CMR INSTITUTE OF TECHNOLOGY

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Improvement Test solutions

Sub:	Basic Geotechnical Engineering							Code:	15CV45
Date:	29 / 05 / 2017	Duration:	90 mins	Max Marks:	50	Sem:	IV	Branch:	CIVIL

Note: Answer all questions. Assume any missing data suitably. Answer to the point. Provide neat sketches whereever necessary

		Marks
1(a)	In a falling head permeability test, the length and area of cross section of specimen are 0.17 m and 21.8×10^{-4} m^2 respectively. Calculate the time required for the head to drop from 0.25 m to 0.10 m. The cross sectional area of stand pipe is $2\times10^{-4}m^2$. The sample has three layers having permeability's 3×10^{-5}m/s for first layer of 0.06 m, 4×10^{-5}m/s for second 0.06 m and 6×10^{-5}m/s for third 0.05 m height. Assume the flow is taking place perpendicular to the bedding plane.	[8]
	Average permeability (3) Equation (2) Time (3)	

$$k_v = \frac{z}{\frac{z1}{k1}+\frac{z2}{k2}+\frac{z3}{k3}} = \frac{(0.06+0.06+0.05)}{\frac{0.06}{3\times10^{-5}}+\frac{0.06}{4\times10^{-5}}+\frac{0.05}{6\times10^{-5}}} = 3.923\times10^{-5}m/s$$

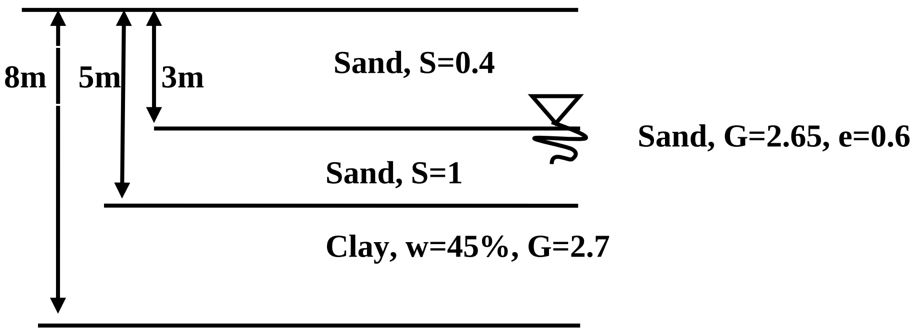
$$k = \frac{2.303\times aL}{At}\times log_{10}\left[\frac{h_1}{h_2}\right]$$

$$k = \frac{2.303\times2\times10^{-4}\times0.17}{21.8\times10^{-4}\times t}\times log_{10}\left[\frac{0.25}{0.1}\right]$$

$$3.923\times10^{-5} = \frac{0.014297}{t}$$

t=364.26 sec

		Marks
(b)	A deep clay stratum underlies sand strata of 5m thickness. The ground water table is found at 3 m from GL. For sand G=2.65 and e=0.6. The sand above water table is 40% saturated. For clay if natural water content is 45% and G=2.7, draw total, effective and neutral pressure variation diagrams upto a depth of 8m from GL.	[8]
	Sketch – 1 Property determination- 2 Computation of stresses-3 Pressure distribution-2	



