Mechanics: The branch of Applied mathematics dealing with motion and forces producing motion.

Soil Mechanics: The branch of Science dealing with Properties and behaviour of soil as they affect its use in Civil Engineering.

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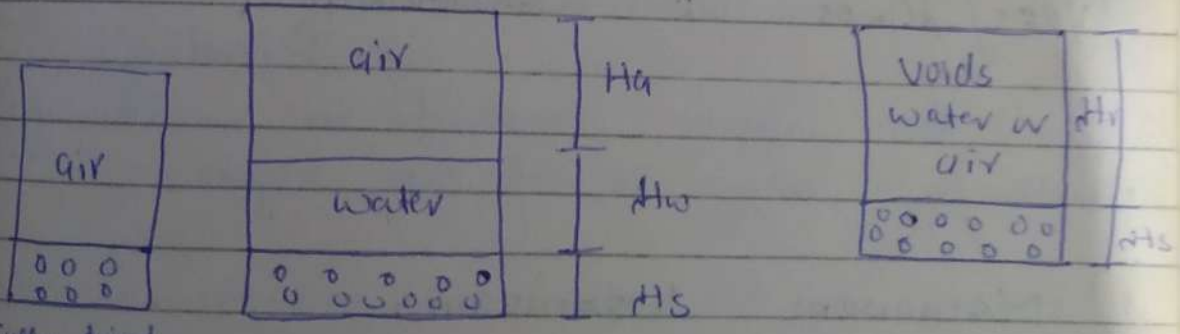
Soil: To an engineer soil is defined as unlemented (soft) aggregates of mineral grains and decayed organic matter with liquid and gas in the empty spaces b/w the solid particles. A soil may contain some or all of the following Contituents.

1) Solid Particles / soil grains
2) Liquid phase (water)
3) Gaseous phase (air or other gases).

Thus soil is a 3 phase system. The space / oblique volume occupied by liquid and gases is called voids.



1) If soil is completely dried then only solid phase and gaseous phase (Air) will be present.
2) If a soil is completely saturated (all the voids filled with water) then only solid phase and liquid phase (water) will be present.
3) If soil is moist (not full dried, nor fully saturated) then solid phase

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liquid and gaseous
and ~~gaseous~~ phase will be present and the soil is called partially suturated soil.

SOIL FORMATION:. Soil are formed by weathering of rocks and by growth and decayed of plants.

WEATHERING:. It is a disintegration of larger rocks into smaller pieces by some external or internal agents. The rocks from which soil is formed is called parent rocks.

TYPES / KINDS OF WEATHERING:.

Depending upon the agents involved in weathering, weathering may be of two types.

1) MECHANICAL WEATHERING:.

It is fragmentation of parents rock by physical forces such as those resulting from temp stresses, from the formation of ice, wind, running water etc.

2) CHEMICAL WEATHERING:.

In chemical weathering, the parents rocks are converted into new minerals by chemical

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reactions / actions. Water and CO_2 from atmosphere play significant role in this type of weathering.

TYPES OF SOIL:. Soil are mainly divided into two categories.

i) ORGANIC SOIL:.

These soil are derived mainly from growth and decay of plant life and in some cases from shed of small organism.

ii) INORGANIC SOIL:. These soil are formed by mechanical or chemical weathering of rocks. The inorganic soil may be residual or transported soil.

a) RESIDUAL:. (stay on own place).

It soil is deposited at place where it was formed.

b) TRANSPORTED SOIL:. If soil is formed at some place have been moved and transported / reposited at some another place different from place of formation, then it is called transported soil.

PHYSICAL PROPERTIES / INDEX PROPERTIES:.

i) WATER CONTENT / MOISTURE CONTENT:.

It is defined as the ratio of the weight

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of water to the weight of soil solids [dry weight of soil] in a given soil sample.

$$w_{total} = \frac{w_w}{w_d}$$

$$W = W_s + W_w$$
$$V = V_s + V_a + V_w$$
$$w = \frac{W - W_d}{W_d}$$

2) Voids ratio (e):.

It is the ratio b/w volume of voids and volume of solids in a given soil sample. It is denoted by small e.

$$e = \frac{\text{Vol of Voids}}{\text{Vol of solids.}}$$

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

3) Porosity:. It is ratio of volume of voids in a given sample to the total volume of soil sample. It may be expressed in percentage or in a decimals.

$$n = \frac{V_v}{V} \times 100$$

$n = \square$ %

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4) DEGREE OF SATURATION:-

It is ratio of volume of water present in the voids of given soil sample to the total volume of soil.

$$S_r = \frac{V_w}{V_v}$$

It is usually expressed in percentage. It is also called percent saturation. Its value ranges from 0 to 1 or 0 to 100 percent.

