Effective Stress & Pore water pressure:

(L0) # Calculate the total pressure and effective pressure of a swimming pool having 5m of water level from ground. [BPDB - 2016]

Soln: Total pressure, $\sigma = \gamma h$

$= 9.81 \times 5 = 49.05 \text{ KN/m}^2$

Pore water pressure, $u = \gamma_w h$

$= 9.81 \times 5 = 49.05 \text{ KN/m}^2$

Effective pressure, $\boxed{\sigma' = \sigma - u}$ $= 0 \text{ KN/m}^2$ (Ans.)

$\boxed{\sigma' = \gamma h - \gamma_w h}$

(L3) # Find the effective stress and total stress in a depth of 8m, where unit weight of saturated soil is 18 KN/m³ and unit weight of water 9.81 KN/m³. BHDB-2013

Soln: Total stress, $\sigma = \gamma h = 18 \times 8 = 144 \text{ KN/m}^2$

Water pressure, $u = \gamma_w h = 9.81 \times 8 = 78.48 \text{ KN/m}^2$

Effective pressure, $\boxed{\sigma' = \sigma - u = \gamma h - \gamma_w h}$

$= 144 - 78.48$

$= 65.52 \text{ KN/m}^2$

(Ans)

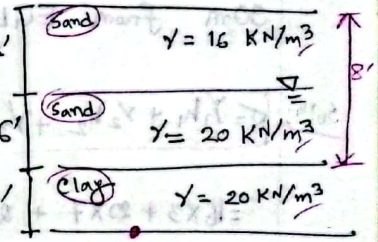
$\gamma_w = 9.81 \text{ KN/m}^3$

(L7) # A sand layer has 8 feet depth, W.T. is at 2' depth below GL. The sand layer is overlying a clay layer of large depth. The moist (above W.T) is 16 KN/m³ and saturated unit weight of sand is 20 KN/m³ and saturated unit weight of clay is 20 KN/m³. Find the total effective pressure at 15' depth. [GTCL - 2016]

Soln:

$\sigma' = \sigma - u$

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



Total pressure, $\boxed{\sigma = \gamma_1 h_1 + \gamma_2 h_2 + \gamma_3 h_3}$

$= 16 \times 0.61 + 20 \times 1.83 + 20 \times 2.13$

$= 88.96 \text{ KN/m}^2$

Water pressure, $\boxed{u = \gamma_w \times (h_2 + h_3)}$

$= 9.81 \times (1.83 + 2.13)$

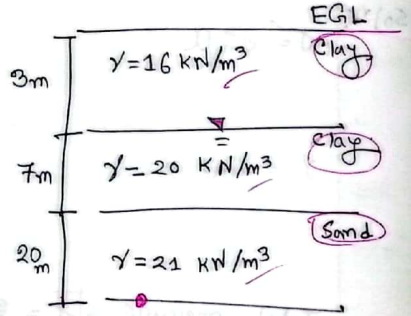
$= 38.85 \text{ KN/m}^2$

Effective pressure, $\boxed{\sigma' = \sigma - u}$ $= 50.11 \text{ KN/m}^2$

(Ans.)

(50) # A clay layer of 10m thickness underlying EGL, water table is lying 3m from EGL. A sand layer of 20m thickness underlying of the clay layer. Unit weight of clay over water table, under water table and saturated unit weight of sand is 16 KN/m³, 20 KN/m³ and 21 KN/m³. Find total stress, effective stress and effective pore water pressure at 30m from EGL.

DNCE-2016



Soln:

$\sigma = \gamma_1 h_1 + \gamma_2 h_2 + \gamma_3 h_3$

$= 16 \times 3 + 20 \times 7 + 21 \times 20$

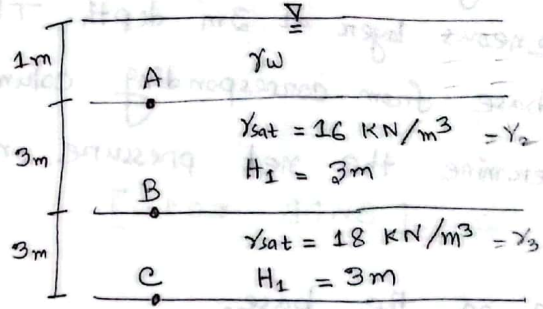
$= 608 \ KN/m^2$

$u = \gamma_w (h_2 + h_3) = 264.87 \ KN/m^2$

$\therefore \sigma' = \sigma - u = 343.13 \ \frac{KN}{m^2}$

(47) # Calculate the effective stress at point C.

BB-2021



Soln:

Effective pressure, $\sigma' = \gamma_1' h_1 + \gamma_2' h_2 + \gamma_3' h_3$

$\Rightarrow \sigma' = \gamma_w h_1 + (\gamma_2 - \gamma_w) h_2 + (\gamma_3 - \gamma_w) h_3$

$= 9.81 \times 1 + (16 - 9.81) \times 3 + (18 - 9.81) \times 3$

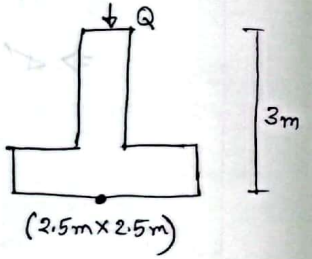
$= 52.95 \ KN/m^2$ (Ans.)

