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) $K_a = \cos\beta \times \dfrac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}$ (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) $K_a = \cos\beta \times \dfrac{\cos\beta + \sqrt{\cos^2\phi - \cos^2\beta}}{\cos\beta - \sqrt{\cos^2\phi - \cos^2\beta}}$ (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) A retaining wall is to be designed against the following
(a) Sliding (b) Overturning
(c) Bearing capacity (d) All of the above.

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

(iv) If the available cohesion and mobilized cohesion along a failure plane are c and c_m, respectively, then factor of safety w.r.t. cohesion is given by

(a) $F_c = \dfrac{c_m}{c}$ (b) $F_c = \dfrac{c}{c_m}$ (c) $F_c = \dfrac{c^2}{c_m^2}$ (d) $F_c = c \times c_m$

(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) Elastic settlement is predominant in
(a) Sand (b) Inorganic clay
(c) Organic soil (d) All of the above.

(vii) 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 $N_\gamma = 5.7$

(viii) The width and depth of a footing are 2 m and 1.5 m, respectively. The water table at the site is at a depth of 3 m below the ground level. The water table correction factor for the calculation of bearing capacity of soil is
(a) 0.875 (b) 1.000 (c) 0.925 (d) 0.500

(ix) In compaction,
(a) Air is expelled out of the voids
(b) Water is expelled out of the voids
(c) Both air and water is expelled out of the voids
(d) The void ratio increases.

(x) Consolidation occurs in
(a) Dry sand (b) Dry clay
(c) Fully saturated clay (d) Partially saturated clay.

Group – B

2. (a) What are the differences between compaction and consolidation? [(CO1) (Remember/LOCQ)]

(b) A 3 m thick layer of silty clay is sandwitched between two layers of dense sand. The effective overburden pressure at the centre of the silt layer is 2 kg/cm^2. However, due to the construction of a raft foundation, this pressure increases to 5 kg/cm^2. Laboratory consolidation test was performed on a 2.5 cm thick sample of the silty clay. The compressions of the sample were found to be 0.26 cm and 0.38 cm under applied stresses of 2 kg/cm^2 and 5 kg/cm^2, respectively. Compute the consolidation settlement of the raft. [(CO1) (Evaluate/HOCQ)]

(c) A 2 m thick layer of saturated clay (liquid limit = 45%, $k = 2.8 \times 10^{-7}$ cm/sec, initial void ratio = 1.25) 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. Determine the final void ratio of the clay, settlement of the proposed building and time (in days) required for 50% consolidation. [(CO1) (Evaluate/HOCQ)]

2 + 4 + 6 = 12

3. (a) What are normally and overconsolidated clays? How preconsolidation pressure is determined for these two types of soil? [(CO1) (Understand/IOCQ)]

(b) It is required to construct of an embankment by compacting a soil from nearby borrow areas. The OMC and MDD of this soil were 22.5% and 1.66 gm/cc, respectively. However, the natural moisture content and bulk density of the soil were 9% and 1.78 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) (Evaluate/HOCQ)]

4 + 8 = 12

Group – C

4. (a) A retaining wall has to retain a sand backfill (e = 0.83, G = 2.68) upto a height of 6m. The water table is located at 2m below ground surface. The soil above the water table has a degree of saturation of 20%. The angles of internal friction of soil above and below the water table are 30° and 26° respectively. Determine the magnitude and point of application of the resultant active thrust on the wall. [(CO2)(Evaluate/HOCQ)]

(b) For the retaining wall (Fig. 1), determine the magnitude and point of application of the resultant active thrust on the wall. [(CO2)(Evaluate/HOCQ)]

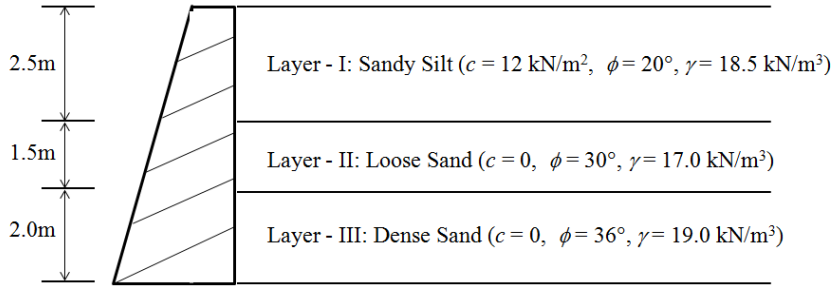

Fig.1

4 + 8 = 12

5. (a) For the retaining wall (Fig. 2), determine the magnitude and point of application of the resultant active thrust on the wall. [(CO2) (Evaluate/HOCQ)]

