

LECTURE 3

The various relations can be grouped into:

- Volume relations
- Weight relations
- Inter-relations

Volume Relations:

As the amounts of both water and air are variable, the volume of solids is taken as the reference quantity. Thus, several relational volumetric quantities may be defined. The following are the basic volume relations:

1. Void ratio (e) is the ratio of the volume of voids (V_v) to the volume of soil solids (V_s), and is expressed as a decimal.

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

2. Porosity (n) is the ratio of the volume of voids to the total volume of soil (V), and is expressed as a percentage.

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

Void ratio and porosity are inter-related to each other as follows:

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

3. The volume of water (V_w) in a soil can vary between zero (i.e. a dry soil) and the volume of voids. This can be expressed as the degree of saturation (S) in percentage.

$$S = \frac{V_w}{V_v} \times 100$$

For a dry soil, $S = 0\%$, and for a fully saturated soil, $S = 100\%$.

4. Air content (a_c) is the ratio of the volume of air (V_a) to the volume of voids.

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

5. Percentage air voids (n_a) is the ratio of the volume of air to the total volume.

$$n_a = \frac{V_a}{V} \times 100 = n \times a_c$$

Weight Relations:

Density is a measure of the quantity of mass in a unit volume of material. Unit weight is a measure of the weight of a unit volume of material. Both can be used interchangeably. The units of density are ton/m³, kg/m³ or g/cm³. The following are the basic weight relations:

1. The ratio of the mass of water present to the mass of solid particles is called the water content (w), or sometimes the moisture content.

$$w = \frac{W_w}{W_s}$$

Its value is 0% for dry soil and its magnitude can exceed 100%.

2. The mass of solid particles is usually expressed in terms of their particle unit weight (γ_s) or specific gravity (G_s) of the soil grain solids.

$$\gamma_s = \frac{W_s}{V_s} = G_s \cdot \gamma_w$$

where γ_w = Unit weight of water

For most inorganic soils, the value of G_s lies between 2.60 and 2.80. The presence of organic material reduces the value of G_s .

3. **Dry unit weight** (γ_d) is a measure of the amount of solid particles per unit volume.

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

4. **Bulk unit weight** (γ_t or γ) is a measure of the amount of solid particles plus water per unit volume.

$$\gamma_t = \gamma = \frac{(W_s + W_w)}{(V_s + V_v)}$$

5. **Saturated unit weight** (γ_{sat}) is equal to the bulk density when the total voids is filled up with water.

6. **Buoyant unit weight** (γ') or **submerged unit weight** is the effective mass per unit volume when the soil is submerged below standing water or below the ground water table.

$$\gamma' = \gamma_{sat} - \gamma_w$$