

SOIL MECHANICS (CIV2202)

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) The void ratio (e) of a soil sample
(a) will be between 0 and 1 ($0 \leq e \leq 1$)
(c) can be practically any value | (b) cannot be more than 1
(d) can exceed unity but practically may not be too high |
| (ii) Dry density of soil is equal to the
(a) Mass of solids to the volume of solids
(c) Density of soil in dried condition | (b) Mass of solids to the total volume of soil
(d) None of the above. |
| (iii) A deposit of fine sand has a porosity n and specific gravity of soil solids is G . The critical hydraulic gradient is equal to
(a) $(G - 1)(1 + n)$
(c) $(G - 1)/(1 + n)$ | (b) $(G - 1)(1 - n)$
(d) $(G - 1)/(1 - n)$ |
| (iv) Which one of the following gives the correct decreasing order of the densities of the soil?
(a) sat > sub > wet > dry
(c) sat > wet > dry > sub | (b) sat > wet > sub > dry
(d) wet > sat > sub > dry |
| (v) The phreatic line in a homogeneous dam is
(a) circular
(c) parabolic | (b) elliptical
(d) hyperbolic |
| (vi) The line of optimums generally corresponds to percentage air voids of about
(a) 0 %
(c) 10 % | (b) 5 %
(d) 20 % |
| (vii) Soil compacted dry of the optimum as compared to that wet of the optimum
(a) has less permeability
(c) shrinks less | (b) swells less
(d) has less resistance to compression |
| (viii) Coefficient of consolidation of a soil is affected by
(a) Compressibility
(c) Both compressibility and permeability | (b) Permeability
(d) None of these |
| (ix) Contact pressure for a rigid footing resting on clay at the edge and the centre are, respectively,
(a) Zero, maximum
(c) Maximum, minimum | (b) Minimum, maximum
(d) Maximum, zero |
| (x) If the pore pressure is measured during un-drained stage of the test, the result can be expressed in terms of
(a) c' and ϕ'
(c) None of the mentioned | (b) c_u
(d) All of the mentioned |

Fill in the blanks with the correct word

- | | |
|---|--|
| (xi) The flow of water through soil is invariably (except in the case of coarse sands and gravels) _____. | (xii) For soils of low permeability, _____ permeameter is used in the laboratory to determine the coefficient of permeability. |
| (xiii) The higher the compactive effort, the _____ the optimum moisture content upto a certain limit. | (xiv) The shear strength for a saturated clay from unconfined compression test is _____ the unconfined compression strength. |
| (xv) A soil has plastic limit of 20 % and plasticity index of 30 %. The liquid limit will be _____. | |

Group - B

2. (a) An oven-dried soil sample of volume 263 cc weighs 364 gm. If the specific gravity of soil solids is 2.50, then determine the water content when the soil becomes fully saturated without any change in volume. Also calculate the water content which will fully saturate the sample and also cause an increase in volume equal to 20% of the original dry volume.

[[CO1, CO2](Analyse/IOCQ)]

- (b) The liquid limit, plastic limit and shrinkage limit of a soil are 55%, 25% and 18%, respectively. If a sample of this soil at liquid limit has a volume of 40 cc and its volume at shrinkage limit is 24 cc, determine the specific gravity of the soil solids and its shrinkage ratio.

[[CO1, CO2](Analyse/IOCQ)]

6 + 6 = 12

3. (a) A 1000 cc core cutter weighing 936 gm was used to find out the in-situ density of an embankment. The weight of core cutter filled with the soil was 2780 gm. Laboratory tests on the sample indicated that a water content of 12 % and specific gravity of soil solids is 2.65. Determine the bulk density, dry density, void ratio and degree of saturation of the sample. If the embankment becomes saturated due to rains, calculate the water content and saturated unit weight. (Assume there is no volume change in sample on saturation).

[[CO1, CO2](Evaluate/HOCQ)]

- (b) An undisturbed sample of clay brought from the field has a volume of 19 cc and weighs 33 gm. On oven drying, the weight of the sample was reduced to 22 gm. The volume of dried sample as obtained by displacement of mercury was 12 cc. Determine the shrinkage limit, specific gravity of soil solids, shrinkage ratio and volumetric shrinkage.

