Course Code: 20CE0161 **R20**

SIDDHARTH INSTITUTE OF ENGINEERING & TECHNOLOGY:: PUTTUR (AUTONOMOUS)
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QUESTION BANK (DESCRIPTIVE)

Subject with Code: Soil Mechanics (20CE0161) **Course & Branch**: B.Tech (AGE)

Year & Sem: III / I **Regulation:** R20

UNIT –I

Part A: Introduction of Soil Mechanics
Part B: Properties of Soils

1	**a.**	Define the terms void ratio, specific gravity of particles, degree of saturation and dry density.	**[L1][CO1]**	**[6M]**
	b.	Develop a relationship between the void ratio, water content, specific gravity of particles and degree of saturation.	**[L2][CO1]**	**[6M]**
2	**a.**	Explain in detail how soils are formed.	**[L1][CO1]**	**[6M]**
	b.	Briefly explain different types of soil structures which can occur in nature.	**[L1][CO1]**	**[6M]**
3	A soil sample has a porosity of 40%. The specific gravity of solids is 2.70. Calculate (a) void ratio, (b) dry density, (c) unit weight if the soil is 50% saturated and (d) unit weight if the soil is completely saturated.		**[L3][CO1]**	**[12M]**
4	A moist soil sample weights 3.52 N. After drying in an oven, its weight is reduced to 2.9 N. The specific gravity of solids and the mass specific gravity are, respectively, 2.65 and 1.85. Determine the water content, void ratio, porosity and the degree of saturation. Assume unit weight of water is 10 kN/m^3.		**[L3][CO1]**	**[12M]**
5	A sample of soil has a volume of 1 litre and a weight of 17.5 N. The specific gravity of the solids is 2.68. If the dry unit weight of the soil is 14.8 kN/m^3, determine (a) water content, (b) void ratio, (c) porosity, (d) saturated unit weight, (e) submerged unit weight and (f) degree of saturation.		**[L3][CO1]**	**[12M]**
6	A soil sample with a grain specific gravity of 2.67 was filled in a 1000 ml container in the loosest possible state and the dry weight of the sample was found to be 1475 g. It was then filled at the densest state obtainable and the weight was found to be 1770 g. The void ratio of the soil in the natural state was 0.63. Determine the density index in the natural state.		**[L3][CO1]**	**[12M]**
7	The result of a sieve analysis of a soil are given below: Total mass of sample = 900 g.		**[L3][CO1]**	**[12M]**

Is Sieve	**Mass of soil retained (g)**
20 mm	35
10 mm	40
4.75 mm	80
2.0 mm	150
1.0 mm	150
0.6 mm	140
425 μ	115
212 μ	55
150 μ	35
75 μ	25
Pan	75

Draw the particle size distribution curve and hence determine the uniformity coefficient and coefficient of curvature.

<table>
<tr><td>8</td><td>a.</td><td>Explain consistency limits of soil with the help of a typical graph drawn between water content and volume of soil and show different states of soil.</td><td>[L1][CO1]</td><td>[6M]</td></tr>
<tr><td></td><td>b.</td><td>Determine the specific gravity of solids from the following observations:
(i) Mass of dry sample = 0.395 kg
(ii) Mass of pycnometer full of water = 1.755 kg
(iii) Mass of pycnometer containing soil and full of water = 2.005 kg</td><td>[L3][CO1]</td><td>[6M]</td></tr>
<tr><td>9</td><td>a.</td><td>A test for the determination for the liquid limit was carried on a soil sample using Casagrande’s apparatus. The following sets of observations were taken. Plot the flow curve and determine the liquid limit.
<table>
<tr><td>No. of Blows (N)</td><td>38</td><td>27</td><td>20</td><td>13</td></tr>
<tr><td>Water content (w) %</td><td>47.5</td><td>49.5</td><td>51.9</td><td>53.9</td></tr>
</table></td><td>[L3][CO1]</td><td>[6M]</td></tr>
<tr><td></td><td>b.</td><td>The sieve analysis of a soil gave the following results:
% passing 75 μ sieve = 8
% retained on 4.75 mm sieve = 35
Coefficient of curvature = 2.5
Uniformity coefficient = 7
The fine fraction gave the following results:
Plasticity index = 3
Liquid limit = 15
Classify the soil according to ISC system.</td><td>[L4][CO1]</td><td>[6M]</td></tr>
<tr><td>10</td><td colspan="2">A test for the relative density of soil in place was performed by digging a small hole in the soil. The volume of the hole was 400 ml and the moist weight of the excavated soil was 9 N. After oven drying the weight was 7.8 N. Of the dried soil, 4 N was poured into a vessel in a very loose state, and its volume was found to be 270 ml. The same wight of soil when vibrated and tamped had a volume of 200 ml. Determine the relative density.</td><td>[L3][CO1]</td><td>[12M]</td></tr>
</table>

