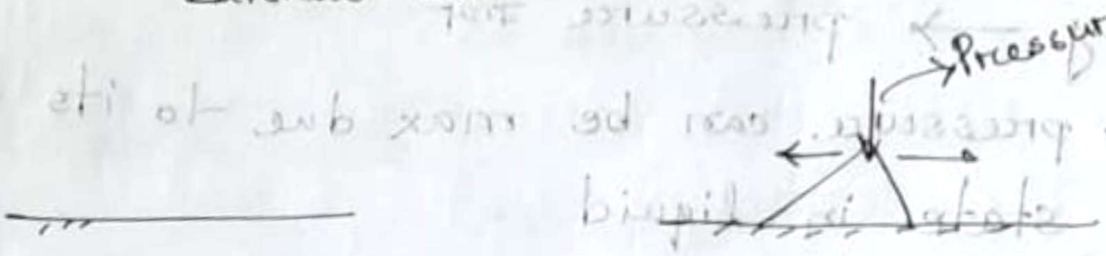
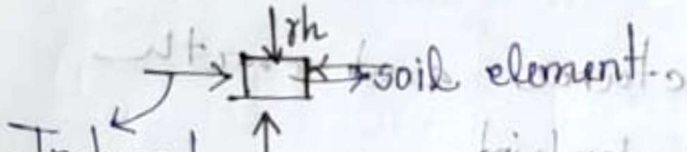
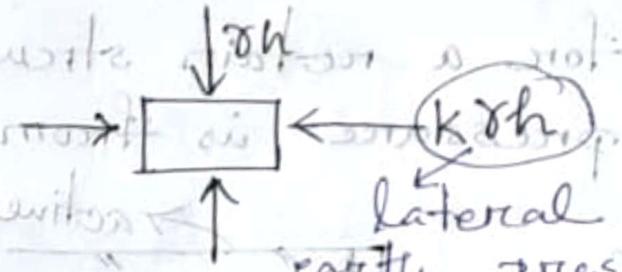
24.11.25
Jornal

EWCE-343

Lateral Earth Pressure



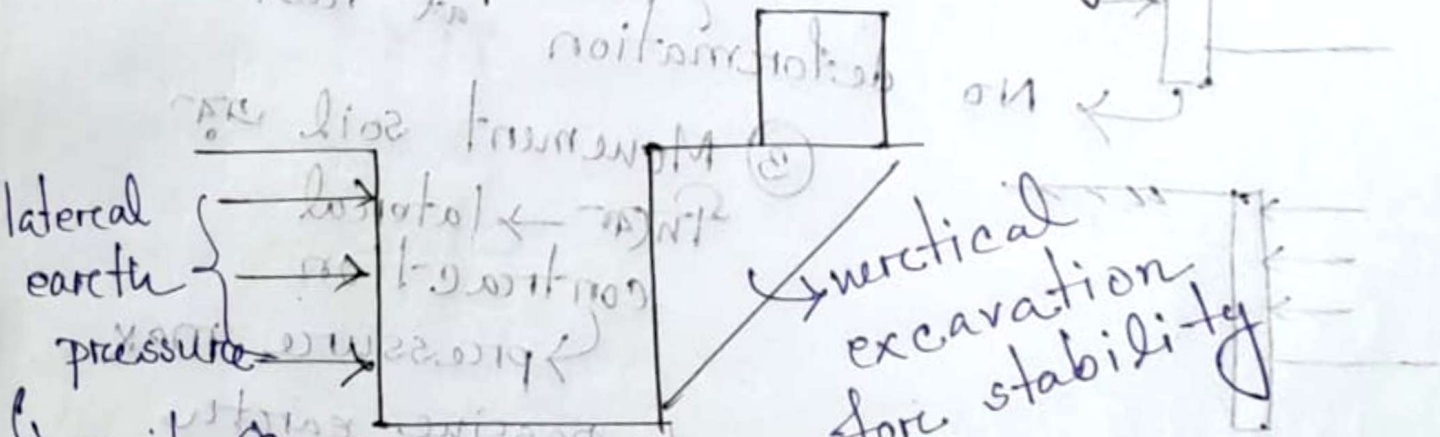




→ for vertical excavation [due to slope],
  ↳ so that it can be stable

→ we do vertical excavation due to limitation of space

→ load is the perpendicular of designed structure



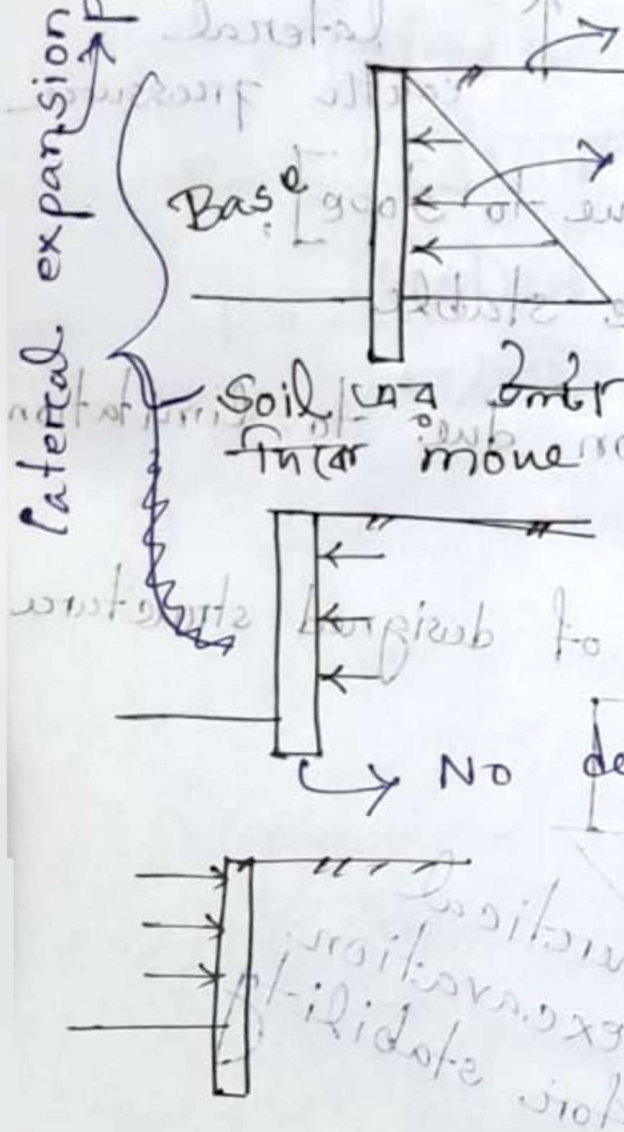
↳ as it as load acting normal to the structure

Sand → pressure ~~कम~~

clay → pressure ~~ज्यादा~~

↳ pressure can be max due to its state in liquid

for a retain structures and earth pressure is from behind,



if γh is linear the $K\gamma h$ is also linear

case

① movement will be outer and downward

② slight n slow movement. → earth pressure at rest

③ Movement soil ~~ज्यादा~~ far → lateral contraction

↳ pressure max

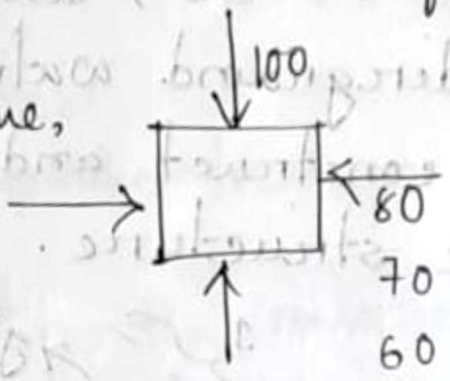
↳ passive earth pressure

earth pressure,

at rest; $k_0 \gamma h$ → co-efficient at rest

ratio $\frac{k_0 \gamma h}{\gamma h} = k_0$

at active,

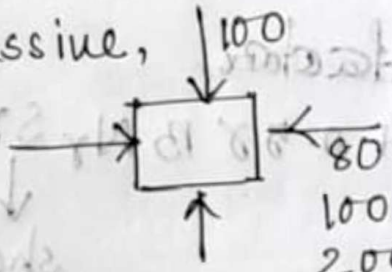


70
60
50
40
(30) → at this pressure slipage occures after this soil will fail.
20

$\frac{100}{300} = 0.3$ → ka

$\frac{30}{100} = 0.3$ → ka

at passive,



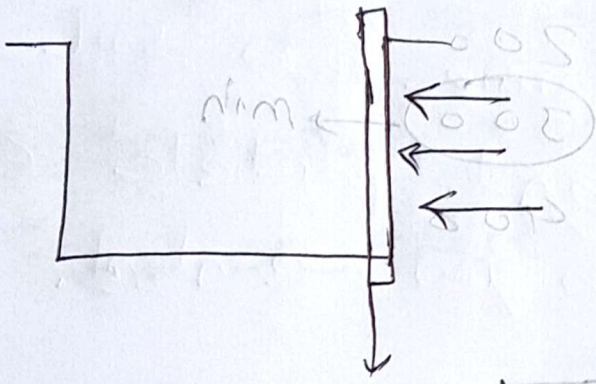
100
200
(300) → slipage occures n then soil fails
400

~~to~~ $\frac{300}{100} = 3$ → k_p

25.11.25 (Tuesday) P-11, 19, 15, 16, 17, 18, 19, 21

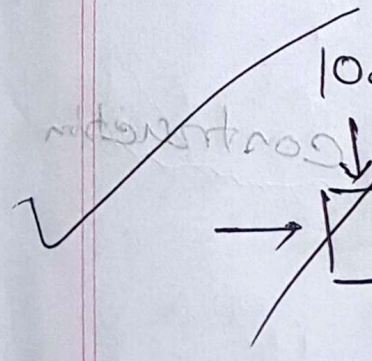
Lateral earth pressure

Soil structure এর উপর pressure
fixed deformation → active.



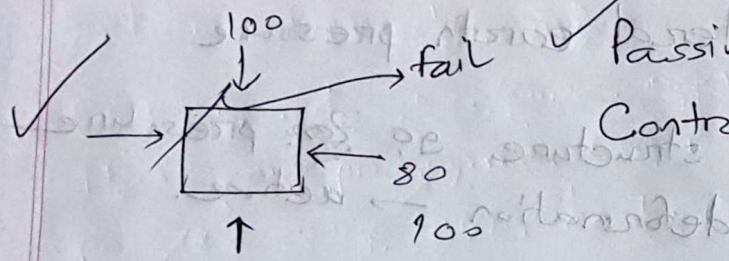
Retaining wall

Passive → Structure soil এর উপর pressure.

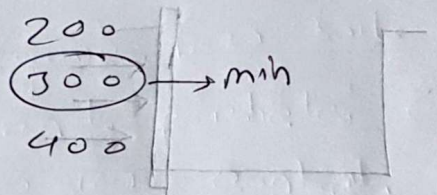


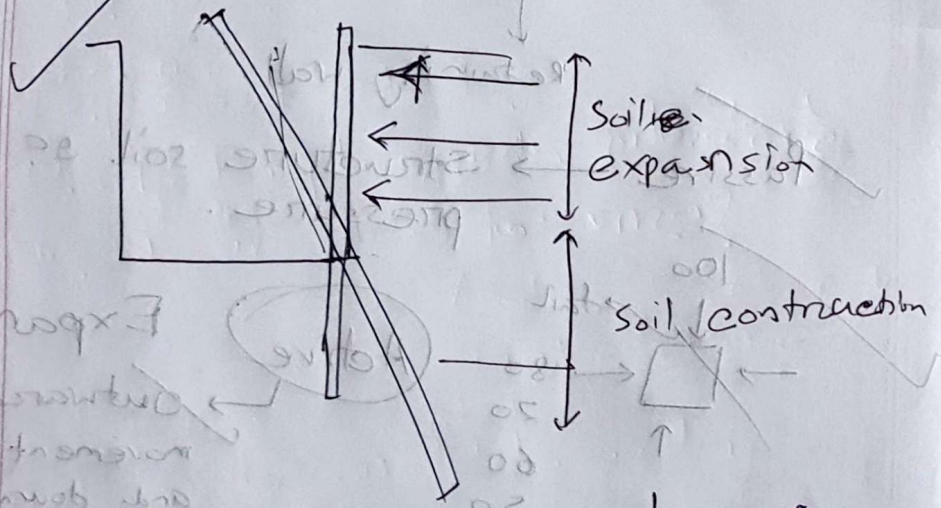
80
20
60
50
40
30 Max
20
10
0

Active → Expansion → Outward movement and downward of soil



Passive
Contraction



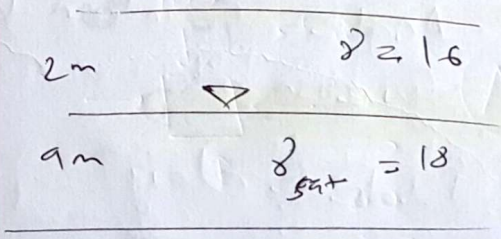


same structure ত
Active & passive

As contraction ↓ value ~~or~~ ~~বেশি~~ ~~High~~ ~~passive~~ ↓ deformation বেশি হয় than active

Q: ↓ It requires more deformation in active than passive
True or false?

Differential settlement = 25mm
Total " = 90mm



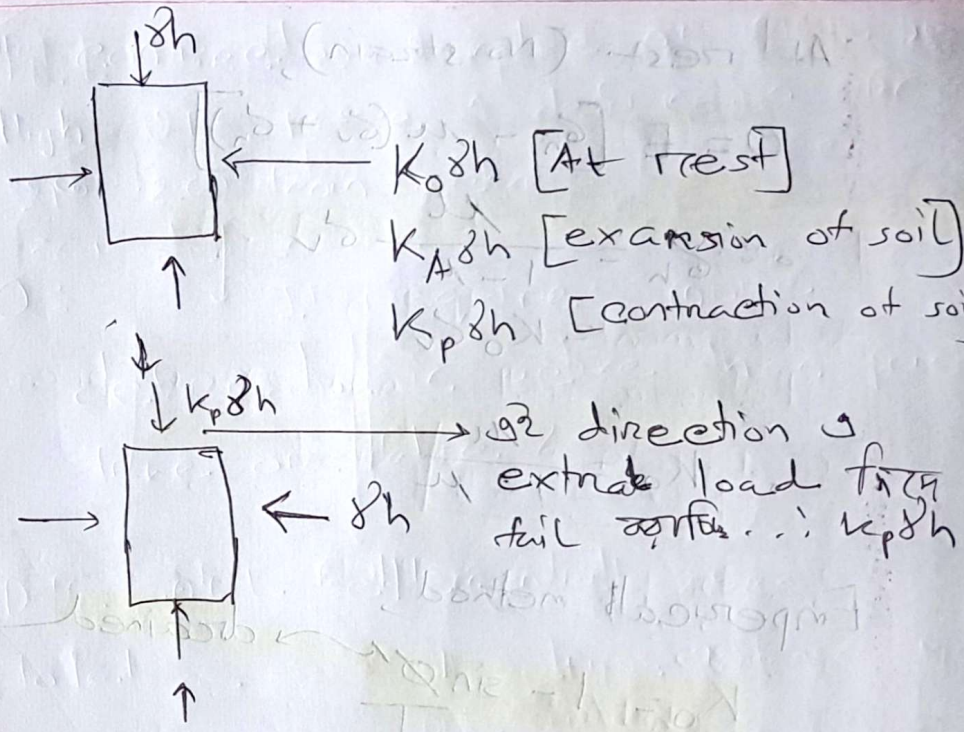
$\sigma = 2 \times 16 + 9 \times 18$
$= 109$
$\mu = 4 \times 9.81 = 39.24$
$\sigma' = 109 - 39.24$
$= 69.8$

Earthquake ত → μ বেশি হয়ে সব, Soil ~~of~~ load দিলে পানির, liquid ~~of~~ ↓ → Liquefaction

~~earthquake এ dynamic~~

earthquake এ force এর pore H_2O এর pressure বেড়ে যায় so μ বেড়ে যায় and pore water pressure দিয়ে soil particle এ and particle এর মধ্যে সরাসরি no contact. So no shear.

