KATIHAR ENGINEERING COLLEGE, KATIHAR ①

CIVIL ENGINEERING, 3rd Year (Semester-VI)

Subject: Soil and Rock Mechanics

Instructor: Prof. RASHID MUSTAFA

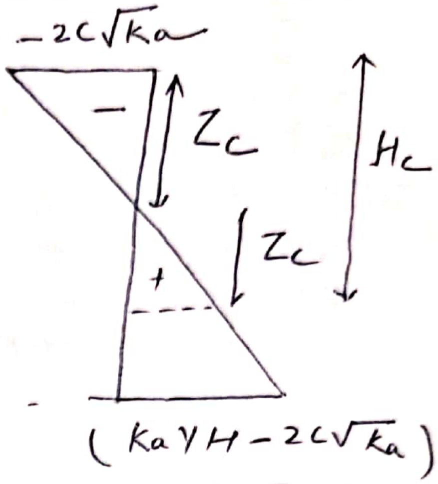
Set-A (Solution)

Q-1 $\left(-13.81 \frac{kN}{m^2}\right)$

$c = 15 \, kN/m^2$

$\gamma = 18 \, kN/m^3$

$\phi = 15^\circ$



Active Earth Pressure diagram

$$K_a = \frac{1-\sin 15}{1+\sin 15} = 0.212$$

Active Pressure at top of the wall $= -2c\sqrt{K_a}$

$= -2 \times 15 \times \sqrt{0.212}$

$= -13.81 \, kN/m^2$

Q-2 (c)

Given Data:

$\gamma = 20 \, kN/m^3$

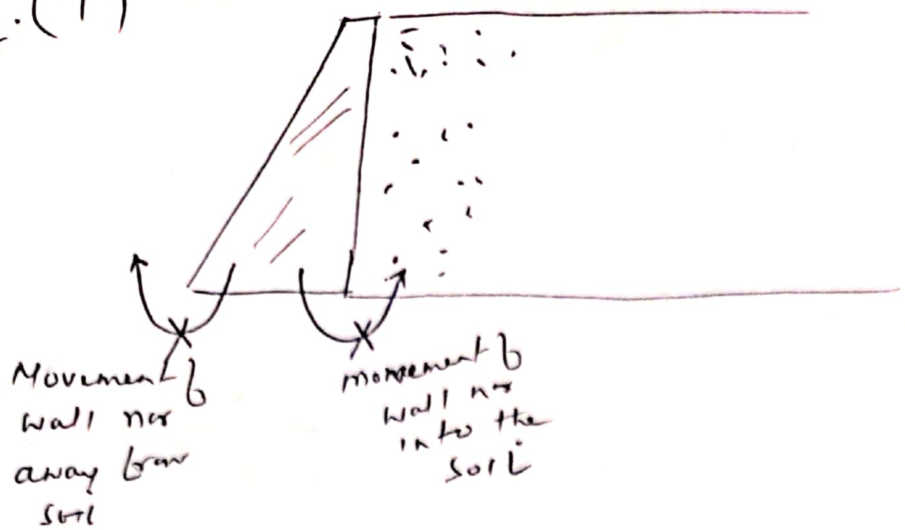
$\phi = 30^\circ$, $K_a = \frac{1-\sin 30}{1+\sin 30} = 1/3$

Excavation depth $(H_c) = 4.0 \, m$

$$H_c = \frac{4c}{\gamma\sqrt{K_a}} = \frac{4 \times c}{20 \times \sqrt{1/3}} = \frac{4\sqrt{3}\, c}{20}$$

$$c = \frac{20 \times 4}{4\sqrt{3}} = 11.55 \, kN/m^2$$

Q-3. (9)



$K_o = 0.5$

$1 - \sin\phi = 0.50$

$\sin\phi = 1/2 = \sin 30$

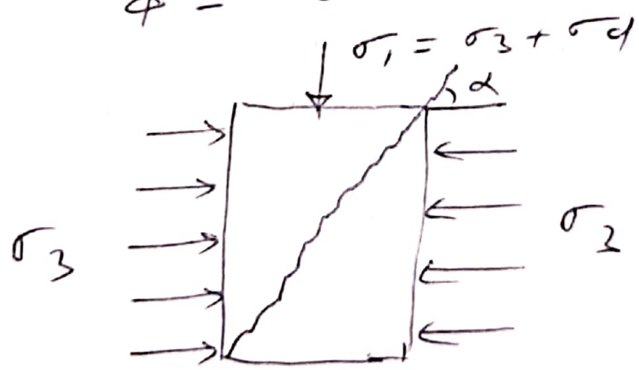
$$\boxed{\phi = 30^\circ}$$

$$\text{Ratio} = \frac{k_p}{K_a} = \frac{3}{1/3} = 9$$

Q-4. (48°)

