Name:- Mulhaar
ID:- 1789
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Section:- A
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Question No:- 1:-

Plastic Equilibrium:-

When every part of soil body is on the verge of its failure, it is called plastic equilibrium. The state where a transition takes place from plastic equilibrium to state of plastic flow represents that the mass has failed.

Angular Distortion:-

It is the angular change that occurs in the relative positions of members extending from a weld. In angular distortion, the distortion is transverse to the welding direction.

Compression Index:-

In order to find the settlement in consolidated clay, the compression index is used. The compression index (C_c) for clay is in the range 0.258. (C_c) value is different for each type of soil → $C_c = \frac{\Delta e}{\log_{10}\left(\frac{P_2}{P_1}\right)}$

Ultimate Bearing Capacity:-

It is the gross pressure at the base of the foundation at which soil fails in shear. It is represented by "q_u".

Poission Ratio Of Soil :-

⇒ Change occurring in the shape of a material while the volume remains constant is poisson ratio.

⇒ Poissons ratio is coefficient of lateral expansion. The soil is not deformed linearly.

Question 1 (Part b) :-

Given Data :-

height, $h = 6m$ $\phi = 30^\circ$

Cohession, $C = 0$ Slope, $H = 1$, $V = 3$

unit weight, $\gamma = 19.2 KN/m^3$

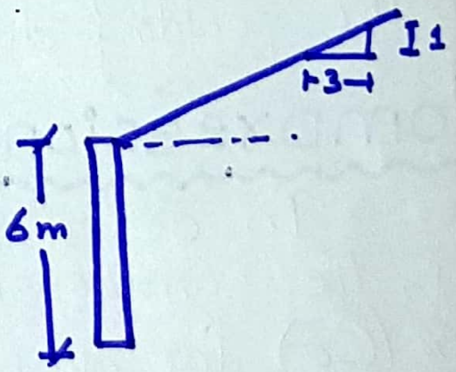
Required :-

Normal forces, $N_{a/b} = ?$

Shear forces, $V_{a/b} = ?$

Solution :-

1st Finding $P_{a/b}$.



$$P_{a/b} = \frac{\gamma \times H^2 \times K_a}{2} \quad \text{—(i)}$$

Finding value of β.

$$\Rightarrow \tan\beta = \frac{P}{B}$$

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

$$\beta = \tan^{-1}\left(\frac{1}{3}\right)$$

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

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

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

$K_a = 0.3948$

$\boxed{K_a = 0.395}$

Now putting values in eq (i)

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

$$\boxed{\frac{P_a}{b} = 136.512 \, KN/m^2}$$

For Normal Stresses;

$$N_a/_b = P_a/_b \cos\beta$$

$$= 136.1512 \times \cos(18)$$

$$\boxed{N_a/_b = 129.83 \, KN/m}$$

For shear stresses;

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

$$V_a/_b = 136.619 \times \sin(18^\circ)$$

$$\boxed{V_a/_b = 42.18 \, KN/m}$$

Question No:- 2 (a)

Bearing Capacity :-

It is the capacity of a soil which supports the load applied to the ground. We can also say that is the maximum average contact pressure between the foundation and the soil which should not produce shear failure in soil

Factors Affecting Bearing Capacity :-

1. **Relative Density :-** The angle of friction is increased when the relative density increases, this inturn also increases the N_q, N_c, N_γ values. When the (N_γ, N_c, N_q) values increase, it causes the bearing capacity to increase as well.

2. **Depth of footing :-** Bearing capacity becomes more when depth of foundation increases. In denser soil, this increase is more visible.

3. **Breadth of foundation :-** Increase in foundation breadth increases the bearing capacity. This increase is also more visible in denser soil compared to sand.

4. Unit Weight Of Soil :-

Unit weight of soil ∝ bearing capacity.

⇒ unit weight will be more in case of dense soil compareed to medium soil.

5. Water Table :-

$$\text{Bearing cacity} \propto \frac{1}{\text{water table}}.$$

Water table comes near to footing and causes decrease in bearing capacity.

Question Nos:- 2(b)

Given Data :-

Dimensions, $B \times L = 2m \times 3m$.

