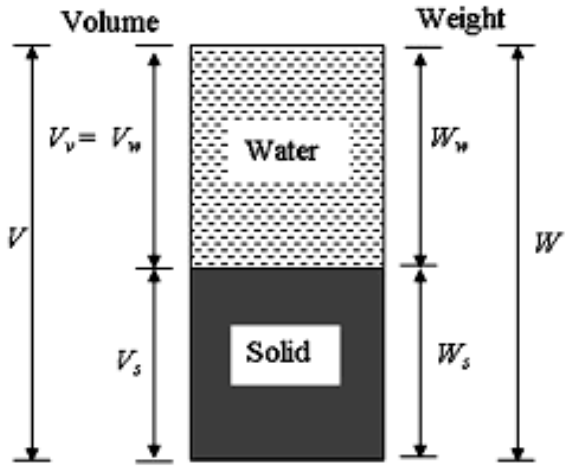
Model Answer: Summer-2022

Subject: Geotechnical Engineering | **Sub. Code: 22404**

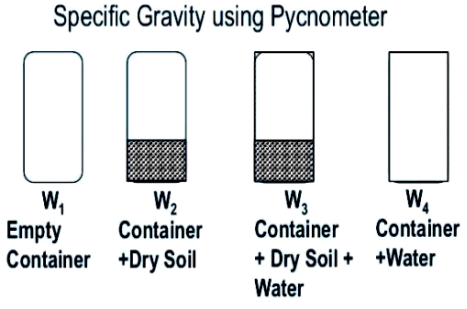
Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for anyequivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1		**Attempt any FIVE of the following:**		**(10)**
	a)	**State the importance of geology for Civil Engineering.**		
	Ans.	**Importance of geology for Civil Engineering:** 1. Geology is essential to know the nature of substrata and hence helpful to decide the depth of foundation for important structures. 2. Geology is also required to know the properties of rock beneath the earth surface which becomes beneficial to design earthquake resistance structures. 3. Geology is important to find the most suitable site for dams, bridges etc. 4. Geology plays vital role in groundwater survey and related recharging process. 5. Geology is significant in tunnel excavation projects as it provides information of rock strata and its engineering properties. 6. Geology is also important to excavate raw materials for stone crushing plant to manufacture aggregates.	**1 each (any two)**	**2**

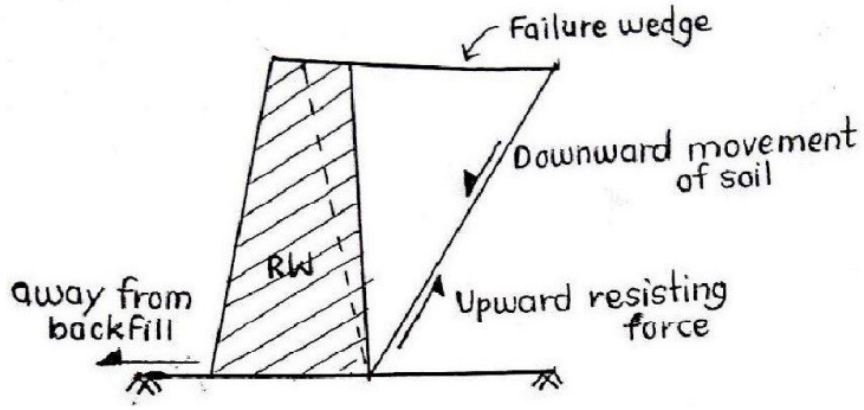
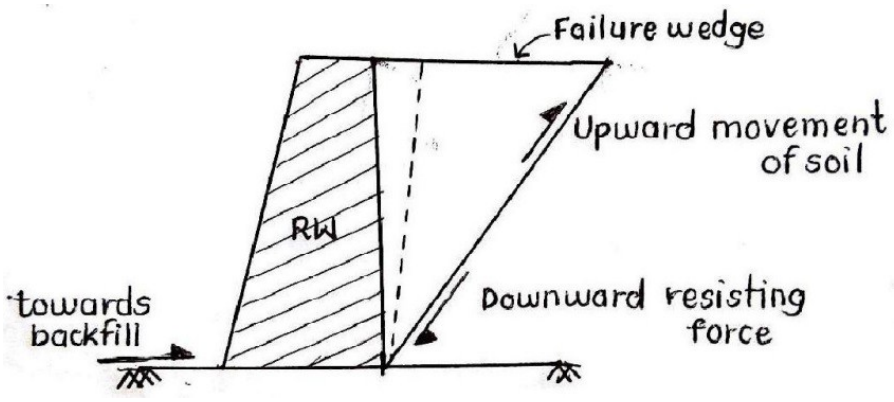
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1	b)	**Give the classification of rock based on its mode of origin.**		
	Ans	**Classification of rock based on its mode of origin :** 1. Igneous rock 2. Sedimentary rock 3. Metamorphic rock	**2**	**2**
	c)	**Define :** **(i) Voids Ratio** **(ii) Water Content**		
	Ans.	**(i) Voids Ratio:** It is the ratio of volume of voids to volume of soil solids, called as voids ratio. **(ii) Water Content:** It is the ratio of weight of water to weight of soil solids, called as water content.	**1** **1**	**2**
	d)	**Draw a neat sketch of fully saturated soil.**		
	Ans.	**Sketch of fully saturated soil:**  **Phase Diagram of Fully Saturated Soil**	**2**	**2**
	e)	**Define zero air voids line.**		
	Ans.	**Zero air voids line:** The line on the compaction curve showing 100 % degree of saturation for different values of optimum moisture content and maximum dry density is called as zero air voids line.	**2**	**2**

