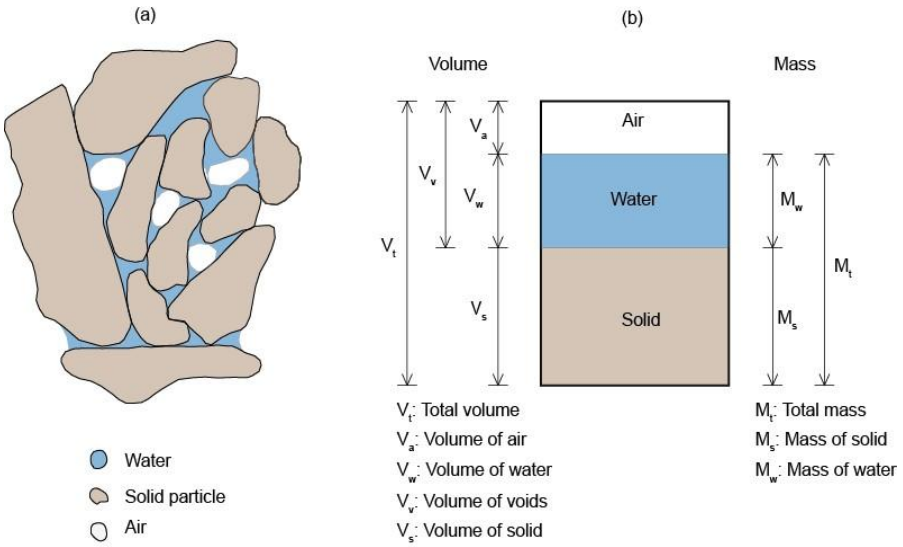
Lab-1

Soil Physics

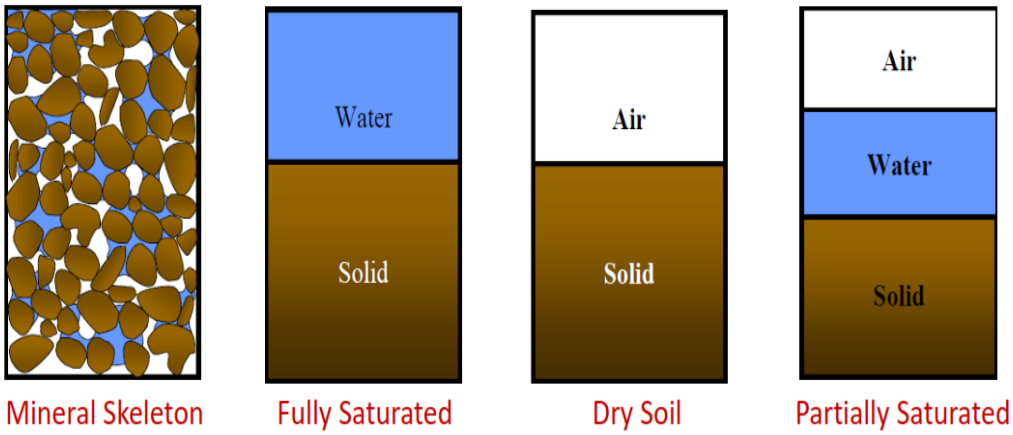
Soil physics is the study of soil's physical properties and processes. It is applied to management and prediction of soil.

Soil physics deals with the dynamics of physical soil components (organic and inorganic) and their phases as solid, liquids, and gases.