Q: Lateral earth pressure বাড়লে কী কী হতে পারে?



$$\sigma_h = K_o\sigma_v = K_o\gamma h$$

$$\epsilon_h = \frac{1}{E}\left[\sigma_h - \mu(\sigma_v + \sigma_h)\right]$$

↓ poisson ratio

At rest (No strain),

$$0 = E\left[\sigma_h - \mu(\sigma_v + \sigma_h)\right]$$

$$\therefore \sigma_h = \frac{\mu}{1-\mu}\sigma_v$$

$$= K_0 \sigma_v$$

$$\therefore K_0 = \frac{\mu}{1-\mu}$$

Empericall method,

$K_0 = 1 - \sin\phi'$ → drained

ϕ' → Angle of internal friction of soil

Normally consolidated clay & sand → $\sin\phi'$

Over consolidated → $K_0 = (1 - \sin\phi')\, OCR^{\sin\phi'}$

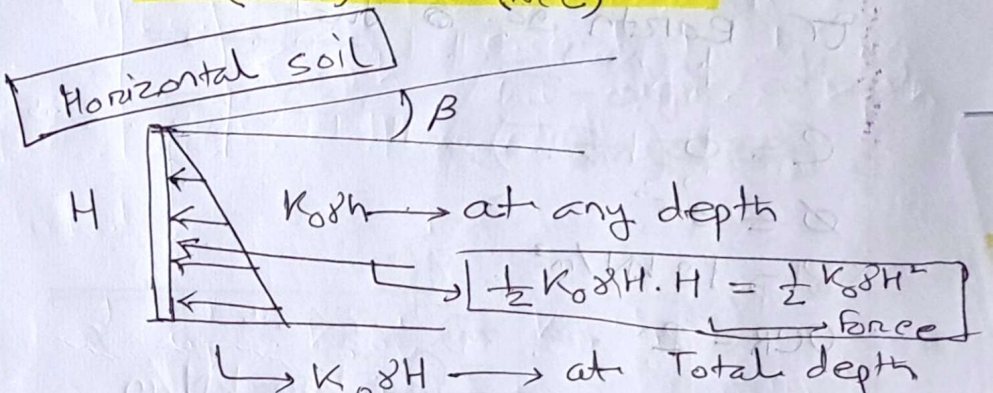
I_p → Plasticity Index

Normally consolidated clay

↳ $K_0(NCC) = 0.19 + 0.233 \log(I_p)$

Over consolidated clay

$K_0(OCC) = K_0(NCC)\sqrt{OCR}$



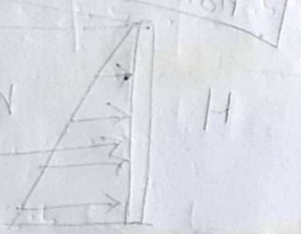
Inclined ढाल → $(1 + 0.5\tan\beta)^2$

1·12·25 (Monday)

P-21, 22, 23

Example:

* Basement Retaining wall এর উপর থাকলে pressure ও Earth এর Just



$C = 0$

$\phi = 35°$

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

$OCR = 2$

Step-1:

For Basement ~~wall,~~ ~~the~~ lateral Earth pressure induced will be ~~earth~~ pressure ~~*~~ at rest. ie co-efficient $= K_o$

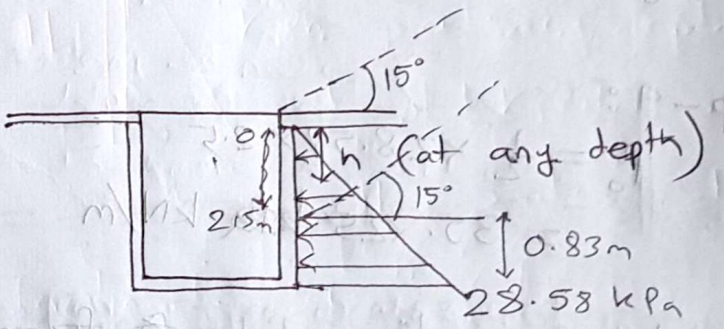
$$K_o = (1 - \sin\phi) OCR^{\sin\phi}$$

$$= (1 - \sin 35°)\ 2^{\sin 35}$$

$$= 0.43 \times 2^{\sin 35} \quad 1.49$$

~~$= 0.64$~~

$= 0.635$ [3-digit atleast লিখতে হবে]



Step-2:

$$P_o(h) = K_o \gamma h$$

$$= 0.635 \times 18 \times h$$

$$= 11.43h$$

Step-3:

$$P_o(h=0) = 11.43 \times 0 = 0$$

$$P_o(h=2.5) = 11.43 \times 2.5 = 28.58 \text{ kPa}$$

Step-4:

$$P_o = \frac{1}{2} \times 28.58 \times 2.5$$

$$= 35.725 \text{ kN/m}$$

* point of action $\frac{1}{3}h$ from base

$$\bar{y} = \frac{2.5}{3} = 0.83 \text{ m}$$

Correction factor for inclination,

$$= (1 + 0.5 \tan\beta)^2 = (1 + 0.5 \tan 15)^2$$

$$= 1.29$$

$$P_{o_{15°}} = 35.65 \times 1.29 = 45.98 \text{ kN/m}$$

Or,

$$\frac{1}{2} K_o \gamma H \times H = \frac{1}{2} K_o \gamma H^2$$

$$= \frac{1}{2} \times 0.635 \times 18 \times 2.5^2 = 35.71 \text{ kN/m}$$

* Math [IMPORTANT]

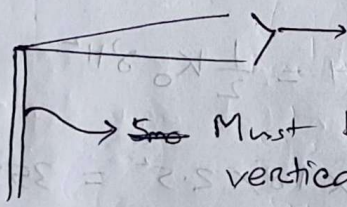
Earth pressure theories.

1) Active earth pressure

- Rankine's theory
  - Cohessionless → Horizontal Ground Surface
  - Cohessive → Horizontal Ground Surface
- ~~Colu~~ Coulomb's theory
  - $c-\phi$ → Inclined Ground Surface

Rankine's theory:

Cohessionless ~~tola~~ soil



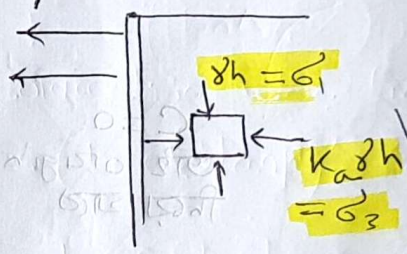
→ Can be inclined or horizontal

→ ~~Sno~~ Must be smooth and vertical

* Last point [Internet ...]

Active pressure — Expansion

outward movement



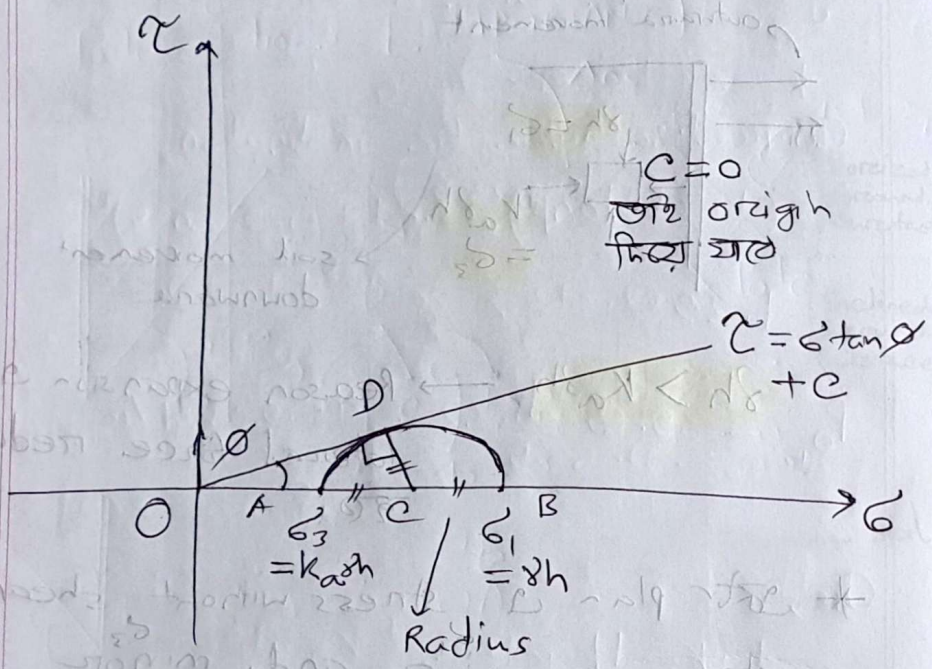
$\gamma h > K_a \gamma h$ → Reason expansion ৭ lateral force reduce হয়।

* ~~ক্ষেত্র~~ plane ৭ stress without shear stress → major (σ_1) and minor (σ_3) principal stress.

Triaxial Quadi

$(\sigma_1, 0)$ → Horizontal

$(\sigma_3, 0)$ → Vertical



$$K_a = \frac{\sigma_3}{\sigma_1} = \frac{OA}{OB}$$

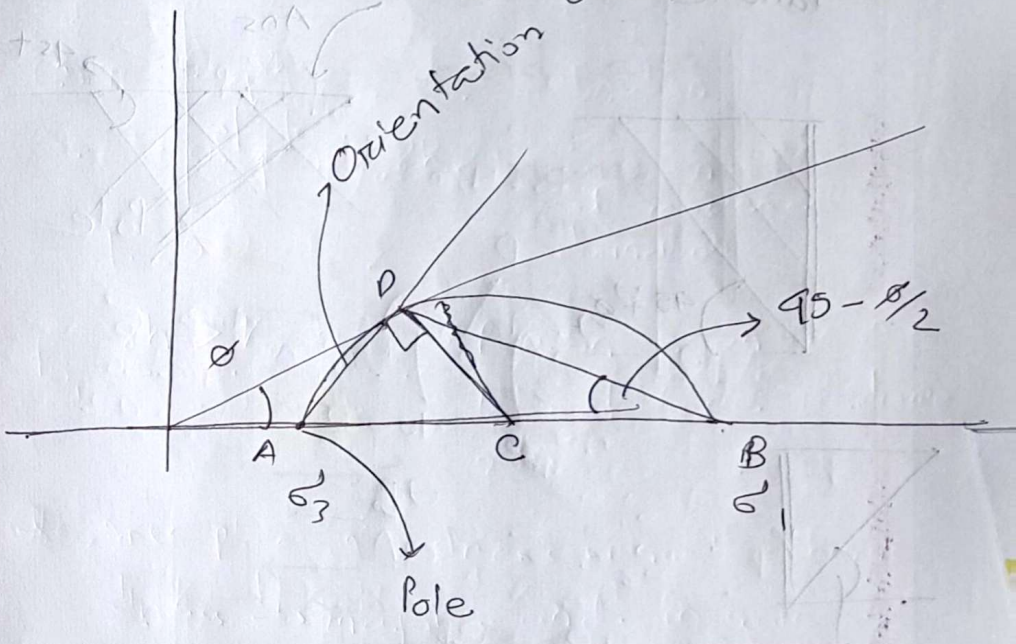
$$= \frac{OC - AC}{OC + BC} = \frac{OC - CD}{OC + CD}$$

$$= \frac{1 - \frac{CD}{OC}}{1 + \frac{CD}{OC}} = \frac{1 - \sin\phi}{1 + \sin\phi}$$

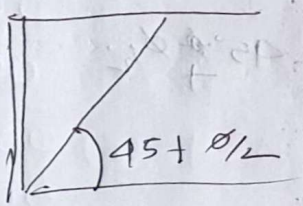
$$= \tan^2\left(45 - \frac{\phi}{2}\right)$$

2.12.25 (Tuesday)

