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) When water flows through a soil mass in upward direction, the effective stress at any depth within the soil mass
   (a) increases
   (b) decreases
   (c) remains unchanged
   (d) may increase or decrease depending on the quantity of water flowing through the soil.

   (ii) The seepage force per unit volume is given by
   (a) $p_s = i^3\gamma_w$ (b) $p_s = i^2\gamma_w$ (c) $p_s = i/\gamma_w$ (d) $p_s = i\gamma_w$
   where, the symbols have their usual meanings.

   (iii) If the discharge and seepage velocities through a soil are 9.52×10^{-3} cm/s and 2.36×10^{-2} cm/s, respectively, then its porosity is
   (a) 0.403 (b) 0.304 (c) 0.340 (d) 0.430.

   (iv) The contour of equal stress within a soil mass is termed as
   (a) Isochrone (b) Isobar (c) Isotherm (d) Isochore.

   (v) The path followed by a water particle during its course of seepage is called
   (a) flow line (b) equipotential line
   (c) hydraulic line (d) all of the above.

   (vi) The quantity of water that will flow through a cylindrical soil sample of 8 cm diameter and 12 cm height in a day under a constant head of 65 cm, if the coefficient of permeability of the soil is 0.01 mm/sec is
   (a) 20.5 lit. (b) 23.5 lit. (c) 25.5 lit. (d) 21 lit.

(vii) The soil that has been deposited in quiet lakes is termed as
(a) Lacustrine soil (b) Alluvial soil
(c) Aeolin soil (d) Colluvial soil.

(viii) The density of submerged soil, ρ_b is given by
(a) $\frac{G\rho_w(1+w)}{(1+e)}$ (b) $\frac{\rho_w G}{1+e}$ (c) $\frac{\rho_w(G+e)}{(1+e)}$ (d) $\frac{\rho_w(G-1)}{(1+e)}$

(ix) Degree of saturation of a natural soil deposit having water content 15%, specific gravity 2.50 and void ratio 0.5, is
(a) 50% (b) 60% (c) 75% (d) 80%.

(x) A triaxial shear test is preferred to direct shear test because
(a) it can be performed under all three drainage conditions with complete control
(b) precise measurement of pore pressure and change in volume during test is not possible
(c) stress distribution on the failure plane, is non uniform
(d) all of the above.

Group – B

2. (a) In a field exploration, a soil sample was collected in a sampling tube of 5 cm internal diameter below ground water table. The length of the extracted sample was 10.2 cm and its weight was 387 gm. If G = 2.67, and the weight of the dried sample is 315 gm, find the porosity, void ratio, degree of saturation and dry density of the sample.

(b) Laboratory test on a sample of soil gave the following results:
(i) Natural water content = 24%
(ii) Liquid limit = 62%
(iii) Plastic limit = 28%
(iv) Percentage of particles less than 2μ = 23%
Determine the liquidity index and activity number of the soil.

(c) Explain various corrections required to be applied to hydrometer readings in the sedimentation analysis.

7 + 2 + 3 = 12

3. (a) 500 gm of dry soil was subjected to sieve analysis. The weight of the soil retained on each sieve is as follows:

IS Sieve Size	4.75 mm	2 mm	1 mm	425 μ	212 μ	150 μ	75 μ
Weight of the soil (gm)	10	165	100	85	40	30	50

Group – E

8. (a) Write a short note on pore pressure parameters.

(b) A soil has an unconfined strength of 120 kN/m^2. In a triaxial compression test a specimen of the same soil when subjected to a chamber pressure of 40 kN/m^2 failed at an additional stress of 160 kN/m^2. Determine (i) The shear strength parameters of the soil and (ii) The angle made by the failure plane with the axial stress in triaxial test.

6 + 6 = 12

9. (a) An unconfined compression test was performed on an undisturbed sample of normally consolidated clay, having a diameter of 4 cm and 8 cm high. Failure occurred under a vertical compressive load of 400 kN. The axial deformation recorded at failure was 7 mm. Find the unconfined compressive strength of the soil. When an identical specimen of the same soil was tested in triaxial compression at a chamber pressure of 100 kN/m^2, the sample failed at deviator stress of 390 kN/m^2. Determine the shear parameters.

(b) An embankment is being constructed of soil whose properties are c'= 35 kN/m^2, ϕ' = 22° (all effective stresses), and γ = 18.85 kN/m^3. The pore pressure parameters as determined from triaxial tests are A = 0.5 and B = 0.9. Find the shear strength of the soil at the base of the embankment just when the height of fill has been raised from 10 m to 25 m. Assume that the dissipation of pore pressure during this stage of construction is negligible and that the lateral pressure at any point is one-half of the vertical pressure.

