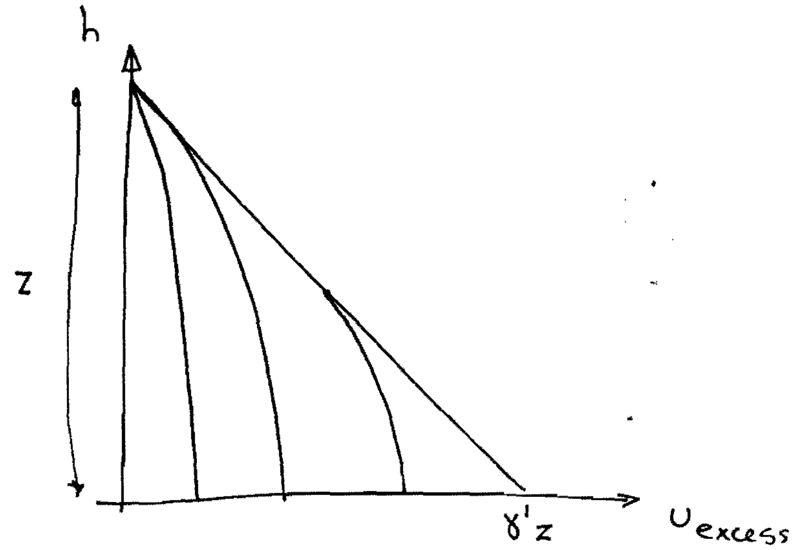
1\. a) Assuming - 1-D behaviour, i.e. no lateral drainage.
- impermeable tank so no base drainage.



b) In phase I $\frac{\partial \rho}{\partial t} = \frac{k\gamma'}{\gamma_w}$

Assuming water content doesn't change significantly in first 25 days & k ~ constant.

$\gamma' = \left(\frac{G_s + e}{1+e}\right)\gamma_w - \gamma_w$ where $e = wG_s$ [Assuming $S_r = 1$]

$= \left(\frac{(1+w)G_s}{1+wG_s} - 1\right)\gamma_w = 3.66 \text{ kN/m}^3$

$k = \frac{\partial \rho}{\partial t}\frac{\gamma_w}{\gamma'} = \frac{108}{25} \times \frac{10}{3.66} = 11.8 \text{ mm/day}$

$= 1.37 \times 10^{-7}$ m/s

c) At end of phase I, we've had $1/3$ of total settlement.

From graph of ρ vs t, settlement slows after ~ 90 days - 400mm settlement

Total settlement $= \dfrac{\gamma' h^2}{2E_o}$

$\therefore \quad \dfrac{3.66 \times 10^2}{2E_o} = 1.2\,m$

$E_o \sim \underline{\underline{152.5 \text{ kPa}}}$

d) $\underline{\underline{1.2m}}$ $\quad$ $3\times$ settlement at end of Phase I.

~~e)~~ ~~Pbr~~

$C_v = \dfrac{E_o k}{\gamma_w} = 2.09 \times 10^{-6}\ m^2/s$

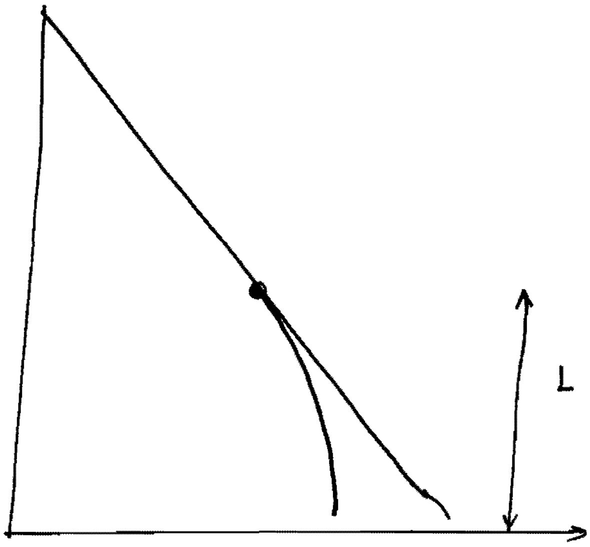
e)