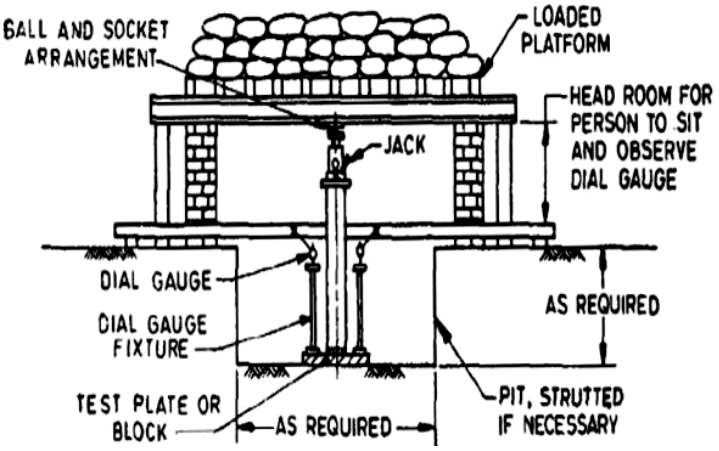
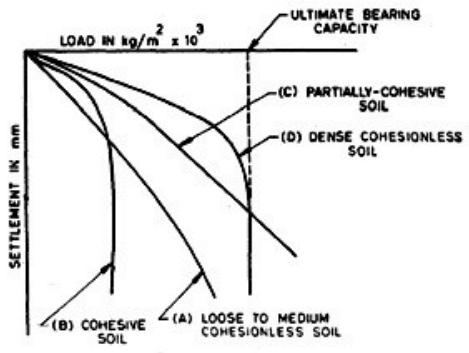
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1	f)	**Define liquid limit.**		
	Ans.	**Liquid Limit:** The minimum water content at which two separated grooved soil parts mix together under 25 blows of Casagrande's liquid limit apparatus; is called as Liquid Limit of soil.	2	2
	g)	**Give the meaning of CBR value.**		
	Ans.	**Meaning of CBR value:** The CBR value i.e. California Bearing Ratio is the ratio of test load to the standard load for specific penetration in soil, expressed as percentage.	2	2
Q.2		**Attempt any <u>THREE</u> of the following:**		(12)
	a)	**Explain Atterberg's limits of consistency.**		
	Ans.	**Atterberg's limits of consistency:** The Atterberg's limit is a basic measure of the critical water content of a fine grained soil, by its shrinkage limit, plastic limit and liquid limit. In each state the consistency and behavior of a soil is different and consequently so its engineering properties.	1	
		Types of consistency limit: i. Liquid limit ii. Plastic limit iii. Shrinkage limit		
		1. **Liquid limit:** The minimum water content at which two separated grooved soil parts mixed together under 25 blows of Casagrande's liquid limit apparatus; is called as liquid limit.	1	4
		2. **Plastic limit:** The minimum water content at which soil begins to crumble into parts when it is rolled into 3 mm diameter thread; is known as plastic limit.	1	
		3. **Shrinkage limit:** The maximum water content at which there is no reduction in volume of soil due to further decrease in water content is termed as shrinkage limit.	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2	b)	**Explain the experimental procedure to determination of specific gravity of soil by Pycnometer.**		
	Ans.	**Procedure to determine of specific gravity of soil by Pycnometer:**		
		1. Clean the pycnometer bottle and dry it. Take the weight of empty pycnometer with conical cap as 'W_1' gm.		
		2. Oven dry the given soil sample passing through 4.75 mm and retained on 75 micron IS sieve, in oven at temperature 105-110^{0}C for 24 hours to get dry soil.		
		3. Place this soil sample about 150-200 gm. in the pycnometer and take its weight as 'W_2' gm.		
		4. Now add the distilled water up to half of height of pycnometer and stirr it using glass rod, so that entrapped air will be removed from soil. Fill the distilled water up to top of conical cap using pipette. Take the weight of pycnometer filled with distilled water as 'W_3' gm.	**2**	**4**
		5. Remove all content from the pycnometer bottle. Wash and clean it with water. Fill the pycnometer bottle with distilled water only up to top of conical cap. Take the weight of pycnometer completely filled with water as W_4 gm.		
		6. Calculate the specific gravity G of given soil as, $G = (W_2-W_1) / ((W_4- W_1) – (W_3- W_2))$	**1**	
		7. Repeat all above steps two more times to calculate average specific gravity of given soil sample.		
		 Pycnometer Bottle with Conical cap	**1**	
		 Experimental Flow Diagram		