Density of sand layer

$$\gamma_{sat} = \frac{\gamma_w(G+eS)}{1+e}$$

When S=0.4

$$\gamma = \frac{10(2.65+0.6\times0.4)}{1+0.6} = 18 \text{ kN/m}^3$$

When S=1

$$\gamma_{sat} = \frac{10(2.65+0.6\times1)}{1+0.6} = 20.31 \text{ kN/m}^3$$

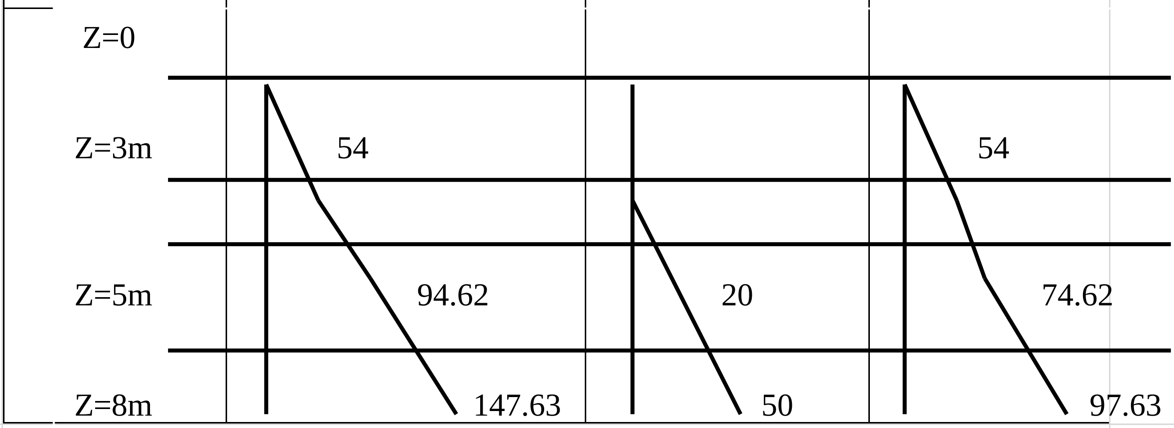
Density of clay layer

$eS=wG;$ $\quad e\times1=0.45\times2.7$

e=1.215

$$\gamma_{sat} = \frac{10(2.7+1.215\times1)}{1+1.215} = 17.67 \text{ kN/m}^3$$

Depth below ground surface	σ, kPa	u, kPa	σ', kPa
Z=0	0	0	0
Z=3m	=18×3=54	0	=54-0=54
Z=5m	=54+20.31×2=94.62	=10 ×2 = 20	=94.62-20=74.62
Z=8m	=94.62+17.67×3=147.63	=20+10 ×3 = 50	=147.63-50=97.63



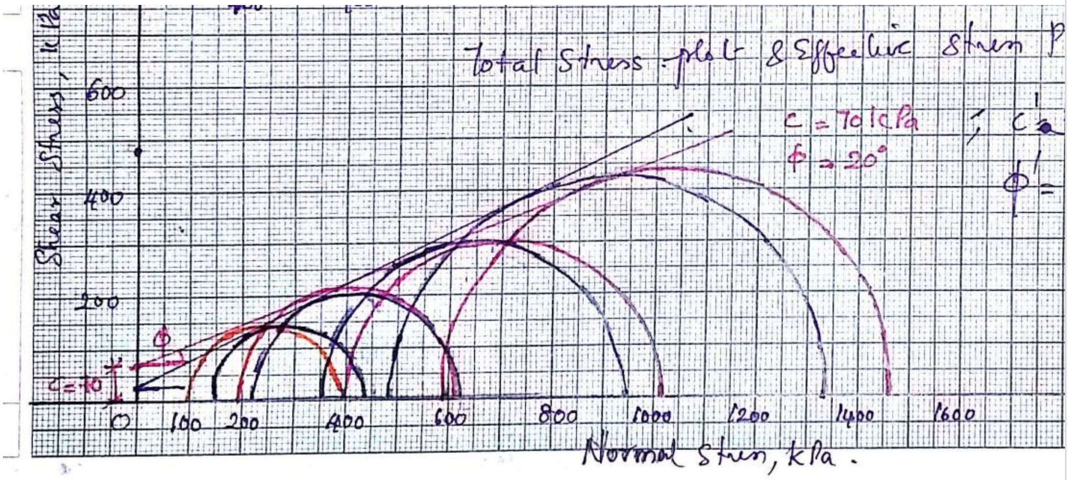
(c) A consolidated undrained test was carried out on a clay sample and the results are as follows: [8]

Cell pressure, kPa	100	200	400	600
Deviator stress, kPa	300	410	610	850
Pore water pressure at failure, kPa	-45	-15	+50	+110

Find the total and effective shear parameters of soil.