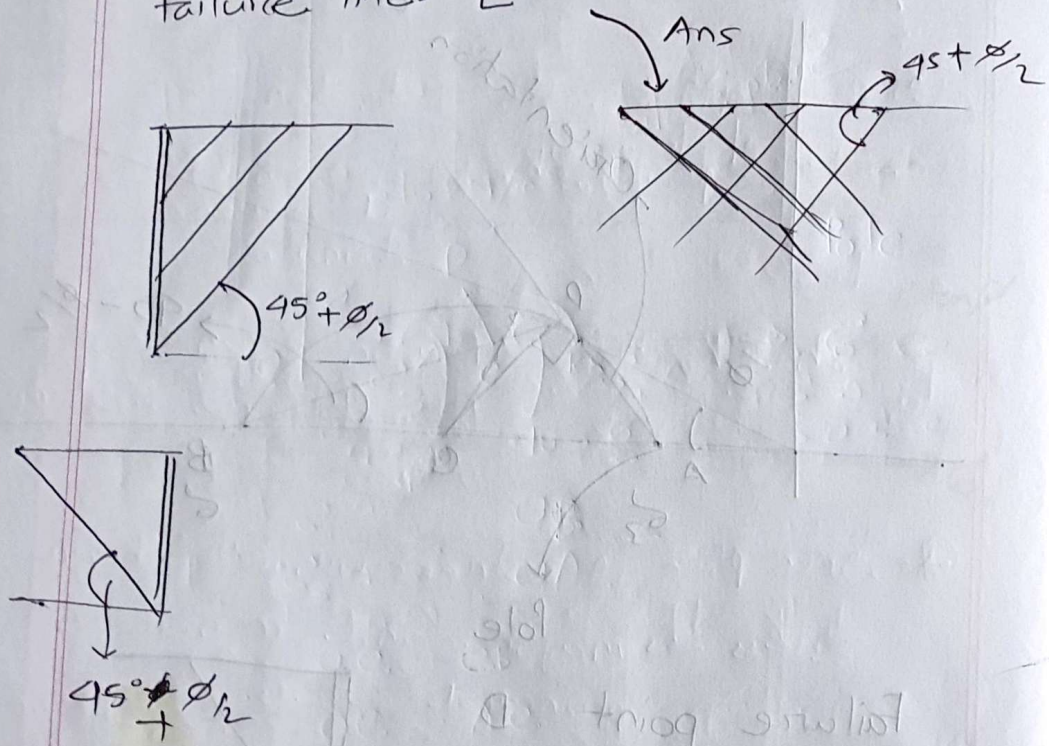
P-25, 49, 43



Failure point D

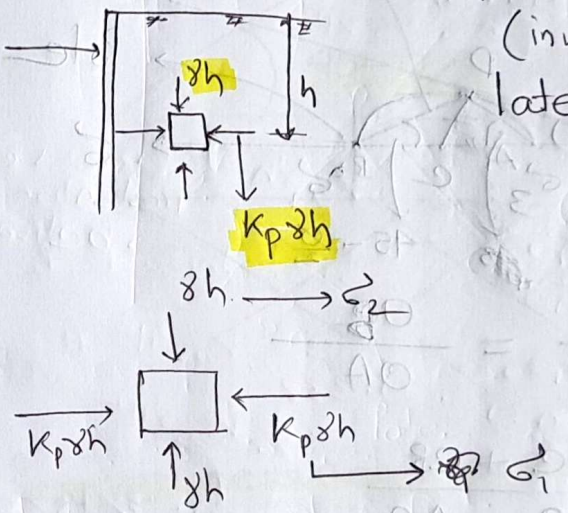


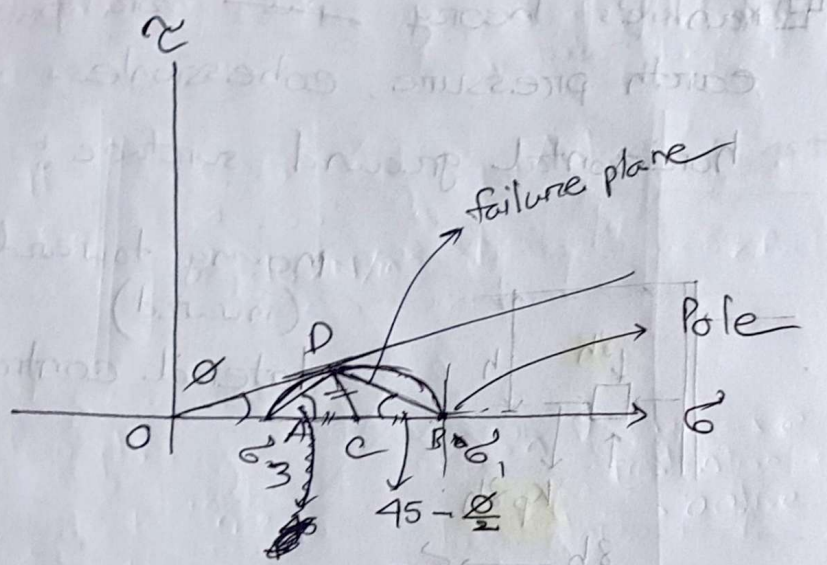
* Drow the ~~quantati~~ qualative failure liner [IMPORTANT]



Rankie's Theory ~~pas~~ for passive earth pressure, cohessionless soil horizontal ground surface :

moving toward soil (inward) lateral contraction





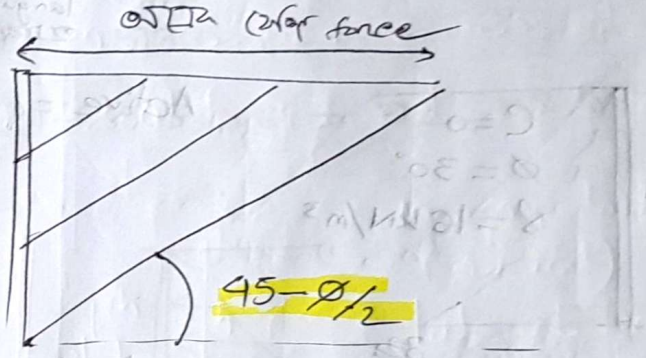
$$K_p = \frac{\sigma_1}{\sigma_3} = \frac{OB}{OA}$$

$$= \frac{OC + CB}{OC - AC}$$

$$= \frac{OC + CD}{OC - CD} = \frac{1 + \frac{CD}{OC}}{1 - \frac{CD}{OC}}$$

$$= \frac{1 + \sin\phi}{1 - \sin\phi} = \tan^2\left(45 + \frac{\phi}{2}\right)$$

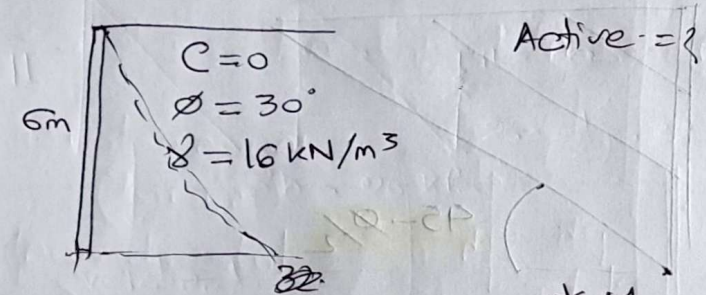
$$= \frac{1}{K_a}$$



Passive pressure > active pressure

Active হলে passive → হয় directly সরাসরি or direction or Expansion, হয় or অন্য language চলে যাবে.

Math:



Active = ?

* Massive retention wall → active

Step-1:

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

$$= \frac{1-\sin 30}{1+\sin 30} = 0.333$$

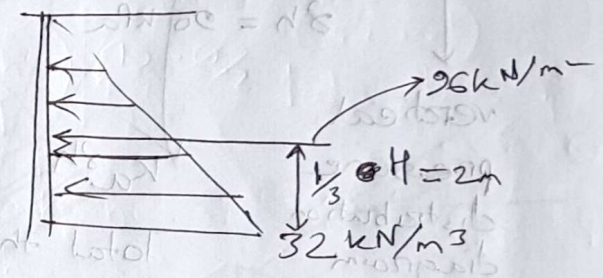
Step-2:

Active pressure any depth $P_a(h) = K_a \gamma h = 0.333 \times 16 \times h = 5.33h$

Step-3:

$P_a(0) = 5.33 \times 0 = 0$

$P_a(6) = 5.33 \times 6 = 32$ kN/m²



Step-4:

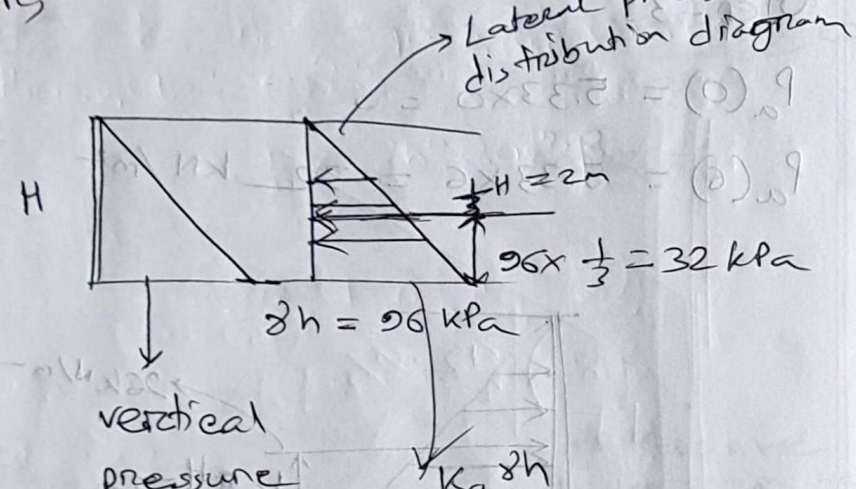
Active thrust $P_a = \frac{1}{2} \times 32 \times 6$

$= 96$ kN/m (প্রতি kN হবে)

$\bar{y} = \frac{1}{3} H = \frac{1}{3} \times 6 = 2$

Bending moment $= 96 \times 2 = 192$ kN-m

Or,



Total thrust, P_a

$= \frac{1}{2} K_a \gamma H \cdot H$

$= \frac{1}{2} K_a \gamma H^2$

$= \frac{1}{2} \times 0.33 \times 16 \times 6^2$

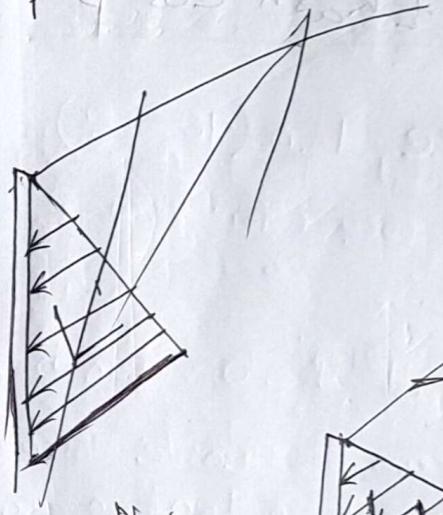
$=$

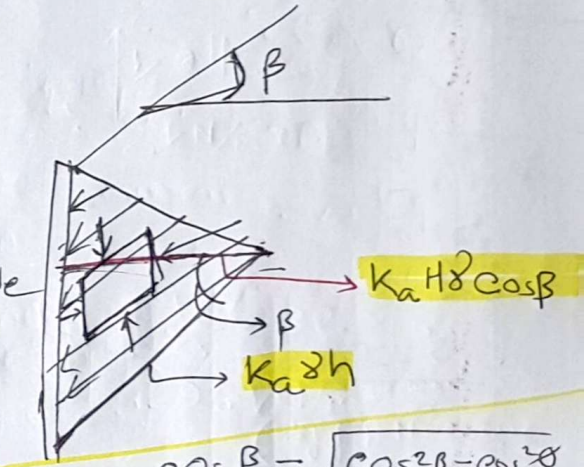
Inclined backfill surface:

~~parallel~~

~~Active pres~~

parallel to ground surface then





Now not right angle triangle

So Height টা বের করতে হবে

H

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

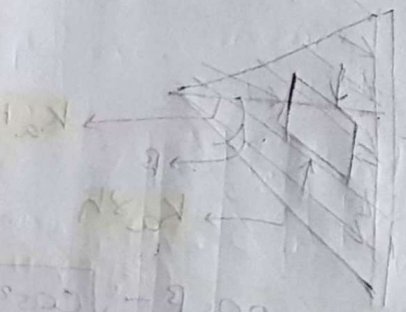
Total thrust, $P_a = \frac{1}{2} K_a H \cos\beta \gamma H$

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

Slide ± ভেতর করে ½ হবে।

$$P_{Horizontal} = \frac{1}{2} K_a \gamma H^2 \cos\beta \times \cos\beta$$

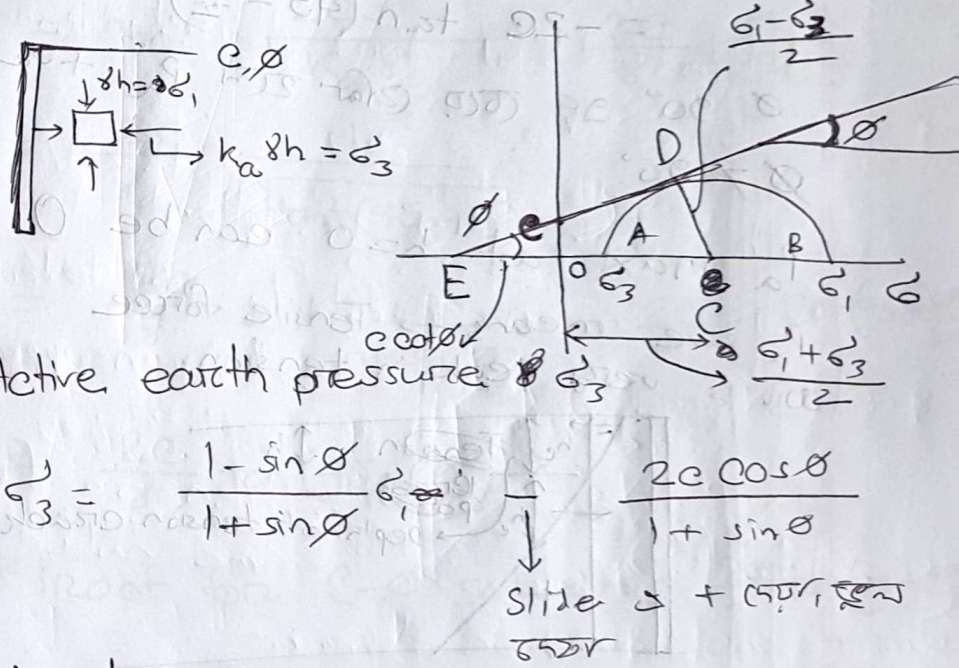
$$= \frac{1}{2} K_a \gamma h^2 \cos^2\beta$$



8.12.25 (Monday)

P-43, 45, 35, 36, 96

Active earth pressure for c-ϕ Soil : Rankine's Theory [IMPORTANT Derivation]



Active earth pressure

$$\sigma_3 = \frac{1-\sin\phi}{1+\sin\phi}\sigma_1 - \frac{2c\cos\phi}{1+\sin\phi}$$

lateral pressure determining.

$$\sigma_3 = K_a \gamma h - 2c\sqrt{K_a}$$

$$P_a = K_a \gamma h - 2c\sqrt{K_a}$$

$h = 0$,

$$P_a = -2c\sqrt{K_a}$$

$$= -2c \tan\left(45 - \frac{\phi}{2}\right)$$

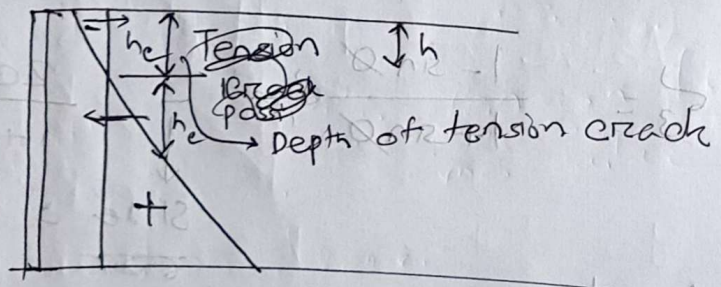
ϕ 90° এর কাছে হলে P_a +ve

$\phi \neq 90°$

P_a max at $h = 0$ can be 0

P_a -ve means → Tensile force

soil is very weak in tension.



