APPLIED GEOTECHNICAL ENGINEERING		CMRIT — CMR INSTITUTE OF TECHNOLOGY, BENGALURU. ACCREDITED WITH A+ GRADE BY NAAC

Internal Assessment Test 1 Solution

1	(a) With neat sketch explain seismic refraction method of soil exploration. Provide neat sketches wherever necessary.	[07]
	Principle, methodology, equations, sketches – 1+3+1+2	

When a shock or impact is made at a point on or in the earth, the resulting seismic (shock or sound) waves travel through the surrounding soil at speeds related to their elastic characteristics. The velocity is given by:

$$v = C\sqrt{\frac{Eg}{\gamma}}$$

where, v = velocity of the shock wave,
E = modulus of elasticity of the soil,
g = acceleration due to gravity,
γ = density of the soil, and
C = a dimensionless constant involving Poisson's ratio.

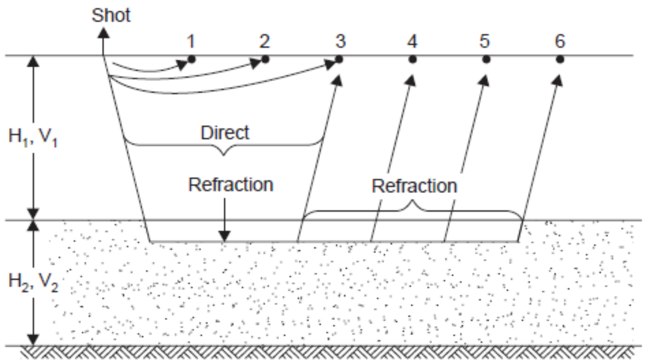
Principle:

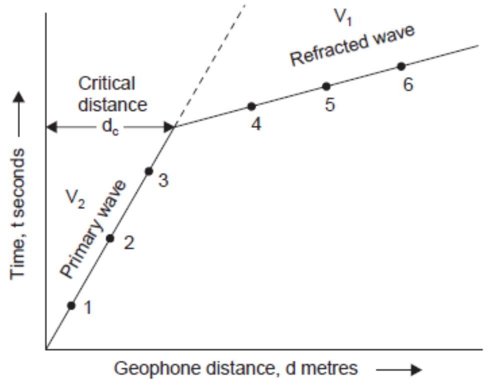
- A shock may be created with a sledge hammer hitting a strike plate placed on the ground or by detonating a small explosive charge at or below the ground surface.
- The radiating shock waves are picked up by detectors, called 'geophones', placed in a line at increasing distances, d1, d2, ..., from the origin of the shock.
- The time required for the elastic wave to reach each geophone is automatically recorded by a 'seismograph'.
- Some of the waves, known as direct or primary waves, travel directly from the source along the ground surface or through the upper stratum and are picked up first by the geophone.
- If the sub soil consists of two or more distinct layers, some of the primary waves travel downwards to the lower layer and get refracted as the surface.
- If the underlying layer is denser, the refracted waves travel much faster.
- As the distance from the source and the geophone increases, the refracted waves reach the geophone earlier than the direct waves.
- The distance of the point at which the primary and refracted waves reach the geophone simultaneously is called the 'critical distance' which is a function of the depth and the velocity ratio of the strata.
- The results are plotted as a distance of travel versus time graph, known as the 'time travel graph'.
- The reciprocal of the slope of the travel-time graph gives the velocity of the wave.
- Depth of the first layer is estimated as

$$H_1 = \frac{d_1}{2}\sqrt{\frac{v_2 - v_1}{v_2 + v_1}}$$

- Second layer thickness is estimated as:

$$H_2 = 0.85H_1 + \frac{d_2}{2}\sqrt{\frac{v_3 - v_2}{v_3 + v_2}}$$





(b) It is desired to establish the location of ground water table in a clayey material. The bore hole was bailed to a depth of 12 m below the ground level and the level of water in the bore hole was observed to rise by 0.8 m on next day and 0.7 m on second day and 0.6 m on third day. Estimate the ground water table. [07]

