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Internal Assessment Test 2 – December. 2023

Sub:	Applied Geotechnical Engineering					Sub Code:	18CV54	Branch:	Civil Engg
Date:	24.05.2023	Duration:	90 min's	Max Marks:	5	Sem / Sec:	6 A		OBE

	Answer any FIVE FULL Questions	MARKS	CO	RB
1 (a)	Using Boussinesq's theory, derive an equation for vertical stress below the center of a uniformly loaded circular area?	[10]	CO2	L3
2 (a)	With a neat sketch explain pressure bulb concept and vertical pressure distribution on a horizontal plane. And list the assumptions made in Boussinesq's theory of stresses in soil.	[10]	CO2	L2
3 (a)	Explain in detail the construction and uses of Newmark's influence chart.	[10]	CO2	L3
4 (a)	Define the terms: i) Net safe bearing capacity ii) Gross safe bearing capacity and Explain General, Local and Punching bearing capacity Shear failures.	[10]	CO4	L2
5 (a)	Explain plate load test in detail. What are its limitations?	[10]	CO4	L2
6 (a)	Determine the allowable gross load and the net allowable load for a square footing of 2 m side and with a depth of foundation of 1m. Use Terzaghi's theory. Take FOS=3.0, unit weight 18 kN/m3, C= 15kPa & ø=25°, Nc =14.8, Nq =5.6, Nɣ =3.2.	[10]	CO4	L3
7 (a)	A water tank is supported by a ring foundation having outer diameter of 10m & inner diameter of 7.5 m. The ring foundation transmits uniform load intensity of 160 kN/m2. Compute the vertical stress induced at a depth of 4 m, below the center of ring foundation using (a) Boussinesq analysis, and (b) Westergaard's analysis, taking μ=0.	[10]	CO2	L3

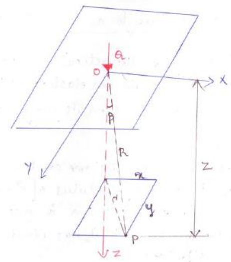
IAT 2 scheme &solution EVEN 2022 23

Subject: Applied Geotechnical Engineering (18CV54)

1. Using Boussinesq's theory, derive an equation for vertical stress below the center of a uniformly loaded circular area?

Answer:

Vertical stress due to concentrated load using Boussinesq's analysis.



using logarithmic stress function, polar stress σ_R at $P(x, y, z)$ is

$$\sigma_R = \frac{3}{2\pi} \frac{Q \cos\beta}{R^2}$$

R = polar distance b/w origin O & point P

β = angle which line OP makes with vertical.

$$R = \sqrt{x^2+y^2+z^2}$$

$$r^2 = x^2+y^2 \Rightarrow R = \sqrt{r^2+z^2}$$

$$\sin\beta = \frac{r}{R} \quad \& \quad \cos\beta = \frac{z}{R}.$$

vertical stress σ_z at P is $\sigma_z = \sigma_R \cos^2\beta$.

$$= \left(\frac{3}{2\pi}\frac{Q\cos\beta}{R^2}\right)\cos^2\beta$$

$$= \frac{3Q}{2\pi}\frac{\cos^3\beta}{R^2} = \frac{3Q}{2\pi}\frac{(z/R)^3}{R^2}$$

$$= \frac{3Q}{2\pi}\frac{z^3}{R^5}$$

$$= \frac{3Q}{2\pi} \times \frac{1}{z^2} \times \frac{z^5}{R^5}$$

$$= \frac{3Q}{2\pi} \times \frac{1}{z^2}\left[\frac{z^5}{(r^2+z^2)^{5/2}}\right]$$

$$= \frac{3Q}{2\pi} \times \frac{1}{z^2}\left[\frac{1}{\left[1+\left(\frac{r}{z}\right)^2\right]^{5/2}}\right]$$

$$\sigma_z = I_B \times \frac{Q}{z^2}$$

where $I_B = \dfrac{3}{2\pi\left[1+\left(\frac{r}{z}\right)^2\right]^{5/2}}$

2. With a neat sketch explain pressure bulb concept and vertical pressure distribution on a horizontal plane. And list the assumptions made in Boussinesq's theory of stresses in soil.

