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Subject: Geotech. & Foundation Engineering

Section: "B"

Semester: 6th

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Question no: 01

Part (A):

① **Plastic Equilibrium:** A body of soil is in a state of Plastic equilibrium if every part of it is on the verge of failure.

⇒ Plastic equilibrium that can be developed samultan-ously throughout a semi-finite mass of soil caused by no force other then gravity.

⇒ Plastic equilibrium limits for cohesionless soils defined by ratio between major and minor Principal stresses.

$$\sigma_1'/\sigma_3' = N\phi' = \tan^2(45° + \phi'/2)$$

② **Angular Distortion:** when two foundations supports walls/columns settles unequally it means the structure is subjected to angular distortion.

or

⇒ Angular Distortion between two points under a structure is equal to the differential settlement between the points divided by the distance between them

⇒ Angular distortion Mathematically: $\frac{\Delta s}{L} = \frac{S_{max} - S_{min}}{L}$

③ **Compressive index:** The compressive index is used to find the settlement in the normally consolidated clay. The total stresses applied is larger then 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.

⇒ Mathematically: $C_c = \frac{\Delta e}{\Delta \log \sigma_{ef}} = \frac{\Delta e}{\log_{10}(P_2/P_1)}$

where Δe = variation of voids ratio.

$\Delta \log \sigma_{ef}$ = variation of effective stresses.

P_1 = Pressure when void ratio is e_1, $P_2 \Rightarrow e_2$

⇒ It typically ranges from 0.1 — 10.

④ **Ultimate Bearing Capacity:** The maximum pressure at the base of the footing which cause shear failure in the soil is called ultimate Bearing Capacity.

⇒ It is denoted by "q_u"

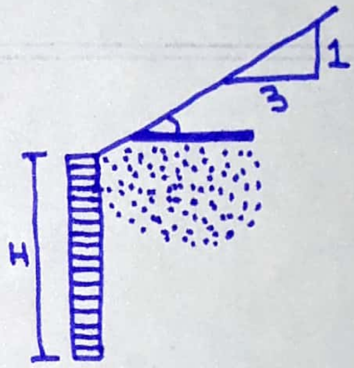
⑤ **Poission ratio of soil:** It is the ratio of transverse contraction strain to longitudinal extension strain in the direction of stretching force. It is also called Poisson coefficient.

Question no: 01

Part (B): A 6m tall cantileuer 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: $H = 6m$, $C = 0$

$\phi = 30°$, $\gamma = 19.2\ KN/m^3$

Slope: $H = 1$, $V = 3$

Required: $\frac{N_a}{b} = ?$, $\frac{V_a}{b} = ?$

Solution: $\boxed{\frac{P_a}{b} = \frac{\gamma * H^2 * K_a}{2}}$

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

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

$\boxed{B = 18°}$

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

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

$\boxed{K_a = 0.3948 \simeq 0.395}$

* $\frac{P_a}{b} = \frac{19.2 * 6^2 * 0.395}{2}$

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

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

$= 136.512 * \cos(18)$

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

* $\frac{U_a}{b} = \frac{P_a}{b} \cdot \sin\beta$

$= 136.512 * \sin(18)$

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

Question no: 02

Part (A): what is Bearing capacity. Also write factors effecting bearing capacity.

Bearing Capacity: It is an engineering property of soil due to which the soil resist the applied load. The bearing capacity is also called the internal strength of the soil.

⇒ It is denoted by "q".

⇒ There are three modes of failure that limit bearing capacity.
(i) General Shear failure.
(ii) local Shear failure.
(iii) Punching Shear failure.

⇒ It depends upon the shear strength of soil as well as shape, size, depth and type of foundation.

Factors Effecting Bearing Capacity:

(i) Relative Density: Greater the relative density of soil, higher will be the value of angle of internal friction ϕ. High the value of angle of internal friction, higher will be the value of Terzughi's bearing factors (N_c, N_γ, N_q).

⇒ Greater the values of N_c, N_γ and N_q, will result into higher value of bearing capacity. The soil having enough relative density will have enough bearing capacity.

