SOIL MECHANICS
(CIV2202)

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) The plasticity chart is obtained by plotting
(a) Plasticity index on x-axis and liquid limit on y-axis
(b) Liquid limit on x-axis and plasticity index on y-axis
(c) Plastic limit on x-axis and plasticity index on y-axis
(d) Plasticity index on x-axis and plastic limit on y-axis

(ii) The degree of saturation (S) is
(a) $S > 0$ (b) $S < 0$ (c) $0 < S < 100$ (d) $0 \leq S \leq 100$

(iii) Toughness index (I_t) lies in the range
(a) $0 < I_t < 1$ (b) $0 < I_t < 2$ (c) $0 < I_t < 3$ (d) $0 < I_t < 4$

(iv) The permeability of soil varies
(a) inversely as square of grain size
(b) as square of grain size
(c) as grain size
(d) inversely as void ratio

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

(vi) During seepage through a soil, direction of seepage is always
(a) Parallel to equipotential lines
(b) Perpendicular to equipotential lines
(c) Perpendicular to streamlines
(d) None of these

(vii) For a Standard Compaction test, the weight of hammer and the drop of hammer are as follows:
(a) 2.6 kg and 450 mm
(b) 2.6 kg and 310 mm
(c) 4.8 kg and 310 mm
(d) 4.9 kg and 450 mm

(viii) The coefficient of compressibility of soil, is the ratio of
(a) Stress to strain
(b) Strain to stress
(c) Stress to settlement
(d) Rate of loading to that of settlement

(ix) For a c-ϕ soil, Coulomb's equation for shear strength (s) can be represented as
(a) $c = s + \sigma \tan \phi$
(b) $c = s - \sigma \tan \phi$
(c) $s = \sigma + c \tan \phi$
(d) $s = c - \sigma \tan \phi$

(x) If a cohesive soil specimen is subjected to a vertical compressive load, the inclination of the cracks to the horizontal is
(a) 90° (b) 45° (c) 22.5° (d) 0

Fill in the blanks with the correct word

(xi) Bentonite clay contains predominantly the clay mineral _____.

(xii) The effective stress controls certain aspects of soil behaviour, notably _____ and _____.

(xiii) Velocity head in soils is invariably _____.

(xiv) The coefficient of compressibility is the ratio of change in void ratio to change in _____ stress.

(xv) The ratio of the volume of voids to the total volume of soil is _____.

Group - B

2. (a) The weight of 1 m^3 of wet soil is 2053 kg. Its dry weight is 1734 kg. Specific gravity of soil solids is 2.67. Determine the water content, void ratio, porosity and degree of saturation. *[(CO1,CO2)(Analyse/IOCQ)]*

(b) A partially saturated soil sample from a borrow pit has a natural moisture content of 25% and bulk density of 1.8 gm/cc. The specific gravity of soil solids is 2.70. Determine the degree of saturation, void ratio, dry density and saturated density. *[(CO1, CO2)(Analyse/IOCQ)]*

(c) The mass specific gravity of a saturated specimen of clay is 1.84 when the water content is 34%. On oven drying the mass specific gravity falls to 1.70. Determine the specific gravity of soil solids and shrinkage limit of the clay.

[(CO1, CO2)(Analyse/IOCQ)]

4 + 4 + 4 = 12

3. (a) The volume and mass of a moist soil are 9×10^{-3} m^3 and 18 kg. It has a moisture content of 14 %. Determine the void ratio, degree of saturation, bulk density and dry density. Assume $G = 2.70$. *[(CO1, CO2)(Analyse/IOCQ)]*

(b) During a sedimentation test for grain size analysis, the corrected hydrometer reading in a 1000 cc uniformly mixed soil at the instant of starting of sedimentation ($t = 0$) was 1.030. After 15 mins., the corrected hydrometer reading at an effective depth of 8 cm was noted to be 1.010. Determine (i) the total weight of soil solids present in the 1000 cc suspension, and diameter corresponding to the 15 min. reading and the percentage finer. Assume $G = 2.72$ and $\mu = 2 \times 10^{-6}$ kN-s/m^2.

