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Zeal Education Society's

ZEAL POLYTECHNIC, PUNE.

NARHE | PUNE -41 | INDIA

FIRST YEAR (FY)

DIPLOMA IN CIVIL ENGINEERING

SCHEME: I SEMESTER: IV

NAME OF SUBJECT: Geo-Technical Engineering

Subject Code: 22404

MSBTE QUESTION PAPERS & MODEL ANSWERS

1. **MSBTE SUMMER-19 EXAMINATION**
2. **MSBTE WINTER-19 EXAMINATION**

22404

21819

3 Hours / 70 Marks Seat No. | | | | | | | | |

Instructions : (1) All Questions are *compulsory.*

(2) Answer each next main Question on a new page.

(3) Illustrate your answers with neat sketches wherever necessary.

(4) Figures to the right indicate full marks.

(5) Assume suitable data, if necessary.

(6) Use of Non-programmable Electronic Pocket Calculator is permissible.

(7) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

Marks

1. Attempt any FIVE of the following : **10**

(a) Define Geology and state its branches.

(b) Define soil as per IS.

(c) Define void ratio and bulk density.

(d) State any four factors affecting permeability.

(e) Define : Cohesion and internal friction.

(f) Define : Ultimate and safe bearing capacity of soil.

(g) State various methods of site investigation.

2. Attempt any THREE of the following: **12**

(a) State formation and classification of soil.

(b) Give step-by-step procedure to determine specific gravity of soil by pycnometer in laboratory.

(c) Draw phase diagram of soil when soil is :

(i) Moist, (ii) Fully saturated

label the diagrams.

(d) Calculate coefficient of uniformity and coefficient of curvature for a soil sample for which D_{10} = 0.430 mm, D_{30} = 0.790 mm and D_{60} = 1.300 mm.

3. Attempt any THREE of the following : **12**

(a) Explain the procedure for determination of plastic limit of soil.

(b) A soil sample is tested in constant head permeability, diameter of sample is 4 cm and length is 10 cm under constant head of 15 cm discharge was found to be 70 cc in 10 mins. Find coefficient of permeability.

(c) Draw shear strength envelope for purely cohesive and cohesionless soil with sketch.

(d) Differentiate between compaction and consolidation.

4. Attempt any THREE of the following : **12**

(a) State the different characterastics of flow-net.

(b) Define with a sketch Active earth pressure and Passive earth pressure.

(c) State any four assumptions in the theory of Terzaghi's analysis of bearing capacity.

(d) Draw a neat leablled sketch of plate load test set-up for gravity loading.

(e) Give four compaction equipments along with their senitability.

5. Attempt any TWO of the following : **12**

(a) Explain the various field applications of geotechnical engineering in details.

(b) Draw particle size distribution curve. Explain mechanical sieve analysis for grading of soil with a sketch.

(c) Explain the direct shear test to determine shear strength of soil with neat sketch.

6. Attempt any TWO of the following : **12**

(a) Following observations were made using standard proctor test on a soil sample :

Bulk Density (gm/cc)	1.75	1.95	2.10	2.20	2.15	2.05
Water content (%)	5	10	15	20	25	30

Determine OMC and MDD by plotting compaction curve on graph.

(b) State the methods of soil stabilization. Explain any one.

(c) State field identification test on soil and explain any one.

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)

(ISO/IEC -270001 – 2005 certified)

SUMMER -2019 EXAMINATION

Subject code: 22404 **Model Answer**

Important Instructions to examiners:

1) The answer should be examined by keywords 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 error such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skill).

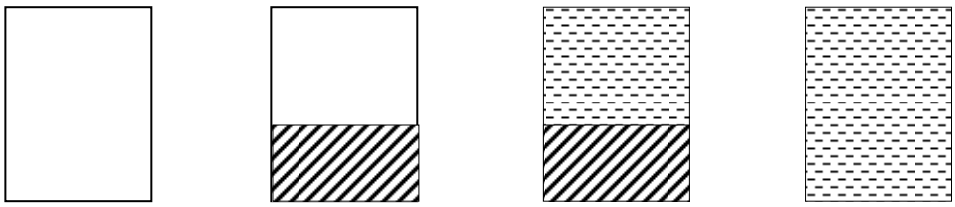
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figure drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

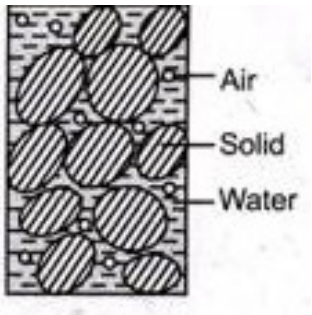
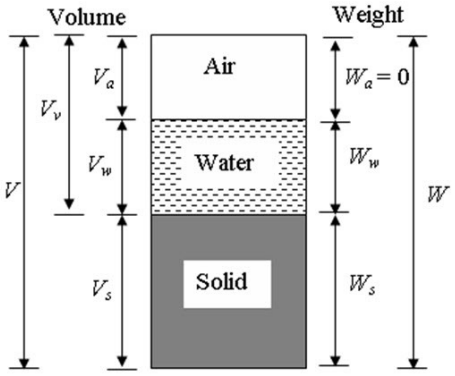
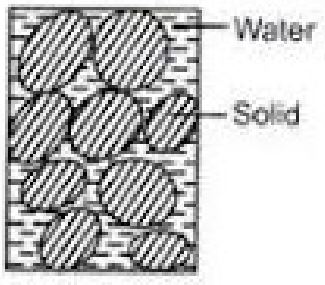
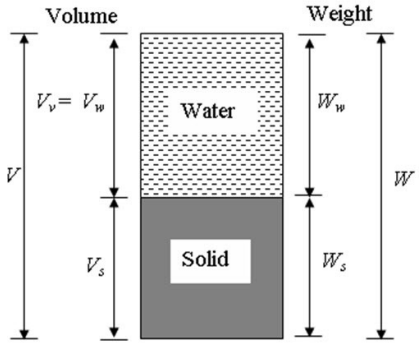
5) Credits may be given step wise for numerical problems. In the some cases, the assumed constants values may vary and there may be some difference in the candidates answer and model answer.

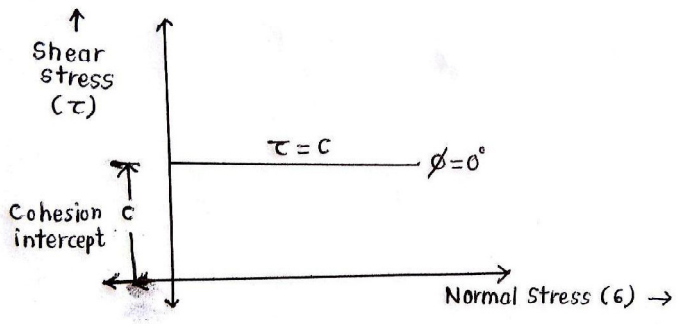
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidates understanding

Q. No.	Question and Model Answers	Marks
1.	**Attempt any FIVE of the following**	**10M**
a)	**Define Geology and state its branches.**	
	Geology : The science that deals with the study of earth as a planet as, 1. It deals with origin, age, interior or structure and history of the earth. 2. It deals with evolution and modification and extinction of various surface features. 3. It deals with material making up the earth. **Branches:** 1. Physical geology 2. Geomorphology 3. Mineralogy 4. Petrology 5. Historical geology 6. Structural geology 7. Economic geology 8. Engineering geology 9. Geo informatics.	**1 M** **1/2 M each (Any two)**

b)	**Define soil as per IS.**	
	Soil is the sediments and other unconsolidated accumulations of solid particles produced by the mechanical and chemical disintegration of rocks regardless of whether or not they contain an admixtures of organic constituent.	**2 M**
c)	**Define void ratio and bulk density.**	
	Void ratio (e) : It is ratio volume of voids (V_V)in soil to the volume of soil solids (V_S). $e = \frac{Vv}{Vs}$ Bulk density (V): It is weight of soil mass per unit volume. $\gamma = \frac{W}{V}$	**1 M** **1 M**
d)	**State any four factors affecting permeability.**	
	1. Particle size. 2. Properties of pore fluid. 3. Voids ratio. 4. Soil fabric and soil stratification. 5. Degree of saturation and foreign matter. 6. Effect of adsorbed water.	**½ each (Any four)**
e)	**Define : Cohesion and internal friction.**	
	Cohesion (C) : Cohesion is the property of soil to hold the soil particles together. It is force of attraction between same particles. **Internal friction :** The resistance to deformation by continuous shear displacement of soil particles upon action of shear stress is called internal friction.	**1 M** **1 M**
f)	**Define : Ultimate and safe bearing capacity of soil.**	
	Ultimate bearing capacity (q_u): The minimum gross pressure intensity at the base of the foundation at which the soil fails in shear. **Safe bearing capacity (q_s):** The maximum pressure which the soil can carry safely without risk of shear failure is called safe bearing capacity. $q_s = (q_{ns}) + (\gamma * D) = (\frac{q_{nf}}{F}) + (\gamma * D)$	**1 M** **1 M**
g)	**State various methods of site investigation.**	
	1. Open excavation 2. Boring 3. Sub surface soundings 4. Geophysical method.	**½ M each**

