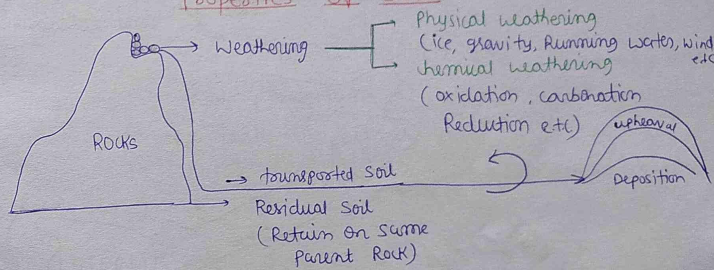
Lecture 1
3|11|19

Soil Mechanics

CHAPTER-1

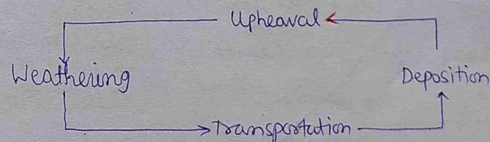
Properties of Soil



→ Soil Disintegrated Part of Rocks.

→ Pedogenesis is the formation of Process of soil.

→ Geological cycle of formation of soil



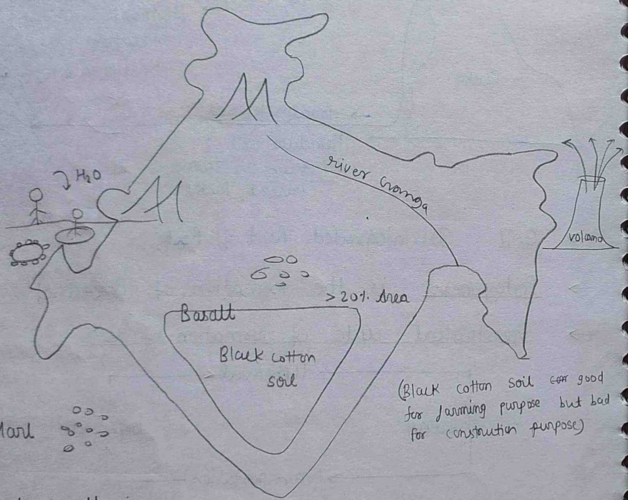
→ Karl Terzaghi is the father of Soil Mechanics

② Types of Soil

Physical weathering and transported soil

1) Alluvial soil	Running water	Near the river bank
2) Lacustrine Soil	Fresh & still water	Lakes, Pond e.t.c
3) Marine soil	Sea water	Sea shores
4) Glacial (till)	Ice	Glacies

5)	colluvial (talus)	Gravity	Mountain valleys
6)	Aeoline (sand dunes)	Wind	Deserts
7)	Loess	Wind blown Silt	After adding water It becomes soft and collapsible



Chemical weathering

8) Marl soil   calcium carbonated soil of Marine originated which is formed due to decomposition of animal bones and aquactic plants.

9) Tuff soil 

It is transported volcanic ash

10) Bentonite soil   It is residual soil. It is formed by volcanic ashes. It is highly plastic clay and shows high swelling and shrinkage due to presence of Montmorillonite clay mineral. It is also used as lubricant in drilling operation

- BLACK COTTON SOIL

It is residual soil formed by Basalt containing a high percentage of clay mineral montmorill-onite. It is dark in colour and good for growing 'cotton'. It shows high swelling and shrinkage and low shear strength.

12) LATERITE SOIL

1) It is type of soil formed due to leeching (washing out of silicious compound and accumulation of FeO_2 and alumi-nium oxide)

2) It is generally found in hilly area having humid climate (Western Ghat, eastern ghat, North east)

13) MUCK SOIL

1) It is a mixture of Inorganic soil and black decomposed organic Matters

14) Peat soil

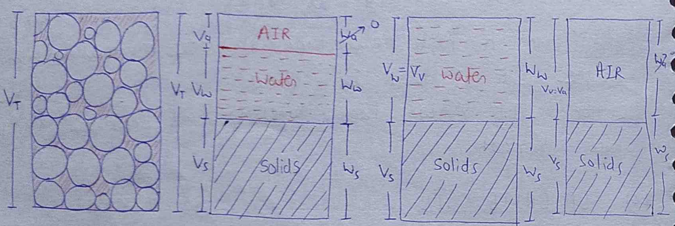
1) It is highly organic soil which almost entirely consist of organic matters in different stages of decomposition. It's colour varies from Black to dark brown and it posses organic order.