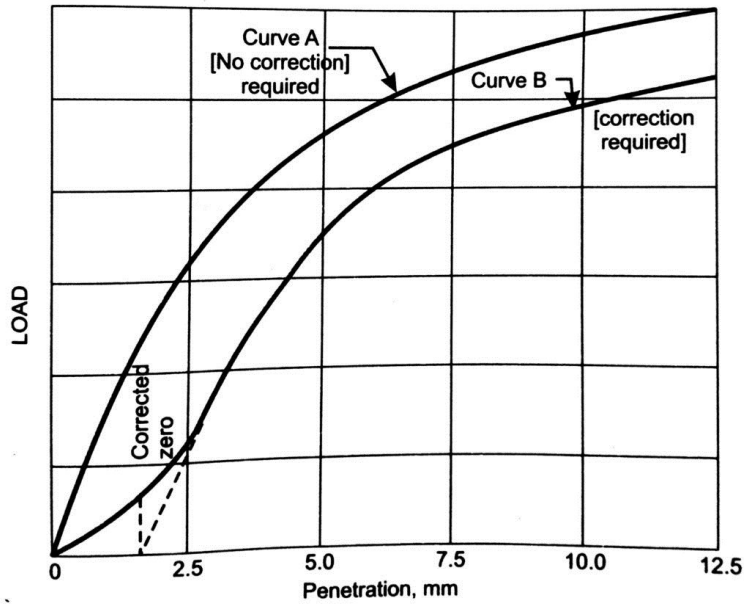
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2	c)	**A soil sample has a porosity of 42 % and specific gravity of the soil is 2.70. Determine voids ratio and dry density.**		
	Ans.	**Given:** $\eta = 42\ \%$; $G = 2.70$		
		Find: $e = ?$; $\gamma d = ?$		
		Solution:		
		$e = \eta / 1 - \eta$	1	
		$e = (42/100) / ((1 – (42/100))$		
		$e = (0.42) / ((1 - 0.42)$		
		$e = 0.42 / 0.58$		
		$e = 0.724$	1	4
		$\gamma d = (\gamma w. G) / (1 + e)$	1	
		$\gamma d = (1 \times 2.70) / (1 + 0.724)$ ($\gamma w = 1$ gm/cc)		
		$\gamma d = 2.70 / 1.724$		
		$\gamma d = 1.566$ gm/cc	1	
	d)	**Explain importance of soil as construction material.**		
	Ans.	**Importance of soil as construction material:**		
		1. Soil is of prime importance in brick manufacturing, which is widely used for masonry works in building construction, waterproofing, flooring etc.		
		2. Soil is important as it can be used for plinth filling material in many flooring works.	1 each (any four)	4
		3. Soil is also important to be used in construction of shoulders and side embankment of highways.		
		4. Soil is important to bind the aggregates in water bound macadam i.e. WBM road construction.		
		5. Pervious and impervious soil is essential in construction earthen dams to ensure required permeability of soil.		

