SOIL MECHANICS - I
(CIVL 2102)

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) Coarsely crystalline plutonic rocks of size 2mm-5mm are termed as
(a) Phaneretic (b) Aphanitic (c) Microcrystalline (d) Cryptocrystalline.

(ii) The hardness value of diamond as per Mohs hardness scale is
(a) 4 (b) 6 (c) 8 (d) 10.

(iii) The saturated unit of the soil having void ratio of 0.324 and specific gravity of soil solids of 2.7 is
(a) 18.2 kN/m^3 (b) 21.3 kN/m^3 (c) 22.4 kN/m^3 (d) 20.4 kN/m^3.

(iv) For well graded gravel, the coefficient of uniformity C_u is greater than
(a) 4 (b) 6 (c) 3 (d) 1.

(v) The soil which is formed by leaching process is known as
(a) Loess soil (b) Loam soil (c) Laterite soil (d) Lacustrine soil.

(vi) The pore water pressure at a depth of 10 m below the ground water table in a soil with saturated unit weight of 20 kN/m^3 is given by
(a) 98.1 kN/m^2 (b) 9.81 kN/m^2 (c) 200 kN/m^2 (d) 20 kN/m^2.

(vii) Allen Hazen's empirical relationship between the coefficient of permeability (k) and effective size (D_{10}) is
(a) $k = 100D_{10}^2$ (b) $k = 50D_{10}^2$ (c) $k = 200D_{10}^2$ (d) $k = 10D_{10}^2$.

(viii) If k_x and k_z are the permeabilities in x- and z- directions, respectively in a two-dimensional flow situation, then the effective permeability k_e is given by
(a) $k_e = k_x + k_z$ (b) $k_e = \sqrt{\frac{k_x k_z}{2}}$ (c) $k_e = \sqrt{k_x k_z}$ (d) $k_e = \frac{k_x + k_z}{2}$

(ix) If the porosity is n, then the seepage velocity (v_s) and discharge velocity (v) are related as,
(a) $v_s = \frac{2v}{n}$ (b) $v_s = \frac{v}{n}$ (c) $v_s = \frac{v}{n^2}$ (d) $v_s = vn$

(x) If a rigid footing rests on a cohesive soil, then
(a) Contact pressure is minimum at the centre of the footing
(b) Contact pressure is maximum at the centre of the footing
(c) Contact pressure is uniform throughout the width of the footing
(d) Settlement is minimum at the centre of the footing.

Group- B

2. (a) Define metamorphic rock. [(CO1)(Remember/(LOCQ)]
(b) Explain how intrusive and extrusive igneous rocks are formed. [(CO1)(Understand/(LOCQ)]
(c) Discuss normal fault and reverse fault with neat sketch. [(CO1)(Create/(HOCQ)]
2 + 4 + 6 = 12

3. (a) List the different processes of weathering of rocks. [(CO1)(Remember/LOCQ)]
   (b) Describe any two engineering properties of rocks. [(CO1)(Understand/LOCQ)]
   (c) Classify the ten minerals starting from softest to hardest as mentioned in the Mohs hardness scale. [(CO1)(Analyze/IOCQ)]

4 + 4 + 4 = 12

Group - C

4. (a) 1 cum of wet soil weights 20 kN. Its dry weight is 18 kN. Sp. Gravity of solids is 2.67. Determine the water content, porosity, void ratio and degree of saturation. Draw a phase diagram. [(CO2)(Evaluate/HOCQ)]
   (b) A partially saturated sample from a borrow pit has a natural moisture content of 15 % and bulk density of 1.9 g/cc. The specific gravity of solids is 2.7. Determine the degree of saturation and void ratio. Determine the saturated density of the sample. [(CO2)(Evaluate/HOCQ)]

6 + 6 = 12

5. (a) Describe in brief AASHTO soil classification system. [(CO2)(Evaluate/HOCQ)]
   (b) Explain in brief about the kaolinite structure with schematic diagram. [(CO2)(Evaluate/HOCQ)]
   (c) The plastic limit of soil is 25% and plasticity index is 8%. When soil is dried from plastic stage, volume changes 25% of its volume at plastic limit. Similarly, the corresponding volume change from liquid limit to dry stage is 34% of its volume at liquid limit. Determine the shrinkage limit and shrinkage ratio. [(CO2)(Evaluate/HOCQ)]

