SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF CIVIL ENGINEERING

QUESTION BANK

III SEMESTER

CE 3365 – SOIL MECHANICS

REGULATIONS - 2023

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Prepared by

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QUESTION BANK

UNIT I - SOIL CLASSIFICATION

History – formation and types of soil – composition - Index properties – clay mineralogy structural arrangement of grains – description – Classification – BIS – US – phase relationship.

PART A

Q. No.	QUESTIONS	BT LEVEL	COMPETENCE
1.	Define degree of saturation and shrinkage ratio.	BT-1	Remember
2.	What are the Atterberg's limits? List its types.	BT-1	Remember
3.	If the volume of voids is equal to the volume of solids in a given soil sample, Find void ratio and porosity.	BT-1	Remember
4.	Define air content in soil.	BT-1	Remember
5.	Draw the Three Phase diagram.	BT-2	Understand
6.	A soil has void ratio of 0.65 and specific gravity 2.80. Determine unit weight of soil.	BT-3	Apply
7.	Define plasticity index and flow index.	BT-2	Understand
8.	Discuss about water content of a soil mass	BT-2	Understand
9.	Differentiate between plasticity and consistency.	BT-2	Understand
10.	The natural water content of an excavated soil from the borrow pit is 35 %. Its liquid limit is 65 % and plasticity limit is 25 %. Determine the Liquidity Index of the soil and comment about the consistency of the soil.	BT-2	Understand
11.	A compacted sample of soil with a bulk unit weight of 19.62kN/m^3 has a water content of 15 percent. Calculate its dry density and degree of saturation? Assume G = 2.65.	BT-3	Apply
12.	How will you represent silty clay and poor graded gravel?	BT-3	Apply

<table>
<tr><td>13.</td><td>Derive the relationship between void ratio and porosity.</td><td>BT-3</td><td>Apply</td></tr>
<tr><td>14.</td><td>Write down the particle size for clay and silt.</td><td>BT-4</td><td>Analyse</td></tr>
<tr><td>15.</td><td>List out methods to determine water content of soil</td><td>BT-4</td><td>Analyse</td></tr>
<tr><td>16.</td><td>A compacted sample of soil with a dry unit weight of 17.84 kN/m^3 has a water content of 11 %. Calculate its dry density.</td><td>BT-4</td><td>Analyse</td></tr>
<tr><td>17.</td><td>Compose a relation for γ_{sat} with G, γ_w and e.</td><td>BT-5</td><td>Evaluate</td></tr>
<tr><td>18.</td><td>A dry clay has a mass of 30 g and volume of 15 cc, what will be the shrinkage limit if the specific gravity of solids is 2.65.</td><td>BT-5</td><td>Evaluate</td></tr>
<tr><td>19.</td><td>Draw the phase diagram for completely dry and fully saturated soil mass.</td><td>BT-6</td><td>Create</td></tr>
<tr><td>20.</td><td>Two clay samples A and B have the following properties:
<table>
<tr><th>Soil properties</th><th>Clay A</th><th>Clay B</th></tr>
<tr><td>Liquid limit</td><td>44%</td><td>55%</td></tr>
<tr><td>Plastic limit</td><td>29%</td><td>35%</td></tr>
<tr><td>Natural water content</td><td>30%</td><td>50%</td></tr>
</table>
Which of the clays A or B would experience larger settlement under identical loads? Conclude with your comments by classifying the soils.</td><td>BT-6</td><td>Create</td></tr>
<tr><td>21.</td><td>Write the expression for Unit weight and Saturated Unit weight.</td><td></td><td></td></tr>
<tr><td>22.</td><td>Differentiate porosity and void ratio</td><td>BT-4</td><td>Analyse</td></tr>
<tr><td>23.</td><td>Define Liquid Limit</td><td>BT-2</td><td>Understand</td></tr>
<tr><td>24.</td><td>Differentiate Air content and Percentage air voids.</td><td>BT-3</td><td>Apply</td></tr>
<tr><td>25.</td><td>Dry unit weight of soil is 13.75 kN/m^3 and water content is 17 %. Determine the bulk unit weight.</td><td>BT-5</td><td>Evaluate</td></tr>
<tr><td colspan="4">PART B</td></tr>
<tr><td>1.</td><td>Explain Indian Standard soil classification system</td><td>BT – 1</td><td>Remember</td></tr>
<tr><td>2.</td><td>(i) By three phase soil system, show that the degree of saturation S (as ratio) in terms of mass unit weight(γ), void ratio (e), specific gravity of soil grains(G) and unit weight of water (γ_w) is given by the expression:
$$\gamma = \frac{(G + eS)\gamma_w}{1 + e}$$ (8)</td><td>BT – 1</td><td>Remember</td></tr>
</table>

	(ii) A compacted cylindrical specimen 50 mm diameter and 100 mm long is to be prepared from dry soil. If the specimen is required to have a water content of 15 % and the percentage of air voids are 20 %, calculate the weight of soil and water required in the preparation of soil where specific gravity = 2.69. (8)		
3.	In an earth dam under construction, the bulk unit weight is 16.5 kN/m^3 at water content 11 %. If the water content has to be increased to 15 %, compute the quantity of water to be added per cu. m of soil. Assume no change in void ratio. Determine the degree of saturation at this water content. Take G = 2.7.	BT – 1	Remember
4.	(i) A partially saturated soil from an earth fill has a natural water content of 22 % and a bulk unit weight of 19 kN/m^3. Assuming the specific gravity of soil solids as 2.65, compute the degree of saturation and void ratio. If subsequently the soil gets saturated, determine the dry density, buoyant unit weight and saturated unit weight. (8) (ii) Explain Indian Standard soil classification system for classifying coarse grained soil. (8)	BT – 2	Understand
5.	Discuss about the grain size distribution of soil by Sieve analysis and Sedimentation analysis.	BT – 2	Understand
6.	Sandy soil in a borrow pit has unit weight of solids as 25.8 kN/m^3, water content equal to11% and bulk unit weight equal to 16.4 kN/m^3. How many cubic meter of compacted fill could be constructed of 3500 m^3 of sand excavated from the borrow pit, if the required value of porosity in the compacted fill is 30 %. Also calculate the change in degree of saturation.	BT -3	Apply
7.	Explain the US soil classification system for soil.	BT- 4	Analyse
8.	(i) A soil has bulk density of 20.1 kN/m^3 and water content of 15%. Calculate the water content if the soil partially dries to density of 19.4 kN/m^3 and void ratio remains unchanged (8) (ii) A soil sample is found to have the following properties. Classify the soil according to IS classification system. Passing 75μ sieve = 10%; passing 4.75 mm sieve = 70%; Uniformity coefficient =8; coefficient of curvature = 2.8; Plasticity index = 4%. (8)	BT – 4	Analyse
9.	Explain the procedure for determining Liquid Limit and Plastic Limit.	BT- 5	Evaluate
10.	(i) A cubic meter of soil in its natural state weighs 17.75 kN, after being dried it weighs 15.08 kN. The specific gravity of the soil is 2.70. Determine the degree of saturation, void ratio, porosity and water content of the original soil sample. (8) (ii)Discuss the Fine grain classification of soils (8)	BT- 6	Create
11.	In its natural condition, a soil sample has a mass of 22.9 N and a volume of 1.15 x 10^{-3} m^3. After being completely dried in the	BT – 1	Remember