Phase I

$$\frac{d\rho}{dt} = \frac{k\gamma'}{\gamma_w}$$

$$\rho = \frac{1}{3E_0} \frac{\gamma' L^2}{2}$$

$$\frac{d\rho}{dt} = \frac{\gamma'}{3E_0} L \frac{dL}{dt}$$



$$\therefore \quad L\,dL = 3C_v\,dt$$

$$L^2 = 6C_v t$$

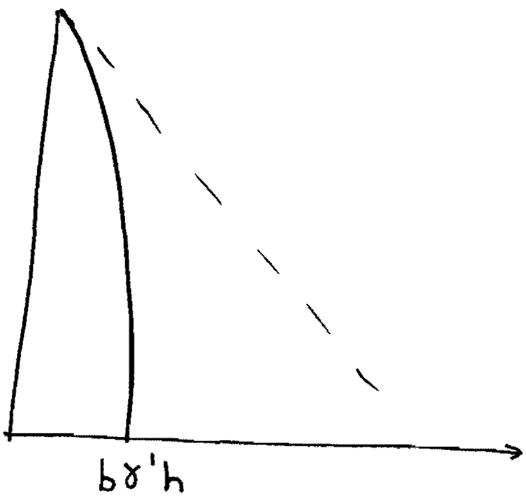
@ end of phase I $\quad t = \frac{h^2}{6C_v}$ $\quad R_v = \frac{1}{3}$

Phase II

$$\frac{d\rho}{dt} = \frac{k}{\gamma_w} 2b\gamma'$$

$$\rho = \left(\frac{\gamma' h^2}{2} - \frac{2}{3} b h^2 \gamma'\right) \frac{1}{E_0}$$

$$\frac{d\rho}{dt} = -\frac{2}{3}\frac{db}{dt}\frac{h^2\gamma'}{E_0} = \frac{k}{\gamma_w} 2b\gamma'$$

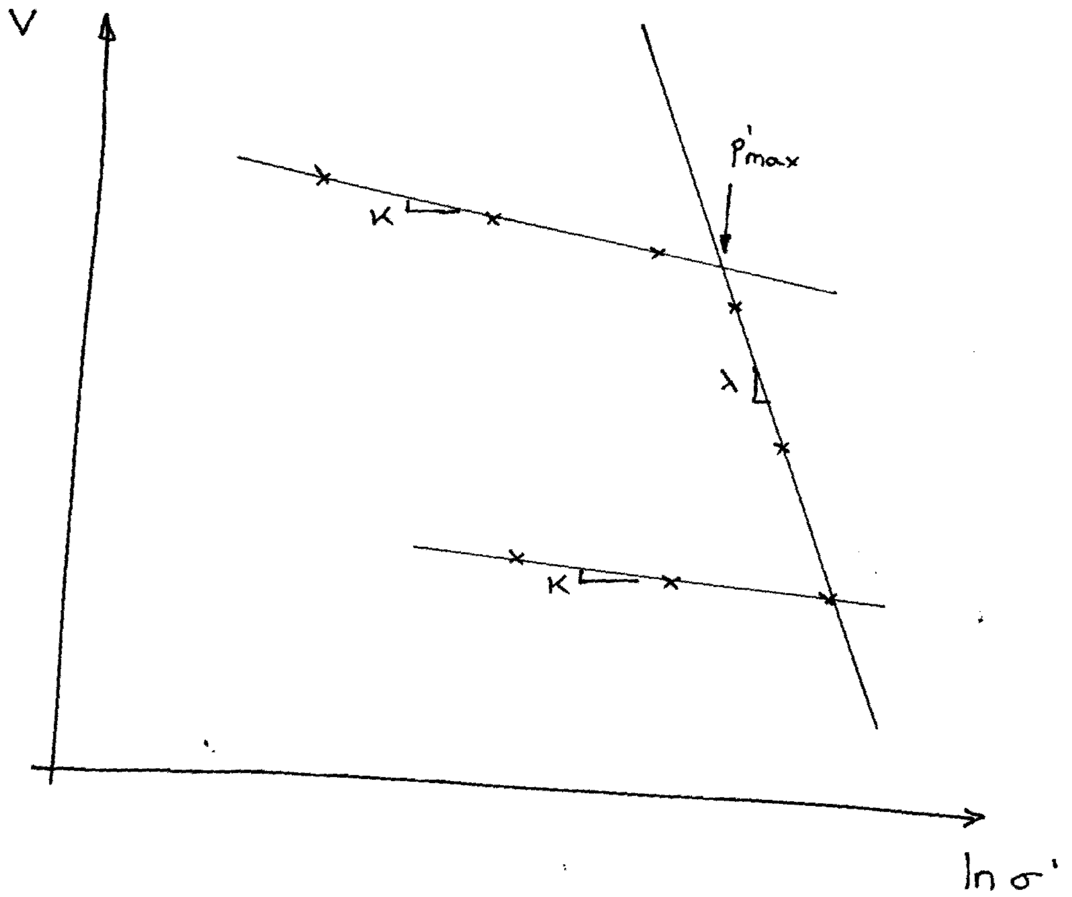


$$\therefore \quad \frac{db}{b} = -\frac{3C_v}{h^2} \qquad \ln(b) - \ln\left(\tfrac{1}{2}\right) = \frac{3C_v}{h^2}\left(\frac{h^2}{6C_v} - t\right)$$

