Name	Waqas Hussain
ID #	7799
Section	"A"
Semester	6th
Subject	GeoTechnical and Foundation Engineering
Paper	Mid term
Instructor	Engr. Liaqat Ali Sir

Question#01:

Part A :- Define the following terms:

1) Plastic Equillibrium :-

Plastic Equilibrium is a state of Stress within a soil mass or a portion of Soil that has been deformed to such an extent So that its ultimate shearing resistance is mobilized.

↳ In the plastic equilibrium state, the Soil is very near to failure.

2) Angular Distortion:-

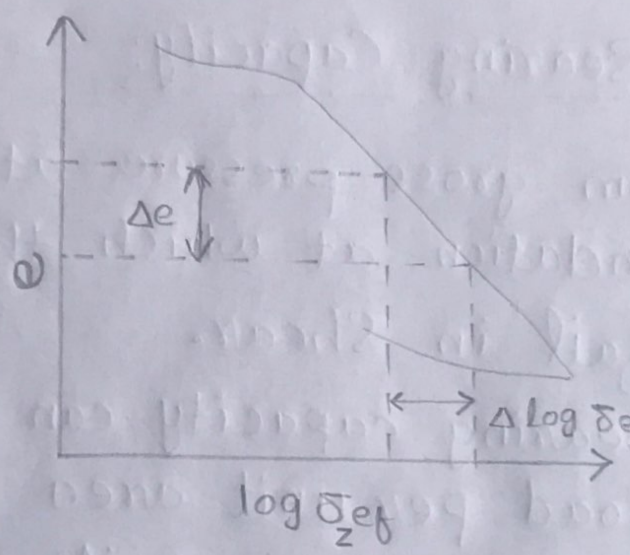
Angul distortion is a type of Settlement in Structures or foundation in which the supports settle down unequally.

↳ It can also be called Differential Settlement or non-uniform settlement

↳ If angular distortion settlement exceeds certain limits in a structure, the Structure could fail in several ways.

3) Compressive index:-

Compressive index describes the variation of the void ratio e as a function of the change of effective stresses σ_{ef} in the logarithmic scale.



It can be calculated by:

$$C_c = \frac{\Delta e}{\Delta \log \sigma_{ef}}$$

where

Δe = variation of void ratio

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

It can also be calculated by

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

where

Δe = change in Void ratio

P_1 = the pressure when the void ratio is e_1.

P_2 = the pressure when the void ratio is e_2.

4) Ultimate Bearing Capacity:

The maximum gross pressure at the base of the foundation at which the Soil does not fail in Shear.

↳ Ultimate bearing capacity can be defined as "The load per unit area of the foundation where shear failure in Soil occurs".

5) Poission Ratio of Soil:-

Poisson ratio of Soil is a measure of the lateral expansion which is compared to longitudinal contraction for longitudinal load.

↳ It measures the deformation in a Soil foundation in a direction normal or perpendicular to the direction of applied force.

Question#01

Part B) A 6m tall Cantilever wall retaining the Soil that has the following properties.

$C = 0$

$\phi = 30^\circ$

$\gamma = 19.2\ kN/m^3$

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 by using Rankine's theory.

Given data:

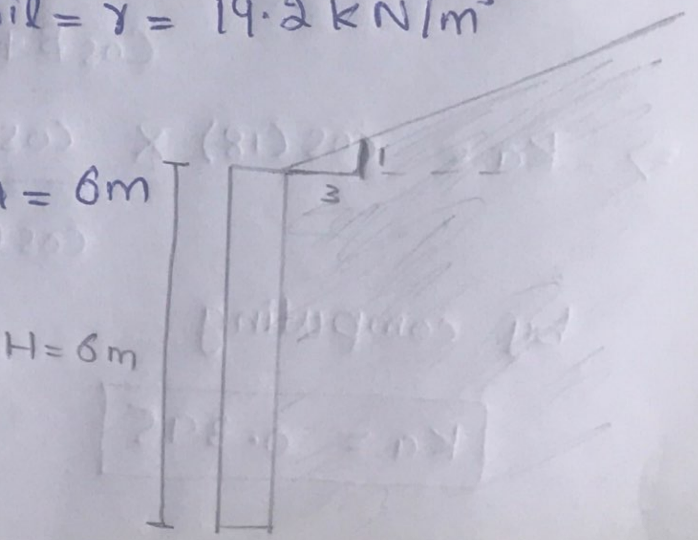
Cohesion value $= C = 0$

~~Angular~~ Angle of internal friction $= \phi = 30^\circ$

unit weight of Soil $= \gamma = 19.2\ kN/m^3$

β = Slope = 3:1

Height of wall $= H = 6m$



Required datas

Total Normal force $= \frac{N_a}{b} = ?$

Total Shear force $= \frac{V_a}{b} = ?$

Solution:

First of all, we have to find out total active forces,
So as we know that

Active forces $= \frac{P_a}{b} = \frac{\gamma . H^2 . K_a}{2}$ —(*)

For Ka, we have to compute the slope first

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

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

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

As we know that

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

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

by computing.