7 + 5 = 12

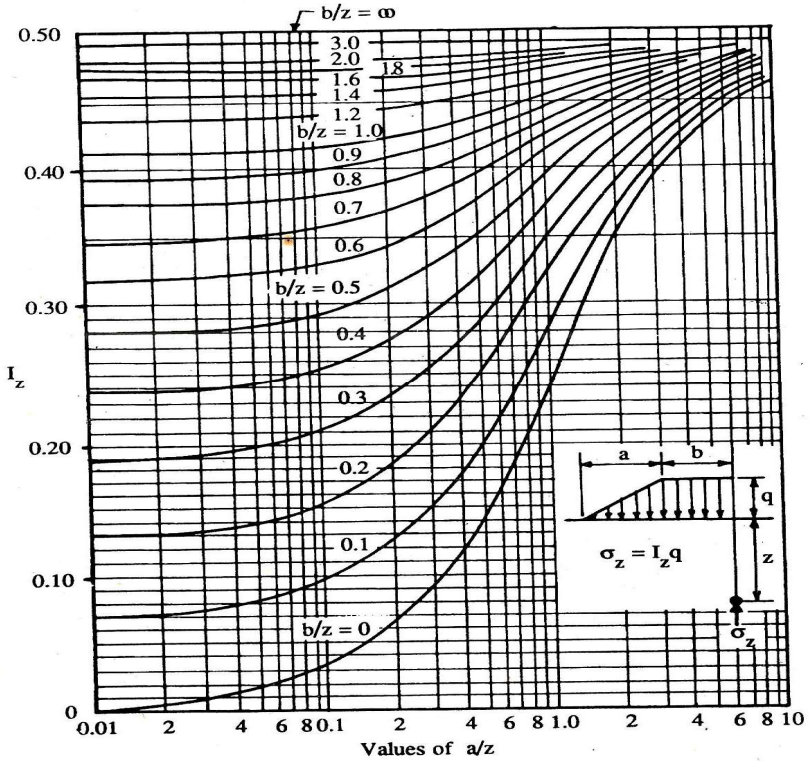

Fig.6

(b) A reinforced concrete water tank shown in the Fig.7 of size 8 m × 8 m and resting on ground surface carries a uniformly distributed load of 250 kN/m². Calculate the maximum vertical pressures at depths of 12 m and 24 m by (i) Point load approximation and (ii) Exact method (Boussinesq).

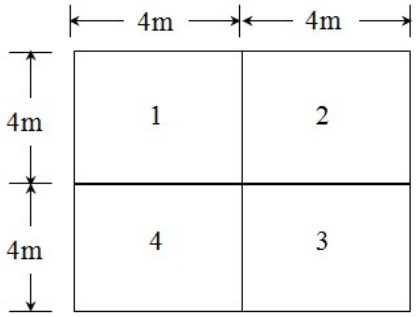

Fig.7

(c) Three footings are placed at locations forming an equilateral triangle of 5 m sides. Each footing carries vertical load of 600 kN. Determine the vertical stress using Westergaard's method at a depth of 2.5 m vertically below the centres of each footing and below the centre of the triangle.

4 + 4 + 4 = 12

Plot the grain size distribution curve and determine the following:

(i) Percentage of gravel, coarse sand, medium sand, fine sand and silt clay fraction in the soil as per IS:1498-1970.
(ii) Effective size.
(iii) Uniformity coefficient and coefficient of curvature.
(iv) The gradation of the soil.

(b) Write a short note on group index.

10 + 2 = 12

Group – C

4. (a) At a site the subsoil consists of 8 m thick layer of dry sand (G = 2.65, e = 0.85, D_{10} = 0.14 mm) which is underlain by a 6 m thick clay layer (G = 2.75, w = 22%) below which there exists a thick layer of rock. The water table is located at a depth of 6 m below the ground level. Neglecting the effect of porosity, determine (i) Height of capillary rise, (ii) Capillary pressure, (iii) Effective stresses at the ground level and at the bottom of sand layer. [Assume C = 0.5 cm²].

(b) Two soils A and B with coefficients of permeability as 0.002 m/s and 0.0004 m/s, respectively are arranged in the manners shown in the Fig.1. Determine (i) The total head at El. 0.0 m and El. +3.0 m in each case and (ii) Quantity of flow in each case. Take El. 0.0 m as datum.

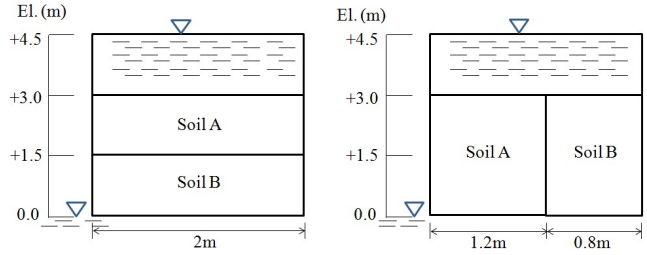

Fig.1

(c) Determine the uplift pressures at the points a, c, d and f at the base of the dam shown in the Fig.2.

