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 alternative for the following: **10 × 1 = 10**

(i) A sample of coarse sand is tested in a constant head permeability meter. 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) Piping ratio is given by

(a) $\frac{D_{15(filter)}}{D_{15(soil)}}$ (b) $\frac{D_{85(filter)}}{D_{15(soil)}}$ (c) $\frac{D_{15(soil)}}{D_{85(filter)}}$ (d) $\frac{D_{15(filter)}}{D_{85(soil)}}$.

(iii) One of the approximate methods for determining vertical stress within a soil mass is
(a) 2.5:1 method (b) 2:1 method (c) 1:2 method (d) 3:1 method.

(iv) 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)

(v) In the consolidated undrained triaxial test on a saturated soil sample, the pore water pressure is zero
(a) during shearing stage only
(b) at the end of consolidation stage only.
(c) both at the end of consolidation and during shearing stages
(d) under none of the above conditions.

(vi) If the soil is dried beyond its shrinkage limit, it will show
(a) high volume change (b) low volume change
(c) moderate volume change (d) no volume change

(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.

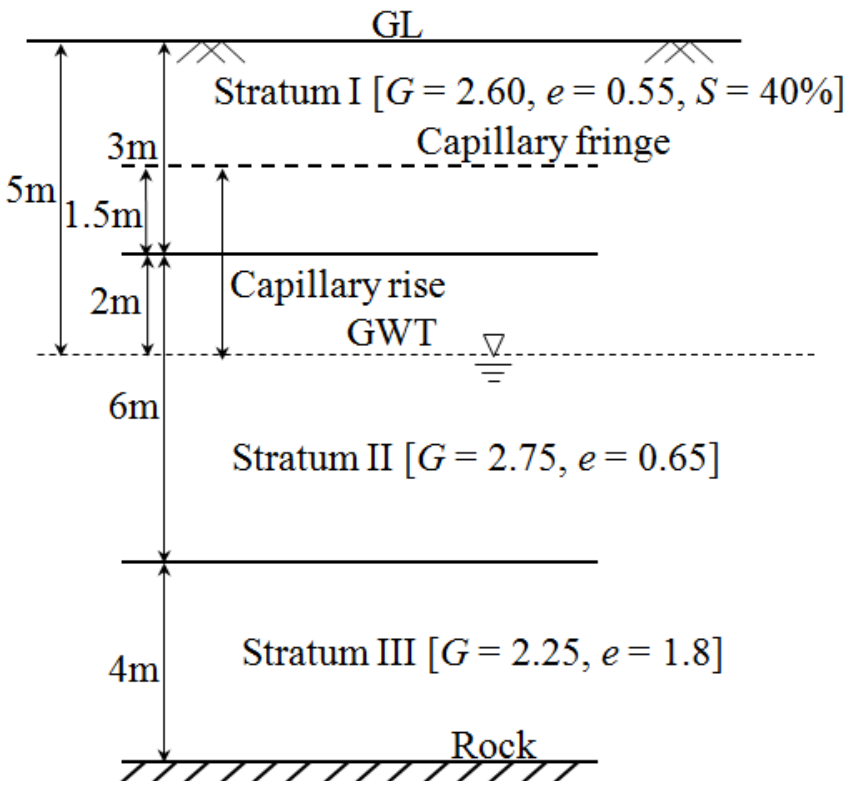
Group - B

2. (a) The following results were obtained from the sieve analysis carried out on a dry soil sample weighing 300 g.

I.S Sieve size	4.75 mm	2.40 mm	1.20 mm	600μ	425μ	300μ	150μ	75μ	Pan
Wt. of soil retained (gm)	11.02	30.45	46.26	48.73	50.27	45.49	40.21	20.33	7.24

[(CO1)Evaluate/IOCQ]

(b) At a particular site there are three layers of soil as shown below. The ground water table (GWT) is at a depth of 5 m below ground level (GL). The average degree of saturation of the sand above the capillary fringe is 40%. The soil is saturated due to capillary action upto a height of 3.5 m above the GWT level. Considering the effect of porosity, calculate the effective stresses at 3 m, 6 m, 9 m and 11 m below GL. *[(CO2) Analyze/HOCQ]*



6 + 6 = 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. [(CO1) Evaluate/HOCQ]

(b) Write short notes on the following (any one):

