APPLIED GEOTECHNICAL ENGINEERING (15CV53)
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:

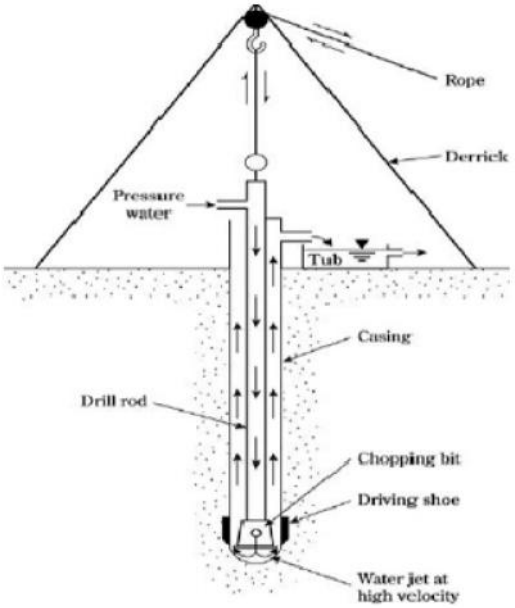
1. To know the geological condition of rock and soil formation.
2. To establish the groundwater levels and determine the properties of water.
3. To select the type and depth of foundation for proposed structure
4. To determine the bearing capacity of the site.
5. To estimate the probable maximum and 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
9. To ascertain the suitability of the soil as a construction material.
10. To determine soil properties required for design
11. Establish procedures for soil improvement to suit design purpose
12. To investigate the safety of existing structures and to suggest the remedial measures.

1 (b) List the different methods of boring. Explain any one method with a neat sketch.

Ans:- Depending upon the type of soil and purpose of boring, the various methods of boring are Auger boring, Wash boring, Percussion boring, Rotary drilling and Core drilling.

Wash Boring

- ✓ Wash boring relies on relatively little drilling action and can form a hole primarily by jetting. This can be undertaken with light equipment without the need for a drilling rig.



- ✓ Suitable for all types of soils but not for rocks and boulders.
- ✓ It consists of driving a casing through which a hollow drill rod with a sharp chisel at the lower end is inserted.

- ✓ Water is forced under pressure through the drill rod.
- ✓ The resulting chopping and jetting action of the bit and water disintegrates soil.

Cuttings are then forced up through the spacing between drill rod and casing.

1 (c) Establish the ground water level by Hvorslev's method, given the following data: depth up to which water table is bailed out =15m, water rise on 1st day=0.80m, water rise on 2nd day=0.70m, water ries on 3rd day=0.60m..

Ans:-

$H_o = h_1^2/(h_1 – h_2) = .0.8^2 / (.80 – .70) = 6.4$ m

$H_1= h_2^2/(h_1 – h_2) = .70^2 / (.80 – .70) = 4.9$ m

$H_2 = h_3^2/(h_2 – h_3) = .60^2 / (.70– .60) = 3.60$ m

1^{st} day $h_{w1} = H_w – H_o =$ <u>8.6 m</u>

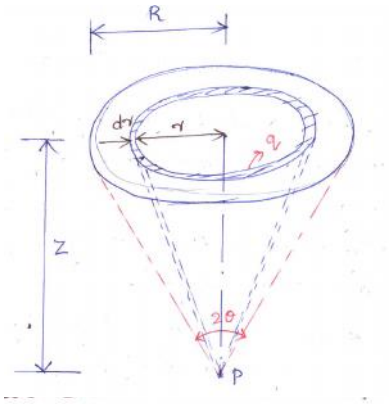
2^{nd} day $h_{w2} = H_w – (h_1 + h_2) - H_1 =$ <u>8.6 m</u>

3^{rd} day $h_{w3} = H_w – (h_1 + h_2 + h_3) - H_2 =$ <u>9.3 m</u>

$h_w = (h_{w1} + h_{w2} + h_{w3})/3 =$ <u>8.83 m</u>

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 = $q \times (2\pi r) dr$.

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

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

Vertical stress due to entire load is given by

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

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

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

Let $r^2+z^2 = u$.

$\therefore 2r\,dr = du$

when $r=0$; $u = z^2$

when $r=R$; $u = R^2+z^2$.

