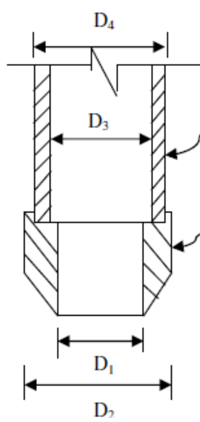
APPLIED GEOTECHNICAL ENGINEERING (17CV53)
SOLUTION – IAT1

1 (a) What are the objectives of soil exploration?

Ans:- Soil investigations are done to obtain the information that is useful for one or more of the following purposes:
1. To know the geological condition of rock and soil formation.
2. To establish the groundwater levels and determine the properties of water.
3. To select the type and depth of foundation for proposed structure
4. To determine the bearing capacity of the site.
5. To estimate the probable maximum and differential settlements.
6. To predict the lateral earth pressure against retaining walls and abutments.
7. To select suitable construction techniques
8. To predict and to solve potential foundation problems

1 (b) Explain with reference to soil samples: area ratio, inside clearance, outside clearance and recovery ratio.

Ans:-



$$\text{Area ratio } A_r = \frac{Max.Cross\ sectional\ area\ of\ the\ cutting\ edge}{Area\ of\ the\ soil\ sample}$$

$$A_r = \frac{D_2^2 - D_1^2}{D_1^2} x\,100$$

Where, D_1 = inner diameter of the cutting edge, D_2 = outer diameter of the cutting edge
For obtaining good quality undisturbed samples, the area ratio should be less than or equal to 10%.

Inside Clearance

$$Ci = \frac{D_3 - D_1}{D_1} x\,100$$

Where D_3 = inner diameter of the sample tube
It helps in reducing the frictional drag on the sample, and also helps to retain the core. For an undisturbed sample, the inside clearance should be between 0.5 and 3%.

Outside Clearance

$$Co = \frac{D_2 - D_4}{D_4} x\, 100$$

Where D_4 = outer diameter of the sample tube
Outside clearance facilitates the withdrawal of the sample from the ground. For reducing the driving force, the outside clearance should be as small as possible. Normally, it lies between zero and 2%.

Recovery Ratio

$$R_r = \frac{L}{H}$$

Where L = length of the sample within the tube, and H = Depth of penetration of the sampling tube

1 (c) Establish the ground water level by Hvorslev's method, given the following data: depth up to which water table is bailed out =32m, water rise on 1st day=2.4m, water rise on 2nd day=2.0m, water ries on 3rd day=1.60m.

Ans:-

$H_o = h_1^2/(h_1 - h_2) =$ 14.4 m

$H_1 = h_2^2/(h_1 - h_2) =$ 10 m

$H_2 = h_3^2/(h_2 - h_3) =$ 6.4 m

1st day $h_{w1} = H_w - H_o =$ 17.6 m

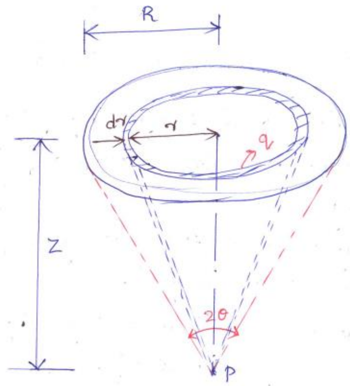
2nd day $h_{w2} = H_w - (h_1 + h_2) - H_1 =$ 17.6 m

3rd day $h_{w3} = H_w - (h_1 + h_2 + h_3) - H_2 =$ 19.6 m

$h_w = (h_{w1} + h_{w2} + h_{w3})/3 =$ 18.27 m

2 (a) Derive the expression for vertical stress under a uniformly loaded circular area by Boussinesq's theory.

Ans:-



Let 'q' per unit area = intensity of load &

R be the radius of loaded area.

Boussinesq's solution can be used to determine σ_z.

Consider an elementary ring of radius r & width dr; Load in = $q \times (2\pi r) dr$.

The load acts at a constant radial distance r from point P.

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

Vertical stress due to entire load is given by

$$\sigma_z = \frac{3q}{z^2} \times \int_0^R \frac{r\,dr \times (z^2)^{5/2}}{(r^2+z^2)^{5/2}}$$

$$= 3q z^3 \int_0^R \frac{r\,dr}{(r^2+z^2)^{5/2}}$$

$$\sigma_z = 3q z^3 \int_{z^2}^{(R^2+z^2)} \frac{du}{2u^{5/2}}$$

Let $r^2+z^2 = u$. when $r=0$; $u = z^2$

$\therefore 2r\,dr = du$ when $r = R$; $u = R^2+z^2$.

$$\sigma_z = \frac{3qz^3}{2}\left[\frac{1}{u^{3/2}}\right]_{z^2}^{R^2+z^2} \times \left(-\frac{2}{3}\right)$$

$$= -qz^3\left[\frac{1}{(R^2+z^2)^{3/2}} - \frac{1}{(z^2)^{3/2}}\right]$$

$$= +qz^3\left[\frac{1}{z^3} - \frac{1}{(R^2+z^2)^{3/2}}\right]$$

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

or $\sigma_z = I_c \cdot q$

where $I_c = \left[1 - \left\{\frac{1}{1+\left(\frac{R}{z}\right)^2}\right\}^{3/2}\right]$

(influence coefficient of circular area)

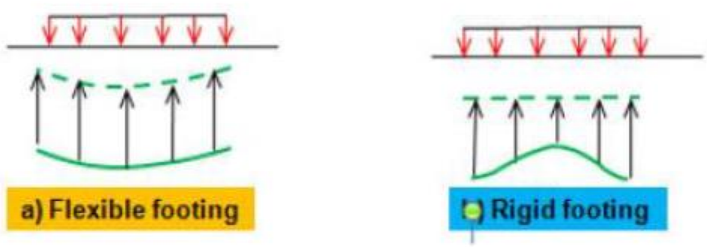
Let 2θ be the angle subtended at point P by load. then $\tan\theta = R/z$

$$I_c = \left[1 - \left\{\frac{1}{1+\tan^2\theta}\right\}^{3/2}\right]$$

$$\boxed{I_c = 1 - (\cos^2\theta)^{3/2} = 1 - \cos^3\theta}$$

2 (b) Explain with a neat sketch, the contact pressure distribution in clayey soils.