UNIT –II

Part A: Permeability of Soils
Part B: Effective Stress

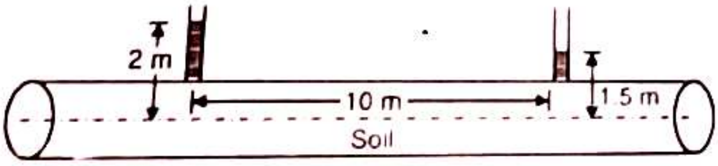
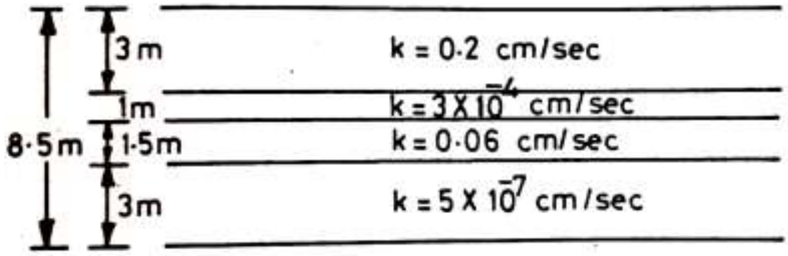
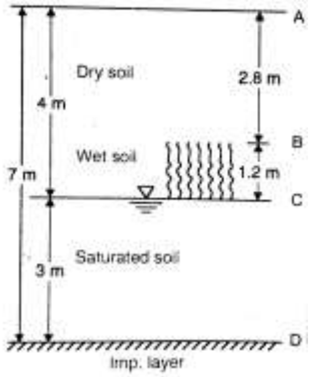
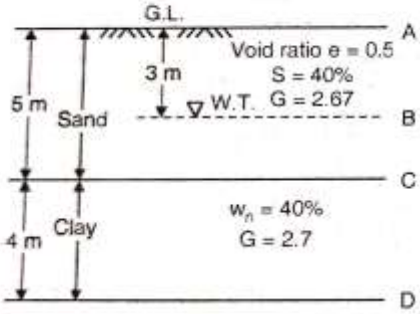
<table>
<tr><td>1</td><td>a.</td><td>What is Darcy’s law? What are its limitations?</td><td>[L1][CO2]</td><td>[6M]</td></tr>
<tr><td></td><td>b.</td><td>Estimate the flow quantity (in litres per second) through the soil in the pipe shown in Figure 2.1. The pressure heads at two locations are shown in the same figure. The internal diameter of the pipe is 1 m and the coefficient of permeability of soil is 1 x 10^{-5} m/s.


Figure 2.1</td><td>[L3][CO2]</td><td>[6M]</td></tr>
<tr><td>2</td><td colspan="2">Elaborate various factors affecting the permeability of soil.</td><td>[L1][CO2]</td><td>[12M]</td></tr>
<tr><td>3</td><td>a.</td><td>The capillary rise in silt is 50 cm and that in fine sand is 30 cm. What is the difference in the pore size of the two soils?</td><td>[L3][CO2]</td><td>[6M]</td></tr>
<tr><td></td><td>b.</td><td>In a falling head permeameter test on a silty clay sample, the following results were obtained:
Sample length = 12 mm
Sample diameter = 80 mm
Initial head = 1200 mm
Final head =400 mm
Time for fall in head = 6 minutes
Stand pipe diameter = 4 mm
Find the coefficient of permeability of the soil in mm/s.</td><td>[L3][CO2]</td><td>[6M]</td></tr>
<tr><td>4</td><td colspan="2">Figure 2.2 shows a cross-section through the strata underlying a site. Calculate the</td><td>[L3][CO2]</td><td>[12M]</td></tr>
</table>