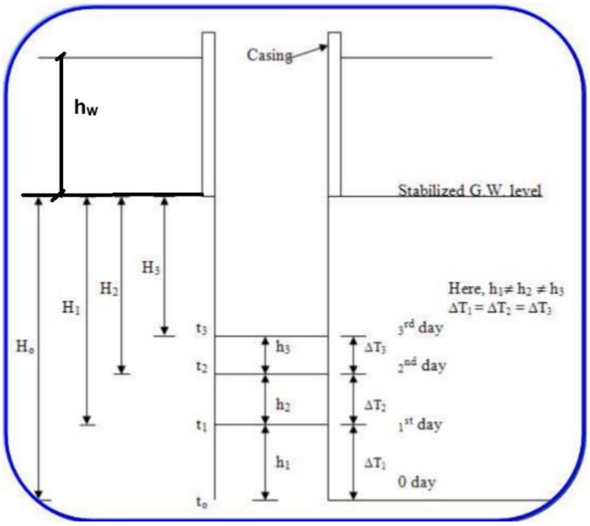
H_0; H_1; H_2, h_{w1}, h_{w2}, h_{w3}, average depth – 1 × 7 = 7

h_1 = 0.8 m
h_2 = 0.7 m
h_3 = 0.6 m

$$H_o = \frac{h_1^2}{h_1 - h_2} = \frac{0.8^2}{0.8 - 0.7} = 6.4\ m$$

$$H_2 = \frac{h_2^2}{h_1 - h_2} = \frac{0.7^2}{0.8 - 0.7} = 4.9\ m$$

$$H_3 = \frac{h_3^2}{h_2 - h_3} = \frac{0.6^2}{0.7 - 0.6} = 3.6\ m$$



Ground water table = 12 - h_w
Based on base ground level
$h_{w1} = (h_w + H_0) – H_0 = 12 – 6.4 = 5.6$ m
Based on H_2
$h_{w2} = (h_w + H_0) – (H_2+h_1+h_2) = 12 – (4.9+0.8+0.7) = 5.6$ m
Based on H_3
$h_{w3} = (h_w + H_0) – (H_3+h_1+h_2+h_3) = 12 – (3.6+0.8+0.7+0.6) = 6.3$ m

$$Average\ water\ table\ depth = \frac{1}{3} \times (5.6 + 5.6 + 6.3) = 5.83\ m$$

(c) List and explain different types of soil samples. Discuss on its suitability with respect to field applications [06]

Non representative, undisturbed and disturbed soil samples – 2 × 3 = 6

Samples are classified as

(i) Non-representative soil samples
(ii) Representative soil samples

Representative soil samples are further classified as

(a) Undisturbed and
(b) Disturbed soil samples

Non-representative Soil Sample

These are mixtures of soil from different soil strata. These samples are obtained by auger boring or sedimentation of wash boring. Such samples may help in determining the depth at which major changes in soil profile occur. In these samples, neither the structure, nor the moisture content nor the particles are preserved.

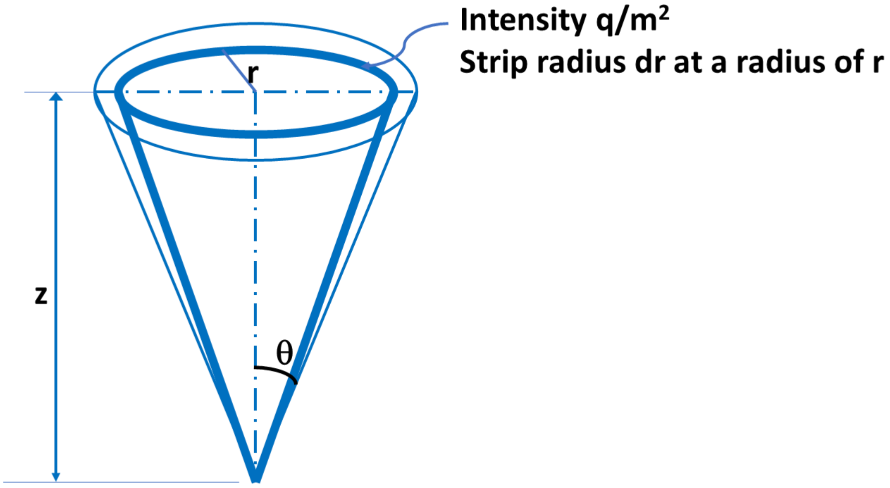
	Representative soil sample - undisturbed The soil sample, in which the particle size distribution as well as the soil structure and the properties of the in situ stratum, remain preserved, is termed as undisturbed soil samples. Such soil samples are required for shear strength, consolidation tests, permeability and consolidation characteristics. This soil samples can be collected by stopping the boring process at a certain level and then inserting the appropriate sampler below the bottom of the bore. Natural water content remains unaffected. Representative soil sample - Disturbed soil sample The soil sample which contains the same particle size distribution as in the in situ stratum, but the natural structure of sample gets partly or entirely disturbed and modified, it is called a representative or disturbed soil sample. These soils represent composition and the natural content of the soil. can be used to determine the index properties of soils such as grain size, plasticity characteristics and specific gravity.	
2	(a) List the assumptions of Boussinesq's theory of stresses in soil. Derive the equation for vertical stress below the centre of a circular area with uniform loadintensity 'q'	[07]

