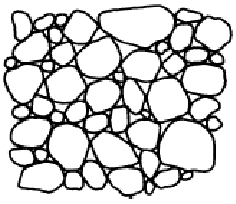
INTRODUCTION

Soil Mechanics
2015 - 2016

Define: Soil

- Naturally occurring particulate material
- Formed, directly or indirectly, from solid rocks (i.e. weathering)
- Composition of soil particles depends on composition of parent rock
- The void space between the particles contain water and/or air



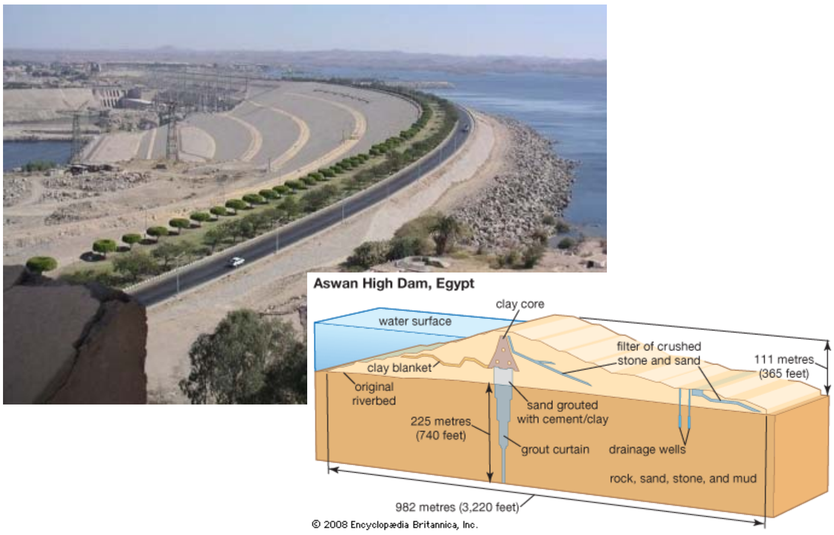
Applications

- Engineer uses the SOIL to build:
  - on it: e.g. buildings, bridges
  - in it: e.g. tunnels
  - with it: e.g. earth dams

Example: Bridge foundations

Example: Tunnel

Example: Earth dam



Example: Failure

Figure 5-2: Bearing Capacity Failure of Silo Foundation
(Vesic, 1975, from Tschebotarioff, 1951)

Example: Failure

Example: Failure

Course Outline

- Needs to understand the mechanics of this particulate material "SOIL"

- Course Outline:
  1. Phase Diagram
  2. Soil Classification
  3. Soil Compaction
  4. Permeability and Seepage
  5. Stresses
  6. Consolidation
  7. Shear Strength
  8. Slope Stability

Intended Learning Outcomes (ILOs)

- By the end of this course, students shall be able to:
  1. Perform fundamental calculations and analysis of soil volume-weight relationships.
  2. Classify soils according to their physical properties.
  3. Understand the process of soil compaction, laboratory and field methods of compaction, and associated evaluation techniques.
  4. Acquire basic principles of 1-D and 2-D flow through soils as well as laboratory and field methods of measuring soil permeability.

Intended Learning Outcomes (ILOs)

- By the end of this course, students shall be able to:
  5. Analyze vertical stress distribution in soil and calculate both overburden stresses and stresses induced due to external load.
  6. Understand the theory of 1-D consolidation and calculate consolidation parameters from laboratory tests.
  7. Estimate the magnitude and time rate of soil settlements.
  8. Understand factors contributing to the strength of soils and how soil strength is measured in the laboratory.
  9. Evaluate stability of slopes using different methods of analyses.