2) It is highly compressible soil

15) LOAM SOIL

(It is a mixture of sand, silt and clay)

PHASE DIAGRAM



3 Phase diagram

Saturated stage

Dry stage

→ 2 Phase dia.

* Soil may contain solid, liquid or Air in the mix form. Separate Representation of these Phases is termed as Phase diagram

Important definition

1) Water content / Moisture content (w)

$$w = \frac{\text{Wt of water}}{\text{Wt of solids}} \times 100 = \frac{W_w}{W_s} \times 100 = \frac{M_w}{M_s} \times 100$$ *

Note ① Range of w $\quad w \geq 0$

Note ② Relation in b/w w, W_s and W_{total}

$w = \frac{W_w}{W_s}$ adding 1 on both side

$$w + 1 = \frac{W_w}{W_s} + 1$$

$$w + 1 = \frac{W_w + W_s}{W_s} = \frac{W_{total}}{W_s}$$

$$W_s = \frac{W_{total}}{1+w}$$ **

Note ③ Water content can also be expressed in terms of total wt of soil Mass.

$$w' = \frac{\text{wt of water}}{\text{total wt of soil}} \times 100 = \frac{W_w}{W_T} \times 100 = \frac{M_w}{M_T} \times 100$$

Note Range of w' $\quad 0 \leq w' < 100\%$

Relation in b/w w and w'

$$w' = \frac{W_w}{W_T} = \frac{W_w}{W_s + W_w}, \quad w' = \frac{W_w}{W_w\left(\frac{W_s}{W_w} + 1\right)} = \frac{1}{\frac{1}{w} + 1} \Rightarrow$$

$$w' = \frac{w}{1+w}$$

w in terms of w'

$$\because w' = \frac{1}{\frac{1}{w} + 1} \Rightarrow \frac{1}{w} = \frac{1}{w'} - 1 = \frac{1 - w'}{w'}$$

$$w = \frac{w'}{1 - w'}$$

Note Wt. of solids is stable quantity in comparision to total wt of solid mass bcoz it does not changes with change in wt of water. Hence, engineering significant of w is more than w'

2) Void Ratio

$$e = \frac{\text{Vol}^m \text{ of void}}{\text{Vol}^m \text{ of Solids}} = \frac{V_v}{V_s}$$ **

Range of e $\quad e > 0$

It is generally Represented as decimal fraction

3) Porosity (n)

$$n = \frac{\text{Vol}^m \text{ of voids}}{\text{vol}^m \text{ of Soil Mass}} \times 100 = \frac{V_v}{V_T} \times 100$$

Range of n $\quad 0 < n < 100\%$

$n \neq 100\%$ $\because$ if $n = 100\%$ then $V_v = V_T$ which is not possible in soil mass

Note ① Relation b/w e and n

$$\eta = \frac{V_v}{V_T} = \frac{V_v}{V_s + V_v} = \frac{V_v}{V_v\left(\frac{V_s}{V_v}+1\right)}$$

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

e in terms of n

$$\therefore \eta = \frac{1}{\frac{1}{e}+1} \Rightarrow \frac{1}{e} + 1 = \frac{1}{n}$$

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

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

Note ② through the size of individual void is more in coarse grain soil but the total volm of void in fine grain soil is more than that of coarse grain soil due to more no. of voids

Note ③ Relation in b/w V_s and V_{total}

$e = \frac{V_v}{V_s}$ adding ① on both side $1+e = \frac{V_v}{V_s} + 1 \Rightarrow$

$$1+e = \frac{V_v + V_s}{V_s} = \frac{V_{total}}{V_s}$$ (volm of soil) then $$\boxed{V_s = \frac{V_{total}}{1+e}}$$ **

④ Degree of saturation (s)

$$S = \frac{\text{Volume of water}}{\text{volume of void}} \times 100$$

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

⑤ Air content (a_c)

$$a_c = \frac{\text{volume of air}}{\text{volume of voids}} \times 100$$

$$\boxed{a_c = \frac{V_a}{V_v} \times 100}$$

1) For dry stage	$S = 0\%$	$a_c = 100\%$
2) For Saturated stage	$S = 100\%$	$a_c = 0\%$
3) For Partially saturated	$0 < S < 100\%$	$0 < a_c < 100\%$

