EXAM: MID TERM (ONLINE)

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SECTION:	"A"
SEMESTER	6th
SUBJECT:	GEOTECHNICAL AND FOUNDATION ENGINEERING
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QUESTION: 01

PART: A

1. **PLASTIC EQUILIBRIUM:** Plastic Equilbrium can be defined as: "the state of equilbrium in which every part of soil is on verge of failure is called plastic Equilbrium."

(OR)

"It's the state in which the soil will reach to failure or verge of failure.

Noticed when retaining soil is homogenous cohesionless and dry.

The frictional resistance between retained soil and retaining wall is neglected which means frictional resistance is zero.

The retained soil will be in state of plastic Equilbrium.

2. ANGULAR DISTORTION :

Angular Distortion can be defined as " when two foundations support walls / columns settle unequally, it means structure is subjected to angular distortion."

(OR)

Angular Distortion is ratio of differential settlement and the distance b/w two points.

$$\beta = \delta / l$$

β = Angular Distortion
δ = Differential settlement
l = distance b/w two points.

3. COMPRESSIVE INDEX :-

It's used to find settlement in normal consolidated clay.

It's given by :-

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

Where Δe = change in void ratio
P_1 = pressure when void ratio is e_1
P_2 = pressure when void ratio is e_2.
C_c = Compressive Index.

→ In terms of MV :-

MV = change in volume per unit volume of compressible layer

$$S_c = H \times MV \times \Delta P$$

$$MV = \frac{\Delta e / \Delta P}{1 + e_0}$$

4. ULTIMATE BEARING CAPACITY :-

Ultimate bearing capacity is the maximum pressure at base of footing with shear failure in the soil.

→ It is denoted by "q_u".

→ By formula :

$$q_u = C.N_e.S_c.I_c.d_e + qN_qS_qI_qd_q + 0.5\gamma B N_\gamma S_\gamma I_\gamma d_\gamma$$

5. POISSION RATIO OF SOIL :

Poission ratio is the measure of poission effect that describe the expansion or contraction of a material in the direction perpendicular to the direction of loading.

The value of poission ratio is negetive of the ratio of transverse strain to axial strain.

QUESTION: 01

PART: (B)

Given Data :

Cohesion = C = 0
Angle of Internal friction = $\phi = 30°$
Unit weight of soil = $\gamma = 19.2\ KN/m^2$
Horizontal slope = 3
Vertical slope = 1

Required :

Total Normal Force $\left(\frac{Na}{b}\right) = ?$

Total Sheer force $\left(\frac{Va}{b}\right) = ?$

Solution :

As we know that:

Active force is given by

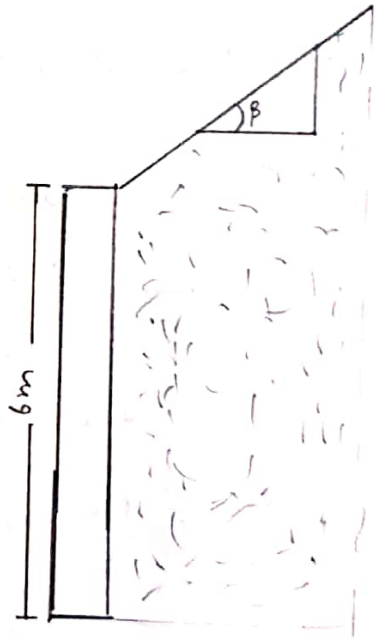
$$\frac{Pa}{b} = \frac{\gamma \cdot H^2 \cdot Ka}{2}$$

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

$\tan(\beta) = 1/3$

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

$\beta = 18°$



Also Ka is given by

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

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

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

$K_a = 0.3948$

$\boxed{K_a = 0.395}$

Now by Formula :-

Active force $\frac{P_a}{b} = \frac{\gamma \cdot H^2 \cdot K_a}{2}$

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

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

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

As the Normal force is

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

$= 136.52 \times \cos(18)$

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

Also 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: 02

PART: (A)

BEARING CAPACITY:

Bearing capacity is defined as: "the engineering property of soil due to which it resist the applied load is called Bearing capacity".

In other words, the internal strength of the soil is called bearing capacity.

→ It is denoted by "q".

FACTORS EFFECTING BEARING CAPACITY

Factors effecting Bearing capacity include:

1. **RELATIVE DENSITY OF SOIL**: The relative density of soil is directly related to the bearing capacity: More the relative density of soil more will be it's angle of friction. More will be N_q, N_c, N_r values. With increase of these values, the bearing capacity also increases. This increase will be more for dense soil/sand as compared to medium and loose sand/soil.

(N_q, N_c, N_r = Terzaghi Bearing Capacity factors).

2. **DEPTH OF THE FOOTING**: The depth of footing (df) is directly related to bearing capacity of soil. This means that with increase in depth of foundation, the bearing capacity of soil will increase.

This increase will be more in case of dense sand/soil as compared to loose.