Depth of tension crack; [IMPORTANT Derivation]

h_c $P_a = 0$ h_c

$$0 = K_a \gamma h_c - 2c\sqrt{K_a}$$

$$\Rightarrow h_c = \frac{2c\sqrt{K_a}}{K_a \gamma} = \frac{2c}{\gamma} \frac{1}{\sqrt{K_a}}$$

$$= \frac{2c}{\gamma} \frac{1}{\sqrt{\tan^2\left(45 - \frac{\phi}{2}\right)}}$$

$$= \frac{2c}{\gamma} \cdot \frac{1}{\tan\left(45 - \frac{\phi}{2}\right)} = \frac{2c}{\gamma} \cdot \cot\left(45 - \frac{\phi}{2}\right)$$

$$= \frac{2c}{\gamma} \tan\left(45 + \frac{\phi}{2}\right)$$

* Proof for $c-\phi$ soil $h_c = \frac{2c}{\gamma} \tan\left(45 + \frac{\phi}{2}\right)$

For purely cohesive soil

$\phi = 0$ [IMPORTANT Derivation]

$$h_c = \frac{2c}{\gamma}$$

* Proof that For purely cohesive soil $h_c = \frac{2c}{\gamma}$

$2h_c$ depth ~~of~~ resultant thrust ~~of~~ lateral 0. so no needed support. Theoretical unsupported Ht.

Because Tension & compression same value direction different

Theoretical unsupported Ht,

$$H_u = 2h_c$$ [IMPORTANT]

$$= 2 \times \frac{2c}{\gamma} \tan\left(45 + \frac{\phi}{2}\right)$$

$$= \frac{4c}{\gamma} \tan\left(45 + \frac{\phi}{2}\right)$$

For purely cohesive soil, [IMPORTANT]

$$H_u = \frac{4c}{\gamma}$$

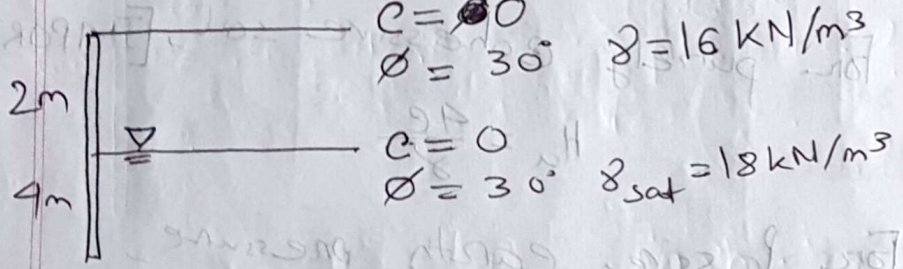
For Passive earth pressure,

$$\sigma_1 = P_p = K_p \gamma h + 2c\sqrt{K_p}$$

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

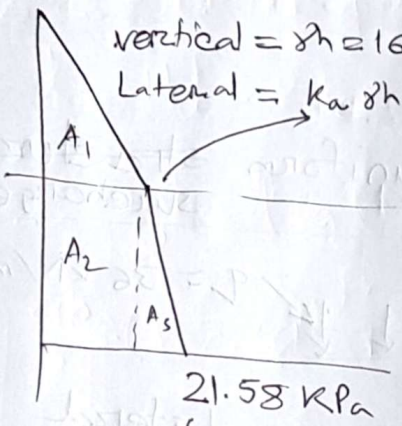
In case of inclined ground surface, [Not required for exam]

Effect of H_2O table:



Lateral earth pressure = ?

*Lateral pressure for effective stress.



$K_{a_1} = \frac{1-\sin 30}{1+\sin 30}$

$= 0.333$

eff vertical

$= 2\times16 + 4\times(18-9.81)$

$= 64.76$

$K_{a_2} = \frac{1-\sin 30}{1+\sin 30}$

$= 0.333$

Active pressure → Area

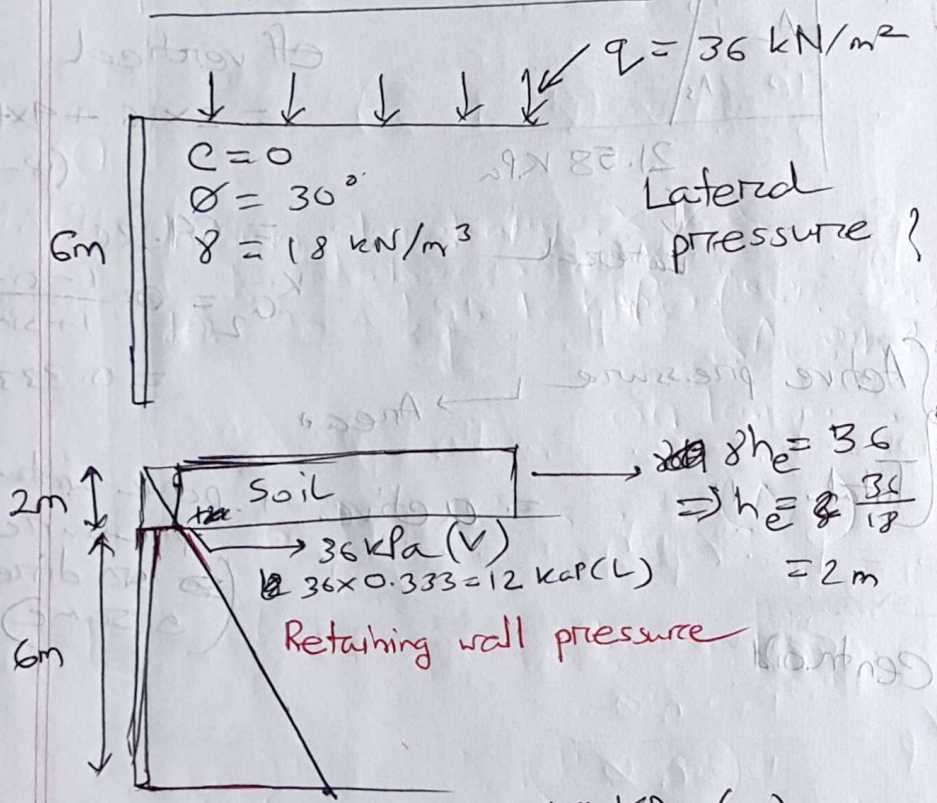
Total = active + pore water pressure (⊥ to direction of same)

Centroid

9.12.25 (Tuesday)

P-51

Effect of uniform ~~structure~~ surcharge:



$\gamma h_e = 36$

$\Rightarrow h_e = \frac{36}{18}$

$= 2m$

$18 \times 8 = 144$ kPa (V)

$144 \times 0.333 = 48$ kPa (L)

Step-1: Equivalent height

$$H_e = \frac{q}{\gamma} = \frac{36}{18} = 2m$$

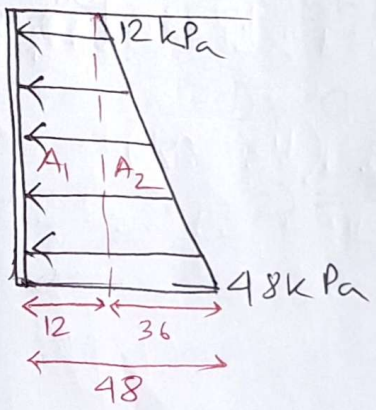
Step-2:

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = 0.333$$

Retaining wall pressure (মাটির চাপ যাচাই করতে হলে as wall নিতে হবে)

Step-3: Eqn.

$$P_a(h) = K_a \gamma (H_e + h)$$



Step: 4 Value determination

$P_a(h=0) = 12\ kPa$

$P_a(h=6) = 48$ "

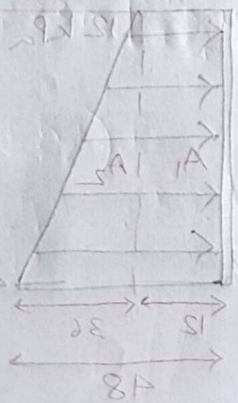
Or,

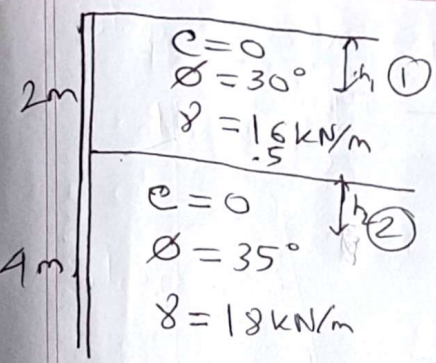
Uniform surcharge × K_a

$\Rightarrow 36 \times \frac{1}{3} = 12\ kPa$ (ত্রিভুজ, ১ম A_1 আয়তন)

Then,

$\frac{1}{2} \times (18 \times 6) = 36\ (A_2)$





Lateral = ?

For layer 1,

$K_{a_1} = \frac{1-\sin\phi_1}{1+\sin\phi_1} = 0.333$

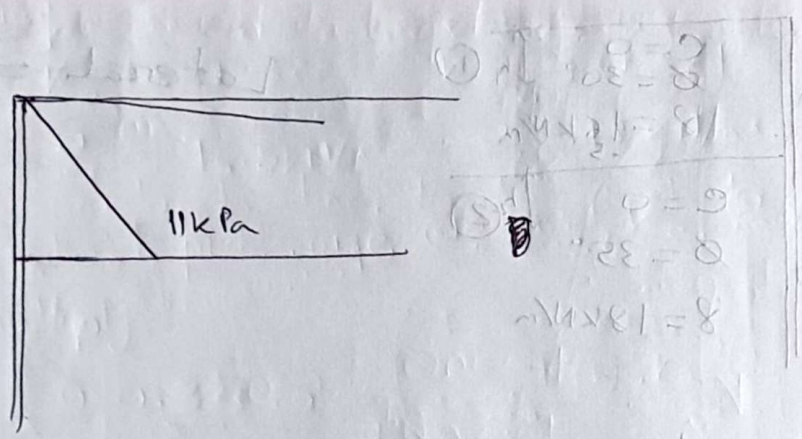
$P_{a_1}(h_1) = K_{a_1} \times \gamma_1 \times h_1$

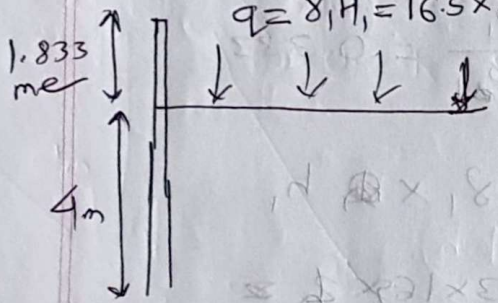
$= 0.333 \times 16 \times h_1$

$= 5.5 h_1$

$P_{a_1}(h_1 = 0) = 0$

$P_{a_{21}}(h_1 = 2) = 5.5 \times 2 = 11\ kPa$





$q = \gamma_1 H_1 = 16.5 \times 2 = 33$ KPa

Layer 1 is acting as a surcharge on layer 2

$$H_e = \frac{q}{\gamma} = \frac{33}{18} = 1.833\,m$$ [Uniform soil এ convert করতে হয়]

$$Pa_2(h_2) = K_{a_2}\gamma_2 (H_e + h_2)$$

$$K_{a_2} = \frac{1-\sin 35}{1+\sin 35} = 0.271$$

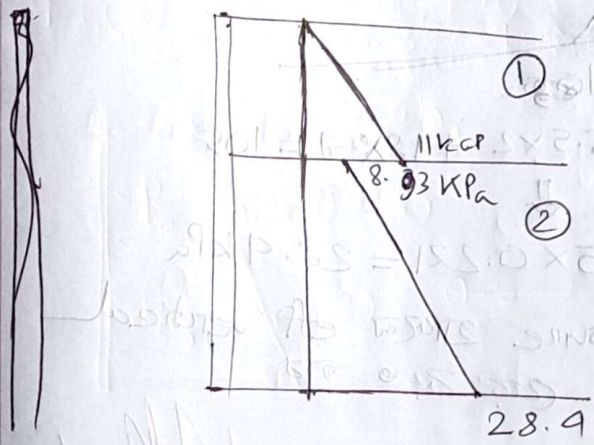
$$Pa_2(h_2) = 0.271 \times 18(1.83 + h_2)$$

$$= 8.93 + 4.88 h_2$$

$$Pa_2(h_2 = 0) = 8.93\,KPa$$

* এখন point এ just উপর নিচে pressure different like shear force.

$$Pa_2(h_2 = 4m) = 8.93 + 4.88 \times 4 = 28.4\,kPa$$



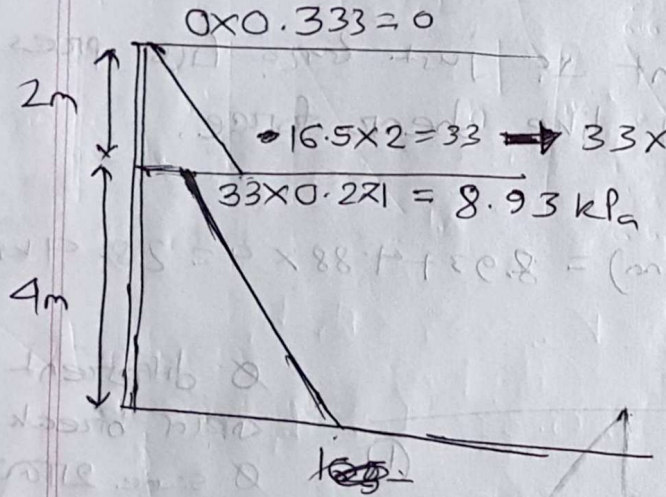
Ø different কারণে break.
Ø same থাকলে change হবে না,
slope ও তার γ এর উপর dependent

তাহলে,

$K_{a_1} = 0.333$ $K_{a_2} = 0.271$

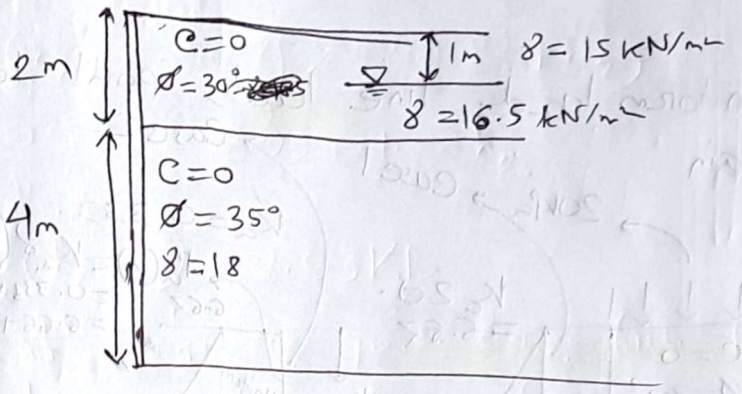
$\gamma_1 = 16.5 kN/m^3$ $\gamma_2 = 18 kN/m^3$

Vertical pressure বের করে K_a দিয়ে multiply.