(i) Bentonite and Peat

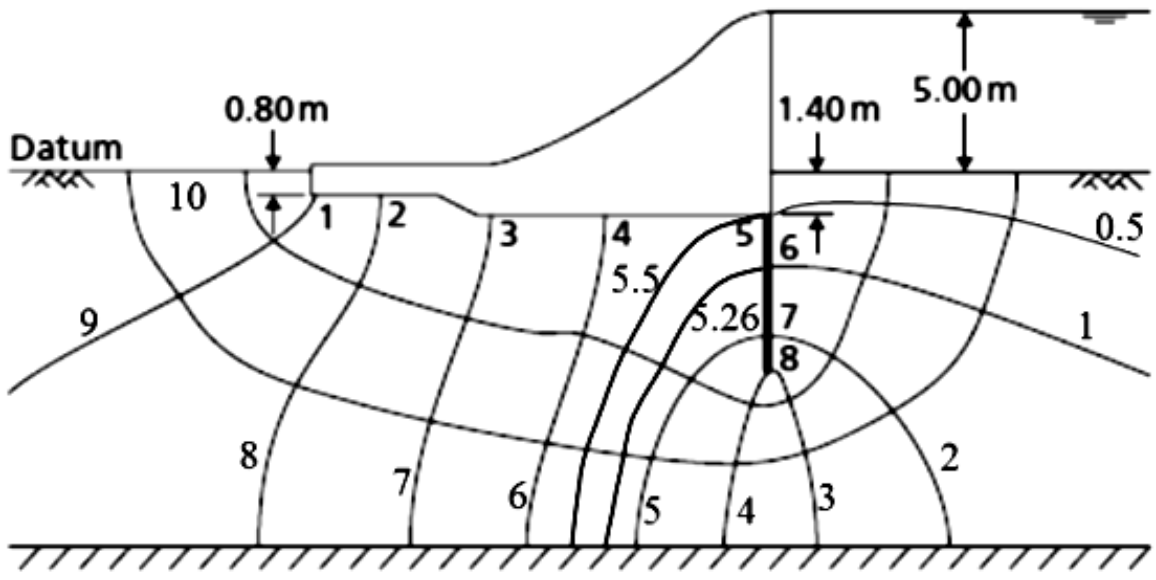
(ii) Hydrometer composite corrections. *[(CO2)Understand/HOCQ]*

6 + (3 + 3) = 12

Group - C

4. (a) A layer of silty soil of thickness 6 m lies below the ground level (GL) and below the silt layer lies a clay stratum. The ground water table (GWT) is at a depth of 5 m below the ground surface. The following data are available for both the silt and clay layers of soil; Silt layer: D_{10} = 0.018 mm, e = 0.7 and G = 2.65 and Clay layer: e = 0.8 and G = 2.75.
Considering the effect of porosity, determine the effective stresses at (i) GL, (ii) GWT level, (iii) 3 m below GL and (iv) 9 m below GL. [Assume C = 0.4 cm^2] *[(CO2)(Evaluate/HOCQ)]*

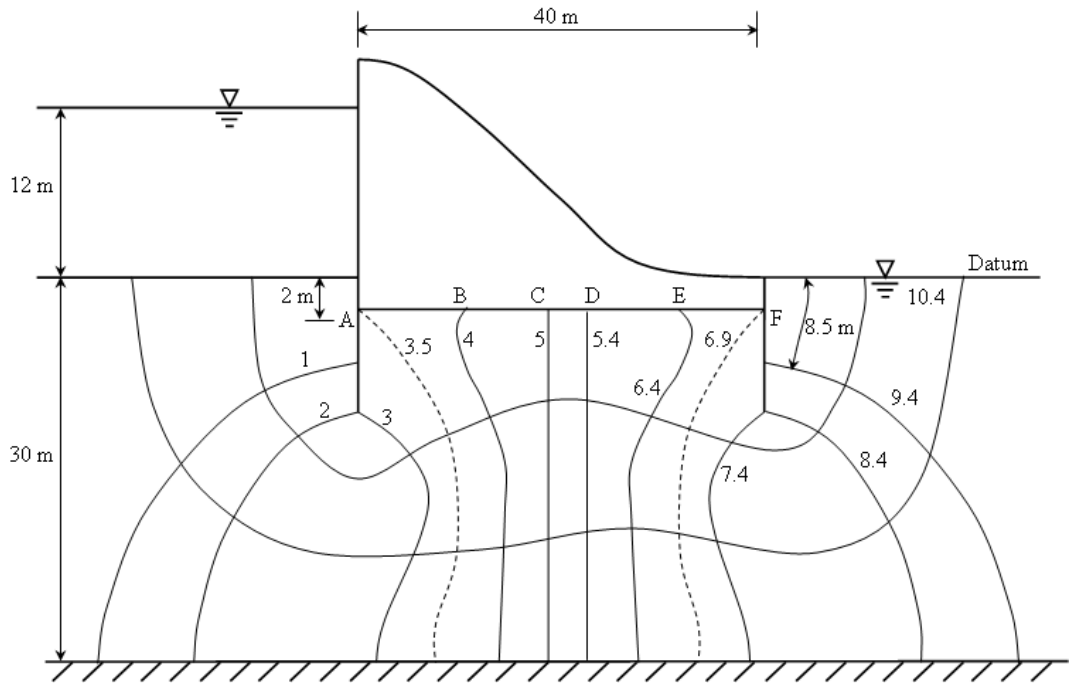
(b) Determine the quantity of seepage under the dam in the figure given below. Calculate the uplift pressures at points 1, 3 and 5 on the base of the dam. The coefficient of permeability of foundation soil is 2.5 × 10−5 m/sec. The points 6, 7 and 8 are lying at 3.07m, 5.20m and 6.0m below datum. *[(CO3)(Evaluate/HOCQ)]*