(66) # A square footing (2.5m X 2.5m) is to be placed on a homogeneous layer at 3m depth. The load on footing base from corresponding column is 50 KN. Determine the net pressure on the base. [BWDB - 2014]

Soln: Net pressure on the base,

$$q_F = \frac{Q}{B \times L} = \frac{50}{2.5 \times 2.5} = 8 \text{ kN/m}^2$$

$$\text{Pressure} = \frac{\text{Load}}{\text{Area}}$$



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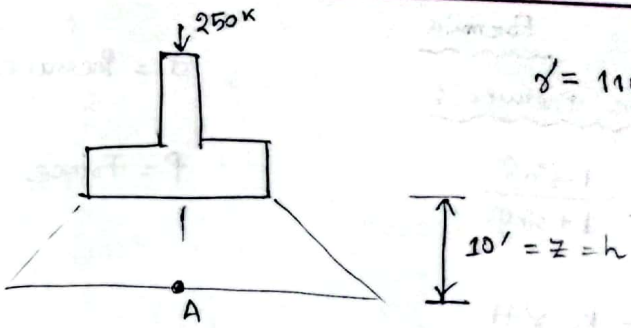
(66) # Compute the stress at point A which is 10' below the base of the single column foundation carrying Q = 250 kip load and size = 10' x 10'; γ = 110 lb/ft³. [WASA - 2014]



γ = 110 lb/ft³

Soln: Pressure increase at point A,

$$\Delta\sigma = \frac{Q}{(B+z)(L+z)}$$

$$= \frac{250}{(10+10)(10+10)} = 0.625 \text{ K/ft}^2$$

$$= 625 \text{ lb/ft}^2$$

So, Stress at point A,

σ = Soil pressure + Footing Pressure

$$\sigma = \gamma h + \Delta\sigma$$

$$= 110 \times 10 + 625$$

$$= 1725 \text{ lb/ft}^2 \quad \text{(Ans.)}$$

Earth Pressure on Retaining Wall :

Formula

σ = Pressure (lb/ft^2)

P = Force (lb/ft)

Active Pressure :

$$K_a = \frac{1-\sin\varphi}{1+\sin\varphi}$$

$$\sigma_a = K_a \gamma H$$

$$P_a = \frac{1}{2} K_a \gamma H^2$$

$$\sigma_{a\,(surcharge)} = K_a \gamma H + K_a q$$

$$P_{a\,(surcharge)} = \frac{1}{2} K_a \gamma H^2 + K_a q$$

Passive Pressure :

$$K_p = \frac{1+\sin\varphi}{1-\sin\varphi}$$

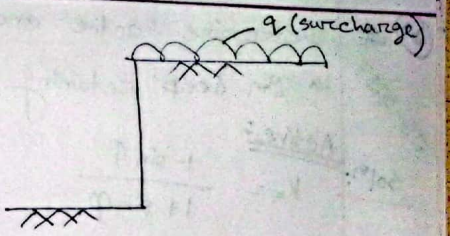
$$\sigma_p = K_p \gamma H$$

$$P_p = \frac{1}{2} K_p \gamma H^2$$

$$\sigma_{P\,(surcharge)} = K_p \gamma H + K_p q$$

$$P_{p\,(surcharge)} = \frac{1}{2} K_p \gamma H^2 + K_p q$$

At Rest :



$$K_o = 1 - \sin\varphi$$

$$\sigma_o = K_o \gamma H$$

$$P_o = \frac{1}{2} K_o \gamma H^2$$

$$\sigma_{a\,(surcharge)} = K_o \gamma H + K_o q$$

$$P_{o\,(surcharge)} = \frac{1}{2} K_o \gamma H^2 + K_o q$$

Depth below ground Level :

- Tensile Crack depth, $z = \frac{2 C_u}{\gamma \sqrt{K_a}}$
- Depth of excavation without any lateral support,

$$H_e = \frac{4 C_u}{\gamma \sqrt{K_a}}$$

$$\therefore H_e = 2 \times z$$

- Location of force $= \frac{H}{3}$

(69) # JB-2017

Determine active and passive pressure diagram of a 3m deep retaining wall, where $\gamma = 20\ KN/m^3$, $\varphi = 35°$.

Soln:

Active:

$$K_a = \frac{1-\sin\varphi}{1+\sin\varphi} = \frac{1-\sin 35°}{1+\sin 35°} = 0.27$$

Active pressure, $\sigma_a = K_a \gamma H$

$= 0.27 \times 20 \times 3$

$= 16.2\ KN/m^2$

Passive:

$$K_p = \frac{1+\sin\varphi}{1-\sin\varphi} = \frac{1+\sin 35°}{1-\sin 35°} = 3.69$$

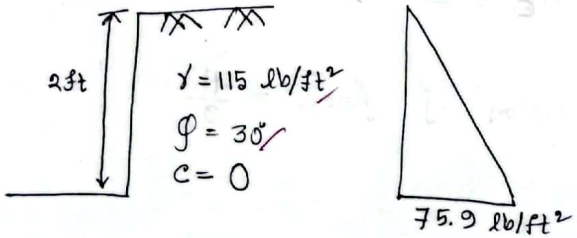
Passive Pressure, $\sigma_p = K_p \gamma H$

$= 3.69 \times 20 \times 3$

$= 221.4\ KN/m^2$ (Am.)

(70) # EGCB-2015

Determine the active earth pressure of following soil profile.



Soln:

$$K_a = \frac{1-\sin\varphi}{1+\sin\varphi} = \frac{1-\sin 30°}{1+\sin 30°} = 0.33$$

Active earth pressure,

$\sigma_a = K_a \gamma H$

$= 0.33 \times 115 \times 2$

$= 75.9\ lb/ft^2$ (Am.)

(69) # Determine the active earth pressure of a sandy soil at a depth 4.5m, where $\varphi = 37°$ and $\gamma = 16.5\ KN/m^3$. [PGCB-2019]

Soln:

$$K_a = \frac{1-\sin\varphi}{1+\sin\varphi}$$

$$= \frac{1-\sin 37°}{1+\sin 37°}$$

$$= 0.249$$

Active earth pressure,

$\sigma_a = K_a \gamma H$

$= 0.249 \times 16.5 \times 4.5$ $(KN/m^3 \times m)$

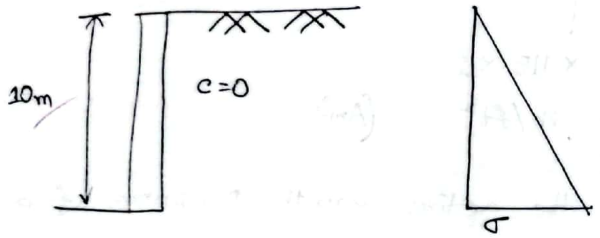
$= 18.49\ KN/m^2$

(Am.)

