FOUNDATION ENGINEERING
(CIV3103)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) If the coefficient of active earth pressure K_a is 1/3, the coefficient of passive earth pressure K_p is
(a) 3 (b) 4.5
(c) 6 (d) 9

(ii) The active earth pressure caused by a cohesionless backfill on a smooth vertical retaining wall may be reduced by
(a) Compacting the backfill (b) Providing a surcharge load on the backfill
(c) Saturating the backfill with water (d) None of the above

(iii) In-situ vane shear strength is used to measure shear strength of
(a) Very soft and sensitive clays (b) Stiff and fissured clays
(c) Sandy soils (d) Rock

(iv) The factor of safety of an infinite slope in a sand deposit is 1.732. If the angle of shearing resistance is 30°, the safe slope angle is
(a) 19.5° (b) 17.4°
(c) 18.4° (d) 21.6°

(v) An analysis of the condition of complete bearing capacity failure is usually termed as
(a) General shear failure (b) Terzaghi's analysis
(c) Bearing failure (d) All of the mentioned

(vi) The ultimate bearing capacity of a soil is 300 kN/m^2, the depth of foundation is 1 m and unit weight of soil is 20 kN/m^3. The net safe bearing capacity with a factor of safety of 2.5 is
(a) 100 kN/m^2 (b) 112 kN/m^2
(c) 80 kN/m^2 (d) 120 kN/m^2

(vii) In the Engineering News record formula for determining the safe carrying capacity of pile, the factor of safety used is
(a) 2 (b) 2.5
(c) 3 (d) 6

(viii) The types of hammer used for driving piles are
(a) Drop hammer (b) Diesel hammer
(c) Vibratory hammer (d) All of the above

(ix) According to the theory of elasticity, the coefficient of earth pressure at rest, k_0 for a soil with Poisson's ratio, μ is given by
(a) $k_0 = \frac{\mu}{1-\mu}$ (b) $k_0 = \frac{\mu}{1+\mu}$
(c) $k_0 = \frac{2\mu}{1-\mu}$ (d) $k_0 = \frac{\mu}{2-\mu}$

(x) Allowable bearing pressure for a foundation depends on
(a) Allowable settlement only
(b) Ultimate bearing capacity of soil only
(c) Both allowable settlement and ultimate bearing capacity
(d) None of these

Fill in the blanks with the correct word

(xi) The yield of a retaining wall required to reach plastic equilibrium in active case is _____ than that in the passive case.

(xii) A foundation is said to be shallow if its depth is _____than its width.

(xiii) IS code recommends a bearing capacity equation, which is similar to _____.

(xiv) In the passive state of cohesionless soil, minor principal stress is _____.

(xv) The minimum depth of exploration below an isolated footing is _____ times the width of footing.

Group - B

2. (a) A retaining wall has to retain a sand backfill (e = 0.7, G = 2.55) upto a height of 6.5 m. The water table is located at a depth of 2 m below the ground surface. The soil above the water table has a degree of saturation of 15 %. The angle of internal friction of soil above and below the water table are 32° and 28° respectively. Evaluate the magnitude and point of application of the resultant active thrust above the toe of the wall. *[(CO1, CO2)(Evaluate/HOCQ)]*

(b) A retaining wall with a smooth vertical backface has to retain a backfill (c = 17 kN/m^2, ϕ = 15°, γ = 18.5 kN/m^3) upto a height of 5.5 m. Determine (i) magnitude and point of application of the resultant active thrust above the toe of the wall, (ii) depth of the zone of tension cracks, (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. *[(CO1, CO2)(Analyse/IOCQ)]*

6 + 6 = 12

3. (a) The retaining wall (Fig. 1) is designed to retain a 3 m high sandy backfill that has a friction angle of 34° and a unit weight of 17 kN/m^3. The base of the wall rests on the existing ground that consists of clayey sand having an effective cohesion and friction angle of 10 kPa and 25°, respectively. The unit weights of clayey sand and concrete are 18 kN/m^3 and 23 kN/m^3, respectively. Determine the factor of safety of the retaining wall with respect to sliding and overturning. [Given: $\delta = (2/3)\phi$ and adhesion factor = 2/3]. *[(CO1, CO2)(Analyse/IOCQ)]*

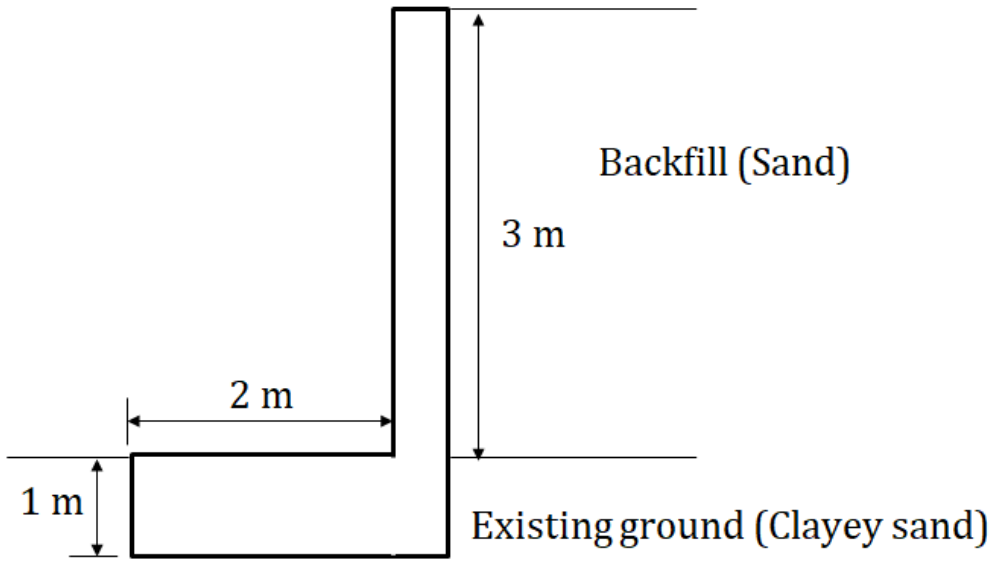

Fig. 1

(b) Evaluate the total active earth pressure on the 7 m high retaining wall shown in Fig. 2. Also determine the line of action of lateral force from the base of the wall. *[(CO1, CO2)(Evaluate/HOCQ)]*

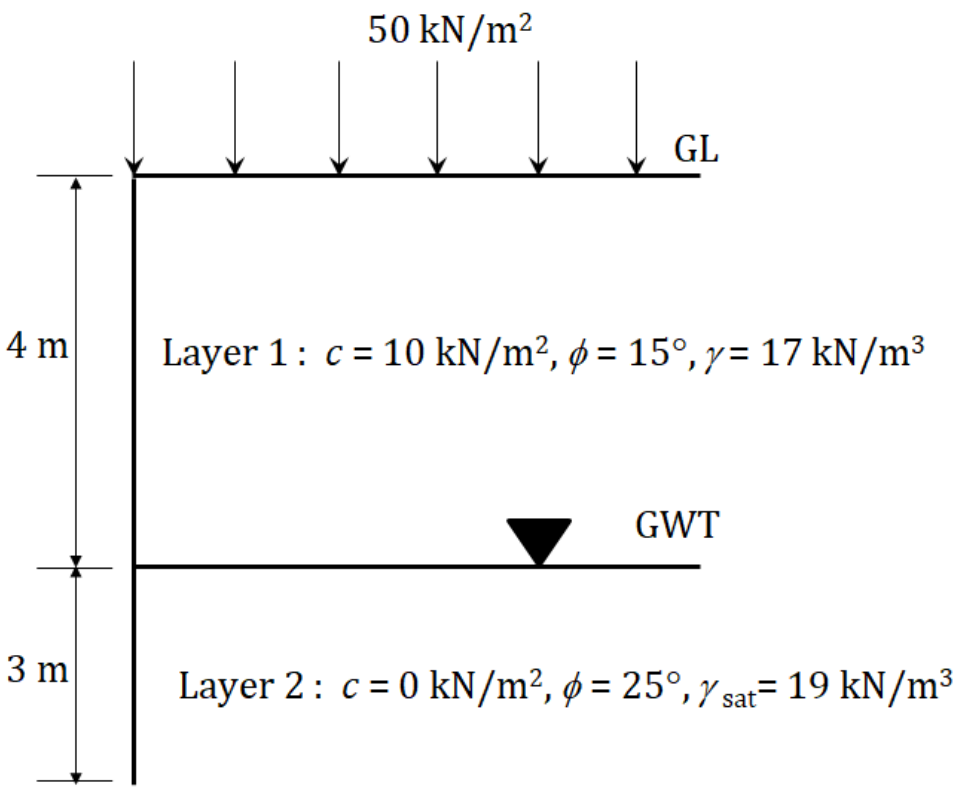

Fig. 2

6 + 6 = 12

Group - C

4. (a) The observed standard penetration test values in a deposit of loose and dense sand were 20 and 30, respectively, at a depth of 12 m with hammer efficiency of 85%. The average unit weights of loose and dense sand are 16 and 17 kN/m^3, respectively. The other data given are: (a) drill rod length correction factor = 0.9, (b) borehole correction factor = 1.05, (c) sampler correction factor for loose and dense sand are 0.9 and 0.8, respectively. Determine N_{60} and $(N_1)_{60}$ at this depth and water table is well below this depth. The sampler was used with liner. *[(CO3)(Evaluate/HOCQ)]*

(b) Identify the critical height of an infinite slope made of clay (c' = 22 kN/m^2, ϕ' =15°, e = 0.5, 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 26° with the horizontal. Use: $N_S = \frac{c'}{\gamma H_c} = \cos^2\beta\,(\tan\beta - \tan\phi')$.

