(v) The void ratio and specific gravity of a soil are 0.75 and 2.65, respectively. The critical hydraulic gradient for the soil is given by
(a) 0.94 (b) 0.90 (c) 0.86 (d) 0.84.

(vi) Classify the soil as per the IS soil Classification system:
Liquid Limit= 90%, Plastic Limit= 40%
(a) CH (b) MH or OH (c) CL (d) ML or OL.

(vii) The natural void ratio of a sand sample is 0.6 and density index is 0.6. If its voids ratio in the loose state is 0.9, then its voids ratio in the densest state will be,
(a) 0.2 (b) 0.3 (c) 0.4 (d) 0.5.

(viii) A soil has liquid limit 35%, plastic limit= 20% and shrinkage limit 10% and natural moisture content =25%. Its liquidity index, plasticity index and shrinkage index are
(a) 0.67, 15 and 25 (b) 0.67, 25 and 15
(c) 0.33, 15 and 10 (d) 0.33, 20 and 15.

(ix) In an unconfined compression test on stiff clay, if the failure plane made an angle of 52° to the horizontal, the angle of friction resistance is
(a) 16° (b) 14° (c) 12° (d) 13°.

(x) An oven- dried soil having a mass of 200 gm is placed in a pycnometer which is then completely filled with water. The total mass of the pycnometer with water and soil inside is 1605 gm. The pycnometer filled with water alone has a mass of 1480 gm. Calculate the specific gravity of soil.
(a) 2.67 (b) 2.66 (c) 2.56 (d) 2.65.

## Group - B

2. (a) An embankment, having total volume of 2000 $m^3$ is to be constructed having a bulk density of 1.98 g/cc and a placement water content of 18%. The soil is to be obtained either from borrow area A or B, which have voids ratio of 0.78 and 0.69 respectively and water content of 16% and 12% respectively. Taking $G$ = 2.66 for both the soils, determine the volume of soil required to be excavated from each of the areas. If the cost of excavation is Rs.35 per $m^3$ in each area, but cost of transportation is Rs.32 and 36 per $m^3$ from areas A and B respectively. Which of the borrow area is more economical?

(b) The results of a sieve analysis performed on a dry soil sample weighing 500 gm are given below:

| I.S Sieve | 4.75 mm | 2.40 mm | 1.20 mm | 600μ | 425μ | 300μ | 150μ | 75μ |
|---|---|---|---|---|---|---|---|---|
| Wt. of soil retained (gm) | 11.41 | 55.85 | 78.15 | 87.22 | 85.65 | 75.82 | 69.02 | 36.88 |





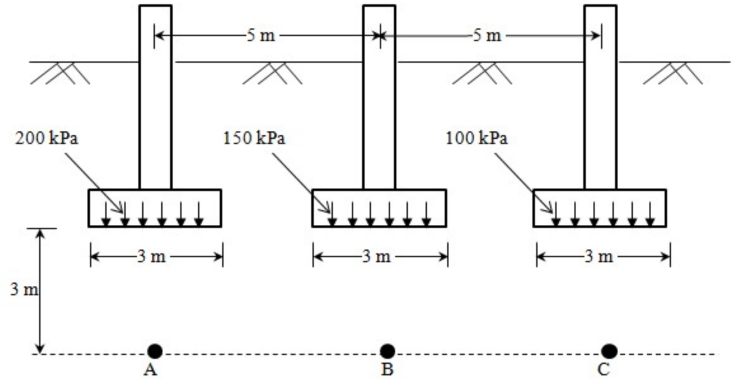


*Fig.6*

(b) The footings of three adjacent columns of a building lie on the same straight line and carry gross loads of 10 kN, 15 kN and 12 kN respectively. The centre-to-centre distance between the first (on left) and second (at centre) footing is 4 m while that between the second and the third (on right) is 3.5m. The sub-soil consists of a 6 m thick clay layer which is underlain by a layer of dense sand. Plot the distribution of gross vertical stress intensity (due to overburden pressure & stress increment due to footing load) on a horizontal plane through the middle of the clay layer. The properties of the clay are as follows: $G$ = 2.70, $e$ = 0.55, $w$ = 0%. [Assume the footings to be founded at the ground level].

**6 + 6 = 12**

## Group - E

8. (a) A vane, 10cm long and 8 cm in diameter, was pressed into soft clay at the bottom of a bore hole. Torque was supplied and gradually increased to 45 N-m when failure took place. Subsequently, the vane was rotated rapidly so as to completely remould the soil. The remoulded soil was sheared at a torque of 18 N-m. Calculate the cohesion of the clay in the natural and remoulded states and also the value of the sensitivity.