Ans:-



When the footing is flexible, it deforms into the shape of a bowel, with the maximum deflection at the centre. The contact pressure distribution is uniform If the footing is rigid, the settlement is uniform. The contact pressure distribution is minimum at the centre and the maximum at the edges(infinite theoretically). The stresses at the edges in real soil cannot be infinite as theoretically determined for an elastic mass.

2(c) A point load of 500 kN due to monument acts on the ground surface. Calculate the vertical pressures at point 5m directly below the load and at a distance of 4m from the load. Assume μ = 0. Use (1) Boussinesq's analysis (2) Westergaard's analysis.

Ans:-

3 b) $Q = 500$ kN, $z = 5$m, $r = 4$m, $\mu = 0$.

Boussinesq's analysis –

vertical pressure directly below 5m $= 0.4775 \times \frac{500}{5^2}$

$= 9.55$ kN/m^2

(σ_z) at $r = 4$m $= \frac{3Q}{2\pi}\left[\frac{1}{1+\left(\frac{r}{z}\right)^2}\right]^{5/2} \times \frac{1}{z^2}$

$= \frac{3 \times 500}{2\pi}\left[\frac{1}{1+\left(\frac{4}{5}\right)^2}\right]^{5/2} \times \frac{1}{5^2} = 2.77$ kN/m^2

Westergaards

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

σ_z directly below 5 m $= \frac{Q}{\pi z^2} = \frac{500}{\pi \times 5^2} = 6.366$ kN/m^2

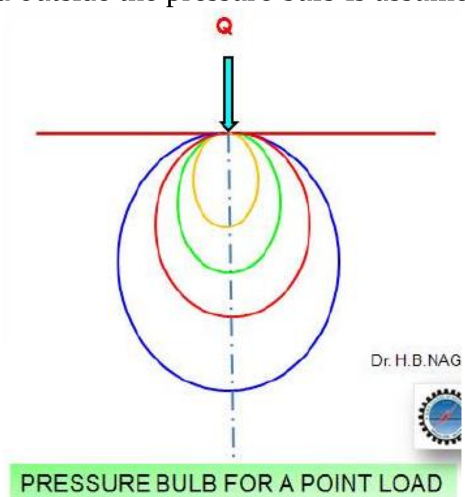
σ_z at $r = 4$m & $\mu = 0$ $= \frac{Q}{\pi z^2} \times \frac{1}{\left(1+2(r/z)^2\right)^{3/2}}$

$= \frac{500}{\pi \times 5^2} \times \frac{1}{\left(1+2(4/5)^2\right)^{3/2}} = 1.849$ kN/m^2

3 (a) What do you understand by pressure bulb? Illustrate with a sketch.

Ans:-

Isobar/pressure bulb 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.



3 (b) A square footing 1.2m*1.2m rests on a saturated clay layer 4m deep. W_L = 30% γ_{sat} = 17.8 kN/m^3, w= 28% and G=2.68. Determine the settlement if the footing transfers a load of 300 kN.

Ans:- H= 4m, $\Delta\sigma = P/(H + B)^2 = 11.09$ kPa, e = w*G/Sr = 0.75, $C_c = 0.009(30-10) = 0.18$

$\sigma = \gamma_{sub} * H/2 = 35.6$ kPa

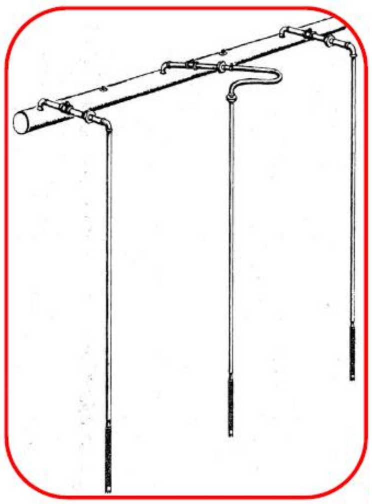
$$Sc = \left\{\frac{C_c}{1+e}\right\} * H * \log_{10}\left(\frac{\sigma + \Delta\sigma}{\sigma}\right)$$

$$Sc = \left\{\frac{0.18}{1+0.75}\right\} * 4 * \log_{10}\left(\frac{35.6 + 11.09}{35.6}\right)$$

= 0.0484m.

(c) Explain dewatering by well point system.

Ans:-



- ✓ A well point system consists of a number of well points spaced along a trench or around an excavation site.
- ✓ These well points in turn are all connected to a common header that are attached to one or more well point pumps.
- ✓ Well point assemblies-are made up of a well point, screen, riser pipe, and flexible hose swinger and joint with tuning.
- ✓ These are generally installed by jetting.
- ✓ They provide for entry of water into the system by creation of a partial vacuum.
- ✓ The water is then pumped off through the header pipe.

Advantages of well point system

- ✓ Installation is very rapid
- ✓ Requires reasonably simple and less costly equipment
- ✓ Water is filtered and carries little or no soil particles.
- ✓ There is less danger of subsidence of the surrounding ground than with open-sump pumping