<table>
<tr><td></td><td>oven sample weighs 20.35 N. Find bulk density, water content, void ratio, porosity, degree of saturation, air content, dry density and percentage air voids.</td><td></td><td></td></tr>
<tr><td>12.</td><td>(i) Derive the relationship between porosity and void ratio. (6)
(ii) A partially saturated sample from a borrow pit has a natural moisture content of 15% and bulk unit weight of 1.9 g/cc. G = 2.7. Determine the degree of saturation and void ratio. What will be the unit weight of the soil if it gets saturated. (10)</td><td>BT – 2</td><td>Understand</td></tr>
<tr><td>13.</td><td>a. Describe three Atterberg Limits of a soil in detail. (6)
b. Draw the diagram and mark the various soil phases. (6)
c. Define Sensitivity and Thixotropy for a soil. (4)</td><td>BT – 3</td><td>Apply</td></tr>
<tr><td>14.</td><td>A partially saturated soil samples collected from a pit has a natural moisture content of 18% and bulk unit weight of 20 kN/m^3. G = 2.68. Estimate the void ratio and degree of saturation. What will be the unit weight of the soil sample on saturation?</td><td>BT – 4</td><td>Analyse</td></tr>
<tr><td>15.</td><td>A soil mass in its natural state is partially saturated having a water content of 17.5 % and void ratio of 0.87. Determine the degree of saturation, total unit weight, dry unit weight what is the weight of water required to make a mass of 10 m^3 volume to get saturated assume G = 2.69.</td><td>BT-1</td><td>Remember</td></tr>
<tr><td>16.</td><td>A 500 gms of dry soil was used for sieve analysis the masses of soil retained on each sieve is given below:
<table>
<tr><td>I.S. sieve</td><td>2 mm</td><td>1.4 mm</td><td>1 mm</td><td>500 µ</td><td>250 µ</td><td>125 µ</td><td>75 µ</td></tr>
<tr><td>Mass gms</td><td>10</td><td>18</td><td>60</td><td>135</td><td>145</td><td>56</td><td>45</td></tr>
</table>
Plot the grain size distribution curve and compute the following:
. Percentage of gravel, coarse sand, medium sand, fine sand and silt as per I.S 1498
). Uniformity coefficient
. Coefficient of curvature, classify the soil.</td><td>BT – 3</td><td>Apply</td></tr>
<tr><td>17.</td><td>Test on a soil sample from a borrow area resulted specific gravity of 2.7, void ration = 0.65 and water content of 15 %. What is the quantity of soil required to construct an embankment volume of 8000 m^3, if the borrow materials compacted to achieve maximum dry density of 18 kN/m^3 at a moisture content 18 %? Calculate addition quantity of water required for every cubic meter of compacted soil.</td><td>BT-2</td><td>Understand</td></tr>
</table>

18.	A sample of clay was coated with paraffin wax and its mas, including the mass of wax, was found to be 697.5 g. The sample was immersed in water and the volume of the water displaced was found to be 355 ml. The mass of the sample without wax was 690 g, and the water content of the representative specimen was 18 %. Determine the bulk density, dry density, void ratio and the degree of saturation. The specific gravity of the solids was 2.7 and that of the wax was 0.89.	BT-2	Understand

UNIT II - EFFECTIVE STRESS AND PERMEABILITY			
Soil - water – Static pressure in water - Effective stress concepts in soils – Capillary phenomena– – Permeability – Darcy's law – Determination of Permeability – Laboratory Determination (Constant head and falling head methods) and field measurement pumping out in unconfined and confined aquifer – Factors influencing permeability of soils – Seepage - Two dimensional flow – Laplace's equation – Introduction to flow nets – Simple problems Sheet pile and weir.			
PART A			
Q. No.	**QUESTIONS**	**BT LEVEL**	**COMPETENCE**
1.	List out the methods of drawing flow net.	BT-1	Remember
2.	List the methods of finding field-permeability	BT-1	Remember
3.	What are the different types of soil water?	BT-1	Remember
4.	Define capillary rise.	BT-1	Remember
5.	Define permeability.	BT-1	Remember
6.	Write down the methods available for determination of permeability in the laboratory?	BT-5	Evaluate
7.	State Darcy's law.	BT-5	Evaluate
8.	State the assumptions in construction of flow net.	BT-2	Understand
9.	What are the factors affecting permeability?	BT-2	Understand
10.	Write typical range of co-efficient of permeability for gravel, sand, silt and clay.	BT-6	Create
11.	List out the methods of drawing flow net.	BT -3	Apply
12.	What are the various types of field permeability test.	BT-1	Remember
13.	Define flow net. Draw a neat sketch.	BT-5	Evaluate
14.	What is Quick sand condition? List the conditions for the occurrence of quick sand condition.	BT-1	Remember

