Mid Term Exam

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Section : A

Subject : Geotechnical Engineering

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Question - 1

Part-A :-

Define the following Terms

1. Plastic Equilibrium
2. Angular Distortion
3. Compressive index
4. Ultimate Bearing capacity
5. Poission Ratio of Soil

1) Plastic Equilibrium:-

Plastic Equilibrium state are this state when the soil will near to failure or verge to failure.

⇒ when the retaining soil is homogeneous, cohesionless semi-infinite and dry.

The friction resistance blw the retained soil and retaining wall is neglected mean frictional resistance is zero.

The retained soil will be in ~~soil~~ state of plastic Equilibrium.

2) Angular Distortion :-

When two foundations support wall/column settle unequally it means the structure is subjected to angular distortion

OR

Angular distortion is the ratio of the differential settlement and the distance b/w two point.

$$\beta = \frac{\delta}{l}$$

where

β = Angular distortion

δ = Differential settlement

l = distance b/w two point

3) Compressive Index :-

$$Cc = \frac{\Delta e}{\log_{10}\left(\frac{P_2}{P_1}\right)}$$

where

Cc = compressive index

Δe = change in void Ratio

P_1 = The pressure when the void ratio is e_1

P_2 = The Pressure when the void ratio is e_2

Compressive Index in term of M_v

M_v = Change in volume per unit volume of compressible layer.

$$S_c = H \times M_v \times \Delta P$$

$$M_v = \frac{\Delta e / \Delta P}{1 + e_o}$$

4) Ultimate Bearing Capacity :-

The maximum pressure at the base of footing with shear failure in the soil. It is donated by q_u.

By Formula

$$q_u = CN_c S_c I_c d_c + qN_q S_q I_q d_q + 0.5 \gamma B N_\gamma S_\gamma I_\gamma d_\gamma$$

5) Poisson Ratio of Soil :-

Poisson Ratio is a measure of the Poisson effect, that described the expansion or contraction of a material in the directions perpendicular to the direction of loading.

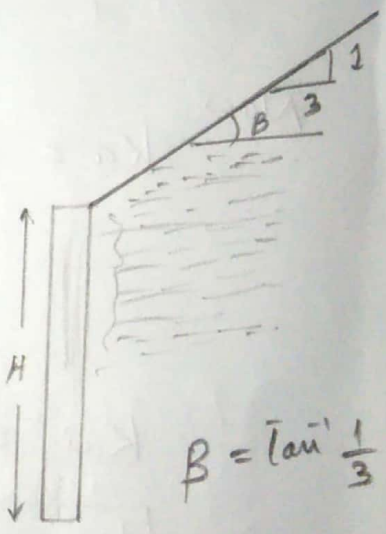
The value of poisson ratio is negative of the ratio of Transverse Strain to axial strain.

Question = 01

Part-B :- A 6m tall cantilever wall retaining the soil that has the following properties:

↳ $C = 0$, $\phi = 30°$, $\gamma = 19.2\ KN/m^3$.

And the ground surface behind the wall is inclined at a slope of 3 horizontal and 1 vertical The wall has moved sufficiently to develop active condition. Determine the total normal and shear force acting on the back of this wall using Rankines Theory.



$\beta = \tan^{-1}\frac{1}{3}$

$\beta = 18°$

GIVEN DATA :-

Height = $H = 6m$

$C = 0$

$\phi = 30°$

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

Slope $H = 3$, $V = 1$

Required :-

$$\frac{Na}{b} = ? \quad , \quad \frac{Va}{b} = ?$$

Solution :-

As we know that

$$\frac{Pa}{b} = \frac{\gamma \times H^2 \times Ka}{2} \longrightarrow \text{eq (1)}$$

First of all we find β.

$$\tan\beta = \frac{1}{3} \Rightarrow \beta = \tan^{-1}(1/3)$$

$$\boxed{\beta = 18^\circ}$$

As we know that

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

Now

$$K_a = \cos(18) \times \frac{\cos(18) - \sqrt{\cos^2(18) - \cos^2(30)}}{\cos(18) + \sqrt{\cos^2(18) - \cos^2(30)}}$$

$$K_a = 0.3948$$

$$\boxed{K_a = 0.395}$$

eq(1) $\Rightarrow$

$$\frac{P_a}{b} = \frac{\gamma \times H^2 \times K_a}{2} = \frac{19.2 \times 6^2 \times 0.395}{2}$$

