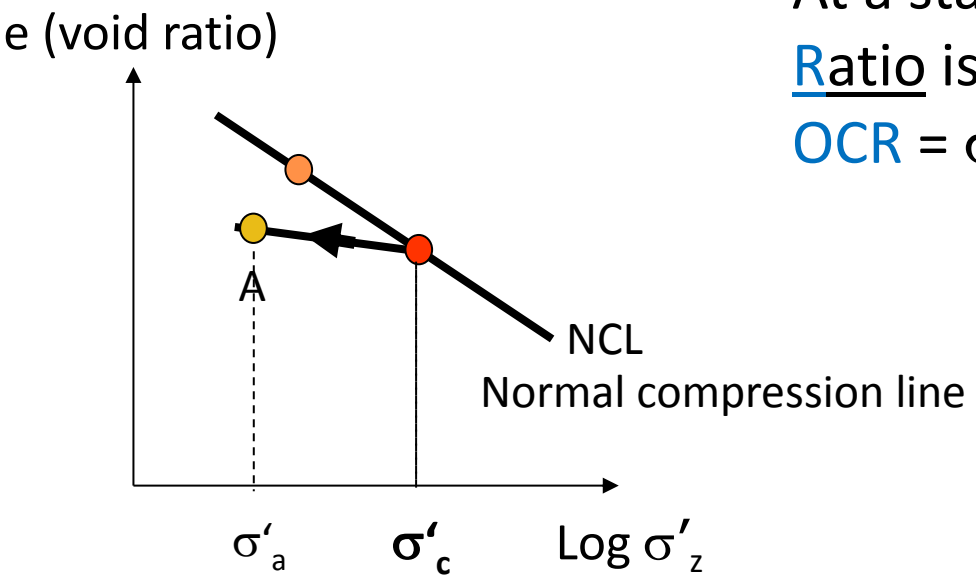
- Stress increase in the ground (caused by the construction of foundations or other reason) may compress soil and lead to foundation settlement.
- Laboratory consolidation test is usually used to determine the following compressibility parameters (used to calculate settlement and its rate):
  - Compression Index (C_c) & Swell Index (C_s)
  - Coefficient of Volume Compressibility (m_v)
  - Coefficient of consolidation (C_v)





Compressibility Parameters

Normally Consolidated and Overconsolidated Clays



At a state A the OverConsolidation Ratio is

OCR = σ'_c / σ'_a

Preconsolidation pressure:

σ'_c is the point of intersection of the swelling line through A and the NCL

If OCR > 1 overconsolidated soil

If OCR = 1 normally consolidated

Rates of loading and seepage

Depending on loading rate and drainage rate

Drained loading conditions

Undrained loading conditions

Loading rate < Drainage rate

- If the rate of drainage is *quicker* than the rate of loading, effective stress and volume changes occur quickly - these are called **drained loading** conditions.
- This loading usually happens in coarse soils (Sand and Gravel), and causes **immediate** settlement. How?
- Drained strength parameters (ϕ', c') are used here.

Rates of loading and seepage

Depending on loading rate and drainage rate

Drained loading conditions

Loading rate < Drainage rate

Undrained loading conditions

Loading rate > Drainage rate

- On the contrary, if the rate of drainage is *slower* than the rate of loading, the pore pressure increases and the effective stress and volume changes occur very slowly - these are **undrained loading** conditions.
- This loading usually happens in fine soils (Silt and Clay), and causes **consolidation** settlement. WHY?
- Undrained strength parameter (c_u) is used here.

How to study the course?

- Learning resources
- Attend and participate - with interest
- Prepare well for your exams

Learning resources

- The presentation for each lecture will be available on-line:

  on the **Balckboard**.

- Please download/print the presentation hand-out and bring it along with you.

- Also make sure you have the required text book and any other useful references/ links for the course available.

Attend and participate - with interest

- Plan to attend the lectures and tutorials – with **intention** to understand and enjoy the subject.
- No one ever can make student understand a subject if he is not **interested**.
- Participate in any **interactive** discussion, questions, or quizzes.
- Work by **YOURSELF** on any Homework or Assignment and submit your reports **ON-TIME**.

Prepare well for your exams

- Do not panic
- Allow enough time to prepare for your mid-term exams and final exam.

Work Hard (but not too hard)