Lateral earth pressure:

PSM
↳ ans
12 ques out of 16.

2015-16
3 → point load
4 →
6 → Culman's graph

14-15 →
5
6 → culman graph
7
8 1 → earth pressure at rest. (Short note)

13-14
2 c-φ soil → passive earth pressure theory.
6 → culman graph.
7 →
8

12-13
6 → culman graph
7
8

11-12
3 (b)

10-11
1 (b) theory active earth pressure c-φ
3
4 (a)

9-10
2 (b)
4 (b)

8-9
1
4 (a)

7-8
1
2

Formulas

1. For earth pressure at rest:

✓ $K_0 = (1 - \sin\phi)$ → NC soil
✓ $K_0 = (1 - \sin\phi)\, OCR^{\sin\phi}$ → OC soil

→ Jacky

Alpan
$K_0 = 0.19 + 0.233 \log I_P$ → NC soil
$K_{0(OCC)} = K_{0(NCC)} \sqrt{OCR}$ → OC soil

for Sloping surface $(1 + 0.5 \tan\beta)^2$ → multiplied

2. Cohesionless soil:

✓ $K_a = \frac{1 - \sin\phi}{1 + \sin\phi} = \tan^2(45 - \frac{\phi}{2})$ active earth pressure

✓ $K_p = \frac{1 + \sin\phi}{1 - \sin\phi} = \tan^2(45 + \frac{\phi}{2})$ passive earth pressure

3. Partially cohesive soil (c-φ soil)

Active earth pressure $P_{ac} = K_a \gamma h - 2c\sqrt{K_a}$.

Critical height $h_c = \frac{2c}{\gamma\sqrt{K_a}} = \frac{2c}{\gamma} \tan(45 + \frac{\phi}{2})$

Theoritical unsupported height $H_u = 2h_c = \frac{4c}{\gamma\sqrt{K_a}}$.

* Active earth force $P_{ac} = \frac{1}{2} K_a \gamma h^2 - 2cH\sqrt{K_a} + \frac{2c^2}{\gamma}$
* Passive " " $P_{pc} = K_p \gamma h + 2c\sqrt{K_p}$

4) Cohesionless backfill with sloping surface.

$$K_a = \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\varphi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\varphi}}$$

Active thrust $P_a = \frac{1}{2} K_a \gamma H^2 \cos\beta$.

horizontal active thrust $P_{ah} = \frac{1}{2} K_a \gamma H^2 \cos^2\beta$.

$$K_p = \frac{\cos\beta + \sqrt{\cos^2\beta - \cos^2\varphi}}{\cos\beta - \sqrt{\cos^2\beta - \cos^2\varphi}}$$

passive thrust, $P_p = \frac{1}{2} K_p \gamma H^2 \cos\beta$.

passive $\downarrow$ inward $\downarrow$ upward.

Active $\downarrow$ downward $\downarrow$ outward.

5) point load

$m > 0.4$

$$P_h = \frac{1.77Q}{H^2} \cdot \frac{m^2 n^2}{(m^2+n^2)^3}$$

$m \leq 0.4$

$$P_h' = \frac{1.77Q}{H^2} \frac{0.4^2 n^2}{(0.4^2+n^2)^3}.$$

$$P_h' = P_h \cos^2(1.1\alpha)$$

6 Line Load:

$m > 0.4$

$$P_h = \frac{4q}{\pi H} \frac{m^2 n}{(m^2+n^2)^2}$$

$m \leq 0.4$

$$P_h = \frac{4q}{\pi H} \frac{0.4^2 n}{(0.4^2+n^2)^2}$$

7) $\Rightarrow$ · For Sand $c = 0$.

Nc clay $c = 0$

Saturated clay · $\phi = 0$.

purely cohesive soil · $\phi = 0$

Sand / Granular material · $c = 0$

8) Culmann's line $\psi = 90 - \theta - \delta$.

9)
$$K_a = \frac{\sin^2(\alpha+\phi)}{\sin^2(\alpha)\,\sin^2(\alpha-\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\beta)}{\sin(\alpha-\delta)\sin(\alpha+\beta)}}\right]^2}$$

$\alpha \rightarrow$ angle of wall with horizontal

$\delta \rightarrow$ angle of wall friction

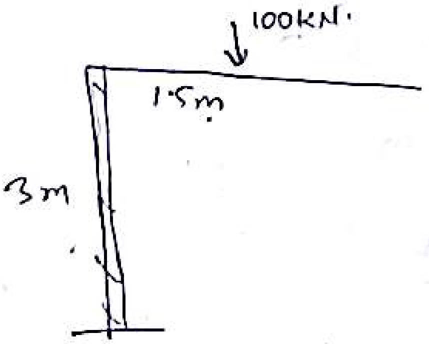
$\beta \rightarrow$ slop of soil surface.

2015-16

(3) point load

$x = 1.5m$
$H = 3m$
$m = \frac{x}{H} = \frac{1.5}{3} = 0.5$

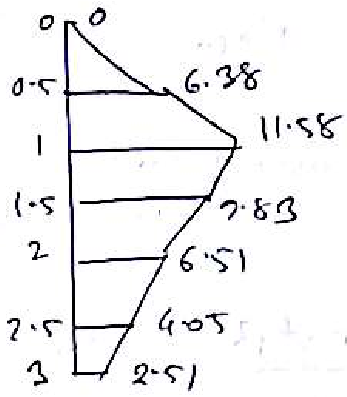
$m > 0.4$



$$P_h = \frac{1.77Q}{H^2} \frac{m^2 n^2}{(m^2+n^2)^3}$$

$$= \frac{1.77 \times 100 \times 0.5^2 \times n^2}{3^2 \times (0.5^2+n^2)^3}$$

depth in m	$n = \frac{y}{H}$	$P_h = \frac{1.77 \times 100 \times 0.5^2 \times n^2}{3^2 \times (0.5^2+n^2)^3}$
0	0	0
0.5	0.167	6.38
1	0.33	11.58
1.5	0.5	9.83
2	0.667	6.51
2.5	0.833	4.05
3	1	2.51

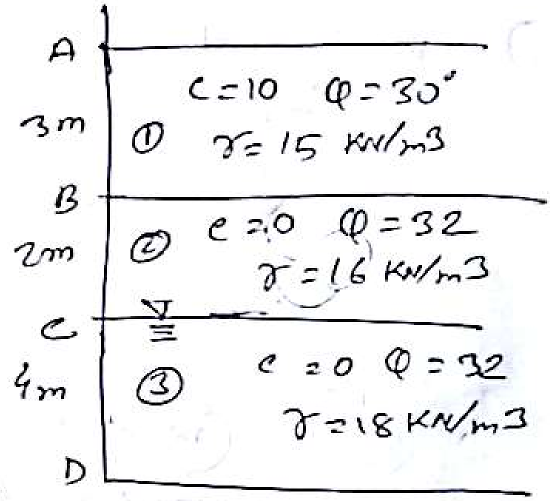


$$\text{total thrust} = \frac{1}{2} \times 0.5 \times 6.38 + \left(\frac{6.38+11.58}{2}\right) \times 0.5 + \left(\frac{11.58+9.83}{2}\right) \times 0.5 + \left(\frac{9.83+6.51}{2}\right) \times 0.5 + \left(\frac{6.51+4.05}{2}\right) \times 0.5 + \left(\frac{4.05+2.51}{2}\right) \times 0.5 = \boxed{}$$

(4)

layer ①

$$K_{a(1)} = \frac{1-\sin 30}{1+\sin 30} = \frac{1}{3}$$



at A

$$P_{ac(A)} = K_{a(1)}\gamma h - 2c\sqrt{K_{a(1)}}$$
$$= \tfrac{1}{3}\times 15\times 0 - 2\times 10\times\sqrt{1/3}$$
$$= -11.54$$

at B for layer 1.

