Geotechnical Engineering–I

BSc Civil Engineering – 4th Semester

Lecture # 2

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by

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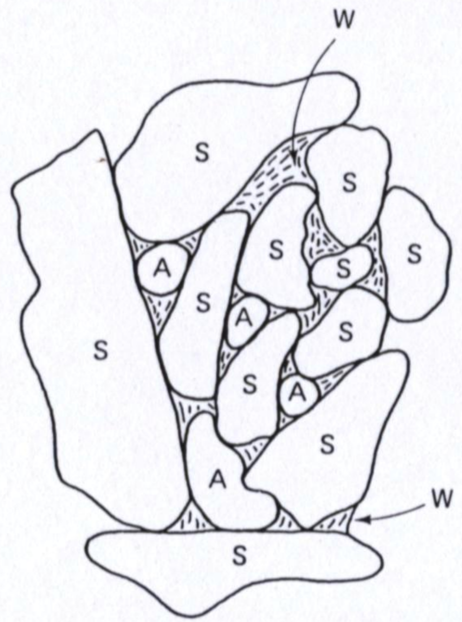
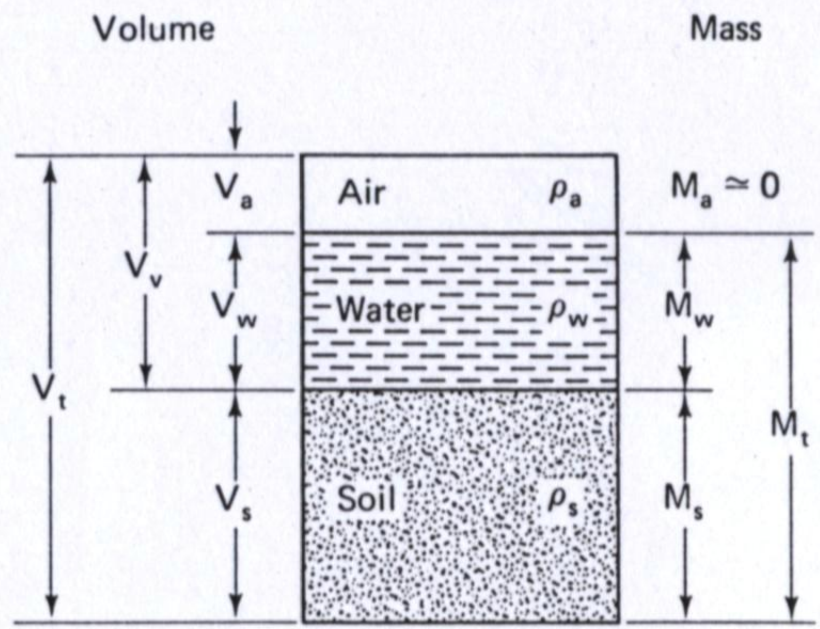
Lecture Handouts: https://groups.google.com/d/forum/geotec-1