Major principal stress, effective major and minor principal stress (3)
Mohr's circle (3)
Shear parameters with units (2)

Cell pressure, kPa,σ3, kPa	100	200	400	600
Deviator stress, kPa	300	410	610	850
Pore water pressure at failure, kPa	-45	-15	50	110
Major Principal stress, σ1, kPa	400	610	1010	1450
Effective major principal stress, σ1', kPa	445	625	960	1340
Effective minor principal stress, σ3', kPa	145	215	350	490



2(a) Define sensitivity and thixotropy of clays.
A shear vane of 75 mm diameter and 110 mm length was used to measure the shear strength of soft clay. If a torque of 600 N-m was required to shear the soil, calculate the shear strength of soft clay. The vane was then rotated rapidly to cause remoulding of the soil. The torque required in the remoulded state was 200 N-m. Determine the sensitivity of the soil. [6]

Definition (2)
Undrained shear strength (1.5)
Remoulded shear strength (1.5)
Sensitivity (1)

Sensitivity is the measure of loss of strength with remoulding. Sensitivity, S_t is defined as the ratio of unconfined compressive strength of clay in undisturbed state to unconfined compressive strength of same clay in remoulded state at unaltered water content.

The word Thixotropy is derived from two words: *thixis meaning touch and tropo meaning to change*. Therefore thixotropy means any change that occurs by touch.

If a remoulded soil is allowed to stand, without loss of water, it may regain some of its lost strength. In soil engineering, this gain in strength of the true soil with passage of time after it has been remoulded is called thixotropy. It is mainly due to a gradual re orientation of water molecules in the absorbed water layer and due to re establishment of chemical equilibrium.

	Thixotropy of soils is of great importance in soil engineering. For example, when a pile is driven into ground, the loss of strength occurs due to disturbance caused. Thixotropy indicates how much shear strength will be regained after the pile has been driven and left in place for some time. D=0.075m H=0.11 $$c_u = \frac{T}{\pi d^2\left[\frac{H}{2}+\frac{d}{6}\right]}$$ $$c_u = \frac{600}{\pi \times 0.075^2\left[\frac{0.11}{2}+\frac{0.075}{6}\right]}$$ $$c_u = 503\ kPa$$ Remoulded cohesion, $$c = \frac{200}{\pi \times 0.075^2\left[\frac{0.11}{2}+\frac{0.075}{6}\right]} = 167.7 \text{ kPa}$$ $Sensitivity, S_t = \frac{503}{167.67} = \frac{600}{200} = 3$	
(b)	List and explain the factors affecting permeability of soils.	[6]
	Explanation on 6 different factors (6)	
	In soils, the interconnected pores provide passage for water. A large number of such flow paths act together, and the average rate of flow is termed the coefficient of permeability, or just permeability. It is a measure of the ease that the soil provides to the flow of water through its pores. The different factors affecting permeability are (a) Particle size (b) Structure of soil mass (c) Shape of particles (d) Void ratio (e) Properties of water (f) Degree of saturation (g) Adsorbed water (h) Impurities in water For a laminar flow, coefficient of permeability of soil can be given as $$k = C\left[\frac{\gamma_w}{\mu}\right]\left[\frac{e^3}{1+e}\right]D2$$ This expression can be used to explain the different factors affecting permeability. i. Particle size: Coefficient of permeability is dependent upon the square of the particle size	

D. Higher the particle size, higher is the permeability.

ii. Structure of soil mass:

The coefficient C, takes into account the shape of flow passage. The size of flow passage depends upon the structural arrangement. For the same void ratio, the permeability is more in case of flocculated structure as compared to dispersed structure.

iii. Shape of particles

Angular particles have greater specific surface area as compared to rounded particles. For the same void ratio, angular particles are less permeable than those with rounded particles as the permeability is inversely proportional to specific surface.

iv. Void ratio

Greater the void ratio, greater is the permeability.

v. Properties of water

Coefficient of permeability is directly dependent on unit weight of water and inversely proportional to its viscosity. Since viscosity is dependent upon temperature, coefficient of permeability is dependent upon temperature.

vi. Degree of saturation

Presence of air in soil causes blockage to the flow of water. So if the soil is not saturated, coefficient of permeability decreases.

