Q1 (a)

$$\sigma'_{v\,current} = 20\times2 + 10\times8 = 120\ kPa$$

$$\sigma'_{h\,current} = 120\times1.30 = 156\ kPa$$

(b) (i)

$$\sigma'_{v\,max} = 120\times5 = 600\ kPa$$

$$\sigma'_{h\,max} = 600\times0.61 = 366\ kPa$$

$$p'_{max} = \frac{600+2\times366}{3} = 444\ kPa$$

$$q_{max} = 600-366 = 234\ kPa$$

$$\frac{q}{p'} = 0.89\ln\left(\frac{p_c}{p'}\right)$$

$$\frac{234}{444} = 0.89\ln\left(\frac{p_c}{444}\right)$$

$$p_c = 801\ kPa$$

(ii) current

$$p' = \frac{120+2\times156}{3} = 144\ kPa$$

$$q = 120-156 = -36\ kPa$$

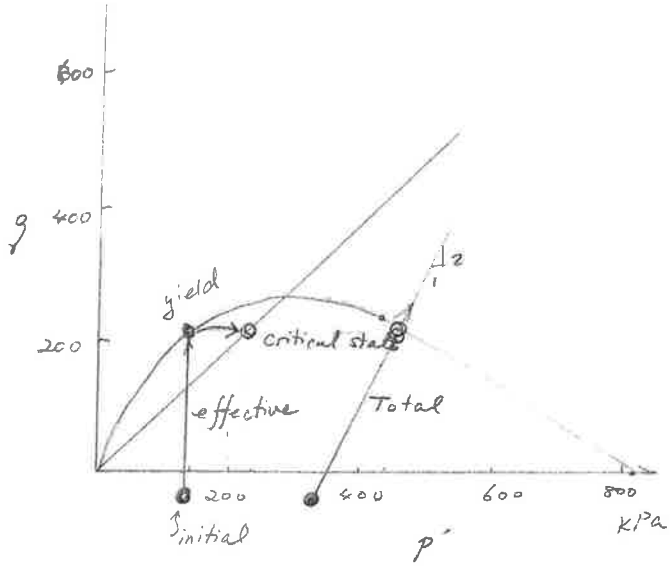
$$v = N - \lambda\ln p_c' + \kappa\ln(p_c/p')$$

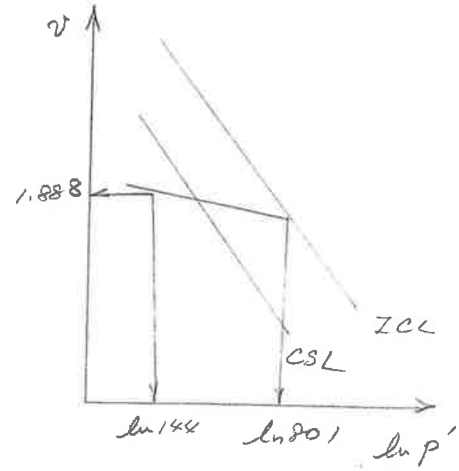
$$= \Gamma + \lambda - \kappa - \lambda\ln p_c' + \kappa\ln(p_c/p')$$

$$= 2.759 + 0.161 - 0.062 - 0.161\ln(801)$$

$$+ 0.062\ln(801/144)$$

$$= 1.888$$





(c) (i) yield stress

$$\frac{q}{144} = 0.89 \ln\left(\frac{801}{144}\right)$$

$$q = 220 \text{ kPa} \qquad p' = 144 \text{ kPa}$$

undrained shear strength

$$1.888 = \Gamma - \lambda \ln p'_{crit}$$

$$= 2.759 - 0.161 \ln p'_{crit}$$

$$p'_{crit} = 224 \text{ kPa}$$

$$q_{crit} = 0.89 \times 224 = 199 \text{ kPa}$$

2 (a) Use (200, 0.1) & (250, 0.25) to extrapolate in finding the lift-off pressure.