$$P_{ac(B)} = K_a \gamma h - 2c\sqrt{K_a}.$$
$$= 15\times\tfrac{1}{3}\times 3 - 2\times 10\sqrt{1/3} = 3.46 \text{ KN/m}^2$$

for layer 2 and 3

$$K_{a(2)} = K_{a(3)} = \frac{1-\sin 32}{1+\sin 32} = 0.31$$

at point B layer ① acts as surcharge load,

$$\sigma_v = \gamma h = 3\times 15 = 45.$$

$$P_{ac(B)} = K_{a(2)}\sigma_v - 2c\sqrt{K_b}..$$
$$= 45\times 0.31 - 2\times 0\sqrt{0.31} = 13.95$$

at point C for layer 2

$P_{ac(c)} = \gamma h K_{a(2)} - 2c\sqrt{K_{a(2)}} + 13.95$ ← $\gamma_1 h_1$

$= 16 \times 2 \times 0.31 - 2 \times 0 \sqrt{0.31} + 13.95$ ← $15 \times 3 \times 0.31$

$= 23.87$

at C for layer 3 and layer 1 acts as surcharge

$\sigma_v = (16 \times 2 + 15 \times 3)$

$P_{ac(c)} = \sigma_v K_{a(3)} - 2c\sqrt{K_{a(3)}}$

$= (16 \times 2 + 15 \times 3) \times 0.31 - 2 \times 0 \sqrt{0.31}$

$= 23.87$

at point D

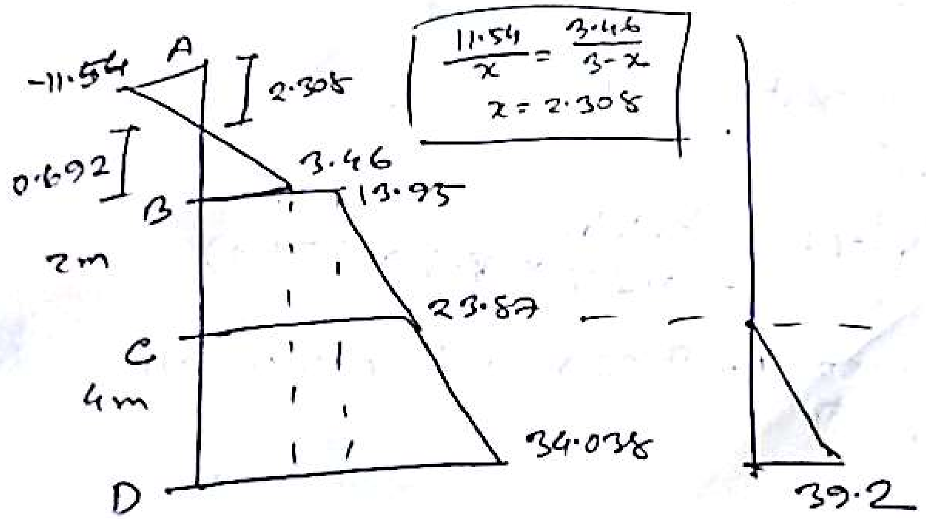
$P_{ac(D)} = 23.87 + K_{a(3)} \gamma h - 2c\sqrt{K_{a(3)}}$

$= 23.87 + 0.31 \times (18 - 9.8) \times 4 - 0.$

$= 34.038$

water pressure at D.

$P_w = \gamma_w h = 9.81 \times 4 = 39.2$ kN/m²



$\frac{11.54}{x} = \frac{3.46}{3 - x}$

$x = 2.308$

lateral thrust

$= \frac{1}{2} \times 3.46 \times 0.692 + 13.95 \times 6$

$+ \frac{1}{2} \times (23.87 - 13.95) \times 2 + 23.87 \times 4 +$

$\frac{1}{2} \times (34.038 - 23.87) \times 4$

$= \boxed{}$.

14-15

(7) $P_h = 200\ kN/m$

Before increasing height

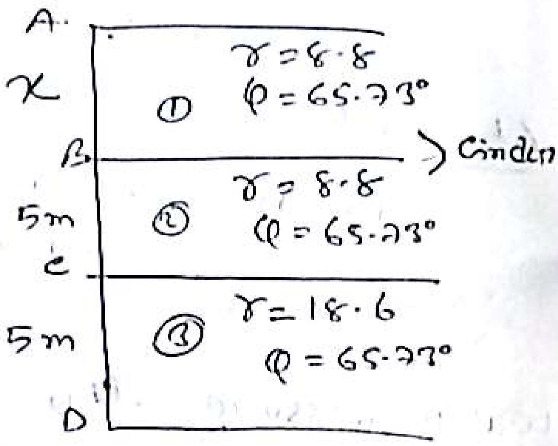
$P_h = \frac{1}{2} K_a \gamma h^2$

$\Rightarrow 200 = \frac{1}{2} \times K_a \times 18.6 \times 10^2$

$\Rightarrow K_a = 0.215$

$\tan(45 - \frac{\varphi}{2}) = 0.215$

$\Rightarrow \varphi = 65.73°$



tan^2 hobe

40.24 degree hobe

let x height added.

at C

$P_{ac(3)} = K_a \gamma_1 h_1$

$= 0.215 \times 8.8 \times (5 + x)$

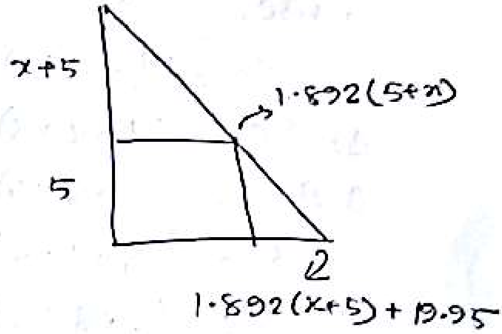
at C, layer ①, ② acts as surcharge on layer ③

$$\sigma_v = \gamma_1 h_1$$
$$= 8.8 \times (5+x)$$

$$P_{ac}(B) = \sigma_v \cdot K_a = 0.215 \times 8.8 \times (5+x)$$

at D

$$P_{ac}(D) = 0.215 \times 8.8 (5+x) + K_a \gamma_2 h_2$$
$$= 0.215 \times 8.8 (5+x) + 0.215 \times \cancel{8.8}\,18.6 \times 5$$
$$= 0.215 \times 8.8 \times (5+x) + 19.995$$
$$= 1.892(5+x) + 19.995$$



total thrust

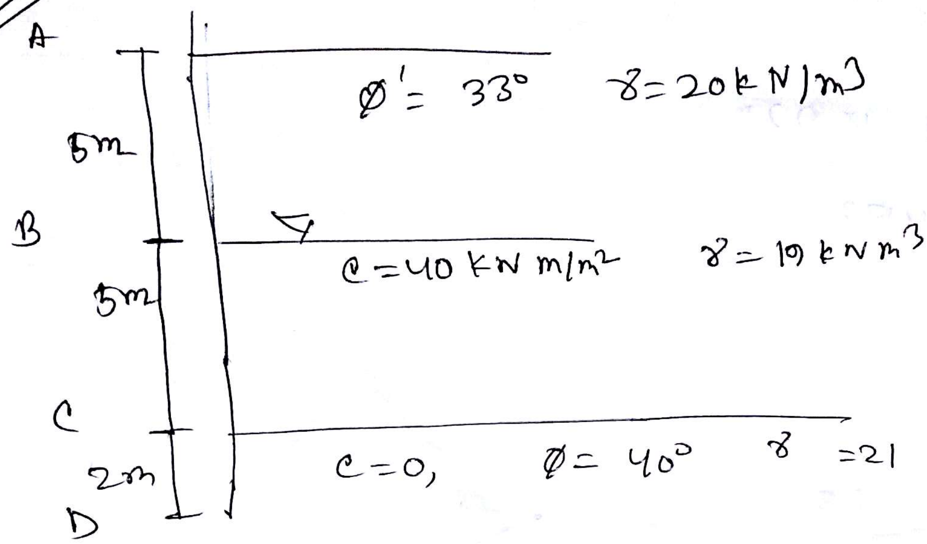
$$= \frac{1}{2} \times 1.892(x+5) \times (x+5) + 1.892(x+5) \times 5 + \frac{1}{2} \times 19.95 \times 5$$