Q. 2	**Attempt any THREE of the following.**	**12**
a)	**State formation and classification of soil.**	
	Soil formation : soil formation is essentially with weathering process of rock. Soil formation mainly takes place due to mechanical disintegration or chemical decomposition of rocks whenever rock get exposed to atmosphere, It is acted by various weathering agencies and it get disintegrated or decomposed into small particles & then it is converted into soil. **Classification of Soil :** **A. Residual Soil** 1. Red Soil 2. Laterite Soil. 3. Black cotton Soil. **B. Transported Soil** 1. Colluvial Soil. 2. Alluvial Soil. 3. Glacial Soil. 4. Lacustarine Soil. 5. Eolian Soil.	**2 M** **½ M each (Any two)** **½ M each (Any two)**
b)	**Give step-by-step procedure to determine specific gravity of soil by pycnometer in laboratory.**	
	1. The mass M_1 of the clean, dry bottle is found. 2. Suitable quantity of oven-dried soil sample, cooled in a desiccator is put in the bottle and the mass M_2 of the bottle with soil is found. 3. Distilled water is then added to the soil inside bottle until the bottle is full, care being taken to see that entrapped air is fully expelled. (either by applying vacuum or by gentle heating and shaking or stirring) The mass M_3 of the bottle with soil and water is found. 4. The bottle is then emptied of its contents, cleaned and filled with distilled water only. The outer surface of the bottle is wiped dry and the mass M_4 of the bottle with water is found.  Empty bottle (Mass M_1) — With dry Soil (Mass M_2) — With Soil & Water (Mass M_3) — With Water (Mass M_4) The specific gravity of soil solids is computed as; $$G = \frac{(M_2 - M_1)}{(M_2 - M_1) - (M_3 - M_4)}$$	**3 M** **1 M**

c)	**Draw phase diagram of soil when soil is :** **(i)Moist, (ii) Fully saturated** **Label the diagrams.**	
	i) Phase diagram of moist soil :  Moist Soil mass  3 Phase system **ii) Fully Saturated Soil :**  Saturated Soil  2 Phase System	**2 M** **2 M**
d)	**Calculate coefficient of uniformity and coefficient of curvature for a soil sample for which D_{10} = 0.430 mm, D_{30} = 0.790 mm and D_{60} = 1.300 mm.**	
	Coefficient of Uniformity = C_u $$C_u = \frac{D_{60}}{D_{10}}$$ $$C_u = \frac{1.300}{0.430} = 3.02$$ Coefficient of Curvature = C_c $$C_c = \frac{(D_{30})^2}{(D_{10}) \text{ X } (D_{60})}$$ $$C_c = \frac{(0.790)^2}{(0.430) \text{ X } (1.300)}$$ $$C_c = 1.11$$ The Cc value is between 1 to 3, therefore soil is well graded	**1 M** **1 M** **1 M** **1 M**

Q.3	**Attempt any THREE of the following:**	**12 M**
a)	**Explain the procedure for determination of plastic limit of soil.**	
	i. Take 20 to 25 gm. air dried soil sample passing through 425 micron IS sieve. ii. Add distilled water in soil and mix it thoroughly for 10 to 15 minutes till soil becomes plastic enough, so that it can be moldable. (It is recommended to keep clayey soils about 24 hours for its maturity.) iii. Make the balls of soil paste and roll it on non-porous glass or marble plate using figure pressure till it becomes soil thread of 3mm diameter. iv. Continue the rolling process till soil starts crumbling and it resembles a uniform thread. v. Compare the prepared soil thread with metal rod of same diameter and then stop the rolling; where soil thread crumbles into different parts. vi. Determine the water content of crumbled soil parts by oven drying method as w %. vii. Repeat all above steps two more times to get average water content as plastic limit (W_P) given soil sample	**1M each**
b)	**A soil sample is tested in constant head permeameter, dia of sample is 4 cm and length is 10 cm under constant head 15 cm discharge was found to be 70 cc in 10 mins. Find coefficient of permeability.**	
	D = 4 cm K= ? L = 10 cm H= 15 cm Q = 70 cc T = 10 min = 600 sec Solution- To find coefficient of permeability by constant head method K = Q.L/(A.h.t) Here, c/s Area of soil sample= A= Π/4 D_2 = Π/4 x 4_2 = 12.566 cm_2 K = 70 x 10/(12.566 x 15x 600) **K = 6.189 x 10^{-3} cm/sec**	**1M** **1M** **1M** **1M**
c)	**Draw shear strength envelope for purely cohesive and cohesion less soil with sketch.**	
	1. purely cohesive soil-  Fig. No. 4(a): Shear strength envelope for purely cohesive soil	**2M**

2. Cohesion less soil –

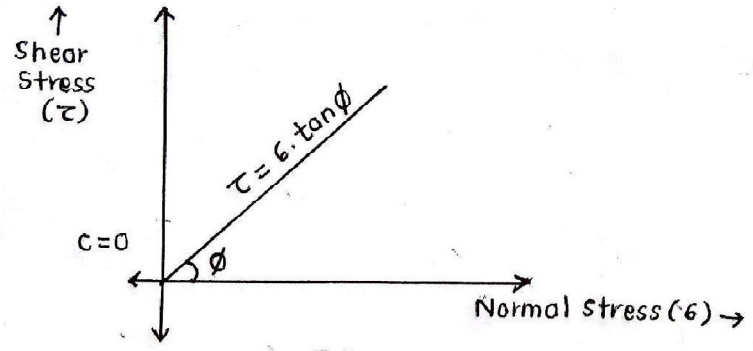


Fig. No. 4(b) : Shear strength envelope for cohesionless soil

2M

d) Differentiate between compaction and consolidation.

Sr. No	Compaction	Consolidation
1	Instant compression of soil under dynamic load is called compaction.	Gradual compression of soil under steady load is called consolidation.
2	It is fast process.	It is very slow process.
3	It is artificial process.	It is natural process.
4	It is done to improve soil properties like bearing capacity, shear strength, impermeability etc.	It takes place due to structural load which does not improve soil properties.
5	Settlement is prevented due to compaction.	Settlement takes place due tocompaction.
6	Compaction is done before construction of structure.	Consolidation takes place after construction of structure.

1M each (any four)

Q.4 Attempt any THREE of the following: **12M**

a) State characteristics of flow-net.

Characteristics of flow net are as follows:

i. The flow lines and equipotential lines in the flow net intersect each other orthogonally.

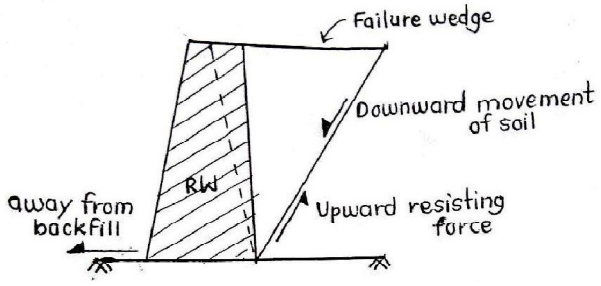
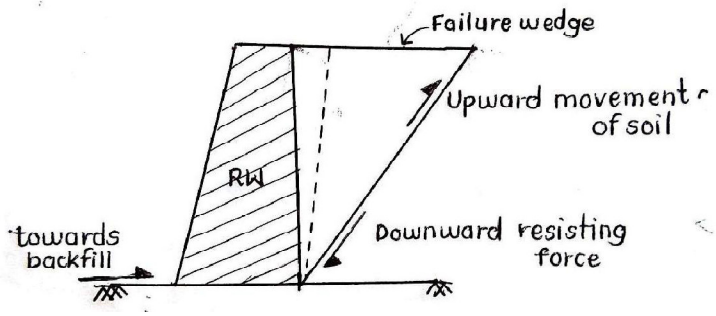
ii. The area or field formed due to intersection of these lines are approximately square.