(90)

DESCO-2015

\#\# Determine the passive pressure on a sheet pile 10 m height if the soil retaining has following properties, $\varphi = 35°$, $\gamma = 19\ KN/m^3$.



Soln:

$$K_p = \frac{1+\sin\varphi}{1-\sin\varphi} = \frac{1+\sin 35°}{1-\sin 35°} = 3.69$$

$$\sigma_p = K_p \gamma H$$

$$= 3.69 \times 19 \times 10$$

$$= 703\ KN/m^2 \quad \text{(Am.)}$$

(91)

BUET MSc-2019, BUET MSc-2017

*** A rigid retaining wall 15′ high supports a backfill of cohesionless soil with $\varphi = 30°$, the water table below the base of the wall. The backfill is dry and has a unit weight of 115 pcf. Determine Rankin's passive earth pressure per meter length (Force) of wall.

Soln:

$$K_p = \frac{1+\sin\varphi}{1-\sin\varphi} = \frac{1+\sin 30°}{1-\sin 30°} = 3$$

The water table below the base of the wall.

No Use

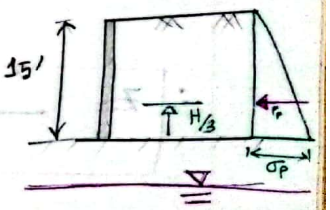
$$\sigma_p = K_p \gamma' H = 3 \times 115\ (lb/ft^3) \times 15\ (ft) = 5175\ lb/ft^2$$

Total passive Force,

$$P_p = \frac{1}{2} K_p \gamma' H^2$$

$$= \frac{1}{2} \times 3 \times 115 \times 15^2$$

$$= 38812.5\ lb/ft$$



Location of Force = $\frac{H}{3} = \frac{15}{3} = 5$ ft from the base of wall. (From bottom)

(Am)

(62) * BUET MSc-2019

A retaining wall has a granular soil backfill with a level top. For the un-drained condition ($\varphi = 0$) of the backfill, determine the maximum depth of the tensile crack if $\gamma = 16\ KN/m^3$ and $C_u = 17\ KN/m^2$.

Soln: Maximum depth of tensile crack,

$$Z = \frac{2C_u}{\gamma\sqrt{K_a}} \qquad (K_a \text{ unknown})$$

Now, $$K_a = \frac{1-\sin\varphi}{1+\sin\varphi}$$

$$= \frac{1-\sin 0^\circ}{1+\sin 0^\circ}$$

$$= 1$$

$$\therefore Z_T = \frac{2C_u}{\gamma\sqrt{K_a}}$$

$$= \frac{2\times 17}{16\times\sqrt{1}}$$

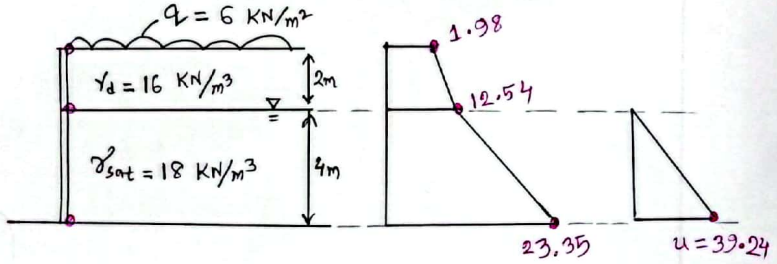
$$= 2.125m \quad \text{(Ans.)}$$

(P.T.O.)

(9c) BPDB-2018, BUET MSc-2014

A retaining wall of 6m height, uniform load acting on the wall is 6 KN/m²; Non-cohesive soil backfill, $\gamma = 18$ KN/m³, $\varphi = 30°$, water table 2m from top. Find out the resultant active force per unit length.

Soln:



$$K_a = \frac{1-\sin\varphi}{1+\sin\varphi} = 0.33$$

$$\gamma' = \gamma_{sat} - \gamma_w = 18 - 9.81 = 8.19 \text{ KN/m}^2$$

At $z = 0$, $\boxed{\sigma_{a0} = K_a q}$ $= 0.33 \times 6$

$= 1.98$ KN/m²

At $z = 2m$, $\boxed{\sigma_{a2} = K_a q + K_a \gamma_d H_1}$

$= 0.33 \times 6 + 0.33 \times 16 \times 2$

$= 12.54$ KN/m²

At $z = 6m$,

$\boxed{\sigma_{a6} = K_a q + K_a \gamma_d H_1 + K_a \gamma' H_2}$

$= 0.33 \times 6 + 0.33 \times 16 \times 2 + 0.33 \times 8.19 \times 4$

$= 23.35$ KN/m²

Pore water pressure, $\boxed{u = \gamma_w H_2}$

$= 9.81 \times 4$

$= 39.24$ KN/m²

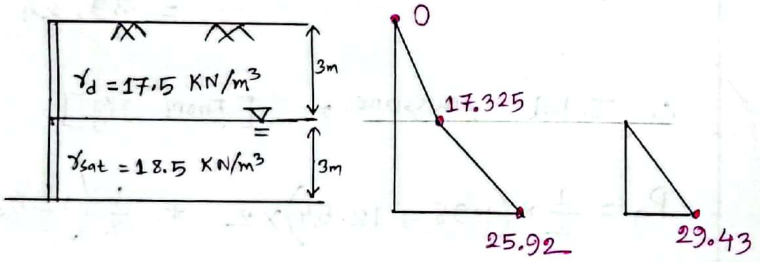
∴ Total pressure, [From fig.]

$$P_a = \frac{1}{2} \times (1.98 + 12.54) \times 2 + \frac{1}{2}(12.52 + 23.35) \times 4 + \frac{1}{2} \times 39.24 \times 4$$

$= 164.78$ KN/m (Ans.)

