SOIL MECHANICS - I
(CIVL 2102)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) If the porosity is *n*, then the seepage velocity (v_s) and discharge velocity (v) are related as,
(a) $v_s = \frac{2v}{n}$ (b) $v_s = \frac{v}{n}$
(c) $v_s = \frac{v}{n^2}$ (d) $v_s = vn$.

(ii) A constant head permeameter is used for
(a) Silty soils (b) Coarse-grained soils
(c) Clayey soils (d) Organic soils.

(iii) The stress developed at a point in the soil exactly below a point load at the surface is
(a) proportional to the depth of the point
(b) proportional to the square of the depth of the point
(c) inversely proportional to the depth of the point
(d) inversely proportional to the square of the depth of the point.

(iv) A load of 2000 kN is uniformly distributed over an area of 3 m × 2 m. The average vertical stress at a depth of 2 m using 2:1 distribution method is
(a) 120 kN/m^2 (b) 100 kN/m^2
(c) 80 kN/m^2 (d) 140 kN/m^2.

(v) The three directions of cleavage at 90° angle are found in
(a) Gypsum (b) Fluorite (c) Feldspar (d) Galena.

(vi) Soil transported by wind are termed as
(a) Alluvial deposit (b) Aeolin deposit
(c) Glacial deposit (d) Colluvial soil.

(vii) Metallic lustre is found in
(a) Diamond (b) Magnetite (c) Muscovite (d) Galena.

(viii) The specific gravity of sands is approximately
(a) 1.6 (b) 2.0 (c) 2.2 (d) 2.6.

(ix) Streak of a mineral is
(a) its tendency to split along certain direction yielding smooth surfaces
(b) its appearance on a broken surface of a mineral
(c) colour of its powder
(d) colour of the mineral itself.

(x) For a soil, if the plasticity index and percent finer than 0.002 mm are 29% and 18%, respectively, then the activity number is
(a) 1.608 (b) 1.614 (c) 1.611 (d) 1.617.

Fill in the blanks with the correct word

(xi) For the determination of permeability of sandy soil, _____ head method is more suitable.

(xii) Allen Hazen's empirical relationship between the coefficient of permeability and effective size is_____.

(xiii) The hydraulic head that would produce a quick condition in a sand (G = 2.67, e = 0.67) stratum of thickness 1.5 m is _____.

(xiv) The Westergaard's analysis is used for _____ soils.

(xv) Foliation is a primary structure of _____ rock.

Group - B

2. (a) What is mineral? How mineral deposits are classified? *[(CO1)(Understand/LOCQ)]*

(b) Write short note on any one of the followings:
(i) Moh's Scale of hardness. (ii) Fractured mineral. *[(CO1)(Understand/LOCQ)]*

(c) Classify sedimentary rocks on the basis of their textures. *[(CO1)(Understand/LOCQ)]*

(2 + 3) + 3 + 4 = 12

3. (a) Discuss dip and strike with neat sketches. *[(CO1)(Apply/IOCQ)]*

(b) Discuss in brief about the different parts of faults with a neat sketch. *[(CO1)(Apply/IOCQ)]*

6 + 6 = 12

Group - C

4. (a) Distilled water was added to 60 gm of dry soil to prepare a suspension of 1 litre. What will be the reading of a hydrometer in the suspension at t = 0 sec., if the hydrometer could be immersed at that time? Assume G = 2.70. *[(CO2)(Evaluate/HOCQ)]*

(b) Two soils were tested for their consistency limits in the laboratory. The following data were obtained:

Soil A:	Soil B
Liquid limit = 38%, Plastic limit = 25%	Liquid limit = 60%, Plastic limit = 30%
Natural moisture content = 40%	Natural moisture content = 50%

Which soil has greater plasticity? Which soil would be a greater foundation material for remoulding? *[(CO2)(Evaluate/HOCQ)]*

(c) A fully saturated soil sample has a volume of 28 cc. The sample was dried in an oven and the weight of the dry soil pat was 48.86 gm. Determine the void ratio, moisture content, saturated density and dry density of the soil mass. Assume G = 2.68. *[(CO2)(Evaluate/HOCQ)]*