15.	Explain the factors that affect the coefficient of permeability.	BT-2	Understand
16.	For a homogeneous earth dam 52 m high and 2 m freeboard, a flow net was constructed and following results were obtained: a. Number of potential drops = 25 b. Number of flow channels = 4 Calculate the discharge per metre length of the dam, if the coefficient of permeability of the dam material is 3 x 10^{-5} m/sec.	BT-4	Analyze
17.	Illustrate the various uses of Flow net in Engineering practices.	BT-2	Understand
18.	In a laboratory permeability test on a clayey soil, the diameter of the stand pipe is 2 cm and the diameter of the permeameter is 120 cm. The height of mould is 130 cm. Determine the time taken for head of water in the stand pipe to drop from 190 cm to 150 cm.	BT -3	Apply
19.	Summarize the assumptions made in construction of flow net.	BT-2	Understand
20.	Differentiate between discharge and seepage velocity.	BT-6	Create
21.	Give the expression for Darcy's Law.	BT-4	Analyze
22.	Define effective stress.	BT-2	Understand
23.	What is meant by total stress, neutral stress and effective stress and give its relationship.	BT-2	Understand
24.	Define hydraulic gradient.	BT-4	Analyze
25.	List out the factors affecting hydraulic conductivity.	BT -3	Apply
	PART B		
1.	Water table is 2 m below ground surface. Above water table there is capillary rise up to ground surface. Also draw total stress diagram up to 10 m. A stratified soil deposit along with the coefficient of permeability of the individual strata. Determine the ratio of K_h and K_V. Assuming an average hydraulic gradient of 0.3 in both horizontal and vertical seepage. Find a. Discharge value and discharge velocities in each layer for horizontal flow and (8) b. Hydraulic gradient and loss in head in each layer for vertical flow. (8)	BT-5	Evaluate
2.	a. The falling head permeability test was conducted on a soil sample of 4cm diameter and 18 cm length. The head fell from 1.0 m to 0.40 m in 20 minutes. If the cross-sectional area of the stand pipe was 1 cm^2, determine the coefficient of permeability. (8) b. Compute the total, effective and pore pressure at a depth of	BT – 1	Remember

	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 specific gravity of the soil may be assumed to be 2.65. (8)		
3.	a. Write a short note on quick sand conditions in soil. (4) b. Find the value of the effective stress at 2 m, 4 m, 6 m, 8 m and 10 m is a soil mass having γ_s =21 kN/m^3. Water table is 2 m below ground surface. Above water table there is capillary rise up to ground surface. Also draw total stress diagram up to 10.00 m. (12)	BT – 1	Remember
4.	A layer of saturated clay 4 m thick is overlain by sand 5 m deep, the water table is 3 m below the surface. Saturated unit weight for clay is 19 kN/ m^3 and sand is 20 kN/ m^3. Bulk unit weight of sand above water table is 17 kN/m^3. a. Plot the total stress, effective stress against depth. If sand to a height of 1 m above water table is saturated with capillary water, how are the above stress affected. (8) b. If in 1st case a 4 m deep sand layer of bulk unit weight is 20 kN/m$_3$ is placed over the surface. Find the effective vertical stress at the centre of clay layer immediately after the fill has been placed and many years after the fill has been placed. (8)	BT – 2	Understand
5.	Describe in detail with neat sketches, the field determination of permeability.	BT – 2	Understand
6.	The water table in a deposit of sand 8 m thick is at a depth of 3 m below the ground surface. Above the water table, the sand is saturated with capillary water. The bulk density of sand is 19.62 kN/m^3. Calculate the effective pressure at 1 m, 3 m and 8 m below the ground surface. Hence plot the variation of total pressure, neutral pressure and effective pressure over the depth of 8 m.	BT -3	Apply
7.	In a falling head permeability test the length and area of cross section of soil specimen are 0.17 m and 21.8 x 10^{-4} m^2 respectively. Calculate the time required for the head to drop from 0.25 m to 0.10 m. The area of cross section of stand pipe is 2.0 x 10^{-4} m^2. The sample has three layers with permeabilities 3 x 10^{-5} m/sec for first 0.06 m, 4 x 10^{-5} m/sec for second 0.06 m and 6 x 10^{-5} m/sec for the third 0.05 m thickness. Assume the flow is taking place perpendicular to the bedding plane.	BT – 1	Remember
8.	A soil sample of height 60 mm, area of cross section 10,000 mm^2 subjected to falling head permeability test. Determine coefficient of permeability of sample in a time interval of 5 minutes. Head is	BT – 4	Analyze

	dropped from 600 mm to 200 mm. If the cross sectional area of the stand pipe 0f 200 mm^2 and if the soil sample is subjected to constant head of 180 mm, calculate the total quantity of water collected in 1 hr after flowing through the soil sample.		
9.	Describe the Unconfined Pumping Out Flow and determine the coefficient of permeability of soil. Also explain Draw Down Curve.	BT- 2	Understand
10.	a. Explain about various factors affecting Co-efficient of permeability. (8) b. The falling head permeability test was conducted on a soil sample of 4cm diameter and 18cm length. The head fell from 1.0m to 0.40m in 20 minutes. If the cross-sectional area of the stand pipe was 1cm2, determine the coefficient of permeability. (8)	BT – 4	Analyze
11.	a. A field pumping test has been carried out in a well was sunk through a horizontal stratum of sand 15 m thick and underlain by a clay stratum. Two observation wells were sunk at horizontal distances of 18 m and 35 m respectively from the pumping well. The initial position of the water table was 2.5 m below the ground level. At a steady state pumping rate of 925litres/min. The drawdown curves in the observation wells were found to be 2.50 m and 1.50 m respectively. Estimate the coefficient of permeability of the sand. (10) b. Define flow net. Discuss about its uses. (6)	BT – 4	Analyze
12.	a. Derive the Laplace equation for two dimensional flow. (8) b. In a falling head permeameter test the initial head is 40cm. The head drops by 5 cm in 10 minutes. Calculate the time required to run the test for the final head to be at 20 cm. If the sample is 6 cm height and 50 cm^2 cross sectional area. Calculate the coefficient of permeability, take area of standpipe is 0.5 cm^2. (8)	BT- 2	Understand
13.	Calculate the ratio of average permeability in horizontal direction to that in the vertical direction for a soil deposit consisting of three Horizontal layers, if the thickness and permeability of second layer are twice of those of the first and those of the third layer twice those of second?	BT – 6	Create
14.	a. For a homogenous earth dam of 52 m height and 2 m free board, the flow net has 22 potential drops and 5 flow channels. Calculate discharge per meter length of the dam, given k = 22 x 10^{-6} m/sec, and exit hydraulic gradient. (10)	BT- 1	Remember