Assumptions

- Generally there exists no point loads/ Load will be spread over a finite area of the foorting
- Assume that the footing is flexible
- Contact pressure is uniform such that uniform load is distributed over the area of the base of the footing

Derivation

Let's determine the vertical stress at point P at a depth z below a uniformly loaded circular area. Let q be the intensity of load per unit area and R be the radius of the loaded area. Using Boussinesq's solution. σ_z is to be determined. Consider an elemental ring of radius dr at a radius r.



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

$$Q = \int_0^R q.2\pi r dr$$

$$\sigma_z = \frac{3}{2\pi z^2}.\int_0^R q.2\pi r dr.\left[\frac{1}{1+\left(\frac{r}{z}\right)^2}\right]^{5/2}$$

$$\sigma_z = \frac{3z^3}{2\pi}.\int_0^R q.2\pi r dr.\left[\frac{1}{z^2+r^2}\right]^{5/2}$$

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

$2rdr = du$

To change the limits

When r= 0; u = z^2

When r= R; u = $z^2 + R^2$

$$\sigma_z = \frac{3z^3}{\cancel{2\pi}}.\int_0^R q.\cancel{2\pi}rdr.\left[\frac{1}{z^2+r^2}\right]^{5/2}$$

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

$$\sigma_z = \frac{3z^3 q}{2}.\left[\frac{du}{u^{3/2}}\right]_{z^2}^{z^2+R^2}.\left[\frac{-2}{3}\right]$$

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

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

$$tan\theta = \frac{R}{z}$$

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

$As\ \theta\ tends\ to\ 0, I_c\ tends\ to\ 1$

$When\ uniformly\ loaded\ area\ tends\ to\ be\ large,$

$vertical\ stress\ will\ be\ close\ to\ q. Similarly\ when\ \ is\ not\ below, solution\ becomes\ compl$

$Such\ cases\ solution\ is\ possible\ through\ isobars.$

(b) Explain construction and uses of Newmark's influence chart. [07]

Construction – 4

Uses - 3

Sometimes its required to determine vertical stresses under uniformly loaded areas of other shapes. For such cases Newmark's influence charts are extremely useful. This is a simple graphical method to evaluate the stresses at any particular depth caused due to any shape of vertical uniformly distributed loading in the interior of a homogenous elastic and isotropic medium.

The ratio R/z is called as relative size or relative radius of circular loaded bearing area, which gives a particular value of vertical stress to applied load. The ratio $\frac{\sigma_z}{q}$ range from 0 to 1. For a given depth, a number of concentric circles can be drawn.

For a given depth we can draw concentric circles for different stress intensities. 10 circles can be drawn. First circle has zero radius. Eleventh circle will have infinite radius. Hence only 9 circles are drawn. Each circle causes a stress of q/10, at a point beneath the centre at the specified depth z since the number of annular space is 10.

If the circles are divided into 20 equal parts. So each sector = q/(10×20) = q/200 = 0.005 q

This value of 0.05 is called as influence value or influence factor (I) of the chart.