Answer:

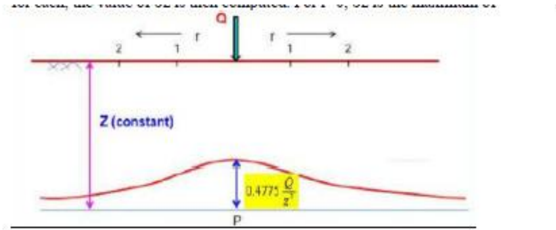
Pressure distribution due to concentrated load on horizontal plane
The vertical stress on horizontal plane at depth „z‟ is given by Z being a
specified depth. For several assumed values of r, r/Z is calculated and the influence factor IB, is found
for each, the value of σz is then computed. For r=0, σz is the maximum of
The maximum pressure ordinate is relatively high at shallow elevations and it decreases with increase depth. In other words, the bell shaped fig flattens out with increasing depth. The vertical stress distribution diagram on a horizontal plane can also be obtained graphically if the isobars of different intensities are available. The horizontal plane is drawn on the isobar diagram.

Pressure distribution due to concentrated load on vertical plane

The vertical stress distribution on a vertical plane at a radial distance of „r" can be obtained from

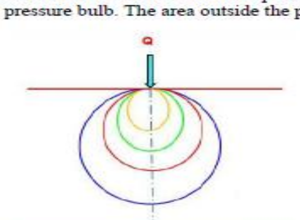
The variation of vertical stress with depth at a constant radial distance from the axis of the load is as shown in figure below.

In this case radial distance „r" is constant and the depth „z" changes. As z increases, r/z decreases, for a constant value of „r" . As r/z decreases Ib value in the equation for increases, but, since z2is involved in the denominator of the expression for , its value first increases with depth, attains a maximum value, and then decreases with further increase in depth.



a) directly under the point load b) at a distance from point load

Isobar:- Isobar is a curve joining the points of equal stress intensity. It is a spatial curved surface of the shape of an electric bulb or an onion. They are useful for determining the effect of the load on the vertical stress at various points. It is generally assumed that an isobar of 0.1Q forms a pressure bulb. The area outside the pressure bulb is assumed to have negligible stresses.



PRESSURE BULB FOR A POINT LOAD

Boussinesq's theory of stress in soils:

Assumptions:-

1)The soil medium is an elastic continuum having a constant value of modulus of elasticity (E). i.e. it obeys Hooke"s law.

2) The soil is homogeneous, i.e. it has identical elastic properties at all points in identical directions.

3) The soil is isotropic, i.e. it has identical elastic properties in all direction at a point.

4) The soil mass is semi-infinite, i.e. it extends to infinity in the downward directions and lateral directions. In other words, it is limited on its top but a horizontal plane and extends to infinity in all other directions.

5) The self weight of the soil is ignored.

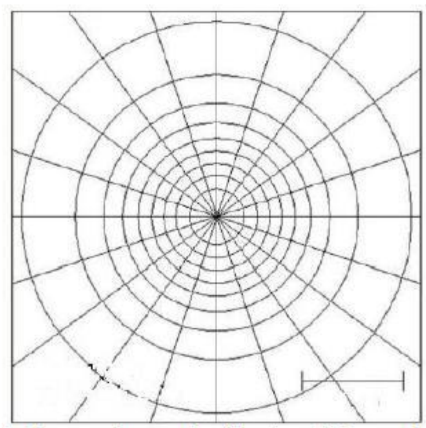
6) The soil is initially unstressed i.e. it is free from residual stresses before the application of the load.

3. **Explain in detail the construction and uses of Newmark's influence chart.**

Answer: Construction of Newmark's Influence chart:-

For the specified depth z, say 10 m, the radii of the circles, R, are calculated from the equation

for relative radii given by, where, R/z is the relative radii,⍰⍰z =
vertical stress at any depth, q = load intensity.
The circles are then drawn to a convenient scale (say, 1 cm = 2 m or 1:200). A suitable number of uniformly spaced rays (to get required influence value) are drawn, emanating from the center of the circles. The resulting diagram will appear as shown in below. On the figure is drawn a line AB, representing the depth z to the scale used in drawing the circles. If the scale used is 1 cm = 2 m, then AB will be 5 cm. The influence value for this chart will be I = (1/c x s). The same chart can be used for other values of the depth "z" . The length AB is taken equal to the depth "z "of the given problem and to that scale the loaded diagram is plotted on a tracing sheet to be superimposed later on the Newmark‟ s chart to obtain the vertical stress at the desired point.