4 + 4 + 4 = 12

5. (a) 50 gm of oven-dried soil with particle size smaller than 75 microns is used in a hydrometer analysis. The corrected hydrometer reading after 2 minutes in a 1000 cc soil suspension was 25.0. The effective depth, H_e for R_h of 25 is 12.13 cm. Assume specific gravity of soil solids as 2.75 and viscosity of water as 0.01 Poise, determine the coordinates of the point on the grain size curve. *[(CO2)(Evaluate/HOCQ)]*

(b) A 1000 cc core cutter weighing 946.80 gm was used to find out the in-situ unit weight of an embankment. The weight of core cutter filled with soil was noted to be 2770.60 gm. Laboratory tests on the sample indicated a water content of 10.45% and specific gravity of solids of 2.65. Determine the bulk unit weight, dry unit weight, void ratio and degree of saturation of the sample. If the embankment becomes saturated due to rains, evaluate the water content and the saturated unit weight (assume there is no change in volume on saturation). *[(CO2)(Evaluate/HOCQ)]*

6 + 6 = 12

Group – D

6. (a) At a construction site, a 4 m thick clay layer is followed by a 6 m thick gravel layer which is resting on impervious rock. A surcharge of 30 kN/m^2 is applied suddenly at the surface of the clay layer. The saturated unit weight of the soils are 18 kN/m^3 and 20 kN/m^3 for the clay and gravel layers, respectively. The water table is at the ground level. Determine the effective stresses at 4 m and 10 m below GL. *[(CO3)(Evaluate/HOCQ)]*

(b) In a falling head permeameter, the sample used is 20 cm long having a cross-sectional area of 24 cm^2. Determine the time required for a drop of head from 25 cm to 12 cm if the c/s area of the stand pipe is 2 cm^2. The sample of soil is made of three layers. The thickness and coefficient of permeability of the first, second and third layers from the top are 8 cm, 6 cm and 4 cm; 1×10^{-4} cm/sec, 6×10^{-4} cm/sec, 9×10^{-4} cm/sec, respectively. Assume that the flow is taking place perpendicular to the layers. *[(CO4) (Evaluate/HOCQ)]*

(c) At a given location (Fig.1), 9 m thick saturated clay (w = 35%, G = 2.7) is underlain by sand. The sand layer is under artesian pressure equivalent to 3 m of water head. It is proposed to make an excavation in the clay. Determine the depth of up to which an excavation can be made before the bottom heaves. *[(CO3)(Evaluate/HOCQ)]*

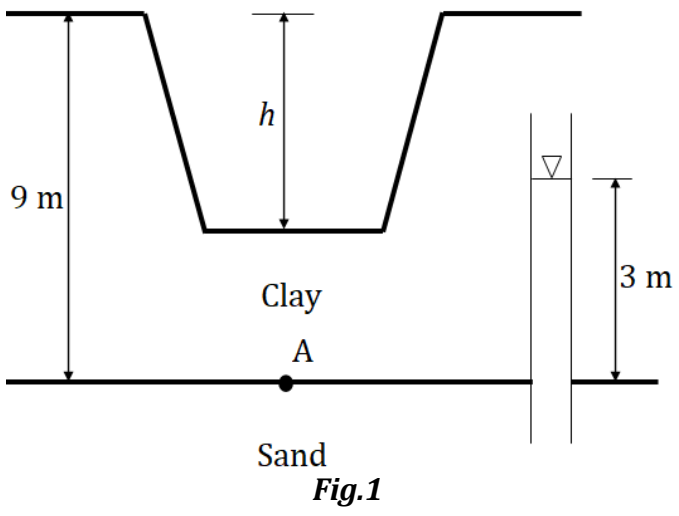

Fig.1

4 + 4 + 4 = 12

7. (a) A granular soil deposit is 7 m deep and lies over an impermeable layer. The ground water table is 4 m below the ground surface. The deposit has a zone of capillary rise of 1.2 m with a saturation of 50%. Determine the effective stresses at ground level, at the level of capillary rise, at ground water table level and at the bottom of the granular deposit. Assume e = 0.6 and G = 2.65. *[(CO3)(Evaluate/HOCQ)]*