	b. List the characteristics of flow nets. (6)		
15.	The sub soil strata at a site consist of fine sand 1.8 m thick overlying a stratum of clay 1.6 m thick. Under the clay stratum lies a deposit of coarse sand extending to a considerable depth. The water table is 1.5 m below the ground surface. Assuming the top fine sand to be saturated by capillary water, calculate the effective pressures at ground surface and at depths of 1.8 m, 3.4 m and 5.0 m below the ground surface. Assume for fine sand G = 2.65, e = 0.8 and for coarse sand G = 2.66, e = 0.5. What will be the change in effective pressure at depth 3.4 m, if no capillary water is assumed to be present in the fine sand and its bulk unit weight is assumed to be16.68 kN/m^3. The unit weight of clay may be assumed as 19.32 kN/m^3.	BT – 1	Remember
16.	Explain in detail with neat sketches, the laboratory determination of permeability methods.	BT- 2	Understand
17	a. A constant head permeability test was conducted on a sandy soil of 160 mm in length, cross sectional area is 6000 mm^2 and porosity is 40 % under a constant head of 300 mm. Discharge was found out to be 45 x 10^3 mm^3 in 18 seconds. Calculate the coefficient of permeability, discharge velocity and seepage velocity. (8) b. List out the four methods of obtaining flow net. (8)	BT – 4	Analyze
18	a. A drainage pipe beneath a dam has become clogged with sand; coefficient of permeability of the sand is 7.5 m/day. The average difference in head water and tail water elevation is 21 m and it has been observed that there is a flow of 160 litres per day through the pipe. The pipe is 97 m long and has a cross-sectional area of 0.02 m^2. Find out up to what length of the pipe is filled with sand? (8) b. A flow net analysis was performed for estimating the seepage loss through the foundation of a coffer dam, results of the flow net analysis gave a number of flow line 'N_f'=6 and number of drops 'N_d'=16. The head of water lost during seepage was 5m. Assume the co-efficient of permeability of the soil is 'k'=4x10^{-5} m/min. Estimate the seepage loss per meter length of the coffer dam per day. Also estimate the exit gradient if the average length of the last flow field is 0.9 m. (8)	BT – 1	Remember

UNIT III - COMPACTION AND CONSOLIDATION			
Compaction – theory – laboratory and field technology – field Compaction method – factors influencing compaction–Components of settlement –– Immediate and consolidation settlement – Factors influencing settlement – Terzaghi‘s one dimensional consolidation theory – Computation of rate of settlement. –- √t and log t methods. e-log p relationship consolidation settlement N-C clays – O.C clays – Computation			
PART A			
Q. No.	**QUESTIONS**	**BT LEVEL**	**COMPETENCE**
1.	Define compaction.	BT-1	Remember
2.	Define coefficient of compressibility.	BT-1	Remember
3.	Define primary and secondary consolidation.	BT-1	Remember
4.	Define over consolidated, normal consolidated and under consolidated soils.	BT-1	Remember
5.	Define coefficient of consolidation and compression index.	BT-1	Remember
6.	What are the stages of consolidation.	BT-1	Remember
7.	Differentiate between coefficient of consolidation and degree of consolidation.	BT-2	Understand
8.	Explain about the assumptions made in Terzaghi’s one dimensional consolidation theory?	BT-2	Understand
9.	List various field compaction equipments along with its suitability.	BT-3	Apply
10.	Explain the terms immediate settlement and co-efficient of volume compressibility.	BT-2	Understand
11.	Define Optimum Moisture content.	BT-1	Remember
12.	Solve the compression index of remoulded soil sample with liquid limit of 40%.	BT-3	Apply
13.	Write the use of consolidation test data?	BT-3	Apply
14.	What is a zero air voids line? Draw a compaction curve and show the zero air voids line.	BT-4	Analyze
15.	Identify the limitations of Terzaghi’s analysis in one dimensional consolidation theory.	BT-4	Analyze
16.	State whether the following statement is true or false and justify your answer. The efficiency of compaction improves with increase in compactive effort.	BT-4	Analyze
17.	Difference between modified and standard compaction test.	BT-5	Evaluate
18.	State Drainage path lengths for single and double drainage	BT-5	Evaluate