(b) A cylindrical specimen of dry sand was tested in a triaxial test. Failure occurred under a cell pressure of 120 $kN/m^2$ and a deviator stress of 400 $kN/m^2$.
i) What was the angle of shearing resistance of the soil?
ii) What were the normal and shear stresses on the failure plane?
iii) What angle did the failure plane make with the major and minor principal planes?

iv) What was the maximum shear stress on any plane in the specimen at the instant of failure and how was the plane in question oriented with the major principal plane?

(c) Explain the Mohr-Coulomb strength envelop. Sketch the stress–strain relationship for dense and loose sand.

**3 + 6 + 3 = 12**

9. (a) A soil sample is initially subjected to a cell pressure of 100 kPa. Draw stress paths for the loading conditions when
   i) The cell pressure is kept constant and the major principal stress is increased to 200 kpa.
   ii) Both the cell pressure and major principal stress are increased to kPa.
   iii) Major principal stress is maintained constant and cell pressure is increased to 200 kPa.
   iv) Major principal stress is kept constant while the cell pressure is decreased to 25 kPa.

(b) A direct shear test on sand ($c$ = 0) gave a failure shear stress of 70 kN/m$^2$ when the normal loads was 200 kN/m$^2$. Draw the Mohr's envelope, and find the principal stresses at failure and the orientation of the principal planes.

(c) A soil sample is subjected to a major principal stress of 2 kg/m$^2$ and a minor principal stress of 1.1 kg/m$^2$. Determine the normal shear stresses acting on a plane inclined at 30° to the major principal stress.

**4 + 6 + 2 = 12**



**B.TECH/CE/4$^{TH}$ SEM /CIVL 2202/2016**
**2016**

# SOIL MECHANICS - I
# (CIVL 2202)

**Time Allotted : 3 hrs** **Full Marks : 70**

***Figures out of the right margin indicate full marks.***

***Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.***

***Candidates are required to give answer in their own words as far as practicable.***

## Group – A
## (Multiple Choice Type Questions)

1. Choose the correct alternatives for the following: **10 × 1 = 10**

(i) A sample of coarse sand is tested in a constant head permeameter. The sample is 20 cm high and has a diameter of 8 cm. Water flows through the soil under a constant head of 1 m for 15 mins. The mass of discharged water was found to be 1.2 kg. The co-efficient of permeability of the soil is
(a) 0.0053 cm/sec (b) 0.0076 cm/sec
(c) 0.0086 cm/sec (d) 0.0096 cm/sec.

(ii) If kx and kz are the co-efficients of permeability in horizontal and vertical direction respectively, the the equivalent co-efficient of permeability is given by
(a) $\sqrt{k_x k_z}$ (b) $k_x k_z$ (c) $(k_x k_z)^{\frac{1}{3}}$ (d) $k_x / k_y$

(iii) In order to compute the seepage loss through the foundation of a cofferdam, flownets were constructed. The result of the flownet study gave Nf = 6, Nd = 16. The head of water lost during seepage was 6 m. If the co-efficient of permeability of the soil is 4 × 10-5 m/min, then, the seepage loss is
(a) 0.65 m$^3$/(day-m) (b) 0.85 m$^3$/(day-m)
(c) 0.13 m$^3$/(day-m) (d) 0.23 m$^3$/(day-m)

(iv) The flow lines and equipotential lines intersect with each other at an angle of
(a) > 90° (b) 90° (c) ≤ 60° (d) 45°.

**Group - D**

6. (a) A rectangular raft of size 30 m × 12 m founded at a depth of 2.5 m below the ground surface is subjected to a uniform pressure of 150 kPa. Assume the centre of the area is the origin of the coordinates (0,0) and the corners have the coordinates (6,15). Calculate the stresses at a depth of 20 m below the foundation level by the methods of Boussinesq and Westergaard at coordinates of (0,0), (6,15) and (10,25). Neglect the effect of foundation depth on stresses.

(b) ABCD is a raft foundation of a multi-storey building (as shown in figure 5), wherein AB = 20 m, BC = 12 m, $AA_1$ = 4 m and $A_1O$ = 6 m. The uniformly distributed load over the raft is 350 kN/m². Determine the vertical stress at a depth of 6 m below point O.