$$\Rightarrow 200 = 0.946(x+5)^2 + 9.46(x+5) + 49.875$$

$$\Rightarrow x = 3.55\,m.$$

Ans

2014-15



$ka = \frac{1 - \sin 33^\circ}{1 + \sin 33^\circ} = 0.29$

$B = 0.29 * 20 * 5 = 29$

At B

$k_B = 1$

$Pae = 20 * 5 * 1 - 2 * 40 * \sqrt{1}$

$= 100 - 80 = 20$

$Pa\, e_-(c) = 20 * 5 * 1 + (19 - 9.8) 5 * 1 - 2 * 40$

$= 66.$

$= \cancel{195 - 80} =$

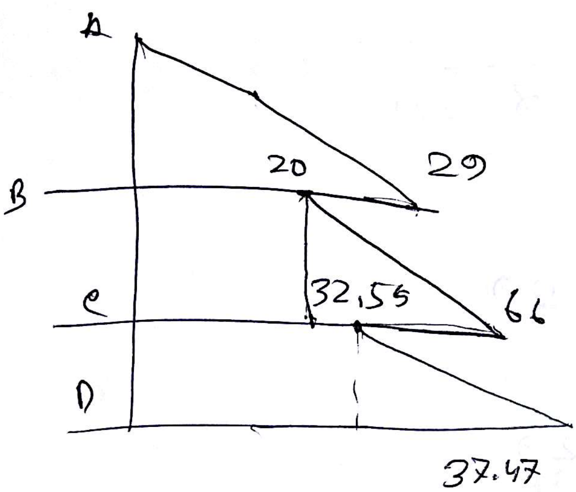
at $c \Rightarrow D$ $kc = \frac{1 - \sin 40^\circ}{1 + \sin 40^\circ} = 0.21744.$

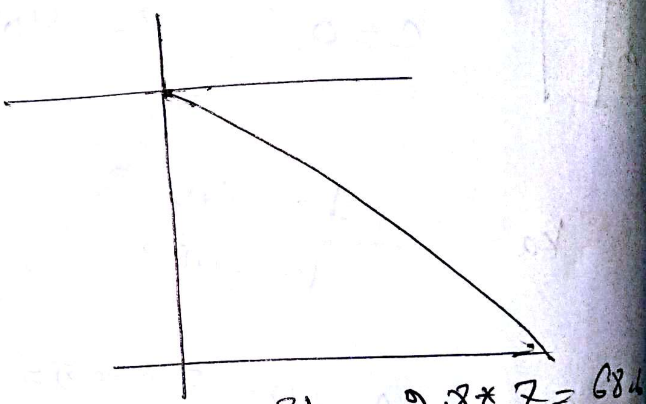
$Pe = \left(5 * 20 + \frac{(19 - 9.8)}{\cancel{19 * 5}}\right) * 0.217 = \cancel{42.40}$
32.55

at $D = (5 * 20 + (19 - 9.8) * 5) * 0.217 + (21 - 9.8) * 0.22 * 2$

$= 32.55 + 4.928$

$= 37.478$





$\gamma_w h = 9.8 * 7 = 68.6$

$\frac{1}{2} * 29 * 5 + (66 - 20) * \frac{1}{2} * 5 + 20 * 5$

$+ 22.55 * 2 + \frac{1}{2} * (37.47 - 32.55) * 2$

$+ \frac{1}{2} * 68.6 * 7$

$= 72.5 + 115 + 100 + 45.1 + 4.92$

$+ 240.1$

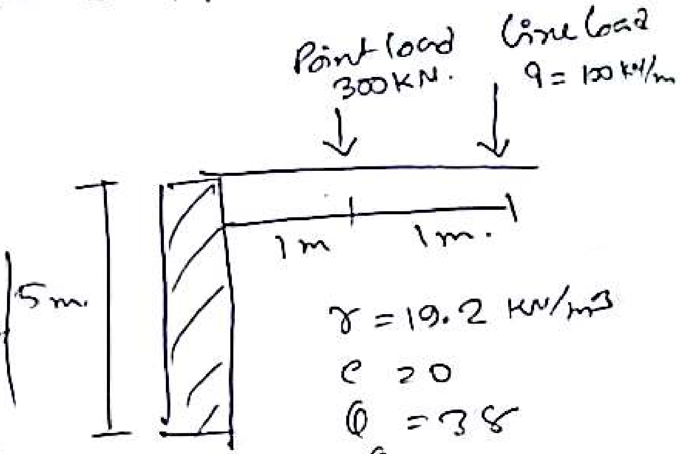
$= \underline{577.62 \text{ kN}}$

14-15 & (a) theory caten.

13-14 (i) theory caten.

(b) culmon graph caten.

(c)



$H = 5m.$

$x = 1m.$

$m = \frac{x}{H} = \frac{1}{5} = 0.2 < 0.4$

$\therefore P_h = \frac{1.77Q}{H^2} \frac{0.4^2 n^2}{(0.4^2+n^2)^3}$

$\gamma = 19.2\ kN/m^3$

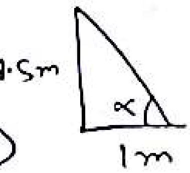
$c = 0$

$\phi = 38$

$\mu = 0.35$

at a lateral distance of 1.5m from the wall

$P_h' = P_h \cos^2(1.1\alpha)$



$\alpha = \tan^{-1}\left(\frac{1.5}{1}\right)$

$= 56.31°$

$= \frac{1.77Q}{H^2} \cdot \frac{0.4^2 n^2}{(0.4^2+n^2)^3} \cdot \cos^2(1.1\alpha)$

$Q = 300$

$\cancel{= \frac{0.0625 \times 300\, n^2}{5^2 (0.16+n^2)^3}}$

$\cancel{= \frac{2.08\, n^2}{(0.16+n^2)^3}}$

$= \frac{1.77 \times 300 \times 0.16\, n^2}{5^2 (0.16+n^2)^3} \times \cos^2(1.1 \times 56.31)$

$= \frac{0.752\, n^2}{(0.16+n^2)^3}$

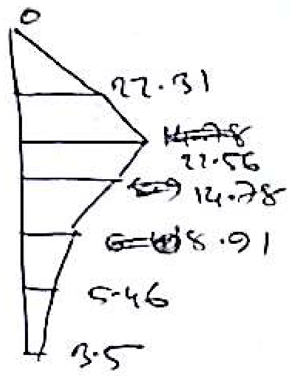
For line load

$$m = \frac{x}{h} = \frac{2}{5} = 0.4$$

$$P_h = \frac{4q}{\pi H} \cdot \frac{0.4^2 n}{(0.4^2 + n^2)^2}$$

$$= \frac{4 \times 100 \times 0.16 \times n}{3.14 \times 5 \times (0.16 + n^2)^2} =$$

$$= \frac{4.08\, n}{(0.16 + n^2)^2} =$$



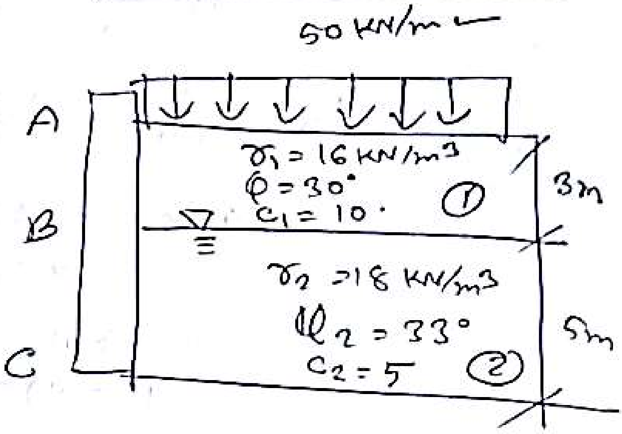
depth, y m.	$n = \frac{y}{H}$	Point load $\frac{0.252 n^2}{(0.16+n^2)^3}$	Line load $\frac{4.08 n}{(0.16+n^2)^2}$	~~total~~
0	0	0	0	0
0.833	~~0.167~~ 0.167	3.12	19.19	22.31
1.667	0.33	4.15	18.41	22.56
2.5	0.5	2.70	12.08	14.78
3.33	0.667	1.50	7.41	8.91
4.167	0.833	0.83	4.63	5.46
5	1	0.48	3.02	3.5

→ value gula 0, 0.5, 1, 1.5, 2 .. হিসেবে নেওয়া না– Load এর value actual না bcoz Chotha Copy Kora.

8

$P_{ac} = K_a \gamma h - 2c\sqrt{K_a}$.

