(iv) When the failure surface cuts the slope, the failure is termed as
(a) Base failure (b) Toe failure
(c) Slope failure (d) Top failure.

(v) The depth of an unsupported vertical cut in cohesive soil is given by,
(a) $\frac{2c}{\gamma\sqrt{K_a}}$ (b) $\frac{1.5c}{\gamma\sqrt{K_a}}$ (c) $\frac{4c}{\gamma\sqrt{K_a}}$ (d) $\frac{6c}{\gamma\sqrt{K_a}}$
where, the symbols have their usual meanings.

(vi) Two series of compaction tests were performed in the laboratory on an inorganic clayey soil employing two different levels of compaction energy per unit volume of soil. With regard to the above tests, the following two statements are made:
I. The optimum moisture content is expected to be more for the tests with higher energy.
II. The maximum dry density is expected to be more for the tests with higher energy.
The correct option evaluating the above statement is
(a) Only (I) is true (b) Only (II) is true
(c) Both (I) and (II) are true (d) Neither (I) nor (II) is true.

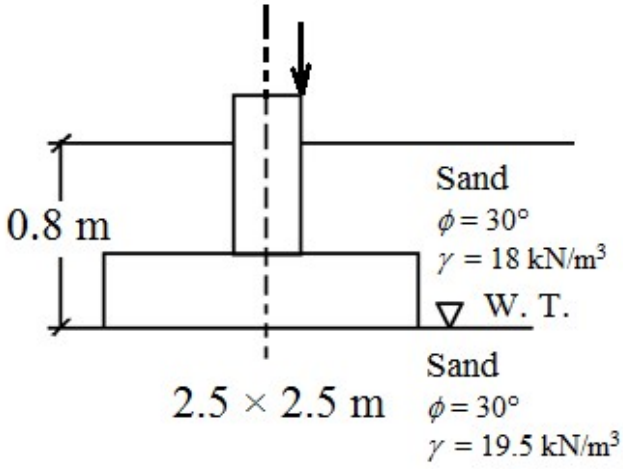
(vii) Quick sand condition occurs when
(a) the void ratio of the soil becomes 1.0
(b) the upward seepage pressure in soil becomes zero
(c) the upward seepage pressure in soil is equal to the saturated unit weight of the soil
(d) the upward seepage pressure in soil is equal to the submerged unit weight of the soil

(viii) Root time method is used to determine
(a) T, time factor
(b) C_v, coefficient of consolidation
(c) a_v, coefficient of compressibility
(d) m_v, coefficient of volume compressibility.

(ix) For $\phi = 0$, Terzaghi's bearing capacity factors are:
(a) $N_c = 1$, $N_q = 5.7$ and $N_\gamma = 0$ (b) $N_c = 0$, $N_q = 5.7$ and $N_\gamma = 1$
(c) $N_c = 5.7$, $N_q = 1$ and $N_\gamma = 0$ (d) $N_c = 1$, $N_q = 0$ and $N_\gamma = 5.7$.

(x) A saturated clay stratum draining both at the top and bottom undergoes 50% consolidation in 16 years under an applied load. If an additional drainage layer was present at the middle of the clay stratum, 50% consolidation would occur in
(a) 2 years (b) 4 years (c) 8 years (d) 16 years.

ultimate load, Q_{ult} for the water table at the base of the footing. (FOS = 3.0) and (ii) Gross ultimate bearing capacity if the water table rises to the GL. Consider general shear failure and use IS method.
Given: N_c = 46.12, N_q = 33.30 and N_γ = 48.03; Shape factors: s_q =1.2 and s_γ =0.8; Depth factors: $d_q = d_\gamma = 1 + 0.1\times\sqrt{N_\phi} \times (D_f/B)$ where, $N_\phi = \tan^2(45+\phi/2)$ and Inclination factors: $i_q = (1-\alpha/90)^2$ and $i_\gamma = (1-\alpha/\phi)^2$.



(9 + 3) = 12

7. (a) A rectangular footing of 2.0 m × 3.0 m size is to be constructed at 1.5 m below GL in a c - ϕ soil having the following properties: n = 40%, G = 2.67, w = 15%, ϕ = 32.5° c = 8 t/m^2. Calculate the safe load which the footing can carry at a factor of safety of 3 against shear failure as per IS code. N_c = 38.13, N_q = 25.85 and N_γ = 35.21.
$s_c = s_q = 1 + 0.2(B/L)$ $s_\gamma = 1 - 0.4\ (B/L)$ and
$d_c = 1 + 0.2\times\sqrt{N_\phi} \times (D_f/B)$, $d_q = d_\gamma = 1 + 0.1\times\sqrt{N_\phi} \times (D_f/B)$ where,
$N_\phi = \tan^2(45 + \phi/2)$ and inclination factor, $i_q = (1 - \alpha/90)^2$ and $i_\gamma = (1 - \alpha/\phi)^2$.