$$\frac{\Delta P_c}{\Delta \varepsilon_c} = \frac{50}{0.15 \times 10^{-2}} = 333 \times 10^{-2}$$

dP_c for 0.1 = 333 × 0.1 = 33.3

∴ 200 − 33.3 = 167 kPa lift-off pressure

σ_v = 10 × 20 = 200 kPa

u = 9 × 10 = 90 kPa

σ_v' = 110 kPa

σ_h' = 167 − 90 = 77 kPa

K_0 = 77/110 = 0.7

(b) $\varepsilon_c = \rho_c / r_c$ and $\gamma = 2\varepsilon_c$

$$d\tau = \frac{d\sigma_r - d\sigma_\theta}{2}$$ elastic deformation $d\sigma_r = -d\sigma_\theta$

$= d\sigma_r = dP_c$ at the cavity wall

$$G = \frac{d\tau}{d\gamma} = \frac{1}{2}\frac{dP_c}{d\varepsilon_c} = \frac{1}{2} \times \frac{50}{0.15 \times 10^{-2}} = 16.7\ MPa$$

$$G_{ur} = \frac{d\tau}{d\gamma} = \frac{1}{2}\frac{50}{0.1 \times 10^{-2}} = 25\ MPa$$

(c)

$$C_u = \frac{750 - 650}{\ln(2 \times 8) - \ln(2 \times 4.9)} = 125\ kPa$$

(d)

$$\frac{\delta A}{A} = 2\varepsilon_c = 2 \cdot \frac{0.005}{2}$$

$$\delta\sigma_c = 125\left[1 + \ln\frac{G}{C_u} + \ln\frac{\delta A}{A}\right]$$

$$= 125\left[1 + \ln\frac{16.7 \times 10^3}{125} + \ln\left(2 \cdot \frac{0.005}{2}\right)\right]$$

$$= 125\left[1 + 4.895 - 5.30\right]$$

$= 74.4$ kPa

support pressure = 167 − 74.4 = 92.6 kPa

Q3

(a) $\gamma_{dry} = \frac{2.65}{1+0.6} \times 10 = 16.6\ kN/m^3$

$\gamma_{sat} = \frac{2.65+0.6}{1.6} \times 10 = 20.3\ kN/m^3$

(b) $\sigma = 16.6 \times 5 \times \cos^2 27 = 65.4\ kPa$

$\tau = 16.6 \times 5 \times \cos 27 \cdot \sin 27 = 33.6\ kPa$

$I_D = \frac{0.8 - 0.6}{0.8 - 0.4} = 0.5$

$I_C = \ln(20{,}000/65.4) = 5.72$

$I_R = I_C \cdot I_D - 1 = 0.5 \times 5.72 - 1 = 1.86$

$\phi_{max} - \phi_{crit} = 5 \times 1.86 = 9.3$

$\phi_{max} = 9.3 + 32 = 41.3$ degrees $\quad FS = \frac{\tan 41.3^\circ}{\tan 27^\circ} = 1.72$

$\phi_{crit} = 32^\circ \quad FS = \frac{\tan 32}{\tan 27} = 1.23$

(c)

$u = \gamma_w (z - h_w) \cos^2\beta$

$\sigma = (\gamma_{dry} h_w + \gamma_{sat}(z - h_w)) \cos^2\beta$

$\sigma' = [\gamma_{dry} h_w + \gamma_{sat}(z - h_w) - \gamma_w(z - h_w)] \cos^2\beta$

$= [\gamma_{dry} h_w + (\gamma_{sat} - \gamma_w)(z - h_w)] \cos^2\beta$

$\tau = [\gamma_{dry} h_w + \gamma_{sat}(z - h_w)] \cos\beta \sin\beta$

$$\tan\phi'_{mob} = \frac{[\gamma_{dry} h_w + \gamma_{sat}(z - h_w)] \tan\beta}{\gamma_{dry} h_w + (\gamma_{sat} - \gamma_w)(z - h_w)}$$

$$\frac{\tan 32^\circ}{\tan 27^\circ} = \frac{16.6 \cdot h_w + 20.3(z - h_w)}{16.6\, h_w + 10.3(z - h_w)}$$