C_1 এর value C_2 কোথায় থেকে আসছে?



for Soil ①

$$K_{a(1)} = \frac{1 - \sin\phi_1}{1 + \sin\phi_1}$$

$$= \frac{1 - \sin 30}{1 + \sin 30}$$

$$= 0.33$$

at A,

$$P_{ac} = q_0 \cdot K_{a(1)} + K_a \gamma h - 2c_1\sqrt{K_{a(1)}}$$

$$= 50 \times 0.33 + 0.33 \times 16 \times 0 - 2 \times 10 \times \sqrt{0.33}$$

$$= 5.02 \text{ kN/m}.$$

For Soil 2

$$K_{a(2)} = \frac{1 - \sin\phi_2}{1 + \sin\phi_2} = \frac{1 - \sin 33}{1 + \sin 33} = 0.29$$

at B for Soil 1.

$$P_{ac} = q_0 K_{a(1)} + K_{a_1} \gamma_1 h_1 - 2c_1\sqrt{K_{a_1}}$$

$$= 50 \times 0.33 + 0.33 \times 16 \times 3 - 2 \times 10 \times \sqrt{0.33}$$

$$= 20.85$$

at B we have to consider both the surcharge load and the overlaying soil.

$\sigma_v = q_0 + \gamma_1 H_1$

$= 50 + 16 \times 3 = 98 \text{ kN/m}^2$

$P_{ac} = K_{a2}\sigma_v - 2C_2\sqrt{K_{a2}}$

$= 0.29 \times 98 - 2 \times 5 \times \sqrt{0.29} = 23.03 \text{ kN/m}.$

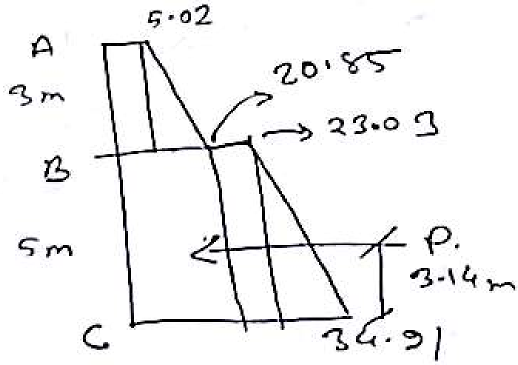
<u>at C</u>

$P_{ac} = q_0 K_{a(2)} + K_{a(2)}\gamma_2 h_2 - 2C_2\sqrt{K_{a2}} + \gamma_1 H_1 K_{a(2)}$

$= 50 \times 0.29 + 0.29 \times (18 - 9.81) \times 5 - 2 \times 5 \times \sqrt{0.29}$
$+ (16 \times 3) \times 0.29$

$= 34.91 \text{ kN/m}^2$

Neglecting water pressure.



Total thrust

$= (5.02 + 20.85) \times \frac{1}{2} \times 3$

$+ \frac{1}{2} \times 5 \times (23.03 + 34.91)$

$= 183.655 \text{ kN/m}.$

Now, taking moment at C.

$183.655 \times h = 40.96 \times \frac{8}{2} + 23.97 \times [5 + \frac{1}{3} \times 3] + 89.55 \times (5/2) + 29.7 \times (5/3)$

$\Rightarrow h = 3.14 \text{ m. from base.}$

<u>Note</u>

$5.12 \times 8 = 40.96$

$\frac{1}{2} \times (20.85 - 5.02) \times 3 = 23.97$

$(23.03 - 5.02) \times 5 = 89.55$

$(34.91 - 23.03) \times \frac{1}{2} \times 5 = 29.7$

12-13 ⑥ graph later.

⑦ Basic Consideration:

Ranking theory → Rankine considered the equilibrium of a soil element

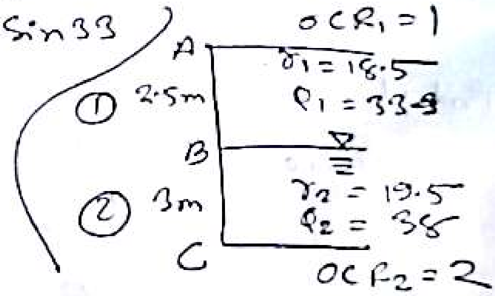
Columb's theory → Columb considered the equilibrium of a soil wedge during failure in a soil mass.

→

$$K_{o(1)} = (1-\sin\phi_1)\, OCR_1^{\sin\phi_1}$$

$$= (1-\sin 33) \times 1^{\sin 33}$$

$$= 0.46$$



at B

for Soil 1

$$P_o = K_{a(1)} \cdot \gamma_1 H_1$$

$$= 0.46 \times 18.5 \times 2.5$$

$$= 21.275 \ KN/m^2$$

For Soil 2

$$K_{o(2)} = (1-\sin\phi_2)\, OCR_2^{\sin\phi_2}$$

$$= (1-\sin 38)\, 2^{\sin 38} = 0.59$$

at B, for soil 2, we have to consider overlying soil.

$\sigma_v = \gamma_1 H_1 = 18.5 \times 2.5 = 46.25 \ kN/m^2$

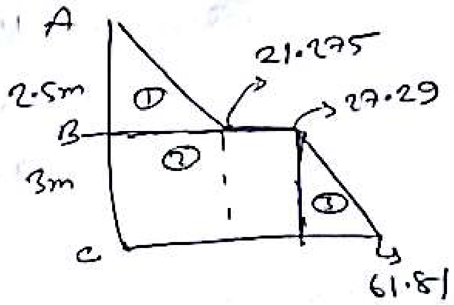
$\sigma_h = K_{o(2)} \sigma_v = 0.59 \times 46.25 = 27.29 \ kN/m^2$

at c

$P_o = 27.29 + K_{o(2)} \gamma_2 H_2$

$= 27.29 + 0.59 \times 19.5 \times 3$

$= 61.81$



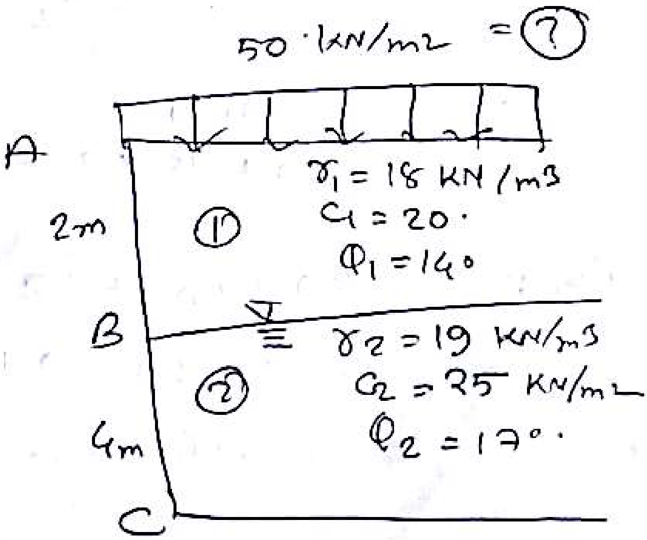
total thrust

$= \frac{1}{2} \times 21.275 \times 2.5 + 3 \times 27.29 + \frac{1}{2} \times (61.81 - 27.29) \times 3$

$= 160.24 \ kN/m.$

12-13

⑧ passive mode



$P_{pc} = K_p \gamma h + 2c\sqrt{K_p}.$

at 1

$K_{p(1)} = \frac{1 + \sin\varphi}{1 - \sin\varphi}$

$= \frac{1 + \sin 14}{1 - \sin 14} = 1.64.$

At A $\qquad \sigma_v = q_0 = 50 \ kN/m^2$

$$P_{pc(A)} = \sigma_v K_{p(1)} + K_{p(1)} \gamma h + 2 c_1 \sqrt{K_{p(1)}}$$

$$= 50 \times 1.64 + 1.64 \times 18 \times 0 + 2 \times 20 \times \sqrt{1.64}$$

$$= 133.22 \ kN/m^2$$

at B

for soil 1.