$C = 100 \ kN/m^2$

$\phi = 6^\circ$



$$\alpha = 45 + \frac{\phi}{2} = 45 + \frac{6}{2} = 48^\circ$$

Q-5 (0.646)

$C = 50 \ kN/m^2, \quad \phi = 30^\circ$

$\gamma = 18 \ kN/m^3$

$$OCR = \frac{\text{Past overburden Pressure}}{\text{~~Past~~ Present overburden}}$$

$$= \frac{125}{75} = \left(\frac{5}{3}\right) = 1.67 > 1 \ \left(\begin{matrix}OC \\ \text{material}\end{matrix}\right)$$

$(k_0)_{oc} = (k_0)_{NC} \times \sqrt{OCR}$

$(k_0)_{oc} = (1-\sin\phi) \times \sqrt{1.67}$

$(k_0)_{oc} = (1-\sin 30) \times \sqrt{1.67}$

$(k_0)_{oc} = 0.646$

Q-6 (c)

Direct shear test $\longrightarrow$ $\sigma_n = 150\ kN/m^2$

$\tau = 50\ kN/m^2$

A/c to Mohr - Coulomb Eqn

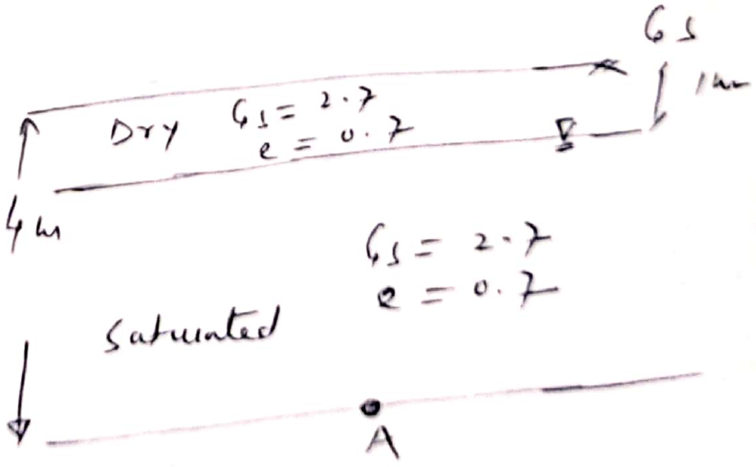
$\tau = c + \sigma_n \tan\phi$

For sandy soil $c = 0$

$50 = 150 \tan\phi$

$\phi = \tan^{-1}\left(\frac{50}{150}\right) = 18.435°$

Now



Dry Density $(\gamma_d) = \frac{G\gamma_w}{1+e}$

$= \frac{2.7 \times 10}{1.7}$

$= 15.88\ kN/m^3$

Saturated Density $(\gamma_{sat}) = \left(\frac{G+e}{1+e}\right)\gamma_w$

$= \left(\frac{3.4}{1.7}\right) \times 10$

$= 20\ kN/m^3$

Effective stress at A $= (15.88 \times 1) + 3 \times 20 - 3 \times 10$

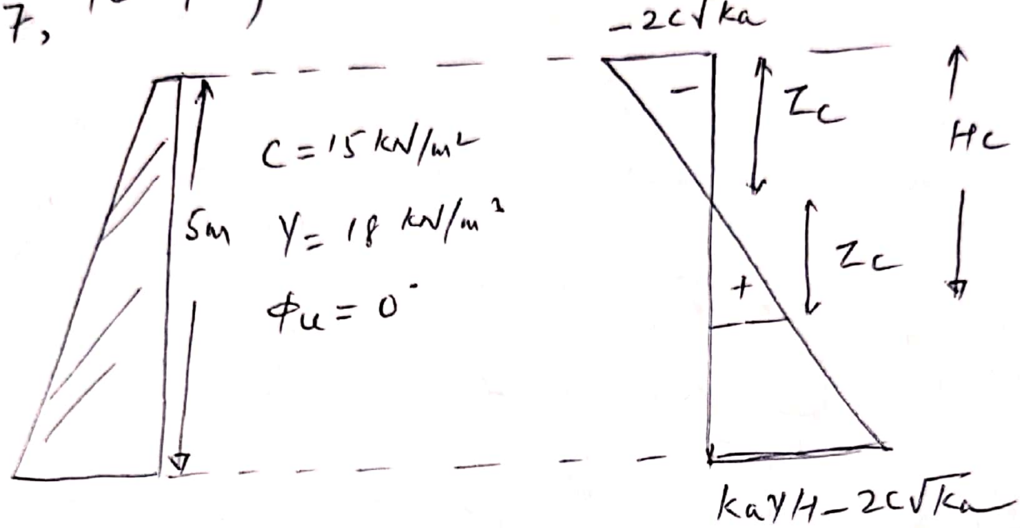
$= 45.88 \ kN/m^2$

Shear strength at A (τ_A) $= \sigma_n' \tan\phi'$

$= 45.88 \tan(18.435^\circ)$

$= 15.3 \ kN/m^2$

Q-7 (1.67, 90 kN/m)