<table>
<tr><td></td><td>conditions for a soil layer of height H.</td><td></td><td></td></tr>
<tr><td>19.</td><td>Draw a consolidation curve for normally consolidated and over consolidated clay.</td><td>BT-6</td><td>Create</td></tr>
<tr><td>20.</td><td>List any four equipment/ methods for field compaction of Soil.</td><td>BT-6</td><td>Create</td></tr>
<tr><td>21.</td><td>List various factors affecting compaction.</td><td>BT-1</td><td>Remember</td></tr>
<tr><td>22.</td><td>What are the factors influencing settlement?</td><td>BT-3</td><td>Apply</td></tr>
<tr><td>23.</td><td>Differentiate between compaction and consolidation.</td><td>BT-2</td><td>Understand</td></tr>
<tr><td>24.</td><td>What are the stages of settlement?</td><td>BT-3</td><td>Apply</td></tr>
<tr><td>25.</td><td>Give the expression for immediate settlement.</td><td>BT-5</td><td>Evaluate</td></tr>
<tr><td colspan="4">PART B</td></tr>
<tr><td>1.</td><td>Explain in detail the procedure of Modified Proctor Compaction test.</td><td>BT-1</td><td>Remember</td></tr>
<tr><td>2.</td><td>Discuss the effect of compaction on various engineering properties of soils.</td><td>BT-3</td><td>Apply</td></tr>
<tr><td>3.</td><td>In a laboratory consolidometer test on a 20 mm thick sample of saturated clay taken from a site,50 % consolidation point was reached in 10 minutes. Estimate the time required for the clay layer of 5m thickness at the site for 50 % compression if there is drainage only towards the top. What is the time required for the clay layer to reach 50 % consolidation if the layer has double drainage instead of single drainage.</td><td>BT-1</td><td>Remember</td></tr>
<tr><td>4.</td><td>Discuss the factors affecting compaction in detail.</td><td>BT-1</td><td>Remember</td></tr>
<tr><td>5</td><td>The following data obtained in a compaction test. Specific Gravity = 2.65. Determine OMC and Maximum Dry Density. Draw Zero Air Void Line
<table>
<tr><td>Moisture content (%)</td><td>2</td><td>4.2</td><td>5.5</td><td>6.6</td><td>7.5</td><td>10</td></tr>
<tr><td>Wet Density (kN/m^3)</td><td>20.2</td><td>20.8</td><td>21.7</td><td>22.0</td><td>22.1</td><td>22.0</td></tr>
</table></td><td>BT-4</td><td>Analyze</td></tr>
<tr><td>6.</td><td>A clay layer of 8 m thick with single drainage settles by 120 mm in 2 years. The co-efficient of consolidation for this clay was found to be 6×10^{-3} cm^2/sec. Calculate the likely ultimate consolidation settlement and find out how long it will take to undergo 90 % of this ultimate settlement.</td><td>BT-2</td><td>Understand</td></tr>
<tr><td>7.</td><td>Illustrate with a neat sketch the procedure of Standard Proctor compaction test.</td><td>BT-1</td><td>Remember</td></tr>
</table>

8.	a. Draw the compaction curve and explain the procedure for determine OMC and Maximum Dry density. (6) b. A clay layer 4m thick is subjected to a pressure of 55 kN/m^2, If the layer has a double drainage and undergoes 50 % consolidation in one year, determine the coefficient of consolidation. Take time factor as 0.196. If the coefficient of permeability is 0.02 m/yr , Determine the settlement in one year.(10)	BT-3	Apply
9.	a. List the different components of settlement? Explain their occurrence with respect to the change in soil systems. (6) b. A 20 mm thick undisturbed sample of saturated clay is tested in laboratory with drainage allowed through top and bottom. Sample reaches 50 % consolidation in 35 min. If clay layer from which sample was obtained is 3m thick and is free to drain through top and bottom surfaces, calculate the time required for same degree of consolidation in the field. What is the time required if the drainage in the field? is only through the top? (12)	BT-4	Analyze
10.	a. Explain in detail of the determination of coefficient of consolidation using root t method. (8) b. Explain in detail of the determination of coefficient of consolidation using log t method. (8)	BT-5	Evaluate
11.	a. A layer of soft clay is 6 m thick and lies under a newly constructed building. The weight of sand overlying the clay layer produces a pressure of 2.6 kg/cm^2 and the new construction increases the pressure by 1.0 kg/cm^2. If the compression index is 0.5. Compute the settlement if Water content is 40 % and specific gravity of grains is 2.65. (8) b. Explain in detail the laboratory determination of co-efficient of consolidation. (8)	BT-6	Create
12.	A clay layer of 10 m thickness underlies a sand stratum of 10 m and overlies a pervious layer. The sand layer carries a point load of 10 MN. Assume e =0.7 and G = 2.72, L.L. = 60 % and C_v= 25 x 10^{-4} cm^2/sec. the water table is located 5 m above the top of the clay layer. Find how long would the clay take to settle 4.7 cm.	BT-4	Analyzing
13.	a. Discuss the effect of compaction on various engineering properties of soils. (8) b. A 1 cm thick laboratory soil sample reaches 60% consolidation in 33 sec. under double drainage condition.	BT-4	Analyze

	Find how much time will be required for a 10 m thick layer in the field to reach the same degree of consolidation if it has drainage face on one side only? (8)		
14.	A laboratory compaction test on soil having G = 2.67 gave a maximum dry unit weight of 17.8 kN/m^3 and a water content of 15 %. Determine the degree of saturation, air content and percentage air voids at the maximum dry unit weight. What would be theoretical maximum dry unit weight corresponding to zero air voids at the optimum water content?	BT-2	Understand
15.	Derive the equation for Terzaghi's theory of one dimensional consolidation with a neat sketch.	BT-1	Remember
16.	Subsurface exploration at the side of the proposed building reveals the existence of 2.4 m thick layer of soft clay below a stratum of coarse sand which is 4 m thick and extends from the ground surface up to the top of the clay layer. The ground water table is 2.5 m below the ground surface. Laboratory tests indicate the natural water content of the clay as 40%, average liquid limit 45% and specific gravity of solids as 2.75. The unit weight of the sand above and below water table is 17.8 kN/m^3 and 21 kN/m^3. Estimate the probable settlement of the building, if its construction will increase average vertical pressure on the clay layer by 71 kPa.	BT-5	Evaluate
17.	A 5 m thick saturated soil stratum has a compression index of 0.25 and coefficient of permeability 3.2 $x10^{-3}$ mm/sec. If the void ratio is 1.9 m at vertical stress of 0.15 N/mm^2. Compute the void ratio when the vertical stress is increases to 0.2 N/mm^2, also Estimate the settlement due to above stress increase and time required for 50 % consolidation and 90 % consolidation.	BT-6	Create
18.	Differentiate Modified and Standard compaction test.	BT-4	Analyze

UNIT IV - STRESS DISTRIBUTION AND SHEAR STRENGTH

Stress distribution in homogeneous and isotropic medium – Boussines of theory – (Point load, Line load and udl) Use of Newmarks influence chart - Shear strength of cohesive and cohesion less soils – Mohr-Coulomb failure theory – shear strength - Direct shear, Triaxial compression, UCC and Vane shear tests.

