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.

(c) Determine the critical height of an infinite slope made of clay (c' = 40 kN/m^2, ϕ' =18°, 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 24° with the horizontal.

6 + 3 + 3 = 12

9. (a) An excavation is to be made in a soil deposit with a slope of 25° to the horizontal and to a depth of 25 m. The soil has the following properties: c' = 35 kN/m^2, ϕ' = 15°, γ = 20 kN/m^3. Determine (i) FOS of the slope assuming full friction is mobilized and (ii) FOS w.r.t. friction if the FOS with respect to cohesion is 1.5. [Given: for β = 25°, ϕ' = 15°, S_n = 0.03 & for β = 25°, S_n = 0.047, ϕ_m' = 13°]

(b) For the problem as shown in the Fig.5, compute the consolidation settlement by Skempton and Bjerrum method. The compressible layer of depth 24 m is divided into four layers. The net pressure (q_n) transmitted by the foundation is 150 kN/m^2. [Given: β = 0.7]

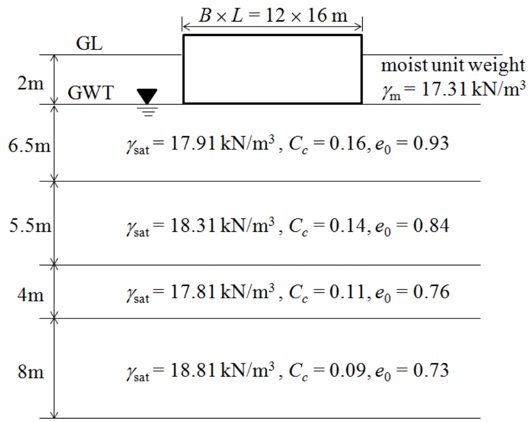


Fig.5

(c) For ordinary method of slices, derive the expression of factor of safety, $F = \frac{c'L + \tan\varphi' \sum (W_i \cos\theta_i - u_i l_i)}{\sum W_i \sin\theta_i}$, considering effective stress method of analysis, where, the symbols have its usual meanings.

2 + 4 + 6 = 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 <u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> 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 factor of safety of a slope of infinite extent having slope angle of 30° and made of cohesionless soil (friction angle = 36°) is given by
(a) 1.258 (b) 1.315 (c) 0.945 (d) 1.212.

(ii) If, q_n = 200 kN/m^2, E_s = 90 kg/cm^2, μ = 0.35, I_f = 0.82, then the immediate settlement (without corrections) of a rigid concrete footing 1.5 m × 1.5 m in size is given by
(a) 20.45 mm (b) 28.45 mm
(c) 24.45 mm (d) 30.45 mm.

(iii) If the available friction angle and mobilized friction angle along a failure plane are ϕ' and ϕ_m', respectively, then factor of safety with respect to friction is given by
(a) $F_\phi = \frac{\tan^2\phi'}{\tan^2\phi_m'}$ (b) $F_\phi = \frac{\tan\phi'}{\tan\phi_m'}$ (c) $F_\phi = \frac{\tan\phi_m'}{\tan\phi'}$ (d) $F_\phi = \frac{\tan\phi'}{\cos\phi_m'}$

(iv) An excavation was made in saturated soft clay (unit weight = 18 kN/m^3) with vertical sides. If the depth of tension crack is 6 m, the cohesion of the soil is given by
(a) 50 kN/m^2 (b) 54 kN/m^2 (c) 58 kN/m^2 (d) 48 kN/m^2

(v) Rankine's earth pressure theory is based on the following assumption(s)
(a) backfill material is cohesionless
(b) backfill surface is horizontal
(c) there is no friction between wall surface and backfill soil
(d) all of the above.

(vi) When the failure surface passes through the toe of a slope, the failure is termed as
(a) base failure (b) toe failure
(c) slope failure (d) top failure.

(vii) The ultimate bearing capacity on saturated homogeneous cohesive soil is equal to (as per IS)
(a) $5.17\ N_c s_c d_c i_c$
(b) $cN_c s_c d_c i_c + \sigma'(N_q - 1) \times s_q d_q i_q$
(c) $cN_c s_c d_c i_c + \sigma'(N_q - 1) \times s_q d_q i_q + 0.5\gamma B\ N_\gamma \times s_\gamma d_\gamma i_\gamma$
(d) $5.14\ c s_c d_c i_c$.