(98) A retaining wall is 6m Ht, water table 3m from top. Unit wt of soil above and below the water table is $\gamma = 17.5\ KN/m^3$ and $\gamma = 18.5\ KN/m^3$ respectively, $\phi = 30°$. Draw Active pressure diagram and find out the resultant active force per unit length. [DESCO – 2019]

Soln:



$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = 0.33$$

$$\gamma' = \gamma_{sat} - \gamma_w = 18.5 - 9.81 = 8.69\ KN/m^2$$

At $z = 0m$, $\boxed{\sigma_{a0} = 0\ KN/m^2}$ [∵ No Surcharge]

At $z = 3m$, $\boxed{\sigma_{a3} = K_a \gamma_d H_1}$

$= 0.33 \times 17.5 \times 3$

$= 17.325\ KN/m^2$

At $z = 6m$, $\boxed{\sigma_{a6} = K_a \gamma_d H_1 + K_a \gamma' H_2}$

$= 0.33 \times 17.5 \times 3 + 0.33 \times 8.69 \times 3$

$= 25.92\ KN/m^2$

Pore water, $\boxed{u = \gamma_w H_2}$

$= 9.81 \times 3 = 29.43\ KN/m^2$

Total active force per unit length,

$$P_a = \frac{1}{2} \times 17.325 \times 3 + \frac{1}{2} \times (17.325 + 25.92) \times 3 + \frac{1}{2} \times 29.43 \times 3$$

$= 135\ KN/m$ (Ans.)

$\gamma = 20\ KN/m^3$ (Let)

(9t) The unconfined compression of the soil is 50 Kpa. Determine the depth of excavation without any lateral support. [BWDB - 2014]

Soln: Undrained shear strength,

$$C_u = \frac{q_u}{2} = \frac{\text{Unconfined compression}}{2}$$

$$= \frac{50}{2} = 25\ KPa$$

For unconfined compression, $\phi = 0^\circ$

$$\therefore K_a = \frac{1-\sin 0}{1+\sin 0} = 1$$

∴ Maximum unsupported depth,

$$H_E = \frac{4C_u}{\gamma\sqrt{K_a}}$$

$$= \frac{4\times 25}{20\times\sqrt{1}}$$

$$= 5m \quad (Am.)$$

Permeability :

BADC-2020

(9y) Piezometer reading of a soil at two points R_A & R_B are 20cm and 10cm. Length between these two point is 10 cm. Permeability coefficient of the soil is 0.15 mm/sec. Calculate Rate of flow between this two points, through cross sectional area of $10\ cm^2$.

Soln: Piezometer reading of R_A, $h_A = 20$ cm

Piezometer reading of R_B, $h_B = 10$ cm

Length bet^n two points, $L = 10$ cm

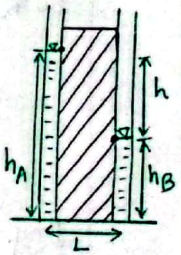
$K = 0.15$ mm/sec $= 0.015$ cm/sec ; $A = 10\ cm^2$

Rate of Flow, $Q = ?$

Now, $h = h_A - h_B = 20 - 10 = 10$ cm

$$i = \frac{h}{L} = \frac{10\ cm}{10\ cm} = 1$$

[i = hydraulic gradient]



Rate of flow (in permeability), (Darcy's Law)

$$Q = KiA = 0.015 \times 1 \times 10$$

$$= 0.15\ cm^3/sec \quad (Am.)$$

Phase Relationship:

✓ Porosity (of Total Volume), $n = \frac{V_v}{V}$

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

✓ Void ratio (to solid), $e = \frac{V_v}{V_s}$

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

✓ Degree of Saturation, $Se = \omega G_s$

✓ Water content, $\omega(\%) = \frac{W_w}{W_s} \times 100$

$$\Rightarrow \omega\% = \frac{W - W_s}{W_s} \times 100$$

✓ Unit wt., $\gamma = \frac{W}{V} = \frac{W_w + W_s}{V_a + V_w + V_s}$

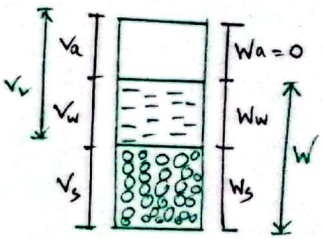
✓ $\gamma = \rho g$

✓ Density, $\rho = \frac{M}{V}$

✓ $\gamma = \gamma_d (1+\omega)$

✓ $\gamma = \gamma_{BULK} = G_s \gamma_w$; $G_s = \frac{\gamma}{\gamma_w}$

✓ Dry wt., $\gamma_d = \frac{W_s}{V}$



✓ $\gamma_d = \frac{\gamma}{1+\omega}$

✓ $\gamma_d = \frac{G_s \cdot \gamma_w}{1+e}$

✓ $\gamma_d = \frac{G_s \gamma_w}{1 + \left(\frac{\omega G_s}{S}\right)}$

✓ $\gamma_{BULK} = \gamma = \frac{G_s \cdot \gamma_w (1+\omega)}{1+e}$

- $\gamma_{sat} = \frac{(G_s + e)\gamma_w}{1+e}$
- $\gamma' = \frac{(G_s - 1)\gamma_w}{1+e}$

✓ $Se = \omega G_s$

✓ Dry Soil, $S = 0$

✓ Saturated Soil, $S = 1$

✓ γ_{sat} = wet

γ' = Submerged

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

For γ_{sat}, $e \to e_{max}$

✓ Relative density,

$$Dr(\%) = \frac{e_{max} - e}{e_{max} - e_{min}}$$

✓ Relative Compaction,

$$R(\%) = \frac{\gamma_{d\,(Field)}}{\gamma_{d\,(Lab)}}$$

$\gamma_w = 9.81$ KN/m^3

$\gamma_w = 62.4$ lb/ft^3

$\rho_w = 1000$ kg/m^3

$\rho_w = 1$ gm/cm^3

Weight-Volume relationship

(99) In its natural states, a moist soil has a volume of 0.4 ft^3 and weight 50 lb, the oven dry weight of soil is 40 lb. Calculate the bulk unit weight, dry unit weight and moisture content of the sample.