		equivalent permeability of the layered system in the vertical and horizontal direction. Assume that each layer is isotropic.  **Figure 2.2**		
5		Draw the neat sketch of Variable Head Permeameter and derive the equation for determining coefficient of permeability.	**[L2][CO2]**	**[12M]**
6	**a.**	Define total stress, neutral stress and effective stress. What is the importance of the effective stress?	**[L1][CO2]**	**[6M]**
	b.	What is a quick sand? How would you calculate the hydraulic gradient required to create quick sand condition in a sample of sand?	**[L2][CO2]**	**[6M]**
7		A granular soil deposit as shown in Figure 2.3 is 7 m deep over an impermeable layer. The ground water table is 4 m below the ground surface. The deposit has a zone of capillary rise of 1.2 m with a saturation of 50%. Plot the variation of total stress, pore water pressure and effective stress with the depth of deposit, e = 0.6 and G = 2.65.  **Figure 2.3**	**[L3][CO2]**	**[12M]**
8		For the subsoil conditions shown in Figure 2.4, draw the total, neutral and effective stress diagrams upto a depth of 9 m, neglecting capillary flow.  **Figure 2.4**	**[L3][CO2]**	**[12M]**
9		Compute the total, effective and pore pressure at a depth of 20 m below the bottom of a lake 6 m deep. The bottom of lake consists of soft clay with a thickness of more than 20 m. The average water content of the clay is 35% and the specific gravity of the soil may be assumed to be 2.65.	**[L3][CO2]**	**[12M]**

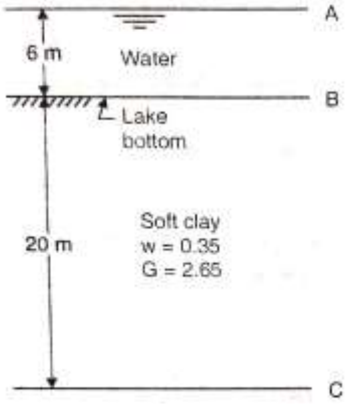
<table>
<tr><td></td><td colspan="2">

Figure2.5 – Lake Profile</td><td></td><td></td></tr>
<tr><td>**10**</td><td>**a.**</td><td>What is a flow net? Describe its properties and applications.</td><td>**[L2][CO2]**</td><td>**[6M]**</td></tr>
<tr><td></td><td>**b.**</td><td>Explain the uses of a flow net.</td><td>**[L1][CO2]**</td><td>**[6M]**</td></tr>
</table>

UNIT –III

Part A: Stress Distribution of Soils

Part B: Compaction

<table>
<tr><td>**1**</td><td>**a.**</td><td>State the assumptions made in computing stresses below the ground surface due to a point load acting on it.</td><td>**[L1][CO3]**</td><td>**[6M]**</td></tr>
<tr><td></td><td>**b.**</td><td>Derive an expression for the vertical stress at a point due to a line load.</td><td>**[L2][CO3]**</td><td>**[6M]**</td></tr>
<tr><td>**2**</td><td>**a.**</td><td>Discuss the basis of the construction of Newmark's influence chart. How it is used?</td><td>**[L1][CO3]**</td><td>**[6M]**</td></tr>
<tr><td></td><td>**b.**</td><td>A monument weighing 15 MN is erected on the ground surface. Considering the load as a concentrated one, determine the vertical pressure directly under the monument at a depth of 8 m below the ground surface.</td><td>**[L3][CO3]**</td><td>**[6M]**</td></tr>
<tr><td>**3**</td><td>**a.**</td><td>Explain Wastergaads's theory for the determination of the vertical stress at a point. How is it different from Boussinesq's solution?</td><td>**[L1][CO3]**</td><td>**[6M]**</td></tr>
<tr><td></td><td>**b.**</td><td>A water tower has a circular foundation of 10 m diameter, If the total weight of the tower, including the foundation is 2 x 10^4 kN, calculate the vertical stress at a depth of 2.5 m below the foundation level.</td><td>**[L3][CO3]**</td><td>**[6M]**</td></tr>
<tr><td>**4**</td><td colspan="2">An exaction 3 m x 6 m for foundation is to be made to a depth of 2.5 m below ground level in a soil of bulk unit weight 20 kN/m^3. What effect this exaction will have on the vertical pressure at a depth of 6 m measured from the ground surface vertically below the centre of foundation? I_N for m = 0.43 and n = 0.86 is 0.10.</td><td>**[L3][CO3]**</td><td>**[12M]**</td></tr>
<tr><td>**5**</td><td colspan="2">Derive the equation for vertical stress under a strip load (a) at a point below the centre of the strip (b) point not below the centre of the strip.</td><td>**[L2][CO3]**</td><td>**[12M]**</td></tr>
<tr><td>**6**</td><td colspan="2">A sample of soil was prepared by mixing a quantity of dry soil with 10% by mass of water. Find the mass of this wet mixture required to produce a cylindrical, compacted specimen of 15 cm diameter and 12.5 cm deep and having 6% air content. Find also the void ratio and the dry density of the specimen if G = 2.68.</td><td>**[L3][CO4]**</td><td>**[12M]**</td></tr>
<tr><td>**7**</td><td colspan="2">The following are the results of a standard compaction test performed on a sample of soil.
<table>
<tr><td>Water Content (%)</td><td>7.7</td><td>11.5</td><td>14.6</td><td>17.5</td><td>19.7</td><td>21.2</td></tr>
<tr><td>Mass of wet soil (kg)</td><td>1.7</td><td>1.89</td><td>2.03</td><td>1.99</td><td>1.96</td><td>1.2</td></tr>
</table>
If the volume of the mould used was 950 c.c. and the specific gravity of soil grains was 2.65,make necessary calculations and plot the water content – dry density curve and obtain the optimum water content and maximum dry density.</td><td>**[L3][CO4]**</td><td>**[12M]**</td></tr>
<tr><td>**8**</td><td colspan="2">Give a detailed account on effect of compaction on engineering properties of soils.</td><td>**[L1][CO4]**</td><td>**[12M]**</td></tr>
<tr><td>**9**</td><td>**a.**</td><td>Elaborate on factors affecting compaction.</td><td>**[L1][CO4]**</td><td>**[6M]**</td></tr>
<tr><td></td><td>**b.**</td><td>Describe the methods used in field for compaction.</td><td>**[L1][CO4]**</td><td>**[6M]**</td></tr>
<tr><td>**10**</td><td colspan="2">An earthen embankment of 10^6 m^3 volume is to be constructed with a soil having a void ratio of 0.80 after compaction. There are three borrow pits marked A, B, and C, having soils with void ratios 0.90, 1.50 and 1.80, respectively. The cost of</td><td>**[L5][CO4]**</td><td>**[12M]**</td></tr>
</table>

	exaction and transporting the soil is Rs.0.25, Rs.0.23 and Rs.0.18 per m^3, respectively. Calculate the volume of soil to be excavated from each pit. Which borrow bit is the most economical? Consider specific gravity of soil solids as 2.65.		

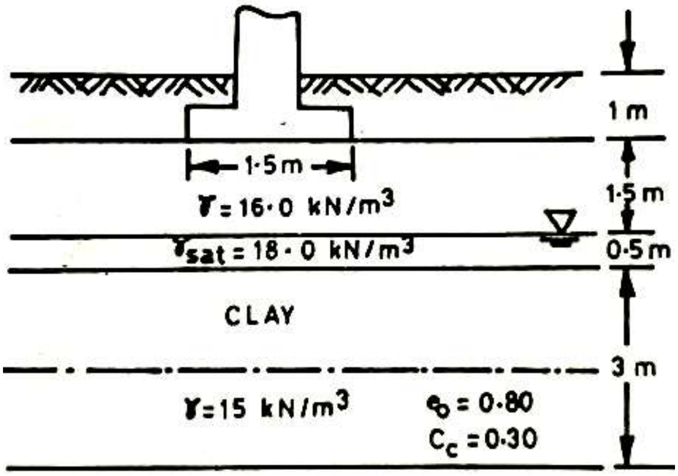
UNIT –IV

Consolidation

1	**a.**	Differentiate between 'Compaction' and 'Consolidation'.	**[L2][CO5]**	**[6M]**
	b.	State the assumptions made by Terzaghi for theory of one-dimensional consolidation.	**[L1][CO5]**	**[6M]**
2		Define the following items: (i) Coefficient of compressibility (ii) Coefficient of volume change (iii)Compression index (iv)Expansion index (v) Recompression index	**[L1][CO5]**	**[12M]**
3	**a.**	Describe various stages of consolidation of soils.	**[L1][CO5]**	**[6M]**
	b.	Differentiate between normally consolidated and the overconsolidated soils. How would you determine the preconsolidation pressure?	**[L2][CO5]**	**[6M]**
4		The following results were obtained from a consolidation test: Initial height of sample, H_i = 2.5 cm Height of solid particles, H_s = 1.25 cm	**[L3][CO5]**	**[12M]**

Pressure in kg/cm^2	**Dial reading in cm**
0.00	0.000
0.13	0.000
0.27	0.004
0.54	0.016
1.08	0.044
2.14	0.104
4.80	0.218
9.60	0.340
15.00	0.420

		Plot the pressure-void ratio curve and determine (a) the compression index and (b) the preconsolidation pressure.		
5	**a.**	With a neat graph outline the steps involved in determination of coefficient of consolidation using *Square-root of time* method.	**[L1][CO5]**	**[6M]**
	b.	In a consolidation test the following results have been obtained. When the load was changed from 50 kN/m^2 to 100 kN/m^2, the void ratio changed from 0.70 to 0.65. Determine the coefficient of volume decrease, m_v and the compression index, C_c.	**[L3][CO5]**	**[6M]**
6		A compressible layer is expected to have total settlement of 15 cm under a given loading. It settles by 3 cm at the end of two months after the application of load increment? How many months will be required to reach a settlement of 7.5 cm? What is the settlement in 18 months? The layer has double drainage.	**[L3][CO5]**	**[12M]**
7		A saturated soil stratum 6 metres thick lies above an impervious stratum and below a pervious stratum. It has a compression index of 0.28 and a coefficient of permeability of 3.5 x 10^{-4} cm/sec. Its void ration at a stress of 150 kN/m^2 is 1.95. Determine: (i) the change in void ratio due to an increase in stress to 210 kN/m^2 (ii) settlement of the soil stratum due to the above increase in stress and (iii) time required for 50% consolidation. Assume time factor T_v for 50% consolidation as 0.20.	**[L3][CO5]**	**[12M]**
8		A homogeneous clay layer 12 m thick is expected to have an ultimate settlement of 332 mm. After a time span of 3 years, the average settlement was measured to be	**[L4][CO5]**	**[12M]**

	152 mm. How much longer will it take for the average settlement to attain 237 mm?		
9	Undrained soil sample 30 m thick got 50% consolidation in 20 minutes with drainage allowed at top and bottom in the laboratory. If the clay layer from which the sample was obtained is 3 m thick in field condition, estimate the time it will take to consolidate 50% with (i) double surface drainage (ii) single surface drainage, if in both cases, consolidation pressure is uniform.	**[L4][CO5]**	**[12M]**
10	A footing has a size of 3.0 m by 1.50 m and it causes a pressure increment of 200 kN/m^2 at its base as shown in Figure4.1. Determine the consolidation settlement at the middle of the clay layer. Assume 2:1 pressure distribution and consider the variation of pressure across the depth of the clay layer. $\gamma_w = 10\ kN/m^3$.  **Figure4.1**	**[L4][CO5]**	**[12M]**