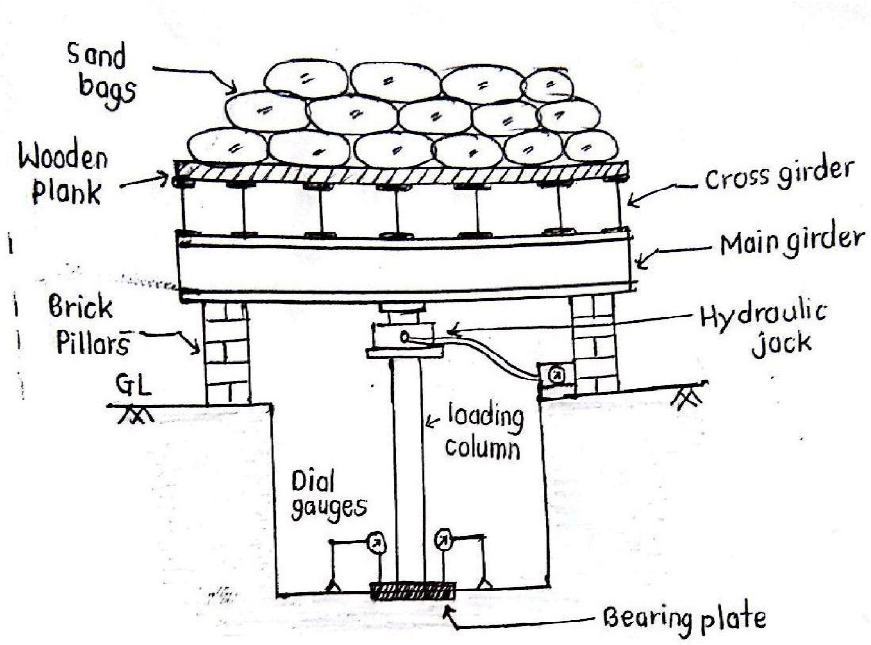
iii. The quantity of water flowing through each channel is almost same.

iv. Smaller dimensions of the field indicate greater hydraulic gradient and more velocity of flow.

v. The potential drop between two adjacent equipotential lines is same.

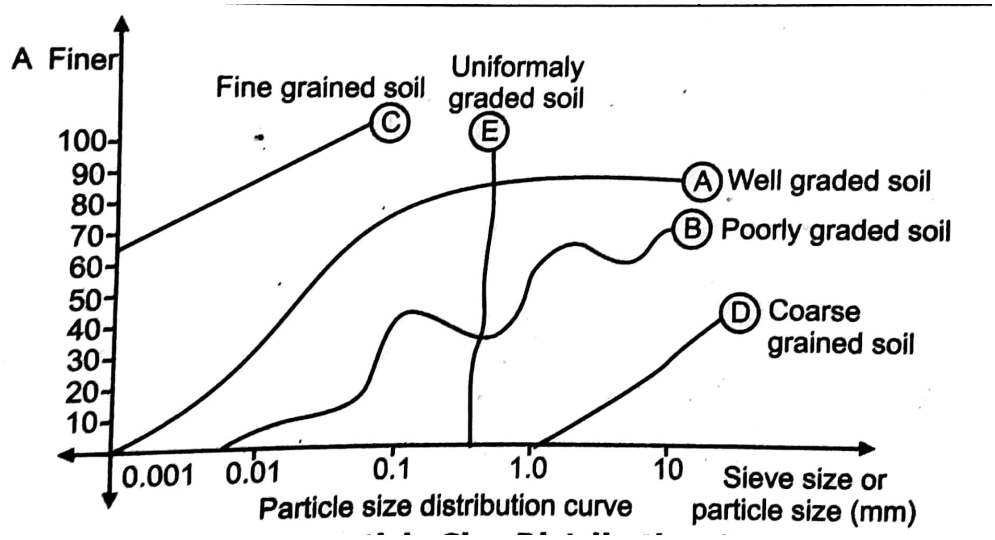
1M each (any four)

b)	**Define with sketch active and passive earth pressure.**	
	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.	**1M**
		**1M**
	Passive earth pressure: The maximum earth pressure on retaining wall which is developed due to movement of wall towards backfill is called as passive earth pressure.	**1M**
		**1M**
c)	**State any four assumptions in theory of Terzaghi's analysis of bearing capacity.**	
	Assumptions of Terzaghi's bearing capacity theory: 1. Soil behaves like ideally plastic material. 2.Soil is homogeneous , isotropic and its shear strength is represented by Coloumb's equation. 3. The total load on footing is vertical and uniformly distributed. 4. The footing is long enough with L/B = ∞ . 5.The shear strength above base of footing is neglected and taken as uniform surcharge γ Df. 6.The elastic zones developed has straight boundaries inclined at $\psi = \varphi$.	**1M each (any four)**

d)	**Draw a neat labeled sketch of plate load test set up for gravity loading.**	
	 Fig.No.8(a) : Plate Load Test	**2M sketch** **2M labelling**
e)	**Give four compaction equipments along with their seniitability**.	
	Types of Compaction Equipment: **1) Compaction by rolling:** **a) Smooth wheel rollers :** **Suitability:** These rollers best suitable for subgrade or base coarse compaction of cohesion less soils. **b) Pneumatic tyred rollers:** **Suitability:** Pneumatic tyred rollers are effective for compacting cohesive as well as cohesion less soils. Light rollers are effective for compacting soil layers of small thickness. **c) Sheep foot roller:** **Suitability:** Suitable only for fine grained soil i.e. cohesive soil **2) Compaction by Rammers:** Ramming equipments consists of three types: dropping weight type, internal combustion type and pneumatic type. Rammers or tampers are used to compact the soil of light to medium structure i.e. for plinth filling, PCC etc. **Suitability:** Suitable for all types of soil. **3) Compaction by vibratory compactors :** The vibrating equipment, mounted on screeds, plates or rollers are of two types: a) Dropping weight type and b) Pulsating hydraulic type. By giving vibration to soil, soil particles are packed together and compaction of subgrades and base course of both flexible and rigid pavement. **Suitability:** Suitable for compacting granular soils. With no fines in layer up to 1 m. **4) Compaction by Tamping:** Tamping rod is used to compact coarse grained cohesion less soils of lesser thickness.	**1M each (½ M name and ½ M suitability) (any four)**

Q.5	**Attempt any TWO of the following.**	**12 M**
(a)	**Explain the various field application of geotechnical engineering in details.**	
	The field of geotechnical engineering includes some of the important applications as: a) Foundation design b) Pavement Design c) Design of earth retaining structures d) Design of earthen dams e) Design of embankments f) Underground structures. **a) Foundation design-**Every civil engineering structure like a building, bridge, highway, or a dam lies in or on the surface of earth. Foundation is required is required to transmit the load of structure to soil safely and efficiently. Therefore bearing capacity of soil and knowledge of stress distribution below the loaded area, settlement of foundation, effect of vibration, effect of ground water etc. is essential to known. b) **Pavement Design:** A pavement is a hard crust placed on soil (subgrade) for the purpose of providing a smooth and strong surface on which vehicles can move. Pavement is of two types either flexible or rigid. Thickness of pavement depends upon subsoil and its component parts. It also depends upon the effect of repetition of loading intensity of traffic, construction materials, earth fills or cut etc. c) **Design of earth retaining structures:** When sufficient space is not available for a mass of soil to spread and form a slope, a structure is required to retain the soil. an earth retaining structure is also required to keep the soil at different levels on its either sides. The knowledge of active earth pressure, passive earth pressure, density and moisture content is essential for design of earth retaining structures. d) **Design of earthen dam:** In construction of earthen dam, soil is main constituent which may be homogeneous and heterogeneous. Therefore, its design requires thorough knowledge of index properties, plasticity characteristics, particle size distribution, specific gravity, permeability, consolidation, compaction and shear strength. since failure of an earthen dam may cause widespread catastrophe, extreme care is taken its design and construction. **e) Design of Embankment:** Due to up and downs in earth surface, stability of structure may disturb. So for stable design of slopes of filling and cutting, the knowledge of shearing strength, angle of repose and frictional coefficient is essential for the design of slopes in embankment or in cutting etc. **f) Underground Structures and miscellaneous:** design and construction of underground structure such as pipe lines, tunnels, underground buildings etc. requires the knowledge of density of soil, consolidation of soil, bearing capacity of soil and water condition of sub soil strata is essential.	**2M** **4M for any Four Explai nation**

(b)	**Draw particle size distribution curve. Explain mechanical sieve analysis for grading of soil with sketch.**	



Particle size distribution curve

2M for Graph

Mechanical sieve analysis: The process of analyzing the particle size present in soil by using mechanical means is known as mechanical sieve analysis. By performing mechanical sieve analysis, a particle size distribution curve is plotted for grading of soil.

