FOUNDATION ENGINEERING
(CIVL 3141)

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) 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.

(ii) Standard penetration test employs the following type of sampler
(a) Rotary (b) Split spoon (c) Piston (d) None of the above.

(iii) The maximum net pressure intensity causing shear failure of soil is known as
(a) Safe bearing capacity (b) Net safe bearing capacity
(c) Net ultimate bearing capacity (d) Ultimate bearing capacity

(iv) A soil sampler has inner and outer radius 25 and 30 mm, respectively. The area ratio of the sampler is
(a) 24% (b) 34% (c) 44% (d) 54%.

(v) Negative skin friction on piles
(a) Is caused due to relative settlement of the soil
(b) Is caused in soft clays
(c) Decrease the pile capacity
(d) All of these.

(vi) As per IS code, the minimum centre to centre spacing of end-bearing piles of diameter D is
(a) $2.5D$ (b) $3D$ (c) $3.5D$ (d) $4D$

(vii) For analysis of cantilever sheet pile wall, the point of rotation lies
(a) above dredge level (b) between dredge level and toe of the wall
(c) below the toe of the wall (d) at the dredge level.

(viii) 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.

(ix) The cantilever sheet pile wall gains its stability from
(a) active pressure above dredge level (b) passive resistance below dredge level
(c) anchor (d) both active pressure and passive resistance.

(x) In the case of anchored bulkhead, the tie rod is placed
(a) at the top of the sheet pile
(b) at the bottom of the sheet pile
(c) at a certain depth below the top but above the excavation level
(d) at the excavation level.

Fill in the blanks with the correct word

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

(xii) The rigidity correction factor as per IS code for computing the settlement of the rigid footing is _____.

(xiii) As per IS code, inside clearance of a soil sampler should be _____.

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

(xv) The piles driven at an inclination to resist inclined loads are known as _____ piles.

Group - B

2. (a) A 1.8 m wide continuous strip footing is founded at a depth of 1 m below the ground level in a homogeneous bed of dense sand (ϕ = 36°, γ = 19.5 kN/m^3). Determine the net ultimate, net safe and gross 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]. The shape, depth and inclination factors are given in Table 1*. Consider the direction of the load to be vertical downward.

[(CO1)(Analyse/IOCQ)]

(b) A footing 4 m × 2 m in plan transmits a pressure of 400 kN/m^2 on a cohesive soil having modulus of elasticity as 5 × 10^4 kN/m^2 and Poisson's ratio as 0.5. Determine the immediate settlement of the footing at the centre assuming it to be (i) flexible, (ii) rigid. [Given: I_f = 1.53 and 1.20 for flexible and rigid footings, respectively]. Take depth correction factor as 1.0.

[(CO2)(Analyse/IOCQ)]

8 + 4 = 12

3. (a) Evaluate the depth at which a circular footing of 1.5 m diameter be founded to provide a factor of safety of 3, if it has to carry a safe vertical load of 1985 kN. The foundation soil has c = 19 kN/m^2, ϕ = 35°, and γ = 18 kN/m^3. Use IS code method. [Given: for ϕ = 35°, N_c = 46.12, N_q = 33.30, N_γ = 48.03]. The shape, depth and inclination factors are given in Table 1*.

[(CO1)(Analyze/IOCQ)]

(b) A plate load test was done in a dry cohesionless soil with a 30 cm square bearing plate, which settles by 15 mm when the loading intensity is 200 kN/m^2. Determine the settlement of a square footing of size 1.5 m ×1 .5 m under the same intensity of loading. Also determine the load intensity if the permissible settlement of the prototype foundation is 40 mm.