$$P_{pc(B)} = 133.22 + K_{p(1)} \gamma_1 H_1$$

$$= 133.22 + 1.64 \times 18 \times 2$$

$$= 192.26 \ kN/m^2$$

at B $\quad$ for soil 2

$$K_{p(2)} = \frac{1 + \sin \phi_2}{1 - \sin \phi_2} = \frac{1 + \sin 17}{1 - \sin 17} = 1.83$$

$$\sigma_{v(B)} = q_0 + \gamma_1 H_1$$

$$= 50 + 18 \times 2 = 86 \ kN/m^2$$

$$P_{pc(B)} = K_{p(2)} \sigma_{v(B)} + K_{p(2)} \gamma h + 2 c_2 \sqrt{K_{p(2)}}$$

$$= 86 \times 1.83 + 1.83 \times 19 \times 0 + 2 \times 25 \sqrt{1.86}$$

$$= 225.6 \ kN/m^2$$

at c

for soil 2

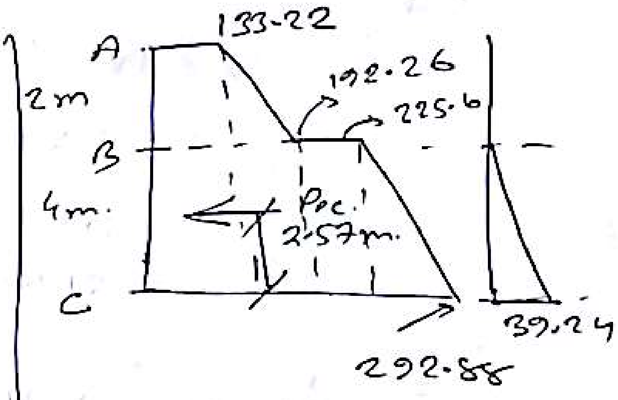
$$P_{PC(c)} = 225.6 + K_{P(2)} \gamma_2' H_2$$
$$= 225.6 + 1.83 \times (19 - 9.81) \times 4$$
$$= 292.88 \text{ kN/m}^2$$

water pressure at c

$$P_w = \gamma_w H_2 = 9.81 \times 4 = 39.24 \text{ kN/m}^2$$

Total thrust = Σ total Area.

$$= (133.22 \times 2) + \tfrac{1}{2} \times 2 \times (192.26 - 133.22) + (225.6 \times 4) + \tfrac{1}{2} \times 4 \times (292.88 - 225.6) + \tfrac{1}{2} \times 4 \times 39.24$$



$$= 266.44 + 59.04 + 902.4 + 134.56 + 78.48$$
$$= 1440.92 \text{ kN/m}.$$

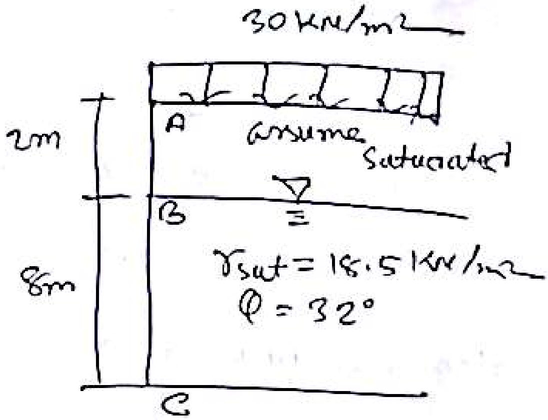
Taking moment about c.

$$1440.92 \times h = 266.44 \times (4+1) + 59.04 \times (4 + \tfrac{2}{3}) + 902.4 \times \tfrac{4}{2} + 134.56 \times (\tfrac{4}{3}) + 78.48 \times (\tfrac{4}{3})$$

$\Rightarrow \quad h = 2.57$ (from base)

11-12

3 (b) Active pressure is working.



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

$$= \frac{1-\sin 32}{1+\sin 32}$$

$$= 0.307$$

at A

$$\sigma_v = 30 \text{ KN/m}^2$$

$$P_{ac(A)} = \sigma_v . K_a$$

$$= 0.307 \times 30$$

$$= 9.21 \text{ KN/m}^2$$

Since nothing is given. $c = 0$.

at B

$$P_{ac(B)} = 9.21 + K_a . \gamma_{sat} . h_1$$

Since γ for 2m is not given.

$$= 9.21 + 0.307 \times 18.5 \times 2$$

$$= 20.57 \text{ KN/m}^2$$

at C

$$P_{ac(C)} = 20.57 + K_a(\gamma_{sat} - \gamma_w) \times h_2$$

$$= 20.57 + 0.307 \times (18.5 - 9.81) \times 8$$

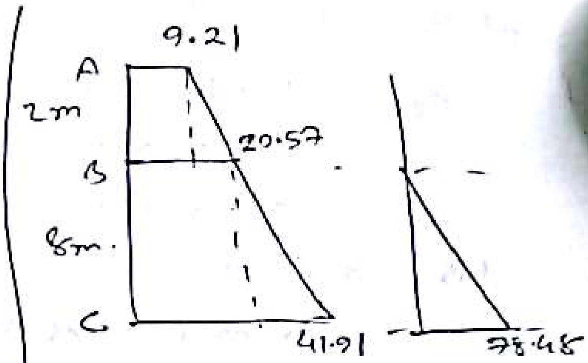
$$= 41.91 \text{ KN/m}^2$$

water pressure $P_w = \gamma_w . h = 9.81 \times 8 = 78.48$

lateral thrust

$= (9.21 \times 2) + \frac{1}{2} \times 2 \times (20.57 - 9.21) + (20.57 \times 8) + \frac{1}{2} \times 8 \times (41.91 - 20.57) + \frac{1}{2} \times 8 \times 78.48$

$= 593.62$ kN/m.



10-11 1(b) theory later.

(3) (a)

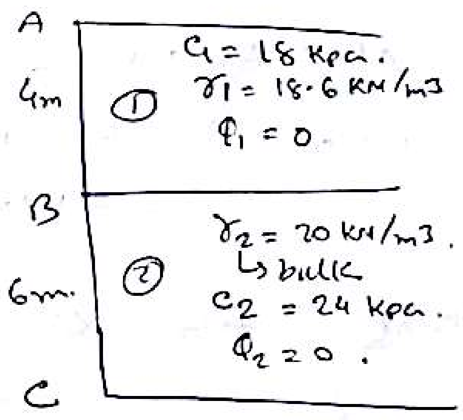
for Case 1.

$K_a = \frac{1 - \sin\phi_1}{1 + \sin\phi_1} = 1$.

depth of tension zone,

$\phi = 0$.

$h_c = \frac{2c}{\gamma} = \frac{2 \times 18}{18.6} = 1.94$ m.



At A

$P_{ac}(A) = K_a \gamma_1 h_1 - 2c\sqrt{K_a}$

$= 0 - 2 \times 18 \times \sqrt{1}$

$= -36$ kN/m²

At B, for layer 1.

$P_{ac(B)} = K_a \gamma_1 h_1 - 2C_1\sqrt{K_a}$

$= 1 \times 18.6 \times 4 - 2 \times 18 \times \sqrt{1}$

$= 38.4$ kN/m²

at B, for layer 2

layer 1 acts as surcharge

$\sigma_v = \gamma_1 h_1 = 18.6 \times 4 = 74.4$

$P_{ac(B)} = K_a \sigma_v - 2C_2\sqrt{K_a}$

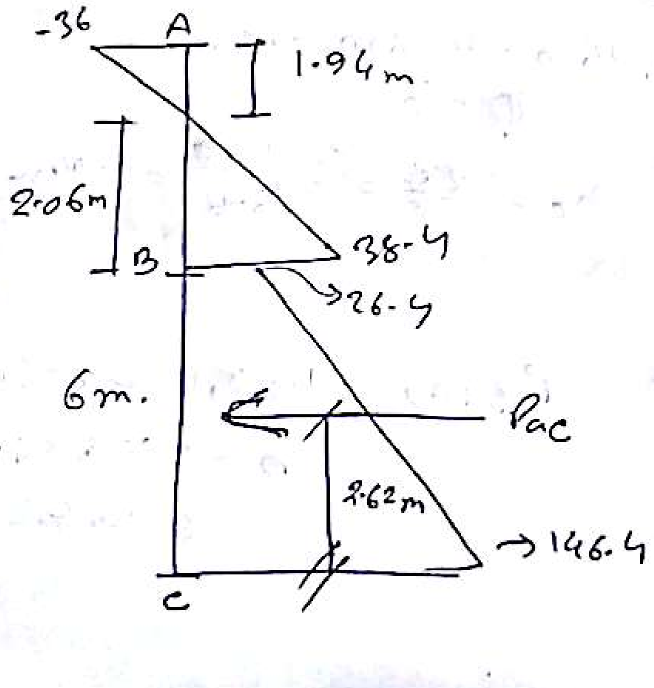
$= 1 \times 74.4 - 2 \times 24\sqrt{1} = 26.4$ kN/m²

at C for layer 2

$P_{ac(C)} = 26.4 + K_a \gamma_2 h_2$

$= 26.4 + 1 \times 20 \times 6 = 146.4$ kN/m²

~~Total thrust~~ $\frac{1}{2} \times 2$



Total thrust

$= \left(\frac{1}{2} \times 2.06 \times 38.4\right) + (26.4 \times 6) + \frac{1}{2} \times 6 \times (146.4 - 26.4)$

$= 39.55 + 158.4 + 360$

$= 557.95 \text{ KN/m}$

Taking moment about c

$557.95 \times h = 39.55 \times \left(6 + \frac{2.06}{3}\right) + 158.4\left(\frac{6}{2}\right) + 360 \times \left(\frac{6}{3}\right)$.