(b) A pumping test was carried out in the field in order to determine the average coefficient of permeability of a 18 m thick sand layer. The ground water table was located at a depth of 2.5 m below the ground level. A steady state was reached

when the discharge from the well was 25 lit/sec. At this stage the drawdown in the test well was 3 m, while the drawdowns in two observation wells situated at 8 m and 20 m from the test well were found to be 2.0 m and 1.5 m, respectively. Determine (i) co-efficient of permeability of the sand layer in m/day, (ii) radius of influence of the test well in m and (iii) effective size of the sand particle i.e., D_{10} in mm. [Assume C = 100 $cm^{-1}sec^{-1}$] *[(CO4)(Evaluate/HOCQ)]*

(c) The section through a dam spillway is shown in Fig.2. Determine the net water pressures at levels 5 and 6 on the cut-off wall located at the upstream end of the spillway. The coefficient of permeability of foundation soil is 2.5×10^{-5} m/sec. The point 6 is situated at a depth of 3.07 m below datum. *[(CO5)(Understand/IOCQ)]*

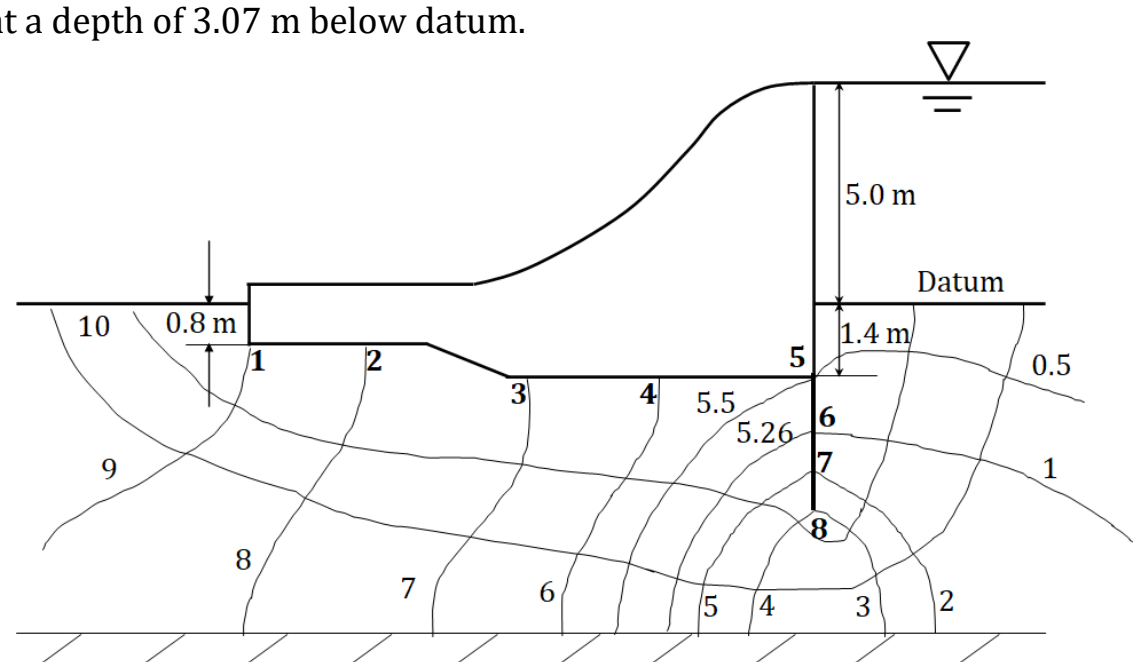

Fig.2

4 + 4 + 4 = 12

Group - E

8. (a) A raft of size 3 m-square (Fig.3) carries a load of 250 kN/m^2. Determine the vertical stress increment at a point 5 m below the centre of the loaded area. Compare the result with that obtained by the equivalent point load method by assuming a point load acting through the centre of the raft. Use Boussinesq's theory. *[(CO6)(Evaluate/HOCQ)]*