[PGCB-2015 ; GTCL-2016]

Soln:

$V = 0.4\ ft^3$, $W = 50\ lb$, $W_s = 40\ lb$

Water weight , $W_w = W - W_s$

$= 50 - 40 = 10\ lb$

Bulk unit weight , $\boxed{\gamma = \frac{W}{V}}$

$= \frac{50}{0.4} = 125\ lb/ft^3$

Dry unit wt. , $\boxed{\gamma_d = \frac{W_s}{V}}$

$= \frac{40}{0.4} = 100\ lb/ft^3$

moisture content, $\boxed{\omega_{(\%)} = \frac{W_w}{W_s} \times 100}$

$= \frac{10}{40} \times 100 = 25\%$

(Am.)

(98) A sample of a sand measured volume 12 cm^3 and weight 32.3 gm. After oven dried the weight of sample is to be measured 31.2 gm. If the solids sand volume is 8.48 cm^3, calculate the void ratio of the sample.

Soln:

$V = 12\ cm^3$

$V_s = 8.48\ cm^3$

Volume of void , $V_v = V - V_s$

$= 12 - 8.48$

$= 3.52\ cm^3$

Void ratio, $\boxed{e = \frac{V_v}{V_s}}$

$= \frac{3.52}{8.48}$

$\therefore e = 0.42$

(Am.)

(9n) Void ratio and volume of soil is given 0.876 and 40 cm^3. Determine the amount of volume of voids and volume of solids.

[WASA - 2014]

Soln:

Porosity, $\eta = \frac{V_v}{V}$ and

$\eta = \frac{e}{1+e} = \frac{0.876}{1+0.876}$

$= 0.467$

$e = 0.876$

$V = 40\ cm^3$

$V_v = ?$

$V_s = ?$

Now, $\eta = \frac{V_v}{V}$

$\Rightarrow 0.467 = \frac{V_v}{40}$

$\therefore V_v = 18.68\ cm^3$

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

$\Rightarrow 0.876 = \frac{18.68}{V_s}$

$\therefore V_s = 21.32\ cm^3$ (Ans.)

$\rho_w = 1000\ kg/m^3$

(10) Determine the specific weight, density and specific gravity of a 1L of fuel oil which has weight of 9N (Take $g = 10\ m/s^2$).

[BB - 2021]

Soln:

Mass, $M = \frac{W}{g} = \frac{9}{10}$

$= 0.9\ kg$

$V = 1L = 10^{-3}\ m^3$

$W = 9N = 9 \times 10^{-3}\ KN$

Specific weight, $\gamma = \frac{W}{V}$

$= \frac{9 \times 10^{-3}}{10^{-3}} = 9\ KN/m^3$

Density, $\rho = \frac{M}{V} = \frac{0.9}{10^{-3}} = 900\ kg/m^3$

Specific gravity, $G = \frac{\gamma_s}{\gamma_w} = \frac{\rho_w}{\rho_w}$

$= \frac{900}{1000}\ \frac{(kg/m^3)}{(kg/m^3)}$

$= 0.9$ (Ans.)

$\gamma_w = 9.81$ KN/m³

(Q2) A saturated soil of $w = 30\%$, $G = 2.65$, determine the dry unit weight. [PGCB-2017]

Soln:

$Se = wG_s$

$\Rightarrow 1 \times e = 0.30 \times 2.65$

$\therefore e = 0.795$

$w = 30\% = 0.30$
$G = 2.65$
$S = 1$ (For Fully Saturated)

Dry unit weight,

$$\gamma_d = \frac{G_s \gamma_w}{1+e} = \frac{2.65 \times 9.81}{1+0.795}$$

$= 14.48$ KN/m³ (Am.)

(Q3) The dry density of a sand with a porosity of 0.381 is 1600 kg/m³. Find the void ratio of the soil and the specific gravity of the solids. [33th BCS]

$\gamma_w = 62.4$ lb/ft³

Soln:

Void ratio,

$$e = \frac{n}{1-n} = \frac{0.381}{1-0.381} = 0.615$$

$n = 0.381$
$\rho_d = 1600$ Kg/m³
$e = ?$
$G_s = ?$

Now, $\rho_d = \frac{G_s \cdot \rho_w}{1+e}$

$\Rightarrow 1600 = \frac{G_s \times 1000}{1+0.615}$

$\therefore G_s = 2.58$ (Am.)

(Q4) In a natural state, a moist soil has a volume of 0.33 ft³ and weight 39.93 lb. The oven dry weight of soil is 34.54 lb. If the specific gravity is 2.75, calculate dry unit weight and void ratio. [BUET MSc-2019], [BCIC-2017]

Soln:

Dry Unit wt., $\gamma_d = \frac{W_s}{V} = \frac{34.54}{0.33}$

$= 104.66$ lb/ft³

$V = 0.33$ ft³
$W = 39.93$ lb
$W_s = 34.54$ lb
$G_s = 2.75$
$\gamma_d = ?$
$e = ?$

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

$\Rightarrow 104.66 = \frac{2.75 \times 62.4}{1+e}$

$\therefore e = 0.63$ (Am.)

(b-8) Water content of a fully saturated soil sample is 50%, specific gravity of soil solid is 2.65, Find the values of bulk unit weight, dry unit weight and void ratio. [SGCL-2017]

Soln:

For Fully Saturated soil,

$S = 1$

$w = 50\% = 0.5$

$G_s = 2.65$

$\gamma = ?$

$\gamma_d = ?$

$e = ?$

$$Se = w G_s$$

$\Rightarrow 1 \times e = 0.5 \times 2.65$

$\therefore e = 1.325$

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

$$= \frac{2.65 \times 9.81}{1 + 1.325}$$

$\therefore \gamma_d = 11.18 \ KN/m^3$

And,

$$\gamma_d = \frac{\gamma}{1+w}$$

$\Rightarrow 11.18 = \frac{\gamma}{1+0.5}$

$\therefore \gamma = 16.77 \ KN/m^3$ (Ans.)