[(CO1, CO4)(Analyse/IOCQ)]

6 + 6 = 12

5. (a) A 65 mm × 130 mm vane was pushed into a clay and rotated; the shearing occurred when the applied torque was 20 N-m. When the vane was further rotated to remould the clay, the torque dropped to 10 N-m. The plasticity index of the clay was 30%. Determine the sensitivity of the clay and the maximum load that can be applied to a 50 mm diameter sample collecting at this depth. *[(CO3)(Apply/IOCQ)]*

(b) A canal having side slopes inclined at angle of 45° with the horizontal is proposed to be constructed in a cohesive soil to a depth of 6 m below the ground surface. The soil properties are: c_u = 10 kN/m^2, ϕ_u = 15°, e = 0.61, G = 2.65. Evaluate 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. Use Taylor's stability number (Table 1). *[(CO1, CO4)(Evaluate/HOCQ)]*

Table 1: Taylor's stability number (S_n)

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	-	-	-

6 + 6 = 12

Group - D

6. (a) Determine the depth at which a circular footing of 1.1 m diameter be founded to provide a factor of safety of 3, if it has to carry a safe load of 1200 kN. The foundation soil has c = 10 kN/m^2, ϕ = 30°, and γ = 18 kN/m^3. The load is concentric and vertical. Use IS code method. [Given: s_c = 1.3, s_q = 1.2, s_γ = 0.6; $i_c = i_q = i_\gamma$ = 1; N_c = 30.14, N_q = 18.40, N_γ = 22.40].

[(CO1, CO5)(Evaluate/HOCQ)]

(b) A plate load test was done in a dry cohesionless soil with a 30 cm square bearing plate, which settles by 10 mm when the loading intensity is 100 kN/m^2. Determine the settlement of a square footing of size 1.2 m × 1.2 m under the same intensity of loading. Also estimate the load intensity if the permissible settlement of the prototype foundation is 40 mm.

[(CO1, CO5)(Analyze/IOCQ)]

8 + 4 = 12

7. (a) A rectangular footing has a size of 2 m × 3 m has to transmit the load of a column at a depth of 1.5 m. Calculate the safe load which the footing can carry at a factor of safety of 2.5 against shear failure when the water table is located at a great depth. The soil has the following properties: n = 40%, G = 2.67, w = 15 %, c = 8 kN/m^2, ϕ = 30°. Also determine the percent reduction in load capacity of the footing if the water table rises up to base of the footing. The load is concentric and vertical. Use IS code method. [Given: $s_c = s_q$ = 1.13, s_γ = 0.73; d_c = 1.26, $d_q = d_\gamma$ = 1.13; $i_c = i_q = i_\gamma$ = 1; N_c = 30.14, N_q = 18.40, N_γ = 22.40].

[(CO1, CO5)(Evaluate/HOCQ)]

(b) A footing 1.8 m square, rests on a soft clay soil with its base at a depth of 1.2 m below the ground surface. The normally consolidated clay stratum is 4 m thick and is underlain by a firm sand stratum. The clay soil has liquid limit = 30%, G = 2.7, water content at saturation = 40%, c = 2.2 kg/cm^2, ϕ = 0. Determine the settlement that would result if the load intensity equal to safe bearing capacity of soil is allowed to act on the footing. The ground water table is located at the ground surface. Take factor of safety as 3. [Given: N_c = 6.9] . *[(CO1, CO5)(Evaluate/HOCQ)]*

9 + 3 = 12

Group - E

8. (a) A concrete pile of 50 cm diameter and 19 m length is driven into a deep stratum of medium dense to dense sand. The average unit weight of soil along the length of the pile is 18 kN/m^3 and an angle of internal friction of 35°. Determine the safe load that can be carried by the pile with a factor of safety of 2.5. [Given: N_q = 58, N_γ = 48.03, K_s = 1.5 and δ/ϕ = 1].

[(CO1, CO6)(Analyse/IOCQ)]

(b) A group of 16 piles with 4 piles in a row were driven into a soft clay extending from ground level to a great depth. The diameter and the length of the piles were 30 cm and 10 m, respectively. The unconfined compressive strength of the clay is 80 kPa. If the piles were placed at 90 cm centre to centre, estimate the allowable load on the pile group on the basis of shear strength failure criteria for a factor of safety of 2.5. [Given: adhesion factor = 0.9 and N_c = 9]. *[(CO1, CO6)(Evaluate/HOCQ)]*

6 + 6 = 12

9. (a) It is required to drive a 300 mm × 300 mm square precast concrete pile into a clay where the undrained shear strength is 25 kPa. With a safety factor of 2.5, determine the pile length that can support a column load of 151 kN. [Given: adhesion factor = 0.7 and N_c = 9]. *[(CO1, CO6)(Evaluate/HOCQ)]*

(b) The piles (300 mm diameter and 8 m long) are used for a column in a uniform deposit of medium clay (unconfined compressive strength = 100 kN/m^2 and adhesion factor = 0.9). There are 16 piles arranged in a square pattern of 4 × 4. For a group efficiency of 1.0, determine the spacing between the piles. [Given: N_c = 9]. *[(CO1, CO6)(Evaluate/HOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	0	35.4	64.6