(vii) The weight of rammer used in IS modified proctor compaction test is
(a) 4.5 kgf (b) 4.6 kgf (c) 2.5 kgf (d) 2.7 kgf.

(ix) If the relative density of sand is 50%, then the type of bearing capacity failure in it will be
(a) general shear failure (b) local shear failure
(c) punching shear failure (d) unpredictable.

(x) A footing of size 2 m × 4 m is subjected to a vertical load with eccentricity of 0.1 m in the direction of the width and 0.2 m in the direction of the length of the footing. The corrected footing size is given by
(a) 1.8 m × 0.6 m (b) 1.9 m × 3.8 m
(c) 1.8 m × 3.8 m (d) 1.6 m × 3.6 m.

Group – B

2. (a) Derive the expression for consolidation settlement $S_c = \frac{C_c}{1+e_0} log \frac{\sigma_0 + \Delta\sigma}{\sigma_0} H$ where the symbols having usual meaning.

(b) Following are the results of a compaction test:

No. of test	1	2	3	4	5	6	7
Weight of the mould + wet soil (kg)	6.607	6.644	6.723	6.795	6.837	6.842	6.829
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 4.944 kg. Specific gravity of solids = 2.67.
(i) Plot the compaction curve showing the optimum moisture content and maximum dry density (ii) Plot the zero air voids line.

4 + 8 = 12

3. (a) A saturated soil stratum 6 m thick lies above am impervious stratum and below a pervious stratum. It has a compression index of 0.28 and a

(i) Water table is 4 m below GL
(ii) Water table is 1.2 m below GL.

4 + 4 + 4 = 12

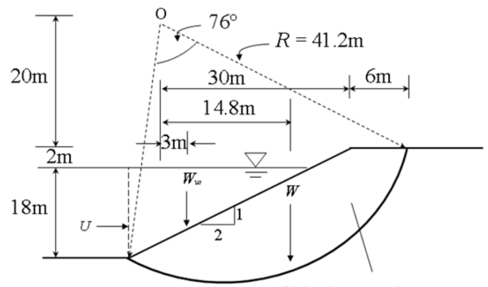
7. (a) A strip footing of width 2 m is to be founded at a depth of 1.2 m below GL in a loose sand deposit having the following properties : ϕ = 25°, c = 0, γ = 17·8 kN/m³.
The water table is at a substantial depth below GL.
(i) Determine the ultimate and safe bearing capacities of the footing, with respect to a factor of safety of 3, using Terzaghi's bearing capacity equation.
(ii) Determine the percent change in the ultimate bearing capacity if the water table rises up to the base of the foundation. Given γ_{sat} = 18·13 kN/m³.
For ϕ =25°; N_c = 12.7, N_q = 25.10 and N_γ = 9.7, N_c' = 14.8, N_q' = 5.6 and N_γ' = 3.2.

(b) State the limitation of Terzaghi's theory in predicting the bearing capacity of a shallow foundation on a cohesive soil deposit.

9 + 3 = 12

Group – E

8. (a) Evaluate the short term stability for the dam shown in the Fig.4. The embankment consists of a saturated soil for which the angle of shearing resistance ϕ_u = 0, and the undrained cohesion, c_u = 70 kN/m². The calculation is to be carried out for the reservoir depth of 18 m and for the case where the reservoir has been completely emptied.

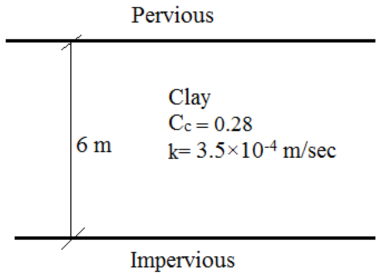


Total mass of block = 720 kg/m
Undrained cohesion, c_u = 70 kN/m²

Fig.4

(b) A footing 4 m × 4 m in plan transmits a pressure of 500 kN/m² on a cohesive soil having modulus of elasticity as 4 × 10⁴ kN/m² and Poisson's ratio as 0.45. Determine the immediate settlement of the footing at the centre assuming it to be (i) flexible, (ii) rigid and (iii) using the rigidity coefficient of permeability of 3.5 × 10^{-4} m/sec. Its void ratio at a stress of 150 kN/m^2 is 1.95. Determine:

(i) The change in void ratio due to an increase in stress to 210 kN/m^2.
(ii) Settlement of the soil stratum due to the above increase in stress and
(iii) Time required for 50 % consolidation.