3 + 4 + 5 = 12

Group - D

6. (a) A layer of silty soil of thickness 6 m lies below the ground level (GL) and below the silt layer lies a clay stratum. The ground water table (GWT) is at a depth of 5 m below the ground surface. The capillary rise is 3.2 m. The following data are available for both the silt and clay layers of soil; Silt layer: e = 0.5 and G = 2.55; Clay layer: e = 0.8 and G = 2.85. Determine the effective stresses at 3 m and 9 m below GL. [(CO3)(Evaluate/HOCQ)]
   (b) Two 60 mm diameter soil samples A and B are placed under constant head as shown in Fig.1. The permeability of sample A is twice that of sample B. Assuming the tailwater level as datum, what is the total head at the interface between the soil samples? If 350 ml of water flows through the sample in 7 mins., determine the permeabilities (in cm/s) of the two soil samples. [(CO4)(Evaluate/HOCQ)]

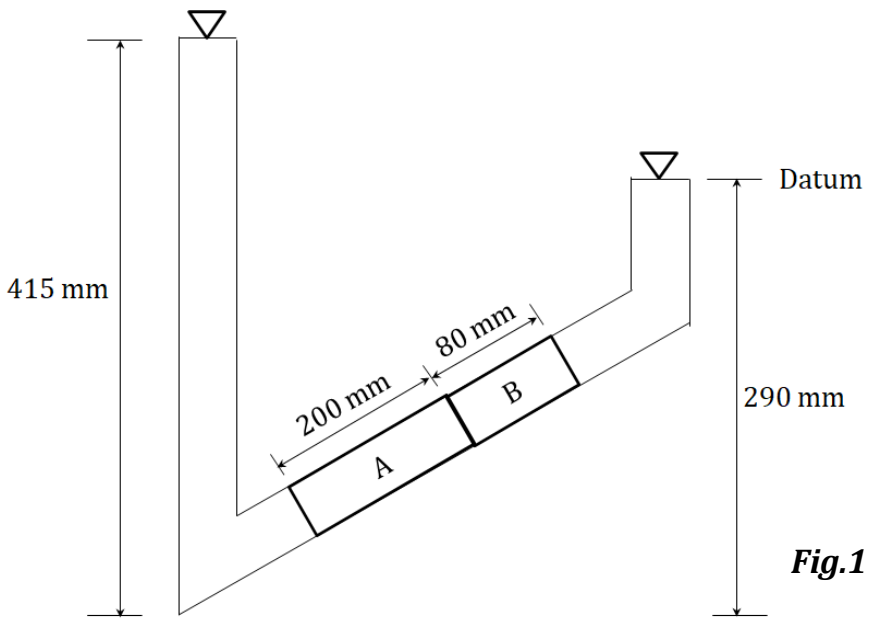

Fig.1

   (c) The dam with the flownet is shown in Fig.2. Determine: (i) The height of the water that would rise, if a piezometer is placed at D and G, (ii) Quantity of seepage loss in $m^3/(day.m)$ under the dam when k = 0.25 mm/sec, and (iii) Exit gradient. [(CO5)(Evaluate/HOCQ)]