$\Rightarrow h = 2.62 \text{ m}$ from base

10-11

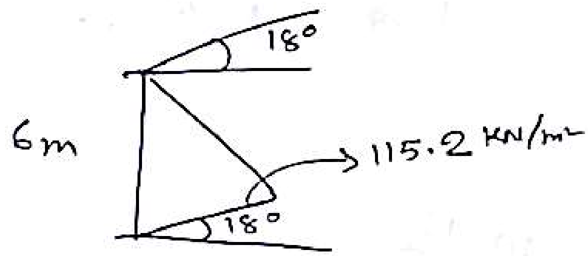
3 (b)

$c = 0$.

$\varphi = 33°$

$\gamma = 18 \text{ KN/m}^3$.

$OCR = 3$.



(a) Earth pressure at rest (since no movement)

$K_o = (1 - \sin\varphi) OCR^{\sin\varphi}$

$= (1 - \sin 33)\, 3^{\sin 33} = 0.83$

lateral pressure $= K_o \cdot (1 + 0.5\tan\beta)^2 \gamma h$.

$= 0.83 \times (1 + 0.5 \tan 18)^2 \times 18 \times 6 \cos 18°$

$= 115.2 \text{ KN/m}^2$

lateral thrust $= \frac{1}{2} \times 6 \times 121.13 \times (\cos 18)^2$

$= 328.69 \text{ KN/m}$.

$\frac{115.2}{\cos 18} = 121.13$

(11) Soil moving outward (active pressure)

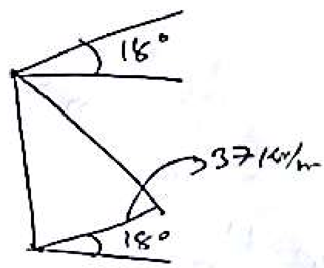
$$K_a = \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\varphi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\varphi}} = \frac{\cos 18 - \sqrt{\cos^2 18 - \cos^2 33}}{\cos 18 + \sqrt{\cos^2 18 - \cos^2 33}}$$

$$= 0.36$$

lateral pressure $= K_a \gamma h \cos\beta$.

$= 0.36 \times 18 \times 6 \times \cos 18$

$= 37\ kN/m^2$



lateral thrust $= \frac{1}{2} \times 6 \times 37$

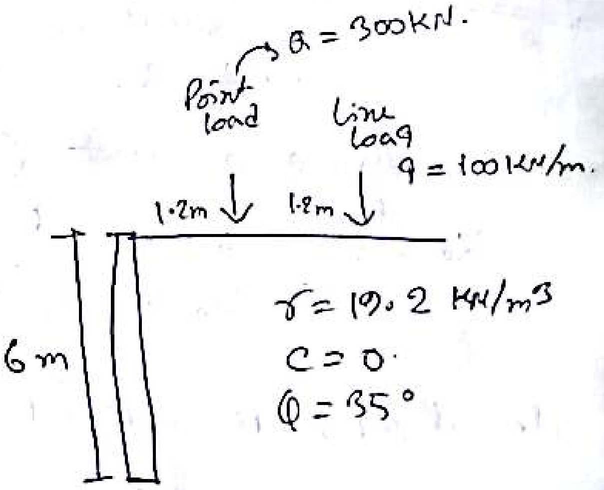
$= 111\ kN/m$.

horizontal thrust $= 111 \cos 18°$

$= 105.6\ kN/m$.

10-11

4 (a)



For point load.

$m = \frac{x}{H} = \frac{1.2}{6}$

$= 0.2 \leq 0.4$.

$$P_h = \frac{1.77Q}{H^2} \cdot \frac{0.4^2 n^2}{(0.4^2 + n^2)^3}.$$

$$= \frac{1.77 \times 300 \times 0.16 \times n^2}{6^2 \times (0.16 + n^2)^3}$$

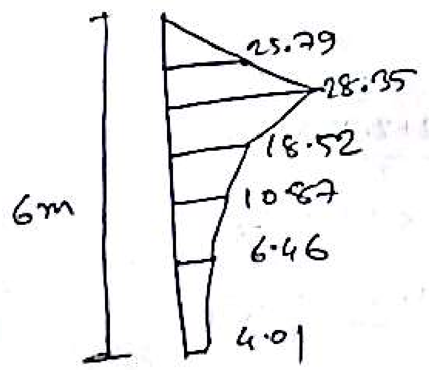
$$= \frac{2.36 n^2}{(0.16+n^2)^3}$$

for line load. $m = \frac{x}{H} = \frac{2.4}{6} = 0.4 \leq 0.4$

$$P_h = \frac{4q}{\pi H} \cdot \frac{\cancel{m^2 n} \; 0.4^2 n}{(0.4^2+n^2)^2}$$

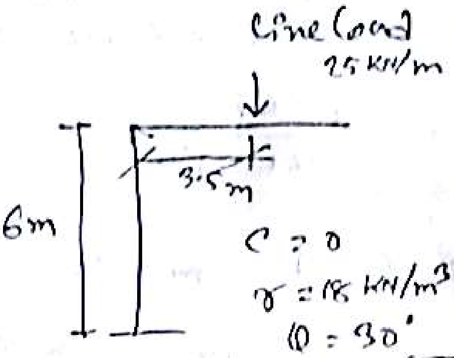
$$= \frac{4 \times 100 \times 0.16 n}{3.14 \times 6 \times (0.16+n^2)^2} = \frac{3.39 n}{(0.16+n^2)^2}$$

depth y m	$n = \frac{y}{H}$	point load $\frac{2.36n^2}{(0.16+n^2)^3}$	line load $\frac{3.39n}{(0.16+n^2)^2}$	total
0	0	0	0	0
1	1/6	9.79	16	25.79
2	1/3	13.01	15.34	28.35
3	1/2	8.46	10.06	18.52
4	2/3	4.70	6.17	10.87
5	5/6	2.60	3.86	6.46
6	1	1.50	2.51	4.01



9-10

2 (b)



$c = 0$

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

$\phi = 30^\circ$

$\mu = 0.5$

$$m = \frac{x}{H} = \frac{3.5}{6} = \cancel{0.588}$$

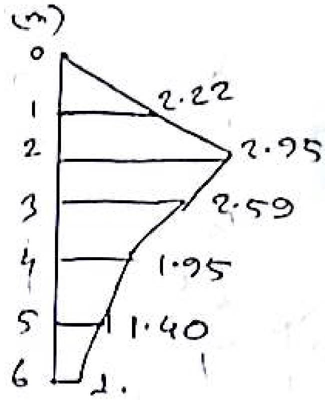
$$= 0.5833 > 0.4$$

$$\therefore P_h = \frac{4q}{\pi H} \cdot \frac{m^2 n}{(m^2+n^2)^2}$$

$$= \frac{4 \times 25}{3.14 \times 6} \times \frac{0.5833^2 n}{(0.5833^2+n^2)^2}$$

$$= \frac{1.81 n}{(0.5833^2+n^2)^2}$$

depth y m	$n = \frac{y}{H}$	$P_h = \frac{1.81 n}{(0.5833^2+n^2)^2}$
0	0	0
1	1/6	2.22
2	1/3	2.95
3	1/2	2.59
4	2/3	1.95
5	5/6	1.40
6	1	1.