Note. Relation b/w S and a_c

$$a_c = \frac{V_a}{V_v} = \frac{V_v - V_w}{V_v} \quad \because V_v = V_a + V_w$$

$$a_c = 1 - \frac{V_w}{V_v} = 1 - S$$

$$\boxed{S + a_c = 1}$$

⑥ Percentage Air voids (n_a)

$$\boxed{\eta_a = \frac{\text{volm of air}}{\text{total volm of soil}} \times 100 = \frac{V_a}{V_T} \times 100}$$

Range of η_a $\boxed{0 \le \eta_a < 100\%}$ $\eta_a \ne 100\%$

Note: Relation b/w η_a and a_c

$$\eta_a = \frac{V_a}{V_T} = \frac{V_a}{V_T} \times \frac{V_v}{V_v}$$ then $$\eta_a = \frac{V_v}{V_T} \times \frac{V_a}{V_v}$$ ($\frac{V_v}{V_T} \to n$, $\frac{V_a}{V_v} \to a_c$)

$$\boxed{\eta_a = n \cdot a_c}$$

unit wt of density

Mass (M) = gm, kg . Density (ρ) = $\frac{\text{Mass}}{\text{Volume}}$ $\left(\frac{gm}{cc}, \frac{kg}{m^3}\right)$

$\rho_w = 1 \frac{gm}{cc}$, $1000 \frac{kg}{m^3}$

$\Rightarrow$ wt ($W = mg$) $\to$ N, KN . unit wt = $\frac{wt}{\text{volm}}$ $\left(\frac{N}{m^3}, \frac{KN}{m^3}\right)$

$\gamma_w = 9810 \, N/m^3$, $9.81 \, KN/m^3$

Ⓐ Bulk unit wt (γ/γ_b) / Bulk density (ρ/ρ_b)

$$\gamma/\gamma_b = \frac{\text{total wt in existing condition}}{\text{total volm of soil}}$$

$$\boxed{\gamma/\gamma_b = \frac{W_{total}}{V_{total}}} \quad \left(\frac{N}{m^3}, \frac{KN}{m^3}\right)$$

$$\boxed{\rho/\rho_b = \frac{M_{total}}{V_{total}}} \quad \left(\frac{gm}{cc}, \frac{kg}{m^3}\right)$$

(B) Saturated unit wt ($\gamma_{saturated}$) or saturated density (ρ_{sat})

$$\gamma_{sat} = \frac{\text{total wt in saturated cond}}{\text{total vol}^m \text{ of soil}}$$

$$\boxed{\gamma_{sat} = \frac{W_{sat}}{V_T}} \quad \boxed{\rho_{sat} = \frac{M_{sat}}{V_T}}$$

(C) Dry unit wt (γ_d) / dry density (ρ_d)

$$\gamma_d = \frac{\text{total wt in dry cond}}{\text{total vol}^m \text{ of soil}} = \frac{W_{dry}}{V_T}$$

$$\boxed{\gamma_d = \frac{W_s}{V_{total}}} , \quad \boxed{\rho_d = \frac{M_s}{V_{total}}}$$

Note ① If soil is dry then it's bulk unit wt will be same as of it's dry unit wt. It means

$\boxed{\text{If } S=0 \text{ then } \gamma_b = \gamma_d}$ — Gamma

Note ② If soil is saturated then it's bulk unit wt. will be same as of it saturated unit wt it mean.