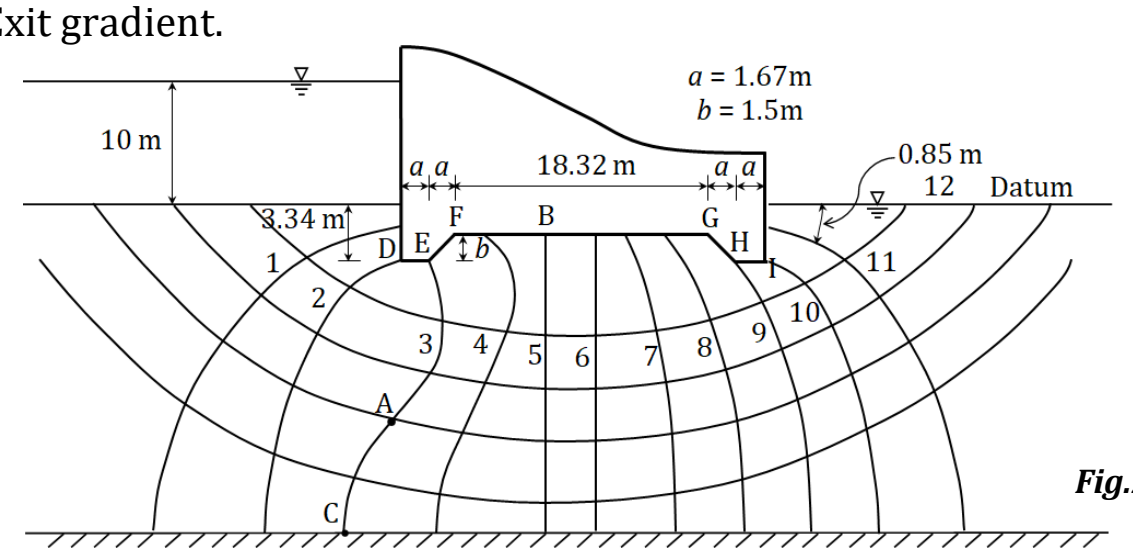

Fig.2

4 + 4 + 4 = 12

7. (a) A 12 m thick layer of relatively impervious saturated clay (γ_{sat} = 18 kN/m^3) lies over a gravel aquifer as shown in Fig.3. Piezometer tube inserted to the gravel layer shows an artesian pressure condition with the water level standing in the tube 4 m above the top surface of the clay stratum. Determine the effective stress at the top of the gravel layer and the depth of excavation that can be made in the clay stratum without bottom heave considering a factor of safety of 1.25. [(CO3)(Evaluate/HOCQ)]

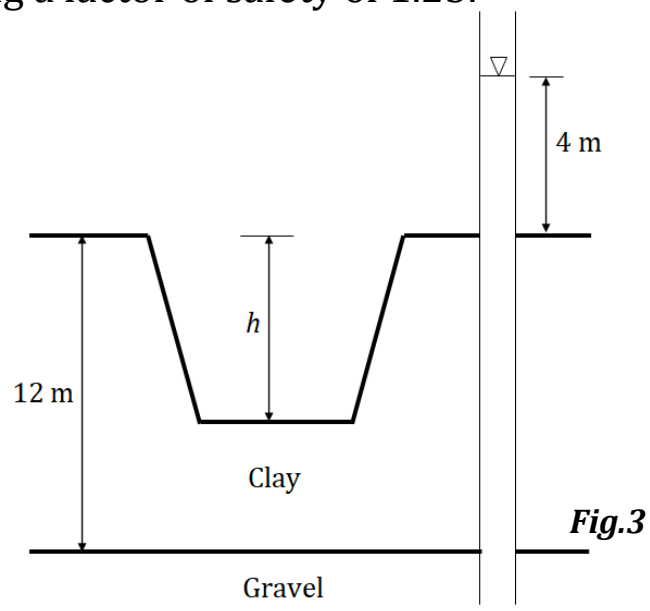

Fig.3

(b) A stratified soil deposit is shown in Fig.4. Assume an average hydraulic gradient of 0.3 in both horizontal and vertical directions. Determine the loss in head in layer – 1 and layer - 2 for vertical flow. [(CO4)(Evaluate/HOCQ)]