(b) Write short notes on Standard Proctor and Modified Proctor test.

7 + 5 = 12

Group – C

4\. (a) A retaining wall has to retain a sand backfill (ϕ = 25°, e = 0.82, G = 2.68) upto a height of 5 m. A uniform surcharge of 60 kN/m^2 is placed over the backfill. The water table is at 2 m below ground surface. The soil above the water table has a degree of saturation of 15%. Determine the magnitude of the resultant active thrust on the wall.

(b) A retaining wall 8 m high with a smooth vertical back supports a saturated clay soil with a horizontal surface. The properties of the backfill are: c = 20 kN/m^2, ϕ = 30°, γ = 17 kN/m^3. Determine (i) the depth of tension cracks, (ii) the critical depth of a vertical cut, (iii) the total active thrust against the wall and its point of application, if cracks are formed in the tension zone and (iv) what will be the depth of tension cracks, if any, if the backfill carries a uniform surcharge of 30 kN/m^2 over the backfill surface?

(c) For the retaining wall shown in the Fig.1, determine the magnitude and point of application of the resultant active thrust on the wall.

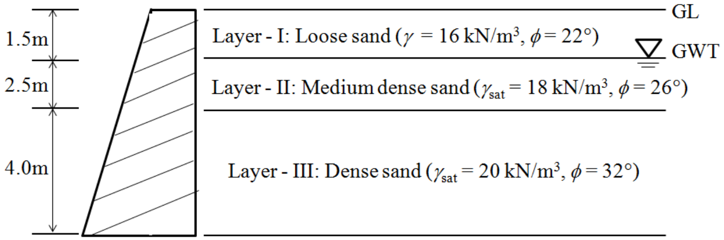


Fig.1

3 + 4 + 5 = 12

5\. (a) For the retaining wall shown in the Fig.2, determine the magnitude and point of application of the resultant active thrust above the toe of the wall.

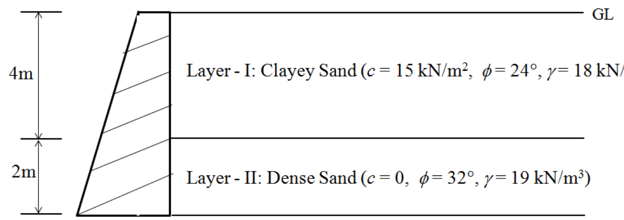


Fig.2

(b) For the cantilever wall shown in Fig.3, check the stability of the wall with respect to (i) overturning, (ii) sliding and (iii) bearing capacity. Take adhesion factor as 0.45. Assume angle of friction between base of the wall and the foundation soil as (2/3)ϕ_f, where, ϕ_f is the angle of friction of the foundation soil. The ultimate bearing capacity of the foundation soil is 600 kN/m^2.

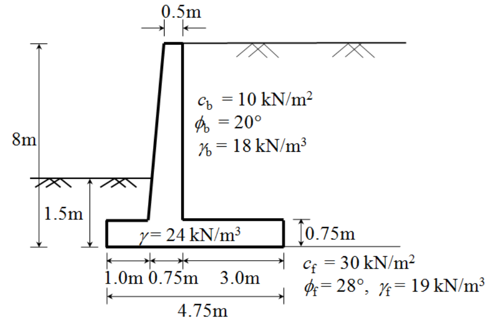


Fig.3

5 + (3 + 2 + 2) = 12

Group – D

6\. (a) A square footing is 2.5 m × 2.5 m in plan. The shear strength properties of the supporting soil are c = 15.2 kN/m^2 and ϕ = 30°. The unit weight of the soil is 17.8 kN/m^3. The depth of the foundation is 1.5 m. Determine the safe bearing capacity for a factor of safety of 2.5. Given: N_c = 46.12, N_q = 33.30 and N_γ = 48.03.

(b) Write a short note on general shear failure and local shear failure.

(c) A strip footing 2 m wide carries a load intensity of 400 kN/m^2 at a depth of 1.2 m in sand. The saturated unit weight of sand is 19.5 kN/m^3 and unit weight above water table is 16.8 kN/m^3. The shear strength parameters are c = 0, ϕ = 35°. For ϕ = 35°, N_q = 41.4 and N_γ = 42.4. Determine the factor of safety with respect to shear failure for the following cases of location of water table: