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CMR INSTITUTE OF TECHNOLOGY, BENGALURU.
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Internal Assessment Test 3 – January. 2023

Sub:	Basic Geotechnical Engineering					Sub Code:	18CV54	Branch:	Civil Engg	
Date:	23.01.2023	Duration:	90 min’s	Max Marks:	50	Sem / Sec:	5 A			OBE

Answer any FIVE FULL Questions

		MARKS	CO	RBT
1 (a)	Define Darcy’s law. Derive the Laplace equation for seepage flow.	[10]	CO2	L3
2 (a)	State the characteristics and uses of flow nets.	[10]	CO3	L2
3 (a)	Explain Mohr-Coulomb failure theory of soils.	[10]	CO3	L2
4 (a)	Explain sensitivity and thixotropy of clay.	[10]	CO4	L2
5 (a)	Explain with a neat sketch, determination of pre-consolidation pressure by casagrandes’s method and also explain spring analogy theory of consolidation of soil	[10]	CO5	L2
6 (a)	The following data relate to a triaxial compression tests performed on a soil sample: And determine the total & effective stress parameters of soil.	[10]	CO4	L3
7 (a)	Explain Vane shear test with neat sketch.	[10]	CO5	L2

Data for Question 6:

Chamber pressure(σ3)	***Max. deviator stress*** **(σ1 – σ3)**	**Pore pressure at maximum deviator stress (u)**
80 kN/m^2	**175kN/m^2**	**45 kN/m^2**
150 kN/m^2	**240 kN/m^2**	**50 kN/m^2**
210 kN/m^2	**300 kN/m^2**	**60 kN/m^2**

CMRIT
Department of Civil Engineering

IAT 3 scheme &solution Odd 2022 23

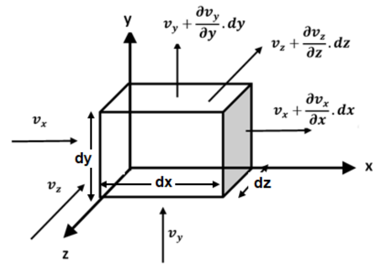
Subject: Basic Geotechnical Engineering (18CV54)

1. **Define Darcy's law. Derive the Laplace equation for seepage flow.**

Answer:

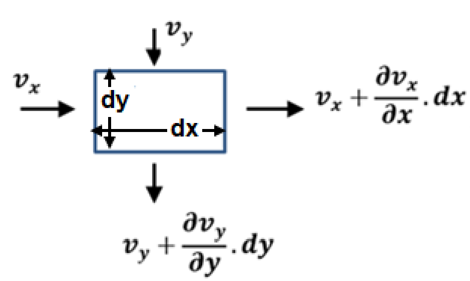
Darcy's Law: Darcy's law says that **the discharge rate q is proportional to the gradient in hydraulic head and the hydraulic conductivity** (q = Q/A = -K*dh/dl). 1M

Laplace equation is derived for 3D or 2D flow. The three-dimensional representation of flow is given in Figure below



Consider a controlled volume dx.dy.dz. Let vx, vy and vz be the velocity of water with which it enters the controlled volume. Let the velocity with which the water leave the section be

$vx+\partial vx/\partial x.dx$
$vy+\partial vy/\partial y.dy$
$vz+\partial vz/\partial z.dz$
$vx+\partial vx/\partial x.dx-$
means velocity∂'vx'increases for a small distance of∂'x'. For a distance dx velocity becomes ∂vx∂x.dx.
For a 2 Flow the same may be presented as follows in Fig below



According to continuity equation, inflow= outflow. Let the section be of unit width
Net loss in volume = 0

$$\left[v_x+\frac{\partial v_x}{\partial x}.dx-v_x\right]dy.1+\left[v_y+\frac{\partial v_y}{\partial y}.dy-v_y\right]dx.1=0 \quad \text{\_\_\_\_\_\_\_\_\_}(1)$$

$$\frac{\partial v_x}{\partial x}.dxdy.1+\frac{\partial v_y}{\partial y}.dxdy.1=0 \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_}(2)$$

3M

$$\frac{\partial v_x}{\partial x}+\frac{\partial v_y}{\partial y}=0 \quad \text{\_\_\_\_\_\_\_\_\_\_\_}(3)$$

$$v=ki=k\frac{h}{L} \quad v_x=-k_x\frac{\partial h}{\partial x} \quad \text{\_\_\_\_\_\_\_}(4)$$

$$v_y=-k_y\frac{\partial h}{\partial y} \quad \text{\_\_\_\_\_\_\_}(5)$$

Substituting (5) and (6) in (3) $\frac{\partial\left(-k_x\frac{\partial h}{\partial x}\right)}{\partial x}+\frac{\partial\left(-k_y\frac{\partial h}{\partial y}\right)}{\partial y}=0$ ___________(7)

$$-k_x\frac{\partial^2 h}{\partial x^2}+-k_y\frac{\partial^2 h}{\partial y^2}=0 \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_}(8)$$