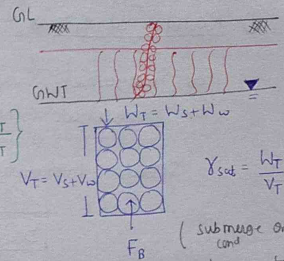
$\boxed{\text{If } S=1 \text{ then } \gamma_b = \gamma_{sat}}$

(d) Submerge unit wt (γ'/γ_{sub}) / Eff. unit wt

When the soil mass is submerge below the G.W.T (Ground water table) It is being acted upon force of buoyancy in vertically upward dirn. Magnitude of which equal the wt of water displaced by soil solid. Hence it result in reduce wt of soil solids. The ratio of submerge wt of soil to the total volm of soil mass is term as submerge unit wt.

$$\boxed{\gamma' / \gamma_{sub} = \frac{(W_s)_{submerged}}{V_T}}$$

Note: Relation in b/w γ' and γ_{sat}



$$(W_T)_{sub} = W_T - F_B = W_T - V_T \gamma_w$$

$$(W_T)_{sub} = V_T \gamma_{sat} - V_T \gamma_w \left\{ \gamma_{sat} = \frac{W_T}{V_T} \right\}$$

$$\gamma' = \frac{(W_T)_{sub}}{V_T} = \frac{V_T \gamma_{sat} - V_T \gamma_w}{V_T}$$

$$\gamma_{sat} = \frac{W_T}{V_T}$$

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

$$\boxed{\rho' = \rho_{sat} - \rho_w}$$

(submerge only when cond buoyancy force will act)
(saturation cond. when buoyancy will not act)

Note: Soil in submerge cond will be in saturated stage but soil in saturated cond need not to be in submerge cond.

Soil mass below the water table is in submerged as well as in saturated cond whereas soil mass in capillary zone is in saturated cond only.

(e) Unit wt of solids (γ_s)

$$\boxed{\gamma_s = \frac{\text{wt of solids}}{\text{vol}^m \text{ of solids}}} \quad \boxed{\gamma_s = \frac{W_s}{V_s}}$$

Note ① $\left\{\gamma_s = \frac{W_s}{V_s}\right\} \neq \left\{\gamma_d = \frac{W_s}{V_T}\right\}$ $\quad \boxed{\rho_s = \frac{M_s}{V_s}}$

Note ② $\gamma_s > \gamma_{sat} > \gamma_b > \gamma_d > \gamma'$

($\gamma_{sat} \simeq 20-21 \, kN/m^3$; $\gamma' \simeq 10 \, kN/m^3$; $\gamma_s \simeq 26-29 \, kN/m^3$)

$$\left\{\gamma' = \frac{1}{2}\gamma_{sat}\right\}$$

(8) Specific Gravity (comparison of wt)

A) True / Absolute sp. gravity

$$G/G_s = \frac{\text{wt of solids of given vol}^m}{\text{wt of std water of same vol}^m (V_s)}$$

$$\boxed{G/G_s = \frac{\gamma_s}{\gamma_w} = \frac{\rho_s}{\rho_w}} \; ★★$$

B) Mass / Bulk / Apparent Specific gravity

$$G_m = \frac{\text{total wt of soil of given vol}^m}{\text{wt of std water of same vol}^m (V_T)}$$

$$\boxed{G_m = \frac{\gamma_b}{\gamma_w} = \frac{\rho_b}{\rho_w}} \; ★$$

Note ① Range of G

for inorganic soil [2.6 to 2.9]*

for organic soil [1 - 2]

Note ② $G_s > G_m$

∴ $\gamma_s > \gamma_b$

Note ③ Specific Gravity is Represented as 27°C

SOUL OF SOIL

① $Se = WG$

② $\gamma_b = \frac{(G+Se)\gamma_w}{1+e}$

③ $\gamma_{sat} = \frac{(G+e)\gamma_w}{1+e}$

④ $\gamma' = \frac{(G-1)\gamma_w}{1+e}$

⑤ $\gamma_d = \frac{G\gamma_w}{1+e}$ $\left\{\gamma_d = \frac{W_s}{V_T}\right\}$

⑥ $\gamma_d = \frac{\gamma_b}{1+w}$

⑦ $\gamma_d = \frac{(1-\eta_a)G\gamma_w}{1+wG}$

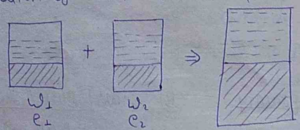
⑧ $e = \frac{n}{1-n}$

⑨ $n = \frac{e}{1+e}$

⑩ $W_s = \frac{W_T}{1+w}$

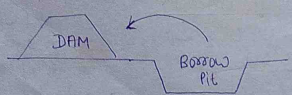
⑪ $V_s = \frac{V_T}{1+e}$

Rule: In the Prm of mixing of soil and excavation and transportation of soil either equate wt of solids (or) volm of solids