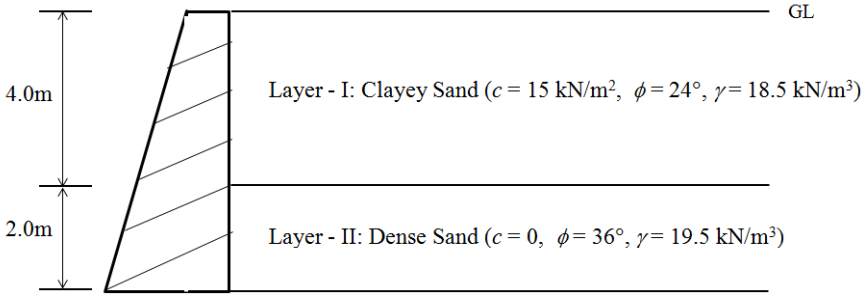

Fig.2

(b) For the cantilever wall (Fig. 3), check the stability of the wall with respect to (i) overturning, (ii) sliding and (iii) 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 550kN/m². [(CO3) (Evaluate/HOCQ)]

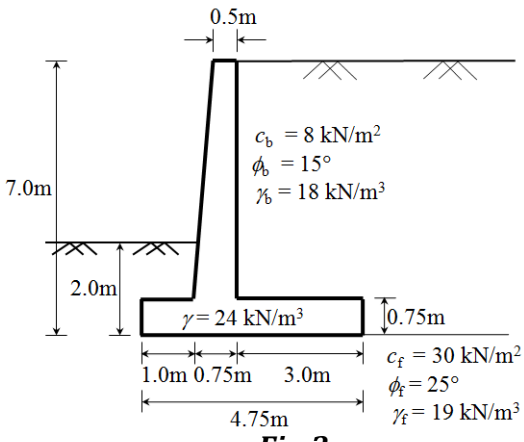

Fig.3

5 + (3 + 1 + 3) = 12

Group – D

6. (a) A 2 m wide continuous strip footing is founded at a depth of 1.2 m below the ground level in a homogeneous bed of dense sand (ϕ = 36°, γ = 18.5 kN/m^3). Determine the net ultimate, net safe and safe bearing capacity of the footing. Assume a factor of safety of 3.0. Use IS code method. [Given: for ϕ = 36°, N_c = 50.59, N_q = 37.75, N_γ = 56.31]. [(CO4) (Evaluate/HOCQ)]

   (b) A column of a building, carrying a safe load of 1380 kN has to be supported by a square footing. The footing is to be placed at 1.2 m below ground level in a soil (ϕ = 35°, γ = 18.5 kN/m^3). Determine the minimum size of the footing to have a factor of safety of 2.5 against shear failure. Use Terzaghi's theory. [Given: for ϕ = 35°, N_c = 57.8, N_q = 41.3, N_γ = 42.4]. [(CO4) (Evaluate/HOCQ)]

   (c) Explain general shear failure in soil for shallow foundation. [(CO4) (Remember/LOCQ)]

6 + 4 + 2 = 12

7. (a) A column footing of 5.8 m × 1.8 m is founded at a depth of 1.5 m below ground level in a soil (c = 11 kN/m^2, ϕ = 20°, saturated unit weight = 17.5 kN/m^3) . Determine the safe bearing capacity of the footing with a factor of safety of 3.0, when the ground water table is located at (i) GL, (ii) 0.6 m below GL, (iii) 2 m below GL and (iv) 4 m below GL. Use IS code method. [Given: for ϕ = 10°, N_c = 8.35, N_q = 2.47, N_γ = 1.22; for ϕ = 15°, N_c = 10.98, N_q = 3.94, N_γ = 2.65; for ϕ = 20°, N_c = 14.83, N_q = 6.40, N_γ = 5.39]. [(CO4) (Evaluate/HOCQ)]

   (b) Calculate the net ultimate bearing capacity of a rectangular footing 2 m × 4 m in plan, founded at a depth of 1.5 m below the ground surface. The load on the footing acts at an angle of 15° to the vertical and is eccentric in the direction of width by 15 cm. The cohesion, friction angle and saturated unit weight of the soil are 15 kN/m^2, 25° and 18 kN/m^3, respectively. The ground water table is at a depth of 2 m below the ground surface. Use IS: 6403-1981 recommendations. [Given: for ϕ = 25°, N_c = 20.72, N_q = 10.66, N_γ = 10.88]. [(CO4) (Evaluate/HOCQ)]