@ 95 % consolidation, $\quad \rho = \frac{19}{20} \times \frac{\gamma' h^2}{2E_0} = \frac{19\gamma' h^2}{40E_0}$

$$\frac{1}{2} - \frac{2}{3} b = \frac{19}{40} \qquad b = \frac{3}{80} \qquad t = \underline{\underline{570 \text{ days}}}$$

2.



At 10m depth $\sigma_v' = 60\,kPa$

$$\gamma_{bulk} = \left(\frac{G_s + e}{1+e}\right)\gamma_w$$

$e = 1.68$

$v = 2.68$

σ_v	10	20	60	100	200	400	200	1[illegible]
h	20	19.85	19.61	19.39	18.58	17.77	17.92	18.[illegible]
v	2.733	2.713	2.68	2.650	2.539	2.429	2.449	2.[illegible]

$\lambda = 0.16$ $\quad K = 0.03$

max stress ~ exp(4.4) ~ <u>81 kPa</u>

$\lambda - K + \Gamma \sim 3.39$ $\quad \Gamma \sim \underline{3.26}$

$d_{10} = 20$ microns

Capillary rise $= \dfrac{3 \times 10^{-5}}{d_{10}} = 1.5\,m.$

Surcharge $= 1.5\,\gamma_{sat} + 8.5\,\gamma_{dry}$

$\gamma_{dry} = 18\ kN/m^3$ $\qquad e = 0.47$

$\gamma_{sat} = 21.2\ kN/m^3$

~~γ_{sat}'~~

Surcharge = 185 kPa

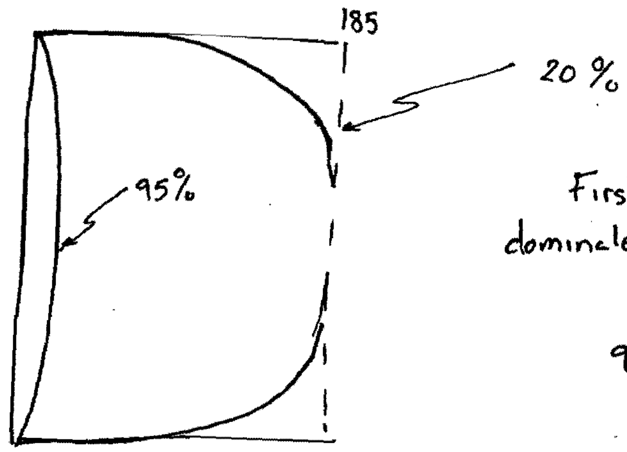
σ_v' new = 245 kPa

$V = 2.5$

$\dfrac{\Delta v}{v_0} = \dfrac{0.18}{2.68} = 6.7\,\%$

$\rho = \underline{1.34m}$

c)



First 20% settlement will be dominated by K behaviour

95% dominated by λ

c) cont.

$C_{v\lambda}$ => 50% in 5 minutes on 20mm thick sample

$R_v = 0.5$ => $T_v \sim 0.2$

$$\frac{C_v t}{d^2} = 0.2 \qquad C_v = \frac{0.2 \times (10\text{mm})^2}{5 \text{ minutes}}$$

$= 4 \text{ mm}^2/\text{minute}$

$= 2.1 \text{ m}^2/\text{yr}$

$R_v = 0.2$ => $T_v \sim 0.03$

$$C_{v\kappa} \sim \frac{\lambda}{\kappa} C_{v\lambda} = 21.3 \text{ mm}^2/\text{min}$$

$11.2 \text{ m}^2/\text{yr}$

$$\frac{C_v t}{d^2} = 0.03 \qquad t = \frac{0.03 \times 10^2}{11.2} = 98 \text{ days}$$