[(CO2)(Analyze/IOCQ)]

9 + 3 = 12

***Table 1: Shape, depth and inclination factors (IS: 6403-1981)**

Sl. No.	Shape of base	Shape factors		
		s_c	s_q	s_γ
1	Continuous strip	1.0	1.0	1.0
2	Rectangle	$1+0.2\frac{B}{L}$	$1+0.2\frac{B}{L}$	$1-0.4\frac{B}{L}$
3	Square	1.3	1.2	0.8
4	Circle	1.3	1.2	0.6
Depth factors				
$d_c = 1+0.2\frac{D}{B}\sqrt{N_\phi}$				
$d_q = d_\gamma = 1$ for $\phi < 10°$				
$d_q = d_\gamma = 1+0.1\frac{D}{B}\sqrt{N_\phi}$ for $\phi > 10°$				
Inclination factors				
$i_c = i_q = \left(1-\frac{\alpha}{90°}\right)^2, i_\gamma = \left(1-\frac{\alpha}{\phi}\right)^2$				

Group - C

4. (a) Classify soil investigation with the help of a flow chart. *[(CO3)(Understand/LOCQ)]*

(b) Illustrate auger boring. *[(CO3)(Understand/LOCQ)]*

(c) The observed standard penetration test value in a deposit of loose sand was 45 at a depth of 9 m. The average unit weight of the soil is 18 kN/m^3. The other data given are: (a) hammer efficiency = 55%, (b) drill rod length correction factor = 0.9, and (c) borehole correction factor = 1.05. Determine N_{60} and $(N_1)_{60}$ at this depth and water table is well below this depth. The sampler was used without liner.

[(CO3)(Analyze/IOCQ)]

4 + 4 + 4 = 12

5. (a) Define inside clearance, outside clearance and recovery ratio. *[(CO3)(Understand/LOCQ)]*

(b) The inner diameters of a sampling tube and that of a cutting edge are 74 mm and 72 mm, respectively, their outer diameters are 76 mm and 78 mm, respectively. Determine the inside clearance, outside clearance and area ratio of the sampler.

[(CO3)(Analyze/IOCQ)]

(c) In a deposit of normally consolidated dry sand, a cone penetration test was conducted. Following are the results:

Depth (m)	q_c (MN/m^2)
1.5	3.5
3.0	5.0
4.5	7.5
6.0	9.0
7.5	11.0
9.0	13.0

Assuming the dry unit weight of sand to be 16.5 kN/m^3, estimate the average peak friction angle of the sand.

[(CO3)(Analyze/IOCQ)]

3 + 3 + 6 = 12

Group - D

6. (a) A concrete pile of 40 cm diameter and 15 m length is driven into a deep stratum of loose to medium dense sand. The saturated unit weight of soil along the length of the pile is 18 kN/m^3 and an angle of internal friction of 40°. Determine the safe load that can be carried by the pile with a factor of safety of 2.5. The water table is located at GL. [Given: N_q = 150, N_γ = 109.41 and δ/ϕ = 1]. *[(CO4)(Analyse/IOCQ)]*

(b) A square pile group of 9 piles with 3 piles in a row passes through a recently filled up soil. The depth of fill, L_n = 4 m. The diameter of the pile is 40 cm, and are spaced at 90 cm apart. If the soil is cohesive with q_u = 50 kN/m^2, γ = 17 kN/m^3, estimate the negative frictional load on the pile group. *[(CO5)(Analyse/IOCQ)]*

6 + 6 = 12

7. A concrete pile of 55 cm diameter is driven to a depth of 27 m through a layered system of dry sandy soil. The following data are available:

(i) Top layer - I: Thickness = 8 m, γ_d = 16 kN/m^3, ϕ = 30°

(ii) Layer - II: Thickness = 15 m, γ_d = 17 kN/m^3, ϕ = 35°

(iii) Layer - III: Extends to a great depth, γ_d = 18 kN/m^3, ϕ = 38°.

Determine the safe load on with factor of safety of 2.5. [Given: N_q = 100, N_γ = 85 and δ/ϕ = 1]. *[(CO4)(Evaluate/HOCQ)]*

12

Group - E

8. Fig. 1 shows a cantilever sheet pile wall penetrating a clayey soil. Determine the theoretical depth of embedment ($D_{\text{theoretical}}$) and (ii) The actual depth of embedment [$D_{\text{actual}} = 1.5D_{\text{theoretical}}$]. *[(CO6)(Evaluate/HOCQ)]*

