# Geotechnical Engineering–I

*BSc Civil Engineering – 4th Semester*

Lecture # 4

6-Feb-2015

*by*

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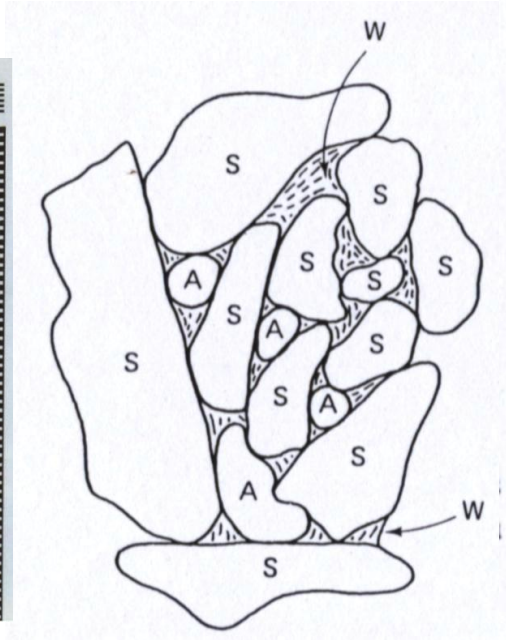
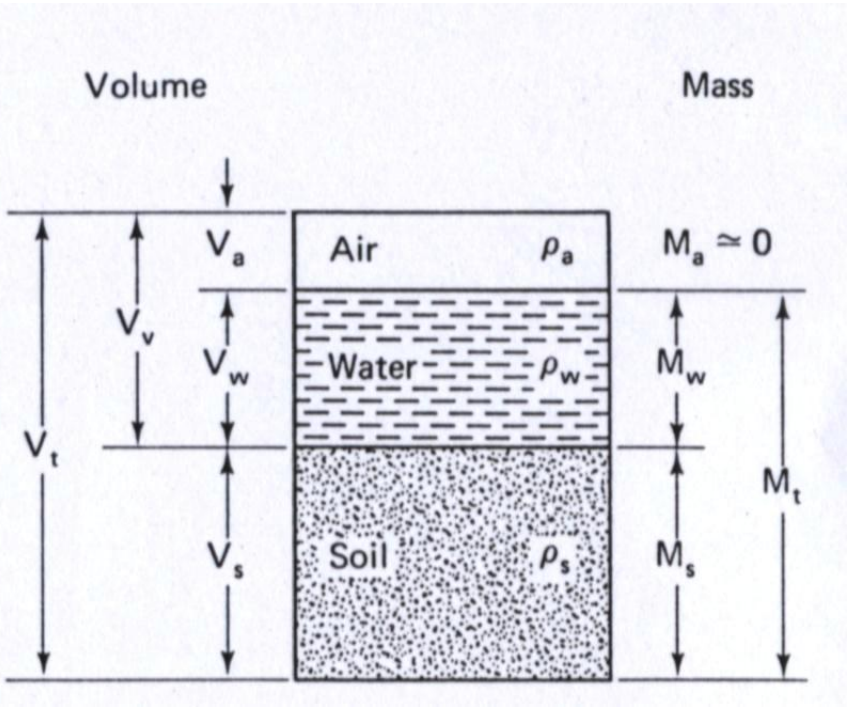
# REVIEW:
# Soil as a Three Phase System

| | | |
|---|---|---|
| S: | Solid | Soil particle |
| W: | Liquid | Water |
| A: | Air | Air |

# REVIEW:
## Weight-Volume Relationships

$$e = \frac{n}{1-n}$$

$$\gamma_b = G_s.\gamma_w\left(\frac{1+w}{1+e}\right)$$

$$\gamma_{sub} = \frac{\gamma_w(G_s-1)}{(1+e)}$$

$$n = \frac{e}{1+e}$$

$$\gamma_d = \frac{G_s.\gamma_w}{1+e}$$

$$\gamma_d = \frac{\gamma_b}{1+w}$$

$$\theta_v = n.S_r$$

$$n = 1 - \frac{W_s}{G_s.\gamma_w} \bullet \frac{1}{V}$$

$$e = \frac{w.G_s}{S}$$

$$e = \frac{V.G_s.\gamma_w}{W_s} - 1$$

$$\gamma_{sat} = \frac{(G_s+e)\gamma_w}{1+e}$$

# WEIGHT-VOLUME RELATIONSHIPS

## Problem #1

A moist soil sample weighs 346 g. After drying at 105° C its weight is ~~248~~ 284 g. The specific gravity of the mass and of the solids is 1.86 and 2.70 respectively.

DETERMINE:
a) water content
b) void ratio
c) degree of saturation
d) porosity.

## Problem #2

A soil deposit is being considered as a fill for a building site. In its original state in the borrow pit the void ratio is 0.95. Based on laboratory tests, the desired void ratio in its compacted state at the building site should not be no greater than 0.65.

FIND: The percentage decrease (or loss) of volume of the deposit from its original state.