vii. Adsorbed water

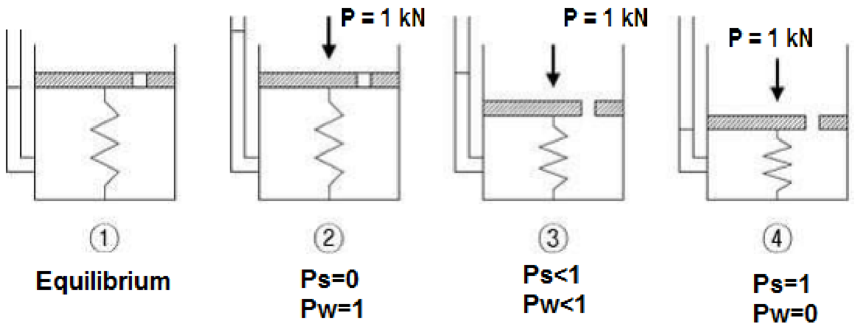
Fine grained soils have a layer of adsorbed water around it and this will not mover under gravity. It causes an obstruction to flow passage. Thus coefficient of permeability decreases with presence of adsorbed water.

viii. Impurities in water

Foreign matter has a tendency to block the flow passage and reduce the effective voids. Thus coefficient of permeability decreases if impurities are present in water.

(c) With help of neat sketches explain spring analogy for consolidation. [6]

Figure -1
Explanation- 5

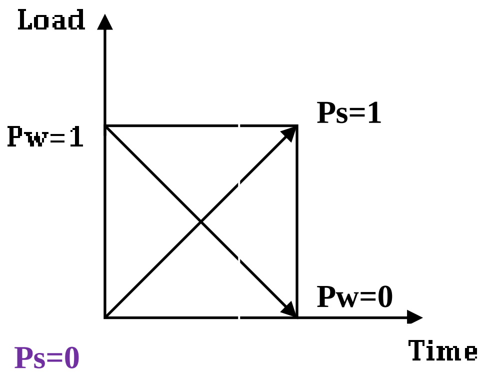


The consolidation process is often explained with an idealized system composed of a spring, a container with a valve in its cover, and water. In this system, the spring represents the compressibility or the structure itself of the soil, and the water which fills the container represents the pore water in the soil.

- The container is completely filled with water, and the valve is closed. (Fully saturated soil)

- A load of 1 kN is applied onto the cover, while the valve is still unopened. At this stage, only the water resists the applied load. (Development of excessive pore water pressure)
- As soon as the valve is opened, water starts to drain out through the valve and the spring shortens. (Drainage of excessive pore water)

After some time, the drainage of water no longer occurs. Now, the spring alone resists the applied load. (Full dissipation of excessive pore water pressure. End of consolidation)



3 (a)	Explain briefly UU, CU and CD tests.	[4]
	Explanation of different tests (1.5×2+2)	

In shear tests, there are basically three stages:

(1) Saturation stage

(2) Consolidation stage

(3) Shearing stage

In saturation stage, to simulate the weakest condition, the soil is saturated. This is called as saturation stage.

In consolidation stage, the excess pore water pressure developed in the sample is may be allowed to drain off. If the excess pore water pressure is drained off , it is called as consolidated sample, designated as C. If the excess pore water pressure is not made to dissipate, it is called as unconsolidated sample, designated as U

During shearing stage, within the saturated sample, pore water pressure is developed on application of deviator stress. If the excess pore water pressure developed in the sample is made to drain off it is called as drained test, designated as D. If the excess pore water pressure developed in the sample is made to not allowed to drain, pore water pressure develops and it is called as undrained test, designated as U. in undrained test, pore water pressure measurement is involved.

UU tests- Unconsolidated Undrained test: This is the quickest test, because neither consolidation is involved or drainage is involved. It is appropriate for immediate safety of foundations and structures resting on clays where the permeability is low. It is also applicable to determine embankment stability where immediate rapid drawdown can occur.

Long term stability of slopes, embankments and earth supporting structures in cohesive soils require the use of effective strength parameters. Hence on such soils, tests are conducted with pore water pressure measurements or drainage measurements.

