(iv) If the spacing of stone column is S, then the equivalent diameter D_e for equilateral triangular pattern of stone column arrangement is given by
(a) $D_e = 1.05S$ (b) $D_e = 1.15S$
(c) $D_e = 0.95S$ (d) $D_e = 1.25S$

(v) Stone column is used as ground improvement technique in
(a) Sandy soil (b) Clayey soil (c) Gravelly soil (d) Rock.

(vi) For designing end bearing piles of square cross-section in clays having average unconfined compressive strength of 6 t/m^2, the net ultimate capacity may be taken as :
(a) 15 t/m^2 (b) 18 t/m^2 (c) 20 t/m^2 (d) 27 t/m^2.

(vii) To conduct pile load test on a raker pile, the load should be applied
(a) horizontally
(b) vertically
(c) along longitudinal axis of pile
(d) normal to longitudinal axis of pile.

(viii) The observed value of the standard penetration number (N) at 10 m depth of a silty sand deposit is 13. The unit weight of the soil is 16 kN/m^3. The N value after correcting the overburden pressure will be
(a) 12 (b) 13 (c) 14 (d) 15.

(ix) 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%.

(x) In the seismic exploration method, velocities V_1 and V_2 were 600 m/sec and 4000 m/sec respectively. The distance corresponding to the break point of velocities was 30 m. Based on this detail, what is the depth of overburden?
(a) 11.5 m (b) 12.5 m (c) 12.9 m (d) 13.2 m.

Group – B

2. (a) A group of 6 bored cast insitu piles (diameter = 40 cm, length = 18 m, center to center distance = 1.0 m and cut off level 1.5 m) arranged in a square pattern pass through a sand layer overlaying a soft deposits which is consolidating under the fill load and rests in stiff clay strata. The soil properties of the different strata are given in Fig.1.

(b) Distinguish between representative and undisturbed sample.

(c) A seismic refraction survey of an area gave the following data:

Distance from impact point to geophone in m	15	30	60	80
Time of first wave arrival in sec	0.025	0.05	0.10	0.11

i) Plot the time travel versus distance and determine velocities of the top and underlying layer of the soil.
ii) Determine the thickness of the first and second layer.

5 + 2 + 5 = 12

Group – D

6. (a) Figure 2 shows a cantilever sheet pile wall penetrating a granular soil. Determine (i) Theoretical depth of embedment (D), (ii) The total length of sheet piles for a 30% increase in D and (iii) The minimum section modulus of the sheet piles if allowable bending stress is 172 MPa.

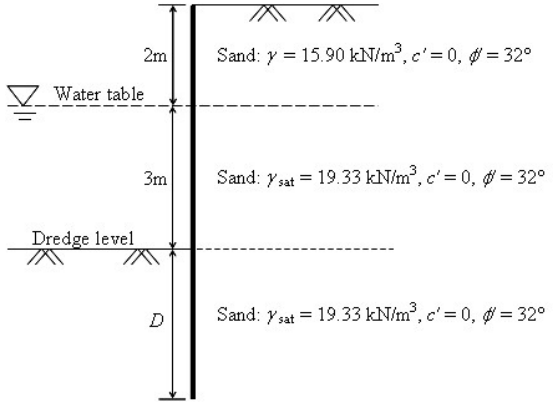

Figure 2

(b) A square footing of size 3m × 3m is founded at a depth of 2m below ground level in medium dense sand (N = 30). The water table is at the base level of the footing. Compute the net ultimate bearing capacity by Teng's method.

(c) A footing of size 3m × 3m is to be constructed at a depth of 1.5m below ground surface. The water table is at the base of the foundation. The average static cone penetration resistance of the cohesive soil obtained at the site is 20 kg/cm^2. Determine the safe bearing pressure for a settlement of 40mm.

8 + 2 + 2 = 12

7. (a) Two plate load tests were conducted at the level of prototype foundation in cohesionless soil. The following data are given:

Size of plate	Load applied (kN)	Settlement recorded (mm)
0.3m × 0.3m	30	25
0.6m × 0.6m	90	25

If a square footing has to carry a load of 2000 kN, determine the required size of the footing for the same settlement of 40mm.

(b) Determine the depth of embedment and the force in the tie rod for the anchored bulkhead shown in the Figure 3 by applying directly a factor of safety of 2.0 to the passive pressure using free earth support method. The backfill and the soil below the dredge line is sand, having the following properties: G = 2.6, e = 1.0 and ϕ = 30°. Assume the soil above the water table is dry. [Take γ_w as 10 kN/m^3].

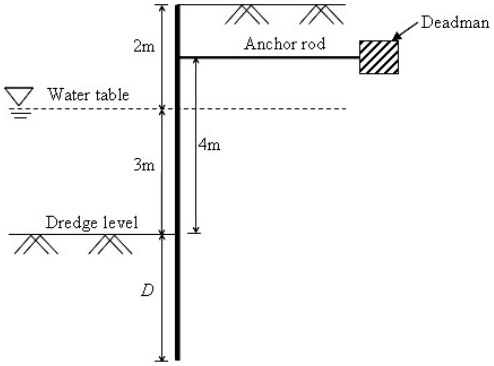

Figure 3

4 + 8 = 12

Group – E

8. (a) What do you mean by ground improvement? State different types of ground improvement methods. What are the factors that affect the choice of ground improvement methods to be adopted at a particular site?

