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) The equivalent diameter of stone column for an equilateral triangular pattern and a square pattern are respectively,
(a) 1.05S and 1.17S (b) 1.05S and 1.13S
(c) 1.13S and 1.05S (d) 1.07S and 1.13S
where, S is the spacing between the stone columns.

(ii) The net ultimate bearing capacity for continuous footing as per Teng's method is given by,
(a) $q_{nd} = 0.16\left[5N^2BR_w + 3(100 + N^2)D_f R'_w\right]$ (b) $q_{nd} = 0.16\left[3N^2BR_w + 5(100 + N^2)D_f R'_w\right]$
(c) $q_{nd} = 0.16\left[3D_f R'_w + 5(100 + N^2)N^2BR_w\right]$ (d) $q_{nd} = 0.16\left[3N^2BR_w + 5(100 + N^2)D_f R'_w\right]$
where, the symbols have their usual meanings.

(iii) Free earth support method is used to analyze
(a) Cantilever sheet pile wall (b) Anchored bulk head
(c) Both (a) and (b) (d) Neither (a) nor (b).

(iv) A square footing of size 3 m × 3 m is founded at a depth of 2 m below ground level in medium dense sand (q_c = 119 kg/cm^2). The water table is at the base level of the footing. The ultimate bearing capacity (by Teng's method) is
(a) 24.08 kg/cm^2 (b) 25.08 kg/cm^2
(c) 26.08 kg/cm^2 (d) 27.08 kg/cm^2

(v) The primary function of geogrid is
(a) Separation (b) Filtration (c) Drainage (d) Reinforcement.

(vi) In a plate load test conducted on cohesion less soil, a 600 mm square test plate settles by 15 mm under a load intensity of 0.2 N/mm^2. All conditions remaining the same, settlement of a 1 m square footing will be
(a) less than 15 mm (b) greater than 25 mm
(c) 15.60 mm (d) 20.50 mm.

(vii) The number of blows observed in a Standard Penetration Test (SPT) for different penetration depths are given as follows :

Penetration of sampler	Number of blows
0	6
150	8
300	10

The observed *N* value is

(a) 8 (b) 14 (c) 18 (d) 24

(viii) Four columns of building are to be located within a plot size of 10 m × 10 m. The expected load on each column is 4000 kN. Allowable bearing capacity of soil deposit is 100 kN/m^2. The type of foundation to be used is

(a) Isolated foundation (b) Raft foundation
(c) Pile foundation (d) Combined foundation.

(ix) The main advantage of rotary boring is

(a) It can be used in all types of soil /rock.
(b) There is minimum disturbance to the soil.
(c) It is economical for bore holes of diameter less than 100 mm.
(d) To stabilize the walls of the bore hole bentonite slurry can be used.

(x) The thickness of top soil in a seismic-refraction test is

(a) Directly proportional to seismic velocity
(b) Inversely proportional to seismic velocity
(c) Directly proportional to square root of seismic velocity
(d) Inversely proportional to square root seismic velocity.

Group – B

2. A group of 6 bored cast in-situ piles (diameter = 50 cm, length = 18 m, center to center distance = 1.5 m and cut off level 1.2 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.

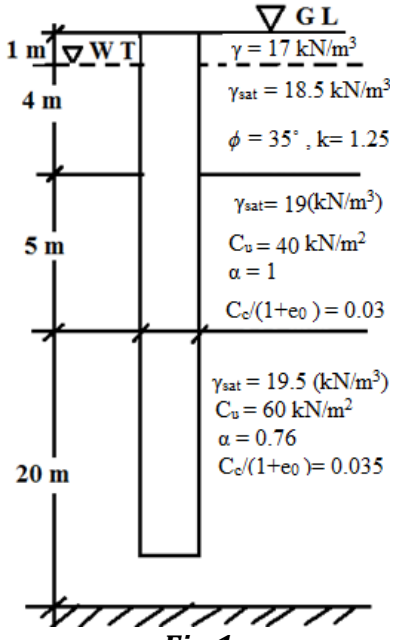

Fig.1

(i) Determine the ultimate load carrying capacity of the individual pile (Q_u).
(ii) If the total load imposed on the foundation is 250 kN, estimate settlement of the pile group.