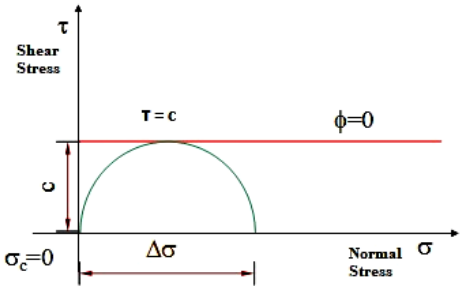
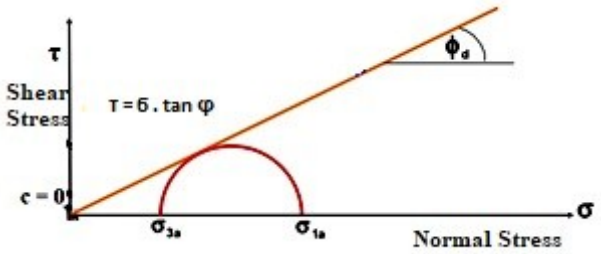
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3		**Attempt any THREE of the following:**		(12)
	a)	**State the factors affecting permeability.**		
	Ans.	**Factors affecting permeability:** 1. Void ratio 2. Particle size i.e. diameter of soil particle 3. Stratification of soil layer 4. Entrapped air 5. Impurities in voids 6. Adsorbed water or degree of saturation 7. Viscosity of pore fluid 8. Temperature of pore fluid 9. Shape of particle	1 each (any four)	4
	b)	**State Rankine's theory assumptions made for non-cohesive soil.**		
	Ans.	**Rankine's theory assumptions made for non-cohesive soil:** 1. The soil mass is semi-infinite, homogeneous dry and cohesion less. 2. The ground surface is plane which may be horizontal or inclined. 3. The back of wall is vertical is smooth. 4. The wall yields about the base thus satisfy deformation condition for plastic equilibrium. 5. The soil element is in state of plastic equilibrium i.e. on verge of failure.	1 each (any four)	4

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	c)	**Explain active earth pressure and passive earth pressure for no surcharge condition.**		
	Ans.	**Active earth pressure:** The minimum earth pressure on retaining wall which is developed due to movement of wall away from backfill is called as active earth pressure.	1	
			1	
		Active Earth Pressure for No Surcharge Condition		
		Passive earth pressure: The maximum earth pressure on soil exerted by retaining wall developed due to movement of wall towards backfill is called as passive earth pressure.	1	4
			1	
		Passive Earth Pressure for No Surcharge Condition		