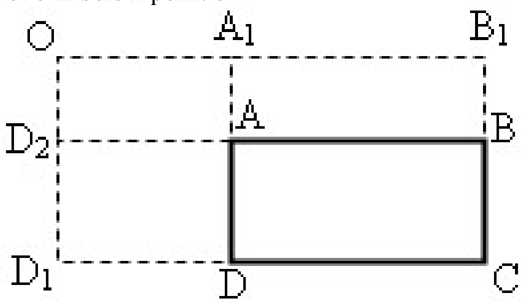


*Fig.5*

(c) A water tank is required to be constructed with a circular foundation having a diameter of 16 m founded at a depth of 2 m below the ground surface. The estimated distributed load on the foundation is 325 kN/m². Assuming that the sub-soil extends to a great depth and is isotropic and homogeneous, determine the stresses at points: $P_1$($r$ = 0, $z$ = 8 m), $P_2$($r$ = 8 m, $z$ = 8 m), $P_3$($r$ = 0, $z$ = 16 m) and $P_4$($r$ = 8m, $z$ = 16 m), where, $r$ is the radial distance from the central axis and $z$ is the depth below ground level. Neglect the effect of the depth of foundation on the stresses.

**6 + 3 + 3 = 12**

7. (a) Three parallel strip footings (shown in figure 6) 3 m wide each and 5 m apart centre to centre transmit contact pressures of 200, 150 and 100 kN/m², respectively. Calculate the vertical stress due to the combined loads beneath the centres of each footing i.e. at points A, B and C at a depth of 3 m below the base. Assume the footings are placed at a depth of 2 m below the ground surface. Use Boussinesq's equation for line loads.





i) Plot the particle size distribution curve of the soil.
ii) Find out the percentage of gravel, coarse sand, medium sand, fine sand and silt present in the soil.
iii) Determine the uniformity co-efficient and the co-efficient of curvature. Hence comment on the type of soil.

(c) Describe with neat sketches the structure of Kaolinite and Montmorillonite.

**3 + 5 + 4 = 12**

3. (a) An undisturbed saturated specimen of clay has a volume of 18.5 cc and a mass of 30.2 g. On oven drying, the mass reduces to 18.0 g. The volume of dry specimen as determined by displacement of mercury is 9.98 cc. Determine shrinkage limit, specific gravity, shrinkage ratio and volumetric shrinkage.

(b) A 500 gm of dry soil was used for combined sieve and hydrometer analysis. The soil mass passing through 75μ sieve = 130 gm. Hydrometer analysis was carried out on a mass of 40 gm that passed through 75μ sieve. The average temp recorded during the test was 31˚C.
Given: $G$= 2.65, $C_m$=0.5, $C_d$= 0.6, $C_t$= 0.915, $\mu$= 8.15× $10^{-3}$ poise, $H_{e1}$= 22.0 cm for $R_h$= 0, $H_{e2}$= 10.0 cm for $R_h$= 30, $Aj$= 30 cm² and $V_h$= 40 cm³.
The hydrometer reading $R_h$ = 15.00 after a lapse of time of 120 min after the start of the test. Determine the particle size 'D' and percentage finer N%?

(c) Write short notes on the following (any one):
i) Bentonite and Peat
ii) Hydrometer composite corrections

**4 + 6 + 2 = 12**

**Group - C**

4. (a) A falling head permeability test was carried out on a 15 cm long sample of silty clay. The diameter of the sample and the stand-pipe were 9.8 cm and 0.75 cm, respectively. The water level in the stand-pipe was observed to fall from 60 cm to 45 cm in 12 mins. Determine the co-efficient of permeability of the soil in m/day, height of water level in the stand-pipe after another 120 mins. and time required for the water level to drop to 10 cm.

(b) At a particular site (as shown in figure 1) lies a layer of fine sand 8 m thick below the ground surface and having a void ratio of 0.7. The GWT is at a depth of 4 m below ground surface. The average degree of saturation of the sand above the capillary fringe is 50%. The soil is saturated due to capillary action to a height of 2.0 m above the GWT level. Considering the effect of porosity, calculate the effective pressures at ground level, fringe level, ground water table level, at the depth the of 6 m below the ground level. [Given: $G$ = 2.65]

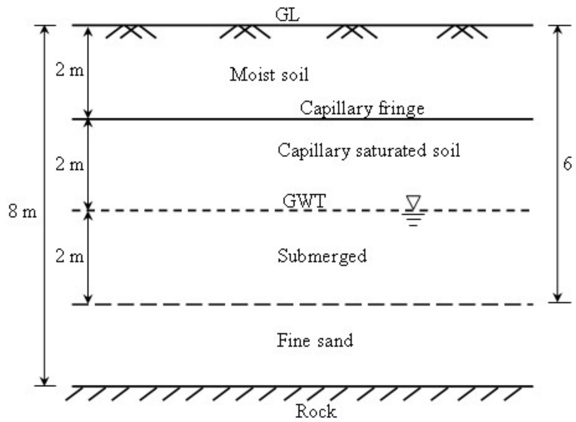


*Fig.1*

(c) A single row of sheet piles (as shown in figure 2) is driven upto a depth of 4 m in a bed of clean sand having a co-efficient of permeability of 0.002 cm/sec. An impermeable layer of very stiff clay exists at a depth of 10 m below the GL. The sheet pile wall has to retain water upto 4 m above GL. The height of water level on the downstream side is 0.5 m. The length of the last element is 1.1 m. Determine the quantity of seepage loss considering unit width of the sheet piles, the piezometric heads at points A and C, factor of safety against piping. [Given: $G$ = 2.67, $e$ = 0.95].

