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SUBJECT : GEOTECHNICAL ENGINEERING.

SECTION : B

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MODULE : 6th

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1- Define the following terms:
(A)

i) PLASTIC EQUILIBRIUM:

Plastic equilibrium is that state in a soil after which the soil could not resist more stress i.e. ultimate shearing resistance of soil is achieved.

ii) ANGULAR DISTORTION:

It is defined when two foundations support walls/columns settled unequally it means the structure is subjected to angular distortion.

iii) COMPRESSIVE INDEX:

Compressive index represents deformation characteristics of overconsolidated soil.

It describes variation of the void ratio "e" as a function of change of effective stress.

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

iv) ULTIMATE BEARING CAPACITY:

It is the maximum pressure at the foundation of structure causing shear failure in the soil. It is denoted by " q_u ".

v) POISSON RATIO OF SOIL:

It is defined as the negative ratio of transversal strain to the axial strain in an elastic material which is subjected to uniaxial stress.

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

- $C = 0$
- $\phi = 30^\circ$
- $\gamma = 19.2 \text{ KN/m}^3$

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.

Sol:

Given data:

$$H = 6\text{m}, C = 0, \phi = 30^\circ$$

$$\gamma = 19.2 \text{ KN/m}^3, \text{ Slope : } H = 3, V = 1.$$

Required

$$\frac{N_a}{b} = ? \quad , \quad \frac{V_a}{b} = ?$$

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

$$\rightarrow \tan \beta = \frac{1}{3}$$

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

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

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

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

$$K_a = 0.395$$

Now,

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

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

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

$$\rightarrow \frac{N_a}{b} = \frac{P_a}{b} \cos B$$

$$= 136.512 \cos(18)$$

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

$$\rightarrow \frac{V_a}{b} = \frac{P_a}{b} \sin B$$

$$= 136.512 \sin(18)$$

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

2- What is bearing capacity. Also write factors effecting bearing capacity.

Ans: Bearing capacity is the engineering property of a soil due to which the soil resists the applied load. It is also called "Internal strength of the soil." It is denoted by " q_v ".

FACTORS EFFECTING BEARING CAPACITY:

1- RELATIVE DENSITY:

- Greater the relative density of soil, higher will be the value of angle of internal friction which is denoted by " ϕ ". Higher the value of angle of friction higher will be values of Terzaghi's bearing factors (N_c, N_q, N_r).
- Greater the value of N_c, N_q, N_r will result into higher value of bearing capacity.
- The soil having enough relative density will have enough bearing capacity.

$$\gamma_{\text{relative}} = \frac{e_{\text{max}} - e}{e_{\text{max}} - e_{\text{min}}}$$

2- DEPTH OF FOOTING (D_f):

The bearing capacity of soil increase with the increase of depth of the footing. The increase will be maximum for the dense soil as compared to loose soil.

3. BREADTH OF FOOTING:

The bearing capacity of soil increases with the increase in the breadth of the footing. The increase will be maximum for dense soil as compared to loose soil.

4. UNIT WEIGHT OF SOIL:

The bearing capacity of the soil increases with the increase in the unit weight of soil. This increase will be maximum for dense soil as compared to loose soil.

5. WATER TABLE:

If the water table increases so the bearing capacity will decrease because of the liquification of the soil thus its bearing capacity will be decreased.

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 resistance $\phi = 20^\circ$ ($N_c = 14.8$, $N_q = 6.4$, $N_r = 2.9$). Use Meyerhof's analysis
Unit cohesion $c_u = 20 \text{ kN/m}^2$.

Ans:

Given data

$$L = 3\text{m}$$

$$B = 2\text{m}$$

$$D_f = 1.6\text{m}$$

$$\gamma = 18\text{KN/m}^3$$

$$C_u = 20\text{KN/m}^3$$

$$\text{F.O.S} = 3$$

$$\phi = 20^\circ$$

Required

$$q/s = ?$$

Formula

$$q_u = C N_c \cdot S_c d_c i_c + q N_q \cdot S_q d_q i_q + \frac{1}{2} \gamma B N_r \cdot S_r d_r \cdot i_r$$

As there is no "B" so $\therefore i_c = i_q = i_r = 1$.