Procedure:

i) Initially keep the given soil sample in rapid moisture meter for 2-3 hours to get oven dried soil. Break the visible lumps present in soil using fingers with light pressure.

ii) Arrange the set of I.S. sieves in descending order i.e. coarser sieve at top and finer sieve at bottom. The IS sieve set must include sieves of size 4.75mm, 2.36mm, 1.18mm, 600mic., 300 mic, 150 mic, 75 and pan.

iii) Take the soil sample about 500-1000gm and put it on topmost sieve. Keep lid and pan at top and bottom respectively.

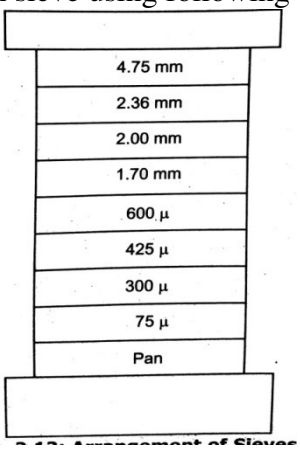
iv) Now, shake this assembly of sieve on mechanical sieve shaker for 10-15 minutes, so that soil sample will be sieved completely.

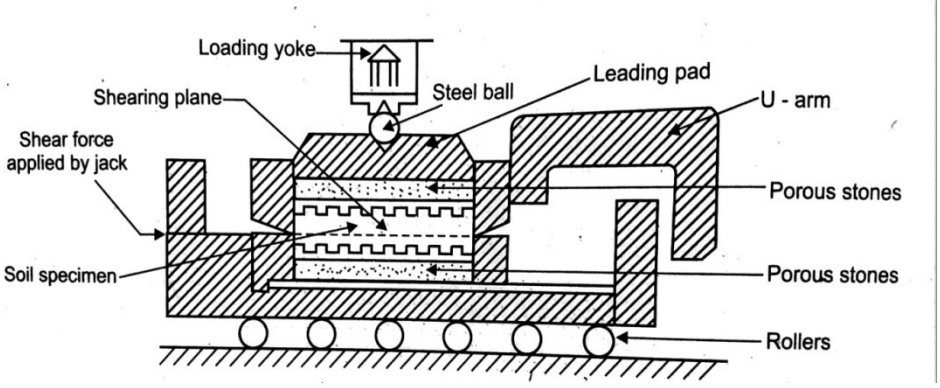
4M for Procedure And sketch

Seive size	Mass Retained (gm)	Cumulative mass retained (gm)	%Cumulative mass retained	%Finer Passing

v) Take the weight of soil mass retained on each sieve separately in grams.

vi) Calculate % finer for each sieve using following tabular format.



.(c)	**Explain the direct shear test to determine shear strength of soil with neat sketch.**	
	Procedure: 1. Take 2.5 kg air dried soil sample passing through 4.75mm and retained on 2.36mm IS sieve and measure the internal dimensions of of shear box. Also determine the average thickness of the grid plates. 2. Fix the upper part of the box to the lower part using locking screws. Attach the base plate to the lower part. 3. For performing a UU test, plain toothed grids (without perforations) are used at the top and bottom faces of samples. Shear force is applied immediately after applying the normal load. Place the grid plate in the shear box keeping the serrations of the grid at right angles to the direction of shear. Place the porous stone over the grid plate. 4. Weigh the shear box with base plate, grid plate and porous stone. Place the soil specimen in the box. Tamp it directly in the shear box at the required density. 5. When the soil in the top half of the shear box is filled weigh the box with soil specimen and fix the loading pad on the box. Mount the box contained on the loading frame. 6. Bring the upper half of the box in contact with the proving ring. Check the contact by giving a slight movement. Fill the container with water if the soil is to be saturated. 7. Mount the loading yoke on the ball placed on the loading pad. Mount the dial gauge on the loading yoke to record the vertical displacement and another dial gauge on the container to record the horizontal displacement. 8. Place the weights on the loading yoke to apply a normal stress. Allow the sample to consolidate under the applied normal stress. Note the reading of the vertical displacement dial gauge. 9. Remove the locking screws using the spacing screws, raise the upper part slightly above the lower part such that the gap is slightly larger than the maximum particle size. Remove the spacing screws and adjust all the dial gauges to read zero. The proving ring should also read zero. 10. Apply the horizontal shear load at a constant rate of strain of 0.2mm/minute. Record the reading of proving ring, the vertical displacement dial gauge and horizontal displacement dial gauge at regular time intervals. Take few readings at closer intervals. 11. Continue the test till the specimen fails or till a strain of 20% is reached. At the end of the test, remove specimen from the box and take a representative sample for water content determination. 12. Repeat the test on identical specimens under the normal stresses of 50, 100, 200, 400, KN/m. plot the graph by taking the values of Normal stress as abscissa and the maximum shearing stress as ordinate.  **Direct shear test Arrangement**	**4M for Procedure** **2M for sketch**

Q.6	Attempt Any TWO of the following	12 M

a) Following observations were made using standard proctor test on a soil sample:

Bulk density gm/cc	1.75	1.95	2.10	2.20	2.15	2.05
Water content (%)	5	10	15	20	25	30

Determine OMC and MDD by plotting compaction curve on graph.

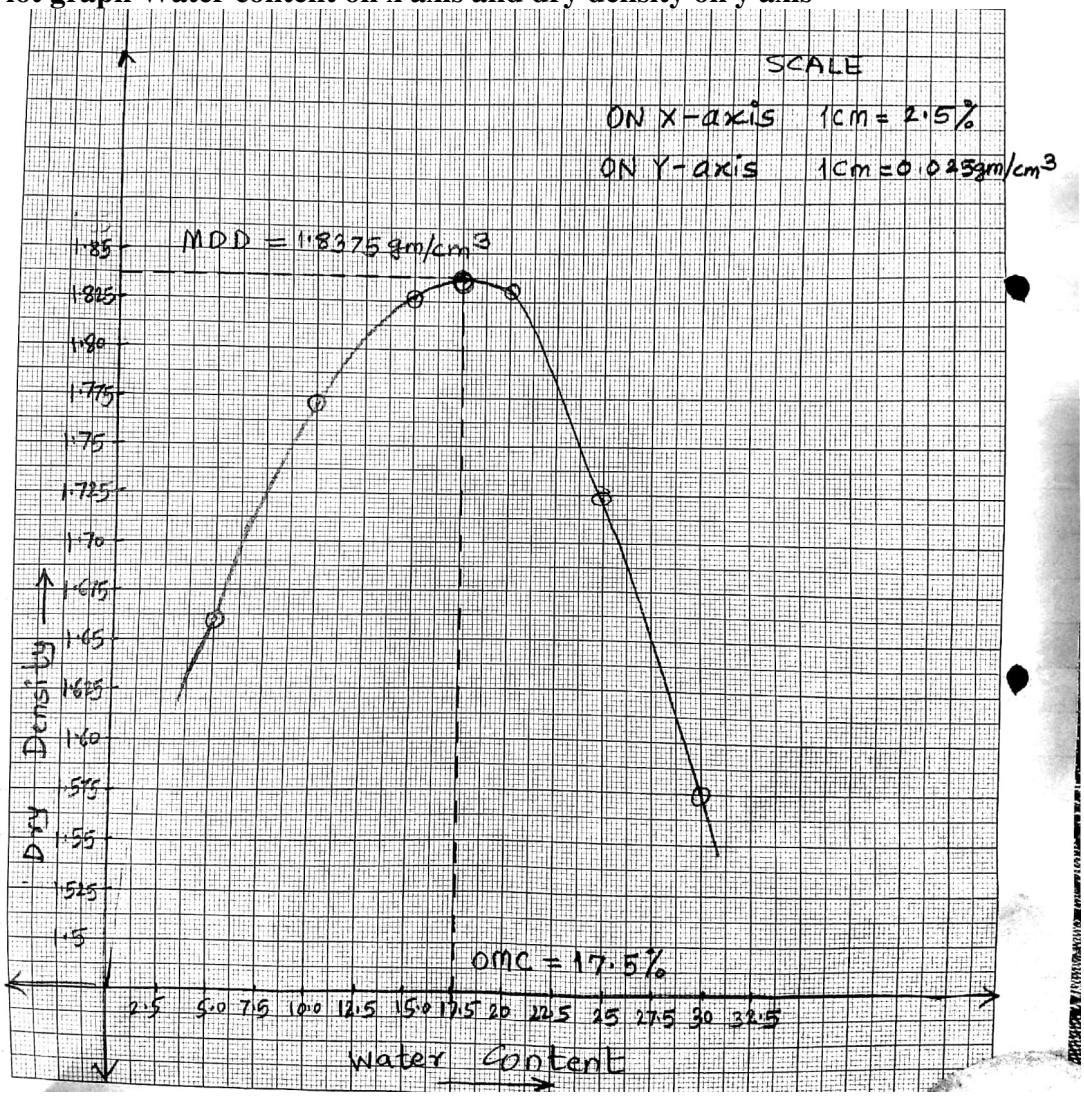
Calculate dry density for each reading as