$(W_s)_1 + (W_s)_2 = (W_s)_{mix}$

$(V_s)_1 + (V_s)_2 = (V_s)_{mix}$



$(W_s)_{dam} = (W_s)_{B.P}$

$(V_s)_{dam} = (V_s)_{B.P}$

1) Relation in b/w S, e, w, G

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

∵ $\gamma_w = \frac{W_w}{V_w} \Rightarrow W_w = V_w \times \gamma_w$

∵ $\gamma_s = \frac{W_s}{V_s} = G\gamma_w \Rightarrow W_s = V_s . G . \gamma_w$

$w = \frac{W_w}{W_s} = \frac{V_w . \gamma_w}{V_s\, G\gamma_w}$

$Gw = \frac{V_w}{V_s}$ — (B)

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

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

$e = \frac{1}{S} \cdot \frac{V_w}{V_s}$

$Se = \frac{V_w}{V_s}$ — (A)

from (A) and (B) [$Se = WG$]

2) Relation in b/w $\gamma_b, G, e, S, \gamma_w$

$\gamma_b = \frac{W_{total}}{V_{total}} = \frac{W_s + W_w}{V_T}$

∵ $W_w = V_w \gamma_w$

∴ $W_s = V_s . G . \gamma_w$

∴ $V_s = \frac{V_T}{1+e} \Rightarrow V_T = V_s(1+e)$

∴ $\gamma_b = \frac{W_s + W_w}{V_T} = \frac{V_s . G . \gamma_w + V_w \gamma_w}{V_s(1+e)}$

∴ $\gamma_b = \frac{V_s\left(G\gamma_w + \frac{V_w}{V_s}\gamma_w\right)}{V_s(1+e)}$ from eqn (A) $\frac{V_w}{V_s} = Se$

[∴ $\gamma_b = \frac{(G+Se)\gamma_w}{1+e}$] --- ②

3) γ_{sat}

If $S = 1$ then $\gamma_b = \gamma_{sat}$

$\gamma_b = \frac{G + Se}{1+e} = \gamma_{sat}$

[$\gamma_{sat} = \frac{(G+e)\gamma_w}{1+e}$] ---- ③

④ $\gamma' = \gamma_{sat} - \gamma_w$

$$\gamma' = \left(\frac{G+e}{1+e}\right)\gamma_w - \gamma_w = \frac{(G+e-1-e)\gamma_w}{1+e}$$

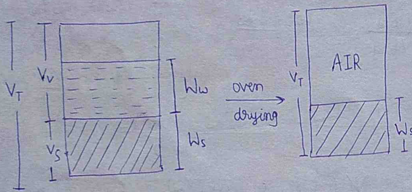
$$\boxed{\gamma' = \frac{(G-1)\gamma_w}{1+e}} \quad ---- ④$$

⑤ γ_d

if $S=0$ then $\gamma_b = \gamma_d$

$$\gamma_b = \frac{(G+Se)\gamma_w}{1+e} = \gamma_d \quad \text{then} \quad \boxed{\gamma_d = \frac{G\gamma_w}{1+e}} \; -- ⑤$$

⑥ Relation b/w γ_b, γ_d and w



$$\gamma_d = \frac{W_{dry}}{V_{dry}} = \frac{W_s}{V_T}$$

$$\therefore W_s = \frac{W_T}{1+w}$$

$$\therefore \gamma_d = \frac{W_s}{V_T} = \frac{W_T}{1+w} \times \frac{1}{V_T}$$

$$= \frac{W_T}{V_T} \times \frac{1}{(1+w)}$$

$$\gamma_b = \frac{W_T}{V_T} \text{ and } w = \frac{W_w}{W_s}$$

$$\boxed{\gamma_d = \frac{\gamma_b}{1+w}} \; — ⑥$$

⑦ Relation in b/w γ_d, η_a, γ_w, w and G

$$\therefore V_T = V_v + V_s = V_a + V_w + V_s$$

$$1 = \frac{V_a + V_w + V_s}{V_T} = \frac{V_a}{V_T} + \frac{V_w + V_s}{V_T} = \eta_a + \frac{V_w+V_s}{V_T}$$