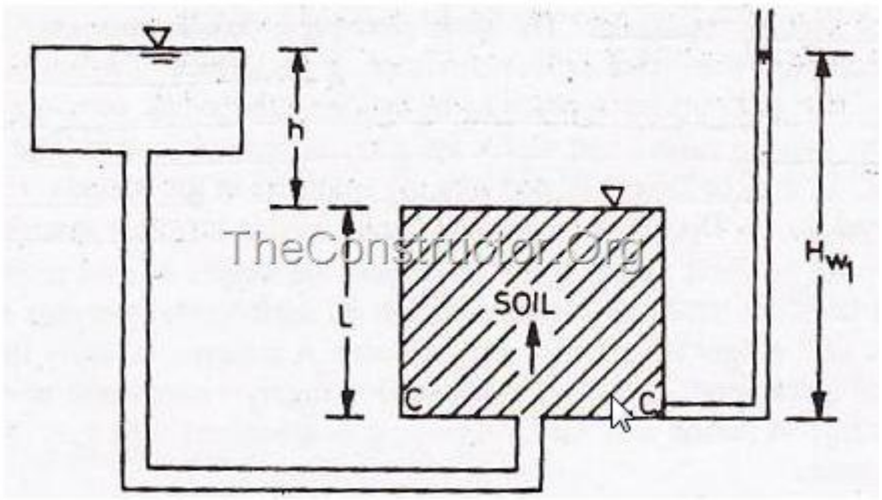
CU tests- Consolidated Undrained test- Generally for soils with low permeability, to evaluate long term stability, CU tests are conducted wherein no pre water pressure measurements are involved.

CD tests- Consolidated Drained test- Generally for granular soils with high permeability, to evaluate long term stability, CD tests are conducted wherein drainage is involved.

(b)	Explain quick sand condition and critical hydraulic gradient. Also derive an expression for critical hydraulic gradient.	[4]

Definition of quick sand condition and critical hydraulic gradient (1)
Expression (3)

The effective stress is reduced due to upward movement of flow of water. When the head causing upward flow is increased, a stage is reached when the effective stress is reduced to zero. The condition so developed is known as quick sand condition. Quick sand is not any special type of sand, but it is a condition of zero effective stress in cohesionless soils.



From the above figure

$\sigma' = \sigma - u$

$\sigma' = \gamma_{sat} L - \gamma_w H_{w1}$

$\sigma' = \gamma_{sat} L - \gamma_w h - \gamma_w L$

$\sigma' = \gamma_{sub} L - \gamma_w h$

When effective stress becomes equal to 0, $\sigma' = \gamma_{sub} L - \gamma_w h$ or

$h/L = \gamma_{sub} / \gamma_w$ ______________________ (1)

$\gamma_{sub} = \gamma_{sat} - \gamma_w$ ____________________ (2)

But

$$\gamma_{sat} = \frac{\gamma_w(G+eS)}{1+e} = \frac{\gamma_w(G+e)}{1+e}$$

Therefore, $\gamma_{sub} = \gamma_{sat} - \gamma_w$

$$\gamma_{sub} = \frac{\gamma_w(G+e)}{1+e} - \gamma_w = \frac{\gamma_w[G+e-1-e]}{1+e} = \frac{\gamma_w(G-1)}{1+e} \text{ \_\_\_\_\_\_\_\_\_\_ (3)}$$

Substituting (3) in (1)

$$\frac{h}{L} = \frac{\gamma_{sub}}{\gamma_w} = \frac{\gamma_w(G-1)}{1+e} \times \frac{1}{\gamma_w} = \frac{(G-1)}{1+e} = i_c$$

This *ic* is called as critical hydraulic gradient.

When G=2.67 and e=0.67, ic becomes equal to 1 or effective stresses are reduced to zero.

If the critical gradient is exceeded, the soil moves upward, and the soil surface appears to be boiling. The quick condition is also known as boiling condition. During this stage, a violent and visible agitation of particles occurs. The discharge suddenly increases due to an increase in the coefficient of permeability occurred in the process. If a weight is placed on the surface of the soil, it sinks down. The soil behaves as a liquid having no shear strength.

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