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Paper: Geotechnical & foundation Engineering
(Solved theory only)

Q.No(01)
(5+5)

A:- Define the following terms:-

(1) Plastic Equilibrium:-
Plastic Equilibrium state of stress within a soil mass or a portion thereof that has been deformed to such as extent that is ultimate shearing resistance is mobilized.

(2) Angular Distortion:-
Angular Distortion β, is the ratio of the differential settlement δ and the distance l between two points. It is crucial to understand beforehand the range of ~~7H~~ & angular distortion that will possibly cause unacceptable damage to the structure

(3) Compressive Index:-
The compressive index is used to find the settlement in the normally consolidated clay. The total stress applied is

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of ultimate bearing capacity for soil 1 are determined by methods given by Terzaghi and Bureau of Indian Standard. These values are tabulated in table. table no 3 Below

Q) Effect of Depth of footing on Bearing Capacity:-

The depth of footing is important parameter which governs the ultimate bearing capacity of the soil. For different soils by keeping other parameters constant, the effect of depth of strip footing on ultimate bearing capacity of soil is studied. In this study it is assumed that irrespective of variation in depth of foundation the properties of soil remain constant the values of ultimate bearing capacities determined for different soils by IS code method are as shown in table.

table no 5 in another file

(3) **Effect of width of footing on Bearing Capacity:-**

The width of footing is important Parameter which governs the ultimate bearing capacity of the soil for different soils by keeping other Parameters constant, the effect of width of strip footing on ultimate bearing capacity of soil is studied. The values of ultimate bearing capacities of soil determined for different soils by IS code method are shown in Table

table no 1 in attached file.

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Q: No 2

A: What is Bearing capacity: Also write factors effecting Bearing Capacity.

Ans: **Bearing Capacity:-** In geotechnical engineering, bearing capacity is 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:-

1:- Effect of shape of footing on Bearing Capacity:-

The shape of footing is an important parameter which governs the ultimate bearing capacity of the soil. In general strip, square rectangular and circular shaped footing are used. For soil 1 by keeping after other parameters constant, the effect of shape of footing on ultimate bearing capacity of soil is studied. The values

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larger than the stress in the field, to which the soil sample has been undergone in the past. This kind of clayey soil is used said to be normally consolidated clay.

(4) Ultimate Bearing Capacity:- In geotechnical engineering, bearing capacity is the capacity of soil to support the loads applied to the ground. Ultimate bearing capacity is the theoretical maximum pressure which can be supported without failure; allowable bearing capacity is the ultimate bearing capacity divided by a factor of safety.

(5) Poission Ratio of Soil:- Plainly, Pission's ratio is the negative of ratio of transversal strain to the axial strain in an elastic material, which is subjected to an uniaxial stress

⇒ Material: Possion's ration

Saturate clay: 0.40–0.50
Clay: 0.30 – 0.45
Sand: 0.20 – 0.45

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Q No:3

A:- What is Settlement. What are its types explain in detail?

Ans:- **Settlement:-** In geotechnical engineering, settlement is defined as the vertical movement of the ground, generally caused be changes in stresses within the earth... settlement is most likely to occur when increased vertical stresses are applied to the ground on or above soft or loose soil strata.

Types:-

1: Immediate settlement.
2: Consolidation settlement (ΔHc)
3: Secondary settlement/creep (ΔHc)
4: Immediate settlement computation.
5: Secondary compression/creep.
6: Sands.
7: Clays.

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on one side. this, however, is an extreme case. The Principal settlements for most Projects occur in 3 to 10 years.
Dominates is saturated/nearly saturated fine grained soils where consolidation theory applies.
Here we are interested to estimate both consolidation settlement and how long a time it will take or most of the settlement to occur.

3: Secondary settlement/creep (ΔHC)

Occurs under constant effective stress due to continuous rearrangement of clay predominates in highly plastic clays and organic clays.

4: Immediate settlement calculations:-

Immediate settlement computation Formula

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1: Immediate settlement:-

Immediate settlement takes place as the load is applied or within a time period of about 7 days.
Predominates in cohesion less soils and unsaturated clay.
Immediate settlement analysis are used for all fine-grained soils with large including silts and clays with a degree of saturation <90% and for all coarse grained soils with large co-efficient of permeability (say above 10.2 m/s).