(b-9) Water content, specific gravity and void ratio of a soil sample are 20%, 2.68 and 0.78, Now calculate dry unit weight, degree of saturation and porosity. [BIWTA-2019]

Soln:

$w = 20\% = 0.20$

$G_s = 2.68$

$e = 0.78$

$\gamma_d = ?$

$S = ?$

$n = ?$

Dry Unit weight,

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

$$= \frac{2.68 \times 9.81}{1 + 0.78}$$

$= 14.77 \ KN/m^3$

$$Se = w G_s$$

$\Rightarrow S \times 0.78 = 0.2 \times 2.68$

$\therefore S = 0.687$

$= 68.7\%$

Porosity,

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

$$= \frac{0.78}{1 + 0.78}$$

$= 0.43$ (Ans.)

(b-6) Determine the soil is saturated or not. Where porosity $n = 0.6$, water content $w = 54.54\%$, and specific gravity $G_s = 2.75$. If the soil is saturated, find out the value of γ_d. [BCIC-2019]

Soln: Void ratio, $e = \frac{n}{1-n}$

$= \frac{0.6}{1-0.6} = 1.5$

$\boxed{Se = wG_s}$

$\Rightarrow S \times 1.5 = 0.5454 \times 2.75$

$\therefore S = 1 = 100\%$

So, the soil is fully saturated.

Dry Unit weight,

$\boxed{\gamma_d = \frac{G_s \gamma_w}{1+e}}$

$= \frac{2.75 \times 9.81}{1+1.5}$

$= 10.79 \ KN/m^3$ (Ans)

(b-9) 100 cm^3 sample of moist soil has a mass of 212.25 gm. Water content 16%, specific gravity of soil is 2.68. Calculate bulk density, dry density, void ratio and porosity of the soil. [BB AD-2018], [DNCC-2016]

Soln: Bulk density, $\boxed{\rho = \frac{M}{V}}$

$= \frac{212.25}{100} = 2.12 \ g/cm^3$

Dry density, $\boxed{\rho_d = \frac{\rho}{1+w}}$

$= \frac{2.12}{1+0.16} = 1.83 \ g/cm^3$

$V = 100 \ cm^3$
$M = 212.25 \ gm$
$w = 16\% = 0.16$
$G_s = 2.68$
$\rho = ? \quad \rho_d = ?$
$e = ? \quad n = ?$

$\boxed{\rho_d = \frac{G_s \rho_w}{1+e}}$

$\Rightarrow 1.83 = \frac{2.68 \times 1}{1+e} \quad \therefore e = 0.465$

Porosity, $\boxed{n = \frac{e}{1+e}} = \frac{0.465}{1+0.465}$

$= 0.317$

$= 31.7\%$ (Ans)

(ক) An undisturbed sample of clayey soil have wet weight 285 N, dry weight 250 N and volume 14×10^3 cm^3. If $G_s = 2.70$, then calculate w, e and S. [HBFC - 2018]

Soln: Water content, $\boxed{w(\%) = \frac{W_w}{W_s} \times 100}$

$$= \frac{W - W_s}{W_s} \times 100$$

$$= \frac{285 - 250}{250} \times 100$$

$$= 14\% \qquad = 0.14$$

Now,

$$\boxed{\gamma_d = \frac{W_s}{V}} = \frac{250}{14 \times 10^3} = 0.01786 \text{ N/cm}^3$$

$$= 17.86 \text{ KN/m}^3$$

$$\boxed{\gamma_d = \frac{G_s \gamma_w}{1+e}}$$

$$\Rightarrow 17.86 = \frac{2.70 \times 9.81}{1+e} \qquad \therefore e = 0.483$$

$$\boxed{se = w G_s}$$

$$\Rightarrow S \times 0.483 = 0.14 \times 2.70 \qquad \therefore S = 0.7812$$

$$= 78.12\% \text{ (Ans)}$$

$\rho_w = 1$ gm/cm^3

(খ) Total volume of a soil sample is 150 cm^3, saturated weight is 250 gm and dry weight of the sample is 210 gm. If the specific gravity of the soil is 2.6, find out the saturation of the soil sample. [DESCO - 2019]

Soln: Water content, $\boxed{w(\%) = \frac{M_w}{M_s} \times 100}$

$$\Rightarrow w = \frac{M - M_s}{M_s} \times 100$$

$$= \frac{250 - 210}{210} \times 100 \qquad = 19\% = 0.19$$

$V = 150$ cm^3
$M = 250$ gm
$M_s = 210$ gm
~~$V = 150$~~
$G_s = 2.6$
$S = ?$

$$\boxed{\rho_d = \frac{M_s}{V}} = \frac{210}{150} = 1.4 \text{ g/cm}^3$$

$$\boxed{\rho_d = \frac{G_s \rho_w}{1+e}}$$

$$\Rightarrow 1.4 = \frac{2.6 \times 1}{1+e} \qquad \therefore e = 0.85$$

$$\boxed{se = w G_s}$$

$$\Rightarrow S \times 0.85 = 0.19 \times 2.6$$

$$\therefore S = 0.576 \qquad = 57.6\% \text{ (Ans.)}$$

$1\ gm/cm^3 = 62.428\ lb/ft^3$

$1\ gm/cm^3 = 9.81\ KN/m^3$

(20) A 27.50 lb soil sample has a volume of 0.22 cft, moisture content of 15.20% and specific gravity of soil solids is 2.67. Compute the bulk density, dry density, degree of saturation and void ratio. [32th BCS]

Soln:

Bulk unit weight,

$$\gamma = \frac{W}{V} = \frac{27.50}{0.22}$$

$$= 125\ lb/ft^3$$

Bulk density, $\rho = \frac{\gamma}{62.428}$ (g/cm^3)

$$\Rightarrow \rho = \frac{125}{62.428}$$

$$= 2.002\ g/cm^3$$

Dry density, $\rho_d = \frac{\rho}{1+w}$

$$= \frac{2.002}{1+0.152} = 1.74\ g/cm^3$$

$W = 27.50$ lb

$V = 0.22$ cft

$w = 15.20\% = 0.152$

$G_s = 2.67$

$\rho = ?$ $\rho_d = ?$

$S = ?$ $e = ?$

Now, $\rho_d = \frac{G_s \cdot \rho_w}{1+e}$

$$\Rightarrow 1.74 = \frac{2.67 \times 1}{1+e}$$

$$\therefore e = 0.534$$

And, $Se = wG_s$

$$\Rightarrow S \times 0.534 = 0.152 \times 2.67$$

$$\Rightarrow S = 0.76 = 76\%$$ (Ans)