[[CO1, CO2](Analyse/IOCQ)]

6 + 6 = 12

Group - C

4. (a) At a site (Fig. 1) the subsoil consists of a 6 m thick layer of dry sand ($G = 2.65$, $e = 0.60$, $D_{10} = 0.14$ mm) which is underlain by a 3 m thick clay layer ($G = 2.75$, $w = 19\%$) below which there exists a thick layer of rock. The ground water table (GWT) is located at a depth of 4 m below the ground level (GL). The height of capillary rise within the sand layer is 1 m. Determine the effective stresses at (i) level of capillary rise, (ii) GWT level, (iii) bottom of sand layer and (iv) bottom of clay layer.

[[CO1, CO3](Analyse/IOCQ)]

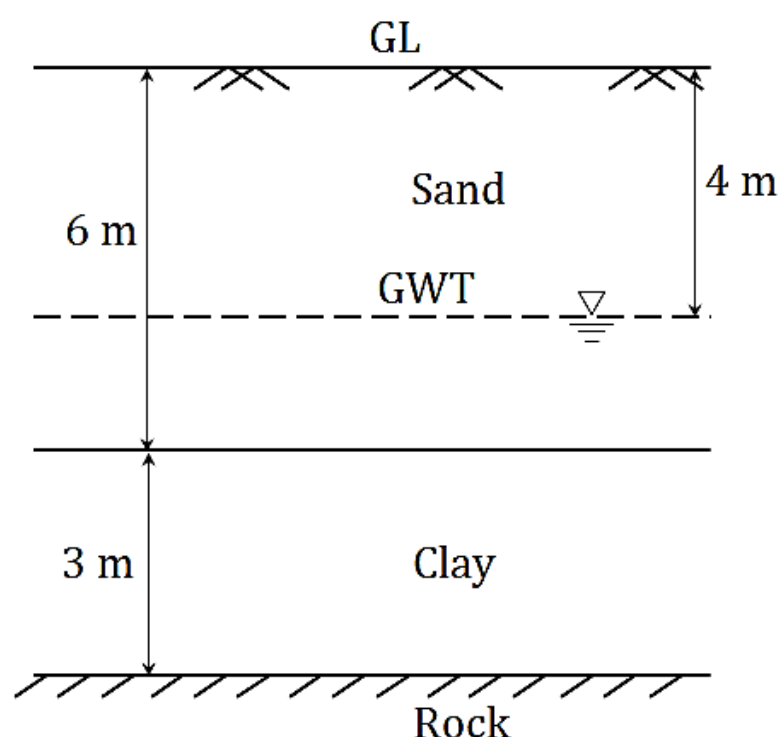


Fig. 1

- (b) A sand sample of 35 cm² cross-sectional area and 20 cm long was tested in a constant head permeameter. Under a head of 50 cm, the discharge was 125 ml in 10 min. The dry weight of sand used for the test was 1200 gm, and $G = 2.68$. Determine (i) the co-efficient of permeability in cm/sec, (ii) the discharge velocity, and (iii) the seepage velocity.

[[CO1, CO3](Analyse/IOCQ)]

- (c) The section through a dam spillway is shown in Fig. 2. Determine the quantity of seepage under the dam and uplift pressure at point 1. The coefficient of permeability of foundation soil is 3×10^{-5} m/sec.

[[CO1, CO3](Analyse/IOCQ)]