Height of tension Crack (Z_c) $= \dfrac{2c}{\gamma\sqrt{k_a}} = \dfrac{2 \times 15}{18 \times \sqrt{1}}$

$= 1.67 \ m$

Total Active Thrust after tension Crack (P_a) $= \int_{Z_c}^{H} (p_a)\, dz$

$= \int_{1.67}^{5} (k_a \gamma z - 2c\sqrt{k_a})\, dz$

$= \int_{1.67}^{5} (18z - 30)\, dz$

$= 18\left[\frac{z^2}{2}\right]_{1.67}^{5} - 30\left[z\right]_{1.67}^{5}$

$P_a = 199.899 - 99.9$

$= 90 \text{ kN/m}$

Q-8 $\left(0.044 \frac{N}{mm^2}, 26.565^\circ\right)$

S.No	Load (kg)	Normal Stress (N/mm²)	Proving ring dial gauge	Shear Stress (N/mm²)
1.	36.8	0.10	17	0.094
2.0	146.9	0.40	44	0.244

Area $= 60 \times 60 = 3600 \text{ mm}^2$

Normal stress $(\sigma_n) = \dfrac{\text{Load}}{\text{Area}} = \dfrac{36.8}{3600} \times 9.81 = 0.10 \text{ N/mm}^2$

Shear stress $(\tau) = \dfrac{\text{Proving ring Constant} \times \text{Proving ring dia gauge}}{\text{Area}}$

$= \dfrac{20 \times 17}{3600} = 0.094 \text{ N/mm}^2$

A/c to Mohr-Coulomb Equation ~~for sample~~ for First reading

$\tau = c + \sigma_n \tan\phi$

$0.094 = c + 0.10 \tan\phi$ ——— (1)

For 2nd reading

$0.244 = c + 0.40 \tan\phi$ ——— (2)

Solving Equation (1) & (2) [operate (2) − (1)]

$0.30 \tan\phi = 0.15$

$\phi = \tan^{-1}\left(\dfrac{0.15}{0.30}\right) = 26.565^\circ$

From (1)

$$c = 0.094 - 0.1 \tan 26.565$$

$$c = 0.044 \ N/mm^2$$

Q-9 (0, 34.38) UU Test ($\epsilon_v = 0$)

Cell Pressure (σ_3) = 100 N/mm^2

Deviator Load (P_d) = 150 kN

Lateral Strain (ϵ_L) = 10 %

$$\text{Deviator stress} (\sigma_d) = \frac{P_d}{A_c}$$

Where $A_c \rightarrow$ Corrected Area

$$A_c = \frac{A_0}{(1-\epsilon_L)} = \frac{\frac{\pi}{4} \times 50^2}{(1-0.10)}$$

$$= 2181.66 \ mm^2$$

$$\text{Deviator stress} (\sigma_d) = \frac{150 \times 10^3}{2181.66} = 68.76 \ N/mm^2$$

$$\sigma_1 = \sigma_3 + \sigma_d = 100 + 68.76 = 168.76 \ N/mm^2$$

For clay $\phi = 0$

$$\sigma_1 = \sigma_3 \tan^2 \alpha + 2c \tan \alpha$$

$$168.76 = 100 \tan^2(45) + 2c \tan 45$$

$$c = \frac{68.76}{2} = 34.38 \ N/mm^2$$

Q-10 (0, 43.44) CD Test (Saturated Sand)

