1.3 PHASERELATION: -

A soil may be a three Phase system consisting of solid practical, water and air, the void space between the soil grains is filled partly with water and partly with air.(Three phase)

In case of dry soil mass, the voids are filled with air only. In case of perfectly saturated soil, the voids are filled completely. (Two phase)

The total volume (V) of the soil mass consists of

(i)Volume of air(Va)

(ii)Volume of water(Vw) and

(iii)Volume of solids (Vs)

iv) Volume of voids, $V_v = V_a + V_w$

The Weight of air is considered to be negligible, hence the weight of total voids is equal to the weight of water(W_w) $W_a = 0$

$W_v = W_w + W_a W_v = W_w$

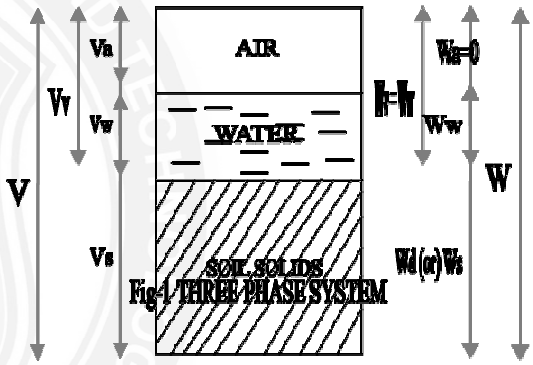

Fig 1.1 Three phase relation diagram

1.3.1. DEFINITION: -

1. Void ratio(e): -

   It is defined as the ratio of volume of voids (V_v) to the volume of soil solids (V_s) no unit. Expressed as number or in decimal form.

$$e = \frac{V_V}{V_S}$$

   *Coarse grained soils, e=0.5to 0.9 *fine grained soils, e =0.7to1.5

2. Porosity(n): -

   It is defined as the ratio of volume of voids to the total volume (V) of soil mass Expensed as %.It is also referred to as percentage voids.0 < n < 100%

$$n = \frac{V_V}{V} X100\ \%$$

3. Degree of Saturation(s):

It is defined as the ratio volume of water(Vw) present in a soil mass to the volume of voids (Vv) Expressed as % it is also referred to as percent saturation.

$$S = \frac{V_W}{V_V} X100\%$$

For dry soil mass, s= 0

For fully saturated, s= 100%

4. Air content:(a_c)

It is defined the ratio of volume of air (Va) present in a soil mass to the volume of voids (V_v) expressed as a number in decimal form.

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

$$a_c = \frac{V_V - V_W}{V_V} = 1 - \frac{V_W}{V_V}$$

$$a_c = 1\text{-}S$$

5. Percentage air voids:(n_a)

It is defined as the ratio of volume air (V_a) present in a soil mass to the total volume of soil mass (v), Expressed as%

$$\eta_a = \frac{V_a}{V} X100\%$$

6. Water content:(w)

It is defined as the ratio of water (W_w) present in a soil mass to the weight of soil solids (W_s) it is usually as %. It is also referred to as moisture content.

$$w = \frac{W_w}{W_s} x100\ \%$$

Range – 0 to∞ forsand–10%to30% for clay– 5%to300%.

1.3.2. UNIT WEIGHTS AND DENSITIES: -

1) Unit Weight of water:(γ_w)

It is the ratio weight of a given a volume water (W_w) to the volume of water (V_w) at a stated temperature.

$$\gamma_w = \frac{W_w}{V_w}\ \text{KN/m}^3$$

Density of Water, $\rho_w = \frac{M_W}{V_w} = \frac{mass\ of\ water}{volume\ of\ water}$ g/cc

γ_w@4°c=19.81KN/m^3 and ρ_w @ 4°c = 1g/cc

2) Bulk Unit Weight :(γ)

It is the Weight of soil mass (w) to the volume of soil mass (V)

$$\gamma = \frac{W}{V} KN/m^3$$

For saturated–moist unit weight

3)Bulk density :(ρ)Mass per unit volume of soil mass.

$$\rho = \frac{M}{V} g/cc$$

4)Dry unit weight(γ_d)

It is the ratio of weight soil solids(W_s)to the volume of soil mass(V)

$$\gamma_d = \frac{W_s or W_d}{V} KN/m^3$$

5)Dry density(ρ_d)

It is the ratio of soil solids (M_s) to the volume soil mass(V).

$\rho_d = \frac{M_{sor M_d}}{V}$ g/cc

6)Saturated unit weight(γ_{sat})

It is the ratio of weight of fully saturated soil mass (W_{sat}) to the total volume of soil mass(V)

$$\gamma_{sat} = \frac{W_{sat}}{V} KN/m^3$$

7)Saturated Density(ρ_{sat}): -

It is ratio of mass of fully saturated soil mass (M_{sat}) to the total volume of soil mass(V)

$\rho_{sat} = \frac{M_{sat}}{V}$ g/cc for fully saturated soil mass,

$\gamma=\gamma_{sat}$(or)$\rho=\rho_{sat}$Submerged unit Weight

8)Buoyant(or)Effective unit Weighty): (γ_{sub})or (γ'):

It is the ratio of submerged weight of soil mass (W_{sub})to the total volume of soil mass(v).

$$\Upsilon_{sub=\Upsilon'} = \Upsilon_{sat} - \Upsilon_w$$

$$\gamma_{sub} or \gamma' = \frac{W_{sub}}{V} KN/m^3$$

9)Submerged density(ρ_{sub}) (ρ'):

It is the ratio of submerged mass of soil mass (M_{sub}) to the total volume of soil mass(V)

$$\rho_{sub} or \rho' = \frac{M_{sub}}{V} g/cc$$

$\gamma' = \gamma_{sat} - \gamma_w$ (or) $\rho' = \rho_{sat} - \rho_w$

10) Unit weight of soil solids (γ_s): -

It is the ratio of weight of soil solids (W_s) to the volume of soil solids (V_s)in a given soil mass

$$\gamma_{sub} = \frac{W_s}{V_s} KN/m^3$$

11) Density soil solids(ρ_s): -

Mass of soil solids (M_s) per unit volume of soil solids (V_s) in a given soil mass

$$\rho_s = \frac{M_s}{V_s} g/cc$$

Conversion:

$$1gcc = \frac{10^6 X\ 9.81}{10^3 X 10^3} \frac{m^3 XN}{KgxKN}$$

1 g/cc = 9.81KN/m^3

12) Specific gravity:(G) or (G_s)Specific gravity of soil particles:

It is defined as the ratio of the weight of a given volume of soil particles (W_s) to the weight of an equivalent volume of pure water at a stated temperature. (W_w)

Ratio of unit weight of soil particles (γ_s) to the unit weight of pure water at a stated temperature.(γ_w)

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

* for sand, G=2.64to2.67

* for clay, G= 2.70to 2.80

* for silt, G = 2.68 to 2.70

13) Specific gravity of soil mass: -(G_m)

It is the ratio of bulk unit weight of (γ) soil mass to the unit weight of pure water (γ_w)at a stated temperature.

$$G_m = \frac{\gamma_m}{\gamma_w} or \frac{\rho}{\rho_w}$$