Construction of Newmark's influence chart

1. For a given depth, R can be determined
2. With this R, draw concentric circles at a convenient scale say 1 cm = 2 m or 2cm = 1 m or so on.
3. Draw equally spaced rays to get the influence value

4. At the side draw a line AB, representing the depth z to the scale used in the constriction of the chart.
5. If ‘s’ is the number of rays drawn, and c is the annular space, influence value of the chart is (1/(c×s))
6. If the stress is required for another depth, a fresh plan is made such that the new depth = distance AB on the chart.

Application of Newmark’s chart

1. Plan of the loaded area is made on a tracing sheet to the same scale as the line segment AB on the chart representing the depth z.
2. Let be the point where stresses are required.
3. Now place he tracing sheet over the chart such that the point P coincides exactly with the centre
4. Count the number of meshes, vertical stress

$$\sigma_z = I.n.q$$

Where I is the influence value = (1/(c×s))

n – number of meshes under the loaded area

q – uniformly distributed load

(c) A concentrated load of 960 kN load acts vertically at the ground surface. Determine the vertical stress at a point which is at a) depth of 3.0 m below the load b) at a depth of 3 m and a radial distance of 2 m. [06]

Case 1 – 3

Case 2 - 3

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

Case 1:

r = 0 and z = 3 m; Q = 960 kN

$$\sigma_z = \frac{3}{2\pi \times 3^2}.\frac{960}{\left[\left(\left(\frac{0}{z}\right)^2+1\right)\right]^{\frac{5}{2}}} = 50.93\ kPa$$

Case 2:

r = 2 m and z = 3 m; Q = 960 kN

$$\sigma_z = \frac{3}{2\pi \times 3^2}.\frac{960}{\left[\left(\left(\frac{2}{3}\right)^2+1\right)\right]^{\frac{5}{2}}} = 35.26\ kPa$$

3 (a) Explain the terms pressure bulb and isobar. Also explain significant depth. [05]

Isobar, pressure bulb, significant depth – 2+2+1

This is curve joining the points of equal stress intensity, otherwise it’s a curve of equal stress.

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

$$Let\ \sigma_z = 0.1\ Q = I_B.\frac{Q}{z^2}$$

$$I_B = 0.1 \times z^2$$

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

$$At\ r = 0;\ \sigma_z = 0.1\ Q = 0.4775.\frac{Q}{z^2}$$

$$r = 2.185\ m$$

Isobars are useful for determining the effect of the load on the vertical stress at various points. The zone within which the stresses have a significant effect on the settlement is known as pressure bulb. It is generally assumed as an isobar of 0.1 Q. the area outside the pressure bulb will have negligible stresses.

The shape of an isobar approaches a lemniscate curve

Isobars of other stress intensity can also be drawn. The isobars of higher intensity shall be within the isobar of 0.1Q.

Significant depth is that depth at which vertical stress is 10% of load intensity.

(b) What is stabilization of bore holes and its importance? Explain bentonite slurry method. [05]

Definition, explanation, advantages and disadvantages – 1+2+1+1

The support provided over depth for borehole is called as stabilisation of boreholes. The methods for bore hole stabilisation are

(i) Steel casing – hydraulically pushed

(ii) Drilling mud – Bentonite slurry

Stabilisation using drilling mud:

Bentonite slurry is a thin mixture of water and bentonite clay which when mixed in powdered form with drilling water created high density suspension.

Advantages:

- It is more viscous, therefore lift cuttings will be at a lower velocity
- It will cake the edges of the borehole and the outside of the core and will largely eliminate the seepage of water out of the borehole thus reducing problems of loss of return.
- Smaller volumes of flush fluid will be required and the fluid may be recirculated via a settling tank (where the cuttings are allowed to drop out of suspension.
- Cake formed on the outside of the borehole has the effect of considerably improving borehole stability and the prevention of softening of weak rock cores.

Disadvantages:

- Difficult to dispose the bentonite mixed soil cake at the end of drilling of a borehole.
- Bentonite mud must be properly mixed using appropriate equipment, inorder to ensure that it is of the correct consistency and does not contain unmixed dry bentonite lumps, capable of clogging flush path in the borehole.

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