Geotechnical And Foundation Engineering

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Module: 9

Submitted to:

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Q. No (01)

(A) Define the Following terms:~

1) Plastic Equilibrium:~

Plastic Equilibrium is a state when Permanent changes occur or it is the stage when irrversible strain takes place due to the application of constant stress.

2) Angular Distortion:~

It is a type of differential settlement. It is the unequal settlement of two foundations support walls/columns of the structure.

3) Compressive Index:~

It is a number that is used to findout the settlement in the normally consolidated clay. The total stress applied is larger than the stress in the field to which the soil sample has been undergone in the past. this kind of clayey soil is said to be normally consolidated clay

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

4) Ultimate Bearing Capacity :-

The maximum pressure that is a soil resists due to applied load without causing failure.

5) Poission Ratio of Soil :-

Poission's Ratio represents a change in shape of a material while the volume is maintained constant. In soil terminology poission's ratio also known as the co-efficient of lateral expansion and is affected by the following factors:

a) The soil is a descrete and stratified mediums mostly not elastic and anisotropic.

b) The soil is not deformed linearly.

Poission's ratio in soil mechanics is a rather conditional parameter.

(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 forces acting on the back of this wall using Rankine's Theory.

Given Data :~

Cohesion $(c) = 0$

Angle of Internal friction $(\phi) = 30°$

Unit weight of soil $(\gamma) = 19.2 \ kN/m^3$

Horizontal slope = 3

Vertical slope = 1

Required :~

Total Normal Force $\left(\frac{N_a}{b}\right) = ?$

Total shear Force $\left(\frac{V_a}{b}\right) = ?$

Sol :~

As we know that

Active force is given by,

$$\frac{Pa}{b} = \frac{r \cdot H^2 \cdot Ka}{2}$$

As $\tan(\beta) = \frac{Perpendicular}{Base}$

$$\tan(\beta) = \frac{1}{3}$$

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

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

Also Ka is given by,

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

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

$$= 0.951 \times \frac{0.951 - \sqrt{0.904 - 0.75}}{0.951 + \sqrt{0.904 - 0.75}}$$

$$Ka = 0.3948$$

$$\boxed{Ka = 0.395}$$

Now by Formula

Active Force $\frac{Pa}{b} = \frac{r \cdot H^2 \cdot Ka}{2}$

$$= \frac{19.2 \times (6)^2 \times 0.395}{2}$$

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

$$\boxed{\frac{P_a}{b} = 136.52 \text{ KN/m}}$$

As the Normal Force is,

$$\frac{N_a}{b} = \frac{P_a}{b} \cdot \cos\beta$$

$$= 136.52 \times \cos(18)$$

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

Also the shear Force is,

$$\frac{V_a}{b} = \frac{P_a}{b} \cdot \sin\beta$$

$$= 136.52 \times \sin\beta$$

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

Q.No (02)

(A) What is Bearing capacity. Also write factors effecting Bearing capacity.

Ans Bearing Capacity:~

It is an Engineering Property of soil because of which when load is applied on the ground surface, then the capacity of soil due to which this applied load is resisted is called Bearing capacity of that soil.

→ Denoted by "q"

→ It is also called the internal strength of the soil.

Factors Affecting Bearing Capacity:~

1) Relative Density of the Soil :~

Relative Density has a direct relation with the bearing capacity of soil. Higher the relative density of soil, Higher will be the Terzaghi Bearing capacity factors (N_c, N_q, N_r) due to which the Bearing capacity will increase.

2) Depth of the Footing:~

The bearing capacity increases with the increase in depth of the footing (D_f), and this increase will be maximum for the dense soil/ sand as compared to loose or medium sand/soil.

3) Width of the Footing :~

The Bearing capacity of soil increases with the increase in the width (breadth) of the footing, and this increase will be maximum for the dense soil/sand as compared to loose or medium sand/soil.

4) Unit weight of the soil :~

It also has a direct relation with the bearing capacity of a soil. Increase in unit weight of soil causes increase in the Bearing capacity of soil, and this increase will be maximum for the dense soil/ sand as compared to loose/ sand.

5) Water Table :~

It has indirect relation with the Bearing capacity of soil. Due to bearness of water table to the footing, the shear strength b/w the soil particles reduces hence the Bearing capacity decreases.

(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/m3. The angle of shear resisting $\emptyset = 20°$ ($N_c = 14.8$, $N_q = 6.4$, $N_\gamma = 2.9$). Unit cohesion $C_u = 20$ KN/m2. use Meyerhof analysis.

Given Data :~

Footing Dimensions = 2m × 3m (b = 3 , h = 2)

Factors of safety = 3

Depth of foundation (D_f) = 1.6m

Unit weight of soil (γ) = 18 KN/m3

Angle of shear resistance (ϕ) = 20°

Unit Cohesion (C_u) = 20 KN/m2

$N_c = 14.8$

$N_q = 6.4$

$N_\gamma = 2.9$

Required:~

Maximum safe load (q/s) = ?