SOIL AS A THREE PHASE SYSTEM

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





SOIL AS A THREE PHASE SYSTEM

V = Total volume of soil mass

V_s = Volume of soil solids

V_w = Volume of water

V_a = Volume of air

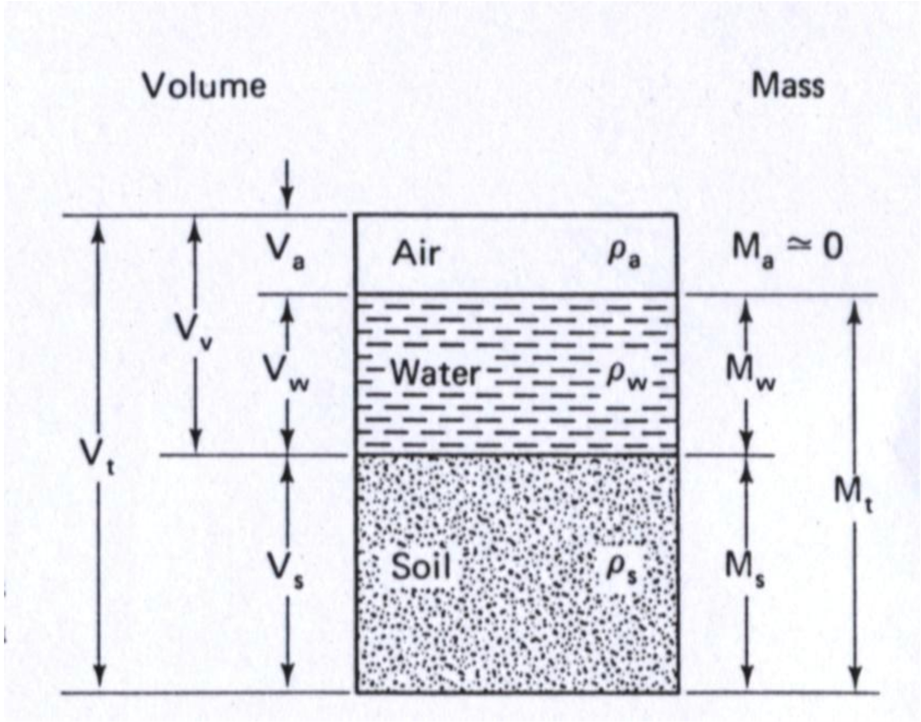
$V_v = V_a + V_w$ = Volume of voids

W = Total weight of soil

W_s = Weight of soil solids

W_a = Weight of air ≈ 0

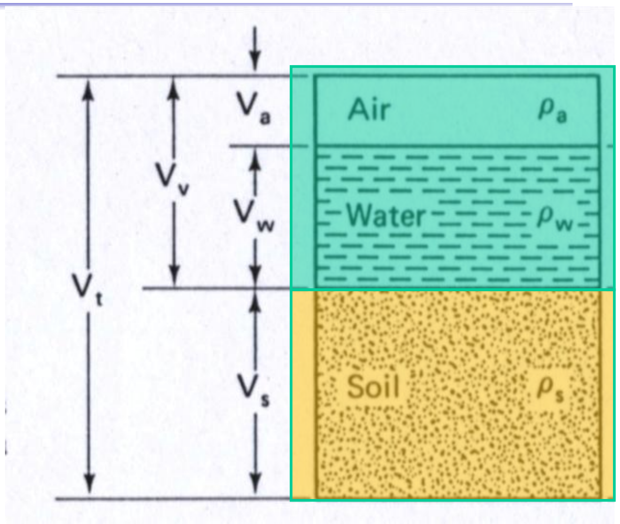
W_w = Weight of water



VOLUMETRIC RATIOS

1) **Void ratio**, ***e***

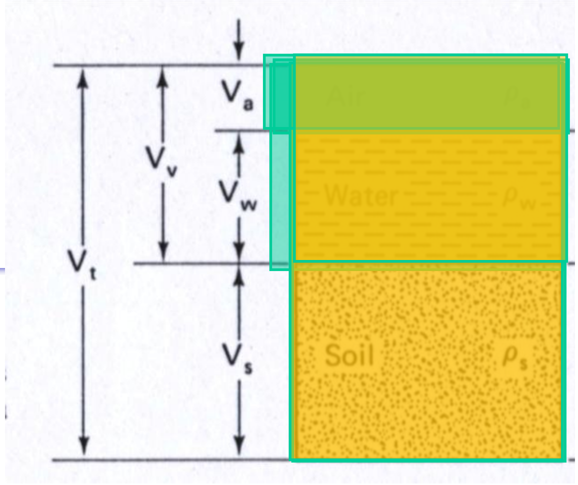
$$e = \frac{\text{Volume of voids}\,(V_v)}{\text{Volume of solids}\,(V_s)} \qquad (0 < e < \infty)$$



For sands, $0.5 \le e \le 0.9$

For clays, $0.7 \le e \le 1.5$ (or even higher)

VOLUMETRIC RATIOS



2) **Porosity, *n***

$$n = \frac{\text{Volume of voids}(V_v)}{\text{Total volume of soil sample}(V_t)}$$

$(0 < n < 1)$

Typical range, 9-70%

For sands, $25\% \le n \le 50\%$

3) **Air Porosity, n_a'**

$$n_a' = \frac{Volume\ of\ air\,(V_a)}{Total\ volume\ of\ soil\ sample\,(V_t)}$$

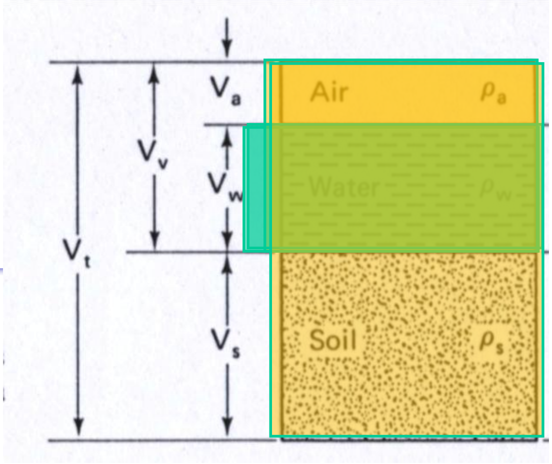
$(0 < n_a' < 1)$

4) **Percentage Air Voids, n_a**

$$n_a = \frac{Volume\ of\ air\,(V_a)}{Volume\ of\ voids\,(V_v)}$$

$(0 < n_a < 1)$

VOLUMETRIC RATIOS



5) **Degree of Saturation/ Saturation Ratio**, ***S (or S_r)***

$$S = \frac{Volume\ of\ voids\ containing\ water\,(V_w)}{Total\ volume\ of\ voids\,(V_v)} \times 100\%$$