(b) Describe with figures (if necessary), the following terms related to stone column design: (i) pattern, (ii) equivalent diameter, (iii) replacement ratio and (iv) stress concentration factor.

(c) What is grouting? What are the different grouting techniques? State the principle of chemical grouting.

5 + 4 + 3 = 12

9. (a) State the design principle of preloading with vertical drains.

(b) How the safe load on stone column is estimated based on bulging alone?

(c) Describe filtration and soil reinforcement functions of geotextiles.

(d) State the principle of soil nailing. What are driven nails and grouted nails?

2 + 2 + 4 + 4 = 12

FOUNDATION ENGINEERING
(CIVL 3202)

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) Preloading with vertical drains is used for ground improvement in
(a) clayey soil (b) sandy soil
(c) rock (d) both clayey and sandy soil.

(ii) The net allowable bearing pressure as per modified Teng's equation is given by

(a) $q_s = 53(N-3)\left[\frac{B+0.3}{2B}\right]^2 R_w F_d$

(b) $q_s = 53(N-3)\left[\frac{B-0.3}{2B}\right]^2 R_w F_d$

(c) $q_s = 53(N+3)\left[\frac{B-0.3}{2B}\right]^2 R_w F_d$

(d) $q_s = 53(N-3)\left[\frac{B+0.3}{2B}\right]^3 R_w F_d$

where the symbols have their usual meanings.

(iii) The stability number for sheet pile walls embedded in cohesive soils (with cohesion, c and unit weight, γ) and retaining backfill (height, H) is given by

(a) $\frac{1.25c}{\gamma H}$ (b) $\frac{1.5c}{\gamma H}$ (c) $\frac{2c}{\gamma H}$ (d) $\frac{0.5c}{\gamma H}$

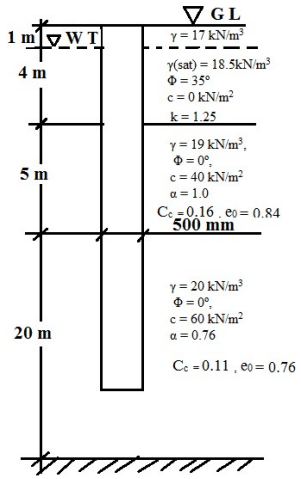

Figure 1

Estimate the ultimate load carrying capacity $(Q_u)_{group}$ and settlement of the pile group.

(b) A square pile group (3×3) passes through a recently constructed fill. The depth of fill L_n= 3 m. The diameter of the pile is 30 cm and spaced 90 cm center to center. If the soil is cohesive with q_u = 60 kN/m² and γ = 15 kN/m³, compute the negative frictional load on the pile group.

9 + 3 = 12

3. (a) A steel pipe pile of 61 cm outside diameter with a wall thickness of 2.5 cm is driven into loose sand (D_r = 30%) under submerged conditions to a depth of 20 m. The submerged unit weight of the soil is 8.75 kN/m² and the angle of internal friction is 33°. The EI value of the pile is 4.5 × 10² MN-m². Compute the ground line deflection of the pile under a lateral load of 258 kN at ground level under a free head condition using the non-dimensional parameters of Reese and Matlock. The value of η_h = 6 MN/m³ for a submerged condition. If the pile is fixed against rotation, calculate the deflection at the ground.

(b) A concrete cast in situ bored pile of 45 cm diameter is driven to a depth of 16 m through a layered system of sandy soil (c = 0). The following data are available. The cut off level is 1.5 m below GL.

Layer	Thickness m	λ_{sat} (kN/m³)	Strength parameters		Void ratio (e)	K_s	N_q
			C_u	ϕ			
1	8	16.5	-	30°	0.60	1	-
2	6	15.5	-	35°	0.65	1.5	-
3	Extends to a great depth	16.0	-	38°	0.65	2.0	95

For $\phi = 35^0$, N_λ= 48.03 and for $\phi = 40^0$, N_λ= 109.41

Assume that the value of δ in all the layers of sand is equal to ϕ. The water table is at ground level. Calculate the value of Qu and Qa with FOS = 2.5.

5 + 7 = 12

Group – C

4. (a) For a layer of saturated clay deposits, the following are given in Table-1:

Table - 1

Depth below the ground surface (m)	Standard penetration number, N_{60}
4.5	9
6.0	12
7.5	12
10.5	20

The average effective unit weight of the soil is 9.69 kN/m³. The other data given are:
(i) hammer efficiency = 0.7, (ii) drill rod length correction factor = 0.95, (iii) borehole diameter correction factor = 1.15, (iv) sampler correction factor = 0.80. Determine the corrected SPT value for standard energy 60%.

(b) Discuss the difference between static cone penetration test and standard penetration test. How SCPT and DCPT correlated with SPT?

(c) If a deposit at a site happens to be a saturated overconsolidated clay with a value of q_c = 8.8 MN/m², determine the unconsolidated compressive strength of clay given overburden pressure, p_0 = 127 kN/m³. N_k = 18. If we neglect the overburden pressure then calculate unconsolidated compressive strength of clay.

8 + 2 + 2 = 12

5. (a) What are the various phases of a subsoil exploration program? Briefly explain them.