σ_d = 220 kPa

σ_3 = 100 kPa

} PWP(U) = 50 kPa

$c' = 0$

$\sigma_1 = \sigma_3 + \sigma_d = 220 + 100 = 320 \text{ kpa}$

$\sigma_1' = (\sigma_1 - U) = (320 - 50) = 270 \text{ kpa}$

$\sigma_3' = (\sigma_3 - U) = (100 - 50) = 50 \text{ kpa}$

$\sigma_1' = \sigma_3' \tan^2\alpha + \cancel{2c' \tan\alpha}$

$270 = 50 \tan^2\alpha$

$\tan^2\alpha = 5.4$

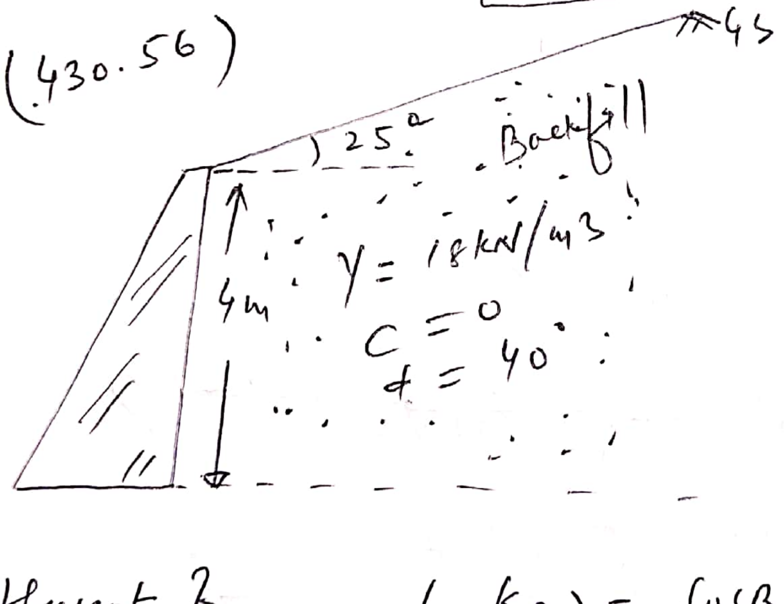
$\tan\alpha = 2.324$

$\alpha = \tan^{-1}(2.324) = 66.718$

$45 + \frac{\phi'}{2} = 66.718$

$\boxed{\phi' = 43.44°}$

Q-11 (430.56)



Coefficient of Passive earth Pressure $(K_p) = \cos\beta \dfrac{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}$

$$K_p = \cos 25 \frac{\cos 25 + \sqrt{\cos^2 25 - \cos^2 40}}{\cos 25 - \sqrt{\cos^2 25 - \cos^2 40}}$$

$K_p = 2.99$

Passive earth Thrust (P_p) $= \frac{1}{2} k_p \gamma H^2$

$= \frac{1}{2} \times 2.99 \times 18 \times 4^2$

$= 430.56$ kN/m

Q-12 (d)

Q-13. (d)

1 ✗
2 ✗
3 ✓

Q-14 (a)

Q-15. True

~~END OF THE SOLUTION~~

Q-16 (c)

$c = 15$ kN/m^2, $\gamma = 20$ kN/m^3

FOS $= 1.5$; $S_n = 0.05$

$$S_n = \frac{c}{F_c \cdot \gamma \cdot H}$$

$$H = \frac{c}{S_n \cdot F_c \cdot \gamma} = \frac{15}{0.05 \times 1.5 \times 20} = 10\text{m}$$

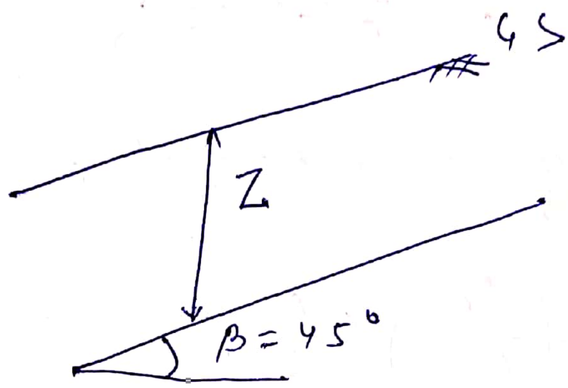
Safe height $= 10$ m

Q-17 (a)

$$B = \frac{\Delta u}{\Delta \sigma_3} = \frac{0.15 - 0.07}{0.26 - 0.10}$$

$$= \frac{0.08}{0.16} = 0.50$$

Q-18



$$\sigma_n = \gamma z \cos^2\beta$$

$$\tau = \gamma z \cos\beta \cdot \sin\beta.$$

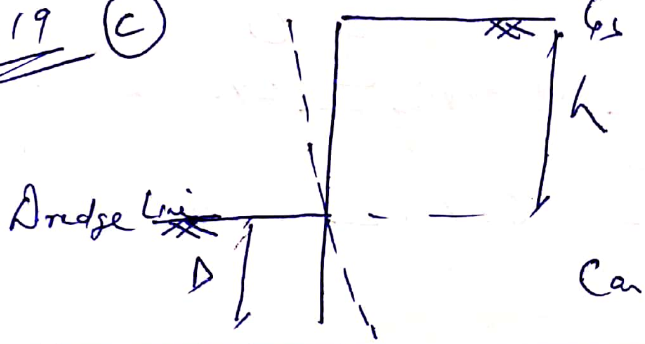
$$FOS = \frac{\tau_f}{\tau} = \frac{c' + \sigma_n' \tan\phi'}{\gamma z \cos\beta \cdot \sin\beta} = \frac{c' + \gamma z \cos^2\beta \cdot \tan\phi'}{\gamma z \cos\beta \cdot \sin\beta}$$

