# GEOTECHNICAL ENGINEERING ( May / June 2017)

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1.) a.) same normal stress = 200kPa
peak shear stress → 150kPa
→ 180kPa

i) sand ⇒ $c' = 0$

$\tau_f = \sigma_n' \tan \phi'$

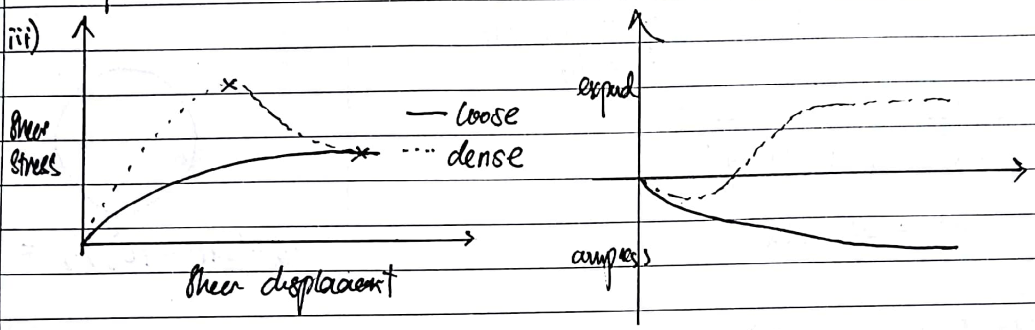
$\phi' = 36.87°$

$\phi'_p = 41.99°$

ii) friction angle at ultimate state of dense sand ≈ loose sand's friction angle.

$\phi_{ultimate, dense} = 36.87°$

iii)




Advantages:-
→ simple and relatively simple to conduct
→ normal and shear stresses were measured directly.
→ imposed a plane strain condⁿ

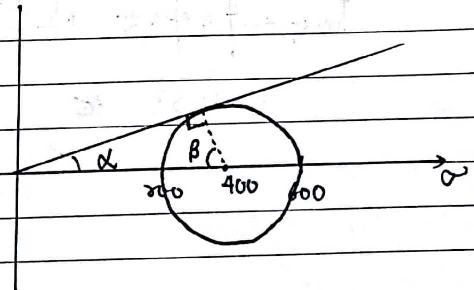
Disadvantages.
→ failure plane is forced.
→ drainage isn't controlled
→ lateral stress not known.

b.) i) $\sigma_3 = 200kPa$
$w_i = 55\%$
max axial load = 800N
cross. s. Area = 2000 mm²
normal axial stress at failure = 400kPa

$\sigma_1 = 400kPa + 200$
$= 600\ kPa$

$q = 600 - 200 = 400kPa$

ii)




iii) $R = 200$
$\alpha = 30°$
$\beta = 60°$

$\frac{\tau_f}{R} = \sin\beta$

$\tau_f = 100kPa$

$\frac{x}{R} = \cos\beta$

$x = 173.205$

$\sigma_f = 400 - 173.2$
$= 226.8kPa$

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iv.) effective ~~fricti~~ friction angle => $\phi' = 30°$

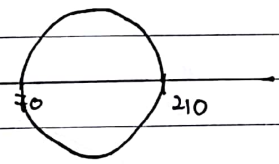
v.) water content at the end of the test decreases. as $w = \frac{M_w}{M_s}$, NC soil will be compacted at end of the test, which decreases the void ratio and thus decreasing water content.

c.) $\phi' = 30°$  $p_0 p_f = 130\,kPa$

$\sigma_{3f} = 200$  $\sigma_{3f}' = 200 - 130 = 70$

$$\frac{\sigma_1'}{\sigma_3'} = \left(\frac{1 + \sin\phi'}{1 - \sin\phi'}\right)$$

$\sigma_1' = 210\,kPa$

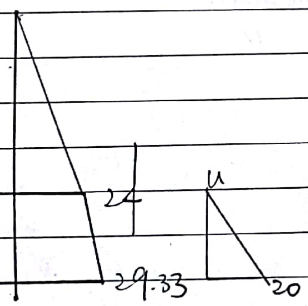



$c_u = (210 - 70)\,\frac{1}{2} = 70\,kPa$

2.) a.) Use Rankine's

$\gamma_w = 10\,kN/m^2$  $K_A = \left(\frac{1 - \sin\phi'}{1 + \sin\phi'}\right) = \frac{1}{3}$

i)




$\sigma_A' = \frac{1}{3}\,\sigma_z'$

$\sigma_{z,4m}' = 4 \times 18 = 72$  $\sigma_{z,6}' = 6 \times 18 - 2(10) = 88$

$\sigma_{A,4m}' = 24$  $\sigma_{A,6}' = 29.33$

$$\text{Thrust} = 24 \times 4 \times \frac{1}{2} + \frac{(29.33 + 24) \times 2}{2} + \frac{20 \times 2}{2}$$