* H_2O pressure এখানে eff vertical pressure থেকে বাদ হবে

Home Assignment:



H_2O table এর capilary rise এর নিচের layer ও saturated হবে but এখানে H_2O table নেই as H_2O table → lateral movement হবে and ও pressure 0 (atmosphere এর সমান same)

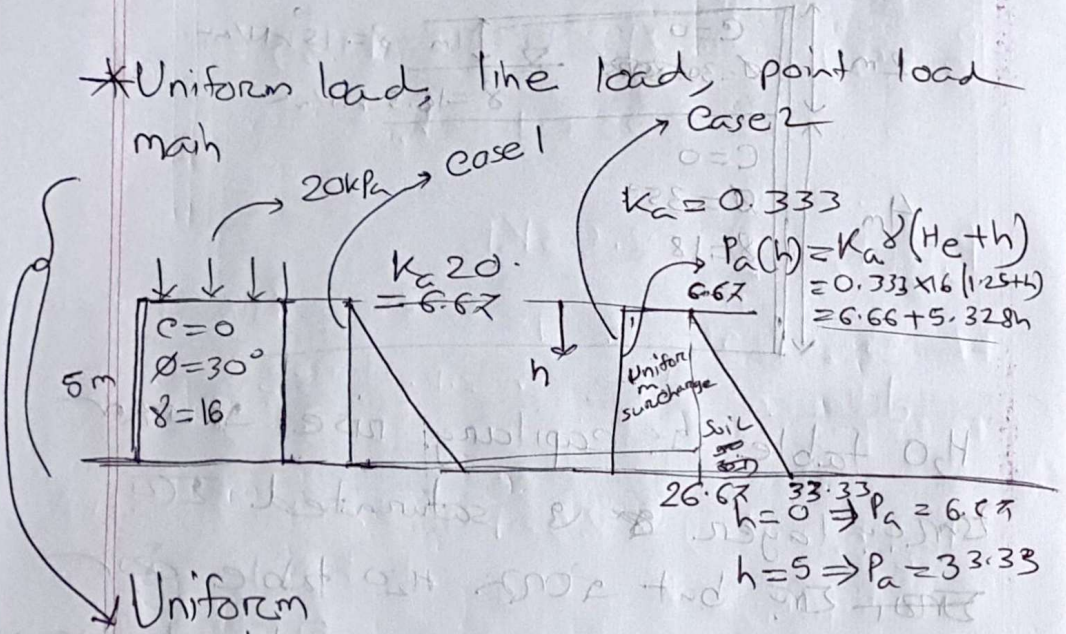
b. but capilary rise এ কিছু pressure0.

Generally γ different হয়ে থাকে but saturate হলে γ different.

22.12.25 (Sunday)

P-59, 52, 55 65 পর্যন্ত

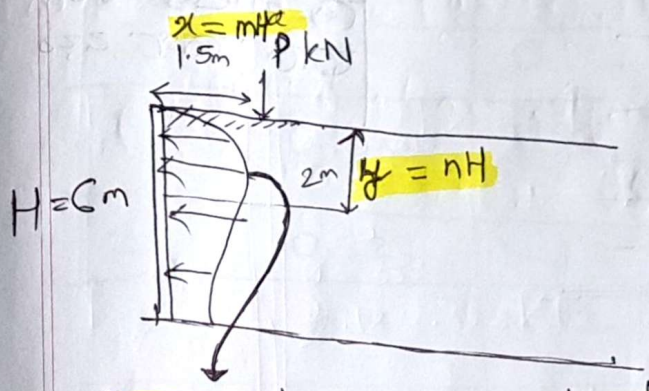
*Uniform load, line load, point load main



Uniform surcharge

*Surcharge → backfill soil এ প্রযোজ্য,

Point load,



∴ $n = \frac{1}{3}$ $m = 0.333$

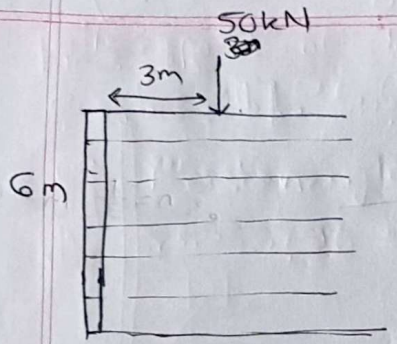
max value around $\frac{1}{3}$ depth এ হয়

$m = \frac{1.5}{6} = 0.25 = \frac{x}{H}$

Any depth lateral earth pressure,

$m > 0.4 \Rightarrow \sigma_h = \frac{1.77 Q_p}{H^2} \frac{n^2}{(m^2+n^2)^3}$

$m \leq 0.4 \Rightarrow \sigma_h = \frac{0.28 Q_p}{H^2} \frac{n^2}{(0.16+n^2)^3}$



Retaining wall
ca atleast 6ft
হোৱা হোৱা ২২২

Step-1

$$m = \frac{3}{6} = 0.5$$

Step-2

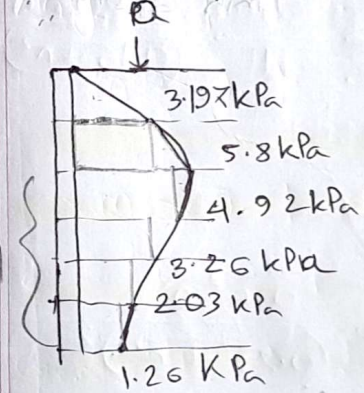
$$\sigma_h = \frac{1.77Q}{H^2} \times \frac{n^2}{(m^2 + n^2)^3}$$

$$= \frac{1.77 \times 50}{6^2} \times \frac{n^2}{(0.5^2 + n^2)^3}$$

$$= \frac{2.46\, n^2}{(0.25 + n^2)^3}$$

Depth (h) (m)	$n = \frac{y_{axis}}{H}$	σ_h
0	0	0
1	0.16	3.19
2	0.333	5.80
3	0.5	4.92
4	0.66	3.26
5	0.833	2.03
6	1	1.26





Total thrust = total area

$$A_1 = \frac{1}{2} \times 1 \times 3.19 = 1.59 \text{ kN/m}$$

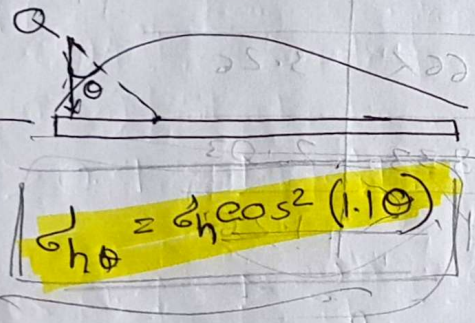
$$A_2 = \frac{1}{2}(3.19 + 5.8) \times 1 = 4.49 \text{ kN/m}$$

$$\left(1.1 + \frac{1}{2}\right) + \left(1.1 + \frac{1}{3}\right)$$

Probable class test (Point load) application

যখন point of load এর কাছে হবে তখন centroidal এর মান হয়ে Trapezium এ Rectangle and triangle

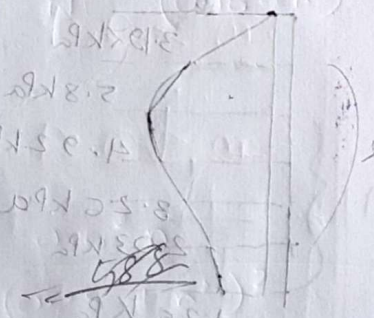
I তারপর মান, তারপর centroid এর মান

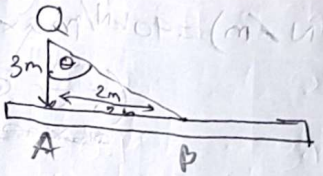


Retaining wall

$\sigma_{h\theta} = \sigma_h \cos^2(1.1\theta)$

এভাবে kinda max $\frac{1}{3}$ এর মধ্যে min এ তারপর

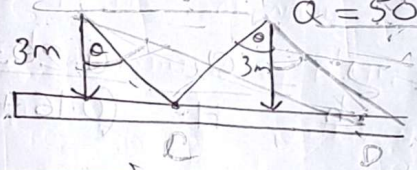




$\theta = \tan^{-1}\frac{2}{3} = 33.69°$

$\cos^2(1.1 \times 33.69) = 0.64$

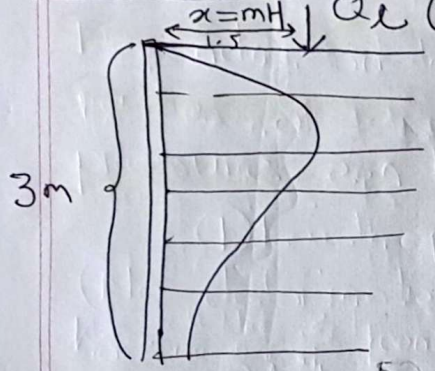
$Q = 500\,kN$



As এর middle এর 2 টা multiply করা and একই θ same but different point থেকে 2 টা MF add করে মান বের করা হয়।

23.12.25 (Tuesday)

Line load: Q_L (kN/m) = 40kN/m ax = $\frac{1}{3}$ dept



(6 ঘর ভুল ভুল)

$m > 0.4 \Rightarrow \sigma_h = \frac{4Q_L}{\pi H} \frac{m^2 n}{(m^2+n^2)^2}$

$m \leq 0.4 \Rightarrow \sigma_h = \frac{Q_L}{H} \frac{0.203\, n}{(0.16+n^2)^2}$

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

$\sigma_h = \frac{4 \times 40}{\pi \times 3} \frac{0.5^2 n}{(0.25+n^2)^2}$

$= \frac{4.24\, n}{(0.25+n^2)^2}$

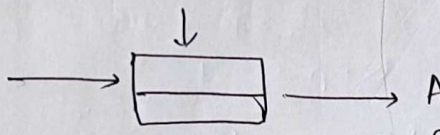
Depth	n	σ_h
0	0	0
0.5		
1		
1.5		
2		
2.5		
3		

29.12.25 (Monday)

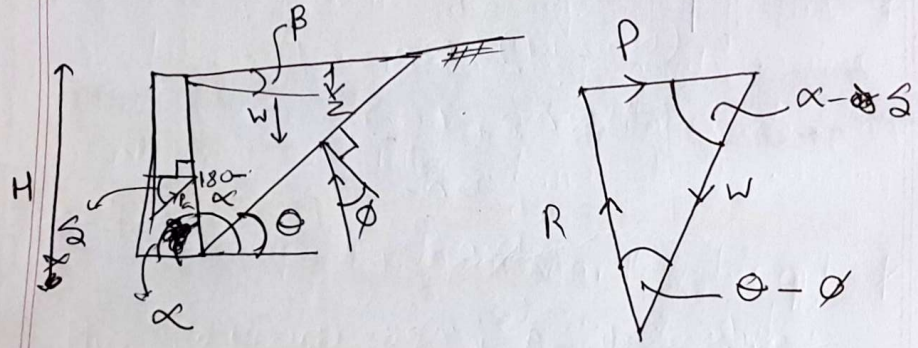
P-66, 68, 70, 72, 74

* Failure - 2D

Coloumbs Theory of Lateral Earth pressure:



→ Angle of internal friction of soil



R, P_a, ϕ → are resultant forces

δ এর মান ক্ষেত্র বিশেষে $\delta = \phi - (\frac{2}{3}$ to $\frac{3}{4})\phi$

Rankines theory অনুযায়ী,

wall vertical $\therefore \alpha = 90°$

wall smooth $\therefore \delta = 0$

Horizontal surface plan $\beta = 0$

*Justify Rankine's theory,

$$\sin^2(\alpha+\phi) = \sin^2(90+\phi) = \cos^2\phi$$

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

$$= \frac{\sin^2(90+\phi)}{\sin^2 90 \sin^2(90-0)\left[1+\sqrt{\frac{\sin(\phi+0)+\sin(\phi-\beta)}{\sin(90-0)\sin(90+0)}}\right]}$$

$$= \frac{\cos^2\phi}{\left(1 \mp \sqrt{\frac{\sin\phi \ \sin\phi}{\sin 1 \times 1}}\right)^2}$$

$$= \frac{\cos^2\phi}{(1 \mp \sin\phi)^2}$$

$$= \frac{1 - \sin^2\phi}{(1 \mp \sin\phi)^2}$$

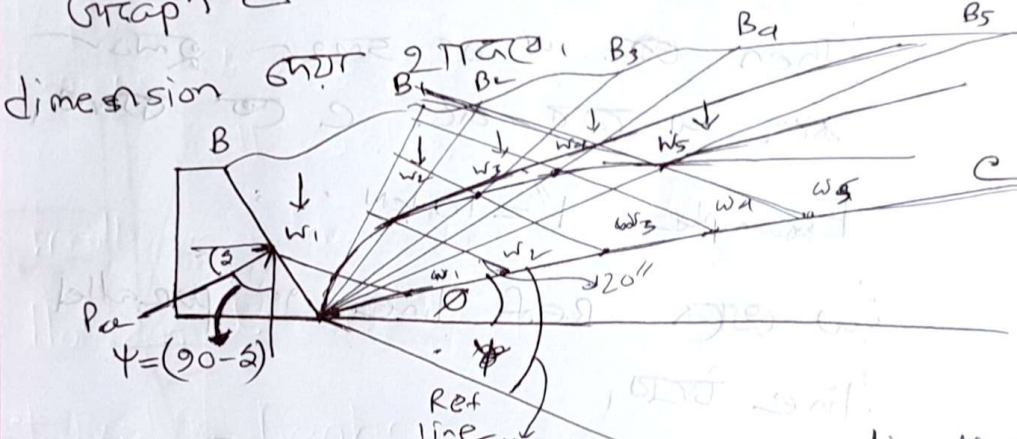
$$= \frac{(1 - \sin\phi)(1 + \sin\phi)}{(1 \mp \sin\phi)^2}$$

$$= \frac{1 \mp \sin\phi}{1 \mp \sin\phi}$$

Plus হওয়ার কথা। As its active Passive এ (−) হবে

Culman's method:

Graph এ Retaining wall আঁকব। dimension দেয়া থাকবে।



Horizontal line আঁকব। Structure এর direction এ ϕ angle আঁকব। Failure surface (9-5) assume করব।

Horizontal and vertical scale should be same.