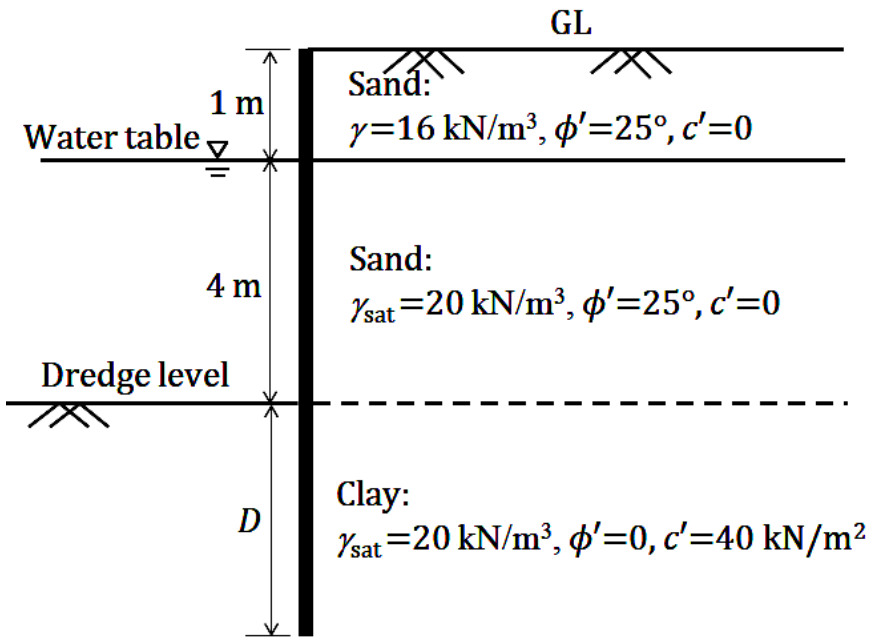

Fig.: 1

12

9. An anchored bulkhead 6.5 m high retains sand (ϕ = 25° and γ = 19 kN/m^3) on both sides as shown in Fig. 2. The anchor rods are 1.15 m below the top and depth of embedment is 1.75 m. Determine the factor of safety against failure. Comment, if the depth of embedment is adequate for a factor of safety of 2. If not, then obtain the depth of embedment for a factor of safety of 2 by drawing active and passive earth pressure diagrams. *[(CO6)(Analyse/IOCQ)]*

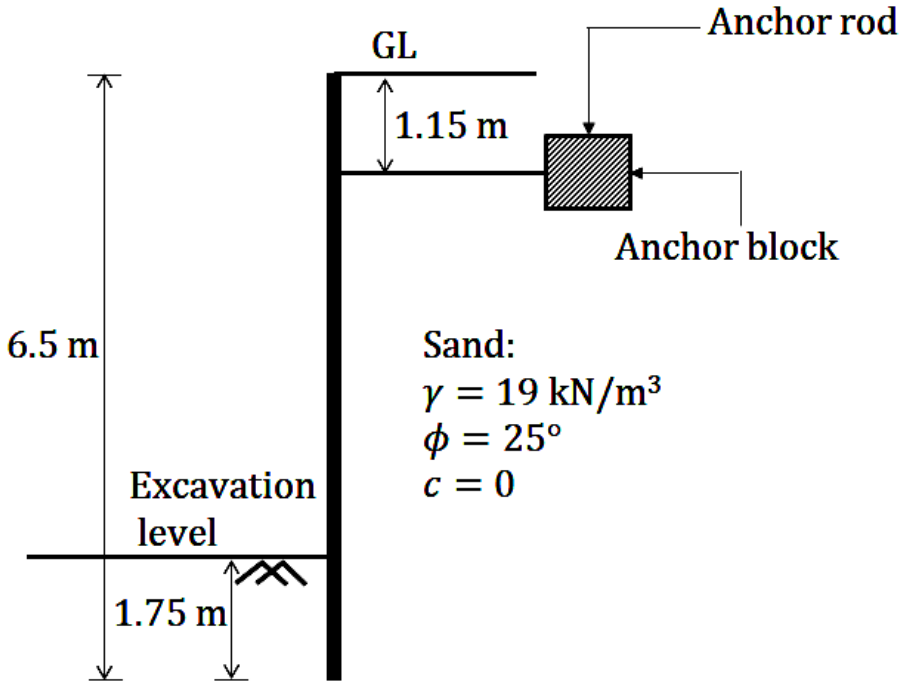

Fig.: 2

12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	11.46	63.54	25