PART A

Q. No.	QUESTIONS	BT LEVEL	COMPETENCE
1.	Define Cohesion.	BT-1	Remember

2.	What do you meant by Thixotropy?	BT-1	Remember
3.	What is the effect of pore pressure on shear strength of soil?	BT-1	Remember
4.	What is angle of internal friction?	BT-1	Remember
5.	Why triaxial shear test is considered better than direct shear test?	BT-1	Remember
6.	When is vane shear test adopted? Write the expressions to determine the shear strength of soil.	BT-1	Remember
7.	Show the coulomb's expression for shear strength.	BT-2	Understand
8.	List the assumptions made in Boussinesq's analysis of stress distribution.	BT-2	Understand
9.	Classify the types of shear test based on drainage conditions?	BT-2	Understand
10.	Describe the sensitivity of soils.	BT-2	Understand
11.	Write the principle behind Newmark's influence chart?	BT-3	Apply
12.	Write down the expressions to determine the shear strength of soil by vane shear test.	BT-3	Application
13.	Write down the Mohr's-Coulomb failure criterion for soils and explain the terms involved.	BT-3	Application
14.	List out the advantages of direct shear test.	BT-4	Analyze
15.	Outline the Boussinesq formula for vertical stress distribution in soil under a point load.	BT-2	Understand
16.	Compare Boussinessq's and Westerguard analysis for stress distribution.	BT-4	Analyze
17.	Explain the merits of triaxial test.	BT-5	Evaluate
18.	Explain the term Deviator stress.	BT-5	Evaluate
19.	Draw the Mohr's Circle diagram for UCC test and mention the salient features.	BT-6	Create
20.	Draw the typical stress-strain curve for specimens failed by brittle failure and plastic failure.	BT-6	Create
21.	Define stress path.	BT-1	Remember
22.	Discuss the disadvantages of direct shear test.	BT-4	Analyze
23.	Explain the term stress isobar or pressure bulb.	BT-6	Create
24.	List out the shear stress parameters	BT-4	Analyze
25.	Explain the demerits of triaxial test.	BT-5	Evaluate
PART B			
1.	The stress on a failure plane in a drained test on a cohesion-less soil are as under:	BT-1	Remember

<table>
<tr><td></td><td>Normal stress (σ) = 100 kN/m^2
Shear stress (τ) = 40 kN/m^2.
i. Find the angle of shearing resistance and the angle which the failure plane makes with the major principal plane. (7)
ii. Find the major and minor principal stresses. (6)</td><td></td><td></td></tr>
<tr><td>2.</td><td>A concentrated point load of 200 kN acts at the ground surface. Find the intensity of vertical pressure at a depth of 10m below the ground surface and situated on the axis of the loading. What will be the vertical pressure at a point at a depth of 5m and at a radial distance of 2m from the axis of loading? Use Boussinesq analysis.</td><td>BT-1</td><td>Remember</td></tr>
<tr><td>3.</td><td>a. Describe the Newmark's chart and its application. (5)
b. A concentrated load of 22.5 kN acts on the surface of a homogeneous soil mass of large extent. Find the stress intensity at a depth of 3 m, 6 m, 9 m, 12 m, and 15 m directly below the point load; draw the vertical stress distribution diagram along vertical axis. (8)</td><td>BT-1</td><td>Remember</td></tr>
<tr><td>4.</td><td>a. The results of three consolidated undrained triaxial tests on identical specimens of a particular soil are as follows: (7)
<table>
<tr><th>Test No.</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>Confining stress, kPa</td><td>200</td><td>300</td><td>400</td></tr>
<tr><td>Deviatoric stress at peak, kPa</td><td>244</td><td>314</td><td>84</td></tr>
<tr><td>Pore water pressure at peak , kPa</td><td>55</td><td>107</td><td>159</td></tr>
</table>
Find the value of total and effective shear strength parameters.
b. A shear vane of 7.5 cm diameter and 11 cm length was used to measure the shear strength of soft clay. If a torque of 600 N-m was required to shear the soil. Find the shear strength.(6)</td><td>BT-1</td><td>Remember</td></tr>
<tr><td>5.</td><td>A direct shear test was performed on 60 mm x 60 mm sample of dry sand. The normal load was 360 N. The failure occurred at a shear load of 180 N. Plot the Mohr strength envelope and determine ϕ. Assume c = 0. Also, Identify the principal stresses at failure.</td><td>BT-2</td><td>Understand</td></tr>
</table>

<table>
<tr><td>6.</td><td>Describe the Vane Shear test in detail and classify the methods adopted in this test-Fully Submerged Vane and Partially Submerged Vane.</td><td>BT-2</td><td>Understand</td></tr>
<tr><td>7.</td><td>A series of three consolidated undrained tests were conducted on an identical clay specimen of 50 mm diameter and height of 120 mm. Deviator load at failure 'p_t', confining pressure 'σ_3' and pore water pressure 'U' recorded are presented below. Identify the total and effective strength parameters both by analytical and Mohr circle method.
<table>
<tr><th>Trial No</th><th>p_t (N)</th><th>σ_s(kN/m^2)</th><th>U (kN/m^2)</th></tr>
<tr><td>1</td><td>100</td><td>510</td><td>-65</td></tr>
<tr><td>2</td><td>200</td><td>720</td><td>-10</td></tr>
<tr><td>3</td><td>40</td><td>11 0</td><td>80</td></tr>
</table></td><td>BT-2</td><td>Understand</td></tr>
<tr><td>8.</td><td>a. A concentrated load 10 kN acts on the surface of a soil mass. Using Boussinesq analysis find the vertical stress at points 3m below the surface on the axis of loading and at radial distance of 2 m from axis of loading but at same depth of 3m. (8)
b. Explain Taylor’s square root time method for determining co-efficient of consolidation. (5)</td><td>BT-3</td><td>Application</td></tr>
<tr><td>9.</td><td>In a triaxial test, a soil specimen was consolidated under a cell pressure of 200 kPa and simultaneously a back pressure of 100 kPa is applied to saturate the specimen. Thereafter, with drainage prevented, the cell pressure was raised to 250 kPa resulting in an increased pore pressure of 149 kPa. Maintaining the same cell pressure of 250 kPa, now the deviator stress was increased to 170 kPa and pore pressure of 220 kPa was observed. Identify the pore pressure parameters A and B.</td><td>BT-3</td><td>Application</td></tr>
<tr><td>10.</td><td>An unconfined compression test was conducted on an undisturbed clay sample. The sample had a diameter of 37.5 mm and length 80 mm. Load at failure measured by proving ring was 28 N and the axial deformation at failure point was 13mm. Determine the unconfined compressive strength and the undrained shear strength of clay. Examine and plot all the results on Mohr's Circle.</td><td>BT-4</td><td>Analyze</td></tr>
<tr><td>11.</td><td>Two identical soil specimens were tested in a triaxial apparatus. First specimen failed at a deviator stress of 770 kN/m^2 when the cell pressure was 200 kN/m^2. Second specimen failed at a deviator</td><td>BT-4</td><td>Analyze</td></tr>
</table>

