B.TECH/CE/4TH SEM/CIVL 2202/2021

SOIL MECHANICS - II
(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) If a cutting is made in a soil mass having c = 16 kN/m^2, ϕ = 15° and γ = 18 kN/m^3 with side slopes of 30° to the horizontal upto a depth of 12 m below ground level, then the factor of safety of the slope with respect to cohesion (if, S_n = 0.046) is
(a) 1.65 (b) 1.61 (c) 1.68 (d) 1.63

(ii) The factor of safety with respect to friction when, ϕ' = 18° and $\phi'_m = 13°$ is
(a) 1.403 (b) 1.407 (c) 1.404 (d) 1.409.

(iii) The depth of an unsupported vertical cut in a soil (ϕ' = 16°, c' = 19.1 kN/m^2 and γ = 18.5 kN/m^3) is
(a) 5.48 m (b) 5.42 m (c) 5.54 m (d) 5.36 m

(iv) A vertical wall 6 m high, retains a 20° (with horizontal) soil (c' = 0 and ϕ' = 40°) slope. The coefficient of active earth pressure as per Rankine's theory is
(a) 0.15 (b) 0.45 (c) 0.25 (d) 0.35

(v) In bearing capacity check for a retaining wall, the eccentricity of the resultant vertical load from the centre of the base should be
(a) $\le \frac{B}{3}$ (b) $\le \frac{B}{4}$ (c) $\le \frac{B}{5}$ (d) $\le \frac{B}{6}$.
where, B is the width of the base of the wall.

(vi) The weight of rammer used in IS light compaction test is
(a) 2.3 kgf (b) 2.6 kgf (c) 2.5 kgf (d) 2.7 kgf

(vii) The corrected cross-sectional area at failure (A_f) can be obtained from original cross-sectional are (A_0) in an unconfined compression test using the relation
(a) $A_f = A_0/(1-\varepsilon_l)$ (b) $A_f = A_0(1-\varepsilon_l)$
(c) $A_f = A_0/(1-\varepsilon_v)$ (d) $A_f = \dfrac{V_0/(1+\varepsilon_v)}{l_0/(1\pm\varepsilon_l)}$

(viii) In a triaxial test carried out on a cohesionless soil sample with a cell pressure of 20 kPa, the observed value of applied stress at the point of failure was 40 kPa. The angle of internal friction of the soil is
(a) 10° (b) 15° (c) 25° (d) 30°

(ix) A 6 m thick double draining clay layer settles by 30 mm in 3 years under the influence of certain loads. Its final consolidation settlement was estimated to be 120 mm. If a thin layer of sand having negligible thickness is introduced at a depth 1.5 m below the top surface, the final consolidation settlement of clay layer will be
(a) 60 mm (b) 120 mm (c) 240 mm (d) 30 mm.

(x) A direct shear test was conducted on a cohesionless soil (c = 0) specimen under a normal stress of 200 kN/m^2. The specimen failed at a shear stress of 100 kN/m^2. The angle of internal friction of the soil is
(a) 26.6° (b) 29.5° (c) 30.0° (d) 32.6°.

Group – B

2. (a) A vane, 10 cm long and 8 cm in diameter, was pressed into soft clay at the bottom of a bore hole. Torque was supplied and gradually increased to 45 N-m when failure took place. Subsequently, the vane rotated rapidly so as to completely remould the soil. The remoulded soil was sheared at a torque of 18 N-m. Calculate the cohesion of the clay in the natural and remoulded states.

(b) Sketch the stress–strain relationship for dense and loose sands and explain it.

(c) Three identical specimens of a partially saturated clay were subjected to an undisturbed triaxial test and the following results were obtained:

Sample no.	Cell pressure (kg/cm^2)	Deviator stress (kg/cm^2)
1	0.5	0.80
2	1.0	0.97
3	1.5	1.13

Determine the shear parameters of the soil.

(2 + 2) + 3 + 5 = 12

3. (a) An unconfined compression test was performed on an undisturbed sample of normally consolidated clay, having a diameter of 3.75 cm and 7.5 cm high. Failure occurred under a vertical compressive load of 116.3 kg. The axial deformation recorded at failure was 0.9 cm. A remoulded sample of the same soil failed under a compressive load of 68.2 kg, and the corresponding axial compression was 1.15 cm. Determine the unconfined compressive strength and cohesion of the soil in the undisturbed as well as remoulded state. Also determine the sensitivity of the soil and hence classify it accordingly.

(b) A soil sample is initially subjected to a cell pressure of 100 kPa. Draw stress paths for the loading conditions when

(i) The cell pressure is kept constant and the major principal stress is increased to 200 kPa.
(ii) Both the cell pressure and major principal stress are increased to 200 kPa.
(iii) Major principal stress is maintained constant and cell pressure is increased to 200 kPa.
(iv) Major principal stress is kept constant while the cell pressure is decreased to 25 kPa.