$1.23(16.6\, h_w + 10.3(z - h_w)) = 16.6\, h_w + 20.3(z - h_w)$

$$1.23\,(6.3h_w + 10.3z) = -3.7h_w + 20.3z$$

$$11.45\,h_w = 7.631z$$

$$h_w = 0.67z$$

Most critical at <u>5m depth</u> //

$h_w = 0.67 \times 5 = \underline{3.35\,m}$ //

(d) ○ put drainage pipe at the rock - sand interface to reduce the poe pressure

○ install some ground anchors /piles

○ Retaining walls and change slope angle.

○

Q4 (a) (i) $K_{0,nc} = 1 - \sin\phi' = 1 - \sin 24° = 0.59$

$$K_{0,oc} = K_{n,oc}\left[1 + \frac{(n-1)(n_{max}^{\alpha} - 1)}{n_{max} - 1}\right]$$

$\alpha = 1.2 \sin\phi'_{crit} = 1.2 \sin 24° = 0.488$

$$= 0.59\,(1 + 1.7^{0.488} - 1)$$

$$= 0.764$$

$\sigma_v = 20 \times 5 = 100$ kPa

$u = 10 \times 5 = 50$ kPa

$\sigma_v' = 100 - 50 = 50$ kPa

$\sigma_h' = 0.764 \times 50 = 38.2$ kPa

$\sigma_h = 38.2 + 50 = 88.2$ kPa

$s = (\sigma_v + \sigma_h)/2 = (100 + 88.2)/2 = 94.1$ kPa

$s' = (\sigma_v' + \sigma_h')/2 = (50 + 38.2)/2 = 44.1$ kPa

$t = (\sigma_v' - \sigma_h')/2 = (50 - 38.2)/2 = 5.9$ kPa

(ii) $t_{cnH} = s'_{crit} \sin 24°$

$$s'_{cnH} = \frac{12.4}{\sin 24°} = 30.4 \text{ kPa}$$

$\Delta\sigma_v = 40$ kPa $\quad \Delta\sigma_h = 30$ kPa

$$\Delta s = \frac{40 + 30}{2} = 35 \text{ kPa} \quad \Delta t = \frac{40 - 30}{2} = 5 \text{ kPa}$$