	stress of 1370 kN/m^2 under a cell pressure of 400 kN/m^2. Examine the value of c and ϕ analytically. If the same soil is tested in a direct shear apparatus with a normal stress of 600 kN/m^2, estimate the shear stress at failure.		
12.	a. Direct Shear Test was conducted on Compacted Sand Shear Box Dimensions 60mm x 60 mm. The readings are listed below. <table><tr><td>**Normal load (N)**</td><td>110</td><td>225</td><td>340</td></tr><tr><td>**Peak shear load (N)**</td><td>95</td><td>195</td><td>294</td></tr><tr><td>**Ultimate shear load (N)**</td><td>65</td><td>135</td><td>200</td></tr></table>Examine the angle of shearing resistance in Dense compacted state and Loose state.(10) b. Define Deviator stress and discover its significance in Triaxial shear strength test. (6)	BT-4	Analyze
13.	Discuss in detail about the Boussineq's analysis to find vertical stress and horizontal shear stress for point load.	BT-5	Evaluate
14.	a. An unconfined compression test was carried out on a sample of clay had a diameter of 38 mm and a length of 76 mm. The load at failure measured by the proving ring was 45 N and axial deformation of the sample at failure was 15 mm. Estimate the unconfined compressive strength, undrained shear strength and undrained cohesion of the clay sample. (8) b. How do you find the shear strength of soil using vane shear test? and derive the formula used to calculate the shear strength. Invent where this test is mostly used? (8)	BT-6	Create
15.	Explain the triaxial shear tests based on drainage and them applicability. Mention its merits and demerits.	BT-2	Understand
16.	a. What is the shear strength in terms of effective stress on a plane within a saturated soil mass at a point where the total normal stress is 295 kN/m^2 and the pore water pressure is 120 kN/m^2? The effective stress parameters for the soil are c' = 12 kN/m^2 and φ'= 30^0. (10) b. List advantages and disadvantages of direct shear test. (6)	BT-1	Remember

17.	An embankment consists of clay fill for which c'=25 kN/m^2 and ϕ'=27° (from consolidated undrained tests with pore-pressure measurement). The average bulk unit weight of the fill is 20 kN/m^3. Estimate the shear-strength of the material on a horizontal plane at a point 20 m below the surface to the embankment, if the pore pressure at this point is 180 kN/m^2 as shown by a piezometer.	BT-5	Evaluate
18.	In vane shear test conducted in a soft clay deposit failure occurred at torque of 42 N-m afterwards. The vane was allowed to rotate rapidly and test was repeated in the remoulded soil. The torque at failure in the remoulded soil was 17 Nm. the sensitivity of soil. In both cases the vane was pushed completely inside soil. The height of vane and diameter across blades are 100 mm and 80mm respectively. What will be the change in the above results if top of the vane is not in contact with soil?	BT-3	Application

UNIT 5 - SLOPE STABILITY

Infinite slopes and finite slopes — Friction circle method – Use of stability number –Guidelines for location of critical slope surface in cohesive and c - soil – Slope protection measures.

PART A

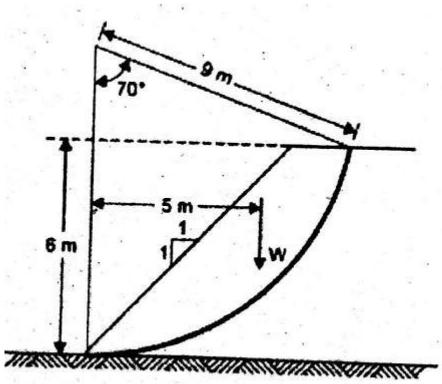
Q. No.	QUESTIONS	BT LEVEL	COMPETENCE
1.	Name the different types of slope failure?	BT-1	Remember
2.	Define finite slope.	BT-1	Remember
3.	Write the formula for finding factor of safety with respect to cohesion and friction.	BT-1	Remember
4.	What are the factors leading to failures of slope?	BT-1	Remember
5.	List the types of FOS used in stability of slopes.	BT-1	Remember
6.	Define Taylor’s Stability Number and mention its utilization for slope stability analysis.	BT-1	Remember
7.	Draw a Slip Circle for a failure plane in a slope and show the forces involved.	BT-2	Understand
8.	State the influence of tension crack in factor of safety if the cracks are filled with water and without water.	BT-2	Understand
9.	Sketch the slip circle for a failure plane in a slope and show the	BT-2	Understand

	forces involved.		
10.	Explain critical depth.	BT-2	Understand
11.	Identify when and where the circular failure surface is mobilized.	BT-3	Apply
12.	Write the expression for FOS for friction.	BT-5	Evaluate
13.	Why circular failure surface is mobilized?	BT-3	Apply
14.	Distinguish between finite slope and infinite slope.	BT-4	Analyze
15.	Classify the different modes of failure of finite and infinite slopes.	BT-4	Analyze
16.	List the three forces acting in circular failure while analysing through friction circle method?	BT-4	Analyze
17.	A cuffing is to be made in clay for which the cohesion is 350 kN/m^2; Bulk unit weight is 20 kN/m^3, Determine the maximum depth for a cutting of side slope 1.5 to 1. Factor of safety to be 1.5. Take the stability number as 0.17.	BT-5	Evaluate
18.	Evaluate the maximum depth of soil having undrained cohesion is 50 kN/m^2, Unit weight of soil is 19kN/m^3, Stability number is 0.20.	BT-5	Evaluate
19.	Elaborate the effect of depth of failure surface on the stability of infinite slope in cohesionless soil.	BT-6	Create
20.	Discuss about the three critical conditions for which the stability analysis of an earth dam is carried out.	BT-6	Create
21.	Give the expression for stability number.	BT-3	Apply
22.	Define infinite slope.	BT-1	Remember
23.	Develop points on various slope protection measures.	BT-3	Apply
24.	Write the expression for FOS for cohesion.	BT-5	Evaluate
25.	When will you adopt friction circle method?	BT-6	Create
	PART B		
1.	A slope of very large extent of soil with properties c'= 0 and ϕ= 32° is likely to be subjected to seepage parallel to the slope with water level at the surface. What will be the maximum angle of slope for a FoS is 1.5 treating it as an infinite slope. For this angle of slope what will be the FoS if the water level were to come	BT-1	Remember