2: Consolidation settlement (ΔHC)

Consolidation settlement are time dependent and take months to years to develop. The leaning tower of Pisa in Italy has been undergoing consolidation settlement for over 700 years. The lean is caused by consolidation settlement ~~for most~~ being greater

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Consolidation/secondary compression: At the end of secondary consolidation settlement the soil has reached a new Ko-state (at-rest state)

To find secondary consolidation settlement in the field (ΔH_s).

$$\Delta H_s = \Delta C_\alpha \log \frac{t_{100(f)} + \Delta t}{t_{100(f)}}$$

6: Sands

Maximum total settlement = 40mm for isolated footings = 40 to 65mm for rafts

Maximum differential settlement between adjacent columns = 25mm

7: Clays

Maximum total settlement = 65mm for isolated flootings = 65 to 100mm for rafts

Maximum differential settlement between adjacent columns = 40mm

The differential settlement between adjacent may al be evaluated in terms of angular

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distortion given by : $(\Delta H diff) = \Delta / L$

Where Δ = relative settlement between the two Points and L = Horizontal distance between the two Points. Based on a large number of settlement observations and Performance of structures.

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Question 01 (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 Rankin's theory.

Given Data:-

$H = 6m$
$C = 0$
$\phi = 30°$
$\gamma = 19.2\ kN/m^3$

Slope = Horizontal = 1
vertical = 3

Required:-

$N_{ab} = ?$

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$\frac{V_a}{b} = ?$

Solution:-

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

$\beta =$

$\beta = \tan\beta\left(\frac{1}{3}\right)$
$18°$

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

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

$K_a = 0.3948$

$K_a = 0.395$

Now

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

$= 136.512 \text{ kN/m}$

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

$= 136.512 \times \cos(18)$

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

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

$$\boxed{e_1 = 0.983}$$

Now

$$S_1 = \frac{H}{1+e_0} \times C_c \log_{10}\left(\frac{P_f}{P_i}\right)$$

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

$$2.47 \times 0.03611 \times 1000$$

$$0.08920 \times 1000$$

$$\boxed{S_c = 89.39\,mm}$$

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Question 03(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:-

$C_c = 0.31$

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

$e_0 = 1.02$

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

$H = 5m$

Required:-

$e_1 = ?$

$S_c = ?$

Solution:-

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

$$= \frac{e_0 - e_1}{\log_{10}\left(\frac{P_2}{P_1}\right)}$$

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$q_{n.s} = \frac{q_{n.u}}{F.O.S}$

$= \frac{733.2}{3} = 244.4 \, kN/m^2$

$= 244.4 + (18 \times 1.6)$

$273.2 \, kN/m^2$

Total safe load on rectangular footing:

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

$= 1639.2 \, kN$

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Depth Factor:-

$d_c = 1 + 0.2 \frac{D}{B} \tan\alpha$

$= 1 + 0.2 \frac{1.6}{2} \tan 55$

$= 1.23$

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

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

$= 1.11$

Now putting values:-

$q_u = (N_c \cdot S_c \cdot d_c \cdot i_c + q N_q \cdot d_q \cdot S_q \cdot i_q + \frac{1}{2} \gamma N_\gamma \cdot S_\gamma \cdot d_\gamma \cdot i_\gamma$

$(18 \times 1.6 \times 6.4 \times 1.11 \times 1.11 \times 1)$

$= (20 \times 14.8 \times 1.3 \times 1.23 \times 1) + (20 \times 14.8 \times 1.3 \times 1.23 \times 1)$

$(20 \times 14.8 \times 1.3 \times 1.23 \times 1)$

$= (20 \times 14.8 \times 1.3 \times 1.23 \times 1)$

$+ (0.5 \times 20 \times 2 \times 2.9 \times 1.11 \times 1.14 \times 1)$

$q_u = 762\ kN/m^2$

$q_{nu} = q_u - \gamma$

$762 - (18 \times 1.6)$

$733.2\ kN/m^2$

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Solution:-

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

First For the shape factor:-

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

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

$$= 55^\circ$$

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

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

$$= 1.27 \approx 1.3$$

$$S_q = S_\gamma = 1 + 0.1 \frac{B}{L} \tan^2\alpha$$

$$= 1 + 0.1 \frac{2}{3} \tan^2 55$$

$$= 1.14$$

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Question 02(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 footing is at 1.6m below the ground surface. The unit weight of soil is $18 kN/m^3$, the angle of shear resistance $\phi = 20°$ ($N_c = 14.8$, $N_q = 6.4$, $N_\gamma = 2.9$) unit cohesion $C_u = 20 kN/m^2$ use Meyerhof analysis.

Given data:—

$L = 3m$

$B = 2m$

$D_f = 1.6m$

$F.O.S = 3$

$\gamma = 18 kN/m^3$

$c = 20 kN/m^2$

$\phi = 20°$

Required:—

$q_s = ?$

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

$$= 136.512 \times \sin(18)$$

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

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