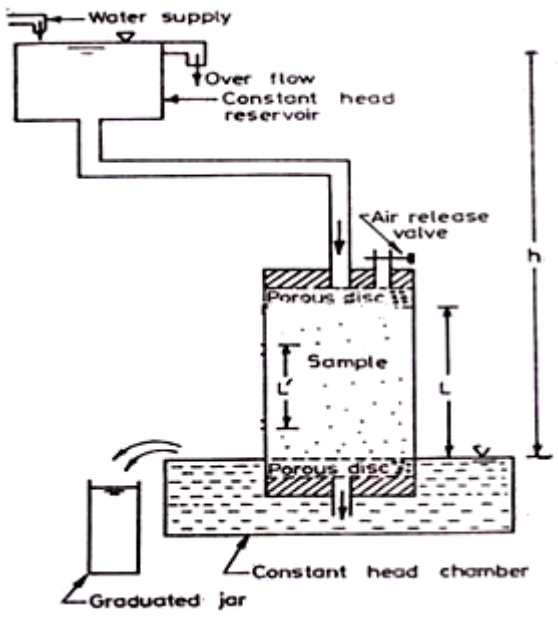
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	d)	**Explain the plate load test for determination of bearing capacity of soil.**		
	Ans.	**Plate load test for determination of bearing capacity of soil:** 1. Excavate a pit of depth equal to 5 times to that of breath of proposed footing. 2. Keep the suitable bearing plate of specified size (30, 45, 60, 75 cm square in plan) on soil. Arrange the loading column on it as shown in figure below. 3. Now apply the load on test plate above soil using sand bags or reaction truss loading at a rate of $(1/5)^{th}$ to $(1/10)^{th}$ of total estimated load. 4. Note down the settlements after 1,5,10,20,40,60 minutes at corresponding applied loads. 5. Loading should be continued till 25 mm total settlement or soil failure, whichever is achieved earlier. 6. Finally plot a graph of load vs. settlement to find out load before failure as bearing capacity of soil.	3	
		 **Experimental setup of Plate Load Test**	1	4
		 **Load Settlement Curve**		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4		**Attempt any <u>THREE</u> of the following:**		(12)
	a)	**State the effect of water table on bearing capacity of soil.**		
	Ans.	**Effect of water table on bearing capacity of soil:** As ground water table rises towards footing base, bearing capacity of soil decreases. 1. When the water table reaches the ground where the depth is greater footing the bearing capacity is reduced by 50% or more. 2. When water table is above base of footing-submerged weight of soil should be considered for bearing capacity. 3. When water table is somewhat below the base of footing-elastic wedge is partially saturated soil should be considered. 4. When water table is at a depth D equal to width of footing below the base of footing-a linear interpolation in reduction factor should be made for bearing capacity calculations. 5. The bearing capacity is not affected for purely cohesive soil. But decreases for non-granular soil with presence of water table. 6. Presence of water table for shallow depth give poor bearing capacity as compared for larger depth foundation.	**1 each (any four)**	**4**
	b)	**Explain field situations where compaction is required.**		
	Ans.	**Field situations where compaction is required:** 1. Compaction of supporting soil of building foundation is required to avoid vertical settlement in shallow isolated footings. 2. Compaction is necessary for natural subgrade soil to carry load of road pavement safely without defects. 3. Compaction is required for earthen dam soil to reduce permeability to control seepage loss of water. 4. Compaction of slopes and soils along hill sides is necessary to avoid probable landslides. 5. Compaction is necessary for the ballast at required density so as to maintain the drain ability of railway tracks. 6. Compaction of abutment is essentially required to ensure load carriage of deck slab of bridges.	**1 each (any four)**	**4**

