Soil Mechanics

HW 2

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Problem ① : (A) Show that $\gamma_d = \dfrac{e\,S\,W_w}{(1+e)\,w}$

$\gamma_d = \dfrac{W_{solid}}{V_{solid} + V_{air}}$, $e = \dfrac{V_v}{V_{solid}} \rightarrow V_{air} = e\,V_{solid}$

$= \dfrac{W_{solid}}{V_{solid} + e\,V_{solid}}$

$= \dfrac{W_{solid}}{V_{solid}(1+e)}$, $\dfrac{W_{solid}}{V_{solid}} = \gamma_{solid}$

$= \dfrac{\gamma_{solid}}{1+e}$, $\gamma_{solid} = G_s\,\gamma_w$

$= \dfrac{G_s\,\gamma_w}{(1+e)}$, $Se = G_s\,w \rightarrow G_s = \dfrac{Se}{w}$

$= \dfrac{Se\,\gamma_w}{(1+e)\,w}$

(B) Show that $e = \dfrac{\gamma_{sat} - \gamma_d}{\gamma_d - \gamma_{sat} + \gamma_w}$

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

$$\longrightarrow \gamma_d (1+e) = G_s \gamma_w \quad \text{----} \ (1)$$

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

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

$$\gamma_{sat} (1+e) - \gamma_w e = G_s \gamma_w \quad \text{---} \ (2)$$

(1) = (2) :

$$\gamma_d (1+e) = \gamma_{sat} (1+e) - e \gamma_w$$

$$\gamma_d + e \gamma_d - \gamma_{sat} - e \gamma_{sat} + e \gamma_w = 0$$

$$e (\gamma_d - \gamma_{sat} + \gamma_w) = \gamma_{sat} - \gamma_d$$

$$e = \frac{\gamma_{sat} - \gamma_d}{\gamma_d - \gamma_{sat} + \gamma_w}$$

Problem 2 :-) $V_T = 0.4\ m^3$ / $M_T = 711.2\ kg$ "moist"

$M_D = 623.9\ kg$

$G_S = 2.68$

(A) $w(\%)$?

$$w = \frac{W_w}{W_{solid}} = \frac{W_{moist} - W_{Dry}}{W_{Dry}} * 100\%$$

$$= \frac{711.2 - 623.9}{623.9} * 100\%$$

$$\rightarrow \boxed{w = 13.99\ \%}$$

(B) γ_{moist} ?

$$\gamma_{moist} = \frac{mass}{volume} = \frac{711.2}{0.4} = 1778\ kg/m^3$$

(C) γ_{dry} ?

$$\gamma_{dry} = \frac{mass}{Volume} = \frac{623.9}{0.4} = 1559.75\ kg/m^3$$

(d) e ?

$$\gamma_{dry} = \frac{G_s \gamma_w}{1+e}$$

$$\gamma_d + \gamma_d e = G_s \gamma_w$$

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

$$= \frac{2.68\ (1000)}{1559.75} - 1$$

$$\rightarrow \boxed{e = 0.718}$$

(e) n ? $n = \frac{e}{1+e} = \boxed{0.418 = n}$

(f) S?

$$Se = G_s w$$

$$S = \frac{2.68\ (0.1399)}{0.718} * 100\ \%$$

$$\rightarrow \boxed{S = 52.22\ \%}$$

Problem 3 :- $\gamma_{moist} = 17.8\ kN/m^3$

$w = 14\ \%$

$G_s = 2.69$

$V_T = 1\ m^3$

(A) W_{dry} ?

$$\gamma_{moist} = \frac{W_T}{V_T} \longrightarrow W_T = (1)(17.8)$$

$$\boxed{W_T = 17.8\ kN}$$

$$w = \frac{W_T - W_{dry}}{W_{dry}}$$

$$0.14 = \frac{17.8 - W_{dry}}{W_{dry}}$$

$$1.14\ W_{dry} = 17.8$$

$$\boxed{W_{dry} = 15.61\ kN}$$

(B) e ?

$$\gamma_{dry} = \frac{G_s \gamma_w}{1+e}$$

$$e = \frac{G_s \gamma_w}{\gamma_d} - 1 \quad ,, \quad \gamma_d = \frac{W_d}{V_T} = \frac{15.61}{1} \text{ KN/m}^3$$

$$e = \frac{2.69(9.81)}{15.61} - 1$$

$$\longrightarrow \boxed{e = 0.691}$$

(C) S ?