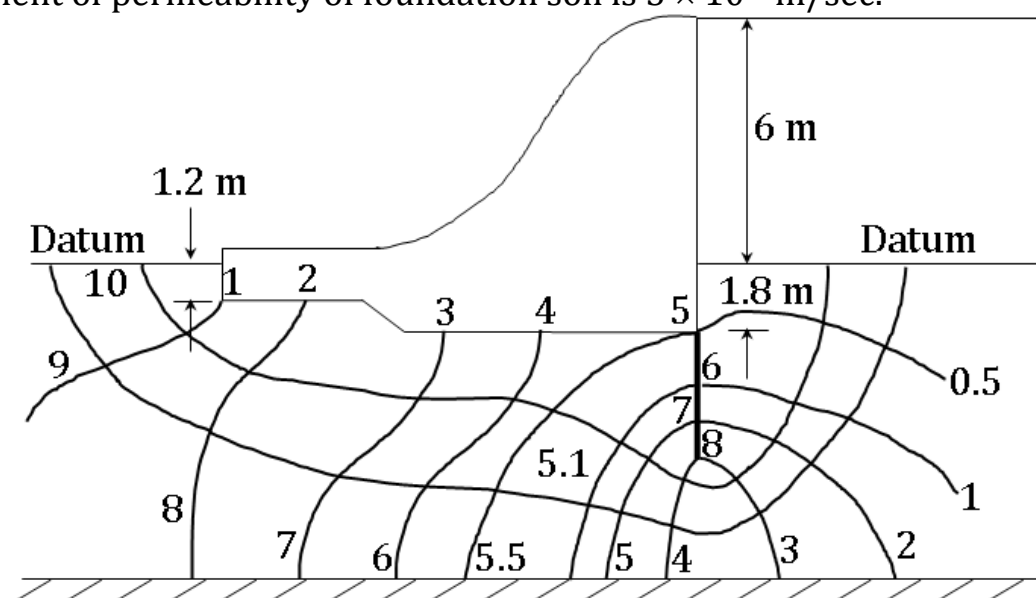


Fig. 2

4 + 4 + 4 = 12

5. (a) The water table in a certain area is at a depth of 3 m below the ground surface. The soil consists of very fine sand (void ratio = 0.8) upto a depth of 12 m. Above the water table the sand has a degree of saturation of 22%, Determine the effective pressure at a depth of 8 m below the ground surface. Also examine the increase in the effective pressure if the soil gets saturated by capillarity upto a depth of 1 m above the water table? Assume $G = 2.65$.

[[CO1, CO3](Analyse/IOCQ)]

- (b) In a falling head permeameter, the sample used is 20 cm long having a cross-sectional area of 24 cm². Determine the time (in min.) required for a drop of head from 25 cm to 9 cm if the c/s area of the stand pipe is 2 cm². The sample of soil is made

of three layers. The thickness and coefficient of permeability of the first, second and third layers from the top are 10 cm, 6 cm and 4 cm; 5×10^{-4} cm/sec, 8×10^{-4} cm/sec, 4×10^{-3} cm/sec, respectively. Assume that the flow is taking place perpendicular to the layers.

[[C01, C03](Analyse/IOCQ)]

- (c) A glass container with pervious bottom containing fine sand in loose state (void ratio = 0.5) is subjected to hydrostatic pressure from underneath until quick condition occurs in the sand. If the specific gravity of sand particles = 2.65, area of cross-section of sand sample = 10 cm^2 and height of sample = 25 cm, identify the head of water required to cause quicksand condition and also the seepage force acting from below.

[[C01, C03](Analyse/IOCQ)]

4 + 4 + 4 = 12

Group - D

6. (a) An embankment of trapezoidal cross-section is to be constructed for a 2 km long highway. The embankment should have a height of 2.5 m and a top width of 12 m. The sides of the embankment are to be sloped at 1.5H : 1V. The soil obtained from the borrow area is tested in the laboratory and is found to have the following properties: natural moisture content = 10 %, in-situ bulk density = 1.9 gm/cc , optimum moisture content (OMC) = 17%, dry density at OMC = 1.65 gm/cc . Determine the quantity of soil to be excavated and the quantity of water to be added to it before constructing the embankment.

[[C01, C04](Evaluate/HOCQ)]

- (b) The void ratio of clay sample A decreased from 0.65 to 0.15 when pressure changes from 100 kg/m^2 to 150 kg/m^2 . The void ratio of clay sample B decreased from 1.2 to 0.9 under the same increment of pressure. The thickness of sample A is 1.5 times that of sample B. The time required for 50% consolidation was three times longer for sample B than for sample A. Determine the ratio of coefficient of permeability of sample A to that of sample B.

[[C01, C04](Evaluate/HOCQ)]

8 + 4 = 12

7. (a) Define preconsolidation pressure and overconsolidation ratio.

[[C01, C04](Understand/LOCQ)]

- (b) The soil in a borrow pit has a void ratio of 0.80. A fill in-place volume of $15,000 \text{ m}^3$ is to be constructed with an in-place dry density of 1900 kg/m^3 . If the owner of the borrow area is to be compensated at Rs. 1.50 per cubic metre of excavation, determine the cost of compensation. Assume $G = 2.70$.

[[C01, C04](Analyse/IOCQ)]

- (c) A 8 m thick saturated clay stratum is sandwiched between a pervious stratum at the top and impervious stratum at the bottom. It has a compression index of 0.36 and coefficient of permeability of $2.5 \times 10^{-4} \text{ cm/sec}$. It has an initial void ratio of 1.62 when the initial effective overburden pressure at the mid-height of the layer is 120 kN/m^2 . Determine (i) void ratio when pressure increases to 210 kN/m^2 , (ii) settlement of the soil stratum due to the above increase of pressure and (iii) time (in hours) required for 40% consolidation.