এরপর δ, ψ আঁকব। C এর উপরে গিয়ে ψ angle আঁকব। Ref line এর w value বের করব। Graph এ small box count করব। Area বের হবে। And perpendicular unit দিব। So' val বের হবে। Then unit vt দিয়ে multiply করব।

Then wt ও new scale নিব।

Then w এবং চাপের মানের মধ্যে w বেড় করে c তে যাবে,

Example $1'' = 10\ kN$.

w থেকে Ref line এর parallel line টানব,

এবং failure surface এর সাথে intersect করানোর পর বেড় করে smooth curve পাব, যে line টানা যায় তাকে Culmann's line (Arch Road) এর curvature change হয় point গুলোর বেড় করব, এই point এ c এর parallel line টানা, Line গুলোর max যেটা সেই wt হবে active thrust

(Normal graph paper এনেও হবে)

→ এর ভিতর বেড় করলে এই line গুলোর equally spaced হবে এবং area same

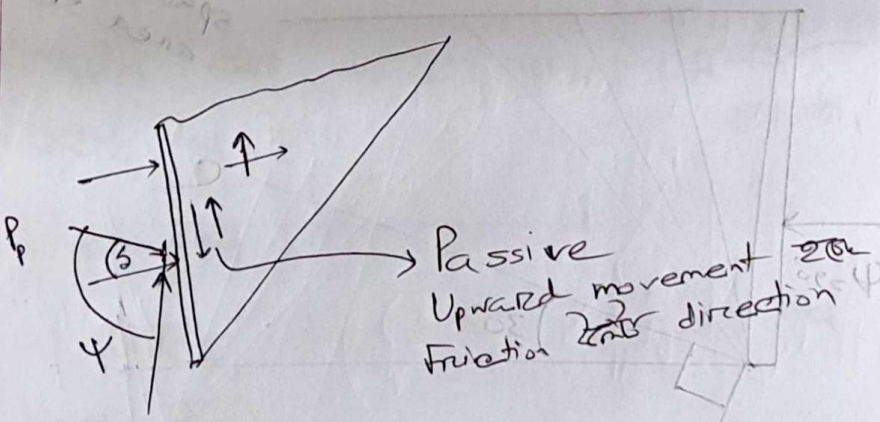
$\therefore \psi = 90°$

$30°$

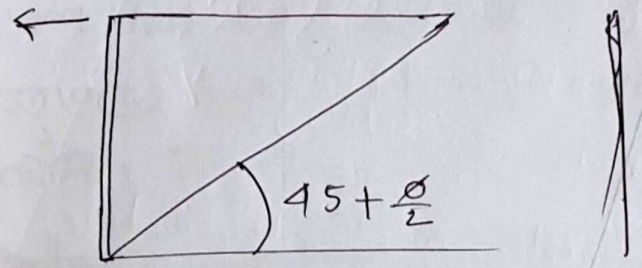
c

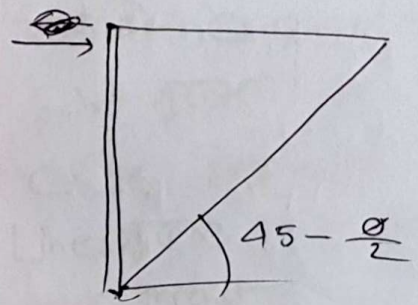
5.1.25 (Monday)

P- 76,



Passive
Upward movement এর
Friction এর direction





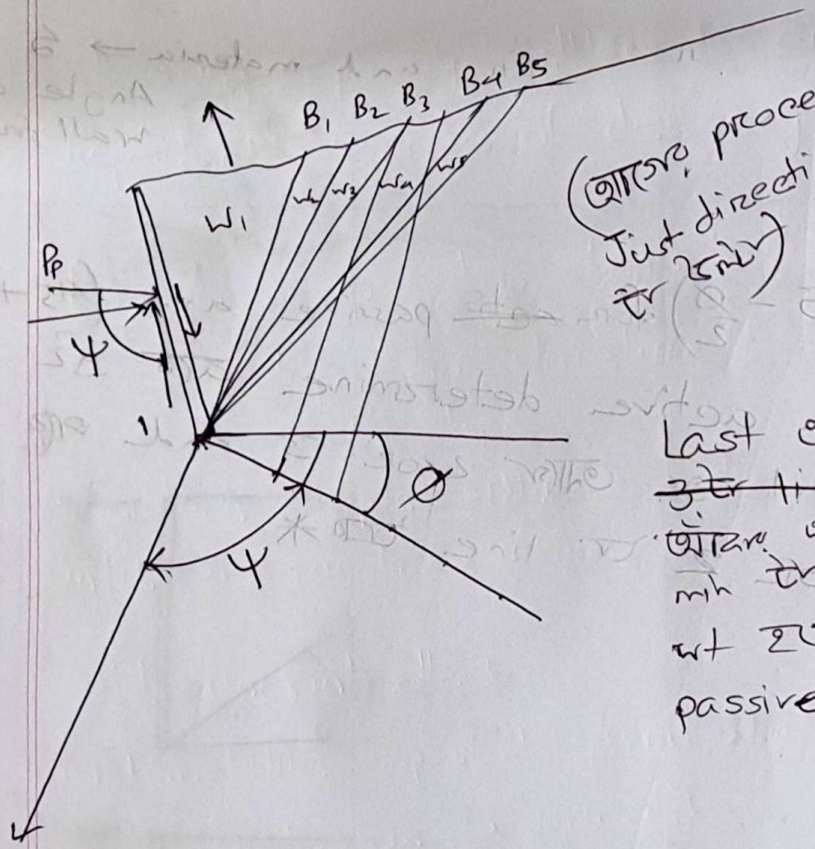
$\delta = 0.67\phi$ or 0.75ϕ [চেষ্টা না হাতানো]

Failure between soil and soil → Angle of internal friction

" " " and materia → δ Angle of wall friction.

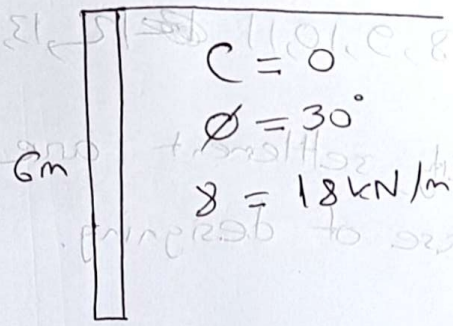
* $(45-\frac{\phi}{2})$ for ~~act~~ passive and $(45+\frac{\phi}{2})$ for active determine করে দেয়া point গুলো আগে 2 or 3 and পরে 3 or 2 বা line টানা *

For passive



(আগের process
Just direction
ঠিক থাকবে)

Last এ line
~~এটা~~ আবার ওই
min ~~হবে~~ ~~হয়~~
এর সমান
passive thrust



$P_a = \frac{1}{2} \times$ ~~1~~ $k_a \gamma H^2$

$= \frac{1}{2} \times \frac{1}{3} \times 18 \times 6^2 = 108$ kN

Assumption → vertical retaining wall and smooth wall

যদি friction angle 20° হয় then ψ = ?
হবে।

Roll No. 20233020

$W_1 = W_2 = W_3 = W_4 = W_5 = W_6$

$= \left(\frac{1}{2} \times 6 \times 3\right) \times 1 \times 18 = 54\ kN$

(A) (h) ↓ 8

Z axis

54 kN = 27.5 mm

55 mm

$\left(\frac{54}{27.5} \times 55 = 108\ kN\right)$

B

C

ψ

ϕ

A

$\psi = 90°$

D

RB Products

8 Inch x 10 Inch

6.1.26 (Tuesday)

P- 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

Bearing capacity, settlement are important in case of designing.

Load propagation depends
- type of structure
- Soil type

Certain depth soil test until a rigid surface

Soil uncontrolled

Water table important perimeter

Soil investigation → Just soil
Site " → soil and underlying structure

21.11.26 (Wednesday)

EWCE-343 (Zoynul Sir)

15, 16, 18, 21, 22, 24, 25, 29, 31

* Boring depth এর math আসবে *

Gross stress increase $= \frac{1800}{3\times3} = 200 kPa$

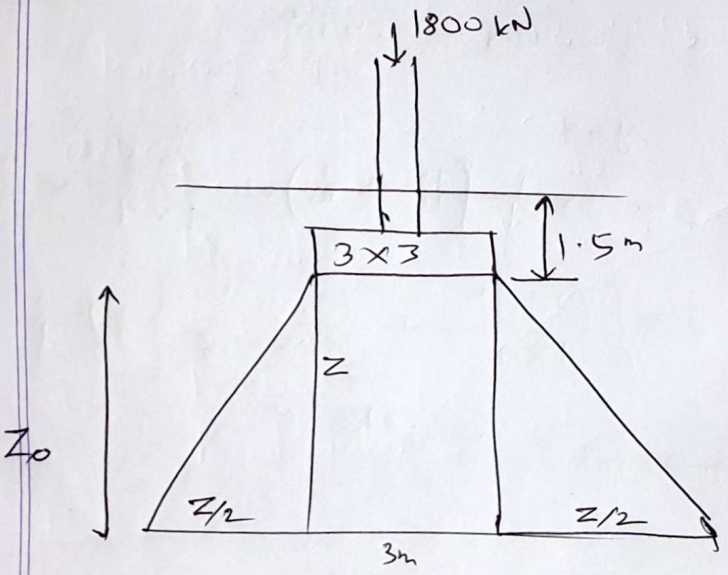
Net stress increase $= 200 - \gamma D_f$

$= 200 - 18\times1.5$

$= 176$

10% of stress increase $= 0.1\times176$

$= 17.6 kPa$



$$\frac{176\times(3\times3)}{(3+z)(3+z)} = 17.6$$

$$\Rightarrow 10 = 9 + 6z + z^2$$

$$\Rightarrow z = 0.162$$

$$\Rightarrow z^2 + 6z + 9 = 90$$

$$\Rightarrow z = 6.4m$$

Boring depth $= 6.4 + 1.5 = 7.9 \approx 8$

At z_o,

$1.5\times16 + 1(16-9.81) + (z_o - 1)(18-9.81)$

$= 24 + 6.19z_o$

$= 22 + 8.19z_o$

$$\frac{176 \times 3 \times 3}{(3+z_0)(3+z_0)} = (22 + 8.19z_0) \times 0.05$$

$$= 1.1 + 0.4095 z_0$$

$$\Rightarrow z_0 = 12.8\text{m}$$

$$31680 \neq (22 + 8.19z_0)(9 + 6z_0 + z_0^2)$$

$$= 198 + 132 z_0 + 22 z_0^2 + 73.71 + 49.14$$

Boring depth = 12.8 + 1.5 = 14.3m

(Ans) min depth 3m

27.1.26 (Tuesday) (Rec)

P- 32, 33, 34, ~~36~~ 35- ~~40~~41, 42-47, 48, 49, 50, 51, 52, 56-59, 60, 61, 62, 63, 64, 67, 68, 75, 78, 76, ~~77~~ (P-82)

Method of Boring:

- Auger Boring
- Hollow stem auger boring
- Wash boring
- Percussion / Cable tool
- Rotary drilling
- ODE >
- Soil sample

* All the undisturbed soil are representative but all the representative are not undisturbed. * Question ~~answer~~,
* Undisturbed → All engineering test

* Sandy soil when its confined its hard as stone.

* Representative ⟶ Grain size analysis
  Atterberg
  Index property

* Non ⟶ Field identification

Major disturbance → inside pressure
vertical load
কাজ হয়, we neglect it

Soil sampling

* Explain the terminology →

  Soil sample, soil sampling, soil sampler,

* Blockhole ⟶ less disturbance

Soil sampler

Split spoon sampler
Shelby tube

17.2.26 (Tuesday) (Rec must)

Soil samplers:

ST → Shelby tube

SS → Split spoon

Core barrel

Sample disturbance

Inside clearance ratio, C_i

$$= \frac{100(D_s - D_c)}{D_c} \%$$

Outside " " C_o

$$= \frac{100(D_w - D_T)}{D_T} \%$$

Area ratio, $A_R = \frac{100(D_w^2 - D_c^2)}{D_c^2} \%$

Inside → 1% – 3%

A_R → should be kept as low as possible < 10%

Recovery ratio, $R_R = \frac{L}{H}$ [96–98%]

L = length of the sample within the tube

H = depth of penetration of the sampling tube

Rock quality designation RQD

RQD %	Rock quality
90–100	Excellent
75–90	Good
50–75	fair
25–50	Poor
0–24	very poor.

It's the ratio of the total length recovered of pieces of core having length greater than or equal to 100 mm (4") to the length of the sampler penetrated into the rock.

- GW Level
- Standard Penetration test

1.5 m ধরে ধরে Hole & then test.

Penetrometer

Hammer wt 140 lb / 63.5 kg

30" or 760 mm ভার drop

SPT value or N-value (whole value)

24.2.26 (Tuesday)

P-103, 117, 107, 123, 118, 119, 127, 139, 190

1.5m → 1.5m → 1.5m Borre hole

Hammer wt 140lb = 65kg
(63.5)

Drop ht = 30" = 750mm

SPT value = 5+8 = 13

N - value

SPT-N

N_f

Total 18" drive
করি।

6" → 7 blow

6" → 5 blow

6" → 8 "

Total last blow
নেব → SPT

1st one ignore
করে দেয়।

Correction for field & pressure

$$N_{60} = \frac{E_H C_B C_S C_R N}{0.6}$$

N_{60} = Corrected SPT

E_H = Hammer efficiency

C_B = Borehole dia correction

↳ 4" bore হলে idea

~~Buckling in~~

Bucking হলে ধরে।

C_R = Drill rod correction

C_S = Sampler correction

↳ Sampler smooth, rough

N = measured SPT-N at field.

Hammer

Energy = wt × distance

$= 140 \times \frac{30}{12}$ ফেলে হওয়া হচ্ছে

60% energy কাজ করলে ideal case ধরা হয়

energy বাড়লে spt value কমে

energy কমলে spt value বাড়ে।

(এটার জন্য) correction

Example,

N = 15 (Field)

$$N_{60} = \frac{0.95}{0.6} \times 1 \times 1 \times 1 \times 15$$

$$= 11.25$$

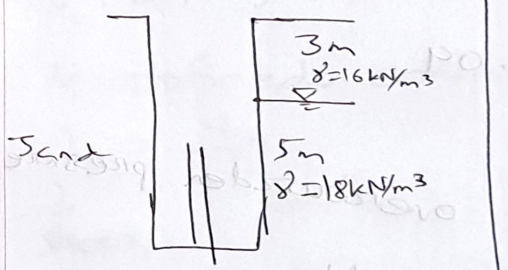
* At field, N must be integer.

∥ correction, not needed.

* Sandy soil → We have to go for further correction

↳ Correction for overburden

Example,



N = 15

N_{60} = 11.25

Eff verticle stress

$\sigma'_v = 3 \times 16 + (18 - 9.81) \times 5$

$= 88.95 \text{ kPa}$

$= 0.91 \text{ kg/cm}^2$

Over burden pressure, $\sigma'_v = 100$ → correction নাও

[formula memorize]

$$C_N = 0.77 \log \frac{2000}{\sigma_0'} \quad \left| \sigma_0' \geq 0.25 \text{ kN/m}^2 \right.$$

↓ better for pressure.

$$C_N = \sqrt{\frac{1}{\sigma_0'}} \quad \left| \sigma_0' \text{ is in tsf or } \text{kg/cm}^2 \right.$$

$$C_N = 0.77 \log \frac{2000}{\sigma_0'}$$

$$= 0.77 \log \frac{2000}{88.95}$$

$$= 1.09$$

$$C_N = \sqrt{\frac{1}{0.91}} = 1.09$$

Correction for overburden pressure,

$N_{1(60)}$ or $(N_1)_{60} = C_N N_{60}$

$= 1.09 \times 11.25$

$= 11.7$

Depth of SPT = Rod length কত হয়,

আরো কিছু water table correction এর জন্য

$$N_{WTC} = 15 + \frac{1}{2}(N_{60} - 15)$$

↳ SPT > 15
fine sand
water table
এর নিচে হলে

Present days → C_N use করা হয়।

Pile → very dense (Normally)

$q_u (kN/m^2) = 12.5 N_{60}$ → clay

Unconfined compressive strength.

$$C_u = \frac{q_u}{2}$$

↓
shear

For BD,

$q_n = 14.3\ N$ → Field N

LL ≤ 35

↓

Liquid limit

16.9 N & LL ⇒ 36 – 50

17.8 N LL ⩾ 50

$$\phi^\circ = 27 + 0.3N_{60} + 0.00054N_{60}^2$$

$$\phi^\circ = \sqrt{N_{60}} + 15$$

↓ more precise

↓ Angle of friction.