(c) An embankment is being constructed of soil whose properties are c'= 33.5kN/m^2, ϕ' = 21° (all effective stresses), and γ = 19.85 kN/m^3. The pore pressure parameters as determined from triaxial tests are A = 0.5, and 0.9. Find the shear strength of the soil at the base of the embankment just after the height of fill has been raised from 10 m to 20 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.

4 + 4 + 4 = 12

Group – C

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

No. of test	1	2	3	4	5	6
Weight of the mould + wet soil (gm)	3526	3711	3797	3906	3924	3882
Water content (%)	8.33	10.40	12.23	16.20	17.92	20.39

The internal diameter and height of the mould were 10 cm and 12.7 cm respectively. The weight of the empty mould is 1.89 kg. Specific gravity of solids is 2.68.

(i) Plot the compaction curve. Hence determine the optimum moisture content and maximum dry density.
(ii) Plot the zero air voids line.

(b) Write short note on preconsolidation pressure.

(6 + 2) + 4 = 12

5. (a) The time to reach 40% consolidation of two-way laboratory 10 mm thick saturated clayey soil sample is 35 seconds. Determine the time required for 60% consolidation of the same soil 10 m thick on the top of a rocky surface subjected to the same loading conditions as the laboratory sample.

(b) A stratum of clay 8 m deep, has w_l = 45 %. The surface of clay is at 10 m below the present ground level, w = 40 % and G = 2.78 for clay. Between ground surface and clay, the subsoil consists of fine sand. The ground water level is 4.5 m below ground level. The average submerged unit weight of sand is 10.4 kN/m^3 and the unit weight of sand above the ground water level is 17 kN/m^3. The clay is normally consolidated. The weight of structure coming on top of the sand above the clay increases the overburden pressure on clay by 40 kN/m^2. Estimate the consolidation settlement of the building.

(c) Write short notes on the following:

(i) Standard proctor

(ii) Modified proctor test.

3 + 5 + 4 = 12

Group – D

6. (a) The soil conditions adjacent to a sheet pile wall are shown in Fig. 1, a surcharge pressure of 50 kN/m^2 being carried on the surface behind the wall. For soil 1, a sand above the water table, $c' = 0$, $\phi' = 38°$, $\gamma = 18$ kN/m^3. For soil 2, a saturated clay, $c' = 10$, $\phi' = 28°$, $\gamma_{sat} = 20$ kN/m^3. Calculate the total active thrust and passive resistance on the wall. Also determine their locations above the toe of the wall.

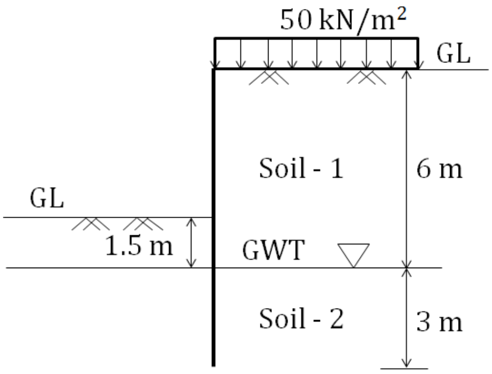

Fig.1

(b) A retaining wall with a smooth vertical backface has to retain a backfill ($c = 20$ kN/m^2, $\phi = 15°$, $\gamma = 18$ kN/m^3) upto a height of 6.5 m. Determine (i) the depth of zone of tension cracks, (ii) magnitude of the resultant active thrust above the toe of the wall, if tension cracks are formed, (ii) intensity of the fictitious uniform surcharge, which, if placed over the backfill can prevent the formation of tension cracks and (iii) the resultant active thrust on the wall after placing the surcharge.

8 + 4 = 12

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

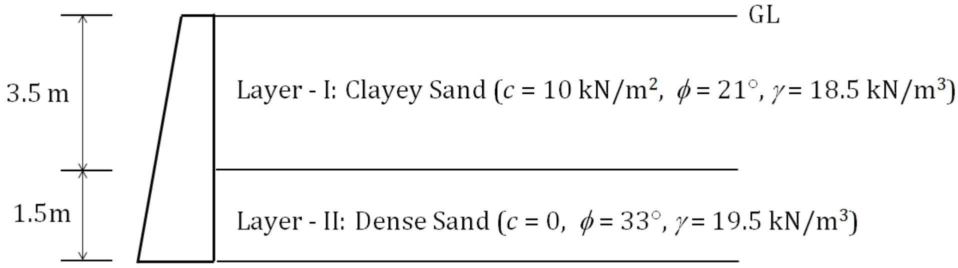

Fig.2

(b) Analyse the stability of the cantilever retaining wall shown in Fig.3, in overturning, sliding and bearing capacity modes of failure. Take adhesion factor as 0.40. 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 700 kN/m^2.