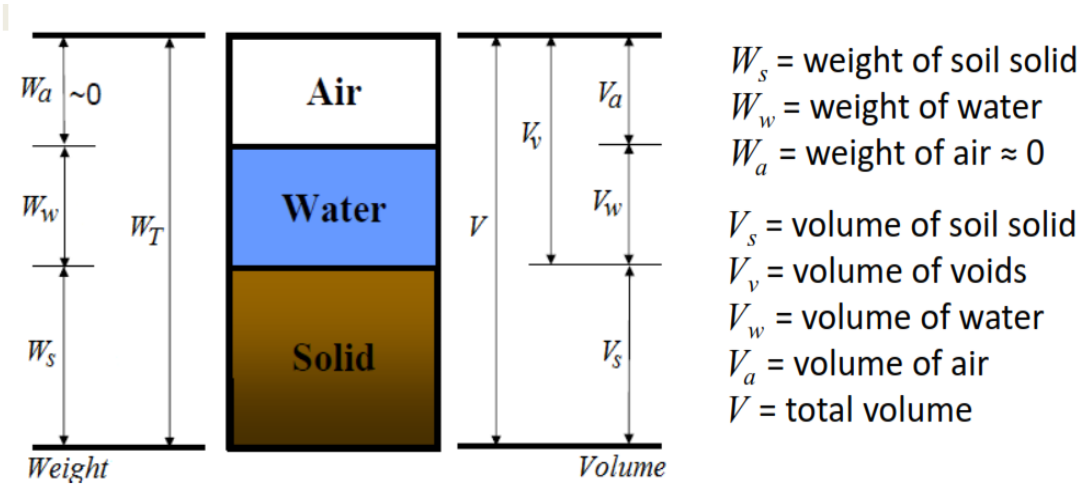


Mass - Volume Relationship

Naturally soil consists of solid particles which make up the soil skeleton and voids which may be full of water if the soil is saturated, may be full of air if the soil is dry, or may be partially saturated as shown:



To develop the weight–volume relationships, we must separate the three phases (that is, solid, water, and air) as shown:



W_s = weight of soil solid
W_w = weight of water
W_a = weight of air ≈ 0

V_s = volume of soil solid
V_v = volume of voids
V_w = volume of water
V_a = volume of air
V = total volume

$$W = W_s + W_w$$

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

The common terms used for Mass-Volume relationships:

1- Gravimetric soil moisture content (w): It is the ratio of mass of water *(Mw)* to mass of solids *(Ms)*, it can be expressed as fraction or percent.

$$W\% = \frac{Mw}{Ms} * 100$$

***2- Volumetric soil moisture content* (θ)**: It is the ratio of volume of water (V_w) to the total volume of soil (V_t). Similar to *w*, θ is also expressed as a ratio or percent.

$$\theta = \frac{Vw}{Vt} = \frac{Vl}{Vs + Vv}$$

Or $\theta = W\% \text{ X } \rho b$

3- Degree of saturation (S): It refers to the relative volume of pore space containing water or liquid in relation to the total porosity and is also expressed as a fraction or percentage.

$$S = \frac{Vw}{Vv}$$

4- Void Ratio (e): It is defined as the volume of Pores (V_v) divided by the volume of solids, V_s. It can be shown that:

$$e = \frac{Vv}{Vs} = \frac{Vg + Vl}{Vo + Vin}$$

5- Total porosity (η): It is the ratio of volume of fluids or water plus air *(Vv)* to total volume *(Vt)*.

$$\eta = \frac{Vv}{Vt} = \frac{Vg + Vl}{Vs + Vl + Vg}$$

$$\eta = (1 - \frac{\rho b}{\rho s})$$

6- Air-filled porosity (η_a): It is the ratio of volume of air (V_a) to total volume of soil (V_t). Or it refers to the relative proportion of air-filled pores.

$$\eta a = \frac{Vg}{Vt}$$

7- Density of Solids (Mean Particle Density) (ρs): - is the ratio of the mass of solids to the volume of solids.

ρs = Ms /Vs ***(g.cm^{-3}), (kg.m^{-3}), (Mg.m^{-3})***

1 g.cm^{-3} = 1 Mg.m^{-3} ***1 kg.m^{-3} = 1/1000 g.cm^{-3}***

8- Dry Bulk Density (ρb): - the ratio of the mass of solids to the total soil volume. ***ρb = Ms /Vt***

Example

A soil is sampled by a core measuring 7.6 cm in diameter and 7.6 cm deep. The core weighs 300 g. The total core plus wet soil weight is 1000 g. On oven drying at 105° C the core plus dry soil weighed 860 g. Calculate wet and dry bulk densities and gravimetric moisture contents.

Solution

Total volume of core = $\pi r^2 h$ = 3.14 (3.8 cm^2) · 7.6 cm=345 cm^3
Core weight = 300 g
Weight of wet soil = 1000 g – 300 g = 700 g
Weight of dry soil = 860 g – 300 g = 560 g
Wet bulk density (Mt /Vt) = 700 g /345 cm^3 = 2.03 g/cm^3
Dry bulk density (Ms / Vt) = 560 g / 345 cm^3 = 1.62 g/cm^3
Gravimetric moisture content (w)=Mw/Ms = = (1000 g – 860 g)/ 560 g = 140 g/560 g = 0.25 or 25%

Homework:
A moist soil sample has a volume of (450 cm^3) and a wet soil of (786 g). The particle density is (2.65 $g.cm^{-3}$) and the dry soil is (731 g). Determine the:
1. Void ratio 2. Porosity 3. Gravimetric water content 4. Degree of saturation 5. Volumetric water content 6. Liquid ratio