LECTURE NOTE

ON

GEOTECHNICAL ENGINEERING **(TH.2)**

3RD SEMESTER IN CIVIL ENGG.

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1st chapter

Def^{n} of soil

Soil is defined as an unconsolidated material, composed of solid particles, produced by the disintegration of rocks.

Soil Engineering

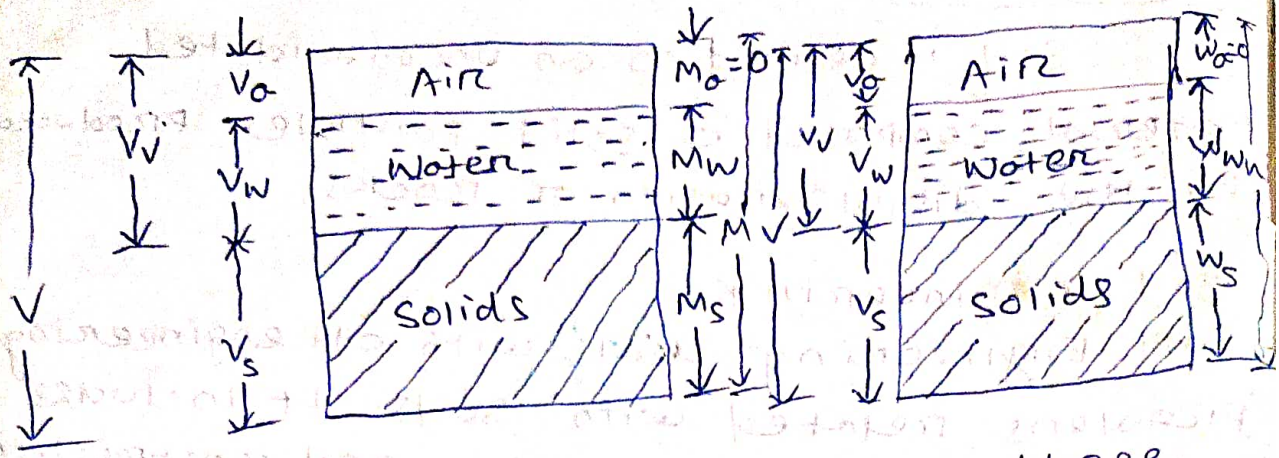
Soil Engineering deals with all engineering problems related with soils. It includes site investigations, design and construction of foundations, earth retaining structures and earth structures.

Scope of soil Mechanics

Soil mechanics has vast application in the construction of various civil Engineering works.

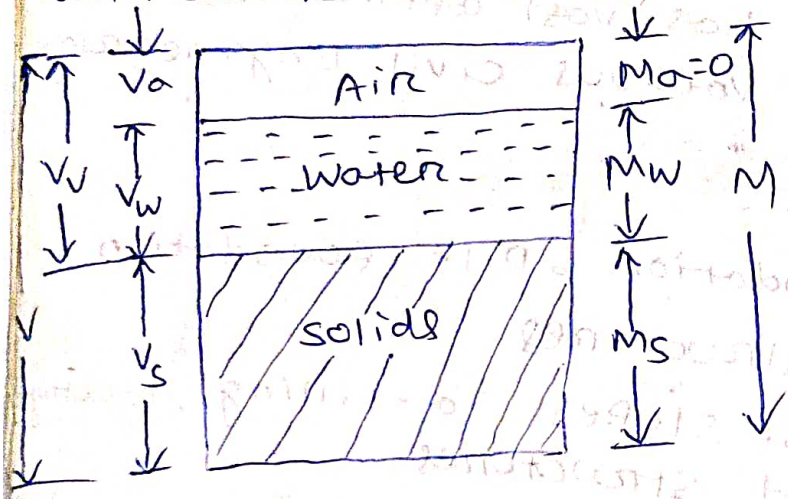
Ex
1 - Fousdation
   a - Shallow foundation, b - Pile foundation
2 - Retaining structures
3 - stability of slopes a - filling, b - cutting
4 - underground structures
   a - Tunnel b - conduit
5 - pavement design
6 - Earth dam
7 - Miscellaneous soil problems
Ex ↓ shrinkage, swelling of soils

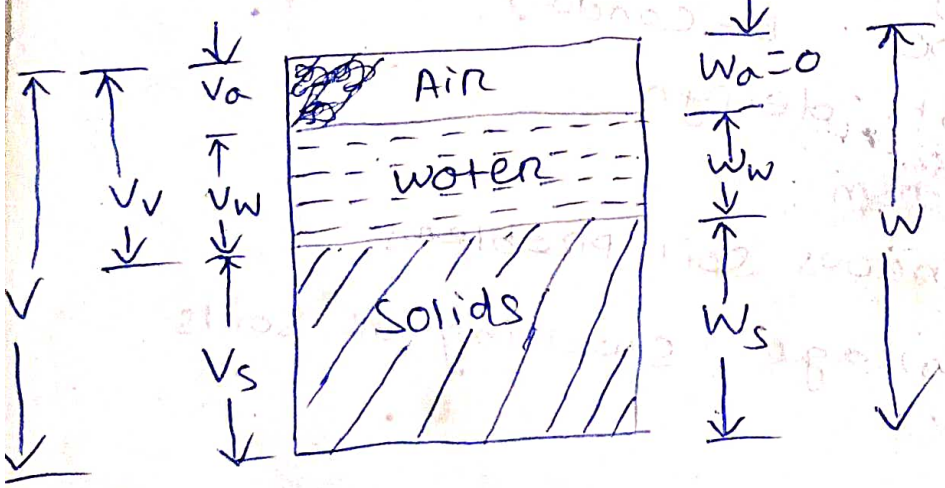
THREE PHASE DIAGRAM (2nd chapter)



$$V_V = V_a + V_W$$

A soil mass is a three phase system consisting of solid particles, water and air. The void space between the soil grains is filled partly with water and partly with air.