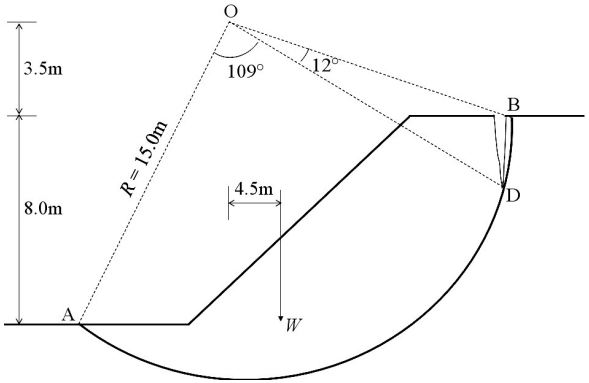
(b) Write a short note on minimum depth of foundation.

8 + 4 = 12

Group – E

8. (a) The following figure shows the cross-section of a cutting in a homogeneous, saturated clay soil inclined at a slope of 2(H):1(V), with a height of 8 m. Bulk unit weight of the soil is 18 kN/m^3 and undrained unit cohesion is 27 kN/m^2 (ϕ_u = 0). Determine the factor of safety against immediate shear failure along the slip circle as shown in the figure under the following

conditions (i) ignoring tension crack, (ii) allowing for the tension crack but without water and (iii) allowing for the tension crack filled with water. [Given: Area of the sliding mass and its centroid distance from O are 110m^2 and 4.5 m, respectively, when the arc length is AB and area of the sliding mass and its centroid distance from O are 108.5m^2 and 3.6 m, respectively, when the arc length is AD].



(b) Determine the critical height of an infinite slope made of clay (c' = 30 kN/m^2, ϕ' =20°, e = 0.65, G = 2.7) under the following conditions (i) when the soil is dry, (ii) when water seeps parallel to the surface of the slope, and (iii) when the slope is submerged. The slope is inclined at an angle of 25° with the horizontal.

(c) A footing 4m × 2m in plan transmits a pressure of 300 kN/m^2 on a cohesive soil having modulus of elasticity as 6 × 10^4 kN/m^2 and Poisson's ratio as 0.35. Determine the immediate settlement of the footing at the centre assuming it to be (i) flexible, (ii) rigid and (iii) using the rigidity factor as recommended by IS code for case (i). [Given: I_f = 1.53 and 1.20 for flexible and rigid footings, respectively]. Take depth correction factor as 1.0.

6 + 3 + 3 = 12

9. (a) Write short notes on:
(i) Elastic settlement. (ii) Types of slope failures.

(b) The shear strength parameters of a soil are: c' = 26.7 kN/m^2, ϕ' = 15°, c'_m = 17.8 kN/m^2 and ϕ'_m = 12°. Calculate the factor of safety (i) w.r.t. strength, (ii) w.r.t. cohesion and (iii) w.r.t. friction, (iv) F_ϕ when F_c = 1, and (v) F_c when F_ϕ = 1. The average intergranular pressure on the failure surface is 120 kN/m^2.

(3 + 4) + 5 = 12

SOIL MECHANICS - II
(CIVL 3102)

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) The active earth pressure coefficient for a backfill (friction angle ϕ) surface inclined at an angle β with the horizontal is given by

(a) $K_a = \cos\beta \times \dfrac{\cos\beta + \sqrt{\cos^2\phi - \cos^2\beta}}{\cos\beta - \sqrt{\cos^2\phi - \cos^2\beta}}$

(b) $K_a = \cos\beta \times \dfrac{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}$

(c) $K_a = \cos\beta \times \dfrac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}$

(d) $K_a = \cos\beta \times \dfrac{\cos\beta - \sqrt{\cos^2\phi - \cos^2\beta}}{\cos\beta + \sqrt{\cos^2\phi - \cos^2\beta}}$

(ii) Taylor's stability number is given by

(a) $N_S = \dfrac{c_u H_c}{\gamma}$ (b) $N_S = \dfrac{\gamma H_c}{c_u}$

(c) $N_S = \left(\dfrac{c_u}{\gamma H_c}\right)^2$ (d) $N_S = \dfrac{c_u}{\gamma H_c}$

where, the symbols have their usual meanings.

