Department of Civil Engineering
Katihar Engineering College, Katihar

Subject: Soil and Rock Mechanics

Topic: Assignment-II Solution

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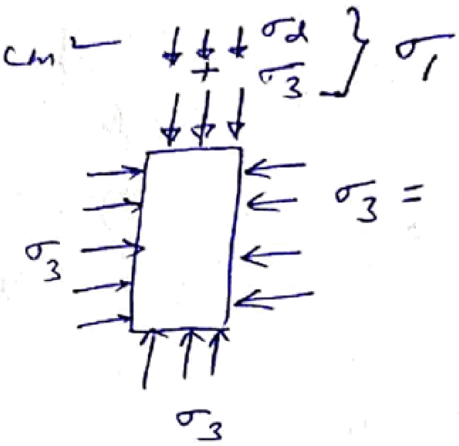
Q-1. (3.32, 35°)

$c = 0.8\ kg/cm^2$

$\phi = 20°$



$\sigma_3 = 1\ kg/cm^2$

Cell Pressure or Confining pressure $(\sigma_3) = 1\ \frac{kg}{cm^2}$

$\alpha = 45 + \frac{\phi}{2}$

$= 45 + \frac{20}{2} = 55°$

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

$\sigma_1 = 1 \times \tan^2(55) + 2 \times 0.8 \times \tan(55)$

$= 4.32\ kg/cm^2$

We know that

$\sigma_1 = \sigma_3 + \sigma_d$

$\sigma_d = (\sigma_1 - \sigma_3) = (4.32 - 1) = 3.32$

deviator stress $(\sigma_d) = 3.32\ kg/cm^2$

Angle made by the failure plane with the axis of sample $= 45 - \frac{\phi}{2} = 45 - \frac{20}{2}$

$= 35°$

Q-2. (50.28)

$c' = 50\ kN/m^2$
$\phi' = 16°$
$\gamma = 16.2\ kg/m^3$

From triaxal test data:

$A = 0.4, \quad B = 0.92$

$\gamma = 16.2 \times 9.81\ N/m^3 = 158.92\ N/m^3$

Let $\Delta\sigma_1 \rightarrow$ increase in the vertical stress due to 3 m construction (5 m to 8 m)

$\Delta\sigma_1 = \gamma \cdot \Delta H$
$= 158.92 \times 3 = 476.76\ N/m^2$

A/c to the question $\Delta\sigma_3 = \frac{1}{2} \times \Delta\sigma_1$
$= \frac{476.76}{2} = 238.38\ N/m^2$

We know that
$\Delta u = B[\Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3)]$

$\Delta u = 0.92[238.38 + 0.4(476.76 - 238.38)]$

$= 307.03\ N/m^2$

Original stress, $\sigma_1 = \gamma \times H_1$
$= 158.92 \times 5 = 794.6\ N/m^2$

Effective stress $(\sigma') = \sigma_1 + \Delta\sigma_1 - \Delta u$
$= 794.6 + 476.76 - 307.03$
$= 964.33\ N/m^2$

$\sigma' = 0.964 \ kN/m^2$

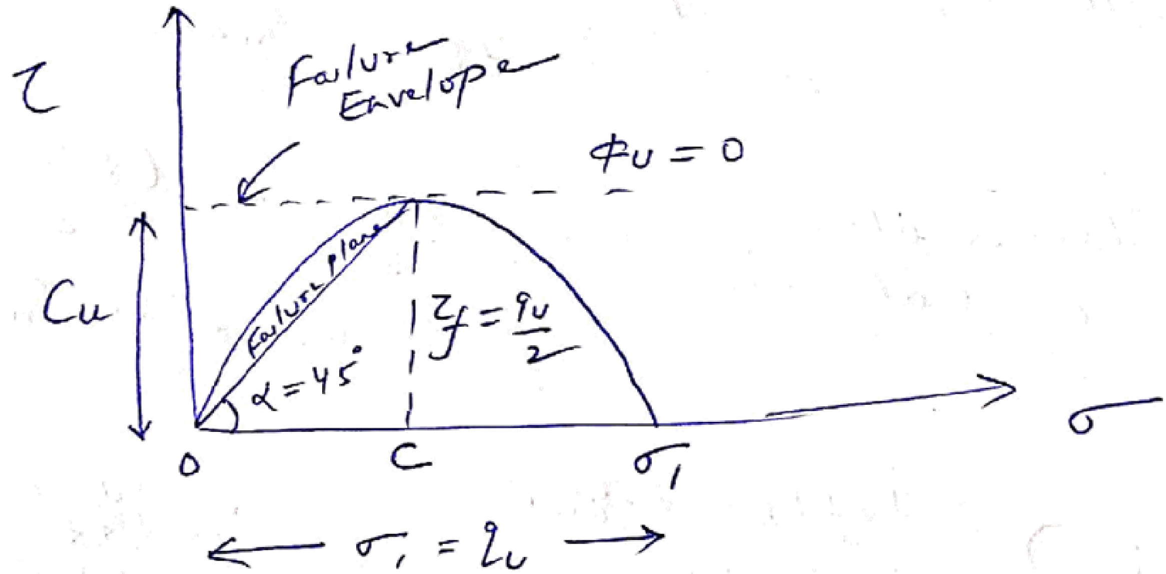
Shear strength (τ_f) $= c' + \sigma' \tan\phi'$

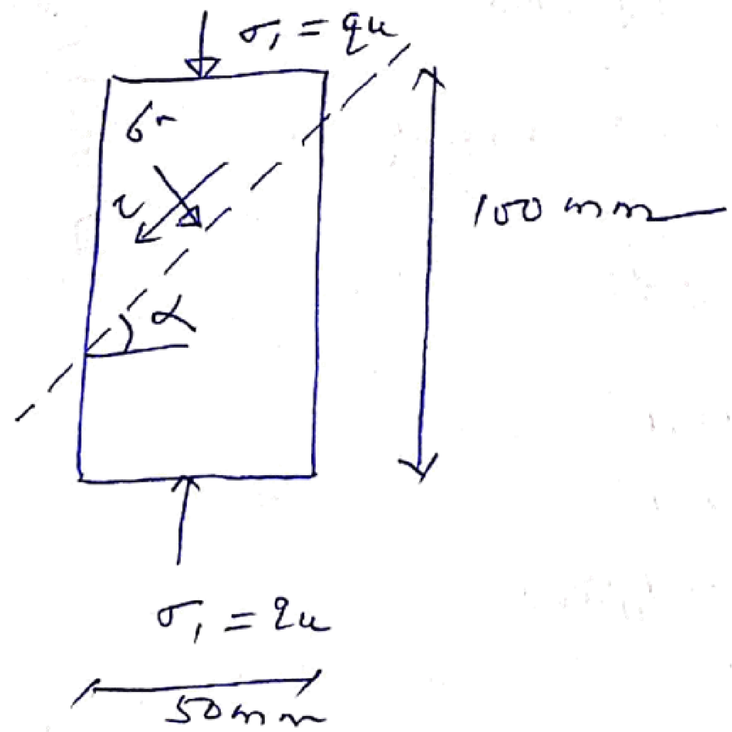
$= 50 + 0.964 \times \tan(16)$

$= 50.28 \ kN/m^2$

Q-3. (34.38)

Unconfined Compression test (UCS) is the special case of Triaxial in which the value of Cell Pressure or Confining pressure (σ_3) is equal to zero.





$P_f = 150\ N$

$\epsilon_L = 0.10$

$$A_f = \frac{A_o}{1-\epsilon_L} = \frac{A_o}{1-\left(\frac{\Delta L}{L}\right)}$$

$$= \frac{\frac{\pi}{4} \times 50^2}{1-0.1} = 2181.7\ mm^2$$

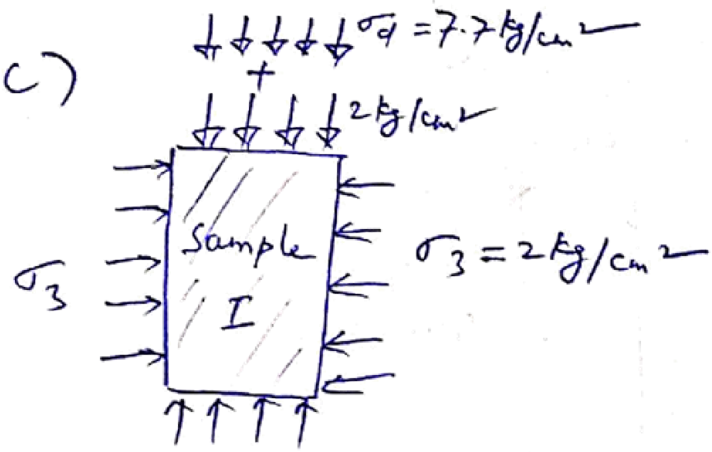
Unconfined Compressive Strength $(q_u) = \frac{P_f}{A_f} = \frac{150}{2181.7} = 0.06875\ \frac{N}{mm^2}$

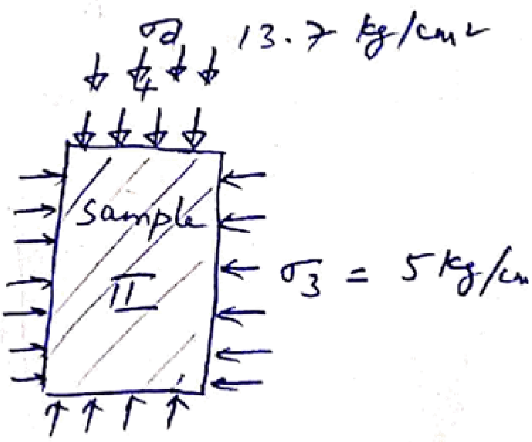
$= 68.75\ kN/m^2$

Shear Resistance or Cohesion $(c_u) = \frac{q_u}{2} = \frac{68.75}{2}$

$= 34.38\ kN/m^2$

Q-4 (c)





$\sigma_1 = \sigma_3 + \sigma_d$

$= 2 + 7.7$

$= 9.7\ kg/cm^2$

$\sigma_1 = \sigma_3 + \sigma_d$

$= 5 + 13.7$

$= 18.7\ kg/cm^2$

For Sample I

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

$9.7 = 2\tan^2\alpha + 2c\tan\alpha$ —— ①

For sample II

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

$18.7 = 5\tan^2\alpha + 2c\tan\alpha$ —— ②

Operate ② − ①

$(5\tan^2\alpha + 2c\tan\alpha) - (2\tan^2\alpha + 2c\tan\alpha) = 9$

$3\tan^2\alpha = 9$

$\tan^2\alpha = 3$

$\tan\alpha = \sqrt{3}$

$\alpha = 60°$

$\alpha = 45 + \phi/2$

$\phi = 2.(\alpha - 45) = 2(60-45)$

$\boxed{\phi = 30°}$

From ②

$18.7 = 5\times3 + 2c\times\sqrt{3}$

$c = \frac{18.7-15}{2\sqrt{3}} = 1.068\ kg/cm^2$

Q-5 (0.503, 3)

Vane shear test is a quick test, used either in the laboratory or in the field to determine the Undrained shear strength of cohesive soil. The vane shear tester consists of four thin steel plates called vanes welded orthogonally to a steel rod.