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

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

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

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

or $\sigma_z = I_c \cdot q$

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

(I_c → influence coefficient of circular area)

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

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

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

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

Ans:-

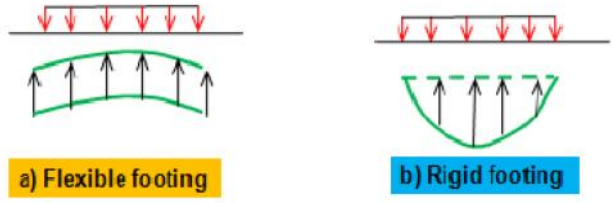


Fig a & b shows the qualitative contact pressure distribution under flexible and rigid footing resting on a sandy soil and subjected to a uniformly distributed load q. when the footing is flexible, the edges undergo a large settlement than at centre. The soil at centre is confined and therefore has a high modulus of elasticity and deflects less for the same contact pressure. The contact pressure is uniform. When the footing is rigid the settlement is uniform. The contact pressure is parabolic with zero intensity at the edge sand maximum at the centre.

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 axis of loading using Westergaard's analysis. Assume μ = 0.

Ans:-

$$\sigma = \left(\frac{Q}{2\pi Z^2}\right) * \left\{\frac{C}{\left[C^2 + \left(\frac{r}{Z}\right)^2\right)^{\frac{3}{2}}}\right\}$$

For Q= 500Kn, C= $1/\frac{\sqrt{(1-2\mu)}}{\sqrt{(2-2\mu)}}$ = 0.707, r=0, Z=5m, σ = 6.365 kN/m^2

For Q= 500Kn, C= $1/\frac{\sqrt{(1-2\mu)}}{\sqrt{(2-2\mu)}}$ = 0.707, r=4, Z=5m, σ = 1.848 kN/m^2

3 (a) Briefly explain the causes of foundation settlement.

Ans:-

1) Underground erosion:- It causes formation of cavities in subsoil which when collapse cause settlement.
2) Structural collapse of soil:- It happens due to the dissolution of materials responsible for inter granular bond of grains.
3) Thermal changes:- It causes settlement in expansive soils.
4) Frost heave:- Thaw leads to settlement. This mainly occurs in structures founded on frost suspectible soils.
5) Vibration and shocks:- They cause large settlement especially in cohesionless soils.
6) Mining subsidence:- Settlement occurs due to removal of minerals and other materials from mines below.
7) Land slides:- Settlement due to land slides can cause serious problems on unstable slopes.
8) Creep:- Foundation settlement may occur due to creep on clay slope.
9) Changes in vicinity:- Changes due to construction of a new building near existing foundation.

3 (b) A circular footing 2 m diameter is resting on the ground surface. The subsoil consists of fine sand of 6m depth underlain by 4m thick clay layer. The ground water table is 1m below ground level. The unit weights of sand above and below water table are 17.6 kN/m^3 and 20 kN/m^3 respectively. The properties of clay are w=40%, liquid limit=45% and G=2.72. Estimate the probable settlement if the footing transfers a uniformly distributed load of 300 kPa.

Ans:- H= 4m, Δσ = 300 kPa, e = w*G/Sr = 1.088, C_c = 0.009(45-10) = 0.315

γ_{sub}(clay) = (2.72-1)/(1+1.088)*10 = 8.24 kN/m^3

γ_{sub}(sand) = 20-10 = 10 kN/m^3

σ = (17.6*1) + (10*5) + (8.24*2) = 84.08 kPa

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

$$Sc = \left\{\frac{0.315}{1+1.088}\right\} * 4 * \log_{10}\left(\frac{84.08 + 300}{84.08}\right)$$

= 0.398m.

(c) Estimate the immediate settlement of a footing of size (2*3) m resting at a depth of 2m in sandy soil whose compression modulus is 10 N/mm^2 and the footing is expected to transmit a unit pressure of 160 kN/m^2. Assume μ=0.28 and I=1.06.

Ans:- μ=0.28, I=1.06, E = 10*10^{-3}*10^6 = 10,000 kPa, B= 2m, q = 160 kN/m^2

$$S_i = (1-\mu^2) * q * B * \frac{I}{E}$$

= (1-0.28^2)*160*2*1.06 / 10000

= 0.0312 m.