(iii) For a soil with friction angle, ϕ', the coefficient of at-rest earth pressure is given by

(a) $k_0 = 1 + \sin\phi'$ (b) $k_0 = 1 - \sin\phi'$

(c) $k_0 = \dfrac{1 - \sin\phi'}{1 + \sin\phi'}$ (d) $k_0 = 1 - \cos\phi'$

Group – B

2. (a) Two clay specimens A and B, with equilibrium void ratios of 0.65 and 0.70 respectively are under a pressure of 200 kN/m^2. If the equilibrium voids ratio of the soils reduced to 0.48 and 0.60, respectively for A and B, when the pressure was increased to 400 kN/m^2, find the ratio of the coefficients of permeability of the two specimens. The time required by the specimen A to reach 40% degree of consolidation is one fourth of that required by the specimen B for reaching 40% degree of consolidation.

(b) Write short notes on:
(i) Square root of time fitting method or Logarithm of time fitting method.
(ii) Height of solid method or change of void ratio method.

4 + (4 + 4) = 12

3. (a) Following are the results of a compaction test:

No. of test	1	2	3	4	5	6	7
Weight of the mould + wet soil (gm)	6607	6644	6723	6795	6837	6842	6829
Water content (%)	13.9	16.3	18.8	19.4	22.8	23.4	26.6

The mould is 12.73 cm high and has an internal diameter of 10 cm. The weight of the empty mould is 4944 gm. Specific gravity of solids is 2.65. Plot (i) compaction curve showing the optimum moisture content and maximum dry density and (ii) zero air voids line (iii) 10% zero air void line.

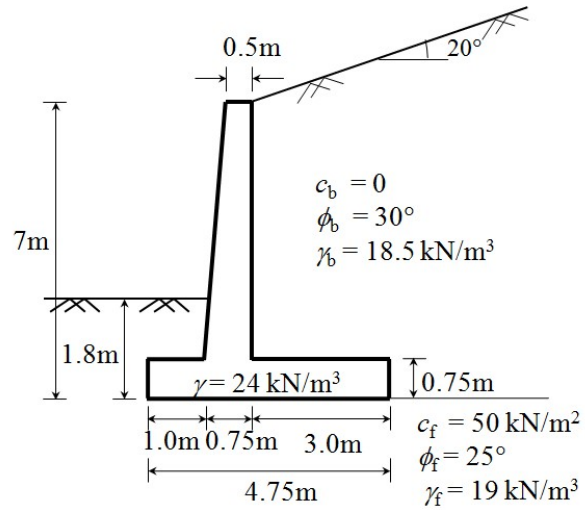
(b) A 3.5 m thick stratum is drained at both the top and bottom. The coefficient of consolidation of the clay is 5 × 10^{-4} cm^2/sec. Determine the time for 50% consolidation of the stratum.

10 + 2 = 12

Group – C

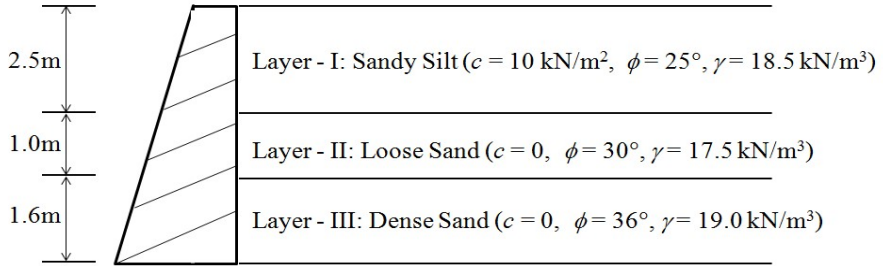
4. (a) Define active and passive earth pressures.

(b) For the cantilever wall shown in the figure below, check the stability of the wall with respect to overturning, sliding and bearing capacity. Take adhesion factor as 0.55. Assume angle of friction between base of the wall and the foundation soil as $(2/3)\phi_f$, where, ϕ_f is the angle of friction of the foundation soil. The ultimate bearing capacity of the foundation soil is 750 kN/m^2.



2 + (4 + 3 + 3) = 12

5. (a) For the retaining wall shown in the figure, determine the magnitude and point of application of the resultant active thrust above toe of the wall.



(b) A wall with a smooth vertical backface has to retain a backfill (c = 25 kN/m^2, ϕ = 12°, γ = 18 kN/m^3) upto a height of 6m. Determine (i) depth of the zone of tension cracks, (ii) magnitude and point of application of the resultant active thrust above toe of the wall, (iii) intensity of the fictitious uniform surcharge, which if placed over the backfill can prevent the formation of tension cracks and (iv) the resultant active thrust after placing the surcharge.

7 + 5 = 12

Group – D

6. A foundation 2.5m square is constructed at 0.8 m below the surface of a uniform sandy soil. Assume that the one way load eccentricity, e = 0.15 m. The soil properties in each layer are given in the figure. Determine (i) the