	down well below the surface? The saturated unit weight of the soil is 20 kN/m^3.		
2.	An infinite slope made of soil with c' =20 kPa, ϕ = 20°, e = 0.65 and G=2.7 is 10m high. The slope angle is 25°. Find the factor of safety with respect to height for the following conditions a. When the soil is dry (8) b. When the slope is submerged. (8)	BT-1	Remember
3.	a. An infinitely long slope having an inclination of 26° in an area underlined by firm cohesive soil (G = 2.72 and e = 0.50). There is a thin, weak layer of soil 6m below and parallel to the slope surface (c = 25 kN/m^2, ϕ'=16°. Find the FoS when the slope is dry. (10) b. If the ground water flow could occur parallel to the slope on ground surface, what FoS would result- Solve. (6)	BT-1	Remember
4.	List the techniques used to improve the stability of slopes in brief.	BT-1	Remember
5.	a. Explain Taylor's stability number. (8) b. Outline some of the uses of Taylor's charts and its applicability.(8)	BT-2	Understand
6.	Explain the various methods to protect slopes from failure with clear sketch. Also list out the factors to be considered in selection of suitable method.	BT-2	Understand
7.	A canal with a depth of 5m has banks with slope 1:1 the properties of soil are C=20 kN/m^2, ϕ = 15°, e = 0.7, G= 2.6. Interpret the factor of safety with respect to cohesion. a. When canal runs full. (8) b. It is suddenly and completely emptied. (8)	BT-2	Understand
8.	a. A slope is to be constructed at an inclination of 30° with the horizontal. Determine the safe height of the slope at factor of safety of 1.5. The soil has the following properties. Take C = 15 kN/m^2, ϕ=22.5°, γ = 20 kN/m^2 (S_n = 0.046). (8)	BT-3	Apply

<table>
<tr><td></td><td>b. Develop some points on total stress method of analysis of stability of slopes. (8)</td><td></td><td></td></tr>
<tr><td>9.</td><td>a. Develop points on differences between finite and infinite slope. (8)
b. Build up points on FOS of a finite slope possessing both cohesion and friction (c - ϕ) by method of slices. (8)</td><td>BT-3</td><td>Apply</td></tr>
<tr><td>10.</td><td>An embankment of 10m high is inclined at 35°to the horizontal. A stability analysis by method of slices gives the following forces: Total normal forces = 900 kN; total tangential force = 420 kN; total neutral force= 200kN. If the length of the failure arc is 23m, examine the FoS with respect to shear strength. The soil has C= 20 kN/m^2 and ϕ = 15°.</td><td>BT-4</td><td>Analyze</td></tr>
<tr><td>11.</td><td>Analyze the stability of soil using friction circle method with neat sketch.</td><td>BT-4</td><td>Analyze</td></tr>
<tr><td>12.</td><td>A new canal is excavated to a Depth of 5m with banks having 1:1 slope. The properties of the soil are cohesion =14 kPa, angle of internal friction =20°, void ratio = 0.65 and specific gravity of solids =2.70. Examine the factor of safety with respect to cohesion when the canal is running full. The Taylor's stability number is given in the table for different slope angles for angle of internal friction = 20°.
<table>
<tr><td>Slope angle</td><td>30°</td><td>45°</td><td>60°</td><td>75°</td><td>90°</td></tr>
<tr><td>Stability number</td><td>0.025</td><td>0.062</td><td>0.097</td><td>0.134</td><td>0.182</td></tr>
</table>
What will be the factor of safety if the slope is changed to be 30° to vertical?</td><td>BT-4</td><td>Analyze</td></tr>
</table>

13.	a. A 45° slope has been excavated to a depth of 8 m in a saturated clay, which has following properties; C_u = 60 kN/m^2, ϕ_u = 0; and unit weight = 20 kN/m^3. Determine the factor of safety for the trial failure surface whose radius is 12 m and arc length is 18.84 m. The area of the trial wedge is 70 m^2 and centre of gravity of the trail wedge is 4.5 m away from the centre of the failure surface. (8) b. Derive from the first principles, the FOS of an infinite slope of cohesionless soil and C - ϕ soil. (8)	BT-5	Evaluate
14.	An infinite sandy soil slope has a saturated unit weight of γ_{sat}=19.5kN/m^3 and angle of internal friction ϕ = 35°.The minimum factor of safety needed for the slope against is 1.3. Estimate the safe angle of slope. a. When the slope is dry without seepage. (8) b. If seepage occurs at and parallel to surface of the slope. (8)	BT-6	Create
15.	Briefly explain about the method of analysis of finite slopes.	BT-2	Understand
16.	A cut 9 m deep is to be made in clay with a unit weight of 18 kN/m^3 and cohesion of 27 kN/m^2. A hard Stratum exists at a depth of 18 m below the ground surface. Determine from Taylor's charts if a 300 slope is Safe. If a factor of safety of 1.50 is desired, examine the safe angle of slope?	BT-4	Analyze

17.	The Figure below shows that details of an embankment made of cohesive soil with ϕ=0 and c=30 kN/m^2.The unit weight of the soil is 18.9 kN/m^3.Determine the factor of safety against sliding along the trial circle shown. The weight of the sliding mass is 360 kN acting at an eccentricity of 5m from the center of rotation .Assume that no tension crack develops. The central angle is 70°. 	BT-5	Evaluate
18.	Discuss the stability analysis of slopes by method of slices for c- ϕ soil.	BT-6	Create