$$Se = G_s w$$

$$S = \frac{2.69\ (0.14)}{0.691} * 100\%$$

$$\longrightarrow \boxed{S = 54.5\ \%}$$

Problem 4 :-) Backfill : $e = 0.8$

$V = 30\ m^3$

Borrow Pit : $e = 1.1$

$V = ??$

$$V = V_s + V_v$$

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

$$\longrightarrow V = V_s \left(1 + e\right)$$

$$\therefore \quad \frac{V_{Back}}{V_{Borrow}} = \frac{V_s(1 + e_{Back})}{V_s(1 + e_{Borrow})}$$

$$\longrightarrow V_{Borrow} = \frac{(1 + 1.1)\ (30)}{1.8}$$

$$\longrightarrow V_{Borrow} = 35\ m^3$$

Problem 5:-) from problem 4: Backfill: $e = 0.8$ / $V = 30 m^3$

Borrow pit : $e = 1.1$ / $V = 35 m^3$

$G_s = 2.7$ / $\omega = 11\%$

(A) γ_{moist} for borrow soil ?

$$\gamma_{moist} = \frac{W_T}{V_T} = \frac{W_w + W_{solid}}{V_v + V_{solid}} \quad ,, \quad \omega = \frac{W_w}{W_{solid}}$$

$$= \frac{\omega W_{solid} + W_{solid}}{e V_{solid} + V_{solid}}$$

$$= \frac{W_{solid}(1+\omega)}{V_{solid}(1+e)}$$

$$= \gamma_{solid} \frac{(1+\omega)}{(1+e)}$$

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

$$= \frac{(2.7)(9.81)(1+0.11)}{2.1}$$

$$= 14 \ KN/m^3$$

(B) S ? (of Borrow soil)

$$Se = G_s w$$

$$S = \frac{2.7\,(0.11)}{1.1} \times 100\,\%$$

$$\rightarrow \boxed{S = 27\%}$$

(C) γ_{moist} for compacted backfill ?

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

$$= \frac{(2.7)\,(9.81)\,(1.11)}{(1.8)}$$

$$\rightarrow \boxed{\gamma_{moist} = 16.33\ KN/m^3}$$

(D) W_T for Borrow soil ?

$$\gamma_{moist} = \frac{W_T}{V_T} \rightarrow 14 = \frac{W_T}{35}$$

$$\rightarrow \boxed{W_T = 490\ KN}$$

Problem 6 :-) $\gamma_{moist} = 17.5\ KN/m^3$ / $w = 11\ \%$ / $\gamma_{d\,max} = 19.2\ KN/m^3$

$\gamma_{d\,min} = 14.1\ KN/m^3$

Dr ?

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

$$\rightarrow \gamma_{moist} = \gamma_d (1+w)$$

$$17.5 = \gamma_d (1.11)$$

$$\rightarrow \boxed{\gamma_d = 15.77\ KN/m^3}$$

$$Dr = \frac{\frac{1}{\gamma_{dmin}} - \frac{1}{\gamma_d}}{\frac{1}{\gamma_{dmin}} - \frac{1}{\gamma_{dmax}}}$$

$$= \frac{\frac{1}{14.1} - \frac{1}{15.77}}{\frac{1}{14.1} - \frac{1}{19.2}}$$

$$= \frac{0.00751}{0.01884}$$

$$\rightarrow \boxed{Dr = 0.398 * 100\% \approx 40\%}$$

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Problem 7 :-) $e_{max} = 0.94$ / $e_{min} = 0.66$

$G_s = 2.65$

Before compaction: $D_r = 55\%$

after compaction : $D_r = 85\%$

(A) γ_{dry} before and after compaction :

before compaction:

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

$$0.55 = \frac{0.94 - e}{0.94 - 0.66}$$

$$0.94 - e = 0.154$$

$$\boxed{e = 0.786}$$

$$\gamma_{dry} = \frac{G_s \gamma_w}{1+e} = \frac{2.65\,(9.81)}{1.786}$$

$$\longrightarrow \boxed{\gamma_{dry} = 14.72\ KN/m^3}$$

After Compaction:-

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

$$0.85 = \frac{0.94 - e}{0.94 - 0.66}$$

$$0.94 - e = 0.238$$

$$\boxed{e = 0.702}$$

$$\gamma_{dry} = \frac{G_s \gamma_w}{1+e} = \frac{2.65\,(9.81)}{1.702}$$

$$\longrightarrow \boxed{\gamma_{dry} = 15.27\ KN/m^3}$$

(B) Final height after compaction ?

$$\frac{\Delta H}{H} = \frac{\Delta e}{1+e_1} \longrightarrow \frac{\Delta H}{3} = \frac{0.784 - 0.702}{1 + 0.784}$$

$$\longrightarrow \Delta H = 0.138$$

final Height = $3 - 0.138 = 2.862\ m$