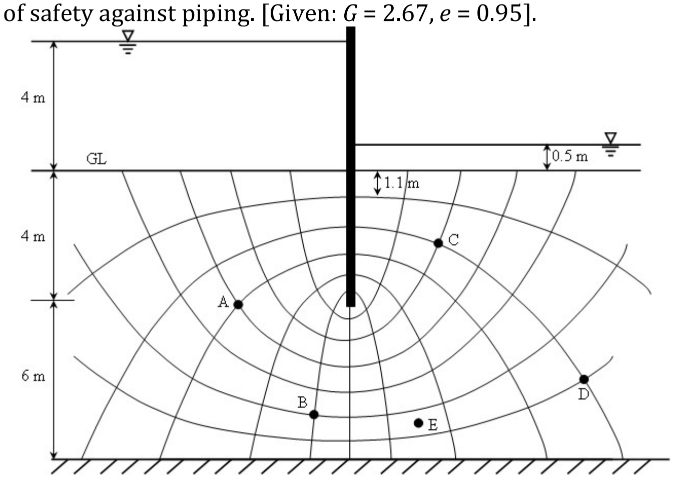


*Fig.2*

**4 + 4 + 4 = 12**

5. (a) The subsoil at a site consists of a fine sand lying in between a clay layer at top and a silt layer at bottom. The co-efficient of permeability of the sand is 100 times that of clay and 20 times that of silt, while the thickness of the





sand layer is one-tenth that of clay and one-third that of silt. Find out the equivalent co-efficient of permeability of the deposit in directions parallel and perpendicular to the bedding planes, in terms of the co-efficient of permeability of the clay layer ($k_c$).

(b) The dam and flownet are shown in figure 3. The dam is 120 m long and has two nos. 10 m long sheet piles driven partially into the granular soil layer. Datum is at the tailwater elevation. Determine the pressures at B, C, D and E.

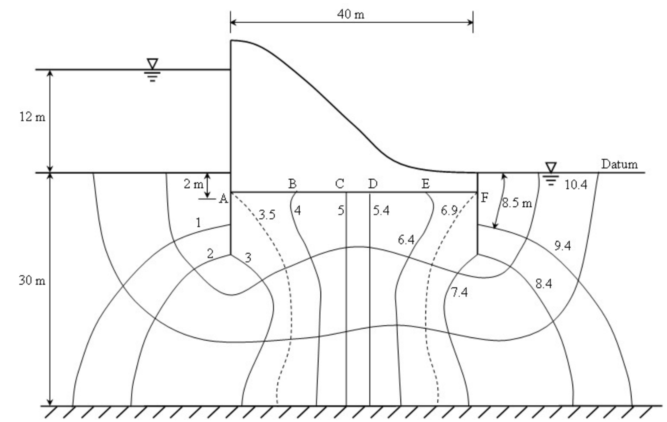


*Fig.3*

(c) A sheet pile wall (shown in figure 4) is driven into a silty soil having co-efficient of permeability of 0.5 × $10^{-6}$ cm/sec. The length of the last element is 3.45 m. Find the pore pressure at points B, C, F and also exit gradient.

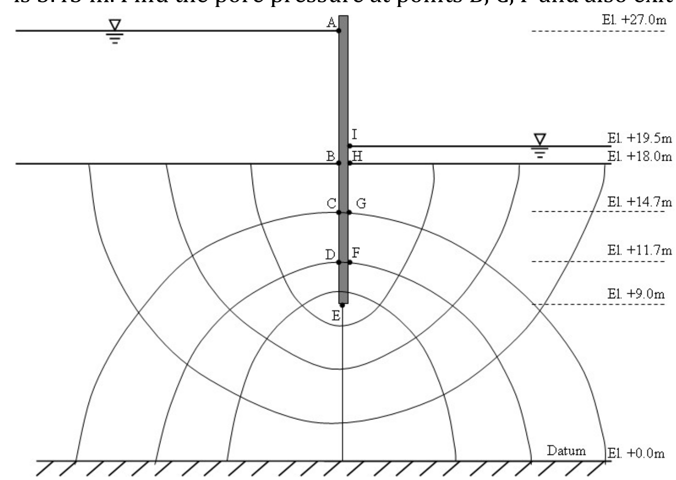


*Fig.4*

**4 + 4 + 4 = 12**