6 + 6 = 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). *[(CO3)(Evaluate/HOCQ)]*

(b) The dam and flow net are shown in figure below. 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 tail water elevation. Determine the pressures at B, C, D and E. *[(CO4)(Evaluate/HOCQ)]*



6 + 6 = 12

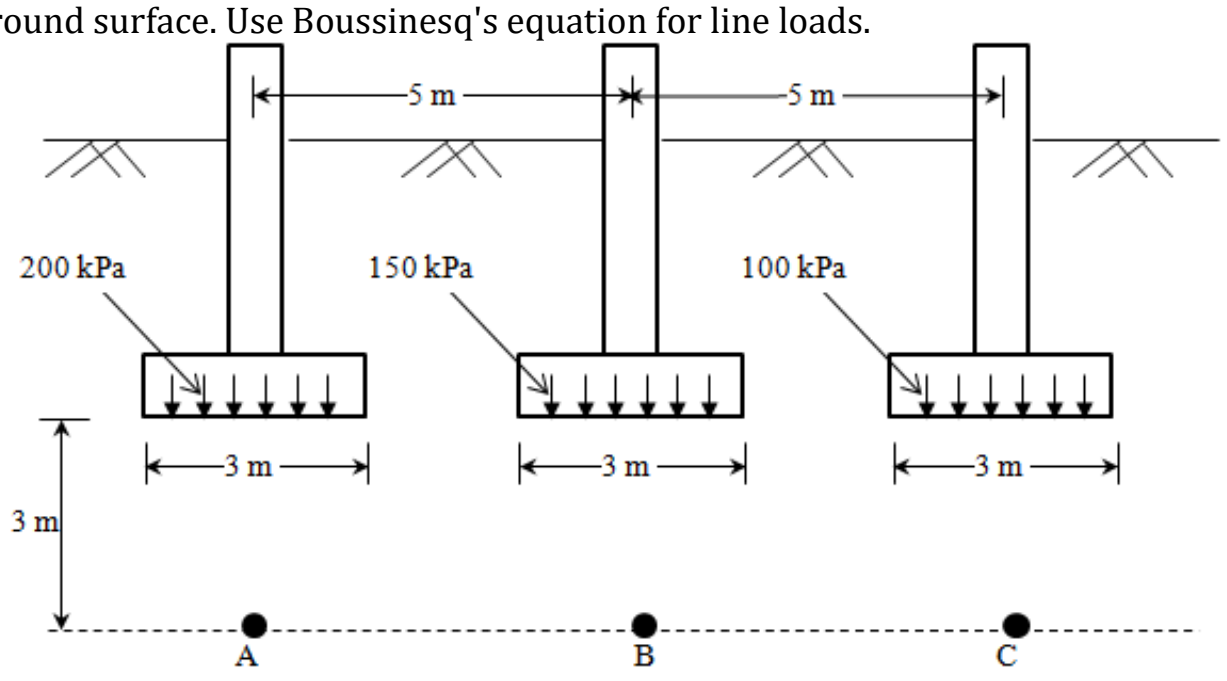
Group - D

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. *[(CO5)(Evaluate/HOCQ)]*

(b) 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/m^2. 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. *[(CO5)(Evaluate/HOCQ)]*

6 + 6 = 12

7. (a) Three parallel strip footings (shown in figure below) 3 m wide each and 5 m apart centre to centre transmit contact pressures of 200, 150 and 100 kN/m^2, 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. *[(CO5)(Evaluate/HOCQ)]*



(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]. *[(CO5)(Evaluate/HOCQ)]*

6 + 6 = 12

Group - E

8. (a) Explain the Mohr - Coulomb strength envelop. [(CO6)(Understand/LOCQ)]

(b) A shear vane of 7.5 cm diameter and 11 cm length was used to measure the shear strength of soft clay. If torque of 600 kg-cm was required to shear the soil calculate the shear strength. The vane was then rotated rapidly to cause remoulding of the soil. The torque required in the remoulded state was 200 kg-cm. Determine the sensitivity of the soil and comment on the type of soil. *[(CO6)(Evaluate/HOCQ)]*

4 + 8 = 12

9. Cylindrical specimen of dry sand was tested in a triaxial test. Failure occurred under a cell pressure of 1.2 kg/cm^2 and deviator stress of 4 kg/cm^2. Determine the following:
   (i) Angle of shearing resistance of the soil.
   (ii) Normal and shear stresses on the failure plane.
   (iii) Angle which the failure plane makes with the minor principal plane.
   (iv) Maximum shear stress on any plane in the specimen at the instant of failure
   (v) Angle which the failure plane makes with the major principal plane. *[(CO6)(Evaluate/HOCQ)]* **12**