3M

For isotropic flow, kx = ky = k. So Equation (8) gets reduced to

$$\frac{\partial^2 h}{\partial x^2}+\frac{\partial^2 h}{\partial y^2}=0 \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_}(9)$$

Equation (9) is called as Laplace equation in terms of head.

Velocity potential □ is given as □ = -kh________(10)

$$\frac{\partial \emptyset}{\partial x}=v_x=-k_x\frac{\partial h}{\partial x} \quad \text{\_\_\_\_\_\_\_\_}(11) \quad \frac{\partial \emptyset}{\partial y}=v_y=-k_y\frac{\partial h}{\partial y} \quad \text{\_\_\_\_\_\_\_\_}(12)$$

Substituting the values of □ in (9), we get Laplace equation in terms of velocity potential $\frac{\partial^2 \emptyset}{\partial x^2}+\frac{\partial^2 \emptyset}{\partial y^2}=0$ ____________(13)

If the soil is anisotropic, then an imaginary section is assumed such that it has a uniform k value given as

$k=\sqrt{k_x.k_y}$ 3M

2. State the characteristics and uses of flow nets.

Answer: A flow net for an isometric medium is a network of flow lines and equipotential lines intersecting at right angles to each other. The path which a particle of water follows in its course of seepage through a saturated soil mass is called a flow line. Equipotential lines are lines that intersect the flow lines at right angles. At all points along an equipotential line, the water would rise in piezometric tubes to the same elevation known as the piezometric head. 4M

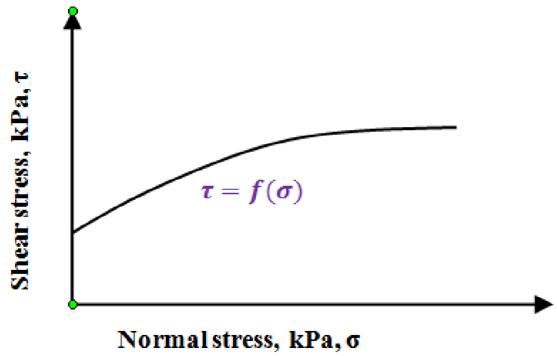
Properties of flownet

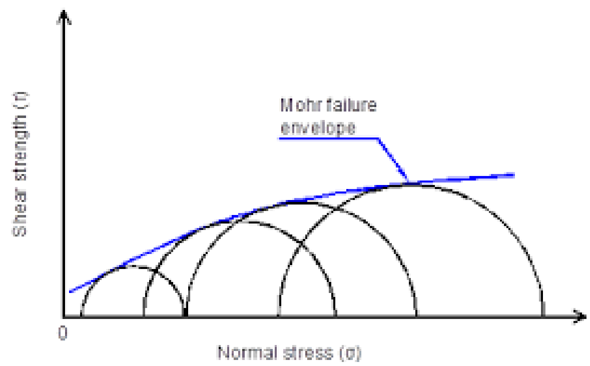
1. Flow and equipotential lines are smooth curves.
2. Flow lines and equipotential lines meet at right angles to each other
3. No two flow lines cross each other.
4. No two flow or equipotential lines start from the same point.
5. Discharge Δq between two flow lines remains constant. Similarly drop in head Δh remains constant between two equipotential drops.
6. The ratio of length and width of each field is constant. Its always considered as squares. 6M

3. Explain Mohr-Coulomb failure theory of soils.

Answer:

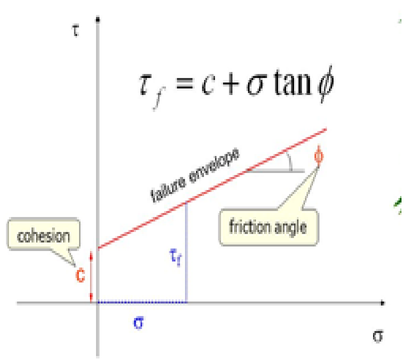
Shear strength of a soil represents the resistance to shear stresses. According to Mohr, failure is caused by a critical combination of normal and shear stresses as represented by equation (1).
Or $\tau = f(\sigma)$ ---- (1)
Graphically equation (1) will be curved in shape as seen in Fig. At failure, the Mohr failure envelope will be tangential to the Mohr's circle. 2M