Dry density $\gamma_d = \frac{\gamma}{1+w} = \frac{1.75}{1+0.05} = 1.666 \text{ gm/cm}^3$

Bulk density gm/cc	1.75	1.95	2.10	2.20	2.15	2.05
Water content (%)	5	10	15	20	25	30
Dry density gm/cc	1.666	1.772	1.826	1.833	1.72	1.576

2M

Plot graph Water content on x axis and dry density on y axis



4M for Graph And result

Optimum Moisture Content by Graph = 17.5%
Maximum Dry Density by Graph = 1.8375 gm/cm^3

b)	**State the methods of soil stabilization. Explain any one.**	
	1) Mechanical Stabilization 2) Cement Stabilization 4) Chemical stabilization 4) Bitumen stabilization 5) Stabilization by heating 6) Electrical stabilization 7) Fly ash stabilization 8) Lime stabilization **1) Mechanical Stabilization:** In this method, stabilization of soil is done without adding any chemicals or admixtures. The procedure of mechanical stabilization is described below. i) Initially soil is excavated using excavator and then it is ground to finer particles using pulveriser. ii) In this pulverized soil, well graded aggregates are spread and mixed till homogeneous mixture will form. iii) Then water is sprinkled upto a optimum moisture content i.e. OMC for getting maximum dry density i.e. MDD. iv) The heavy roller (8-10 tonne capacity) is used to compact soil 15-20 cm thickness as per type of soil available. v) The compacted surface is cured by sprinkling water on it, followed by compaction. The curing and compaction is done alternatively for 7 days. Then the stabilized portion is allowed for its further use. **OR** **2) Cement Stabilization:** The soil is stabilized with Portland cement is known as soil cement and the process is known as Cement stabilization. The stabilization takes place due to the cementing action believed to be the result of chemical action of cement with soil containing silicon during hydration. 5 to 15% cement is added to increase the strength, the strength of soil cement increases with increase in cement content. A stronger and durable soil cement will be produced, if the soil cement water mixture is mixed properly. The normal construction procedure for soil cement bases is as follows: i) shaping the sub grade and scarifying the soil. ii) Pulverising the soil iii) Adding and mixing cement iv) Adding and mixing water v) compacting vi) Finishing vii) Curing viii) Adding wearing surface. **(Note: Explanation of any one or other method from above should be considered.)**	**2M** **4M (for any one)**
c)	**State field identification test on soil and explain any one.**	
	Following are the field identification tests on soil 1. Visual examination 2. Dilatency test 3. Toughness 4. Dry strength 5. Organic and colour 6. Other identification tests **1. Visual Examination:** The visual examination is carried out by eyes only after taking a representative sample of soil and spreading it on a flat surface on plam of the hand. The visual examination is carried out with respect to size, angularity, touch and grading. **2. Dilatency:** This is also a simple test used in field for rough classification of soil. i) A 5cm^3 of soil sample is taken and enough water is added to nearly saturate it. The	**2M** **4M for Any one method**

	part of soil is placed in the open palm of the hand and shaken horizontally, striking rigorously against the other hand several times. ii) The pat is then squeezed between the fingers. The appearance and disappearance of water with shaking and squeezing is referred to as a positive reaction. iii) The reaction is called quick, if water appears and disappears rapidly. It is called slow, if water appears and disappears slowly and no reaction if water does not appear. iv) The type of reaction is observed and recorded. Inorganic soils exhibits a quick reaction whereas clays exhibit none to slow. **3. Dry strength test:** i) The prepared soil sample is completely dried in the sun or by air drying. Its strength is tested by breaking between fingers. ii) Dry strength or resistance to breaking, is a measure of plasticity and is considerably induced by the colloidal fraction content of the soil. iii) If the dry sample can be easily powered, it is said to have low dry strength, whereas, if considerable finger pressure is required to break the lump, it is said to have a medium dry strength and if it cannot be powered at all, it is said to have high dry strength. iv) Dry strength is characteristic of clays of high plasticity. Typical inorganic silts have only a slight dry strength. silty fine sands and silts have practically the same low strength but can be distinguished from each other by their feel during powdering of the dry sample. **(Note: Explanation of any one or other method from above should be considered.)**	

22404

11920

3 Hours / 70 Marks Seat No. | | | | | | | | |

Instructions : (1) All Questions are *compulsory.*

(2) Attempt **all** questions including Question No. 1 which is compulsory.

(3) Answer each next main Question on a new page.

(4) Illustrate your answers with neat sketches wherever necessary.

(5) Figures to the right indicate full marks.

(6) Assume suitable data, if necessary.

(7) Use of Non-programmable Electronic Pocket Calculator is permissible.

(8) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

(9) Preferable solve in sequential order.

Marks

1. Attempt any FIVE of the following : **10**

(a) Define a soil as per I.S.

(b) Define a Rock and state one type of it.

(c) Define voids ratio and porosity.

(d) Define : (i) Water content (ii) Plasticity index

(e) Enlist any two the methods of soil stabilization.

(f) State relation between e, S and W, G.

(g) Define soil exploration.

2. Attempt any THREE of the following : **12**

(a) Write step by step procedure for determination of specific gravity by pycnometer bottle.

(b) The density of soil sample is 2000 kg/m^3 and its water content is 16%. Determine its dry density, void ratio, porosity and degree of saturation.

(c) Explain soil as three phase system with labelled sketch.

(d) Explain the importance of geology in civil Engineering Construction.

3. Attempt any THREE of the following : **12**

(a) Define flow net and state its characteristics with neat sketch.

(b) State any four assumptions made in Terzaghi's analysis of bearing capacity of soil.

(c) Differentiate between active and passive earth pressure.

(d) Draw a neat labelled sketch of plate load test set up for determination of field bearing capacity.

4. Attempt any THREE of the following : **12**

(a) Calculate active earth pressure and passive earth pressure at depth of 9 m in dry cohesionless soil with an angle of internal friction of 30º and unit weight of 17 KN/m^3.

(b) Differentiate between compaction and consolidation with four points.

(c) Explain standard proctor test to determine MDD and OMC of soil.

(d) Explain determination of coefficient of permeability by constant head method.

(e) A sample of soil 10 cm height and 50 cm^2 in c/s area water flows through the soil under a constant head of 80 cm. Water collected in 9 minutes is 450 C.C. find the coefficient of permeability.

5. Attempt any TWO of the following : **12**

(a) (i) Explain field applications of geotechnical engineering.

(ii) State two civil engineering situations where knowledge of geotechnical engineering is used.

(b) In a shear box test, following observations were recorded at the failure of soil specimen :

Normal stress kg/cm^2	1.0	1.50	2.50	3.50
Shear stress kg/cm^2	0.80	1.15	1.42	1.70

Find the value of cohesion C and internal friction ϕ by graphical method.

(c) A soil sample of volume 160 CC, weights 304 gms, when partially saturated. It weights 269.28 gms, when fully dry specific gravity of soil is 2.64. Determine porosity, void ratio, water content and degree of saturation.

6. Attempt any TWO of the following : **12**

(a) Explain with figure laboratory determination of shear strength of soil with direct shear test.

(b) The following are the results of standard compaction test performed on a sample of soil :

Water content %	5	10	15	20	25	30
Bulk density (gm/cc)	1.77	1.98	2.10	2.18	2.16	2.12

Plot the water content dry density curve and obtain the optimum water content (OMC) and its maximum dry density (OMD).

(c) State field methods of compactions. Explain suitability of various compaction equipments.