$FOS = 3$

Depth, $D_f = 1.6m$

$\gamma = 18 kN/m^2$

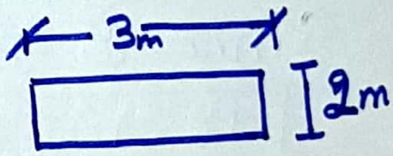
$\phi = 20^\circ$

$C = 20 kN/m^2$

$N_c = 14.8$

$N_q = 6.4$

$N_\gamma = 2.9$.



Required :-

maximum safe load = ?

Solution :-

Shape Factors :

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

$\therefore \alpha = \left(45 + \frac{\phi}{2}\right) = 55^\circ$

$S_c = 1 + 0.2 (2/3) \tan^2 55°$

$S_c = 1.27$

Since $\phi > 10°$ then;

$S_q = S_\gamma = 1 + 0.1 \frac{(2)}{(3)} \tan^2 55$

$S_q = S_\gamma = 1.135$

Now depth

$\Rightarrow d_c = 1 + 0.2 \frac{(1.6)}{2} \tan 55$

$d_c = 1.228$

Since $\phi > 10$

$d_q = d_\gamma = 1 + 0.1 \frac{(1.6)}{2} \tan 55$

$d_q = d_\gamma = 1.11$

Since θ is not given so;

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

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

$\therefore q = D_f \times \gamma_s$
$= 1.6 \times 18$

$q = 28.8 \text{ KN/m}^2$

$q_u = (20 \times 14.8 \times 1.27 \times 1.228 \times 1) + (28.8 \times 6.4 \times 1.135 \times 1.11 \times 1)$
$+ \frac{1}{2} (18 \times 2 \times 2.9 \times 1.135 \times 1.11 \times 1)$

$q_u = 462.56 + 232.2 + 65.76$

$q_u = 760.52 \text{ KN/m}^2$

$\therefore \bar{\delta} = \gamma_s \times D_f$

$q_{nu} = 760.52 - \bar{\delta}$

$q_{nu} = 760.52 - 28.8$

$q_{nu} = 731.7 \, kN/m^2$

$q_{ns} = \frac{q_{nu}}{F.O.S} = \frac{731.7}{3} = 243.9 \, kN/m^2$.

Safe load

$q_s = q_{ns} + \bar{\delta}$

$q_s = 272.7 \, kN/m^2$

or

$q_s = 272.7 \times 2 \times 3$

$q_s = 1636.24 \, kN/m^2$ Answer.

Question No:- 3(a)

Settlement :- Effective vertical stresses produces as a result of load being applied on the ground surface is called settlement. These vertical stresses inturn result in the production of vertical strain which causes movement in downward direction.

Types of Settlement :-

1. **Total Settlement :-** In this type of settlement, each part of structure will settle equally. This settlement mostly takes

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place in the structure which are constructed in rigid footing.

Differential Settlement :-

When different settlement accurs in different parts of the same structure.

=> It is a quite dangerous type of settlement as it causes more damage to a structure compared to total settlement.

=> **Tilt :-** Rotation occuring in a structure due to unequal settlement.

=> **Angular Distortion :-** The unequal settlement of two foundations supporting a column or wall.

Immediate Settlement :-

=> Also called elastic settlement.

=> Soil solids move in lateral direction to the applied vertical load.

$$\delta_i = \frac{qB}{E} * (1 \times U^2) \times I_f.$$

=> In flexible footing settlement is minimum at the cornors & maximum at centre.

=> In rigid footing settlement is same for centre as well as cornor.

Primary Consolidation Settlement:-

It is defined as process in which a decrease occurs in the soil volume. It is caused as a result of volume change in saturated soil due to exclusion of water occupied by void spaces.

Secondary Consolidation Settlement:-

Occurs after the primary condolidation is completed. The soil particles are re-arranged to achieve a stable form.

$$S_c = \frac{H}{1+e_c} \times C_c \log_{10} \frac{P_2}{P_1}.$$

Question No:- 3 (b)

Given Data:-

$C_c = 0.31$

$P_1 = 130 kN/m^2$

$e_o = 1.02$

$P_2 = 170 kN/m^2$

$H = 5m$.

Required Data:-

$e_1 = ?$

$S_c = ?$

Solution:-

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

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

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

$$0.31 \times 0.1165 = 1.02 - e_1$$

$$e_1 = 0.984$$

By formula

Consolidation settlement is

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

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

$$S_c = 0.0893\text{m} \times 1000\text{mm}.$$

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

Answer.