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Section # A
paper # Geotechnical Engineering
Term # Mid Term

Q#01 (a) Define The following Term.

1) Plastic Equilibrium:

→ It is define as "The state of stress with in a soil mass or a portion there of that has been deformed to such an extent that its ultimate shearing Resistance is mobilized"

2) Angular Distortion:

It is define as "The Ratio of the differential settlement δ and distance l between two points."

Note:

It is crucial to understand beforehand the Range of Tilt and Angular distortion that will possibly cause unacceptable damage to the structure.

3) Compressive Index:

It is defined as "The final 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."

4) Ultimate Bearing Capacity:

It is defined as " The capacity in which the theoretical maximum pressure which the soil can be supported without failure". This is called ultimate Bearing capacity.

5) Poission Ratio of Soil:

Poission Ratio of Soil is defined as " The negative ratio of Transverse to Axial Strain".

(b) A 6cm 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 . . . .
. . . . Rankine Theory.

Given Data:

→ Cohesion, "C" = 0
→ Angle of internal friction, "ϕ" = 30°
→ Unit weight of Soil, "γ" = 19.2 kN/m³
→ Horizontal slope = 3
→ vertical slope = 1

Required:

① Total Normal force $\left(\frac{N_a}{b}\right) = ?$

② Total Shear force $\left(\frac{V_a}{b}\right) = ?$

Solution:

we know that

$$\Rightarrow \frac{P_a}{b} = \frac{\gamma \cdot H^2 \cdot K_a}{2}$$

As

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

$$\Rightarrow \tan(\beta) = 1/3$$

$$\Rightarrow \beta = \tan^{-1}(1/3) = 18^\circ$$

Now,

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

putting values

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

$\Rightarrow K_a = 0.3948$ or 0.395

Now, By formula

$$\Rightarrow \frac{P_a}{b} = \frac{\gamma \cdot H^2 \cdot K_a}{2}$$

putting value

$$\Rightarrow \frac{P_a}{b} = \frac{19.2 \times 6^2 \times 0.395}{2} = 136.512 \text{ kN/m}$$

① $$\frac{N_a}{b} = \frac{P_a}{b} \times \cos\beta$$

$$\Rightarrow \frac{N_a}{b} = 136.512 \times \cos(18) = 129.83 \text{ kN/m}$$

② $$\frac{V_a}{b} = \frac{P_a}{b} \times \sin\beta$$

$$\Rightarrow \frac{V_a}{b} = 136.512 \times \sin(18) = 42.18 \text{ kN/m}$$

Q02 (a) what bearing Capacity? Also write factor effecting Bearing Capacity.

Ans: **Bearing Capacity:**

In geotechnical Engineering it is defined as "The Capacity of Soil to support the loads applied to the ground".

→ The Bearing Capacity of Soil is the maximum Average contact pressure between the foundation and the soil which should not produce shear failure in the Soil.

→ **factor Effecting Bearing Capacity:**

The following factor effecting Bearing Capacity.

i) **Unit weight of Soil:**

when the increase of

The unit weight of soil, the bearing capacity will be also increase.

ii) Water Table:

Water Table is indirect relation with the bearing capacity due to water the shear strength between the soil particles reduce hence bearing capacity is decrease.

iii) Width of footing:

When the increase the width of footing, the bearing capacity is also the increase.

iv) Cohesion of Soil:

(9) The soil is more cohesion value the bearing capacity will be increase.

(b) What is the Maximum - - -

- - - - - - - - Meyerhof

Analysis:

Given data:

- → factor of Safety = 3
- → footing dimension = 2m x 3m
- → Unit weight of soil, (γ) = 18 kN/m^3
- → Depth of foundation (D_f) = 1.6m
- → Angle of Shear Stress (ϕ) = 20°
- → Unit Cohesion (C_u) = 20 kN/m^2
- → N_c = 14.8
- → N_q = 6.4
- → N_γ = 2.9

Required:

→ maximum safe load (q_s) = ?

Solution

We know that

$$q_u = CN_c S_c d_c i_c + qN_q S_q i_q + \frac{1}{2}\gamma B N_\gamma S_\gamma d_\gamma i_\gamma$$

$\Rightarrow i_c = i_q = i_\gamma = 1$

we get

$\Rightarrow q_u = C N_c S_c d_c + q N_q S_q + \frac{1}{2} \gamma B N_\gamma S_\gamma d_\gamma$.

➡ find the slope factor

$$\alpha = 45 + \phi/2 = 45 + 20/2 = 55^\circ$$

Now,

$S_c = 1 + 0.2 (B/L) \tan^2\alpha$

$\Rightarrow S_c = 1 + 0.2 (2/3) \tan^2(55) = 1.3$

$\because \phi > 10^\circ$. So

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

$\Rightarrow S_q = S_\gamma = 1 + 0.1 (2/3) \tan^2(55) = 1.135$

➡ for depth factor

(d_c, d_q, d_γ)

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

$\Rightarrow d_c = 1 + 0.2 (1.6/2) \tan(55) = 1.22$

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

$d_q = d_\gamma = 1 + 0.1 (D/B) \tan\alpha$

$d_q = d_\gamma = 1 + 0.1\,(1.6/2)\tan(55) = 1.11$

→ Inclination factor:

for $\theta = 0°$

$i_c = i_q = i_\gamma = 1$

By formula

$\Rightarrow q_u = C N_c \cdot S_c \cdot d_c + q \cdot N_q \cdot S_q \cdot d_q + 1/2\, \gamma \cdot B N_\gamma d_\gamma S_\gamma$

$\Rightarrow q_u = 20(14.8)(1.27)(1.22) + (1.6 \times 18)(6.4)(1.135)(1.11) + 1/2\,(18)(2)(2.5)(1.11)(1.35)$

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

As Net ultimate Bearing capacity is

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

$= 762 - (1.6 \times 18) = 733.2\ kN/m^2$

Net Safe Bearing Capacity is

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

Safe Bearing Capacity is

$q_s = q_{n.s} + \bar{\delta} = 244.4 + (1.6 \times 18)$

$q_s = 273.2\ kN/m^2$

This safe Bearing Capacity over the whole footing will be

$\Rightarrow A \times q_s = 273.2(6m^2) = 1639.2\ kN$

Q03#(a)
What is settlement. What are its Types explain in detail?

Ans: Settlement:

When load is applied on the ground surface this will be produce 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:

On the basis of movement of the structure it is divided into two types.

① Total settlement
② Differential settlement

① Total Settlement

→ It is also called uniform settlement. In this type of settlement each part of structure will settle equally.

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

→ The total settlement mostly take place in the type of settlement the utility services such as water supply, sewage line etc may be decreased and the structure will remain same.

Limitation 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.

→ Differential settlement:

→ Different settlement in different part of the same structure is called differential settlement.

→ It is more danger than total settlement.

Types of differential settlement.

Two Type.
i- Tilt
ii. Angular distortion.

i- Tilt

Of the entire structure rotate due to unequal settlement.

ii. Angular Distortion:

When the two foundation support walls/colums settle unequally it means the structure is subjected to Angular distortion.

(b) A Soil has Compressive . . .
. . . . - - - - - - 5m Thickness.

Given data:

→ Compressive Index of Soil $(C_c) = 0.31$
→ Initial Stress/pressure $(P_1) = 130 kN/m^2$
→ Initial void Ratio $(e_0) = 1.02$

- final Stress /pressure $(P_2) = 170\,kN/m^2$
- Straction thickness $(H) = 5m$

Required:

final void Ratio $(e_1) = ?$
Total Settlement. $(S_c) = ?$

SOLUTION:

Compressive index is given by.

$$C_c = \frac{\Delta e}{\log_{10}(P_2/P_1)} = \frac{e_0 - e_1}{\log_{10}(P_2/P_1)}$$

putting value, we get

$$\Rightarrow 0.31 = \frac{1.02 - e_1}{\log_{10}(170/30)}$$

or,

$$\Rightarrow e_1 = 0.984$$

As we know That

$$S_c = \frac{H}{1+e_0} \times C_c \, (\log_{10})(P_2/P_1)$$

putting values

$$\Rightarrow S_c = \frac{5}{1+1.09} \times 0.31 \log_{10}\left(170/130\right)$$

$$\Rightarrow S_c = 0.0893m$$

Convert it "mm", we get

$$\Rightarrow S_c = 89.3mm$$