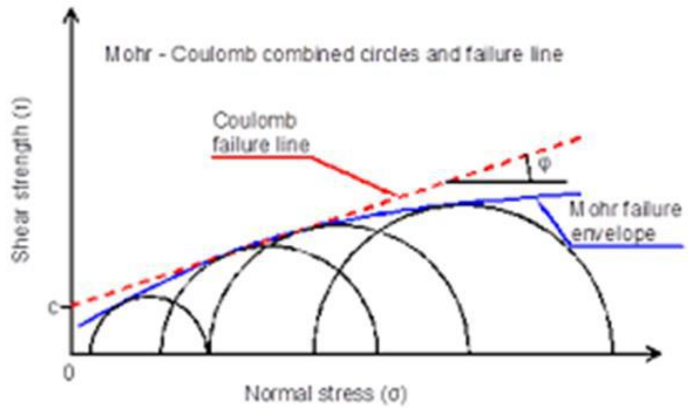




3M

Coulomb modified Mohr's theory by stating that shear strength of soil is dependent on two parameters: cohesion between the soil particles and the friction between the particles. Accordingly Equation (1) was modified and the equation for modified failure envelope is given by Equation (2). Mohr's modified failure envelope is given in Fig.5.2
$\tau = c + \sigma \tan\varphi$ ---- (2) 2M





3M

4. Explain sensitivity and thixotropy of clay.

Answer:

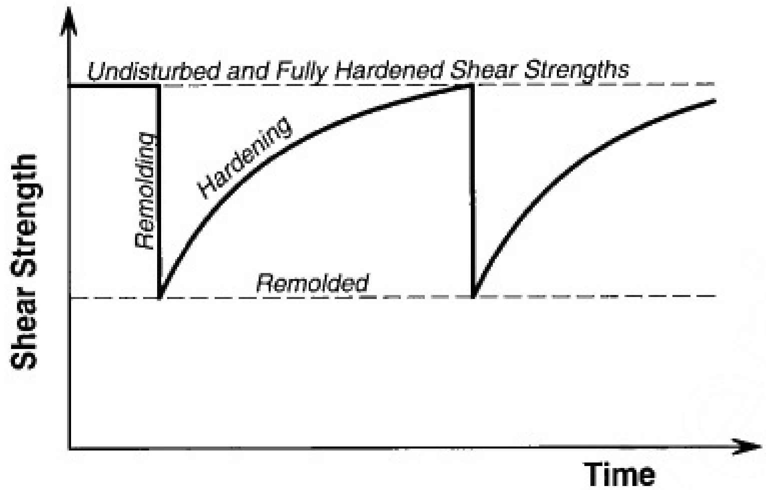
Sensitivity is the measure of loss of strength with remoulding. Sensitivity, St is defined as the ratio of unconfined compressive strength of clay in undisturbed state to unconfined compressive strength of same clay in remoulded state at unaltered water content.

$St = qu(undisturbed)/qu(remoulded)$

S. No	**Classification**
1-4	Normal
4-8	Sensitive
8-15	Extra-sensitive
>15	Quick

5M

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 remolded 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 remolded is called thixotropy. 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. 3M