$1\ gm/cm^3 = 9.81\ KN/m^3$

(২২) 100 cm^3 sample of moist soil has a mass of 212.25 gm, water content 16%. Specific gravity of soil is 2.68, calculate (a) void ratio (b) Dry unit weight of soil and (c) Degree of saturation. [PGCB-2018]

Soln:

Bulk density, $\rho = \frac{M}{V}$

$\Rightarrow \rho = \frac{212.25}{100} = 2.12\ g/cm^3$

$V = 100\ cm^3$

$M = 212.25\ gm$

$w = 16\% = 0.16$

$G_s = 2.68$

$e = ?$ $\gamma_d = ?$

$S = ?$

Bulk unit weight,

$\gamma = \rho \times g$

$= 2.12 \times 9.81$

$= 20.79\ KN/m^3$

Dry Unit wt., $\gamma_d = \frac{\gamma}{1+w}$

$= \frac{20.79}{1+0.16}$

$= 17.92\ KN/m^3$

Now, $\gamma_d = \frac{G_s \cdot \gamma_w}{1+e}$

$\Rightarrow 17.92 = \frac{2.68 \times 9.81}{1+e}$

$\therefore e = 0.467$

$Se = wG_s$

$\Rightarrow S \times 0.467 = 0.16 \times 2.68$

$\therefore S = 0.9182 = 91.82\%$ (Am.)

(৮৮নং math এর মত কিছুটা)

(২২) The moist weight of 0.006 m^3 of soil is 10 Kg. If moisture content of the soil is 13% and specific gravity of the soil is 2.71, find the porosity of the soil sample. [TGTDCL - 2021]

Soln:

$\gamma = \frac{W}{V} = \frac{98.1 \times 10^{-3}}{0.006}$

$= 16.35 \text{ KN/m}^3$

$\gamma_d = \frac{\gamma}{1+w} = \frac{16.35}{1+0.13}$

$= 14.46 \text{ KN/m}^3$

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

$\Rightarrow 14.46 = \frac{2.71 \times 9.81}{1+e}$

$\therefore e = 0.83$

Porosity, $n = \frac{e}{1+e} = \frac{0.83}{1+0.83}$

$= 0.4536$

$= 45.36\%$ (Am.)

$V = 0.006 \text{ m}^3$

$W = 10 \text{ Kg}$

$= 10 \times 9.81$

$= 98.1 \text{ N}$

$= 98.1 \times 10^{-3} \text{ KN}$

$w = 13\% = 0.13$

$G_s = 2.71$

$n = ?$

(২৩) In a field hole, ~~is~~ cut off volume is 1.1 ft^3 and the wet mass of the hole is 130 lb, dry mass is 119 lb. Determine the degree of saturation if specific gravity is 2.7. [BWDB-2016]

Soln:

$\gamma = \frac{W}{V} = \frac{130}{1.1} = 118.18 \text{ lb/ft}^3$

$\gamma_d = \frac{W_s}{V} = \frac{119}{1.1} = 108.18 \text{ lb/ft}^3$

$\gamma_d = \frac{\gamma}{1+w}$

$\Rightarrow 108.18 = \frac{118.18}{1+w}$

$\Rightarrow w = 0.0924 = 9.24\%$

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

$\Rightarrow 108.18 = \frac{2.7 \times 62.4}{1+e}$

$\therefore e = 0.557$

$Se = w G_s$

$\Rightarrow S \times 0.557 = 0.0924 \times 2.7$

$\therefore S = 0.4479$

$= 44.79\%$ (Am.)

$V = 1.1 \text{ ft}^3$

$W = 130 \text{ lb}$

$W_s = 119 \text{ lb}$

$G_s = 2.7$

$S = ?$

$\gamma_w = 9.81\ KN/m^3$

(২৪) A saturated clay soil has 45% moisture content and $G_s = 2.7$, determine the unit weight of soil? [DPDC-2019]

Soln: For fully saturated soil, $S = 1$

$Se = wG_s$

$\Rightarrow 1 \times e = 0.45 \times 2.7$

$\therefore e = 0.81$

$w = 45\% = 0.45$

$G_s = 2.7$

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

$$= \frac{(2.7 + 0.81) \times 9.81}{1 + 0.81}$$

$$= 19.02\ KN/m^3 \quad (Ans.)$$

Hints: S এর value দেওয়া থাকলে,

$$\gamma_{sat} = \frac{(G_s + Se)\gamma_w}{1+e}$$

$\gamma_w = 62.4\ pcf$

(২৫) Find the unit weight of a saturated soil, γ_{sat} if the unit weight of dry soil is $\gamma_d = 110$ pcf and specific gravity, $G_s = 2.7$. [DPDC-2014, PGCL-2017]

Soln: Dry unit wt.,

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

$$\Rightarrow 110 = \frac{2.7 \times 62.4}{1+e} \qquad \therefore e = 0.531$$

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

$$= \frac{(2.7 + 0.531) \times 62.4}{1 + 0.531}$$

$\therefore \gamma_{sat} = 131.69\ pcf$ (Ans.)

(২৬) Saturated unit weight and moisture content are 19.3 KN/m³ and 28% respectively. Calculate void ratio. [SGFL-2021]

Soln:

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

$$\Rightarrow \gamma_{sat} = \frac{\left(\frac{e}{\omega} + e\right)\gamma_w}{1+e}$$

$$\Rightarrow \gamma_{sat} = \frac{\frac{e}{\omega}(1+\omega)\gamma_w}{1+e}$$

$$\Rightarrow 19.3 = \frac{e/0.28 \times (1+0.28) \times 9.81}{1+e}$$

$\therefore e = 0.755$ (Am.)