$R_v = 0.95$ $\qquad T_v = 1$

$$\frac{C_v t}{d^2} = 1 \qquad t = \frac{100}{2.1} = \underline{\underline{47.6 \text{ years}}}$$

d) Surcharge $= (6.5\,\gamma_{sat} + 3.5\,\gamma_{dry} - 5\,\gamma_w)$

$= 150.8$ kPa

$\Delta\sigma_v' = 34.2$

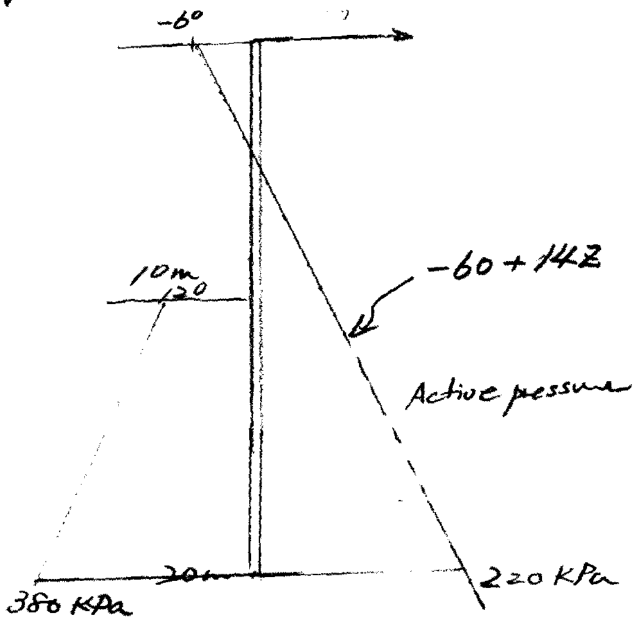
$$\frac{\Delta v}{v} \simeq \frac{\kappa \ln\left(\frac{245}{210.8}\right)}{2.5} = 0.0018$$

$0.0018 \times 20 =$ $\underline{\underline{36\text{mm heave}}}$

$$t = \frac{d^2}{C_v} = \frac{100}{11.2} = \underline{\underline{8.9 \text{ years}}}$$

3/ (a) Active side

$\sigma_h = \sigma_v - 2S_u = 20z - 2(30+3z) = -60 + 14z$



passive side

$\sigma_v = 20(z - 10)$

$S_u = 30 + 3z$

$\sigma_h = \sigma_v + 2S_u = 20(z-10) + 2(30+3z)$

$= 26z - 140$

at 10m = $260 - 140 = 120$ kPa

at 20m = $520 - 140 = 380$ KPa

(b) σ_h (active) = 0

$-60 + 14z = 0 \quad z = \underline{4.29m}$

Resisting moment

$= 120 \times 10 \times 5 + \frac{1}{2} \times (380 - 120) \times 10 \times 10 \times \frac{1}{3}$

$= 1.03 \times 10^4$ kN.m/m

Active moment

$= \frac{1}{2} \times 220 \times (20 - 4.29) \times (20 - 4.29) \times \frac{1}{3}$

$= 9.05$ kNm/m

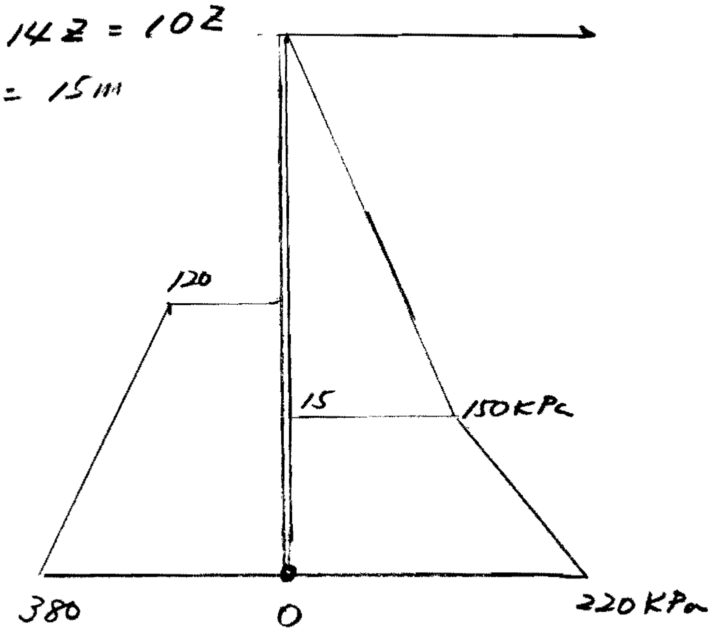
Not failure.