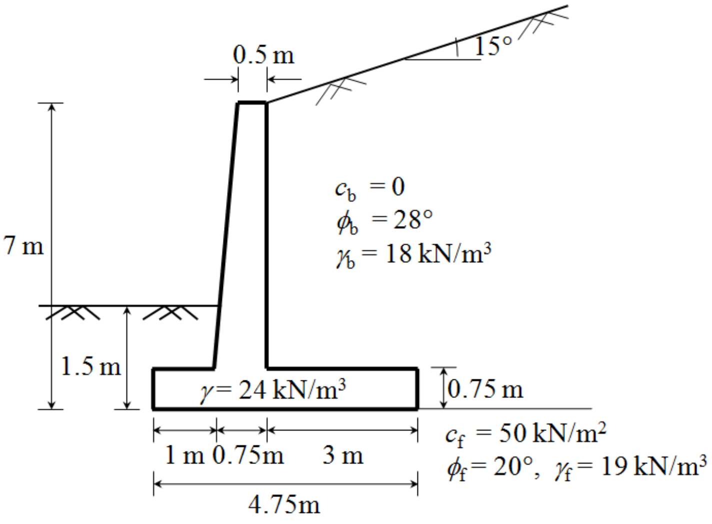

Fig.3

5 + (3 + 2 + 2) = 12

Group – E

8. (a) A slope has to be made from a granular soil [γ_{sat} = 19 kN/m³, ϕ' = 30°, e = 0.70, G = 2.65]. If a factor of safety of 1.4 is needed against slope failure, determine the safe angle of the slope when (i) the slope is dry or submerged without seepage, (ii) the seepage occurs at and parallel to the surface of the slope, (iii) If seepage occurs parallel to the slope with water table at a depth of 3 m, what is the factor of safety available on a slip plane parallel to the ground surface at a depth of 5 m assuming the slope angle as that obtained in case (i)? and (iv) What will be the factor of safety under case (ii) when the slope angle is kept as that obtained in case (i)? The degree of saturation above water table is 30%.

(b) 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 is shown in Fig. 4. Bulk unit weight of the soil is 17.5 kN/m³ and undrained unit cohesion is 22 kN/m² (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 114 m² and 4.5 m, respectively, when the arc length is AB and area of the sliding mass and its centroid distance from O are 110 m² and 3.6 m, respectively, when the arc length is AD]

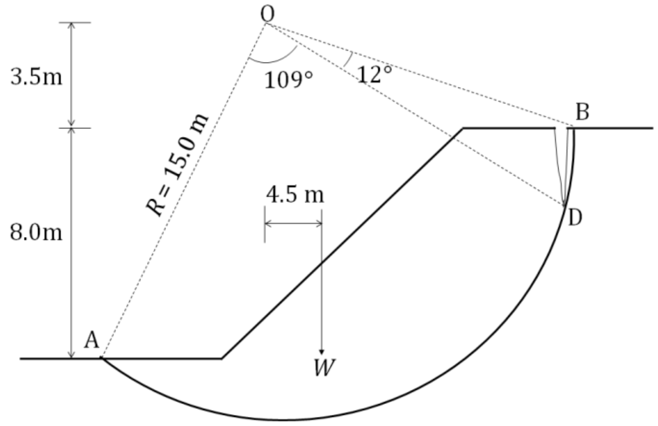

Fig. 4

(c) Develop the expression of factor of safety, $F = \frac{c'L + \tan\phi' \sum (N_i - U_i)}{\sum W_i \sin\theta_i}$ by making use of method of slices, where, the symbols have their usual meanings.

4 + 4 + 4 = 12

9. (a) Determine by Culmann's method the critical height of an embankment having a slope angle of 40° and the constructed soil having c' = 20 kN/m², ϕ' = 15°, and effective unit weight = 18 kN/m³. Find the allowable height of the embankment if $F_c = F_\phi = 1.35$.

(b) A canal having side slopes inclined at angle of 45° with the horizontalis proposed to be constructed in a cohesive soil to a depth of 5 m below the ground surface. The soil properties are: c_u = 12 kN/m², ϕ_u = 15°, e = 1.0, G = 2.65. Using Taylor's stability chart (Table 1), determine the factor of safety with respect to cohesion against failure of the bank slopes, when (i) the canal is full of water and (ii) there is a sudden drawdown of water in the canal.

Table 1: Taylor's stability number

β \ ϕ	0°	5°	10°	15°	20°	25°
90°	0.261	0.239	0.218	0.199	0.182	0.166
75°	0.219	0.195	0.173	0.152	0.134	0.117
60°	0.191	0.162	0.138	0.116	0.097	0.079
45°	0.170	0.136	0.108	0.083	0.062	0.044
30°	0.156	0.110	0.075	0.046	0.0625	0.009
15°	0.145	0.068	0.023	-	-	-

(c) The shear strength parameters of a soil are: c' = 30 kN/m², ϕ' = 20°, $c'_m = 18$ kN/m² and $\phi'_m = 15°$. Calculate the factor of safety with respect to (i) strength, (ii) cohesion, (iii) friction, (iv) F_ϕ when F_c = 1, (v) F_c when F_ϕ = 1. The average intergranular pressure on the failure surface is 130 kN/m².

3 + 4 + 5 = 12

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