$H \rightarrow$ Height of the vane

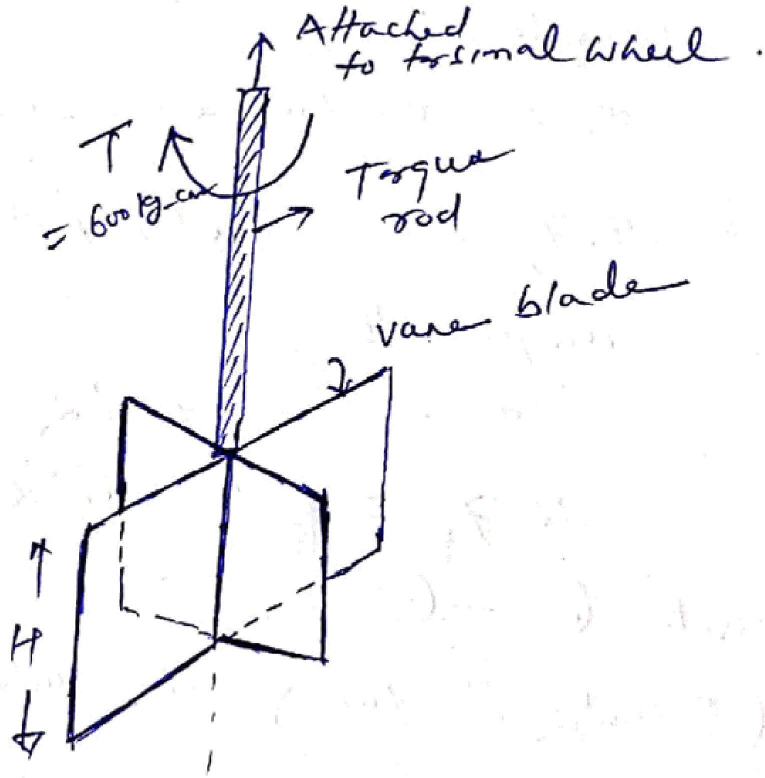
$= 11\ cm$

D = Diameter of the vane

$D = 7.5\ cm$

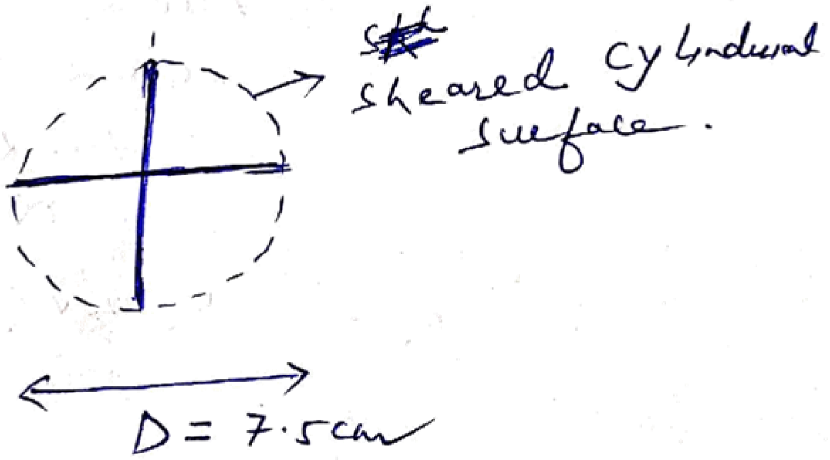
T = Torque

$= 600\ kg\text{-}cm$



Let S be the shear strength

$$S = \frac{T}{\pi D^2 \left[\frac{H}{2} + \frac{D}{6}\right]}$$



$$S = \frac{600}{\pi \times 7.5^2 \times \left[\frac{11}{2} + \frac{7.5}{6}\right]}$$