$$\frac{P_a}{b} = 136.512 \text{ KN/m}$$

To find Normal force $\left(\frac{Na}{b}\right)$

As we know that

$$\frac{Na}{b} = \frac{Pa}{b} \times \cos\beta$$

$$\frac{Na}{b} = 136.512 \times \cos(18)$$

$$\boxed{\frac{Na}{b} = 129.83 \text{ KN/m}}$$

To find Shear force $\left(\frac{Va}{b}\right)$

As we know that

$$\frac{Va}{b} = \frac{Pa}{b} \sin\beta$$

$$\frac{Va}{b} = 136.512 \times \sin(18)$$

$$\boxed{\frac{Va}{b} = 42.18 \text{ KN/m}}$$

Question 2

Part-A : What is bearing capacity. Also write factor affecting bearing capacity.

Bearing capacity :-

It is the Engineering property of soil because of which when load is applied on the ground surface and this load is resisted then such capacity of soil is called Bearing capacity.

Factor Affecting of Bearing capacity :-

1) **Relative density of soil :-** if the Relative density of soil is greater, the value of angle of internal friction will be greater, Heigher will be Tarzaghi bearing capacity factor due to which the value of bearing capacity will increase.

2) **Depth of footing :-**

The bearing capacity increase with increase of depth of footing, higher will be Tarzaghi bearing capacity factor.

3) Width of footing :-

If the width of footing increase the bearing capacity also increase. and Higher will Terzaghi bearing capacity factor.

4) Unit weight of soil :-

The unit weight of the soil increase the bearing capacity also increase.
It mean the that the unit weight of soil is directly proportional to the bearing capacity.

5) Cohesion of soil :-

If the cohesion of the soil is more cohesion value, the bearing capacity is also increase with them.

6) Water Table :-

Water table is indirect relation with the bearing capacity due to water is the shear strength b/w the soil partical reduce hence bearing capacity is decrease

Question = 02

Part-B :- What is the maximum safe load which can be supported by rectangular footing 2m by 3m with a safety factor of 3. The base of the footing is at 1.6m below the ground surface. The unit weight of soil is $18 KN/m^3$ The angle of shear resisting $\phi = 20°$ [$N_c = 14.8$, $N_q = 6.4$, $N_\gamma = 2.9$]. Unit cohesion $C_u = 20 KN/m^2$. Use Meyerhof Analysis.

GIVEN DATA :-

$\Rightarrow$ $L = 3m$, $B = 2m$

$\Rightarrow$ $D_f = 1.6m$

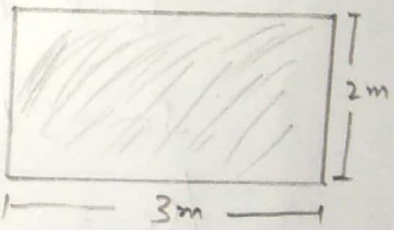
$\Rightarrow$ $FOS = 3$

$\Rightarrow$ $\gamma = 18 KN/m^3$

$\Rightarrow$ $C = 20 KN/m^2$

$\Rightarrow$ $\phi = 20°$

$\Rightarrow$ $N_c = 14.8$, $N_q = 6.4$, $N_\gamma = 2.9$



Required :-

$q_s = ?$

Solution:- As we know that

$$q_u = C N_c S_c I_c d_c + q N_q S_q I_q d_q + 0.5 \gamma_B B N_\gamma S_\gamma d_\gamma I_\gamma$$

Now $I_c = I_q = I_\gamma = 1$

Then

$$q_u = C N_c S_c d_c + q N_q S_q d_q + 0.5 \gamma B S_\gamma d_\gamma N_\gamma \rightarrow (\star)$$

First for the shape factor

$$\alpha = 45 + \frac{\phi}{2} = 45 + \frac{26}{2}$$

$$\boxed{\alpha = 55^\circ}$$

Now

$$S_c = 1 + 0.2 \left(\frac{B}{L}\right) \tan^2 \alpha$$

$$S_c = 1 + 0.2 \left(\frac{2}{3}\right) \tan^2 (55)$$

$$\boxed{S_c = 1.3}$$

Q 7/10, Then $S_\gamma = S_q = 1 + 0.1 \left(B/L\right) \tan^2 \alpha$

$$S_\gamma = S_q = 1 + 0.1 \left(\frac{2}{3}\right) \tan^2 (55)$$

$$\boxed{S_\gamma = S_q = 1.14}$$

Depth factor:

$$dc = 1 + 0.2\left(\frac{D}{B}\right)\tan\alpha$$

$$dc = 1 + 0.2\left(\frac{1.6}{2}\right)\tan(55)$$

$$\boxed{dc = 1.23}$$

Now

$$dr = dq = 1 + 0.1\left(\frac{D}{B}\right)\tan\alpha$$

$$dr = dq = 1 + 0.1\left(\frac{1.6}{2}\right)\tan(55)$$

$$\boxed{dr = dq = 1.11}$$

$$\boxed{q = \gamma \times D}$$

eq (*)

$$q_u = CN_c S_c d_c + qN_q S_q d_q + 0.5\,\gamma B N_r S_r d_r$$

$$q_u = (30 \times 14.8 \times 1.3 \times 1.23) + ((18 \times 1.6) \times 6.4 \times 1.1 \times 1.14) +$$

$$(0.5 \times 30 \times 2 \times 2.9 \times 1.11 \times 1.14)$$

$$q_u = 762\ kN/m^2$$

Now

$$q_{n.u} = q_u - \bar{\delta}$$

$$\boxed{\bar{\delta} = \gamma \times D}$$

$$q_{nu} = 762 - (18 \times 1.6)$$

$$\boxed{q_{nu} = 733.2\ kN/m^2}$$

Then $q_{n.s} = \frac{q_{n.u}}{FOS} = \frac{733.2}{3}$

$$q_{n.s} = 244.4 \text{ kN/m}^2$$

Now

$$q_s = q_{n.s} + \delta$$

$$q_s = 244.4 + (18 \times 1.6)$$

$$q_s = 273.2 \text{ kN/m}^2$$

Total safe load on Rectangular footing

$$A \times q_s$$

$$(9 \times 3) \times 273.2$$

$$1639.2 \text{ kN}$$

Question - 03

Part - A :- What is Settlement. What are the its type explain in detail.

Settlement :- When the load is applied on the ground surface this will be produced effective vertical stress, due to these stress the effective vertical strain will be produced as a result of which the movement will occure in the downward movement is called settlement.

TYPE of Settlement :-

There are two types of settlement on the basis of movement of structure.

1) Total Settlement :-

→ This is the type of settlement also called Uniform settlement.

→ In total settlement each part of structure will settle equally.

→ In ~~the~~ uniform settlement the failure of the the structure is not much as considered as with the differential settlement.

→ A uniform settlement mostly occure in that structures which are constructed in rigid footing.

→ In this type of settlement the utility services such as water supply .. Electricity, sewage line Telephone etc.

Limition for total settlement :-

The soil layer to which the load is to be transfer should be sufficient in bearing to resist the load which is to be applied on it. To spread the coming load over a large area.

2) Differential Settlement :-

→ Differential settlement in different part of some structure is called differential settlement.

→ Differential settlement are more dangerious or undesirable as compare to total settlement because they are cause more damage to a a structure.

Type of Differential settlement :-

1) Tilt
2) Angular Distortion.

1) **Tilt** :- If the entire structure rotate due to unequal settlement is called tilt.

2) **Angular Distortion** :-

When two foundation support wall or column settle unequally its mean that the structure to angular distortion.

Question 3

Part-B :- A soil has compressive index $C_c = 0.31$ At a stress $130\ kN/m^2$. The void ratio was 1.02. Calculate

(1) the void ratio if the stress on the soil is increased to $170\ kN/m^2$

(2) the total settlement of the stratum of 5m thickness.

GIVEN DATA :-

$$C_c = 0.31$$

$$P_1 = 130\ kN/m^2$$

$$e_o = 1.02$$

$$P_2 = 170\ kN/m^2$$

$$H = 5m$$

Required :-

$$e_1 = ?$$

$$S_c = ?$$

Solution :-

As we know that

$$C_c = \frac{\Delta e}{\log\left(\frac{P_2}{P_1}\right)}$$

$$C_c = \frac{e_o - e_1}{\log(P_2/P_1)}$$

$$0.31 = \frac{1.02 - e_1}{\log\left(\frac{170}{130}\right)}$$

$$0.31 = \frac{1.02 - e_1}{0.1165}$$

$$0.0361 = 1.02 - e_1$$

$$e_1 = 1.02 - 0.0361$$

$$\boxed{e_1 = 0.984}$$

(b) $S_c = ?$ As we know that

$$S_c = \frac{H}{1+e_o} \times C_c \log\left(\frac{P_2}{P_1}\right)$$

$$S_c = \frac{5}{1+1.02} \times 0.31 \log\left(\frac{170}{130}\right)$$

$$S_c = 0.08939\ m$$

$$\boxed{S_c = 89.3978\ mm}$$