$$(1-\eta_a) = \frac{V_w+V_s}{V_T}$$

$$\left\{ \begin{array}{l} \because \gamma_w = \frac{W_w}{V_w} \Rightarrow \frac{W_w}{\gamma_w} \\ \because \gamma_s = \frac{W_s}{V_s} = G\gamma_w \Rightarrow V_s = \frac{W_s}{G\gamma_w} \end{array} \right.$$

$$\therefore (1-\eta_a) = \frac{V_w+V_s}{V_T} = \frac{1}{V_T}\left\{\frac{W_w}{\gamma_w} + \frac{W_s}{G\gamma_w}\right\}$$

$$\therefore (1-\eta_a) = \frac{1}{V_T} \cdot W_s\left[\frac{W_w}{W_s} \cdot \frac{1}{\gamma_w} + \frac{1}{G\gamma_w}\right] = \frac{W_s}{\gamma_w} + \frac{1}{G\gamma_w}$$

$$\therefore (1-\eta_a) = \left(\frac{W_s}{V_T}\right) \cdot \frac{1}{\gamma_w}\left[\frac{wG+1}{G}\right] = \frac{\gamma_d}{\gamma_w}\left[\frac{wG+1}{G}\right] \quad \left\{\because \frac{W_w}{W_s} = w\right\} \; \left\{\because \frac{W_s}{V_T} = \gamma_d\right\}$$

$$\boxed{\gamma_d = \frac{(1-\eta_a)G\gamma_w}{1+wG}} \; ----- ⑦$$

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$(V_{s1}) + (V_{s2}) = V_s)_{mix}$ then $\left(\frac{V_T}{1+e}\right)_1 + \left(\frac{V_T}{1+e}\right)_2 = \left(\frac{V_T}{1+e}\right)_{mix}$

$$\frac{1.5}{1+0.5} + \frac{1.7}{1+0.7} = \frac{3.2}{1+e_{mix}} \quad \text{then} \quad \boxed{e_{mix} = 0.6}$$

$$n = \frac{e}{1+e} = \frac{0.6}{1+0.6} = 0.375 \text{ Ans}$$

Prob Determine saturated density

AIR	0.2 CC	–
WATER	0.3 CC	0.3 gm
SOLID	0.5 CC	1.3 gm

$V \cdot \rho_w = 0.2 \times 1 \frac{gm}{cc} = 0.2 \frac{gm}{cc}$

$$\rho_{sat} = \frac{1.3\,gm + 0.3\,gm + \text{wt of water having vol}^n\ 0.2\,cc}{0.5+0.3+0.2}$$

(or)

$$\rho_{sat} = \left(\frac{G+e}{1+e}\right)\rho_w = \left(\frac{2.6+1}{1+1}\right) 1\frac{gm}{cc} = 1.8\frac{gm}{cc}$$

$$G = \frac{\rho_s}{\rho_w} = \frac{\frac{M_s}{V_s}}{\rho_w} = \frac{\frac{1.3}{0.5}}{1} = 2.6$$

$$e = \frac{V_v}{V_s} = \frac{0.5}{0.5} = 1$$

Problem (22) Page No - (8)

$\gamma = \frac{(G+Se)\gamma_w}{1+e}$

Option (b)

$\frac{\gamma}{\gamma_w} = \left(\frac{G+Se}{1+e}\right) = \left(\frac{G+wG}{1+e}\right) = \frac{G(1+w)}{(1+e)}$

Imp

$(1+e) = \frac{G(1+w)\cdot\gamma_w}{\gamma}$ then $e = \frac{G(1+w)\cdot\gamma_w}{\gamma} - 1$

$\frac{e}{G} = (1+w)\frac{\gamma_w}{\gamma} - \frac{1}{G}$

$\frac{e}{G} \Rightarrow \frac{wG}{SG} = (1+w)\frac{\gamma_w}{\gamma} - \frac{1}{G}$

$$S = \frac{w}{(1+w)\frac{\gamma_w}{\gamma} - \frac{1}{G}}$$

Problem (38)