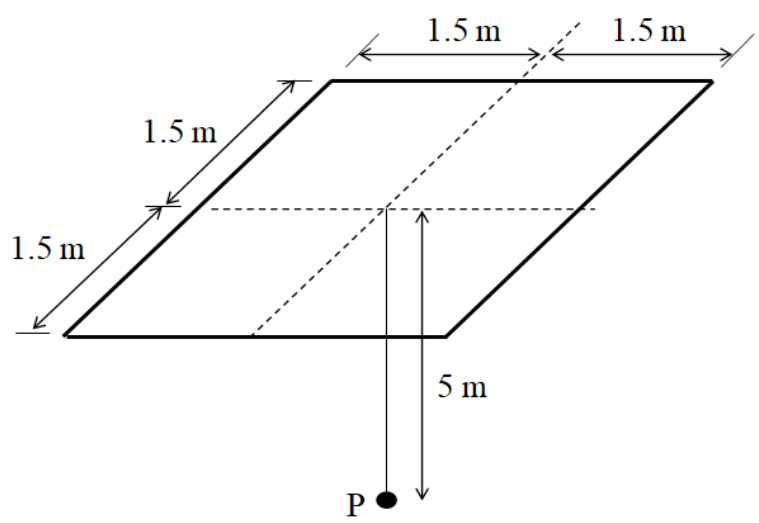

Fig. 3

(b) A concentrated load of 1500 kN is applied at the ground surface. Compute the vertical stresses at a depth of 5 m below the load, and at a distance of 2 m at the same depth. Use Boussinesq's and Westergaard's equations. *[(CO6)(Evaluate/HOCQ)]*

6 + 6 = 12

9. (a) A square footing of width B applies a uniform pressure of q to the underlying soil. Using the 2:1 distribution, estimate the depth at which the stress increment is 30% of the applied pressure q. Use Boussinesq's theory. *[(CO6)(Evaluate/HOCQ)]*

(b) A water tower has a circular foundation of 8 m diameter. If the total weight of the tower, including the foundation is 2×10^4 kN, determine the vertical stress at a depth of 3.2 m below the foundation level. *[(CO6)(Evaluate/HOCQ)]*

(c) A 2 m wide strip footing (Fig.4) is located on the ground surface with a pressure of 72 kN/m^2. Determine the vertical stress at 1.5 m below the ground surface at A (below centreline of the footing), B (edge of the footing) and C (at a distance of 3 m from the edge of the footing). *[(CO6)(Evaluate/HOCQ)]*

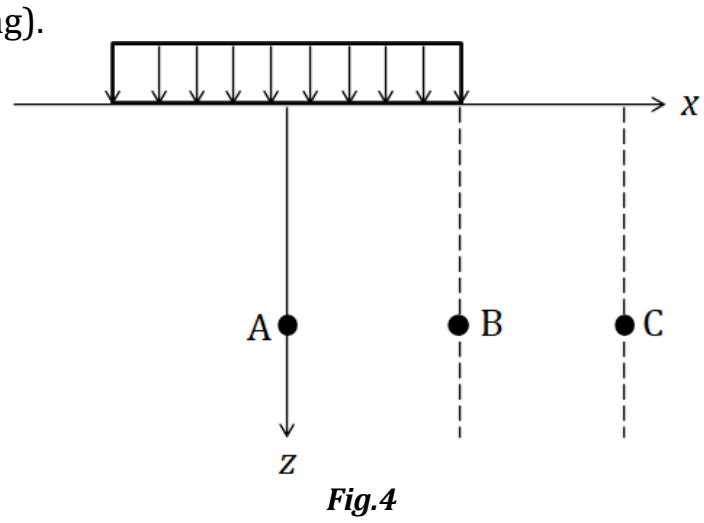

Fig.4

3 + 3 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	12.5	16.67	70.83

Course Outcome (CO):

After the completion of the course students will be able to

CO1 Identify the properties of rocks and which one is suitable for construction purpose.
CO2 Classify soil as per grain size distribution curve and understand the index properties of soil.
CO3 Apply the concept of total stress, effective stress and pore water pressure for solving geotechnical problems.
CO4 Assess the permeability of different types of soil and solve flow problems.
CO5 Estimate the seepage loss, factor of safety against piping failure using flow net related to any hydraulic structure.
CO6 Determine vertical stress on a horizontal plane within a soil mass subjected to different types of loading on the ground surface and also the maximum stressed zone or isobar below a loaded area.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*