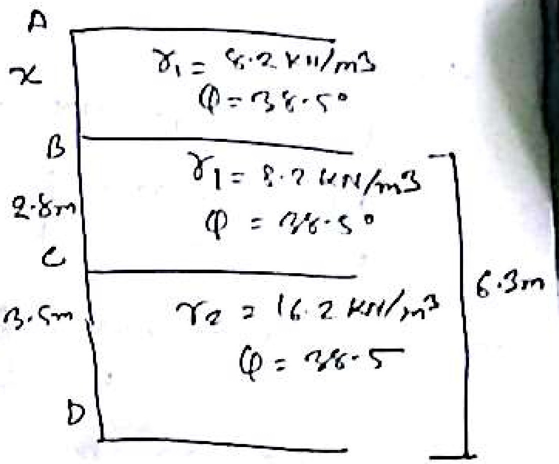


Total thrust $= \left(\frac{1}{2} \times 1 \times 2.22\right) + \left(\frac{2.22+2.95}{2}\right) \times 1 + \left(\frac{2.95+2.58}{2}\right) \times 1 + \left(\frac{2.58+1.95}{2}\right) \times 1 + \left(\frac{1.95+1.40}{2}\right) \times 1 + \left(\frac{1.4+1}{2}\right) \times 1$

$= 11.6\ kN/m$

3(b)

Before increasing the height



$$P_h = \frac{1}{2} K_a \gamma h^2$$

$$\Rightarrow 75 = \frac{1}{2} K_a \times 16.2 \times 6.3^2$$

$$\Rightarrow K_a = 0.233$$

$$\tan\left(45 - \frac{\phi}{2}\right) = 0.233 \quad \leftarrow \text{active}$$

$$\phi = 38.5°$$

let x, height added.

at B, $P_{ac(B)} = K_a \gamma_1 h_1$
$= 0.233 \times 8.2 \times (2.8 + x)$

at B, for layer 2

$$\sigma_v = \gamma_1 h_1 = 8.2 \times (2.8 + x)$$

$$P_{ac}(B) = K_a \sigma_v = 0.233 \times 8.2 \times (2.8 + x)$$

at C,

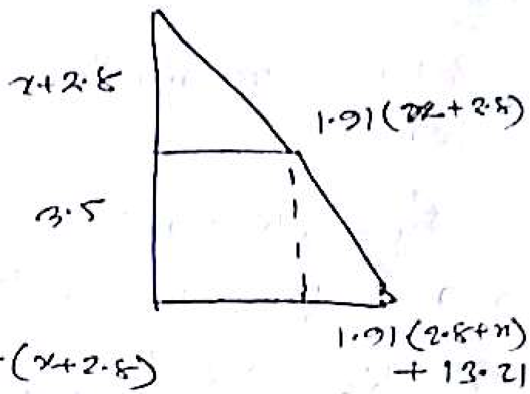
$$P_{ac}(C) = 0.233 \times 8.2 \times (2.8 + x) + K_a \gamma_2 h_2$$
$$= 0.233 \times 8.2 \times (2.8 + x) + 0.233 \times 16.2 \times 3.5$$
$$= 1.91(2.8 + x) + 13.21$$

total thrust

$= \frac{1}{2} \times (x+2.8) \times 1.91 \times (x+2.8)$

$+ 1.91(x+2.8) \times 3.5$

$+ \frac{1}{2} \times 3.5 \times 13.21$



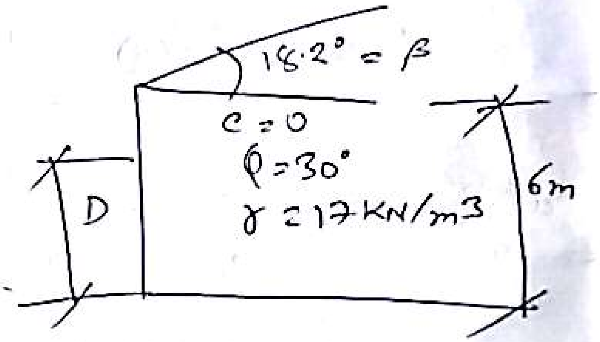
$\Rightarrow 75 = 0.955(x+2.8)^2 + 6.685(x+2.8)$
$+ 23.12$

$\Rightarrow \quad x = 1.85$ m.

9-10

4 (b)

For active pressure



$$K_a = \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\varphi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\varphi}}$$

$$= \frac{\cos 18.2 - \sqrt{\cos^2 18.2 - \cos^2 30}}{\cos 18.2 + \sqrt{\cos^2 18.2 - \cos^2 30}}$$

$= 0.417$

Active thrust $= \frac{1}{2} K_a \gamma H^2 \cos\beta$

$= \frac{1}{2} \times 0.417 \times 17 \times 6^2 \times \cos 18.2$

$= 121.2$ KN/m.

For passive pressure

$$K_p = \frac{1+\sin\phi}{1-\sin\phi} = \frac{1+\sin 30}{1-\sin 30} = 3$$

passive thrust $= \frac{1}{2} K_p \gamma H^2$

$= \frac{1}{2} \times 3 \times 17 \times D^2$

$= 25.5\, D^2$

$\therefore \quad 25.5\, D^2 = 121.2$

$\Rightarrow D = 2.18$ m.

8-9

1 (i)

$\gamma_d = 17.8$ KN/m³, $\phi = 30°$ $H = 8$ m

$$K_p = \frac{1+\sin\phi}{1-\sin\phi} = \frac{1+\sin 30}{1-\sin 30} = 3.$$

passive thrust $= \frac{1}{2} K_p \gamma H^2 = \frac{1}{2} \times 3 \times 17.8 \times 8^2$

$= 1708.8$ KN/m

Final condition

$\gamma_d = 18.8$ KN/m³ $\phi = 35°$

$$K_p = \frac{1+\sin 35}{1-\sin 35} = 3.69$$

passive thrust $= \frac{1}{2} K_p \gamma_d H^2$

$= \frac{1}{2} \times 3.69 \times 18.8 \times 8^2$

$= 2219.9$ KN/m.

$$\text{Ratio} = \frac{\text{Initial}}{\text{final}} = \frac{1708.8}{2219.9} = 0.77 : 1$$

1 (g)

$\gamma = 22\ KN/m^3$

~~H = 4m.~~

$h_c = 4m$ (unsupported height)

Unsupported height $= \frac{4c}{\gamma}$

$\Rightarrow \quad 4 = \frac{4c}{22}$

$\Rightarrow \quad c = 22\ KN/m^2$

1 (h)

$H = 6m.$

$LL = 40\%$

$PL = 25\%$ $\quad I_p = LL - PL$

$OCR = 2.5$ $\quad = 15$

$K_o(NCC) = 0.19 + 0.233 \log I_p = 0.19 + 0.233 \log(15)$
$= 0.46$

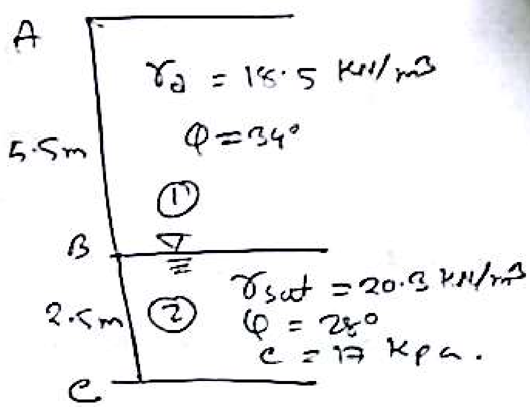
$K_o(OCC) = K_o(NCC)\sqrt{OCR} = 0.46\sqrt{2.5} = 0.73$

Thrust $= \frac{1}{2} K_o \gamma H = \frac{1}{2} \times 0.73 \times \gamma \times 6$
$= 2.19\gamma$

4 (a)

For layer 1.

$$K_{a(1)} = \frac{1-\sin 34}{1+\sin 34} = 0.28$$



For layer 2

$$K_{a(2)} = \frac{1-\sin 28}{1+\sin 28} = 0.36$$

At B for layer (1)

$$P_{ac}(B) = K_{a(1)} \gamma_1 h_1 = 0.28 \times 18.5 \times 5.5$$
$$= 28.5\ KN/m^2$$

at B for layer (2)

layer (1) as Surcharge Load.

