#3.1

Free water comprises greater portion of water in most soils. It is a portion of the pore water ie water occupying the pores [voids].

Hydration water is the water present in the clay mineral crystal lattice. It is a part of the crystal structure.

#3.2

$D_{10} = 0.055 mm$; $k = 10^{-6} cm/s$

$D_{10} = 0.0055 cm$.

$h_c = 1.5/D_{10} = 1.5/0.0055 = 272.73 cm$

$Z = 0.5 \times h_c = 0.5 \times 272.73 = 136.36 cm$

Time taken for 50% maximum capillary rise

$$t = \frac{n \times 272.73}{10^{-6}}\left[\frac{136.36}{272.73} + \ln\left[1 - \frac{136.36}{272.73}\right]\right]$$

From table 3-6

$e_{avg} = \frac{0.85+0.14}{2} = 0.495$

$\Rightarrow n = \frac{0.495}{1.495} = 0.33$

$t = n\,52677030$ secs

$= n\,609.69$ days $= 0.33 \times 609.69$ days

Pore pressure $= \gamma_w Z = 9.81 \times \frac{136.36}{100} = 13.4 kN/m^2$

#3.5

$e = 0.7$; $S_r = 0.8$; $G_s = 2.7$; $\gamma_w = 9.81 kN/m^3$

(a) $\gamma_d = ?$

$e S_r = G_s \omega \Rightarrow \omega = \frac{0.7 \times 0.8}{2.7} = 0.2074$

$\gamma_d = \frac{G_s \gamma_w}{1+e} = \frac{2.7 \times 9.81}{1+0.7} = 15.58 kN/m^3$

(b) $\gamma_d = \frac{\gamma}{1+\omega} \Rightarrow \gamma = 15.58[1+0.2074] = 18.81 kN/m^3$

(c) $\gamma_{sat} = \frac{(G+S_r e)\gamma_w}{1+e}$  $S_r = 1 \Rightarrow \gamma_{sat} = 19.62 kN/m^3$

(d) Water Content $\omega = \frac{0.7 \times 0.8}{2.7} = 0.2074$

## #3.7

$\omega = 24\% = 0.24 = \frac{W_w}{W_s}$

$G_s = 2.75 = \frac{\gamma_s}{\gamma_w}$

$\gamma_s = 2.75 \times \gamma_w$

$e S_r = G_s \omega$

$\Rightarrow e = \frac{2.75 \times 0.24}{1} = 0.66$

[∵ saturated unit weight]

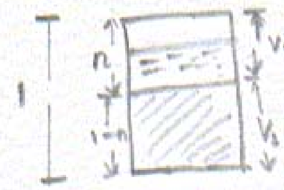
$\gamma_{sat} = \frac{W_w + W_s}{V}$

$V =$

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

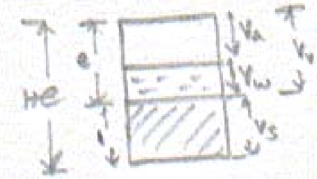
$= \frac{62.4 \times 1.24}{(0.24 + 1/2.75)} = 128.18\ lb/ft^3$

#2 a) $e = \frac{n}{1-n}$




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

$\Rightarrow 1/n = \frac{V_v + V_s}{V_v} = 1 + \frac{1}{e} = \frac{1+e}{e}$




$\Rightarrow e = n(1+e) \Rightarrow e - ne = n$

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

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

$\gamma = \frac{W}{V} = \frac{W_s + W_w}{V} = \frac{W_s\left(1 + \frac{W_w}{W_s}\right)}{V} = \frac{W_s}{V}(1+\omega)$

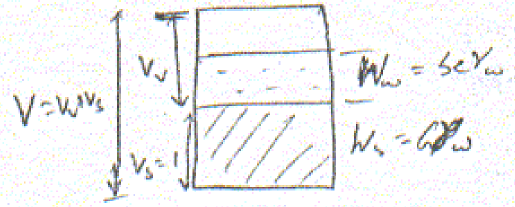
d) $\gamma_d = \gamma/(1+\omega)$

$\gamma = \frac{W_s}{V}(1+\omega) \Rightarrow \gamma_d = \frac{\gamma}{1+\omega}$

(e)

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

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




$$\gamma = \frac{W}{V} = \frac{W_s + W_w}{1+e}$$

$$= \frac{G_s\gamma_w + \gamma_w \times V_w}{1+e}$$

$$= \frac{\gamma_w[G_s + es]}{1+e}$$

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

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

$$\Rightarrow V_w = es$$

substitute $es = G_s w$

$$\Rightarrow \gamma = \frac{\gamma_w(G_s + G_s w)}{1+e} = \frac{\gamma_w G_s}{1+e}[1+w]$$

(f)

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

$$\gamma_d = \frac{W_s}{V} = \frac{W_s/V_s}{V/V_s} = \frac{\gamma_s}{V/V_s} = \frac{\frac{\gamma_s}{\gamma_w}\times\gamma_w}{1+\frac{V_v}{V_s}} = \frac{G_s\gamma_w}{1+e}$$

(h)

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

when $s=1$ ; $\gamma = \gamma_{sat}$

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

(or)

$$\gamma_{sat} = \frac{W}{V} = \frac{W_s + W_w}{V} = \frac{\frac{W_s+W_w}{V_s}}{\frac{V}{V_s}} = \frac{\gamma_s + \frac{W_w}{V_s}}{\frac{V}{V_s}} = \frac{\gamma_s + \frac{V_w \times \frac{W_w}{V_w}}{V_s}}{\frac{V}{V_s}}$$

$$= \frac{\left(\frac{\gamma_s}{\gamma_w} + \frac{V_w}{V_s}\right)\gamma_w}{1+\frac{V_v}{V_s}} = \frac{(G_s+e)\gamma_w}{1+e}$$

(g)

$$S = \frac{w G_s}{e}$$

$$w = \frac{M_w}{M_s} = \frac{V_w \rho_w}{V_s \rho_s}$$

$$\frac{\rho_s}{\rho_w} = G_s \Rightarrow \rho_s = G_s \rho_w$$

$$\therefore w = \frac{S V_v}{V_s G_s} = \frac{S e}{G_s}$$

$$\Rightarrow S = \frac{G_s w}{e}$$