Model Answer: Winter-2019

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

Important Instructions to Examiners

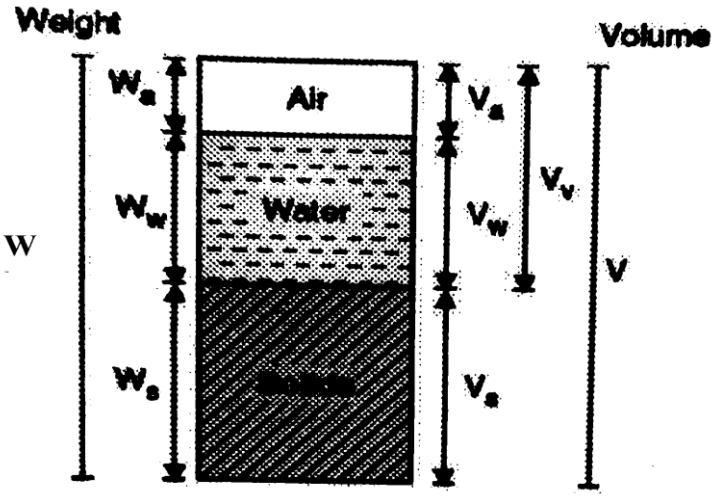
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 the candidate and those in the model answer may vary. The examiner may give credit for any equivalent 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 the model answer.
6) In case of some questions credit may be given by judgment 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.

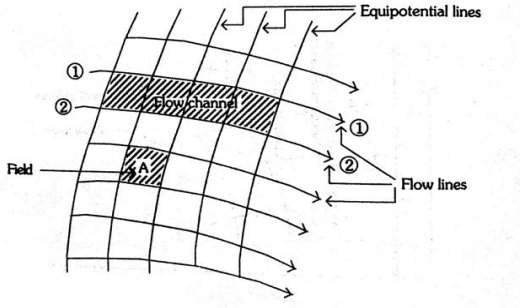
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1		**Attempt any FIVE of the following:**		**10**
	(a)	**Define soil as per I.S.**		
	Ans.	**Definition of soil as per IS:2809-1972:** Soil is the sediment or other unconsolidated accumulation of solid particles produced by physical and chemical disintegration of rock	**2**	**2**
	(b)	**Define a Rock and state one type of it.**		
	Ans.	**Rock:** It is the aggregate of minerals, called as rock.	**1**	
		Types of Rock: 1. Igneous rock 2. Sedimentary rock 3. Metamorphic rock	**1 (any one)**	**2**
	(c)	**Define voids ratio and porosity.**		
	Ans.	**Voids ratio:** It is the ratio of volume of voids to volume of solids called as voids ratio.	**1**	
		Porosity: It is the ratio of volume of voids to the total volume of soil; called as porosity.	**1**	**2**

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1	**(d)**	**Define: (i) Water content (ii) Plasticity index**		
	Ans.	**(i) Water content:** It is the ratio of weight of water to weight of soil solids, measured in percentage, called as water content. **(ii) Plasticity Index:** It is numerical difference between liquid limit and plastic limit values of one particular soil, called as plasticity index.	**1** **1**	**2**
	(e)	**Enlist any two the methods of soil stabilization.**		
	Ans.	**Methods of soil stabilization:** 1. Mechanical stabilization 2. Cement stabilization 3. Lime stabilization 4. Bitumen stabilization 5. Fly ash stabilization 6. Chemical stabilization 7. Stabilization by heating 8. Stabilization by freezing 9. Stabilization by grouting	**1 each (any two)**	**2**
	(f)	**State relation between e, S and W, G.**		
	Ans.	**Relation between e, S and W, G:** S. e = W. G **OR** S = (W. G) / e	**2**	**2**
	(g)	**Define soil exploration.**		
	Ans.	**Soil exploration:** It is the technique of acquiring the information of subsoil before the proposed construction work; is known as soil exploration.	**2**	**2**

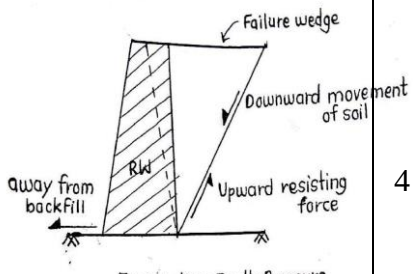
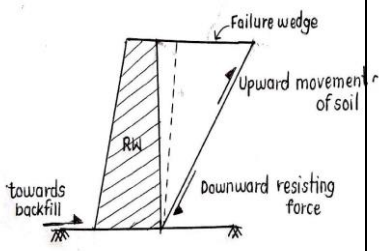
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2		**Attempt any THREE of the following:**		**12**
	(a)	**Write step by step procedure for determination of specific gravity by pycnometer bottle.**		
	Ans.	**Procedure for determination of specific gravity by pycnometer bottle:** 1. Clean the pycnometer 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 105-1100C for 24 hours to get dry soil. 3. Place this soil sample about 150-200 gm. in the pycnometer and take its weight as 'W2' gm. 4. Now add the distilled water to half of height of pycnometer and stirrer 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 'W3' gm. 5. Remove all content from the pycnometer bottle. Wash and clean it with water. 6. Fill the pycnometer bottle with distilled water only up to top of conical cap. Take the weight of pycnometer completely filled with water as W4 gm. 7. Calculate the specific gravity G of given soil as, as $G = (W_2 - W_1) / ((W_4 - W_1) - (W_3 - W_2))$ 8. Repeat all above steps two more times to calculate average specific gravity of given soil sample.	**4**	**4**
	(b)	**The density of soil sample is 2000 kg/m^3 and its water content is 16 %. Determine its dry density, voids ratio, porosity and degree of saturation.**		
	Ans.	Given: $\gamma = 2000$ kg/m^3 $= 2 gm/cc$, $w = 16\ \% = 0.16$, Calculate: $\gamma_d, e, \eta, S = ?$ *To* find dry density γ_d, $\gamma_d = \frac{\gamma}{1 + w}$ $\gamma_d = \frac{2}{1 + 0.16}$ $\boxed{\gamma_d = 1.724 \text{ gm/cc}}$	**1**	

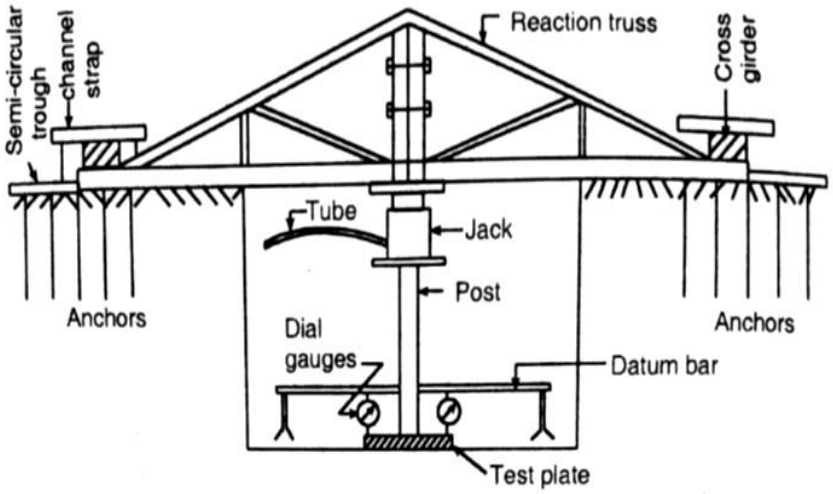
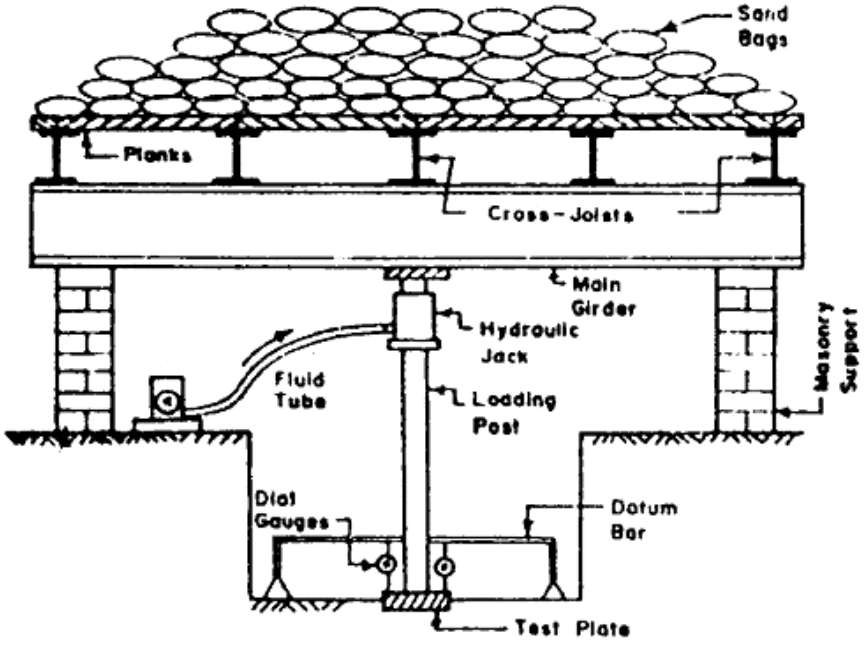
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2	**(b)** **Ans.**	*To* find coids ratio e, Assume specific gravity G = 2.7 Density of water $\gamma_w = 1 gm/cc$ $\gamma_d = \frac{\gamma_w \times G}{1 + e}$ $1.724 = \frac{1 \text{ x } 2.7}{1 + e}$ $\boxed{e = 0.566}$ *To* find porosity η, $\eta = \frac{e}{1 + e}$ $\eta = \frac{0.566}{1 + 0.566}$ $\eta = 0.3614$ $\eta = 0.3614 \times 100$ $\boxed{\eta = 36.14\ \%}$ *To* find degree of saturation S, $S = \frac{w \times G}{e}$ $S = \frac{0.16 \times 2.7}{0.566}$ $S = 0.7632$ $S = 0.7632 \times 100$ $\boxed{S = 76.32\ \%}$	**1** **1** **1**	**12** **4**

