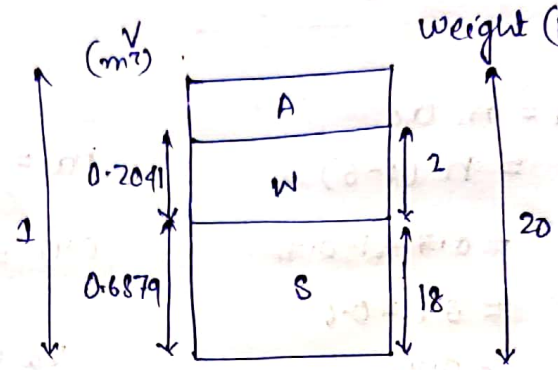
$$V_v = V - V_s$$
$$= 1 - 0.6879$$
$$= 0.3121\ m^3$$

now, phase diagram



water content (w) $= \frac{W_w}{W_s} \times 100 = \frac{2}{18} \times 100 = 11.1\%$.

Porosity (n) $= \frac{V_v}{V} = \frac{0.3121}{1} = 0.3121$ or 31.21%.

void ratio (e) $= \frac{V_v}{V_s} = \frac{0.3121}{0.6879} = 0.45$

degree of saturation (S) $= \frac{V_w}{V_v} = \frac{0.2041}{0.3121} = 0.6539$ 65.39%.

Relationships.

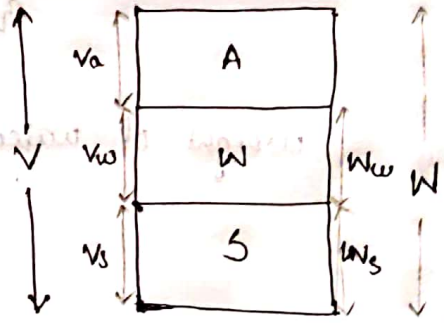
① between void ratio & Porosity

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

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

$$n = \frac{\gamma_s e}{\gamma_s (1+e)}$$

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



3 phase system soil sample

② between vol of solid to total vol.

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

$$V_v = e \cdot V_s$$

$$V = V_v + V_s$$
$$= e V_s + V_s$$
$$= V_s (1+e)$$

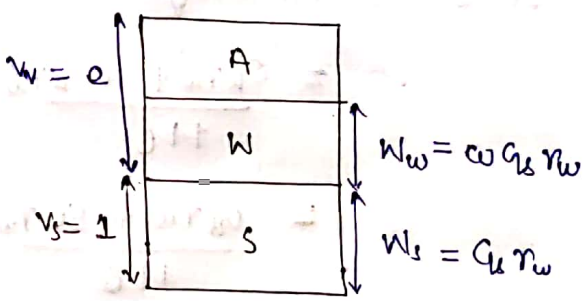
or, $\boxed{V_s = \frac{V}{1+e}}$

③ between w, W_s, W

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

$$W = W_s + W_w$$
$$= W_s + w W_s$$
$$= W_s (1+w)$$

or, $\boxed{W_s = \frac{W}{1+w}}$



④ between G, w, S and e

considering the volume of solid as 1.

$$V_s = 1, \quad e = \frac{V_v}{V_s} \Rightarrow V_v = e$$

$$G_s = \frac{W_s}{V_s \cdot \gamma_w} \Rightarrow W_s = G_s \gamma_w \cancel{V_s}^{1} \Rightarrow W_s = G_s \gamma_w$$

$$w = \frac{W_w}{W_s} \Rightarrow W_w = w W_s \Rightarrow W_w = w G_s \gamma_w$$

$$S = \frac{V_w}{V_v} = \frac{V_w}{e}$$

$$\gamma_w = \frac{W_w}{V_w} \Rightarrow V_w = \frac{W_w}{\gamma_w} \Rightarrow V_w = \frac{w G_s \cancel{\gamma_w}}{\cancel{\gamma_w}}$$

So, $S = \frac{V_w}{e} \Rightarrow Se = V_w \Rightarrow \boxed{S \cdot e = w \cdot G_s}$

⑤ between γ_d, γ_t, ω

$$\gamma_t = \frac{W}{V} = \frac{W_s + W_w}{V} \quad ; \quad \omega = \frac{W_w}{W_s}$$

$$= \frac{W_s + \omega \cdot W_s}{V}$$

$$\gamma_t = \frac{W_s (1+\omega)}{V}$$

$$\gamma_t = \gamma_d (1+\omega)$$

$$\boxed{\gamma_d = \frac{\gamma_t}{1+\omega}}$$

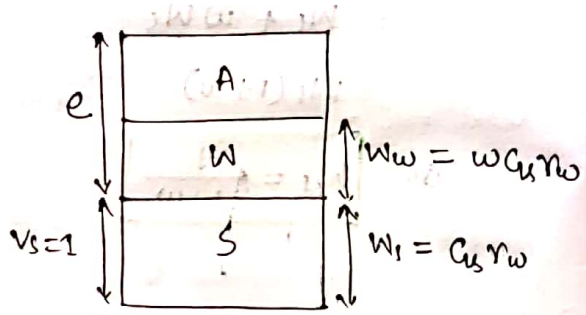
⑥ between γ_t, G_s, γ_w, e, S

$$\gamma_t = W/V \quad ; \text{(considering volume of solid } v_s = 1)$$

$$= \frac{W_s + W_w}{V}$$

$$= \frac{G_s \gamma_w + \omega G_s \gamma_w}{1+e}$$

$$= \frac{G_s \gamma_w + Se \gamma_w}{1+e}$$



$$; \quad Se = \omega G_s$$

$$\boxed{\gamma_t = \frac{(G_s + Se)\gamma_w}{1+e}}$$

for γ_d, $S = 0$, $\gamma_d = \frac{G_s \gamma_w}{1+e}$

for γ_{sat}, $S = 1$, $\gamma_{sat} = \frac{(G_s + e)\gamma_w}{1+e}$

for γ_{sub}, $\gamma_{sat} - \gamma_w$, $\gamma_{sub} = \left(\frac{G_s - 1}{1+e}\right)\gamma_w$