Solution:~

According to Mayerhof's Analysis.

$$q_u = c \cdot N_c \cdot S_c \cdot d_c + q \cdot N_q \cdot S_q \cdot d_q + \frac{1}{2} \gamma \cdot B \cdot N_\gamma \cdot S_\gamma \cdot d_\gamma$$

⟹ For shape Factors:~ (S_c, S_q, S_γ)

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

⟹ $\alpha = \left(45 + \frac{\phi}{2}\right)$

$$= 45 + \frac{20}{2}$$

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

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

$$\boxed{S_c = 1.27}$$

As $\phi > 10^\circ$, So

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

$$= 1 + 0.1\left(2/3\right)\tan^2(55)$$

$$\boxed{S_q = S_\gamma = 1.135}$$

⟹ For Depth Factors:~ (d_c, d_q, d_γ)

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

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

$$\boxed{d_c = 1.22}$$

Also $\phi > 10^\circ$, So

$$d_q = d_\gamma = 1 + 0.1\left(\frac{D}{B}\right)\tan\alpha$$

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

$$\boxed{d_q = d_r = 1.11}$$

Inclination Factors:~

For $\theta = 0°$

$i_c = i_q = i_r = 1$

By formula

$q_u = c N_c \cdot S_c \cdot d_c + q N_q \cdot S_q \cdot d_q + \frac{1}{2} r \cdot B \cdot N_r \cdot d_r \cdot S_r$

$= (20)(14.8)(1.27)(1.22) + [(1.6 \times 18)](6.4)(1.135)(1.11) + \frac{1}{2}(18)(2)(2.9)(1.11)(1.135)$

$$\boxed{q_u = 762 \text{ KN/m}^2}$$

As Net ultimate Bearing capacity is,

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

$= 762 - (1.6 \times 18)$ ($\because \bar{\sigma}$ = over burden Pressure)

$$\boxed{q_{n.u} = 733.2 \text{ KN/m}^2}$$

Net safe Bearing capacity is,

$q_{n.s} = \frac{q_{n.u}}{F.O.S} = \frac{733.2}{3} = 244.4 \text{ KN/m}^2$

Safe Bearing capacity is,

$q_s = q_{n.s} + \bar{\sigma}$

$= 244.4 + (1.6 \times 18)$

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

This Safe Bearing capacity over the whole footing will be $\Rightarrow A \times q_s = 273.2 (6m^2)$

$= 1639.2$ KN

Q.No (03)

(A) What is settlement. What are its types explain in detail.

Ans Settlement:~

When we apply load on the ground surface, then effective vertical stresses produce in the ground. Because of these stresses, vertical strain takes place and movement occurs in the downward direction. This downward moment is called settlement.

Types of settlement:~

There are two types of settlement.

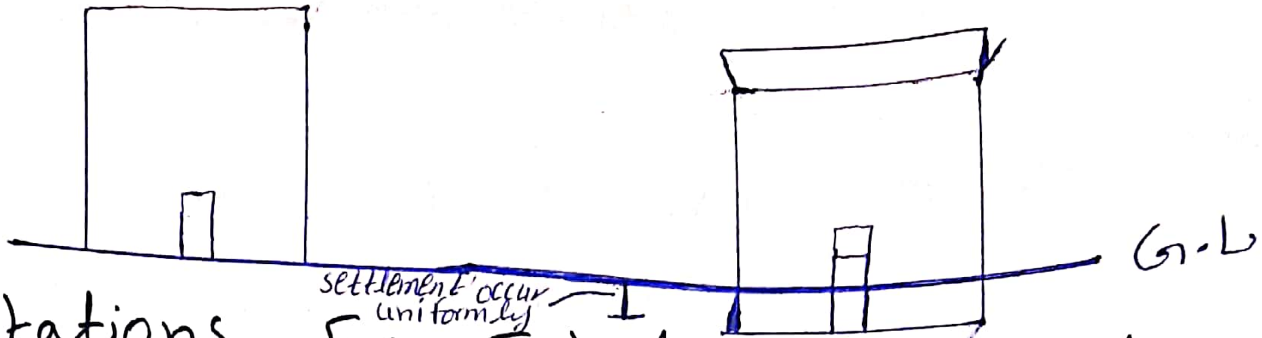
1) Uniform settlement:~

When a building foundation settles by the same amount over its entire area, effectively lowering the structure in place, this type of settlement is called uniform settlement.

→ It ~~is~~ also called total settlement.

→ The failure caused in the structure due to settlement is not much as compared to differential settlement.

→ Uniform settlement mostly take place when the footing of the structure is rigid



Limitations For Total Settlement:~

→ The Soil should have sufficient bearing capacity to resist the upcoming applied load.
→ The coming load should be spread over a large area

2) Differential Settlement:~

When only a part of the foundation is affected by ground failure or part of the foundation is affected to a great extent as compared to other Differential settlement.

Types of Differential Settlement:~

There are two types of Differential settlement.

1) Tilt:~

It is the rotation of the entire structure due to unequal settlement.

2) Angular Distortion:~

It is the unequal settlement of two foundations support walls/colums of the structure.

(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:~

Compressive Index of soil $(C_c) = 0.31$
Initial stress / Pressure $(P_1) = 130\,KN/m^2$
Initial void ratio $(e_o) = 1.02$
Increased or final stress / Pressure $(P_2) = 170\,KN/m^2$
Stratum thickness $(H) = 5m$

Required:~

Final void ratio due to increased stress $(e_1) = ?$
Total consolidation settlement $(S_c) = ?$

Solution:~

As compressive Index is given by,

$$C_c = \frac{\Delta e}{\log_{10}\left(\frac{P_2}{P_1}\right)} = \frac{e_o - e_1}{\log_{10}\left(\frac{P_2}{P_1}\right)}$$

$$0.31 = \frac{1.02 - e_1}{\log_{10}\left(\frac{170}{130}\right)} \Rightarrow 0.31 \times 0.1165 = 1.02 - e_1$$

$e_1 = 0.984$

By Formula,

Consolidation settlement is,

$$\delta_c = \frac{H}{1+e_0} \times C_c \, (\log_{10}) \left(\frac{P_2}{P_1}\right)$$

$$= \frac{5}{1+1.02} \times 0.31 \times \log_{10}\left(\frac{170}{130}\right)$$

$$= 0.0893 m \times 1000 mm$$

$\delta_c = 89.3$ mm