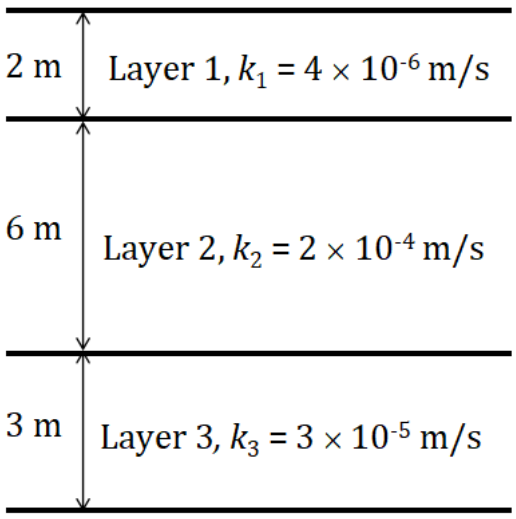

Fig.4

(c) The section through a dam spillway is shown in Fig.5. Determine the net water pressures on the cut-off wall (at levels 5, 7) at the upstream end of the spillway. The points 6, 7 and 8 are lying at depths of 3.5 m, 5.8 m and 6.5 m below datum. [(CO5) (Evaluate/HOCQ)]

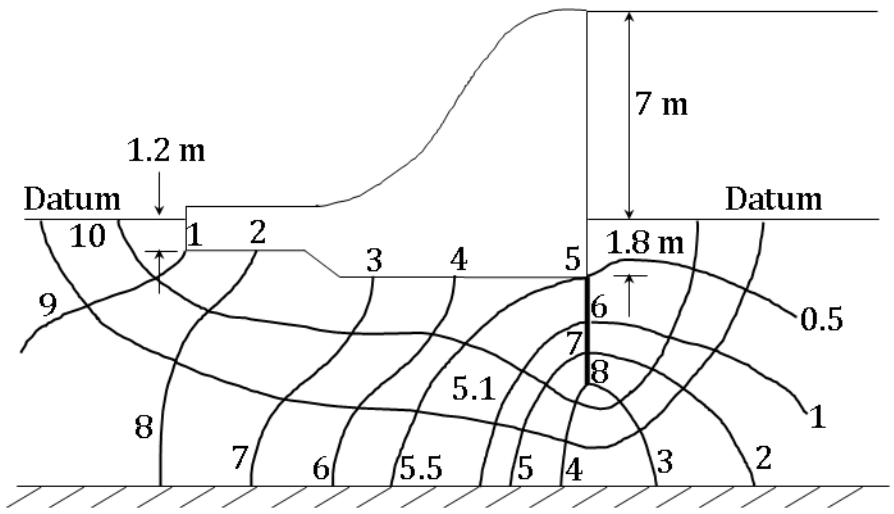

Fig.5

4 + 4 + 4 = 12

Group – E

8. (a) ABCD is a raft foundation of a multi-storey building as shown in Fig.6, wherein AB = 8 m, BC = 5 m, AA_1 = 2 m and A_1O = 3 m. The uniformly distributed load over the raft is 500 kN/m^2. Determine the vertical stress at a depth of 8 m below point O. [(CO6)(Evaluate/HOCQ)]

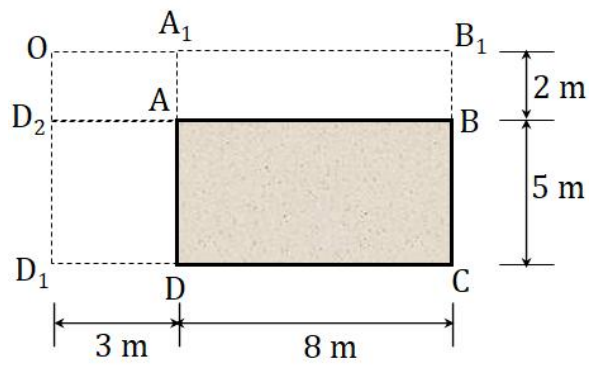

Fig.6

(b) A 4 m wide strip footing is located on the ground surface with a pressure of 148 kN/m². A 8 m thick soft clay layer exists at a depth of 6 m below the foundation. Determine the average increase in vertical stresses at the clay layer under the centerline and edge of the footing. [(CO6)(Evaluate/HOCQ)]

8 + 4 = 12

9. (a) Three parallel strip footings, shown in Fig.7 transmit contact loads of 200, 150 and 100 kN/m, respectively. Calculate the vertical stress due to the combined loads beneath the centres of each footing at a depth of 1.5 m below the base. Use Boussinesq's equation for line loads. [(CO6)(Evaluate/HOCQ)]