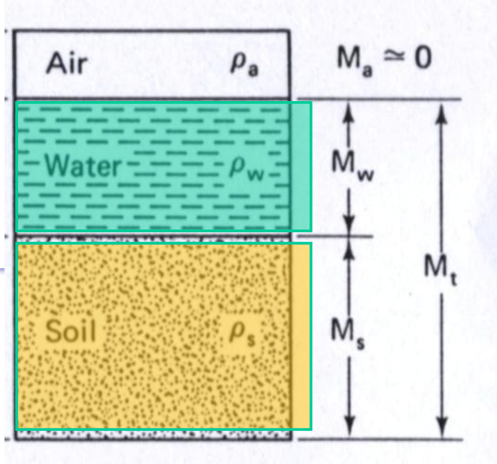
$(0 < S_r < 100\%)$

6) **Volumetric Water Content**, ***θv***

$$\theta_v = \frac{Volume\ of\ voids\ containing\ water\,(V_w)}{Total\ volume\ of\ soil\ sample\,(V_t)}$$

$(0 < \theta_v < 1)$

WEIGHT RELATIONSHIPS



1) **Moisture/Water Content**, ***w***

$$w = \frac{Weight\ of\ \ water\,(W_w)}{Weight\ of\ \ soil\ \ solids\,(W_s)} \times 100\%$$

$(0 < w < \infty)$

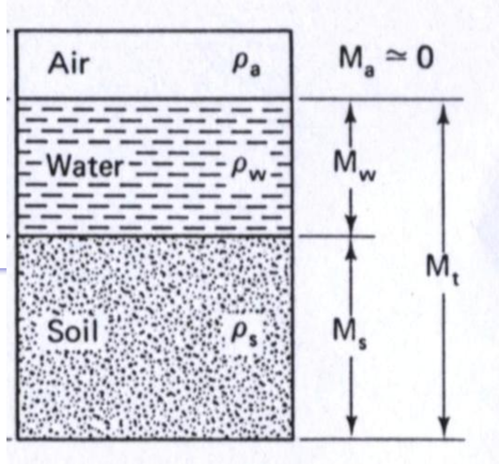
Typical value for Sands >> 10-30%

For clays >> 10% or higher typically

For some organic soils *w*>100%, even up to 500%.

For quick clays *w* is typically > 100%.

WEIGHT RELATIONSHIPS



2) **Unit Weight**, ***γ***

$$\gamma = \frac{Weight}{Volume} = \frac{Mg}{V} \qquad (kN/m^3; lb/ft^3; g/cm^3)$$

3) **Dry Unit Weight**, $\boldsymbol{\gamma_d}$

$$\gamma_d = \frac{Weight\ of\ soil\ solids}{Total\ Volume} = \frac{W_s}{V_t}$$

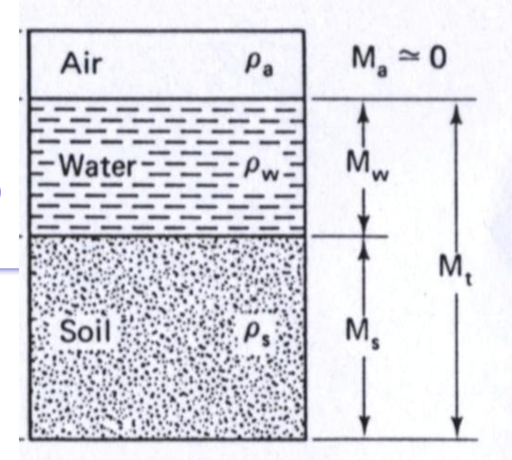
4) **Bulk Unit Weight**, $\boldsymbol{\gamma_b}$

$$\gamma_b = \frac{Total\ Weight}{Total\ Volume} = \frac{W}{V_t}$$

5) **Unit Weight of Soil Solids**, $\boldsymbol{\gamma_s}$

$$\gamma_s = \frac{Weight\ of\ soil\ soilds}{Volume\ of\ soil\ soilds} = \frac{W_s}{V_s}$$

WEIGHT RELATIONSHIPS



6) **<u>Saturated Unit Weight</u>, γ_{sat}**

$$\gamma_{sat} = \frac{Weight\ of\ saturated\ soil}{Total\ \ Volume}$$

7) **<u>Submerged Unit Weight</u>, γ_{sub} (or $\gamma_{bouyant}$)**

$$\gamma_{sub} = \gamma_{sat} - \gamma_w$$

γ_w = 9.81 kN/m^3 $\rightarrow$ 1 g/cm^3

= 1000 kg/m^3

= 62.4 lb/ft^3

Archimede's principle:

The buoyant force on a body immersed in a fluid is equal to the weight of the fluid displaced by that object.

SPECIFIC GRAVITY *(Gs)*

$$G_s = \frac{Unit\ weight\ of\ soil\ soilds}{Unit\ weight\ of\ equal\ volume\ of\ water\ at\ 4°C} = \frac{\gamma_s}{\gamma_w}$$

Generally for soils $2.6 \leq Gs \leq 2.7$

WEIGHT-VOLUME RELATIONSHIPS

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

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

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

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

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

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

$$\theta_v = n.S_r$$

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

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

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

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

CONCLUDED