where,

V_W = volume of water

V_a = volume of air

V_V = volume of void

V_s = volume of solids

V = Total Volume

M_a = Mass of air = 0

M_w = Mass of water

M_s = Mass of solids

M = Total Mass

W_a = Weight of air = 0

W_w = Weight of water

W_s = Weight of solids

W = Total weight

Water content (w)

The water content (w) is defined as the ratio of the mass of water to the mass of solids

$$w = \frac{M_w}{M_s} \quad \text{or} \quad \frac{W_w}{W_d}$$

⇒ The water content is also known as the moisture content (m)

→ It is expressed as a percentage.

Density (ρ)

Density is defined as the ratio of mass to unit volume of soil.

or

$\rho = \frac{M}{V}$ Density is defined as the mass of the soil per unit volume.

Specific gravity (G)

The specific gravity of solid particles (G) is defined as the ratio of the mass of a given volume of solids to the mass of an equal volume of water at 4°C.

It is denoted as

$$G = \frac{\rho_s}{\rho_w} \quad \text{or} \quad G = \frac{\gamma_s}{\gamma_w}$$

The mass density of water ρ_w at 4°C
= 1 gm/ml, 1000 kg/m^3, 1 mg/m^3

Specific gravity of solids for natural soil = 2.65 to 2.80

Void ratio (e)

It is defined as the ratio of the volume of voids to the volume of solids

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

It is expressed as a decimal

Porosity (n)

It is defined as the ratio of the volume of voids to the total volume.

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

It is expressed as percentage.

$$\frac{1}{n} = \frac{V}{V_v} = \frac{V_v + V_s}{V_v}$$

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

$$n = \frac{e}{1+e} \quad \text{---} (1)$$

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

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

Percentage of air voids (n_a)

It is the ratio of the volume of air to the total volume.

$$n_a = \frac{V_a}{V}$$

It is represented as percentage.

Air content (a_c)

Air content is defined as the ratio of the volume of air to the volume of voids

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

It is expressed as a percentage.

When soil is saturated $V_a = 0$

Thus $$n_a = \frac{V_a}{V} = \frac{V_a}{V_v} \times \frac{V_v}{V}$$

$$n_a = n\, a_c$$

Degree of saturation (S_r)

The degree of saturation (S) is the ratio of the volume of water to the volume of voids.

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

The degree of saturation is generally expressed as a percentage. It is equal to zero when the soil is absolutely dry

And 100%. when the soil is fully saturated. The degree of saturation is expressed as S_r

Bulk Mass density (ρ)

The bulk mass density(ρ) is defined as the total mass (M) per unit total volume(V)

$$\rho = \frac{M}{V}$$

The bulk Mass density is also known as the wet mass density or simply bulk density or density. It is expressed in kg/m^3, gm/ml or Mg/m^3

Dry mass density (ρ_d)

The dry mass density ρ_d is defined as the mass of solids per unit total volume

$$\rho_d = \frac{M_s}{V}$$

The dry mass density is also known as the dry density.

Density index (I_D)

The term density index I_D or relative density or degree of density is used to express the relative compactness of a natural soil deposit.

The density index is defined as the ratio of the difference between the voids ratio of the soil in its loosest state e_{max} and its natural voids ratio 'e' to the difference between the voids ratios in the loosest and densest state

$$I_D = \frac{e_{max} - e}{e_{max} - e_{min}}$$

where

e_{max} = voids ratio in the loosest state

e_{min} = voids ratio in the densest state

e = Natural voids ratio of the deposit.

→ When the natural state of the cohesionless soil is in its loosest form $e = e_{max}$ and hence $I_D = 0$

→ When the natural deposit is in its densest state $e = e_{min}$ & hence $I_D = 1$

→ Any intermediate state, the density index varies between zero & one.

Bulk density (ρ)

The bulk density or moist density is the total mass M of the soil per unit of its total volume

$$\rho = \frac{M}{V}$$

It is expressed in terms of g/cm^3 or kg/m^3

Saturated density (ρ_{sat})

When the soil mass is saturated its bulk density is called saturated density. Thus the saturated density is the ratio of the total soil mass of saturated sample to its total volume.

Dry density (ρ_d)

The dry density is the mass of solids per unit of total volume of the soil mass

$$\rho_d = \frac{M_d}{V}$$

Submerged density (ρ')

The submerged density is the submerged mass of soil solids $(M_d)_{sub}$ per unit of total volume V of the soil