# WEIGHT-VOLUME RELATIONSHIPS

## Problem #3

A Shelby-tube sampler is cut such that the volume of the soil in the cut piece is equal to 413 cm3. (From the constant cross sectional area and the average length of the specimen, one can estimate the specimen's volume expediently and reasonably accurately). The weight of the mass was 727g. After drying, the sample's weight is 607g. Assume $G_s = 2.65$ ; $\gamma_w = 1$ gm/cm$^3$ = 9.807 kN/m$^3$.

FIND: a) water content
b) void ratio
c) porosity
d) degree of saturation
e) specific gravity of mass.

# WEIGHT-VOLUME RELATIONSHIPS

## Problem #4

A soil sample has a water content of 8 percent and specific gravity $G_s = 2.66$

FIND: a) void ratio of the sample

b) degree of saturation

c) porosity

d) How much water (in kgs) should be added to $1m^3$ of this soil in order to bring the water content to 13%, assuming that the void ratio remains constant.

## Problem #5

Why is the dry weight (weight of solids) rather than the total wt. Used in defining the water content ? Can the water content exceed 100%. Explain.

# WEIGHT-VOLUME RELATIONSHIPS

## Problem #6

A soil sample was determined to possess the following characteristics: $G_s = 2.74$, $e = 0.69$, and $w = 14$ percent. Determine

a) degree of saturation
b) porosity
c) unit dry weight of the sample.

## Problem #7

A moist soil sample was found to have a volume of 22.3 $cm^3$ & weight of 29.7 g. The dry weight of the sample was determine to be 23g. $G_s = 2.7$

DETERMINE: a) void ratio
b) water content
c) porosity
d) degree of saturation of the sample.

# WEIGHT-VOLUME RELATIONSHIPS

## Problem #8

Laboratory tests on a soil sample yielded the following information:

$G_s \rightarrow$ = 2.71 gm W = 13% , $\gamma_d = 1.8$ g/cc

CALCULATE a) void ratio b) degree of saturation
c) porosity.

## Problem #9

A soil sample has a water content of 8 percent and a degree of saturation 42 percent after adding some water, the degree of saturation altered to 53 percent. Assuming no change in the volume of the voids, determine. $G_s = 2.7$

a) void ratio b) water content
c) specific gravity of the mass of the sample is the altered state.

# RELATIVE DENSITY ($D_r$)

Relative density ($D_r$) is commonly used to indicate the in-situ denseness or looseness of granular soils.

$$D_r = \left( \frac{e_{max} - e}{e_{max} - e_{min}} \right) \times 100$$

where $D_r$ = relative density, usually given as a percentage
$e$ = *in situ* void ratio of the soil
$e_{max}$ = void ratio of the soil in the loosest state
$e_{min}$ = void ratio of the soil in the densest state

***Table 3.3*** Qualitative Description of Granular Soil Deposits

| Relative density (%) | Description of soil deposit |
|---|---|
| 0–15 | Very loose |
| 15–50 | Loose |
| 50–70 | Medium |
| 70–85 | Dense |
| 85–100 | Very dense |

# RELATIVE DENSITY ($D_r$)

$$\gamma_d = \frac{G_s \gamma_w}{1+e} \Rightarrow e = \frac{G_s \gamma_w}{\gamma_d} - 1 \Rightarrow e_{\max} = \frac{G_s \gamma_w}{\gamma_{d(\min)}} - 1$$

$$e_{\min} = \frac{G_s \gamma_w}{\gamma_{d(\max)}} - 1$$

Substituting $e$, $e_{min}$, and $e_{max}$ into equation of $D_r$

$$D_r = \frac{e_{\max} - e}{e_{\max} - e_{\min}} \Rightarrow D_r = \frac{\frac{1}{\gamma_{d(\min)}} - \frac{1}{\gamma_d}}{\frac{1}{\gamma_{d(\min)}} - \frac{1}{\gamma_{d(\max)}}} = \left[\frac{\gamma_d - \gamma_{d(\min)}}{\gamma_{d(\max)} - \gamma_{d(\min)}}\right]\left[\frac{\gamma_{d(\max)}}{\gamma_d}\right]$$

# RELATIVE DENSITY ($D_r$)

## Practice Problem-1

A sand deposit was compacted to an in-situ void ratio of 0.25. Void ratios determined for this soil in the loosest and densest states were found to be equal to 0.7 and 0.3 respectively. Determine the relative density and the corresponding dry density of this soil. Assume specific gravity of the soil to be 2.65.

## Practice Problem-2

A standard test performed in lab to determine the relative density of a soil yielded the following results;

Volume of cylinder = 600 $cm^3$

Weight of soil filling the cylinder in loose form = 1030.4 g

Weight of soil in dense form = 1030.4 g

Volume of the cylinder when soil is in dense form = 561.5 $cm^3$

If the in-situ void ratio of the same soil is 0.487, determine the relative density of soil.

# CONCLUDED