3.3.26 (Tuesday)

Dynamic cone Penetration test (DCPT)

4 বার্ drive 100 mm যায়,
last 3 ~~৪~~ টা sum = N_{dc}

Disadvantage → soil sample collect করা যায় না

4 type:
Light Normal Heavy Super heavy

BD ১ Popular না

~~৪~~

Dutch cone penetration test: 2 টা (Static)

আরেকটা
(CPT)
↳ Europe popular

Pore H_2O pressure measure করা যায়

Cone এর উপর load → cone stress
Jacket এর ১) ॥ Resistance → Cone resistance
a part এ friction → Side friction

Cone resistance q_c = ____

$$f_s = \frac{Q}{A_f} \quad \text{(side friction)}$$

$$R_f = \frac{f_c}{q_c}$$

$$q_c = 0.4N$$

Geophysical methods of exploration

Not important for exam

Soil exploration report

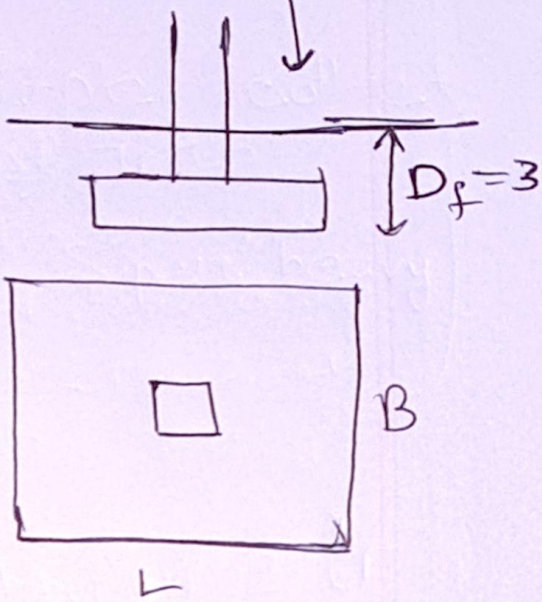
Pile Foundation

Ques cover
22.

2 → Shallow → D < 3
D < B

→ Deep

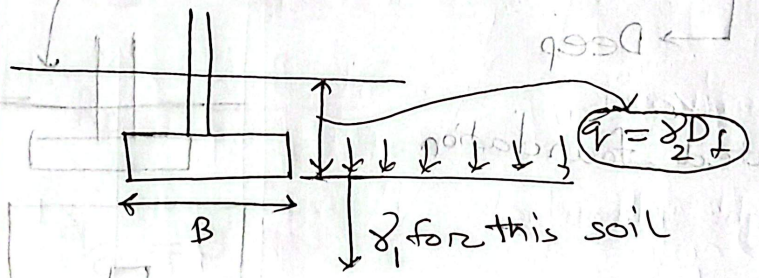
Isolated foundation



31.3.26 (Tuesday)

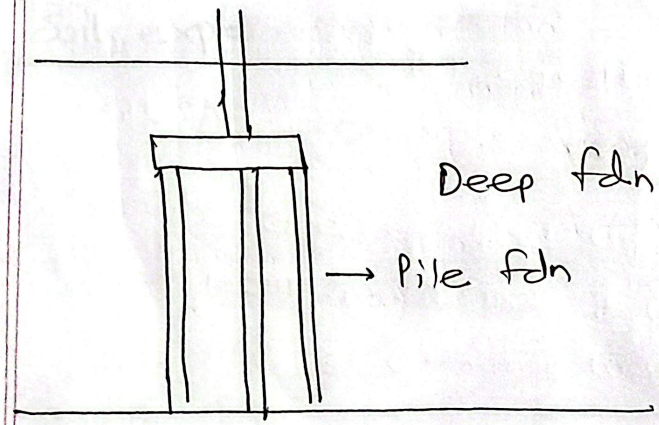
$$q_{ult} = cN_c + \frac{1}{2}B\gamma_1 N_\gamma + qN_q$$

$q = \gamma_2 D_f$



General bearing capacity for shallow fdn

Stiff ↑ soil capacity for load ↑



Driven pile → hammer দিয়ে drive

Reinforcement casing. Then concrete ঢালা হয় → Bored pile

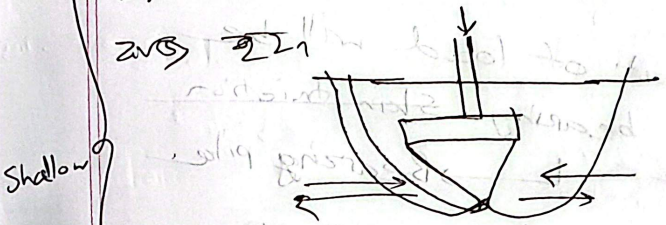
Driven pile → load বেশি নেয়।

Shear strength parameter → c

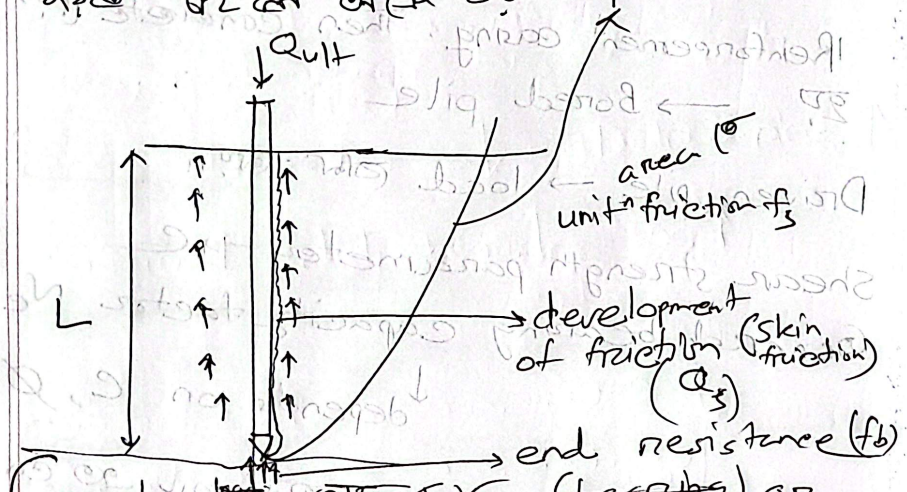
General bearing capacity factor N_c N_γ N_q

↓ depends on c, ∅

Shallow fdn এ load apply করলে soil এও compaction হয়, যে এটা fdn এর integral part হিসেবে কাজ করে।



Deep foundation এ মূলত দুই phenomena follow করে মাটির ভার বহন করে।



mechanism অনুযায়ী

Stiff soil, most of load will be taken by end bearing. Skin friction ~~ne~~ (80% or more) → Bearing pile

Skin friction carry করে → Friction pile (80% or more)

Soil এর soil এর field এ C_u

C_u → undrained condition এ

এখানে 2 C_u same হবে, as 2 layer এর soil এর ই এক ধরে।

Silt → Plastic (Cohessive)
Non-plastic (Cohessionless)

Driven pile :

Cohesive soil (α-method)

friction is a stress

Q_s → skin
Q_b → bearing
Q_{ult}

end bearing → cross sectional area)

A_s skin friction এর ক্ষেত্রে use করা হয়

$$Q_{ult} = Q_s + Q_b$$

Skin, unit area এ friction $f_s = C_u \alpha$

Shear stress create হবে, Cohessive soil এ $\tau = C_u$

Surface area $A_s = \pi DL$

$Q_s = A_s f_s$

Cohessive soil → $\phi = 0$. $N_\gamma = 0$ ∴ $\frac{1}{2} B \gamma N_\gamma = 0$

N_q এরও মান

∴ $q N_q \approx 0$

load $f_b = q_{ult} = cN_c = 9C_u$ ∴ $q_{ult} = CN_c$ (stress)

For deep fdn $N_c = 9$ ধরি $N_c = 9$ ধরি হয়।

$Q_b = f_b \times A_b$
$= 9 N_c A_b$

$C_u = 20$ kPa (Disturbance বেশি

$C_u = 100$ " " কম

reduction factor (α) use করি

$\uparrow C_u$, stiffer $\uparrow$ $\alpha \downarrow$ Disturbance $\uparrow$

$\downarrow C_u$ Soffer $\uparrow$ disturbance $\downarrow$ $\alpha \uparrow$

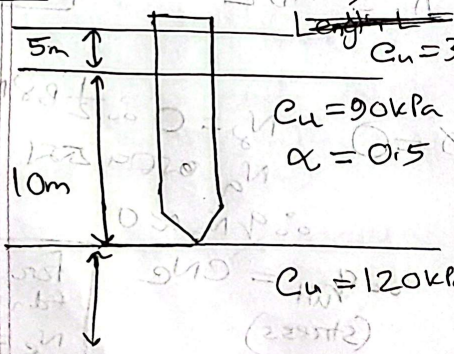
$C_u = 20$ kPa $\longrightarrow \alpha = 0.9$

$C_u = 100$ " $\longrightarrow \alpha = 0.45$

Interpolation

Math:

Dia, $D = 300$ mm



$C_u = 30$ kPa $\phi = 0$ $\gamma = 16$ kN/m³ $\alpha = 0.8$

$C_u = 90$ kPa $\phi = 0$ $\gamma = 17$ kN/m³

$\alpha = 0.5$

$C_u = 120$ kPa $\phi = 0$ $\gamma = 18$ kN/m³

② Ultimate bearing capacity of pile = ?

$A_s = \pi D h$

$Q_s = A_{s_1} f_{s_1} + A_{s_2} f_{s_2}$

$= (\pi \times \frac{300}{1000} \times 5) \times (0.85 \times 30) +$

$(\pi \times \frac{300}{1000} \times 10) \times (0.5 \times 90)$

$= 120.16 + 424.1$

$= 544.3$ kN

$Q_b = A_b f_b$

$= \pi \times \frac{D^2}{4} \times 9 \times C_u$

$= \pi \times \frac{0.3^2}{4} \times 9 \times 120$

$= 76.3$ kN

$Q_{ult} = 544.3 + 76.3 = 620.4$ kN

6/4/26 (Monday)

FWCE-3713 (Zoynul Sir)

Cohesive soil : $C = C_u$ $\phi = 0$ [Normally clay soil]

Cohesionless : $C = 0$ $\phi = \phi$ [Sand, Gravel]

C ε ϕ : Both

Ex- Normally consolidated ^ ঘনত্ব → ϕ হবে
C ॥ হবে

Silt → 2 ধরনের

Sa Particle → silt size But clay → Plastic silt

" " " Quartz → Non-plastic silt

Driven pile:

Cohesionless soil: (β method) [Friction এর (a) Bare এর]

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

(Overburden pressure)

→ effective pressure

(σ vertical)

K = (Lateral)

σ = Normal force on vertical plane

$= k \sigma_v$

$= k \gamma z$

Shear vertical plane

Vertical pressure দ্বারা induced lateral pressure

z = required depth

Skin friction:

$f_s = \sigma \tan\phi$

$= k \sigma_v \tan\phi$

$= k \gamma z \tan\phi$

Drive করলে soil contract করে।

Passive pressure হলে বেড়ে যায়

k, σ_v → soil property dependent

ϕ → failure between soil and soil

pile এর fail → soil এর particle

soil এর pile material

so ϕ বাড়লে, δ → Angle of wall friction বাড়ে,

Horizontal force ↓ ϕ ↓

Concrete এর চেয়ে Horizontal force বেশি

$\delta < \phi$

$\delta = \frac{2}{3}$ to $\frac{3}{4}\phi$

$\therefore f_s = k \sigma_v \tan\delta$

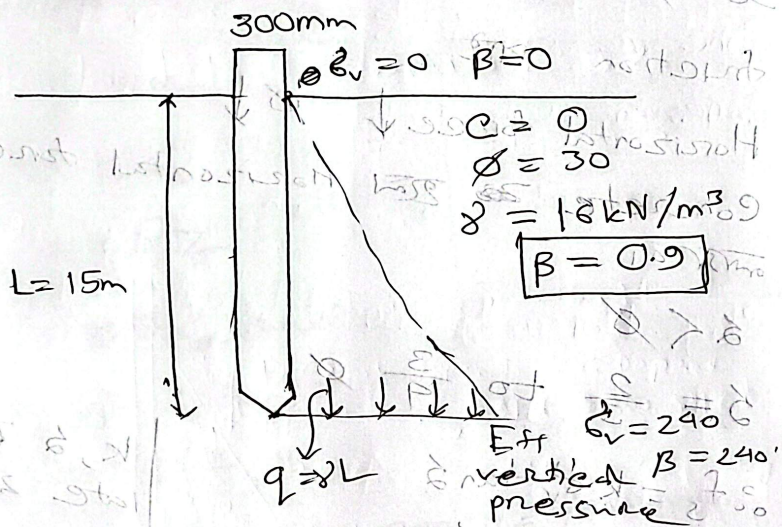
$= \beta \sigma_v$

generally দেয়া থাকে table or chart

k, δ calculate করা tough

$k \tan\delta = \beta$

Math:



$\therefore \sigma_v = \gamma L = 16 \times 15 = 240$ kPa

$f_s = \beta \sigma_v = 0.9 \frac{240+0}{2} = 108$ kPa

↓

overall load এর avg (top & bottom) f_s

$Q_s = A_s \times f_s = \pi D L \times f_s$

$= \pi \times \frac{300}{1000} \times 15 \times 108 = 1526.8$ kN

End bearing,

$f_b = q_{ult} = cN_c + \frac{1}{2} B \gamma N_\gamma + qN_q$

$c = 0$

$B \Rightarrow$ Pile এর dia অনেক ছোট, so neglect করা হয়

$q \Rightarrow$ over burden pressure at pile tip

$= \gamma L$

$N_q =$ factor ~~Chart~~ Graph Fig 13.a থেকে

$\therefore f_b = qN_q$

$= \gamma L N_q$

$N_q = 15$ [for the math]