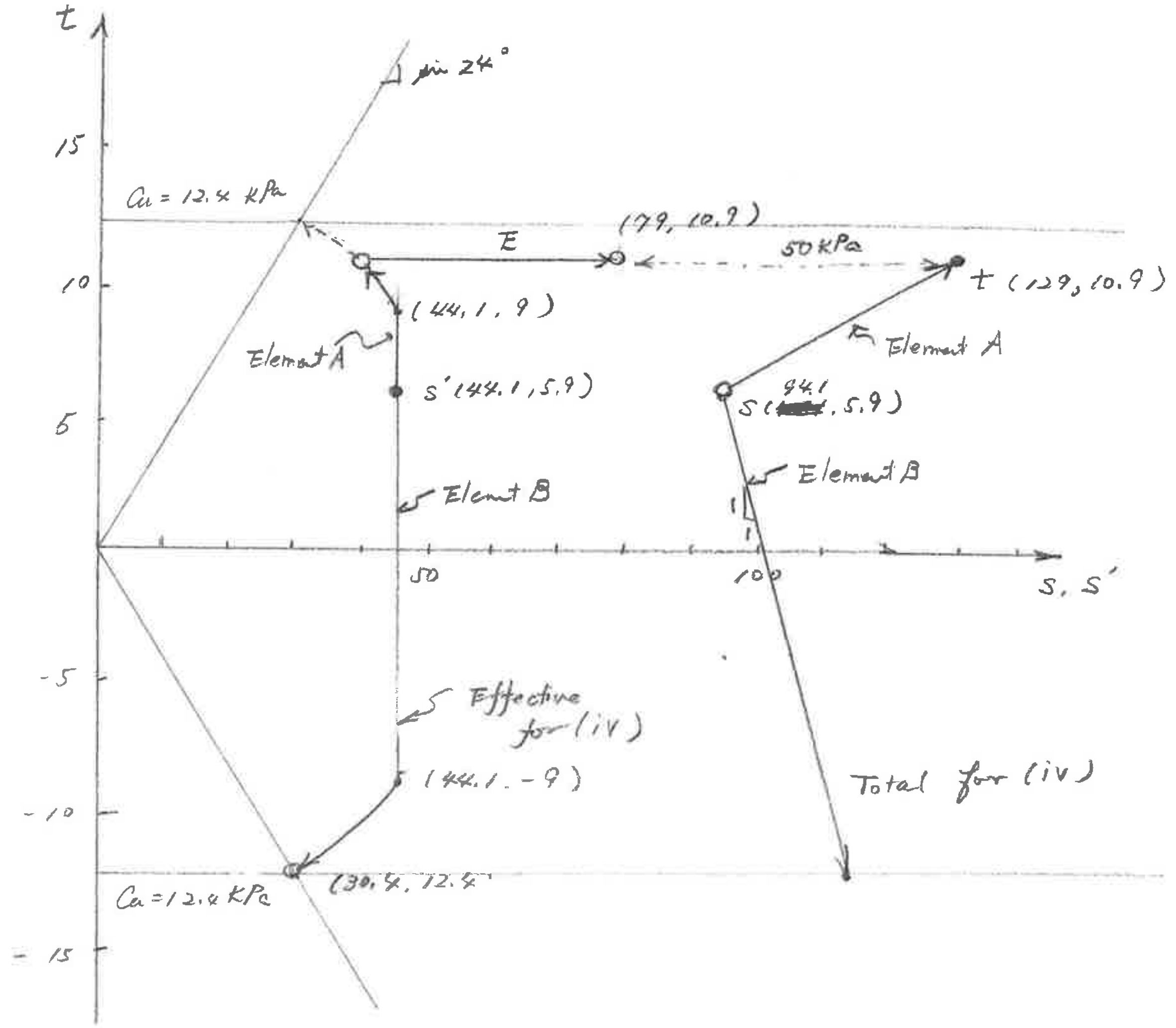
$s = 94.1$ kPa $\rightarrow 129.1$ kPa

$t = 5.9$ kPa $\rightarrow 10.9$ kPa

$s' = 44.1$ kPa until yield (elastic deformation)

then move toward (30.4, 12.4) at failure

(ii) & (iii)



(iv) $\Delta\sigma_v = 0$ $\Delta\sigma_h \uparrow$

$\Delta s = \frac{\Delta\sigma_h}{2}$ $\Delta t = -\frac{\Delta\sigma_h}{2}$ $\therefore \Delta t/\Delta s = -1$

ENGINEERING TRIPOS PART IIA 2011/2012
MODULE 3D2: GEOTECHNICAL ENGINEERING II

(a) Using γ_w = 10 kN/m^3, σ_v' = 120 kPa, σ_h' = 156 kPa
  (b) (i) p_c = 801 kPa
    (ii) v = 1.888
  (c) (i) Yield stress p' = 144 kPa, q = 220 kPa, Undrained shear strength = 199 kPa
    (ii) –

1. (a) 167 kPa, K_0 = 0.7
   (b) G = 16.7 MPa, G_{ur} = 25 MPa
   (c) c_u = 125 kPa
   (d) 92.6 kPa

2. (a) γ_{dry} = 16.6 kN/m^3, γ_{sat} = 20.3 kN/m^3
   (b) F.S. = 1.72 for peak and 1.23 for critical
   (c) h_w = 3.35 m, fail at 5 m depth
   (d) -

3. (a) (i) s = 94.1 kPa, s' = 44.1 kPa, t = 5.9 kPa
     (ii) –
     (iii) –
   (b) –