FoS = 1.14

(c) $\sigma_h = \gamma_w z$

$-60 + 14z = 10z$

$z = 15\,m$



Taking moment around 0

Resisting moment $= 120 \times 10 \times 5 + \frac{1}{2}(380 - 120) \times 10 \times 10 \times \frac{1}{3}$

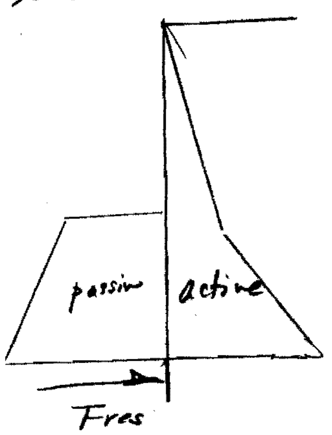
$= 1.03 \times 10^4$ kN·m/m

Acting moment $= \frac{1}{2} \times 200 \times 20 \times 20 \times \frac{1}{3} + \frac{1}{2} \cdot 70 \times 5 \times 5 \times \frac{1}{3}$

$= 1.36 \times 10^4$ kNm/m

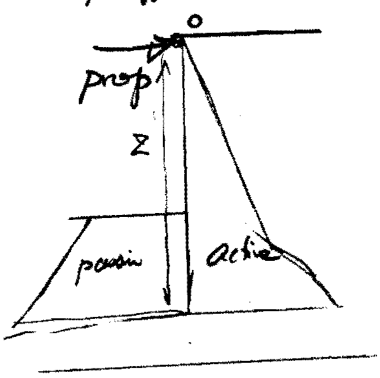
will fail FoS = 0.76

(d) (i) Embed the wall deeper into the bed rock



Need to assess the lateral resistance given by the bed rock

(ii) propped wall



Horizontal equilibrium & Moment equilibrium at the top to compute the wall length and the prop force

Q4

(a)

(i)

Shape correction factor $S_c = 1 + 0.2(10/10) = 1.2$

$\frac{V_{ult}}{A} = 1.2 \cdot 5.14 \times 110 + 32$

$= 710.5$ KPa

$V_{ult} = 710.5 \times 10 \times 10$ KN $=$ <u>71.1 MN</u>

Deduct the foundation weight

$V_{foundation} = 24 \times 10 \times 10 \times 2 = 4.8$ MN

$V = 71.1 - 4.8 =$ <u>66.3 MN</u>

(ii) N_q for $\phi = 26° = \tan^2(45° + \frac{26°}{2}) e^{\pi \tan 26°}$

$= 11.85$

$N_\gamma = 2(N_q - 1)\tan 26° = 2(11.85 - 1) \cdot \tan 26°$

$= 10.58$

$S_q = 1 + (10 \cdot \sin 26°)/10 = 1.44$

$S_\gamma = 1 - 0.3 \cdot 10/10 = 0.7$

$\frac{V_{ult}}{A} = 1.44 \cdot 11.85 \cdot 32 + 0.7 \cdot 10.58 \times \frac{8 \times 10}{2}$

$= 842.3$

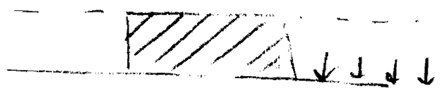
$V_{ult} = 84.2$ MN

Deducting the foundation weight

$V = 84.2 - 4.8 =$ <u>79.4 MN</u>

The short term state is more critical than the long term state.

(b)

(i)  $20 \times 2 = 40$ kPa

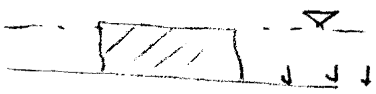
$$\frac{V_{ult}}{A} = 1.2 \times 5.14 \times 110 + 40$$

$$= 718.5 \text{ kPa}$$

$V_{ult} = 71.9$ MN

$V_{foundation} = 4.8$ MN

$V = 71.9 - 4.8 = \underline{67.1 \text{ MN}}$ //

(ii)  $\sigma' = 10 \times 2 = 20$ kPa

$p = 10 \times 2 = 20$ kPa

$$\frac{V_{ult}}{A} = 1.44 \times 11.85 \times 20 + 0.7 \times 10.58 \times \frac{8 \times 10}{2}$$

$$= 637.5 \text{ kPa}$$

$V_{ult} = 63.8$ MN

Add water pressure force acting at the bottom.

$V_w = 20 \times 10 \times 10 = 2$ MN

Deduct the foundation weight = 4.8 MN

$V = 63.8 + 2 - 4.8 = \underline{61.0 \text{ MN}}$ //

This time, the long-term state is more critical than the short-term state.