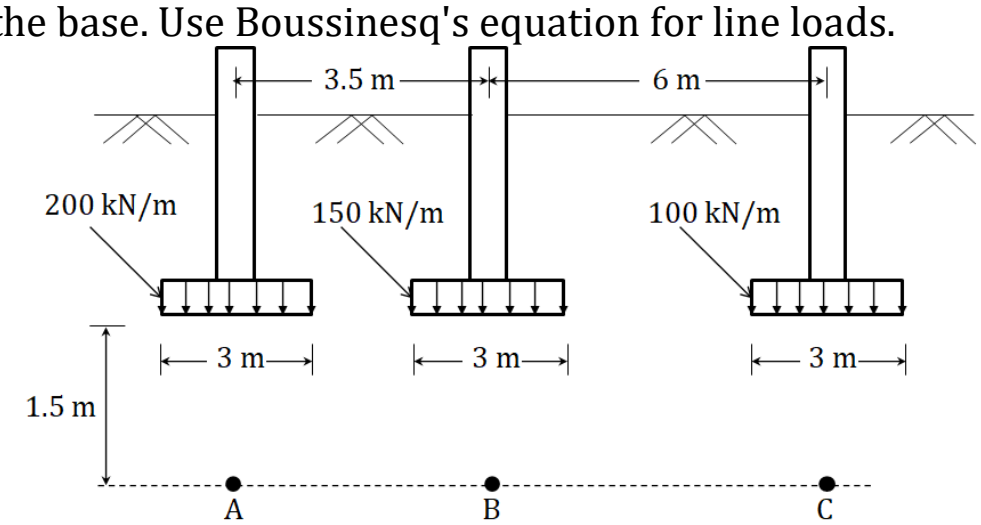

Fig.7

(b) A raft of size 3 m-square as shown in Fig.8, carries a load of 400 kN/m². Determine the vertical stress increment at a point P 5 m below the centre of the loaded area using Boussinesq's theory. Compare the result with that obtained by the equivalent point load method and with that obtained by dividing the area into four equal parts the load from each of which is assumed to act through its centre.

[(CO6)(Evaluate/HOCQ)]

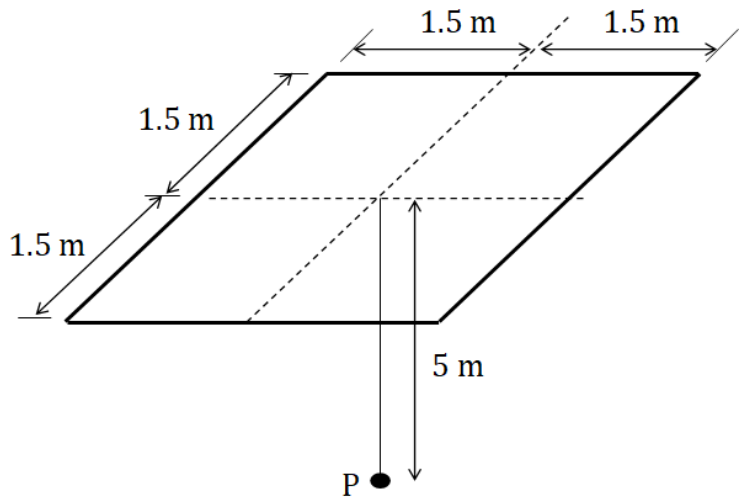

Fig.8

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	14.58	4.17	81.25

Course Outcome (CO):

After the completion of the course students will be able to

CO1 Identify the properties of rocks and which one is suitable for construction purpose.
CO2 Classify soil as per grain size distribution curve and understand the index properties of soil.
CO3 Apply the concept of total stress, effective stress and pore water pressure for solving geotechnical problems.
CO4 Assess the permeability of different types of soil and solve flow problems.
CO5 Estimate the seepage loss, factor of safety against piping failure using flow net related to any hydraulic structure.
CO6 Determine vertical stress on a horizontal plane within a soil mass subjected to different types of loading on the ground surface and also the maximum stressed zone or isobar below a loaded area.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.