(ii) Depth of footing: The bearing capacity of soil increase with the increase of the depth of footing. The increase will be maximum for the dense soil as compared with loose sand.

(iii) Breadth of the footing: Bearing capacity also depends on breadth of the footing. Greater the breath of the foundation/footing, more will be bearing capacity.

(iv) Unit weight of the soil: More the unit weight of soil, more will be its bearing capacity. It will be more incase of dense soil/sand as compared with loose or medium soil/sand.

(v) Water Table: As water table comes up near the footing, the bearing capacity get decreases.

Question no: 02

Part (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 resisting $\phi = 20^\circ$ ($N_c = 14.8$, $N_q = 6.4$, $N_\gamma = 2.9$), unit cohesion $C_u = 20 KN/m^2$. Use meyerhof analysis.

Given Data: $L = 3m$, $FOS = 3$, $c = 20 \, KN/m^2$, $\phi = 20°$,

$\gamma = 18 KN/m^3$,

Required: Safe load $= q_s = ?$

Solution: $q_u = c \cdot N_c \cdot S_c \cdot d_c \cdot i_c + q \cdot n_q \cdot i_q \cdot S_q \cdot d_q + \frac{1}{2} \cdot \gamma \cdot B \cdot N_\gamma \cdot I_\gamma \cdot d_\gamma \cdot S_\gamma$

* **For Shape Factor:**

$\Rightarrow \alpha = 45 + \frac{\phi}{2} \Rightarrow \alpha = 45 + \frac{20}{2} \Rightarrow \boxed{\alpha = 55°}$

$\Rightarrow S_c = 1 + 0.2 \frac{B}{L} \cdot \tan^2\alpha \Rightarrow 1 + 0.2\left(\frac{2}{3}\right) \tan^2(55) \Rightarrow \boxed{S_c = 1.3}$

$\Rightarrow S_q = S_\gamma = 1 + 0.1 \cdot \frac{B}{L} \tan^2\alpha \Rightarrow 1 + 0.1 (2/3) \cdot \tan^2(55)$

$\boxed{S_q = S_\gamma = 1.14}$

* **For depth Factors:**

$\Rightarrow d_c = 1 + 0.2 (D/B) \tan\alpha \Rightarrow = 1 + 0.2\left(\frac{1.6}{2}\right) \cdot \tan(55)$

$\boxed{d_c = 1.23}$

$\Rightarrow d_\gamma = d_q = 1 + 0.1 (D/B) \cdot \tan\alpha \Rightarrow 1 + 0.1 \left(\frac{1.6}{2}\right) \tan(55)$

$\boxed{d_\gamma = d_q = 1.11}$

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

$q_u = (20 * 14.8 * 1.3 * 1.23 * 1) + ((18 * 1.6) * 6.4 * 1.1 * 1.11 * 1) +$

$(0.5 * 20 * 2 * 2.9 * 1.11 * 1.14 * 1)$

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

⇒ $q_{nu} = q_u - \bar{\sigma}$

q_{nu} = net Ultimate Bearing Capacity

q_u = Ultimate Bearing Capacity

$\bar{\sigma}$ = Over-burden pressure.

$q_{nu} = 762 - (18 * 1.6)$

$q_{nu} = 733.2 \, KN/m^2$

⇒ $q_{ns} = \frac{q_{nu}}{F.O.S}$

q_{ns} = Net safe bearing capacity

q_{nu} = net ultimate bearing capacity

F.O.S = Factor of Safety.

$q_{ns} = \frac{733.2}{3}$

$q_{ns} = 244.4 \, KN/m^2$

⇒ $q_s = q_{ns} + \bar{\sigma}$

q_s = Safe bearing capacity

$q_s = 244.4 + (18 * 1.6)$

$q_s = 273.2 \, KN/m^2$

⇒ **Total Safe load on rectangular Footing:**

$A * q_s = (2 * 3) * 273.2$

$A * q_s = 1639.2 \, KN$

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Question no: 03

Part (a): What is settlement. What are its types explain in detail?