[(CO1, CO2)(Analyse/IOCQ)]

(c) A thin-walled sampling tube of 75 mm internal diameter is pushed into a soil, and a 200 mm long undisturbed sample with a mass of 1750 gm was obtained. When dried in the oven, the mass was 1420 gm. Determine the water content, void ratio, bulk density and dry density. Assume $G = 2.70$. *[(CO1, CO2)(Analyse/IOCQ)]*

4 + 4 + 4 = 12

Group - C

4. (a) The sub-soil profile at a site is shown in Fig. 1. The ground water table (GWT) is at a depth of 3 m below ground level (GL). The soil is saturated below the capillary fringe. Determine the effective stress at 3 m and 25 m below GL. Assume $G = 2.6$.

[(CO1, CO3)(Analyse/IOCQ)]

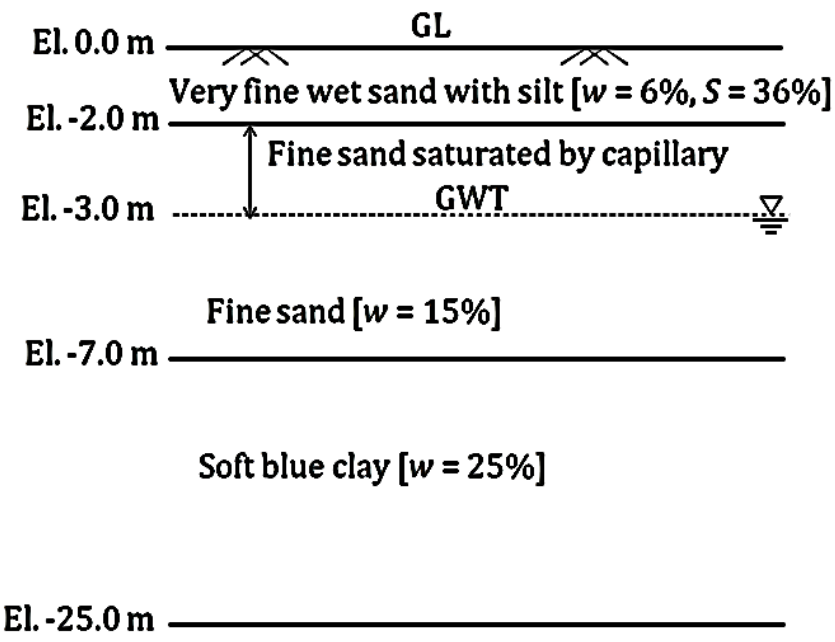

Fig. 1

(b) The subsoil at a site consists of 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 60 times that of clay and 35 times that of silt, while the thickness of the sand layer is one-fourth that of clay and one-eighth that of silt. Determine 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).

[(CO1, CO3)(Analyse/IOCQ)]

(c) A sheet pile wall (shown in Fig. 2) 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 1.5 m. Find the pore pressure at point C, quantity of seepage and exit gradient.

[(CO1, CO3)(Analyse/IOCQ)]