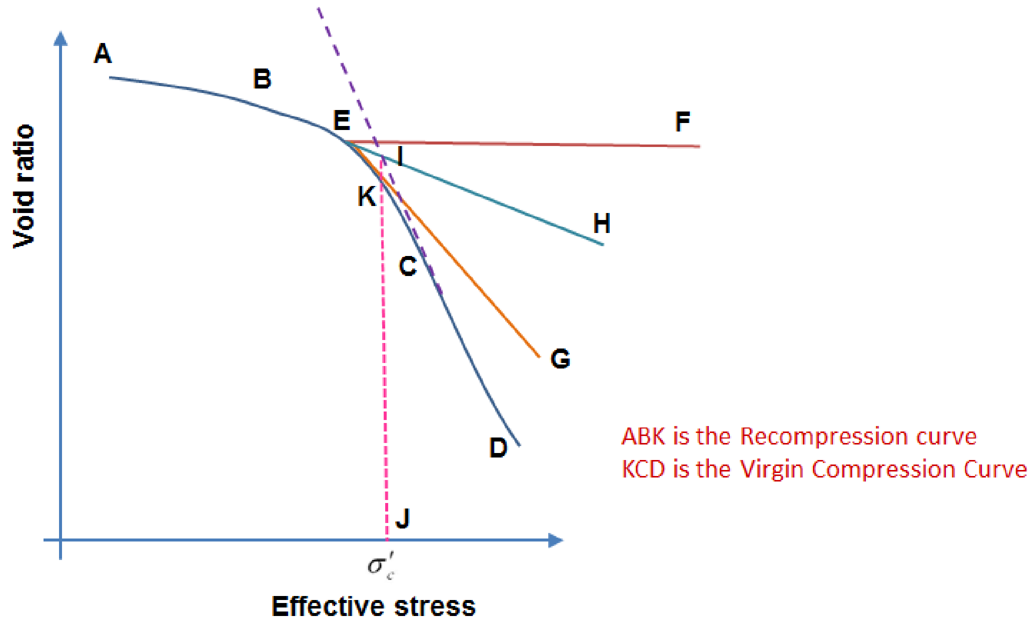


2M

5. **Explain with a neat sketch, determination of pre-consolidation pressure by casagrandes's method and also explain spring analogy theory of consolidation of soil.**

Answer:

The maximum pressure to which the soil has been subjected to it, in the past is called as preconsolidation pressure. Casagrande's method for estimating preconsoldiation pressure is as explained below:
1. Plot void ratio vs effective stress variation and mark it as ABCD.
2. Choose by eye the point of maximum curvature on the consolidation curve Say E.
3. Draw a horizontal line from this point, line EF.
4. Draw a line tangent to the curve at the point E, line EG.
5. Bisect the angle made from the horizontal line EF and the tangent line EG. Name the bisector as EH.
6. Extend the "straight portion" of the virgin compression curve (high effective stress, low void ratio: almost vertical on the right of the graph) up to the bisector line DG so as to intersect at I.
7. Drop vertical IJ and the abscissa of IJ indicate pre consolidation pressure.
8. Vertical IJ intersect e-log $\bar{\sigma}$ curve at K, Curve ABK indicates recompression curve and curve KCD indicate virgin compression curve. 4M



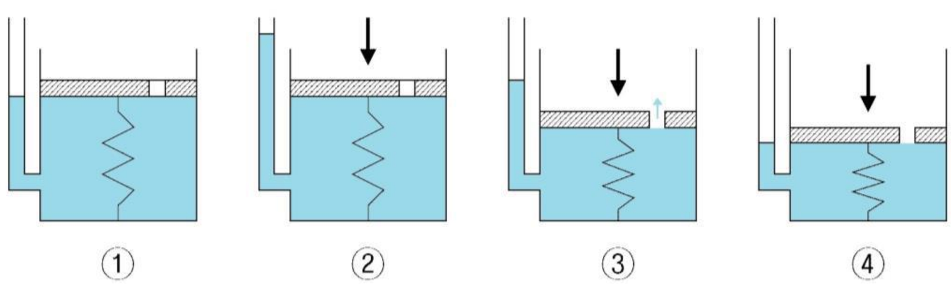
2M

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 hole is closed. (Fully saturated soil)

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

3M



1M

6. **The following data relate to a triaxial compression tests performed on a soil sample: And determine the total & effective stress parameters of soil.**

Chamber pressure(σ3)	***Max. deviator stress* (σ1 – σ3)**	**Pore pressure at maximum deviator stress**

		(u)
80 kN/m²	**175kN/m²**	**45 kN/m²**
150 kN/m²	**240 kN/m²**	**50 kN/m²**
210 kN/m²	**300 kN/m²**	**60 kN/m²**

Answer:

Graphical solution:

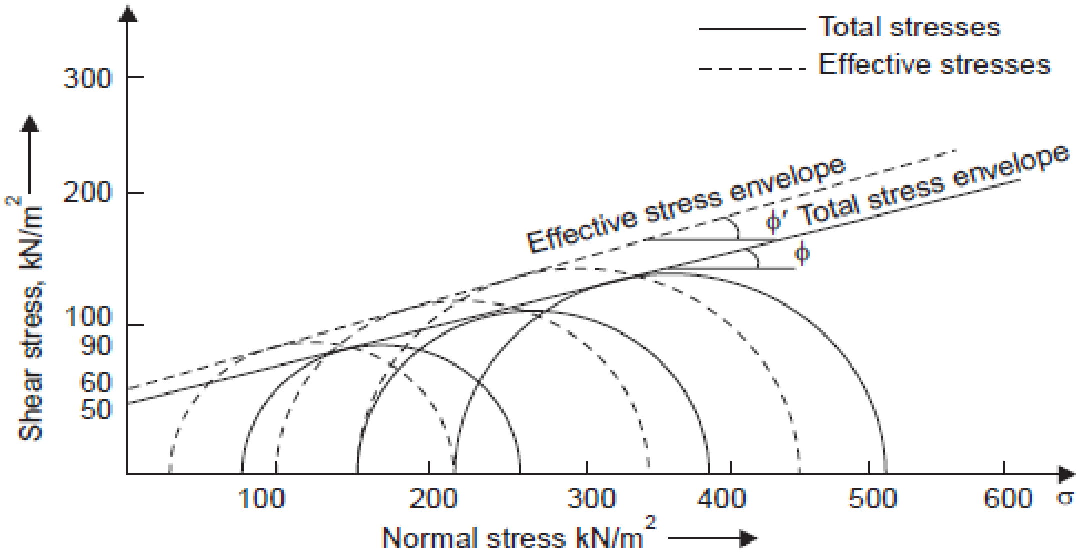
a) Total Stress

Test No.	*Major Principal Stress (σ1)*	*Chamber pressure (σ3)*
1	**255 kN/m2**	**80 kN/m2**
2	**390 kN/m2**	**150 kN/m2**
3	**510 kN/m2**	**210/m2**

b) *Effective stresses = (Total stress – pore pressure)* ***3M***

Test No.	*Major Principal Stress (σ1')*	*Chamber pressure (σ3')*
1	**210 kN/m2**	**35 kN/m2**
2	**340 kN/m2**	**100 kN/m2**
3	**450 kN/m2**	**150 kN/m2**

3M



4M

7. **Explain Vane shear test with neat sketch.**

Answer:

If suitable undisturbed for remoulded samples cannot be got for conducting triaxial or unconfined compression tests, the shear strength is determined by a device called the Shear Vane. The vane shear test may also conducted in the laboratory. The shear vane usually consists of four steel plates welded orthogonally to a steel rod, as shown in Fig below 2M

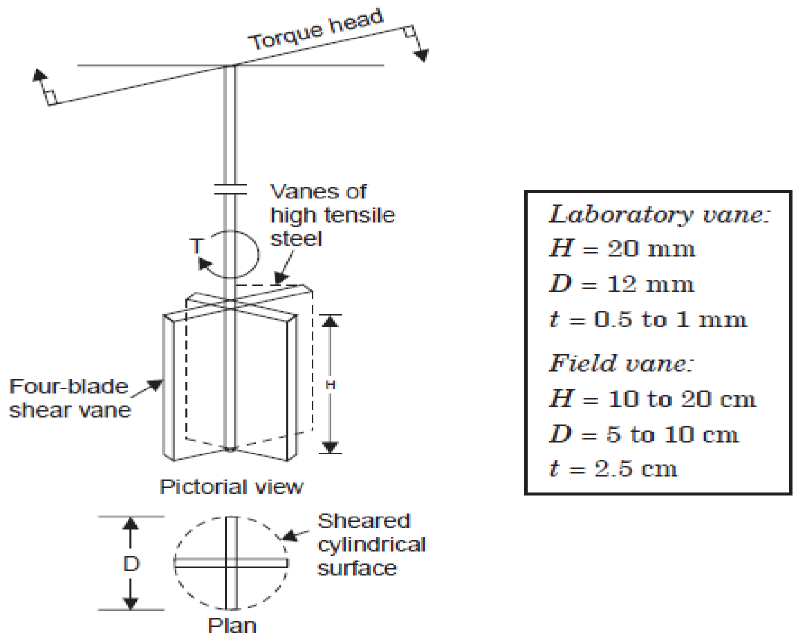


Fig. 5.10. Laboratory shear vane

2M

Working:

The applied torque is measured by a calibrated torsion spring, the angle of twist being read on a special gauge. A uniform rotation of about 1° per minute is used. The vane is forced into the soil specimen or into the undisturbed soil at the bottom of a bore-hole in a gentle manner and torque is applied. The torque is computed by multiplying the angle of twist by the spring constant.

$T=\pi cu.[D^2H/2+D^3/6]$

$cu=T[D^2H/2+D^3/6]$ 3M

Derivation of the formula

Here the shear strength of the soil is constant for the cylindrical sheared surface as well as for the top and bottom of the specimen. T = T1 + T2

For the top and bottom surface,

$T1=2\int_0^{D/2}(cu.2\pi r.dr)$

$T1=2cu.2\pi[r^3/3]_0^{D/2}$

$T1=cu[D^3/6]$

For cylindrical surface,

$T2=cu.2\pi D/2HD/2$

$T2=cu.\pi D^2H/2$ 3M