$S_r = 0$ For fully dry soil

$S_r = 1$ For " saturated soil.

$$S_r = \frac{V_w}{V_v} \rightarrow (A)$$

$$V_v = V_w + V_a$$

$$V_v = V_w$$

$$S_r = \frac{V_w}{V_w} \Rightarrow S_r = 1$$

5) SPECIFIC GRAVITY OF SOIL SOLID:- (G_s)

In soil mechanics specific gravity generally refers to the specific gravity of soil solids and is defined as the ratio of the unit weight of soil solids to the unit weight of water of the same volume at 4 °C.

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

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$$G_s = \frac{V_s \gamma_s}{\gamma_w V_w}$$

$$G_s = \frac{w_s}{w_w}$$

7) BULK / MOIST UNIT WEIGHT / WEIGHT DENSITY:- Its symbol is (γ) and is defined as weight of soil per unit volume.

$$\gamma = \frac{w}{V}$$

It may be expressed in the unit of Pound per cubic feet, Ton/ft³.

8) DRY UNIT WEIGHT:- It is a dry weight or weight of soil solid per unit volume.

$$\gamma_d = \frac{w_d}{V}$$

9) SATURATED UNIT WEIGHT (γ_{ST}):- It is saturated weight of soil sample per unit volume.

$$\gamma_{sat} = \frac{w_{sat}}{V}$$

10) BUOYANT / SUBMERGED UNIT WEIGHT:- It is submerged weight of soil solid per unit volume.

$$\gamma_{sub} = \frac{(w_s)_{sub}}{V}$$

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γ_{sub} is used when soil is below the water table.

11) MASS DENSITY:

It is mass per unit volume.

$$\rho = \frac{\text{Mass of soil sample}}{\text{volume of sample}} = \frac{m}{V}$$

ρ = kg/m^3, $slug/m^3$

12) AIR CONTENT:

It is the ratio of volume of air in soil voids to the volume of voids.

$$a_c = \frac{V_a}{V_v}$$

$a_c + S_r = 1$

$S_r = 1 - a_c$

$S_r = 0$ For fully dry soil

$S_r = 1$ For fully saturated soil.

EXAMPLE. A soil sample taken in the field was found to have weight of 140.5g and having volume 77 cm^3. Find unit weight of soil in Kilo Newton per cubic meter.

Mass of sample = m = 140.5 g = 0.1405×10^{-3} kg

Volume of " = V = 77 cm^3 = 77×10^{-6} m^3

$$\rho = \frac{m}{V} = \frac{0.1405}{77 \times 10^{-6}} = 1820 \text{ kg/m}^3$$

As $1 m^3 = 10^6 cm^3$

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$\gamma = \rho g$

$\gamma = 1820 \times 9.81$

$\gamma = 17854.2 \text{ N/m}^3$

$\gamma = 17.842 \text{ kN/m}^3$

EXAMPLE:- An un disturbed of soil has a volume $100cm^3$ and mass of 190g. After Drying in oven the dry mass is 160gm. The specific gravity of soil is 2.68. Find:?
i) water content w? ii) Dry density iii) Moist Density

Sol. Moist/wet Mass = 190g $\Rightarrow 0.19kg$

Dry mass = m_d = 160g $\Rightarrow 0.16kg$

volume = $V = 100cm^3 \Rightarrow 100 \times 10^{-6} m^3$ $G_s = 2.68$

$w = ?$

$\gamma = ?$

$\gamma_d = ?$

i) $w = \frac{W_w}{W_d}$

Mass of water = $m_w = m - m_d = 190 - 160 = 30g$
$= 0.03kg$

$W_w = m_w g = 0.03 \times 9.81 = 0.29N$

$W_d = 0.16 \times 9.81 = 1.56N$

$\Rightarrow w = \frac{0.29}{1.50} \times 100 = 18.58\%$

ii) $\gamma = \frac{W}{V}$

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$$\gamma = \frac{0.19 \times 9.8}{100 \times 10^{-6}}$$

$\gamma = 18.62 \times 10^{3}\ N/m^{3}$

$\gamma = 18.62\ kN/m^{3}$

iii) $$\gamma_d = \frac{W_d}{V}$$

$$\gamma_d = \frac{0.16 \times 9.8}{100 \times 10^{-6}}$$

$\gamma_d = 15.7 \times 10^{3}\ N/m^{3}$

$\gamma_d = 15.7\ kN/m^{3}$.

∴ Relation between soil Properties :-

1) Relation between γ, γ_d and γ_w $\left(\gamma_d = \frac{\gamma}{1+w}\right)$

Proof:- By def

$$\gamma = \frac{W}{V}$$

$$\gamma = \frac{W_w + W_d}{V}$$

$$\gamma = \frac{W_d}{V} + \frac{W_w}{V}$$

$$\gamma = \frac{W_d}{V} + \frac{W_w}{V} \times \frac{W_d}{W_d}$$

$$\gamma = \frac{W_d}{V}\left(1 + \frac{W_w}{W_d}\right)$$

$$\gamma = \gamma_d\left[1 + w\right]$$

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