Application of Newmark's Influence chart:- Application of Newmark‟ s Influence chart in solving problems is quite easy and simple. The plan of the loaded area is first drawn on a tracing sheet to the same scale as the scale of the line segment AB on the chart representing the depth "z‟ . The location of the point where the vertical stress is required is marked on the plan, say as "P‟ . Now, the tracing sheet is placed over the chart, such that the point „P‟ comes exactly over the center of the chart from where the rays are emanating. Now the number of mesh covered by the plan is counted. In case of partly covered mesh an intelligent judgement of the fraction of mesh covered is required. Let the total number of mesh be equal to "n‟ . Then the vertical stress at the desired depth is given by:
Where I = Influence value = 1/(c x s)
n = Number of meshes under the loaded area
q = uniformly distributed load
c = No. of concentric areas
s = No. of radial line

4. Define the terms: i) Net safe bearing capacity ii) Gross safe bearing capacity and Explain General, Local and Punching bearing capacity Shear failures.

Bearing Capacity failures General Shear Failure	Local/Punching Shear Failure
Occurs in dense/stiff soil	Occurs in loose/soft soil
Φ>36o, N>30, ID>70%, Cu>100 kPa	Φ<28o, N<5, ID<20%, Cu<50 kPa
Results in small strain (<5%)	Results in large strain (>20%)
Failure pattern well defined &	Failure pattern not well

clear	defined	Answer:
Well defined peak in P-Δ curve.	No peak in P-Δ curve	
Bulging formed in the neighbourhood of footing at the surface	No Bulging observed in the neighbourhood of footing	
Extent of horizontal spread of disturbance at the surface large	Extent of horizontal spread of disturbance at the surface very small	
Observed in shallow foundations	Observed in deep foundations	
Failure is sudden & catastrophic	Failure is gradual	
Less settlement, but tilting failure observed	Considerable settlement of footing observed	

Gross Safe Bearing Capacity (q_s) :

It is the maximum pressure which the soil can carry safely without shear failure at the base of foundation.

$$q_s = q_{nu} / FOS + \gamma D_f$$

Net Safe Bearing Capacity (q_{ns}) :

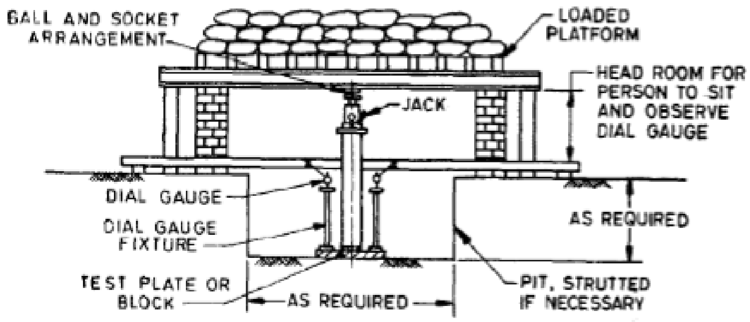
It is the net soil pressure which can be safely applied to the soil considering only shear failure.

Thus, $q_{ns} = q_{nu} / FOS$

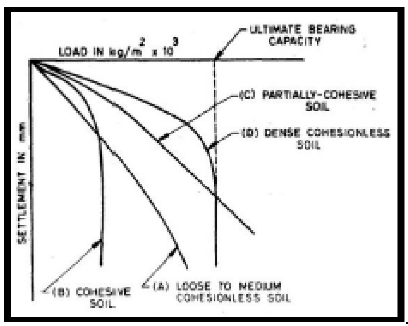
FOS - Factor of safety usually taken as 2.0 - 3.0

5. Explain plate load test in detail. What are its limitations?

Answer:



It is a field test for the determination of bearing capacity and settlement characteristics of ground in field at the foundation level. The test involves preparing a test pit up to the desired foundation level. A rigid steel plate, round or square in shape, 300 mm to 750 mm in size, 25 mm thick acts as model footing. Dial gauges, at least 2, of required accuracy (0.002 mm) are placed on plate on plate at corners to measure the vertical deflection. Loading is provided either as gravity loading or as reaction loading. For smaller loads gravity loading is acceptable where sand bags apply the load. In reaction loading, a reaction truss or beam is anchored to the ground. A hydraulic jack applies the reaction load. At every applied load, the plate settles gradually. The dial gauge readings are recorded after the settlement reduces to least count of gauge (0.002 mm) & average settlement of 2 or more gauges is recorded. Load Vs settlement graph is plotted as shown. Load (P) is plotted on the horizontal scale and settlement (Δ) is plotted on the vertical scale. Red curve indicates the general shear failure & the blue one indicates the local or punching shear failure. The maximum load at which the shear failure occurs gives the ultimate bearing capacity of soil.