$S = 0.503\ kg/cm^2$

$$c = \tau_f = S = 0.503\ kg/cm^2$$

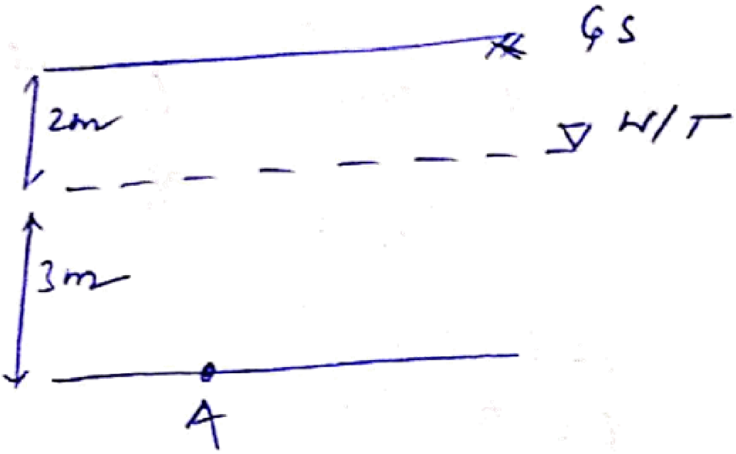
$$\text{Sensitivity } (S_t) = \frac{(q_u)_{undisturbed}}{(q_u)_{remoulded}} = \frac{(C_u)_{undisturbed}}{(C_u)_{remoulded}}$$

We know that $C \propto T$

Sensitivity (S_t) = $\frac{\tau \text{ is in Undisturbed}}{\tau \text{ is in Remoulded}}$

$= \frac{600}{200} = 3.$

Q-6. $\left(60.86 \frac{kN}{m^2}\right)$



Void ratio (e) = 0.60

specific gravity (G_s) = 2.65

Dry density (γ_d) $= \frac{G\gamma_w}{1+e}$

$= \frac{2.65 \times 9.81}{1+0.6} = 16.248 \ kN/m^3$

Saturated Density (γ_{sat}) $= \left(\frac{G+e}{1+e}\right)\gamma_w = \left(\frac{2.65+0.6}{1+0.6}\right) \times 9.81$

$= 19.927 \ kN/m^3$

Submerged Density (γ_{sub}) $= \gamma_{sat} - \gamma_w = 19.927 - 9.81$

$= 10.117 \ kN/m^3$

Effective stress at A (σ'_A) $= 2 \times \gamma_d + 3 \times \gamma_{sat} - 3 \times \gamma_w$

$= 2 \times \gamma_d + 3(\gamma_{sat} - \gamma_w)$

$= 2 \times \gamma_d + 3\gamma_{sub}$

$= 2 \times 16.248 + 3 \times 10.117$

$= 62.85 \ kN/m^2$

We know that

$$K_0 = \frac{\sigma_h'}{\sigma_v'}$$

$$\sigma_h' = K_0 \sigma_v' = 0.5 \times 62.85$$

$$= 31.425 \text{ kN/m}^2$$

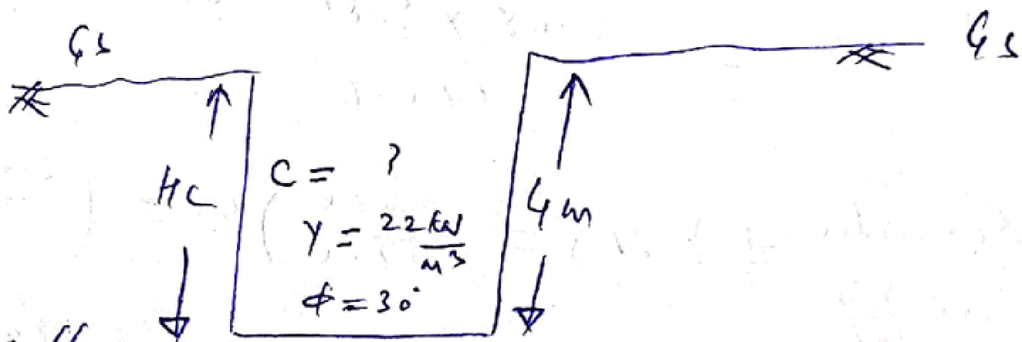
Due to Presence of water.