$$3.5 = \frac{28 + 16 \times z \cos^2 45 \times \tan 40}{16 \times z \times \cos 45 \cdot \sin 45}$$

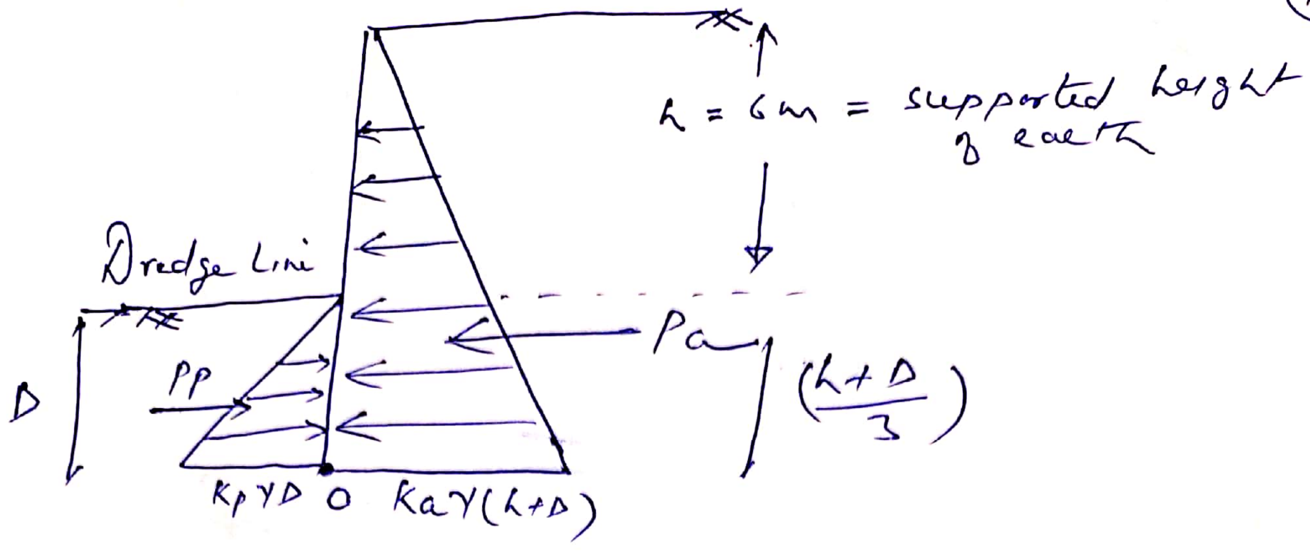
$$\boxed{z = 1.116 \text{ m}}$$

The soil can be excavated upto 1.116 m to have a factor of safety of 3.5 against failure.

Q-19 (c)



Cantilever sheet pile



Taking moment of all forces about O

$$\left(\frac{P_P}{FOS}\right) \times \frac{D}{3} - P_A \times \left(\frac{h+D}{3}\right) = 0 \quad \text{--- (1)}$$

where $P_P = \frac{1}{2} K_P \gamma D^2$

$P_A = \frac{1}{2} K_a \gamma (h+D)^2$

For $\phi = 35°$, $\gamma = 18\ kN/m^3$, $FOS = 2$

$h = 6\ m$

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 35}{1+\sin 35} = 0.271$$

$$K_P = \frac{1}{K_A} = 3.69$$

From (1)

$$\frac{\frac{1}{2} \times 3.69 \times 18 \times D^2}{2} \times \frac{D}{3} - \frac{1}{2} \times 0.271 \times 18 \times (6+D)^2 \times \left(\frac{6+D}{3}\right) = 0$$

$$1.574 D^3 - 4.878 D^2 - 29.268 D - 58.536 = 0$$

$$D = 6.702\ m$$

Q-20 (a) Given Diagram shows Base failure ($D_f > 1$)

$D_f = \frac{H+D}{H} > 1$

Q-21 (d) For fully saturated Soil

$B = 1$

For Dry Soil, $B = 0$

For Normally Consolidated Soil

$A = 0.5$ to 1

<END OF THE SOLUTION>