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2	(c)	**Explain soil as three phase system with labelled sketch.**		12
	Ans.	**Soil as three phase system**: 1. As natural soil contains solid soil particles and water and air present in its voids such complex nature of soil sample is difficult to analyze its physical properties Hence it is simplified and presented in its equivalent 3 phase diagram as shown in figure below. 2. Depending upon three phase diagram of soil its is classified in three categories- 1. Dry soil 2. Partially saturated soil 3. Fully saturated soil. 3. However if we take a dry soil mass, the voids are filled with air only. In case of perfectly saturated soil the voids are filled completely with water. In case of partially saturated soil, both air and water are present in the voids.	**3**	
			**1**	**4**
		Figure.: Three Phase System of Soil		
	(d)	**Explain the importance of geology in civil Engineering Construction.**		
	Ans.	**Importance of geology in civil engineering construction:** 1. Geology is essential to know the nature if 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. It 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. It is significant in tunnel excavation projects as it provides information of rock strata and its engineering properties. 6. It is also important to excavate raw materials for stone crushing plant to manufacture aggregates.	**1 each (any four)**	**4**

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3		**Attempt any THREE of the following:**		**12**
	(a)	**Define flow net and state its characteristics with neat sketch.**		
	Ans.	**Definition of flow net:** It is the grid network formed due to intersection of flow (stream) lines and equipotential lines, called as flow net.	**1**	
		Characteristics of flow net: 1. The flow lines and equipotential lines in the flow net intersects each other orthogonally 2. The area or field formed due to intersection of these lines is approximately square 3. The quantity of water flowing through each channel is almost same. 4. Smaller dimensions of the field indicate greater hydraulic gradient and more velocity of flow. 5. The potential drop between two adjacent equipotential lines is same.	**1 each (any two)**	
			**1**	**4**
		Figure: Flow net		
	(b)	**State any four assumptions made in Terzaghi's analysis if bearing capacity of soil.**		
	Ans.	**Assumptions of Terzaghi's bearing capacity failure theory:** 1. Soil behaves like ideally plastic material. 2. Soil is homogeneous, isotropic and its shear strength is represented by Coloumb's equation. 3. The total load on footing is vertical and uniformly distributed. 4. The footing is long enough with L/B = ∞. 5. The shear strength above base of footing is neglected and taken as uniform surcharge γ_{Df}. 6. The elastic zones developed has straight boundaries inclined at $\psi = \phi$.	**1 each (any four)**	**4**

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	(c)	**Differentiate between active and passive earth pressure.**	**1 each**	**4**
	Ans.	**Difference between active and passive earth pressure:**		

	Active Earth Pressure		Passive Earth Pressure
1	The pressure exerted by backfill soil on retaining wall, is called as active earth pressure.	1	The pressure exerted by retaining wall on soil is known as passive earth pressure.
2	It is developed due to movement of wall away from backfill	2	It is developed due to movement of wall towards backfill.
3	Active earth pressure should be less for stability of retaining structures.	3	Passive earth pressure should be more to ensure stability of retaining structures.
4	 Fig : Active Earth Pressure	4	 Fig. : Passive Earth Pressure

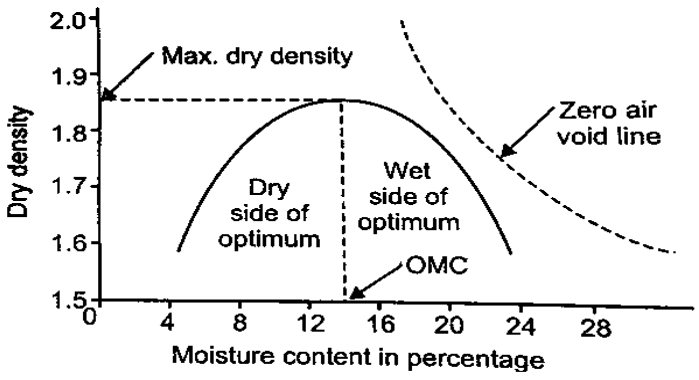
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	(d)	**Draw a neat labelled sketch of plate load test set up for determination of field bearing capacity.**		
	Ans.			
		Figure: Plate Load Test using Reaction Truss Loading		
		OR	**4**	**4**
				
		Figure: Plate Load Test using Gravity Loading		
		(Note: 2 marks for sketch and 2 marks for label.)		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4		**Attempt any THREE of the following:**		**12**
	(a)	**Calculate active earth pressure and passive earth pressure at depth of 9 m in dry cohesionless soil with an angle of internal friction of 30^0 and unit weight of 17 kN/m^3.**		
	Ans.	Given: H = 9 m, $\phi = 30^0$, $\gamma = 17$ KN/m^3, Calculate: P_a *and* $P_p = ?$ *To* find coefiicient active earth pressure K_a , $K_a = \frac{1 - \sin\phi}{1 + \sin\phi}$ $K_a = \frac{1 - \sin 30^0}{1 + \sin 30^0}$ $\boxed{K_a = 0.333}$	**1**	
		Active earth pressure P_a, $P_a = K_a \times \gamma \times H$ $P_a = 0.333 \times 17 \times 9$ $\boxed{P_a = 50.949 \text{ kN/m}^2}$	**1**	
		To find coefiicient passive earth pressure K_p , $K_p = \frac{1 + \sin\phi}{1 - \sin\phi}$ $K_p = \frac{1 + \sin 30^0}{1 - \sin 30^0}$ $\boxed{K_p = 3}$	**1**	
		Passive earth pressure P_p, $P_p = K_p \times \gamma \times H$ $P_p = 3 \times 17 \times 9$ $\boxed{P_p = 459 \text{ kN/m}^2}$	**1**	**4**

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(b)	**Differentiate between compaction and consolidation with four points.**		
	Ans.	**Difference between compaction and consolidation:**		

Sr. No.	Compaction	Consolidation
1	Instant compression of soil under dynamic load is called compaction.	Gradual compression of soil under steady load is called consolidation.
2	It is fast process.	It is very slow process.
3	It is artificial process.	It is natural process.
4	It is done to improve soil properties like bearing capacity, shear strength, impermeability etc.	It takes place due to structural load which does not improve soil properties.
5	Settlement is prevented due to compaction.	Settlement takes place due to consolidation.
6	Compaction is done before construction of structure.	Consolidation takes place after construction of structure.
7	Pore water pressure is not important in compaction.	Pore water pressure is very important in compaction.
8	Compaction does not go indefinitely.	Consolidation goes indefinitely.