(6 + 6) = 12

3. (a) A group of 20 piles, each having a diameter of 400 mm and length of 15 m, is arranged in 4 rows. The centre to centre spacing between the piles is 1.8 m. The estimated load carrying capacity of each pile is 380 kN. Determine efficiency of pile group and the load capacity of pile group using (i) Feld's rule (ii) Converse-Labarre's formula.

(b) A reinforced concrete pile weighing 30 kN (inclusive of helmet and dolly) is driven by a drop hammer weighing 40 kN and having effective fall of 0.8 cm. The average set per blow is 1.4 cm. The total temporary elastic compression is 1.8cm. Assuming the coefficient of restitution as 0.25 and factor of safety of 2, determine the ultimate bearing capacity and the allowable load for the pile.

(c) Design a friction pile group to carry a load of 3000 kN including the weight of the pile cap at a site where the soil is uniform clay to a depth of 20 m, underlain by rock. Average unconfined compressive strength of the clay is 70 kN/m^2, The clay may be assumed to be normally sensitive with liquid limit of 60%. A factor of safety of 3 is required against shear failure. [Take, α = 0.7]

(2 + 2) + 3 + 5 = 12

Group – C

4. (a) A seismic survey was carried out for a large project to determine the nature of the substrata. The results of the survey are given in Fig. 2 in the form of a graph. Determine the depths of the strata.

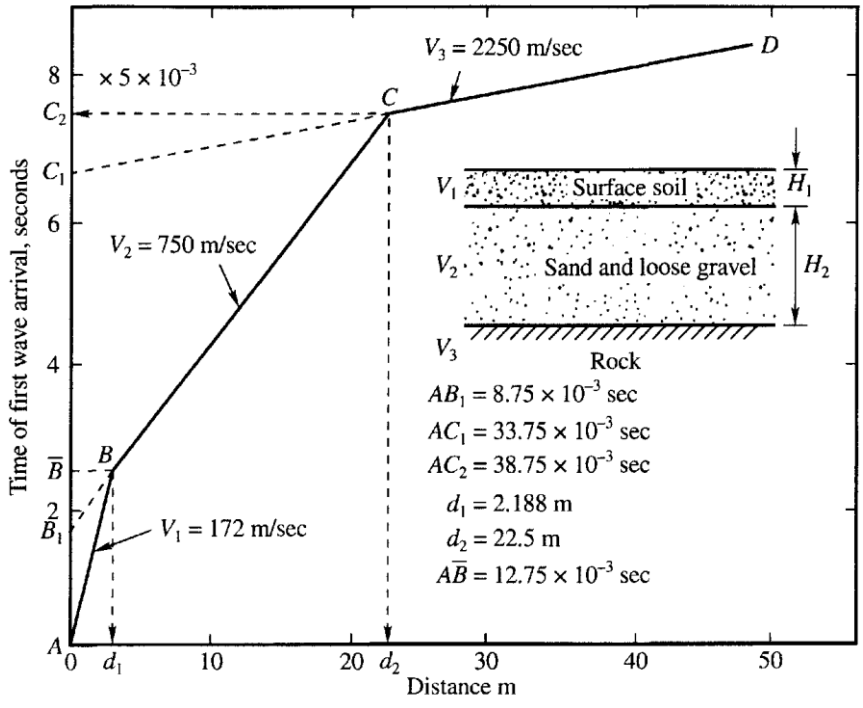

Fig. 2

(b) Distinguished between a disturbed sample and an undisturbed sample.

(c) Enumerate the objectives of site investigation.

6 + 4 + 2 = 12

4. (a) The observed standard penetration test value in a deposit of fully submerged sand was 45 at a depth of 6.5 m. The average effective unit weight of the soil is 9.69 kN/m^3. The other data given are (a) hammer efficiency = 0.8, (b) drill rod length correction factor = 0.9, and (c) borehole correction factor = 1.05. Determine (i) corrected SPT value and (ii) the unconfined compressive strength q_u in a clay deposit for the corrected value of N_{60}.

(b) Define the following terms with respect to subsurface exploration: (a) Area ratio, (b) Inside clearance ratio and (c) Outside clearance ratio.

(c) What are the stages of the site investigation?