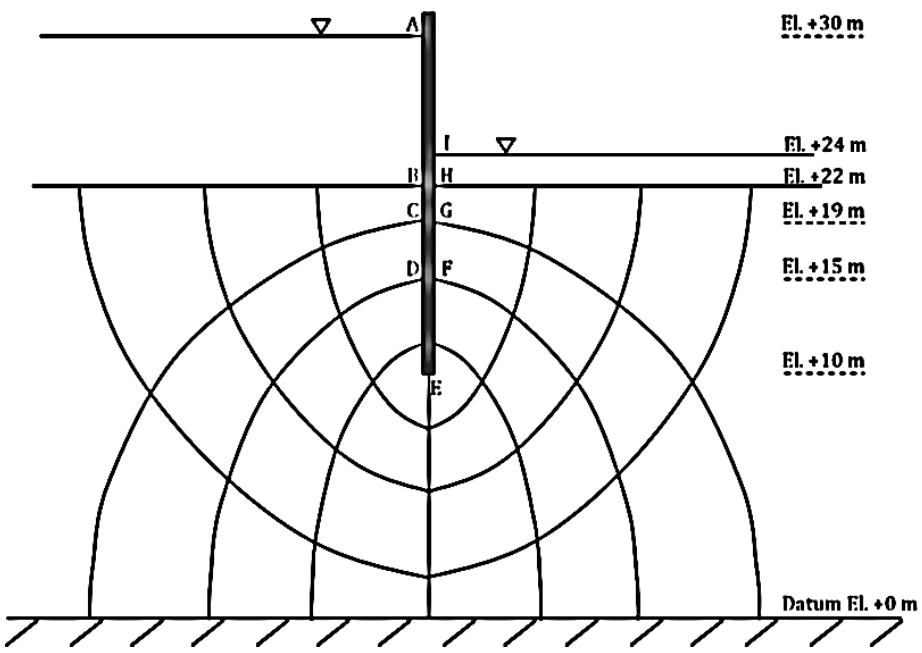

Fig. 2

4 + 4 + 4 = 12

5. (a) Fig. 3 shows a 1.5 m layer of soil ($n = 0.35$, $G = 2.65$), which is subjected to an upward seepage head of 2.2 m. Determine depth of coarse sand that would be required above the existing soil to provide a factor of safety of 2 against piping. Assume that the coarse sand has the same porosity and specific gravity as the soil and there is negligible head loss in sand.

[(CO1,CO3)(Analyse/IOCQ)]

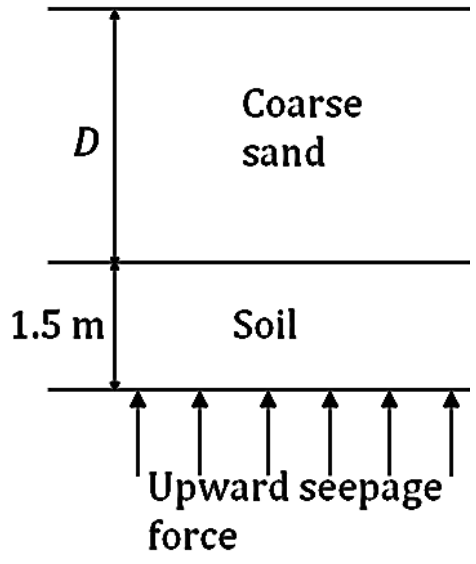

Fig. 3

(b) A stratified soil deposit is shown in Fig. 4. Assume an average hydraulic gradient of 0.4 in both horizontal and vertical direction. Determine (i) the ratio of equivalent permeability in horizontal and vertical direction, (ii) discharge quantity and discharge velocities in each layer for horizontal flow, and (iii) hydraulic gradient and loss of head in each layer for vertical flow. *[(CO1, CO3)(Analyse/IOCQ)]*

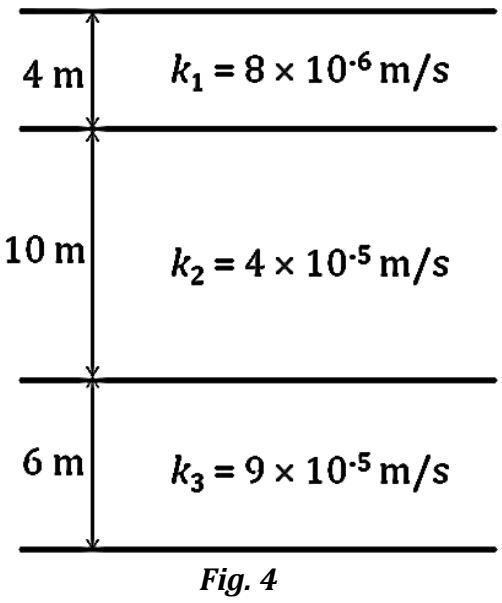

Fig. 4

4 + 8 = 12

Group - D

6. (a) It is required to construct of an embankment by compacting a soil from nearby borrow areas. The OMC and MDD of this soil were 25% and 1.6 gm/cc, respectively. However, the natural moisture content and bulk density of the soil were 12% and 1.8 gm/cc, respectively. Determine the quantity of soil to be excavated and the quantity of water to be added to it, for every 100 m^3 of the finished embankment. *[(CO1, CO4)(Evaluate/HOCQ)]*