Settlement: When load is applied on ground surface this will produce effective vertical stresses, due to these stresses the effective vertical strain will be produced as a result of which movement will occur in downward direction. This downward 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: This is the type of settlement where each part of the structure will settle equally. It is also known as Uniform settlement.

⇒ In uniform settlement the failure is not that much high as compared to differential settlement.

⇒ The total settlement mostly take place in the structure which are constructed in rigid footing (raft).

⇒ 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 transferred should be sufficient in bearing to resist the load which is to be applied on it.

⇒ To spread a coming load over a large area.

(ii) Differential Settlement:

Different settlements in different parts of the same structure is called differential settlement.

⇒ It is more dangerous then total settlement because it causes more damage to a structure as compared to Total Settlement.

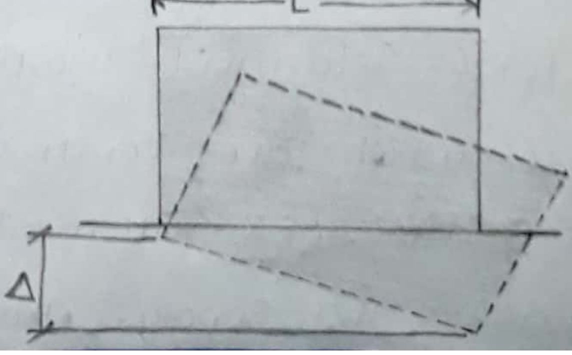
Types of Differential Settlement:

(1). Tilt

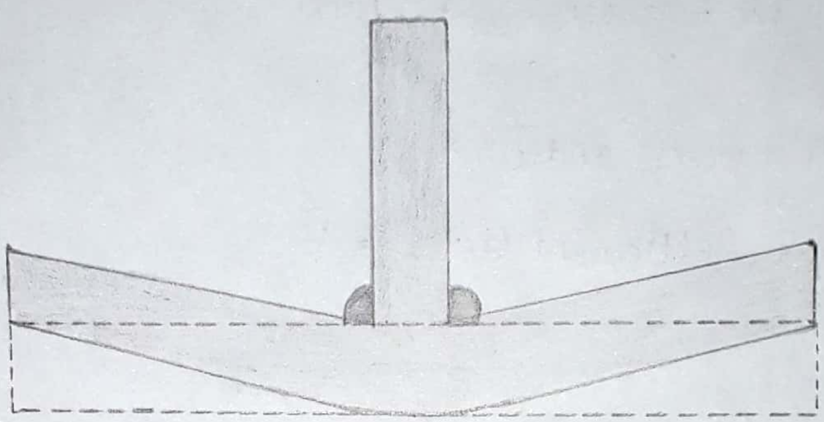
(2). Angular Distortion

(1) Tilt: If the entire structure due to unequal settlement is called tilt.

Base wise tilting



(2) Angular Distortion: When two foundation supports walls/columns, settles unequally it means the structure is subjected to angular distortion.



Angular Distortion

Components of Settlement in foundation:

(i) Immediate Settlement

(ii) Primary Consolidation Settlement

(iii) Secondary Consolidation Settlement

Question no: 03

Part (B): A soil has a compressive index $C_c = 0.31$. At a stress $130 KN/m^2$, the voids ratio was 1.02. Calculate (i) The voids ratio if the stress on the soil is increased to $170 KN/m^2$.

(ii) The total settlement of the stratum of 5m thickness.

Given Data: C_c = compressive index = 0.31

P_1 = Stress = 130 kN/m²

e_0 = voids ratio = 1.02

P_2 = Stress = 170 kN/m²

H = Settlement = 5m

Required: (i) e_1 = voids ratio = ?

(ii) S_c = Settlement (total) = ?

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

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

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

$\boxed{e_1 = 0.983}$ ⇒ voids ratio at $P_2 = 170 kN/m^2$

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

$$S_c = \frac{5}{1+1.02} * 0.31 * \log_{10}(170/130) * 1000\,mm$$

$\boxed{S_c = 89.39\,mm}$ ⇒ Total Settlement.

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