$$\sigma_v = \gamma_1 h_1 = 18.5 \times 5.5 = 101.75\ KN/m^2$$

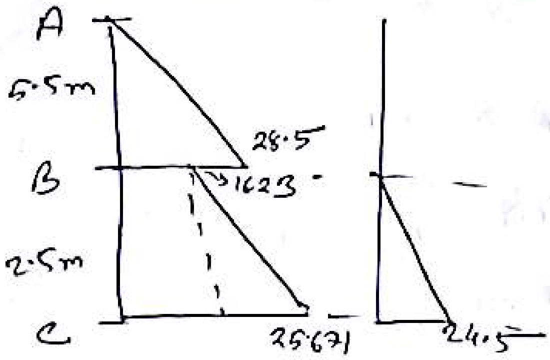
$$P_{ac}(B) = \sigma_v K_{a(2)} - 2c\sqrt{K_{a(2)}}$$
$$= 0.36 \times 101.75 - 2 \times 17 \times \sqrt{0.36}$$
$$= 16.23\ KN/m^2$$

at C

$$P_{ac}(C) = 16.23 + K_{a(2)} (\gamma_{sat} - \gamma_w) h$$
$$= 16.23 + 0.36 \times (20.3 - 9.81) \times 2.5$$
$$= 25.671$$

at C water pressure $P_w = \gamma_w h_2$

$$= 9.81 \times 2.5 = 24.5\ KN/m^2$$



Total thrust $= \frac{1}{2} \times (5.5 \times 28.5) + (2.5 \times 16.23)$
$+ \frac{1}{2} \times 2.5 \times (25.671 - 16.23) + \frac{1}{2} \times (2.5 \times 24.5)$

$= 78.4 + 40.6 + 11.8 + 30.6$
$= 161.4$ KN/m.

07-08

(1) (c) $q_u = 80 KN/m^2 = q_u$
$\gamma = 16 KN/m^3$
$H = 6m$.

Unsupported height $= \frac{4cu}{\gamma} = \frac{4\frac{q_u}{2}}{\gamma} = \frac{4 \times \frac{80}{2}}{16}$
$= 10m$.

So, we can cut upto 10m
that's why no retaining structure
required for 6m.

1 (h)

$\gamma = 16\ kN/m^3$
$\varphi = 32°$
$\beta = 15°$

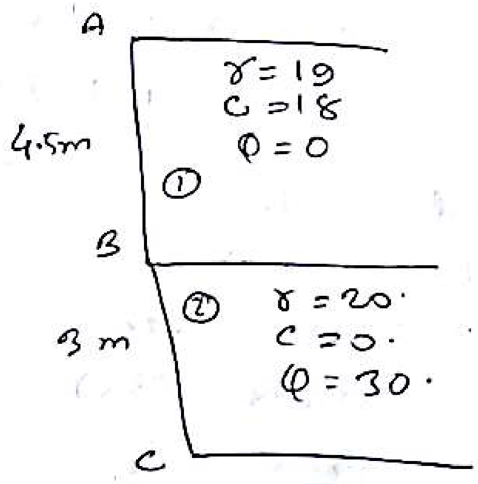
earth pressure at rest → because massive retaining wall

$K_0 = (1-\sin\varphi)(1+0.5\tan\beta)^2$
$= (1-\sin 32)(1+0.5\tan 15)^2$
$= 0.6$

horizontal thrust $= \frac{1}{2} K_0 \gamma H^2 \cos^2\beta$
$= \frac{1}{2} \times 0.6 \times 16 \times 8^2 \times \cos^2 15$
$= 286.62\ kN/m$.

3 (b) layer 1

$K_{a(1)} = \frac{1-\sin 0}{1+\sin 0} = 1$



layer 2

$K_{a(2)} = \frac{1-\sin(30)}{1+\sin 30} = \frac{1}{3}$.

at B, for layer ①

$P_{ac(B)} = K_{a(1)} \gamma_1 h_1 - 2c\sqrt{K_{a(1)}}$
$= 1 \times 19 \times 4.5 - 2 \times 18 \times \sqrt{1} = 49.5\ kN/m^2$

at A. $P_{ac(A)} = K_{a(1)} \gamma_1 h_1 - 2c\sqrt{K_{a(1)}}$
$= 1 \times 19 \times 0 - 2 \times 18 \times \sqrt{1}$
$= -36\ kN/m^2$

length of tension crack

$$h_c = \frac{2c}{\gamma_1} = \frac{2\times18}{19}$$
$$= 1.9\ m$$

at B

for layer 2, layer 1 acts as surcharge

$$\sigma_v = \gamma_1 h_1 = \cancel{19}\times 4.5\times 19 = 85.5\ kN/m^2$$

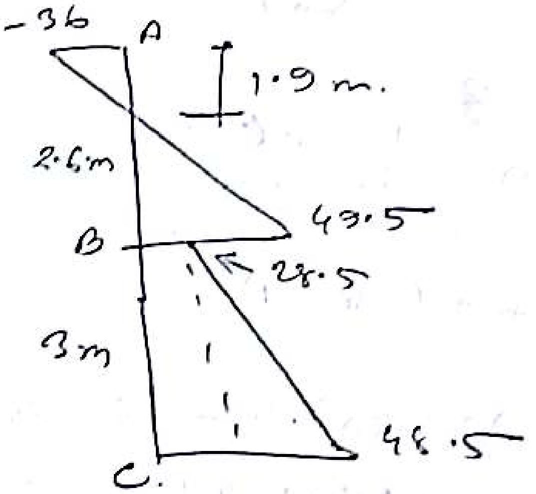
$$P_{ac(B)} = \sigma_v \cdot K_{a(2)} - 2c_2\sqrt{K_{a2}}$$
$$= \tfrac{1}{3}\times 85.5 - 0 = 28.5$$

at C   for layer 2

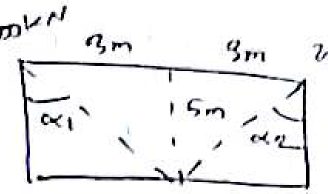
$$P_{ac(C)} = 28.5 + K_{a(2)}\gamma_2 h_2$$
$$= 28.5 + \tfrac{1}{3}\times 20\times 3 = 48.5\ kN/m^2$$

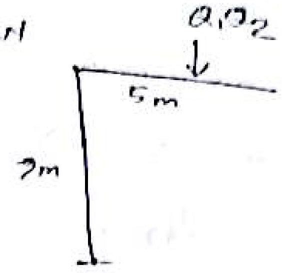
Total thrust

$$= \left(\tfrac{1}{2}\times 2.6\times 49.5\right) + (28.5\times 3) + \cancel{\tfrac{1}{2}\times 3\times} + \tfrac{1}{2}\times 3\times(48.5-28.5)$$
$$= 179.85\ kN/m.$$



4(a)





$$\alpha_1 = \alpha_2 = \tan^{-1}\left(\frac{3}{5}\right)$$
$$= 30.96^\circ$$

$$m = \frac{x}{H} = \frac{5}{9} = 0.56 > 0.4$$

$$P_h = \frac{1.77Q}{H^2} \frac{m^2 n^2}{(m^2+n^2)^3}$$

for two loads at 30.96°

$$P_h' = P_h \cos^2(1.1\alpha) \times 2$$

$$= \frac{1.77 \times 200 \times 0.56^2 n^2}{9^2 \; (0.56^2+n^2)^3} \cdot \cos^2(1.1 \times 30.96) \times 2$$

$$= \frac{\cancel{4.09}\; n^2 \; 1.86}{(0.56^2+n^2)^3}.$$

depth m	$n = \frac{y}{H}$	$\frac{1.86 n^2}{(0.56^2+n^2)^3}$
0	0	0
1.5	1/6	~~37~~ 1.3137
3	1/3	2.7288
4.5	1/2	2.6274
6	2/3	1.9192
7.5	5/6	1.2956
9	1	0.8301

Active thrust =

$$\left(\frac{1}{2} \times 1.5 \times 1.3137\right) + \left(\frac{1.3137 + 2.7288}{2}\right) \times 1.5 +$$

$$\left(\frac{2.7288 + 2.6274}{2}\right) \times 1.5 + \left(\frac{2.6274 + 1.9197}{2}\right) \times 1.5$$

$$+ \left(\frac{1.9107 + 1.2756}{2}\right) \times 1.5 + \left(\frac{1.2756 + 0.6377}{2}\right) \times 1.5$$

$$= 15.42 \text{ kN/m}.$$