$G = \frac{1.04}{4.756 - 5.38 + 1.04} = 2.5$

→ $W_3)_{correct}$ = W_3 + wt of water having vol^m 3ml

= 5.38N + $3\times10^{-6} m^3 \times 9810 \frac{N}{m^3}$ = 5.409

= 5.41

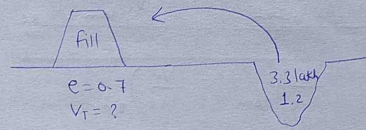
$G)_{correct} = \frac{1.04}{4.756 - 5.41 + 1.04} = 2.694$

⇒ % Error = $\frac{2.694 - 2.5}{2.694} \times 100$ = 7.20% Ans

Problem (32)

	γ_b	w	Cost/m³	$\gamma_d = \frac{\gamma_b}{1+w}$	$V_T = \frac{W_s}{\gamma_d}$	$F = V_T$ Cost/m³
A	15.62	10	80	$\gamma_d = \frac{15.62}{1+0.1}$	$V_T = \frac{W_s}{15.62}\times 1.1$	5.63 W_s
B	13.61	12	60	$\gamma_d = \frac{13.61}{1+0.12}$	$V_T = \frac{W_s}{13.62}\times(1.12)$	4.9 W_s
C	14.85	10	70	$\gamma_d = \frac{14.85}{1+0.1}$	$V_T = \frac{W_s}{14.81}\cdot(1.1)$	5.18 W_s
✓D	12.54	14	50	$\gamma_d = \frac{12.54}{1+0.14}$	$V_T = \frac{W_s}{12.54}\times 1.14$	4.54 W_s

W.B. Q-(44)

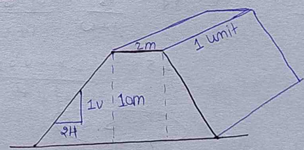


$V_s)_{fill} = V_s)_{B.P.}$

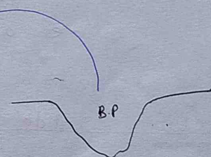
$\frac{V_T}{1+e})_{fill} = \frac{V_T}{1+e})_{B.P.}$

$\frac{V_T}{1+0.7} = \frac{3.2 \text{ lakh}}{1+1.2}$. V_T = 2.55 lakh m³

W.B Q (50)



γ_d = 20 KN/m³
w = 12%



γ = 15 KN/m³
w = 8%

$(W_s)_{dam} = (W_s)_{B.P.}$ $(V_s)_{dam} = (V_s)_{B.P.}$

$\frac{W_T}{1+w})_{dam} = \frac{W_P}{1+w})_{B.P.}$ --- (1)

$V_T)_{dam} = \left(\frac{1}{2}\times20\times10 + 2\times10 + \frac{1}{2}\times20\times10\right) 1m = 220 m^3$

$\gamma_d = \frac{W_s}{V_T} = \frac{\gamma_b}{1+w} = \frac{W_T}{V_T(1+w)}$ $W_s = \frac{W_T}{1+w} = (V_T\cdot\gamma_d)$

= 220 × 20 = 4400 KN

from (1)

$4400 \text{ KN} = \frac{W_T}{1+0.08}$

$W_T)_{B.P.}$ = 1.08×4400 = 4752 KN

$\gamma_b = \frac{W_T}{V_T}$ ⇒ $V_T = \frac{W_T}{\gamma_b} = \frac{4752}{15}$ = 316.8 m³

IInd Approach

$V_s)_{dam} = V_s)_{B.P.}$

$$\frac{V_T}{1+e}\Big)_{dam} = \frac{V_T}{1+e}\Big)_{B.P.}$$

$$\text{No. of trips} = \frac{\text{volm of soil}}{\text{truck capacity}} = \frac{316.8}{6} = 52.8$$

$$\simeq 53 \text{ trips}$$

Dam

$$\gamma_d = \frac{G\gamma_w}{1+e}$$

$$20 = \frac{2.7 \times 9.81}{1+e}$$

$$e = 0.324$$

~~trip~~ B.P.

$$\gamma_b = \left(\frac{G + wG}{1+e}\right)\gamma_w$$

$$\gamma_d = \frac{\gamma_b}{1+w} = \frac{G\gamma_w}{1+e}$$

$$15 = \left(\frac{2.7 + 0.08 \times 2.7}{1+e}\right)9.81$$

$$\boxed{e = 0.908}$$

(D) calcium carbide Method

(Use for Fast Result)