$\gamma_{sat} = 19.3$ KN/m³

$\omega = 28\% = 0.28$

For fully saturated Soil, $e = \omega G_s$

$\therefore G_s = \frac{e}{\omega}$

$e = ?$

(২৭) Void ratio of a soil sample is 50%. If specific gravity of soil solid 2.7 then calculate submerged unit weight. [BPDB-2015]

Soln:

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

$$= \frac{(2.7 + 0.50) \times 9.81}{1 + 0.50}$$

$$= 20.928 \text{ KN/m}^3$$

$e = 50\% = 0.50$

$G_s = 2.7$

Now, $\gamma_{sub} = \gamma_{sat} - \gamma_w$

$= 20.928 - 9.81$

$= 11.118$ KN/m³ (Am.)

Hints:

এখানে Math করার আলাদাভাবে γ' বা γ_{sub} এর সূত্র মুখস্ত করতে হয় না।

$\rho_w = 1\ gm/cm^3$

(২৮) The dry density of a soil is 1.58 gm/cc. If the saturation water content is 50% then what ~~who~~ would be its saturated density and submerged density? [BWDB - 2013]

Soln:

$$\rho_{sat} = \rho_d (1+w)$$

$$= 1.58 \times (1 + 0.50)$$

$$= 2.37\ gm/cm^3$$

$\rho_d = 1.58\ gm/cc$

$w = 50\% = 0.50$

$\rho_{sat} = ?$

$\rho_{sub} = ?$

$$\rho_{sub} = \rho_{sat} - \rho_w$$

$$= 2.37 - 1 = 1.37\ gm/cm^3 \quad (Ans.)$$

(২৯) Dry unit weight of soil is 1.65 gm/cc and specific gravity 2.67. Determine saturated unit weight and void ratio. Calculate the hydraulic head that would produce a quick condition in sand stratum of thickness 1.476 m. [RPGCL - 2017]

$\gamma_w = 1\ gm/cc = \rho_w$

$\gamma_w = 9.81\ KN/m^3$

Soln:

$$\gamma_d = \frac{G_s \cdot \gamma_w}{1+e}$$

$$\Rightarrow 1.65 = \frac{2.67 \times 1}{1+e}$$

$$\therefore e = 0.61$$

$\gamma_d = 1.65\ gm/cc$

$G_s = 2.67$

$\gamma_{sat} = ?$

$H_h = ?$

$h = 1.476\ m$

Now,

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

$$= \frac{(2.67 + 0.61) \times 9.81}{1 + 0.61}$$

$$= 19.98\ KN/m^3$$

Hydraulic head, H_h = Hydraulic gradient × Thickness

$$\Rightarrow H_h = \frac{G-1}{1+e} \times h$$

$$= \frac{2.67 - 1}{1 + 0.61} \times 1.476$$

$$= 1.53\ m \quad (Ans.)$$

(200) The difference between the maximum and minimum void ratio is 0.3 and field void ratio is 0.4. If relative density is 66.6% then find out the saturated density at its loosest condition. Specific gravity of the soil is 2.65.

[BPDB-2016, RPGCL-2017, CPGCBL-2018]

Soln:

Relative density,

$$D_r = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

$e_{max} - e_{min} = 0.3$

$e = 0.4$

$D_r = 66.6\ \%$

$\gamma_{sat} = ?$ $G_s = 2.65$

$$\Rightarrow 66.6 = \frac{e_{max} - 0.4}{0.3} \times 100$$

$\therefore e_{max} = 0.6$

Now,

$$\gamma_{sat} = \frac{(G_s + e_{max})\gamma_w}{1 + e_{max}}$$

$$= \frac{(2.65 + 0.6)\ 9.81}{1 + 0.6}$$

$= 19.92\ KN/m^3$ (Ans.)

(202) A soil having 6′ depth. Its relative density is 40% with minimum void ratio 0.46 and maximum void ratio is 0.9, Its specific gravity is 2.65, Find the dry density of soil. [BHP-2017]

Soln:

$$D_r = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

$D_r = 40\%$

$e_{min} = 0.46$

$e_{max} = 0.9$

$G_s = 2.65$

$\rho_d = ?$

Depth = 6′

$$\Rightarrow 40 = \frac{0.9 - e}{0.9 - 0.46} \times 100$$

$\therefore e = 0.724$

Dry density,

$$\rho_d = \frac{G_s \rho_w}{1 + e}$$

$$= \frac{2.65 \times 1}{1 + 0.724}$$

$= 1.53\ gm/cm^3$ (Ans.)

(202) The soil used in an embankment construction found to have MDD of 19 KN/m³ from standard proctor test. The specifications are: minimum 95% compaction. After finishing by roller, a block of soil is extracted from the compaction layer using a pipe section of 100 mm length and 75mm internal dia. Wet and dry weight of extracted soil is 865 gm and 810 gm respectively. Does the layer meet specifications? [DMTCL-2019]

Soln:

MDD, $\gamma_{d(max)} = 19$ KN/m³

Pipe dia, ~~d = 10~~
$d = 75$ mm

Pipe length, $l = 100$ mm

Volume of sample,

$V = \pi r^2 h$

$\therefore V = \pi\left(\frac{d}{2}\right)^2 \times l$

$= \pi \times \left(\frac{75}{2}\right)^2 \times 100$

$= 441787 \text{ mm}^3$

$= 4.418 \times 10^{-4} \text{ m}^3$

$1 \text{ KN} = 101.97 \times 10^3 \text{ gm}$

Dry weight of sample,

$W_s = 810 \text{ gm} = \frac{810}{101.97 \times 10^3} \text{ KN}$

$= 0.00794 \text{ KN}$

Dry density in field, $\gamma_d = \frac{W_s}{V}$

$= \frac{0.00794}{4.418 \times 10^{-4}} = 17.97 \text{ KN/m}^3$

Now,

$\% \text{ Compaction} = \frac{\text{Dry density in field}}{\text{Max dry density (MDD) in Lab}}$

$= \frac{17.97}{19} \times 100$

$= 94.57\%$

Here, % compaction is 94.57% which is less than the specified 95% compaction.

So, the layer doesn't met the specification.