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	c)	**Explain the procedure of CBR test.**		
	Ans.	**Procedure of CBR test:**		
		1. Take soil sample passing through 4.75 mm IS sieve and add water required for its MDD i.e. equal to OMC determined by proctor test. 2. Fill this moist soil sample in inverted CBR mould (10 cm dia. 15 cm height) by keeping spacer disc of 5 cm thick at bottom. 3. Compact the soil in standard manner and then remove the spacer disc and keep the filled mould under CBR testing machine.	3	
		4. Keep the slotted weights each of 2.5 kg as surcharge load and then apply compressive load at a rate of 1.25 mm per minute through 5 cm dia. plunger. 5. The load required for each 0.5 mm penetration is noted. The loading is continued till soil failure or maximum 12.5 mm penetration. 6. Draw the load penetration curve as shown in figure below. The load at 2.5 mm penetration is noted as Test Load. 7. Calculate % CBR = (Test load/Standard Load) x 100 for given soil sample		4
		 **Load Penetration Curve**	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	d)	**Draw strength envelope for purely cohesive and cohesion less soil.**		
	Ans.	**Shear strength envelope for purely cohesive soil:** 	2	4
		Shear strength envelope for cohesion less soil: 	2	
	e)	**In a constant head Permeameter, diameter of soil sample was 4 cm and length was 14 cm under constant head of 25 cm. The discharge was found to be 80 cc in 10 minutes. Calculate coefficient of permeability.**		
	Ans.	**Given:** Diameter of soil sample, D = 4 cm, Length of soil sample, L = 14 cm, Constant head, h = 25 cm, Time, t = 10 min. = 600 sec, Discharge, Q = 80 cc **Find:** Coefficient of permeability, K = ? **Solution:** Area of soil sample $A = (\pi / 4) \times D^2 = (\pi / 4) \times 4^2$ **$A = 12.566\ cm^2$**	1	4
		Coefficient of permeability K= (Q.L) / (A.h.t) K = (80 x 14) / (12.566 x 25 x 600) **$K = 5.941 \times 10^{-3}$ cm/s**	1 1 1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5		**Attempt any <u>TWO</u> of the following:**		(12)
	a)	**Explain the field applications of geotechnical engineering.**		
	Ans.	**Field applications of geotechnical engineering:** 1. **Design of foundation for various civil structures:** As foundation resting on soil carries load of any particular structure, geotechnical engineering is applicable to design such stable foundations for various loads. 2. **Design of pavement for various types of roads:** Layers of pavement made up of sand, gravel is laid on sub grade soil can be designed in terms of thickness, load carrying capacity using geotechnical engineering. 3. **Design of earth retaining structures:** Geotechnical engineering is also applicable to design and construct earth retaining structures like retaining wall and sheet pile useful for hill roads, landslides. 4. **Design of abutments of bridge:** The end support of bridges i.e. abutments of bridge can be designed on the basis of soil properties like shear strength, compressibility etc. 5. **Design of water retaining structures:** Geotechnical is very much applicable for easy and safe design and execution and maintenance of earthen dam, weir, barrage etc. 6. **Design of underground structures:** Underground pipelines i.e. water supply and sewage lines require geotechnical engineers for effective work. It is also significant in safe excavation of proposed alignment.	**1 each**	**6**

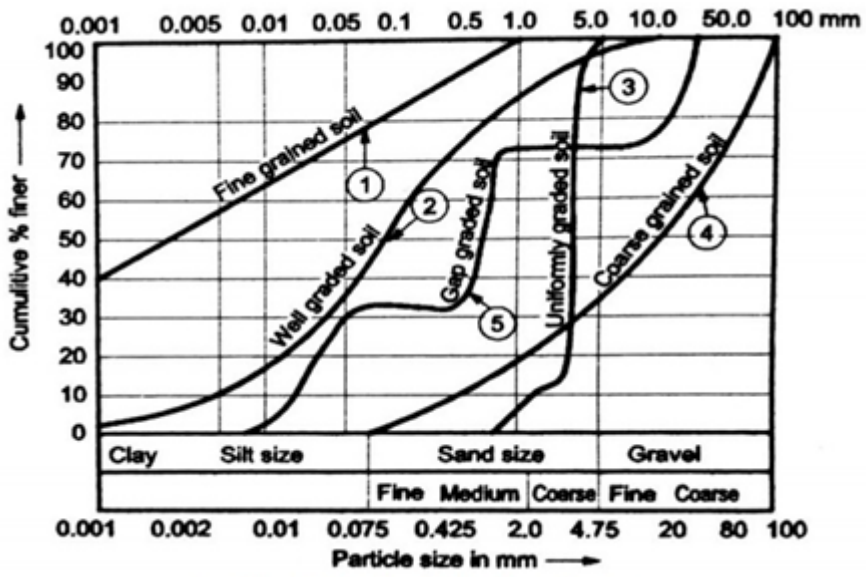
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	b)	**Explain the procedure of determination of coefficient of permeability by constant head method.**		
	Ans.	**Procedure of determination of coefficient of permeability by constant head method:** 1. Take 2.5 Kg air dried soil sample passing through 9.5 mm IS sieve. Add the water in soil equals to its optimum moisture content (OMC) to get required density. 2. Fill the prepared soil sample in permeameter in three different layers. Compact each layer using 25 blows using rammer. Cover the soil with filter paper and porous stones on both sides as shown in figure. 3. Allow to flow the water from water tank into soil in permeameter under constant head h cm for some specific time t in seconds. 5. Measure the discharge of water collected in measuring cylinder as Q in cm^3. 6. Calculate the coefficient of permeability of soil as K=(Q.L)/(A.h.t) in cm/s. 7. Repeat all above steps two more times to get average coefficient of permeability of given soil sample	4	6
		 **Experimental Setup of Constant Head Permeability Test**	2	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	c)	**Explain the sieve analysis test for grading of soil with the help of particle size distribution of curve.**		
	Ans.	**Sieve analysis test for grading of soil:**		