$= 121.33$ ~~kN~~

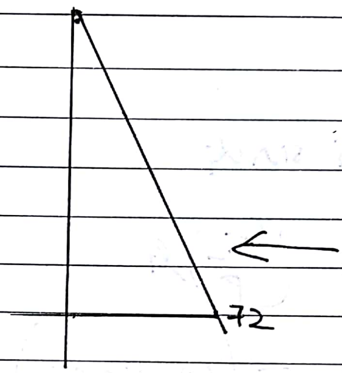
ii)

$\sigma_A = \sigma_z - 2c_u$

$\sigma_{A,6m} = \sigma_{z,6m} - 2c_u$

$= 6(18) - 2(18)$

$= 72$

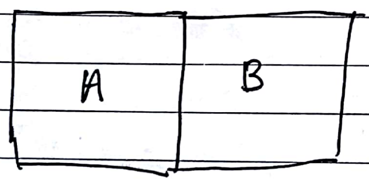



Thrust $= 72 \times 6/2$

$= 216$

iii) ~ A will be the same as total strength analysis is ~~do not~~ not influenced by water pressure.

b.)




$B = L = 10 \qquad z = 5$

$m = n = 2$

$I_r = 0.232$

$\Delta\sigma_{z,A} = 40 \times 0.232 = 9.28$

$\Delta\sigma_{z,B} = 13.92$

$\Delta\sigma_z = 23.2$ kPa.

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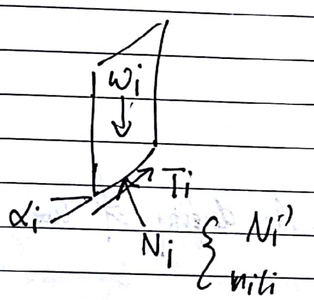
iii) $F = \frac{10(33) + \tan(33)(1060)}{1030}$

$= 0.9887 \rightsquigarrow$ failure.

iv) Fellenius : resultant interslice force = 0
Bishop : assume $X_1 - X_2 = 0$
Spencer : assume forces acted in parallel direction.

} different assumptions caused the difference




$N_i - W_i \cos\alpha_i = 0$

$N_i' + u_i l_i - W_i \cos\alpha_i = 0$

$N_i' = W_i \cos\alpha_i - u_i l_i$

$$F = \frac{c' L_a + \tan\phi' \sum_i (W_i \cos\alpha_i - u_i l_i)}{\sum_i W_i \sin\alpha_i}$$

4)

a.i.

-Cover soil with temporary surcharge
-Cause soil to consolidate, thus improving settlement and strength properties
-Once desired properties have been obtained, surcharge is removed
-Typically 3 to 8 m thick

ii. consolidation, process reduces porewater pressure

- As **$\sigma' = \sigma - u$**
- If u decreases, **$\sigma'$** increases
- And if **$\sigma'$** increases, shear strength increases

b.i. silt content < 12-15%
clay content < 3 %

ii. loose sand can be densified using vibro compaction.
Density is a factor of sand strength property
As density of loose sand increases, the shear strength will be increased

c.i. At low water content, water acts as lubricant, allowing particles to be packed closer, resulting a higher dry density
At high water content, water starts to replace particles as particles cant be packed anymore closer by means of water.
As unit weight of water is lower than soil particles, the dry unit weight decreases as water content increases above the optimum

ii. Dry of optimum – particles are arranged in flocculated manner.
Wet of optimum – particles are arranged in oriented fabric manner

Dry :

- higher shear strength even with the same dry unit weight
- higher hydraulic conductivity

Wet :

- lower hydraulic conductivity

d.

i. Horizontal drains helps to dissipate porewater pressure and lower ground water table

- As **$\sigma' = \sigma - u$**
- If u decreases, **$\sigma'$** increases
- And if **$\sigma'$** increases, shear strength increases

ii. piezometer can be installed before the installation of horizontal drains
initial ground water level can be determined
after the installation of the horizontal drains, piezometers can be used to record the changes in ground water table. Thus, observing the performance of the horizontal drains.

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e.) $D_r = 0.3$
$e_{max} = 0.9$
$e_{min} = 0.3$

$$0.3 = \frac{e_{max} - e_i}{e_{max} - e_{min}}$$

$e_i = 0.72$

$$0.9 = \frac{e_{max} - e_f}{e_{max} - e_{min}}$$

$e_f = 0.36$

ii) since the fill is a 10m thick loose sand fill
- vibrocompaction method can be used for the densification process.
- can be done by inserting vibratory probe into ground.
- ~~either 2~~ most commonly used → terra probe and vibroflot.
- both method densify the sand fill using vibration ~~[illegible]~~.

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