UNIT –V

Shear Strength

1	**a.**	Explain Mohr-Coulomb theory and draw the failure envelope.	**[L1][CO6]**	**[6M]**
	b.	Sketch the stress-strain relationship for dense and loose sand.	**[L1][CO6]**	**[6M]**
2	**a.**	Explain Coulomb's law for shearing strength of soils and its modification by Terzaghi.	**[L1][CO6]**	**[6M]**
	b.	A shear vane of 7.5 cm diameter and 11.0 cm length was used to measure the shear strength of a soft clay. If a torque of 600 N-m was required to shear the soil, calculate the shear strength. The vane was then rotated rapidly to cause remoulding of the soil. The torque required in the remoulded state was 200 N-m. Determine the sensitivity of the soil.	**[L3][CO6]**	**[6M]**
3	**a.**	What is liquefaction of sands? How can it be prevented?	**[L1][CO6]**	**[6M]**
	b.	Explain the effect of initial density on changes in void ratio with the help of Shearing strain Vs Void ratio graph. Define *Critical Void Ratio* locate it on the Shearing strain Vs Void ration graph.	**[L1][CO6]**	**[6M]**
4		With the help of sketch explain how *Direct Shear Test* is conducted? What are its merits and demerits?	**[L1][CO6]**	**[12M]**
5	**a.**	Draw typical Mohr Circle for *Unconfined Compressive Test.* What are the merits and demerits of this test.	**[L1][CO6]**	**[6M]**
	b.	Explain the underlying principle of *Triaxial Compression Test.*	**[L1][CO6]**	**[6M]**
6		Calculate the potential shear strength on horizontal plane at a depth of 3 m below the surface in a formation of cohesionless soil when the water table is at a depth of 3.5 m. The degree of saturation may be taken as 0.5 on the average. Void ratio = 0.5; grain specific gravity = 2.7; angel of internal friction = 30^o. What will be the modified value of shear strength if the water table reaches the ground surface?	**[L3][CO6]**	**[12M]**
7	**a.**	Discuss the shear strength characteristics of cohesionless soils and cohesive soils.	**[L1][CO6]**	**[6M]**

<table>
<tr>
<td></td>
<td>b.</td>
<td>A series of direct shear tests was conducted on a soil, each test was carried out till the sample failed. The following results were obtained.
<table>
<tr><td>Sample No.</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>Normal stress (kN/m^2)</td><td>15</td><td>30</td><td>45</td></tr>
<tr><td>Shear stress (kN/m^2)</td><td>18</td><td>25</td><td>32</td></tr>
</table>
Determine the cohesion intercept and the angle of shearing resistance.</td>
<td>[L3][CO6]</td>
<td>[6M]</td>
</tr>
<tr>
<td>8</td>
<td colspan="2">The following results were obtained from a series of consolidated undrained tests on a soil, in which the pore water pressure was not determined. Determine the cohesion intercept and the angle of shearing resistance.
<table>
<tr><th>Sample No.</th><th>Confining pressure ((kN/m^2)</th><th>Deviator stress at failure (kN/m^2)</th></tr>
<tr><td>1</td><td>100</td><td>600</td></tr>
<tr><td>2</td><td>200</td><td>750</td></tr>
<tr><td>3</td><td>300</td><td>870</td></tr>
</table></td>
<td>[L3][CO6]</td>
<td>[12M]</td>
</tr>
<tr>
<td>9</td>
<td colspan="2">The following results were obtained from a consolidated-undrained (CU) test on a normally consolidated clay. Plot the strength envelope in terms of total stresses and effective stresses and determine the strength parameters.
<table>
<tr><th>Sample No.</th><th>Confining pressure ((kN/m^2)</th><th>Deviator stress (kN/m^2)</th><th>Pore water pressure (kN/m^2)</th></tr>
<tr><td>1</td><td>250</td><td>152</td><td>120</td></tr>
<tr><td>2</td><td>500</td><td>300</td><td>250</td></tr>
<tr><td>3</td><td>750</td><td>455</td><td>350</td></tr>
</table></td>
<td>[L3][CO6]</td>
<td>[12M]</td>
</tr>
<tr>
<td>10</td>
<td colspan="2">Clean and dry sand samples were tested in a large shear box, 25 cm x 25 cm and the following results were obtained:
<table>
<tr><td>Normal load (kN)</td><td>5</td><td>10</td><td>15</td></tr>
<tr><td>Peak shear load (kN)</td><td>5</td><td>10</td><td>15</td></tr>
<tr><td>Ultimate shear load (kN)</td><td>2.9</td><td>5.8</td><td>8.7</td></tr>
</table>
Determine the angle of shearing resistance of the sand in the dense and loose states.</td>
<td>[L3][CO6]</td>
<td>[12M]</td>
</tr>
</table>

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