$$\sigma_w = \gamma_w H = 9.81 \times 3 = 29.43 \text{ kN/m}^2$$

Total Lateral Earth Pressure $= 31.425 + 29.43$

$$= 60.86 \text{ kN/m}^2$$

Q-7 (12.70)



$$K_a = \frac{1 - \sin 30}{1 + \sin 30} = 1/3$$

$$H_c = \frac{4c}{\gamma \sqrt{K_a}} \quad \text{——— (1)}$$

Where $H_c \rightarrow$ Maximum Unsupported depth

$\rightarrow$ Critical height

$$C = \frac{H_c \cdot \gamma \cdot \sqrt{K_a}}{4}$$

$$= \frac{4 \times 22 \times \sqrt{1/3}}{4} = 12.70 \text{ kN/m}^2$$

Q-8 (187.8, 212.29) CD Test

For Ist test, $\sigma_3 = 0.2\,N/mm^2$, $\sigma_1 = 0.46\,\frac{N}{mm^2}$

For 2nd test, $\sigma_3 = 0.4\,N/mm^2$, $\sigma_1 = 0.88\,\frac{N}{mm^2}$

We know that

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

$$0.46 = 0.2\tan^2\alpha + 2c\tan\alpha \quad \text{——(1)}$$

$$0.88 = 0.4\tan^2\alpha + 2c\tan\alpha \quad \text{——(2)}$$

Operate (2) − (1)

$$0.2\tan^2\alpha = 0.42$$

$$\tan^2\alpha = 2.1$$

$$\tan\alpha = 1.45$$

$$\alpha = 55.41^\circ$$

$$\phi = 20.82$$

From (2)