1. Arrange the set of I.S. sieves in descending order i.e. coarser sieve at top and finer sieve at bottom.. The I.S sieve set must include sieves of size 4.75mm, 2.36mm, 1.18mm, 600µ, 300 µ, 150µ, 75µ.
2. Take 500-1000 gm oven dried soil sample and put it on topmost sieve. Keep lid and pan at top and bottom respectively.
3. Now, shake this assembly of sieve on mechanical sieve shaker for 10-15 minutes, so that soil sample will be sieved completely.
4. Take the weight of soil mass retained on each sieve separately in gms.
5. Calculate % finer for each sieve using following tabular format.

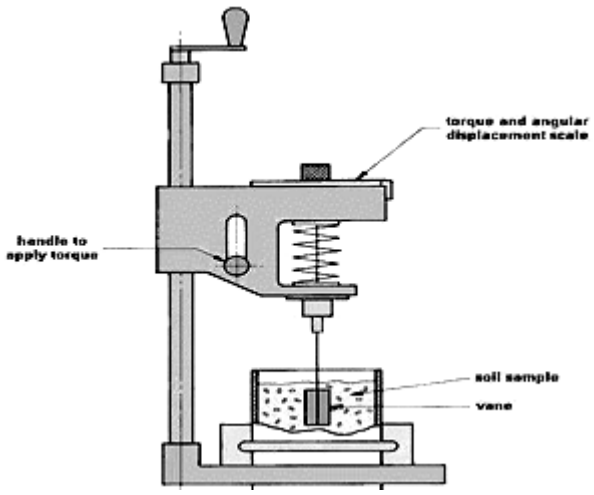
Sieve size (mm)	Weight retained (gm)	Cumulative weight retained (%)	% Cumulative weight retained (%)	% Finer or passing (%)

6. Finally, plot the particular size distribution curve as shown in figure below on a semi log graph paper as sieve size versus % finer of soil to classify soil as well graded, gap graded, uniformly graded, fine grained and coarse grained soil.