<u>Load Settlement Curves</u>

Limitations of plate load test:-

(1) Size effect:- **Since the size of the test plate and the foundation are very different, the results of plate load test do not directly reflect the bearing capacity of the foundation.**

(2) Scale effect:- **The ultimate bearing capacity of saturated clays is independent of the size of the plate but for cohesionless soils, it increases with the size of the plate.**

(3) Time effect:- **A plate load test is essentially for a short duration. For clayey soils it does not give the ultimate settlement.**

(4) Interpretation of failure load:- **The failure load is not well defined, except in case of general shear failure.**

(5) Reaction load:- **It is not practical to provide a reaction of more than 250 KN. Hence test on a plate size larger than 0.6m width is difficult.**

(6) Water table:- **The level of WT affects bearing capacity of the sandy soils. If WT is above the level of footing, it has to be lowered by pumping before placing the plate.**

6. **Determine the allowable gross load and the net allowable load for a square footing of 2 m side and with a depth of foundation of 1m. Use Terzaghi's theory. Take FOS=3.0, unit weight 18 kN/m3, C= 15kPa & ø=25°, Nc =14.8, Nq =5.6, NƔ =3.2.**

Answer:

As ø < 28, it's the case of LSF; $C_m = \frac{2}{3} \times C$

$$C_m = \frac{2}{3} \times 15 = 10\ kPa$$

Square footing, $q_u = 1.3C_mN_c + 0.4B\gamma N_\gamma + \gamma D_f N_q$

$$q_u = 1.3 \times 10 \times 14.8 + 0.4 \times 2 \times 18 \times 3.2 + 18 \times 1 \times 5.6$$

$$q_u = 339.28\ kN/m2$$

$$q_{nu} = q_u - \gamma D_f$$

$$q_{nu} = 321.28\ kN/m2$$

$$q_{ns} = \frac{q_{nu}}{F}$$

$$q_{ns} = 107.09\ kN/m2$$

Net allowable load= $q_{ns} \times area\ of\ footing$

Net allowable load= 107.09 × 2 × 2

Net allowable load= 428.37 kN

$$q_s = q_{ns} + \gamma D_f$$

$$q_s = 125.09\ kN/m2$$

Gross allowable load= $q_s \times area\ of\ footing$

Gross allowable load= 125.09 × 2 × 2

Gross allowable load= 500.36 kN

7. **A water tank is supported by a ring foundation having outer diameter of 10m & inner diameter of 7.5 m. The ring foundation transmits uniform load intensity of 160 kN/m2. Compute the vertical stress induced at a depth of 4 m, below the center of ring foundation using (a) Boussinesq analysis, and (b) Westergaard's analysis, taking μ=0.**

Answer:

Boussinesq's Analysis

$$\sigma_z = q \times \left[1 - \left\{\frac{1}{1+\left(\frac{R}{Z}\right)^2}\right\}^{\frac{3}{2}}\right]$$

$$\sigma_z = 160 \times \left[1 - \left\{\frac{1}{1+\left(\frac{5}{4}\right)^2}\right\}^{\frac{3}{2}}\right] - 160 \times \left[1 - \left\{\frac{1}{1+\left(\frac{3.75}{4}\right)^2}\right\}^{\frac{3}{2}}\right]$$

$$\sigma_z = 23.120\ kN/m2$$

Westergaard's Analysis

$$\sigma_z = q \times \left[1 - \left\{\frac{1}{1+\left(R/_{Cz}\right)^2}\right\}^{1/2}\right]$$

$$C = \sqrt{\frac{1-2\mu}{2-2\mu}} = \sqrt{\frac{1}{2}}$$

$$\sigma_z = 160 \times \left[1 - \left\{\frac{1}{1+\left(5\times\sqrt{2}/_4\right)^2}\right\}^{1/2}\right] - 160 \times \left[1 - \left\{\frac{1}{1+\left(3.75\times\sqrt{2}/_4\right)^2}\right\}^{1/}\right.$$