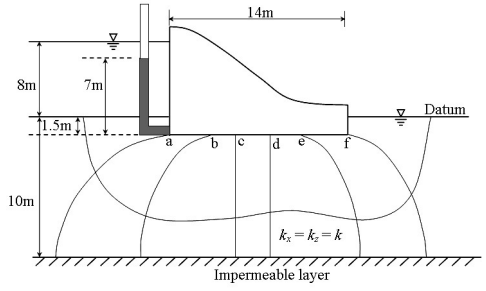

Fig.2

4 + 4 + 4 = 12

5. (a) At a particular site there are three layers of soil shown in the Fig.3. The ground water table (GWT) is at a depth of 3 m below ground level (GL). The soil is saturated due to capillary action to a height of 1.5 m above the ground water table level. Considering the effect of porosity, calculate the effective pressures at 1.5 m, 3 m, 5 m, and 11 m below GL.

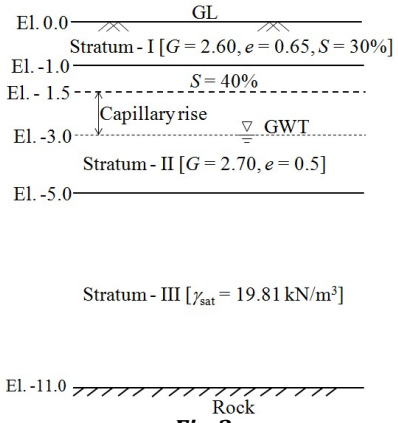

Fig.3

(b) A pumping test was carried out in the field in order to determine the average coefficient of permeability of a 20 m thick sand layer. The ground water table was located at a depth of 3 m below the ground level. A steady state was reached when the discharge from the well was 24 lit/sec. At this stage the drawdown in the test well was 3.5 m, while the drawdowns in two observation wells situated at 10 m and 23 m from the test well were found to be 1.9 m and 1.4 m, respectively. Determine (i) The coefficient of permeability of the sand layer in m/day, (ii) The radius of influence of the test well in m, (iii) The effective size of the sand particle i.e. D_{10} in mm. [Assume $C = 150$ cm^{-1}sec^{-1}].

(c) A single row of sheet piles shown in the Fig.4 is driven upto a depth of 6 m in a bed of clean sand having a coefficient of permeability of 0.005 cm/sec. An impermeable layer of very stiff clay exists at a depth of 14 m below the GL. The sheet pile wall has to retain water upto 5 m above GL. The height of water level on the downstream side is 0.5 m. The length of the last element is 0.8 m. Determine (i) The quantity of seepage loss considering unit width of the sheet piles, (ii) The piezometric heads at points A and D, (iii) Exit gradient and (iv) Factor of safety against piping. [Given: $G = 2.5, e = 0.85$].

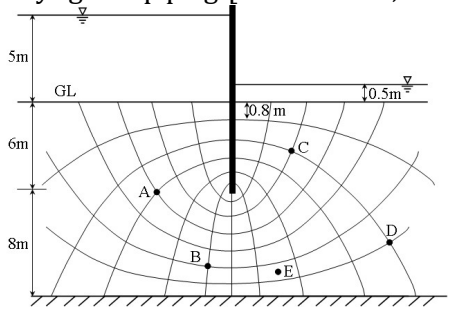

Fig.4

4 + 4 + 4 = 12

Group – D

6. (a) A rectangular raft of size 24 m × 16 m founded at a depth of 2.5 m below the ground surface is subjected to a uniform pressure of 250 kPa. Assume the centre of the area is the origin of the coordinates (0,0) and the corners have the coordinates (8,12). Calculate the stresses at a depth of 18 m below the foundation level using Boussinesq's and Westergaard's methods at coordinates of (8,0), (0,12) and (8,12). Neglect the effect of foundation depth on stresses.

(b) The footings of three adjacent columns of a building lie on the same straight line and carry gross loads of 1200 kN, 1500 kN and 1900 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 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 (resulting from 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: $G = 2.60$, $e = 0.45$, $w = 0\%$. Choose the point of application of 1200 kN load as the origin. Use Boussinesq's method. Assume the footings are founded at the ground level.

6 + 6 = 12

7. (a) A 4 m high embankment is to be constructed as shown in the Fig.5. If the unit weight of the soil used in the embankment is 18 kN/m^3, calculate the vertical stress due to the embankment loading at P_1 and P_3. Use Fig.6 to calculate stress influence coefficient (I_z).

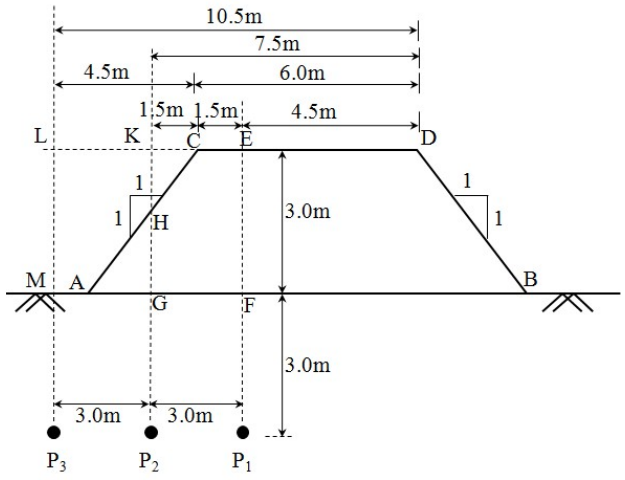

Fig.5