8 + 4 = 12

Group – E

8. (a) What are immediate and consolidation settlements? [(CO5) (Understand/LOCQ)]

   (b) The shear strength parameters of a soil are: c' = 25.0 kN/m^2, ϕ' = 18°, c'_m = 18.0 kN/m^2 and ϕ'_m = 12°. Calculate the factor of safety (i) with respect to strength, (ii) with respect to cohesion and (iii) with respect to friction, (iv) F_ϕ when F_c = 1, (v) F_c when F_ϕ = 1 and (vi) true FOS. The average intergranular pressure on the failure surface is 120.0 kN/m^2. [(CO6) (Evaluate/HOCQ)]

   (c) The cross-section of a cutting (Fig. 4) in a homogeneous, saturated clay soil inclined at a slope of 2(H):1(V), with a height of 8 m is shown in Figure 5. 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 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 110m² and 4.5 m, respectively, when the arc length is AB and area of the sliding mass and its centroid distance from O are 108.5m² and 3.6 m, respectively, when the arc length is AD]. [(CO6) (Evaluate/HOCQ)]

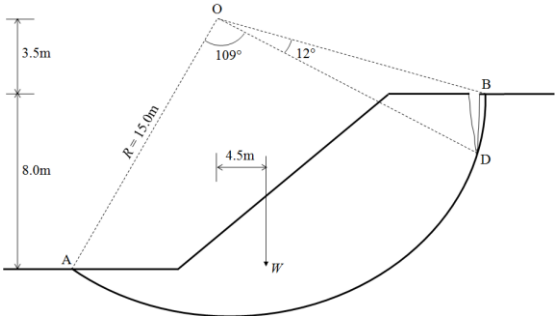

Fig.4

3 + 3 + 6 = 12

9. (a) Determine the critical height of an infinite slope made of clay (c' = 35 kN/m², 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 30° with the horizontal. [(CO6) (Evaluate/HOCQ)]

(b) A flexible square footing of size 8m × 8m is founded at a depth of 2.5 m below the ground surface in loose to medium dense sand with net foundation pressure of 130 kN/m². Standard penetration tests conducted at the site gave the following corrected N_{cor} values. [(CO5) (Evaluate/HOCQ)]

Layer no.	Depth (m)		Thickness (m)	N_{cor}
	From	To		
1	2.5	6.5	4	9
2	6.5	12.5	6	12
3	12.5	18.5	6	16

The water table is located at the base of the foundation. Above the water table γ = 17 kN/m³ and submerged γ_b = 8.5 kN/m³. The modulus of elasticity of the soil is given by $E_s = 250(N_{cor} + 15)$ kN/m². Calculate $\frac{D_f}{\sqrt{BL}}$ and L/B. Compute the elastic settlement assuming μ = 0.35 and the depth of the compressible layer as 16m. [Given: $F_1 = 0.4$, $F_2 = 0.03$ and depth correction factor is 0.82]

(c) For ordinary method of slices, derive the expression of factor of safety in effective stress method of analysis, where, the symbols have their usual meanings.

$$F = \frac{c'L + \tan\phi' \sum (W_i \cos\theta_i - u_i l_i)}{\sum W_i \sin\theta_i}$$

Describe all the terms shown in the above expression. [(CO6)(Evaluate/HOCQ)]

3 + 3 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	30%	43.33%	26.67%

Course Outcome (CO):

After the completion of the course students will be able to

CO1 Assess the compaction and consolidation characteristics of soil for solving geotechnical problems.

CO2 Calculate earth pressure on rigid retaining walls on the basis of classical earth pressure theories.

CO3 Analyze and design rigid retaining walls (cantilever types) from geotechnical engineering consideration.

CO4 Evaluate the bearing capacity of shallow foundation by applying established theory.

CO5 Estimate settlement in soils by different methods.

CO6 Compute safety of dams and embankments on the basis of various methods of slope stability analysis.

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

Department & Section	Submission link:
CE	Google classroom joining code 7b4mjqf
	Google classroom joining link https://classroom.google.com/c/MjQzODkwNDAwMzM0?cjc=7b4mjqf
	Answer script upload link https://classroom.google.com/w/MjQzODkwNDAwMzM0/t/all