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Section: A

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Question No. 1

(part A)

Plastic Equilibrium:- Plastic Equilibrium is that state of stress within a soil mass that is deformed to such an extent that its shearing resistance is mobilized.

Angular Distortion: Angular distortion is the ratio of the relative deflection between two points in a foundation by the distance between them.

Compressive Index: The plot between the void ratio, e versus log σ is called compression curve. The slope of compression curve is called compressive index.

Ultimate bearing capacity:- It is the maximum pressure which can be supported without failure.

Poission Ratio: Ratio of the lateral strain to the longitudinal strain is called Poission Ratio.

Q.No.1

(Part-B)

A 6m tall cantilever wall retaining the soil that has the following properties.

$$C = 0$$

$$\phi = 30^\circ$$

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

And the ground surface behind the soil is inclined at a slope of 3 horizontal and 1 vertical. The wall has moved sufficient 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 (ϕ) = 30°

Horizontal slope = 3

Vertical slope = 1

Required Data:

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

Total Shear Force ($\frac{V_a}{b}$) = ?

Solution:

As we know that

force is given by,

$$\frac{P_a}{b} = \frac{\gamma . H^2 . k_a}{2}$$

As, $\tan(B) = \frac{\text{Perpendicular}}{\text{Base}}$

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

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

Also K_a is given by,

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

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

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

$$K_a = 0.3948$$

$$\boxed{K_a = 0.395}$$

Now as we know that

$$\text{A. Force } \frac{P_a}{b} = \frac{\gamma . H^2 . k_a}{2}$$

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

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

Now as we know that Normal Force is,

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

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

$$\boxed{\frac{N_a}{b} = 129.8 \text{ kN/m}}$$

Now the Shear Force is,

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

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

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

Question No. 2

Bearing Capacity: Bearing Capacity is that property of Soil due to which it can resist the applied load.

Factors Effecting Bearing Capacity: Some of the factors which effects the bearing capacity of soil are given below.

1) **Relative Density of Soil:** The bearing capacity of soil increases with the increase in relative density of soil.

2) **Water Table:** When the water table comes near the footing, the bearing capacity decreases.

3) **Soil Erosion:** The bearing capacity of soil also reduces due to erosion of soil around the foundations.

4) **Spacing between Foundations:** The bearing capacity also decreases with the increase in spacing between foundations.

5) **Unit Weight of Soil:** The bearing capacity of soil is directly proportional to unit weight of soil.

Question No.2

Part (b)

Given Data:

Footing Dimension = 2m × 3m

Factor of safety = 3

Depth of foundation (Df) = 1.6 m

Angle of shear resistance (ϕ) = 20°

Unit cohesion (C_u) = 20 kN/m²

Unit wt of soil (γ) = 18 kN/m³

N_c = 14.8

N_q = 6.4

N_γ = 2.9

Required Data:

Maximum safe load (q_s) = ?

Solution:

According to the Mayerhof's Analysis,

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

For shape factors: (S_c, S_q, S_γ)

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

Inclination Factors:

For $\theta = 0°$

$i_c = i_q = i_r = 1$

By formula.

$$q_u = cN_c \cdot s_c \cdot d_c + qN_q s_q \cdot d_q + \frac{1}{2}\gamma \cdot B \cdot N_\gamma \cdot d_\gamma \cdot s_\gamma$$

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

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

Now as Net ultimate Bearing Capacity is,

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

$$= 762 - (1.6 \times 18)$$

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

Net safe Bearing Capacity is,

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

Now 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 footing will be,

$$\Rightarrow A \times q_s = 273.2 \times (6 \text{ m}^2)$$

$$\boxed{= 1639.2 \text{ kN}}$$

Question No.3

Settlement:

When we apply load on the ground surface So it will produce vertical stresses. Now due to these stresses vertical strain will be produced as a result of which movement will occur in the downward direction. This downward movement is called Settlement.

TYPES OF SETTLEMENT:

There are two types of Settlement.

Total Settlement:

In this type of Settlement, each part of the structure will go downward or settle. In total settlement, the failure of structure is less as compared to that of differential settlement. In this settlement, the utility services are reduced.

Differential Settlement:

The differential settlement causes more damage than the total settlement, So it more danger. This settlement leads to more structur damage.

Question No.3

Part (b).

Given Data:

Compressive Index of soil (C_c) = 0.31

Initial Stress / Pressure (P_1) = 180 kN/m²

Initial void ratio (e_0) = 1.02

Final Stress / Pressure (P_2) = 170 kN/m²

Stratum thickness (H) = 5m

Required Data.

Final void ratio due to increased stress/pressure (e_1) = ?

Total settlement (S_c) = ?

Solution:

As the compressive Index is given by,

$$C_c = \frac{\Delta e}{\log_{10}(P_2/P_1)} = \frac{e_2 - e_1}{\log_{10}(P_2/P_1)}$$

$$0.31 = \frac{1.02 - e_1}{\log_{10}\left(\frac{170}{180}\right)}$$

$$\Rightarrow 0.31 \times 0.115 = 1.02 - e_1$$

$$\boxed{e_1 = 0.984}$$

By formula,

Consolidation settlement is,

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

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

$$= 0.0893 \times 1000$$

$$\boxed{S_c = 89.3 \text{ mm}}$$