[[C01, C04](Evaluate/HOCQ)]

2 + 4 + 6 = 12

Group - E

8. (a) A concentrated load of 800 kN is applied at the ground surface. Determine the vertical pressure (i) at a depth of 3 m below the load, (ii) at a distance of 2 m at the same depth. Use Boussinesq's and Westergaard's equations.

[[C01, C05](Analyse/IOCQ)]

- (b) Determine the shear strength on a horizontal plane at a depth of 2 m below the ground surface in a formation of cohesionless soil ($S = 50\%$, $e = 0.60$, $G = 2.7$, friction angle = 30°) when the water table is at a depth of 4 m. Also determine the reduction (in %) of shear strength when the water rises to the ground surface.

[[C01, C06](Analyse/IOCQ)]

- (c) A saturated specimen of cohesionless soil was tested under undrained conditions in a triaxial compression tests apparatus and the sample failed at a deviator stress of 370 kN/m^2 and the plane of failure made an angle of 58° with the horizontal. Determine the magnitudes of the principal stresses. Also evaluate the magnitude of the deviator stress and the major principal stress at failure for another identical specimen of soil if it is tested under a cell pressure of 122 kN/m^2 .

[[C01, C06](Evaluate/HOCQ)]

4 + 4 + 4 = 12

9. (a) A rectangular foundation, ABCD (Fig. 3), $5 \text{ m} \times 3 \text{ m}$, transmits a uniform pressure of 150 kN/m^2 to the underlying soil. Determine the vertical stress at a depth of 2.5 m below the foundation at a point within the loaded area, 1.5 m away from a short edge and 0.5 m away from a long edge. Use Boussinesq's theory.

[[C01, C05](Evaluate/HOCQ)]

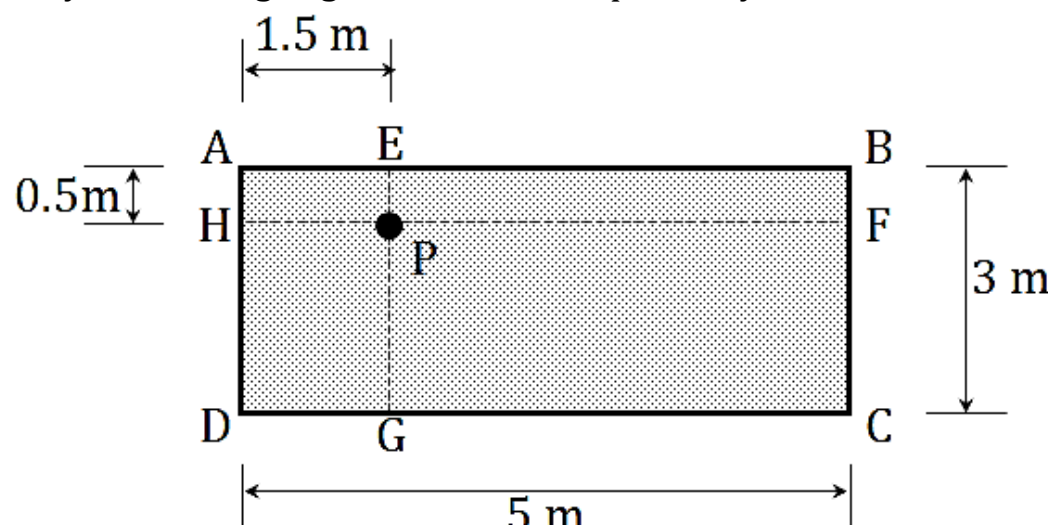


Fig. 3

- (b) An embankment, 5 m high, is made up of soil whose effective stress parameters are $c' = 40 \text{ kN/m}^2$, $\phi' = 25^\circ$ and $\gamma = 17 \text{ kN/m}^3$. The pore pressure parameters as found from triaxial test are $A = 0.50$ and $B = 0.95$. Determine the shear strength of the soil at the base of the embankment just after the fill has been raised from 5 m to 8 m. Assume that the dissipation of

pore water pressure during this stage of construction is negligible, and that the lateral pressure at any point is one-half of the vertical pressure.

[[C01, C06](Analyze/IOCQ)]

8 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	2.1	60.04	37.5