3. **BREADTH OF FOUNDATION**: The breadth of foundation and bearing capacity are directly related to each other which means that more the breadth of foundation, more will be the bearing capacity of soil.

This increase will be more in case of dense soil/sand as compared loose or medium soil/sand.

4. **UNIT WEIGHT OF SOIL**:- Bearing capacity of soil is directly proportional to unit weight of soil. The bearing capacity of soil increases with increase in unit weight.

This increase will be more in case of dense soil/sand as compared to medium or loose sand/soil

5. **WATER TABLE**:- As water table comes near to footing, the bearing capacity of soil is decreased.

QUESTION: 02

PART: (B)

Given Data:

Footing Dimension = 2m x 3 mm (b=3m h=2m)
Factor of Safety = 3
Depth of foundation = Df = 1.6m
Unit weight of soil (γ) = 18 KN/m^3
Angle of Sheer resistance (ϕ) = 20°
Unit Cohesion = 20 KN/m^2
N_c = 14.8
N_q = 6.4
N_γ = 2.9.

Required:

Maximum safe load (q_{ys}) = ?

Solution:

According to Meyerhof analysis's

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

→ **FOR SHAPE FACTOR:** (S_c, S_q, S_γ)

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

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

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

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

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

$$\boxed{S_c = 1.27}$$

As $\phi > 10°$ So

$$S_q = S_r = 1 + 0.1 \left(\frac{B}{L}\right) \tan^2 \alpha$$

$$= 1 + 0.1 \left(\frac{2}{3}\right) \tan^2(55°)$$

$$\boxed{S_q = S_r = 1.135}$$

→ **FOR DEPTH FACTOR :** (d_c, d_q, d_r)

$$d_c = 1 + 0.2 \left(\frac{D_f}{B}\right) \tan \alpha$$

$$= 1 + 0.2 \left(\frac{1.6}{2}\right) \tan(55°)$$

$$\boxed{d_c = 1.22}$$

Also $\phi > 10°$, So

$$d_q = d_r = 1 + 0.1 \left(\frac{D}{B}\right) \tan \alpha$$

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

$$\boxed{d_q = d_r = 1.11}$$

INCLINATION FACTORS :

For $\theta = 0°$

$$i_c = i_q = i_r = 1$$

By formula

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

$$= 20(14.8)(1.27)(1.22) + [(1.6 \times 18)](6.4)(1.135)(1.11) +$$

$$\frac{1}{2}(18)(2)(2.9)(1.11)(1.135)$$

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

As Net ultimate bearing capacity is

$$q_{n.u} = q_u - \acute{S} \quad (\because \acute{S} = \text{overburden pressure})$$

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

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

Net Safe Bearing Capacity is

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

Safe Bearing Capacity is

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

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

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

This safe bearing capacity over whole footing will be

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

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

QUESTION: 03

PART: (A)

SETTLEMENT: When load is applied on ground surface, this will produce effective vertical stresses, due to these stressess effective vertical strain will be produced as a result of which movement will occur in downward direction. This downward movement is called settlement.

TYPES:- On the basis of movement of structure, the settlement is divided into two types.

1. Total Settlement
2. Differential Settlement.

1. TOTAL SETTLEMENT:-

It's also called Uniform settlement. In this type of settlement, each part of structure will settle equally.

In uniform settlement, failure of structure is not as much as considered with the differential settlement.

The total settlement mostly takes place in the 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.

LIMITATIONS FOR UNIFORM/TOTAL SETTLEMENT:

The soil layers to which the load is to be transfered 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:

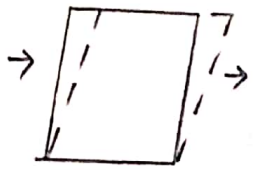
"Different settlement in different parts of same structure is called differential settlement".

Differential settlement causes more danger as compared with uniform / total settlement because it causes more damage to a structure as compared to total / uniform settlement.

TYPES: Differential settlement is of two types.

1. Tilt
2. Angular Distortion.

1. TILT: If the entire structure rotate due to unequal settlement is called tilt.



2. **ANGULAR DISTORTION:**

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

QUESTION: 03

PART: (B)

Given Data:

Compressive Index of soil = $C_c = 0.31$
Initial stress / pressure $(P_i) = 130\ KN/m^2$
Initial void ratio $= C_o = 1.02$
Increased or Final stress/pressure $(P_2) = 170\ KN/m^2$
Stratum Thickness $= H = 5m$.

Required:

Final void ratio due to increased stratum $(C_1) = ?$
Total consolidation settlement $= (S_c) = ?$

SOLUTION:

As compressive Index is given by:

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

$$0.31 = \frac{1.02 - e_1}{\log_{10}\left(\frac{170}{130}\right)} \Rightarrow 0.31 \times 0.1165 = 1.02 - e_1$$

$$\boxed{e_1 = 0.984}$$

By Formula: Consolidation settlement is

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

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

$$= 0.0893m \times 1000\ mm$$

$$\boxed{S_c = 881.3mm}$$