$f_b = qN_q = 240 \times 15 = 3600$ kPa

$Q = A f_b = \frac{\pi}{4} D^2$ $f_b = \frac{\pi \times 0.3^2}{4} \times 3600$

$= 254.5$ kN

Ultimate capacity

$Q_{ult} = Q_s + Q_b = 1526.8 + 254.5 = 1781.3$ kN

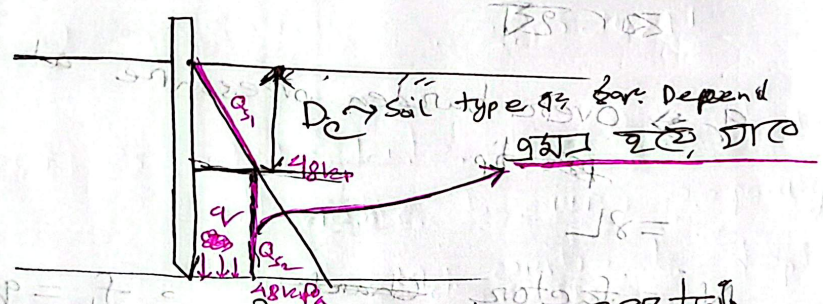
$Q_a = \frac{1781.3}{3} = 593.7$ kN

4.8.23 (Monday)

Factor of safety = 2 to 3

Pile load test করলে $F_S = 2$

No " " " " $F_S = 3$



σ_v → গভীর thought → certain depth এর পরে আর increase হয় না

certain depth → critical depth

$Q_b = f_b A_b$
$= q_b A_b$

$Q_{s_1} = A_{s_1} f_{s_1}$
$= \pi D \times D_c \times \beta \times \frac{\sigma_v}{2}$ → avg of top and bottom

$Q_{s_2} = A_{s_2} f_{s_2}$
$= \pi D \times (L - D_c) \times \beta \times \sigma_v$ → as constant variation

$Q_s = Q_{s_1} + Q_{s_2}$

loose soil ⇒

Loose sand ⇒ $D_c = 10D$ [$\phi = 20-30$]
Dense sand ⇒ $D_c = 15D$ [$\phi = 31-35$]
Medium Dense " ⇒ $D_c = 20D$ [$\phi > 35$]

In math,

$D_c = 10D = 10 \times 0.3 = 3m$

$\sigma_{v_1} = \gamma D_c = 16 \times 3 = 48 kPa$

$A_{s_1} = \pi \times D \times D_c = \pi \times 0.3 \times 3$

$f_{s_1} = \beta \frac{\sigma_v}{2} = 0.9 \times \frac{48}{2}$

$Q_{s_1} = \pi 0.3 \times 3 \times 0.9 \times \frac{48}{2} = 61.07 kN$

$A_{s_2} = \pi \times D \times (L - D_c) = \pi \times 0.3 \times (15 - 3)$

$f_{s_2} = \beta \cdot \sigma_v = 0.9 \times 48$

$Q_{s_2} = 488.5 kN$

$Q_b = A_b f_b$

$= \frac{\pi \times 0.3^2}{4} \times 48 \times 15$

$= 50.89$

$Q_u = Q_s + Q_b = 600.96\ kN$

$Q_{all} = \frac{600.96}{3} = 200.15\ kN$

Ques: Calculate the ~~bea~~ ~~unf~~ allowable bearing capacity considering critical depth

Critical depth বাড়ার হলে → Code অনুসারে limitation থাকে f_s and f_b এর (Exam a দেয় থাকলেও পাস মার্ক পাবে)

Ques: Pile load test should be done

Ans: FS = 2

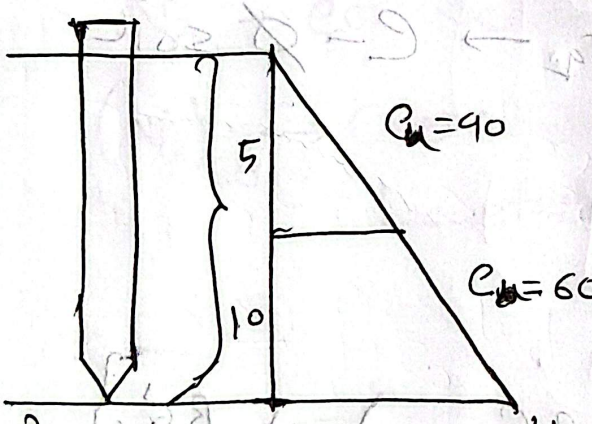
7.4.26 (Tuesday)
EWCE -343 (Zaynul sir)

Cohesive soil – λ method:

$\beta = k \tan\delta$

	Skin friction f_s	End bearing, f_b
Cohesive	αc_u	$9c_u$
Cohessionless	$\beta \bar{\sigma}_{v(av)}$	qN_q
λ-method	$\lambda\left(\bar{\sigma}_{v(av)} + 2c_{u(av)}\right)$	$9c_u$ OR qN_q OR $(9c_u + q_q)$

C=Ø Soil



দুই layer এ ভাগ soil এবার গড় করে end bearing

$\bar{\sigma}_{v(av)} = \frac{\gamma L}{2}$

2 টা layer থাকলে 2 টা c_u এর avg নিতে

$c_{u_{av}} = \frac{40\times5 + 60\times10}{15}$

λ from graph Fig 18

λ-method generally ~~steal~~ steel pile ~~ge~~ ~~ge~~

Small letter ~~the~~ stress.

Q_s } load
Q_b }

$f_b = 9C_u$ → ~~Cohe~~ C-soil [Clay]

qN_q → ∅ − soil [Sandy, Gravel]

$9C_u + qN_q$ → C − ∅ soil

C − ∅ soil:

$f_s = \alpha C_u + \beta \sigma_v$

or $\{\lambda (\sigma_{v(av)} + 2C_{u(av)}) + \beta \sigma_v\}$

$f_b = 9C_u + qN_q$

Bore pile:

$\frac{1}{3} f_s$ of driven pile

$\frac{1}{2} f_b$ " " "

* pile dia > 600 mm ~~or~~ → single pile
otherwise multiple num of piles.

~~Grid~~

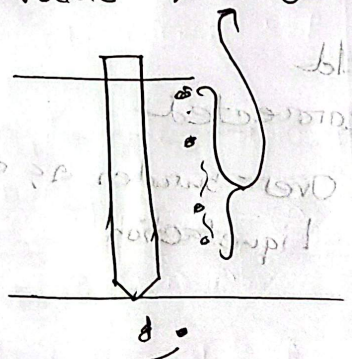
* N → field
N_{60} → corrected
$(N_1)_{60}$ → Overburden ~~ge~~ corrected
Liquefaction

SPT value to bearing capacity

	End bearing	Skin friction
Sand	$400\bar{N}$ (≤ 10000 kPa)	$2\frac{\bar{N}}{d}$ (≤ 60 kPa)
Silt	$300\bar{N}$	$2.67\bar{N}$
Clay	$45\bar{N}$	$5\bar{N}$ (≤ 70 kN/m²)

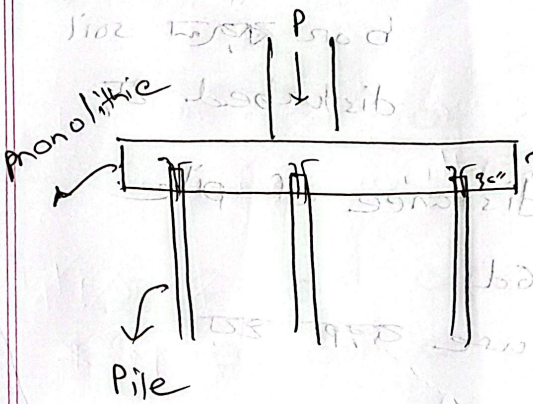
Steel H-Piles = $1\bar{N}$

$\bar{N}$ ⟶ N value ঃ avg



Group pile:

c/c pile distance same রাখার try করা হয় generally



Punching shear check করা হয়, Then thickness

British,

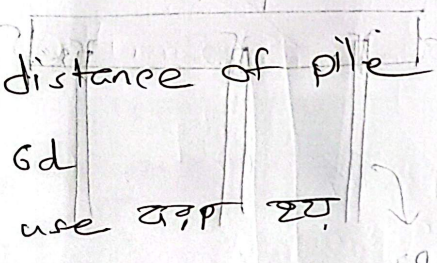
Piled fdn → Pile cap in contact with soil

Pile ,, → Contact না থাকবে

group pile এর

single pile এর carrying capacity থেকে নানা কম হয়।

Cohessive soil → pile drive করলে bore হওয়ায় soil disturbed হয়।



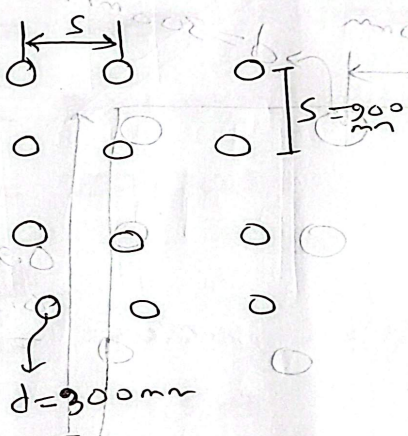
S = c/c distance of pile
= 2d to 6d
Commonly 3d use করা হয়

Efficiency of pile group

$$\eta_g = 1 - \left[\frac{(n_1-1)n_2 + (n_2-1)n_1}{90\, n_1 n_2}\right]\theta$$

η_g = effiency of the group
n_1 = num of rows
n_2 = " " piles in a row

$\theta = \tan^{-1}\frac{d}{s}$ in degree
d = dia of pile
s = spacing of pile



$n_1 = 4$
$n_2 = 3$
$\theta = \tan^{-1}\frac{0.3}{0.9}$
$= 18.4°$

$$\eta_g = 1 - \left[\frac{(4-1)\times 3 + (3-1)\times 4}{90\times 3\times 4}\right]\times 18.4$$

$= 0.71$

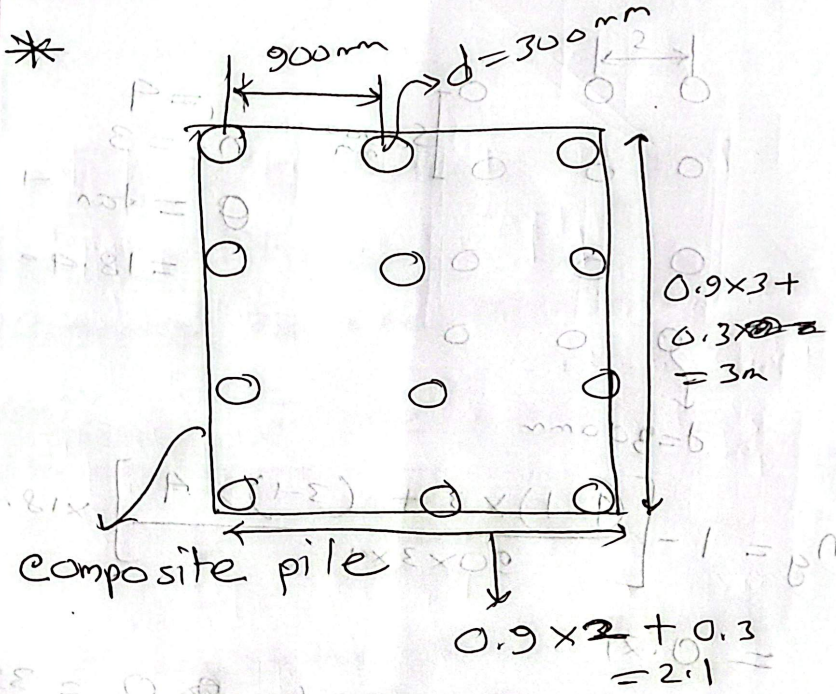
1টি Pile ⇒ $Q_s = 250$kN & $Q_b = 390$kN

$Q_u = Q_s + Q_b = 640$ kN

$Q_{u\,group} = 640 \times 0.71 = 454.4$ kN

FS = 3

$Q_a = \frac{454}{3} = 151$ kN



$C_u = 50$kPa $\alpha = 0.7$

$C_{u\,end} = 100$kPa $L = 15$m

Exam এর
জন্য খুব গুরুত্বপূর্ণ

~~$Q_s = A_s f_{s_1}$~~ ~~$+ A_s f_{s_2}$~~

Composite pile

$Q_s = A_s f_{s_1}$

$= 2 \times (2.1+3) \times 15 \times 0.7 \times 50$

$= 5355$ kN

$Q_{ba} = 9 \times 100 \times 2.1 \times 3 = 5580$ kN

$Q_u = 10935$

One pile :

$Q_s = (\pi \times 0.3 \times 15) \times 0.7 \times 50$

$= 494.5$ kN

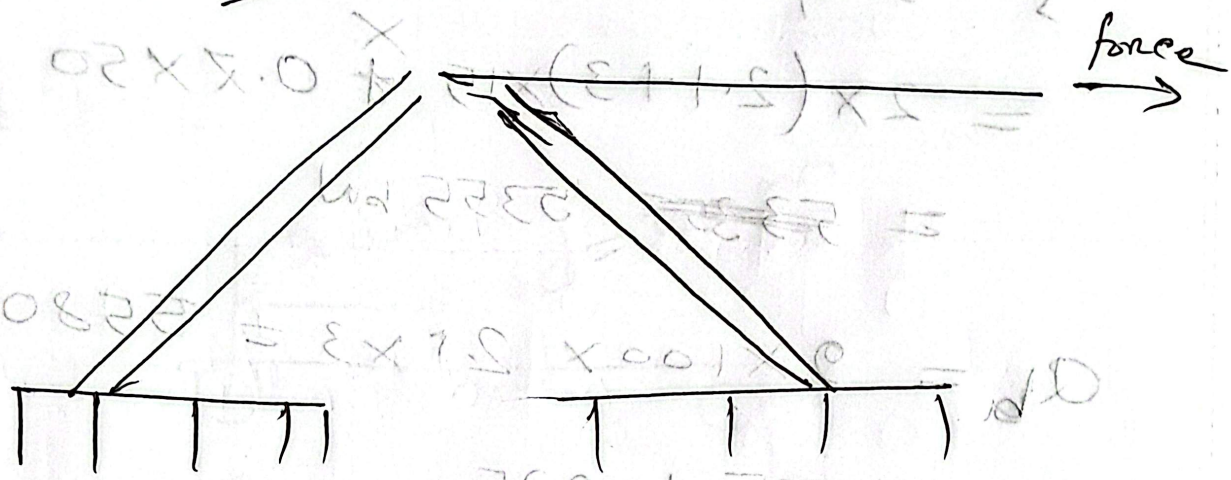
$Q_b = \frac{\pi}{4} \times 0.3^2 \times 9 \times 100 = 63.6$ kN

$Q = 558.1$ kN

$Q_{ugroup} = 558.1 \times 12 = 6696$ kN

$\frac{Q_b\,(composite)}{Q_{ugroup}} = \frac{5580}{6696} = 0.83$

Uplift



movement direction

direction

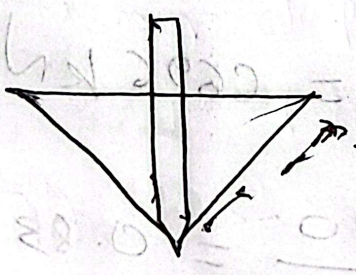
Just f_s

Wt of pile

~~end & friction~~

f_b & f_s

Stiffer soil এ মাটি কিভাবে



f_s

& soil wt