(4 + 2) + 4 + 2 = 12

Group – D

6. (a) A footing of size 3 m × 3 m is to be constructed at a site at a depth of 1.5 m 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 30 kg/cm^2. Determine the safe bearing pressure for a settlement of 40 mm.

(b) Distinguish between free and fixed earth support methods of analysis.

(c) Determine the theoretical depth of embedment, actual depth of embedment [$D_{\text{actual}} = 1.4D_{\text{theory}}$], the force in the tie rod for the anchored bulkhead shown in Fig.3, which has fixed earth support. The backfill and the soil below the dredge line are sand, having the following properties: $G = 2.6$, $e = 0.75$ and $\phi = 27°$. Use equivalent beam method considering the point of zero moment as lying at a depth of $0.1H$ (where, H is the depth of dredge level below original ground level) from the level of dredge line. Assume the soil above the water table is dry.

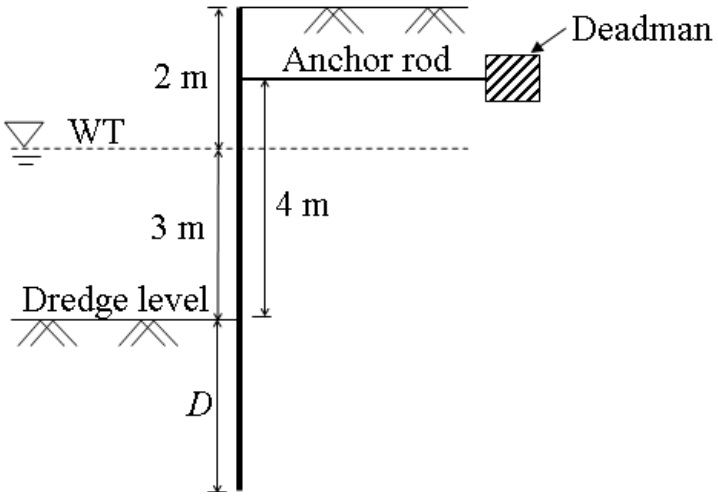

Fig.3

2 + 2 + (6 + 1 + 1) = 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)
0.3 m × 0.3 m	30	25
0.6 m × 0.6 m	90	25

If a square footing has to carry a load of 800 kN, determine the required size of the footing for same settlement of 25 mm.

(b) A cantilever sheet pile wall (Fig.4) penetrates 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 190 MPa.

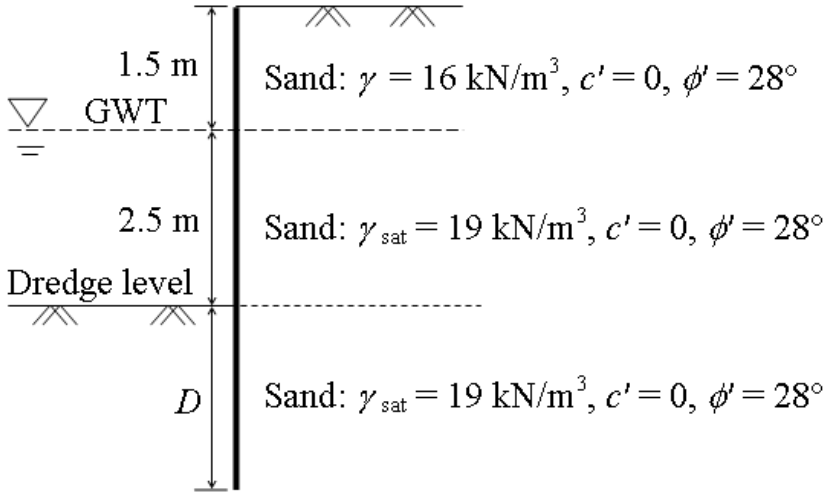

Fig.4

3 + (6 + 1 + 2) = 12

Group – E

8. (a) Define ground improvement. What are the different types of ground improvement methods?

(b) Explain vibrocompaction with the help of a neat sketch.

(c) Describe the separation and moisture barrier functions of geosynthetics.

4 + 4 + 4 = 12

9. (a) Distinguish between principles of ground improvement in cohesive and cohesionless soils.

(b) Explain different types of nails used in soil nailing.

(c) Describe different types of drains (with neat sketches) used in preconsolidation method.

4 + 4 + 4 = 12

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