SHAPE FACTORS:

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

$$\alpha = \left(\frac{20}{2} + 45 \right)$$

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

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

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

$$= 1.27 \approx 1.3$$

P.T.O

$$\begin{aligned}
 S_{q_1} = S_r &= 1 + 0.1 \frac{B}{L} \tan^2 \alpha \\
 &= 1 + 0.1 \frac{2}{3} \tan^2 (55^\circ) \\
 &= 1.14
 \end{aligned}$$

DEPTH FACTORS:

$$\begin{aligned}
 d_c &= 1 + 0.2 \frac{D}{B} \tan \alpha \\
 &= 1 + 0.2 \frac{1.6}{2} \tan (55^\circ) \\
 &= 1.23
 \end{aligned}$$

$$\begin{aligned}
 d_r = d_q &= 1 + 0.1 \frac{D}{B} \tan \alpha \\
 &= 1 + 0.1 \frac{1.6}{2} \tan (55^\circ) \\
 &= 1.11
 \end{aligned}$$

Putting values in the formula

$$\begin{aligned}
 q_u &= C N_c S_c d_c i_c + \gamma D_f N_q \cdot S_q \cdot d_q \cdot i_q + \frac{1}{2} \gamma N_r \cdot S_r \cdot d_r \cdot i_r \\
 &= (20 \times 14.8 \times 1.3 \times 1.23 \times 1) + ((18 \times 1.6) \times 6.4 \times 1.1 \times 1.11 \times 1) + \\
 &\quad (0.5 \times 20 \times 2 \times 2.9 \times 1.11 \times 1.14 \times 1)
 \end{aligned}$$

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

$$\begin{aligned}
 \rightarrow q_{n.u} &= q_u - \bar{\sigma} = q_u - \gamma D_f \\
 &= 762 - (18 \times 1.6) = 733.2 \text{ KN/m}^2
 \end{aligned}$$

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

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

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

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

Total safe load on rectangular footing

$$A \times q_s = (2 \times 3) \times 273.2$$

$$= 1639.2 \text{ kN} \quad \text{ANS.}$$

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

Ans: SETTLEMENT:

When load is applied on the ground surface that will produce effective vertical stresses, due to these stresses the effective vertical strain will be produced as result of which the movement will occur in the downward direction. This downward ~~move~~ movement is called settlement.

TYPES 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 differential settlement. The total settlement mostly takes place in a structure which are constructed in rigid footing. In this type of settlement the utility services such as water supply, electricity, sewage line, telephone etc may be decreased and the structure will remain sound.

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.

2 DIFFERENTIAL SETTLEMENT:

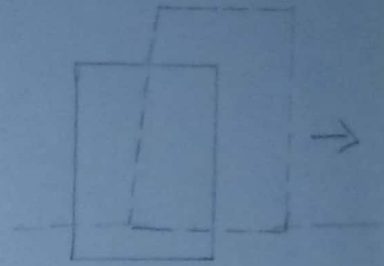
Different ~~is~~ settlement in different parts of the same structure is called differential settlement. Differential settlement is more danger as compared with total uniform settlement, because it causes more damage to a structure as compared to total settlement.

There are two types of differential settlement:

- i) Tilt
- ii) Angular distortion

i- TILT:

If the entire structure rotates due to unequal settlement is called tilt.

ii- ANGULAR DISTORTION:

When two foundations support walls/columns settle unequally it means the structure is subjected to angular distortion.

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 5 m thickness.

Sol:

Given data

$$C_c = 0.31$$

$$P_1 = 130 \text{ kN/m}^2$$

$$e_0 = 1.02$$

$$P_2 = 170 \text{ kN/m}^2$$

$$H = 5 \text{ m}$$

Required

$$e_1 = ?$$

$$S_c = ?$$

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

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

$$0.31 = \frac{1.02 - e_1}{\log_{10}(170/130)}$$

$$e_1 = 0.983$$

Now

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

$$= \frac{5}{1 + 1.02} \times 0.31 \log_{10}\left(\frac{170}{130}\right) \times 1000 \text{ mm}$$

$$S_c = 89.4 \text{ mm}$$