$$0.4\tan^2\alpha + 2c\tan\alpha = 0.88$$

$$(0.4 \times 2.1) + 2c \times 1.45 = 0.88$$

$$c = 0.014\,N/mm^2$$

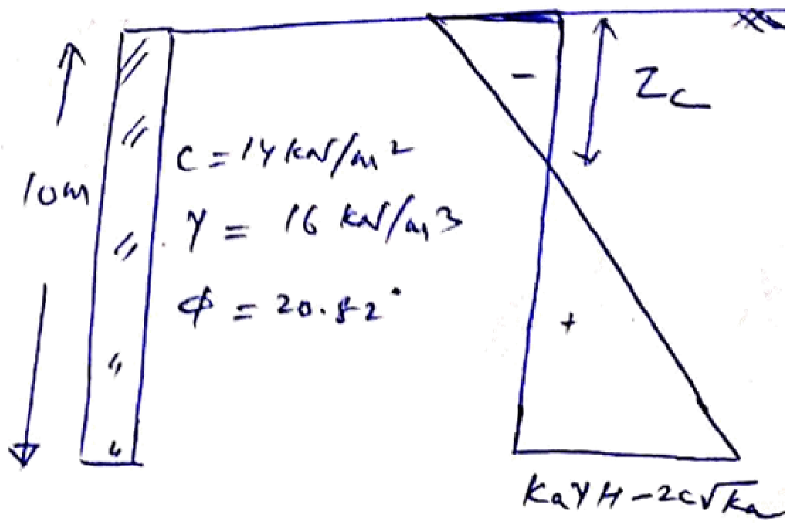
$$= 14\,kN/m^2$$

Depth of tension crack $(z_c) = \frac{2c}{\gamma\sqrt{K_a}}$

$$K_a = \frac{1-\sin 20.82}{1+\sin 20.82}$$

$$= 0.476\,m$$

$$z_c = \frac{2 \times 14}{16 \times \sqrt{0.476}} = 2.54\,m$$



AEP diagram

Earth Pressure at any depth z $(p_a) = K_a \gamma . z - 2c\sqrt{K_a}$

$p_a = 0.476 \times 16 \times z - 2 \times 14 \times \sqrt{0.476}$

$p_a = (7.62z - 19.32)$

$p_a = (7.62\ z - 19.32)$

Active force before tension crack $(P_a) = \int_0^H p_a . dz$

$= \int_0^H (K_a \gamma z - 2c\sqrt{K_a})\ dz$

$= \int_0^{10} (7.62\ z - 19.32)\ dz$

$= 187.8$ kN/m

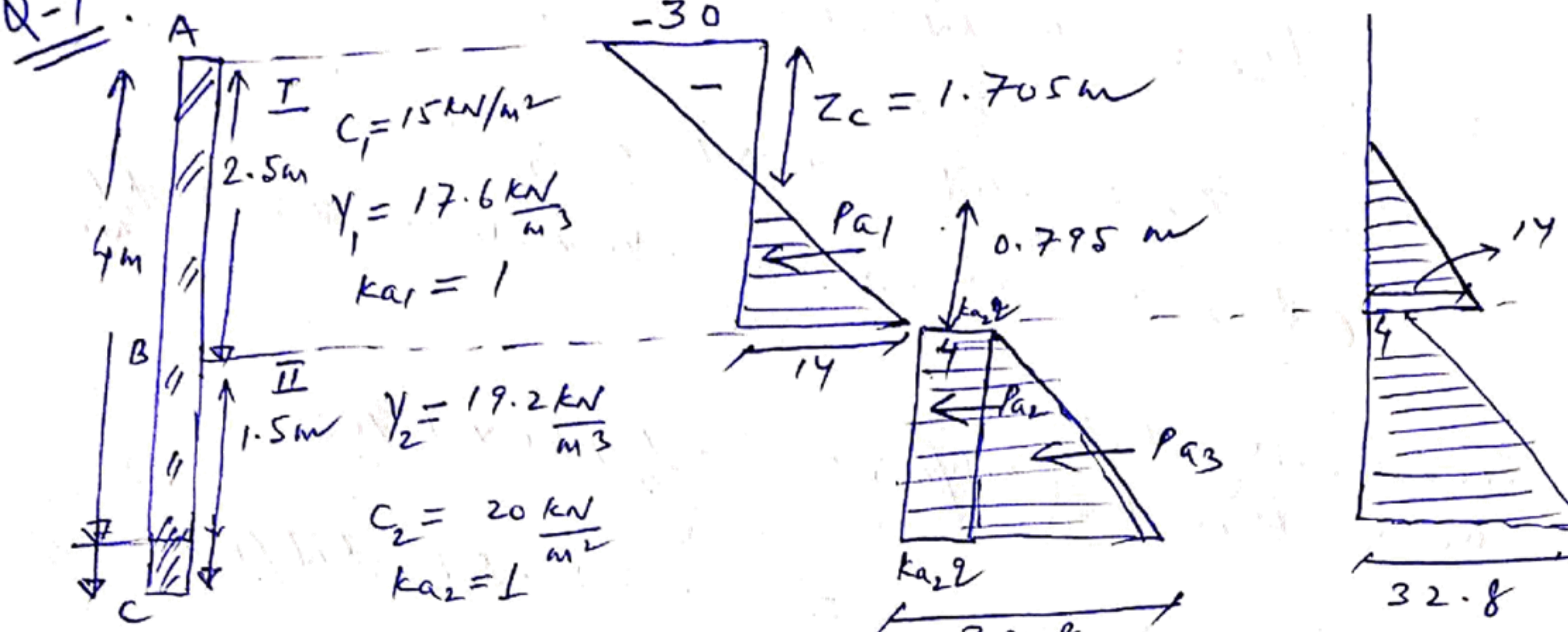
Active force after the tension crack $(P_a) = \int_{z_c}^{H} p_a . dz$

$= \int_{2.54}^{10} (7.62\ z - 19.32)\ dz$

$= 212.29$ kN/m

Q-9.