$\boxed{K_a = 0.395}$

(*) ⇒ $\frac{P_a}{b} = \frac{\gamma \cdot H^2 \cdot K_a}{2}$

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

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

As we know that Normal force = $\frac{N_a}{b}$

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

$= 136.52 \times \cos(18)$

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

Also we know that,

Shear force = $\frac{V_a}{b} = \frac{P_a}{b} \cdot \sin\beta$

$= 136.52 \times \sin(18)$

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

Question#02

Part A) What is Bearing Capacity? Also write factors affecting Bearing capacity.

Sol:

Bearing Capacity:-

Bearing Capacity is the Engineering property of Soil.

↳ It is the ability or Capacity of a Soil to resist the load applied on it.

↳ Bearing capacity is also known as the internal strength of Soil.

↳ It is denoted by "q".

Factors affecting Bearing Capacity:-

The following factors effect bearing capacity of a Soil.

1) Relative density:-

Relative density has a direct relation with bearing capacity

↳ Higher the value of relative density, Higher will be the value of angle of internal friction (ϕ), due to which higher will be the values of Tarzaghi bearing Capacity factors which make the value of bearing capacity higher.

2) Foundation depth:-

↳ The deeper the foundation, the greater will be bearing capacity.

↳ This increase will be maximon in case of dense Soil and will be minimom in case of loose Sand.

3) Foundation width:-

Bearing Capacity of Soil will be maximum if the width of the foundation is more

↳ This increase will be maximum for dense Soil than loose Sand.

4) Unit weight of the Soil:

Bearing Capacity increases with the increase in unit weight of Soil.

5) Spacing between foundations:

If the Spacing between footings are less, the bearing capacity will be more.

↳ It is recommended to have minimum Spacings between footings.

6) Cohesion of the Soil:

Cohesive property of the Soil also effects the bearing capacity.

↳ if the cohesion value of Soil is zero then the bearing capacity will be minimum.

7) Water table:

Bearing Capacity and water table is having inverse relation.

↳ if the water table is above and near to the footings of foundation the bearing capacity will be minimum because the Shear Strength between the Soil particles reduces.

Question #02

Part B: What is the maximum safe load which can 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/m³. 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:

Factor of Safety = F.O.S = 3

Dimension of footing = 2m x 3m

Depth of footing = $D_f = 1.6m$

Unit weight of Soil = $\gamma = 18\ kN/m^3$

Angle of Shear resistance = $\phi = 20$

$N_c = 14.8$

$N_q = 6.4$

$N_\gamma = 2.9$

Unit Cohesion = $C_u = 20\ kN/m^2$

Required data:-

Maximum Safe load = $q_s = ?$

Solution:

As we know, According to Meyerhof's analysis

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

For shape factors (S_c, S_q, S_γ):

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

we know that

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

$$\Rightarrow \alpha = 55^\circ$$

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

$$\Rightarrow \boxed{S_c = 1.272}$$

As given that $\phi > 10^\circ$

So

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

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

$$\boxed{S_q = S_\gamma = 1.136}$$

Now for depth factors (d_c, d_q, d_γ)

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

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

$$\Rightarrow \boxed{d_c = 1.228}$$

As we know that $\phi > 10°$, so

$$d_q = d_\gamma = 1 + 0.1\left(\frac{D_f}{B}\right)\tan\alpha$$

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

$$\Rightarrow \boxed{d_q = d_\gamma = 1.114}$$

(i) $\Rightarrow q_u = C.N_c.S_c.d_c + q.N_q.S_q.d_q + \frac{1}{2}.\gamma.B.N_\gamma.S_\gamma.d_\gamma$; $\because q = D_f \times \gamma$

$$= (20)(14.8)(1.272)(1.228) + [(1.6 \times 18)] (6.4)(1.136)(1.114) + \frac{1}{2}(18)(2)(2.9)(1.136)(1.114)$$