Particle Size Distribution Curve

Marks: 4 + 2 = 6

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6		**Attempt any TWO of the following:**		(12)
	a)	**Explain the vane shear test to determine shear strength of soil.**		
	Ans.	**Vane shear test to determine shear strength of soil:**		
		1. Prepare the fine cohesive soil (passing through 425 micron IS Sieve) by adding sufficient water. Fill the soil in vane mould of vane shear test apparatus completely. 2. Insert the vane blade in the soil sample and Lower the shear vanes in to the specimen gradually with minimum disturbance of the soil specimen so that the top of vanes is at least 10 mm below the top of the soil specimen. 3. Note down spring stiffness and the initial reading of the torque (Θ_1). 4. Rotate the vane at a uniform rate approximately 0.10^0 /sec by suitably operating the torque applicator handle till the specimen fails. Note the final reading of the torque (Θ_2) when soil gets sheared off in the form of hole with specific diameter d. 5. Calculate the torque applied $T= [(\Theta_2 - \Theta_1) \times \pi \times K] / 180^0$. 6. Calculate shear strength of the soil τf, using the formula $\tau f= T / \{\pi \times [(d^2H/2) + (d^3/6)]\}$ in N/mm^2; where, d = Diameter of vane (cm), H = Height of the vane (cm), T = Torque applied (kg-cm).	4	6
		 **Experimental Setup for Vane shear test**	2	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 6	b)	**Explain different methods of soil stabilization.**	2 each (any three)	6
	Ans.	**Methods of soil stabilization:** 1. **Mechanical stabilization:** It is the process of improving properties of soil by changing its gradation. It depends on mechanical strength of aggregate, mineral composition etc. e.g. Compaction at near OMC either static or dynamic. 2. **Cement Stabilization:** It is done by mixing soil and cement together to form a stranger material, which becomes hard & durable & develops strength. e.g. Clay and lime is used for soil containing harmful organic matter. 3. **Bituminous stabilization:** It is done using asphalt as binder due to its chemical properties such as viscosity. Any inorganic soil can be mixed with asphalt e.g. For cohesion less soils, asphalt acts as binding material 4. **Chemical Stabilization:** Different chemicals such as chlorides and silicates area added to soil, it is used where setting and curing time needs to be controlled. It is expensive compared to other method e.g. Chlorides in soil increase electrical attraction and form flocculated structure to improve permeability of soil. 5. **Thermal Stabilization:** It is done by either heating or cooling soil. It is used to drive off pore water or freeze it to improve strength of clayey soils. 6. **Electrical Stabilization:** Electro-osmosis method is used to drain out water from cohesive soils to increase its strength by exchange of anions and cations in soil & water. 7. **Stabilization by Grouting:** Grouting is injecting stabilizer into soil under certain pressure. It is costlier method and works for undisturbed soils. e.g. An area close to existing building can be stabilized using this method. 8. **Stabilization using Geo-textiles:** Geo-textiles are used as reinforcing material in soil they help to drain water, increase strength, decrease mixing of soil, filters the water etc.		

<table>
<tr><th>Que. No.</th><th>Sub. Que.</th><th>Model Answer</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td>Q. 6</td><td>c)
Ans.</td><td>
Differentiate between compaction and consolidation.
Difference between compaction and consolidation:
<table>
<tr><th>Sr. No.</th><th>Compaction</th><th>Consolidation</th></tr>
<tr><td>1</td><td>The expulsion of air from the voids of the soil is compaction.</td><td>The expulsion of water from voids of the soil is consolidation.</td></tr>
<tr><td>2</td><td>It is a quick process.</td><td>It is a slow process.</td></tr>
<tr><td>3</td><td>It is done by artificially.</td><td>It takes place naturally.</td></tr>
<tr><td>4</td><td>It is done by using mechanical means</td><td>It takes place due to self weight of structure.</td></tr>
<tr><td>5</td><td>Short term loading is required.</td><td>Long term loading is required.</td></tr>
<tr><td>6</td><td>Loading is applied in a dynamic way.</td><td>Loading is static and constant.</td></tr>
<tr><td>7</td><td>Any type of soil either it is cohesion or cohesion less can be compacted.</td><td>Consolidation applies to cohesive soils only especially low permeable clay.</td></tr>
<tr><td>8</td><td>Degree of saturation of soil to be compacted should be less than 100%.</td><td>Degree of saturation of soil to be consolidated should be 100%.</td></tr>
<tr><td>9</td><td>Soil properties like shear strength, bearing capacity get improved.</td><td>Soil properties like shear strength, bearing capacity does not improve.</td></tr>
<tr><td>10</td><td>Compaction is done before the construction</td><td>Consolidation takes place after the construction</td></tr>
<tr><td>11</td><td>Pore water pressure is not important in compaction.</td><td>Pore water pressure is very important in consolidation.</td></tr>
<tr><td>12</td><td>Pore water pressure is very important in compaction</td><td>Consolidation goes indefinitely.</td></tr>
<tr><td>13</td><td>Applicable to plinth filling, sub grade soils, earthen dams etc.</td><td>Applicable to heavy loaded structures like sky scrapers, large dams, sculptures etc.</td></tr>
</table>
</td><td>1 each, (any six)</td><td>6</td></tr>
</table>