(b) A 3 m thick layer of saturated clay (liquid limit = 30%, coefficient of permeability = 2×10^{-7} cm/sec, initial void ratio = 1.5) lies in between two permeable layers. The initial effective overburden pressure at the middle of the clay layer is 2 kg/cm^2, and is likely to increase to 5 kg/cm^2 due to the construction of a new building. Evaluate the final void ratio of the clay, settlement of the proposed building and time (in days) required for 50% consolidation. *[(CO1, CO4)(Evaluate/HOCQ)]*

6 + 6 = 12

7. (a) It is required to construct an embankment having a total volume of 65000 cu. m. The required soil is to be collected from borrow pits. It was found that the existing soil has a moisture content of 10 %, void ratio of 0.5 and specific gravity of soil solids of 2.6. Laboratory tests indicate that OMC and MDD of the soil are 18 % and 1.73 gm/cc, respectively. The soil is to be carried from the borrow pits to the construction site by trucks having average net carrying capacity of 6500 kg. Determine the total number of trips the trucks have to make for constructing the entire embankment and the quantity of water that has to be added to the borrowed soil before compaction. *[(CO1, CO4)(Evaluate/HOCQ)]*

(b) In a laboratory consolidation test, the void ratio of the sample reduced from 0.95 to 0.65 as the pressure was increased from 1 to 3 kg/cm^2. If the coefficient of permeability of the soil is 7.5×10^{-4} cm/sec, determine coefficient of volume change and coefficient of consolidation. *[(CO1, CO4)(Analyse/IOCQ)]*

8 + 4 = 12

Group - E

8. (a) A 4 m wide strip footing is located on the ground surface with a pressure of 200 kN/m^2. A 4m thick soft clay layer exists at a depth of 8 m below the foundation. Determine the average increase in vertical stress at the clay layer under the centreline and edge of the footing. *[(CO1, CO5)(Analyse/IOCQ)]*

(b) A soil has an unconfined strength of 160 kN/m^2. In a triaxial compression test, a specimen of the same soil when subjected to a chamber pressure of 45 kN/m^2 failed at an additional stress of 200 kN/m^2. Determine (i) the shear strength parameters of the soil and (ii) the angle made by the failure plane with the horizontal in the triaxial test. *[(CO1, CO6)(Evaluate/HOCQ)]*

(c) A cylindrical sample of soil having a cohesion of 60 kN/m^2 and an angle of internal friction of 22° is subjected to a cell pressure of 125 kN/m^2. Determine the maximum deviator stress at which the sample will fail and the angle made by the failure plane with the horizontal. *[(CO1, CO6)(Analyze/IOCQ)]*

4 + 4 + 4 = 12

9. (a) A line load of 100 kN/m run extends to a long distance. Determine the intensity of the vertical stress at a point 3 m below the surface (i) directly under the line load and (ii) at a distance of 2 m perpendicular to the line load. Use Boussinesq's theory. *[(CO1, CO5)(Analyse/IOCQ)]*

(b) The shear strength parameters of a given soil are, c = 0.12 kg/cm^2 and ϕ = 32°. Undrained triaxial tests are to be carried out on specimens of this soil. Determine (i) deviator stress at which failure will occur if the cell pressure is 2.8 kg/cm^2 and (ii) the cell pressure during the test, if the sample fails when the deviator stress reaches 1.33 kg/cm^2. *[(CO1, CO6)(Analyze/IOCQ)]*

(c) The relationship between the relative density, D_r, and the angle of friction, ϕ', of a sand can be given as, $\phi' = 25 + 0.18D_r$, where, $\phi'$is in degrees and D_r is in %. A drained triaxial test on the same sand was conducted with a chamber confining pressure of 95 kN/m^2. The relative density of the sand was 83%. Determine the major principal stress at failure, the angle that the failure plane makes with the major principal plane and the normal and shear stresses (when the specimen failed) on a plane that makes an angle of 39° with the major principal plane. *[(CO1, CO6)(Evaluate/HOCQ)]*

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	0	70.83	29.17