$$\Rightarrow \boxed{q_u = 761.674 \text{ KN/m}^2}$$

As we know that

$$q_{n.u} = q_u - \bar{\delta}$$

$$= 761.674 - (1.6 \times 18)$$

where
δ = over burden pressure
$= d_f \times \gamma$

$$\boxed{q_{n.u} = 732.874 \text{ KN/m}^2}$$

Also,

$$q_{n.s} = \frac{q_{n.u}}{F.O.S} = \frac{732.874}{3}$$

$$\Rightarrow \boxed{q_{n.s} = 244.291 \ KN/m^2}$$

As we know for Safe Bearing capacity

$$q_s = q_{n.s} + \bar{\sigma} = 244.291 + (1.6 \times 18)$$

$$\Rightarrow \boxed{q_s = 273.091 \ KN/m^2}$$

This is the maximum Safe bearing capacity per square meter of the footing.
For total footing the maximum safe bearing capacity will be,

$$q_s = 273.091 \times 2 \times 3$$

$$\Rightarrow \boxed{q_s = 1638.546 \ KN}$$

Question#03:

Part A) What is Settlement? What are its types? explain in details.

Answer:-

Settlement:-

Settlement can simply be defined as the vertical movement of the ground/structure caused due to applying load.

↳ when load is applied on the ground surface, effective stresses will be produce vertically due to which the downward movement will cause, which we call the Settlement.

Types of Settlement:

On the basis of the downward movement cause due to load, settlement is divided into two types

1) Total Settlement

2) Differential Settlement.

1) Total Settlement:-

when a load is applied on a structure due to which settlement in a structure occur in such a uniform way that each part of the structure settle down equally, then this type of settlement is called Total Settlement.

↳ Total Settlement is also called Uniform Settlement.

↳ In this type of Settlement, the chances of failure in a structure is minimum.

↳ This type of settlement mostly occur in structures having rigid footings (raft footing).

2) Differential Settlement:-

This is that type of Settlement, when each part of the structure do not settle down equally.

↳ In this type of settlement, different part of the same structure settle down unequally or different.

↳ Differential Settlement is more danger than the total Settlement.

↳ In this type of Settlement, more damages occur to a Structure.

↳ This type of Settlement is further divided into two parts.

1) Tilt.
2) Angular Distortion.

1) Tilt:

when one part of the structure settle downs more than the other, due to which the entire structure rotates, then this type of Unequal Settlement is called Tilt.

2) Angular Distortion:

Due to the application of load, when two foundations support wall/column Settle down unequally then we call that the structure in Subjected to angular distortion.

Some other types of Settlement:

1) Immediate settlement.
2) Primary Consolidation Settlement.
3) Secondary Consolidation Settlement.

1) Immediate Settlement:

when a load is applied on structure, and the settlement occur in such a way that the Soil Solid move in lateral direction to the applied vertical load, Such type of Settlement is known as Immediate settlement.

↳ Imediate settlement can be measure as follows

$$S_i = \frac{qB}{E} \times (1-\mu^2) \times I_F$$

where
S_i = immediate Settlement
q = Net pressure of footing
B = width of footing
μ = Poisson Ratio of Soil
E = Young's Modulus
I_F = influence factor, which depends upon the shape and type of footing.

2) Primary Consolidation Settlement:-

As we know that the Soil also contain water voids, so when we applied load on the Soil, the water from the Soil will Squeeze out and in a result Settlement will occur due to load transfer from water voids to the Structure (Soil Solid), this type of Settlement is called primary Consolidation Settlement.

3) Secondary Consolidation Settlement:-

In this type of Settlement, the rearrangement of Soil particles take place to regain a stable form after the primary consolidation Settlement.

↳ This type of Settlement is given by,

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

where S_c = Secondary consolidation Settlement

H = Thickness of the Soil layer.

C_c = Compaction index
e_o = Initial void ratio

P_1 & P_2 = Pressures

Question# 03:

Part 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:

Compressive index = $C_c = 0.31$
Initial Stress = $P_1 = 130 \, kN/m^2$
Initial void ratio = $e_o = 1.02$
Final Stress = $P_2 = 170 \, kN/m^2$
Thickness = $H = 5m$

Required data:-

Final void ratio $= e_1 = ?$

Final Settlement $= S_c = ?$

Solution:-

i) As we know that by compressive index, C_c

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

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

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

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

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

$$\Rightarrow 1.02 - e_1 = 0.036$$

$$\Rightarrow -e_1 = 0.036 - 1.02$$

$$\Rightarrow +e_1 = +0.984$$

$$\Rightarrow \boxed{e_1 = 0.984}$$

ii) As we know by Sc,

$$S_c = \frac{H}{1+e_0} \times C_c \times \log_{10}\left(\frac{170}{130}\right)$$

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

$$= 0.0894 \text{ m}$$

$$\boxed{S_c = 89.4 \text{ mm}}$$ ∵ 1m = 1000 mm

The End

Thank You.