Instructors and TAs Office Hours

- Instructors:

	Sunday	Monday	Tuesday	Wednesday
Prof. Mohamed Elkholy	12 - 2 pm		12 - 2 pm	
Dr. Omar Ezzeldine		12 - 2 pm		2 - 4 pm
Dr. Rami El-Sherbiny		12 - 2 pm		2 - 4 pm
Dr. Manal Salem		12-1 pm		10 am – 12 pm

- Teaching Assistants:

	Sunday	Monday	Tuesday	Wednesday
Eng. Mohamed Kamal			12 – 2 pm	12 – 2 pm
Eng. Ahmed Abdelaziz	8 – 10 am			10 am – 12 pm
Eng. Safwat Elrouby		10 am – 12 pm	10 am – 12 pm	
Eng. Moataz Solaiman	12 – 2 pm		2 – 4 pm	

Grades Distribution

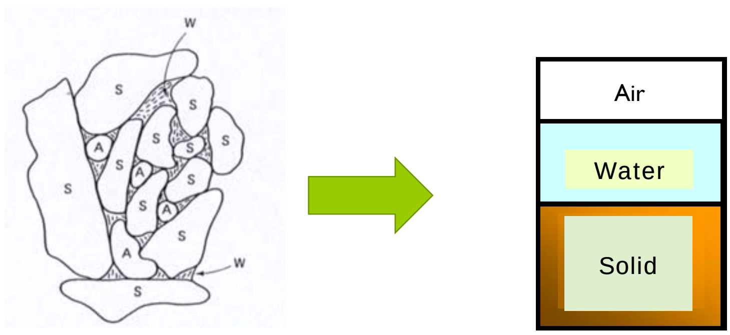
- Final grade will be calculated as follows:
  - Attendance, Participation, HW, and Quizzes 20%
  - Midterm Exam 20%
  - Final Exam 60%

1. PHASE DIAGRAM

Soil Mechanics

2015 - 2016

Phase Diagram



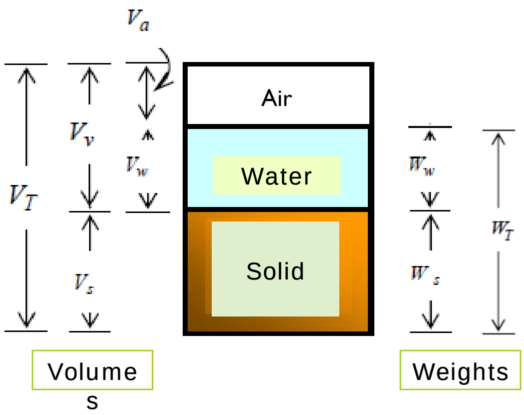
Soil sample

S: Solids
W: Water
A: Air

} Voids

Phase diagram

Weight – Volume Relationships



Weight – Volume Relationships

V_s = Volume of solids

V_v = volume of voids

V_w = volume of water

V_a = volume of air

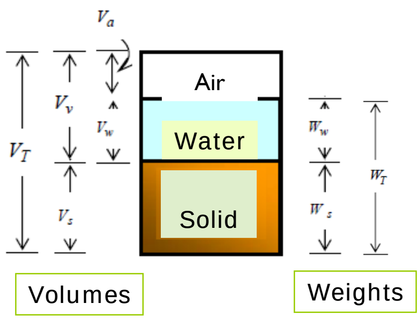
V_T = total volume

$= V_s + V_w + V_a = V_s + V_v$

W_s = weight of solids

W_w = weight of water

W_T = total weight = $W_s + W_w$



Weight – Volume Relationships

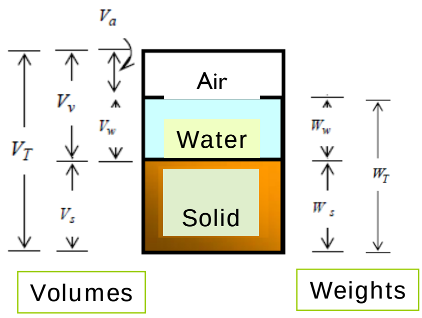
o**Ratios:**

w = water content = $\frac{W_w}{W_s}$ $0 \le w$

S = degree of saturation = $\frac{V_w}{V_v}$ $0 \le S \le 1$

e = void ratio = $\frac{V_v}{V_s}$ $0 < e$

n = porosity = $\frac{V_v}{V_T}$ $0 < n < 1$



Weight – Volume Relationships

o**Densities:** **Weight/Volume**

γ_d = dry unit weight = $\frac{W_s}{V_T}$

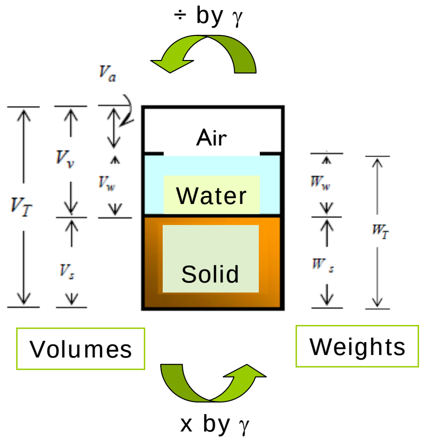
γ_{wet} = wet (bulk) unit weight = $\frac{W_T}{V_T} = \frac{W_s + W_w}{V_T}$