Q-9. (25.58, 32.535)



Layer I

For $\phi = 0$

$ka = 1$

$$Z_c = \frac{2c}{\gamma\sqrt{ka}} = \frac{2\times 15}{17.6\sqrt{1}} = 1.705\ m$$

Lateral Pressure at top $= -2c\sqrt{ka}$

$= -2\times 15\times\sqrt{1} = -30\ kN/m^2$

Lateral Pressure at base $= ka\,\gamma_1 H_1 - 2c\sqrt{ka}$

$= 17.6\times 2.5 - 2\times 15\times\sqrt{1}$

$= 14\ kN/m^2$

In Layer II

Surcharge (q) $= \gamma_1 H_1 = 17.6\times 2.5 = 44\ kN/m^2$

At any depth z_2 below B

$pa_2 = \gamma_2 z_2 ka_2 - 2c_2\sqrt{ka_2} + q\times ka_2$

$pa_2 = 19.2 z_2 - 40 + 17.6\times 2.5\times 1$

$pa_2 = 19.2 z_2 - 40 + 44$

When $z_2 = 0$ (At B)

$p_{a2} = 4 \ kN/m^2$

When $z_2 = 1.5$ (At C)

$p_{a2} = 19.2 \times 1.5 - 40 + 44 = 32.8 \ \frac{kN}{m^2}$

Total negative active thrust (kN/m) $= -\frac{1}{2} \times 30 \times 1.705$

$= -25.58 \ kN/m^2$

Total Active force:

$P_{a1} = \frac{1}{2} \times 14 \times 0.795 = 5.57 \ kN/m$

$P_{a2} = 4 \times 1.5 = 6 \ kN/m$

$P_{a3} = \frac{1}{2} \times (32.8 - 4) \times 1.5 = 21.6 \ kN/m$

Total Active force $(P_a) = P_{a1} + P_{a2} + P_{a3}$

$= 5.57 + 6 + 21.6$

$= 32.535 \ kN/m$

Q-10 (b)

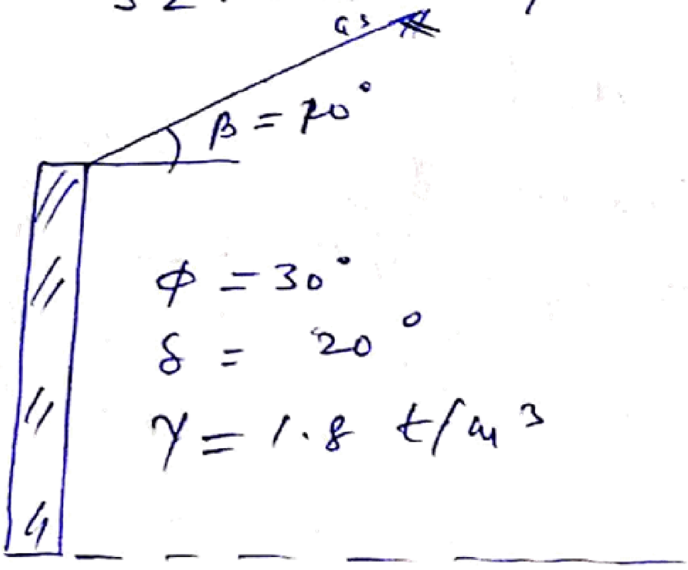
Given

$\beta = 10°$

$\phi = 30°$

$\theta = 0$

$\delta = 20°$



Total Active thrust $(P_a) = \frac{1}{2} K_a \gamma H^2$

Where $$K_a = \left[\frac{\sec\theta \cdot \cos(\phi - \theta)}{\sqrt{\cos(\theta + \delta)} + \sqrt{\frac{\sin(\theta+\delta) \cdot \sin(\phi - \beta)}{\cos(\beta - \theta)}}} \right]^2$$

$$K_a = \left[\frac{\sec 0 \cdot \cos(30 - 0)}{\sqrt{\cos(0 + 20)} + \sqrt{\frac{\sin(30+20) \cdot \sin(30 - 10)}{\cos(10 - 0)}}} \right]^2$$

$$= 0.34$$

$$P_a = \frac{1}{2} \times 0.34 \times 1.8 \times 20^2$$

$P_a = 122.4$ t/m run

HAPPY LEARNING