γ_{sat} = saturated unit weight = $\frac{W_s + \gamma_w V_v}{V_T}$

γ_{sub} = submerged unit weight

$= \frac{W_s + \gamma_w V_v - \gamma_w V_T}{V_T}$

$= \gamma_{sat} - \gamma_w$

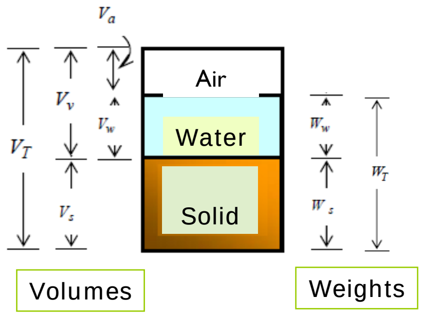


Weight – Volume Relationships

γ_w = density of water = W_w/V_w = 1.0 t/m³ = 1.0 gm/cm³ ≃ 10 kN/m³

γ_s = density of solids = W_s/V_s = 2.5 – 2.8 t/m³

G_s = specific gravity of solids = γ_s/γ_w (dimensionless)



Laboratory Measurements

- How to measure soil water content?
  1. Get the total weight of soil sample = W_T
  2. Oven-dry the sample, then weigh = W_s
  3. Calculate: $w = \frac{W_w}{W_s} = \frac{W_T - W_s}{W_s}$
- How to measure total volume of soil sample (V_T)? By either:
  1. Submerging the sample in container full of mercury. Measure weight of displaced mercury ($W_{mercury}$).
     $V_T = W_{mercury}/\gamma_{mercury}$
  2. Cover the sample with wax, then submerge it in container full of water. Measure weight of displaced water (W_w).
     $V_T + V_{wax} = W_w/\gamma_w$. Then peel the wax, and get W_{wax}, and calculate $V_{wax} = W_{wax}/\gamma_{wax}$. Thus get V_T.

Solving Phase Diagrams

1. Given: w, G_s, and S

Assume W_s = 1

$$w = \frac{W_w}{W_s} = \frac{W_w}{1}$$

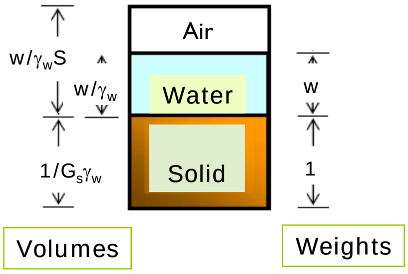
$$\gamma_s = \frac{W_s}{V_s} \qquad V_s = \frac{W_s}{\gamma_s}$$

$$G_s = \frac{\gamma_s}{\gamma_w} \qquad \gamma_s = G_s \gamma_w$$

$$V_s = \frac{W_s}{G_s \gamma_w} = \frac{1}{G_s \gamma_w}$$

$$\gamma_w = \frac{W_w}{V_w} \qquad V_w = \frac{W_w}{\gamma_w} = \frac{w}{\gamma_w}$$

$$S = \frac{V_w}{V_v} \qquad V_v = \frac{V_w}{S} = \frac{w}{S\gamma_w}$$



→ Can get e, n, γ_d

Solving Phase Diagrams

2. Given: e, G_s, and S. Required: w, n, γ_d?

Assume V_s = 1

$$e = \frac{V_v}{V_s} = \frac{V_v}{1}$$

$$S = \frac{V_w}{V_v} \qquad V_w = V_v S = eS$$

$$W_w = \gamma_w V_w = \gamma_w eS$$

$$W_s = \gamma_s V_s = \gamma_w G_s$$

→ Can get w, n, γ_d