1 each (any four) | **4**

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(c)	**Explain standard proctor test to determine MDD and OMC of soil.**		
	Ans.	**Procedure of Standard Proctor Test:** 1. Measure the diameter and height of proctor mould to calculate its volume V in cm^3. Take the empty weight of the mould (without collar and base plate) as W_1 gm. 2. Apply a thin film of grease to inside of mould. Fix the mould to the base plate with the help of wing nuts, place collar on the mould. 3. Take about 5 Kg. of de-aired soil passing through sieve 20 mm in tray. Fill the soil in mould in three equal layers by giving 25 using hammer of 2.6 kg through dropping height 310 mm. Remove the mould and excess soil from top of mould. 4. Take the weight of mould filled with compacted soil as W_2 gm. 5. Calculate the bulk density $\gamma = (W_2 - W_1) / V$ in gm/cc 6. Take the representative soil sample from mould and determine its water content as w % using oven drying method. 7. Calculate dry density γ_d = (bulk density) / (1 + w) in gm/cc. 8. Repeat all above steps by increasing water in soil and determine γ_d and w % for each trial. 9. Plot the compaction curve as water content v/s. dry density to find maximum value of dry density as MDD and corresponding water as OMC.	3	
		 **Figure: Compaction curve to find OMC and MDD of Soil.**	1	4

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(d)	**Explain 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 9.5mm IS sieve. Add the water in soil equals to its optimum moisture content (OMC) to get required density. 2. Apply grease to inside surface of mould, base plate and collar. Clamp the base plate with extension collar. Fill the prepared soil sample in permeameter in three different layers. Compact each layer using 25 blows using rammer. Remove the collar and trim the excess soil for mould. Remove compaction base plate. Cover the soil with filter paper and porous stones on both sides. 3. Place the mould assembly in the drainage base. Fix the top cap on it using rubber sealing gasket. 4. Connect the inlet nozzle of permeameter to outlet of constant head water tank. Close the air vent of mould. Open outlet of permeameter and allow water to flow in the bottom water tank. Wait for some time to establish steady flow. 5. Measure head causing flow 'h'. Collect quantity of water (Q) in the measuring cylinder for suitable time interval (t). 6. Calculate the coefficient of permeability of soil as $K = \frac{Q \times L}{A \times h \times t}$ cm/s. 7. Repeat all above steps two more times to get average coefficient of permeability of given soil sample.	**4**	**4**

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(e)	**A sample of soil 10 cm height and 50 cm^2 in c/s area water flows through the soil under a constant head of 80 cm. Water collected in 9 minutes is 450 C.C. Find the coefficient of permeability.**		
	Ans.	*Given*: L = 10 cm, A = $50cm^2$, h = 80 cm, t = 9 min.=540 sec., Q = 450 *cc* *Calculate*: K=? Coefficient of permeability by constant head method, $K = \frac{Q \times L}{A \times h \times t}$ $K = \frac{450 \times 10}{50 \times 80 \times 540}$ $\boxed{K = 2.083 \times 10^{-3} cm/s}$	**1** **1** **2**	**4**

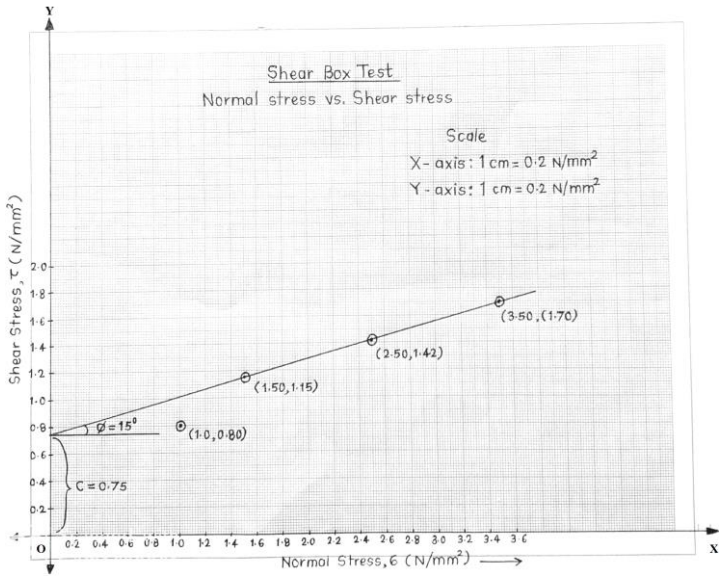
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5		**Attempt any TWO of the following:**		12
	(a)	**(i) Explain field applications of geotechnical engineering.**		
	Ans.	**Field applications of Geotechnical Engineering:** 1. **Design of foundation for various civil structures:** As foundation resting 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 water retaining structures:** Geotechnical is very much applicable for easy and safe design and execution and maintenance of earthen dam, weir, barrage etc. 5. **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 (any four)**	
		(ii) State two civil engineering situations where knowledge of geotechnical engineering is used.		
		Civil engineering situations where knowledge of Geo-Technical Engineering (GTE) is used: 1. Geo-Technical Engineering knowledge is required to find most suitable site for proposed construction work. 2. GTE knowledge is also useful to find the suitability of available soil for planned construction activity. 3. GTE knowledge is useful to design and construction of foundation for various structures like building by knowing bearing capacity, shear strength of soil. 4. It is also helpful for design and construction of pavement for various roads by knowing properties sub grade soil, pavement layers like compaction, bulk and dry density etc. 5. GTE concepts are essential to design and construction of earth retaining structures i.e. retaining wall, sheet pile by studying earth pressure theory. 6. GTE theories are beneficial in design and construction of water retaining structures i.e. dam, weir etc. by determining permeability, shear strength etc. 7. GTE test procedures are necessary in design and construction of abutments of bridge by testing shears strength, earth pressure etc. 8. It plays vital role in design construction of underground structures i.e. pipeline, tunnels etc. by knowing soil erosion, slope stability.	**1 each (any two)**	**6**

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	(b)	**In shear box test, following observations were recorded at the failure of soil specimen.**		

Normal Stress (kg/cm^2)	1.00	1.50	2.50	3.50
Shear Stress (kg/cm^2)	0.80	1.15	1.42	1.70

Find the value of cohesion C and internal friction ϕ by graphical method.

Ans.

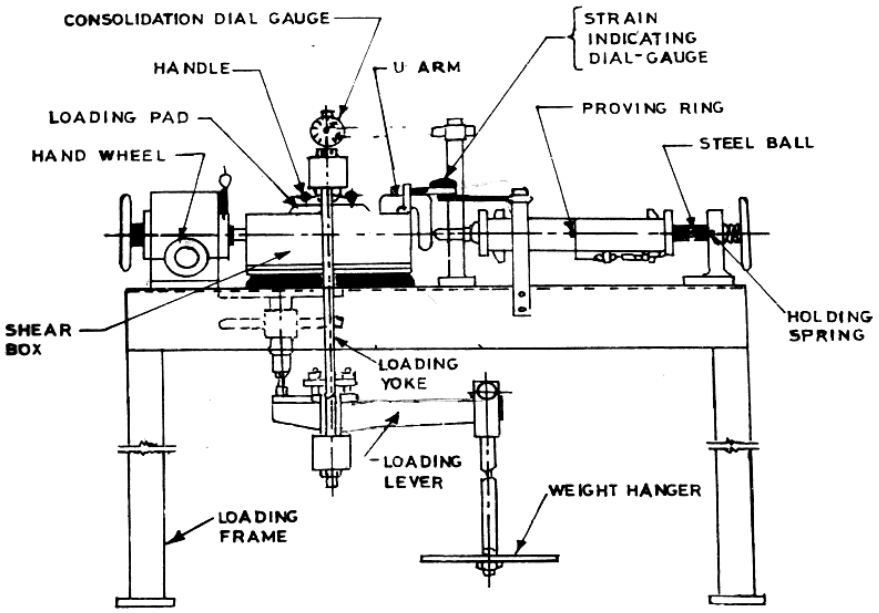
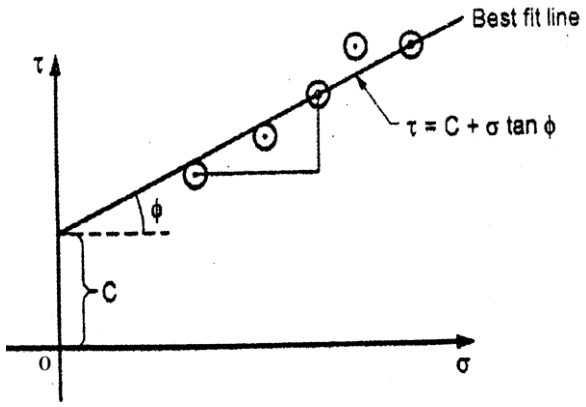


		4	
From above graph:			
1.	Cohesion C = 0.75 N/mm^2	1	
2.	Angle of internal friction $\phi = 15^0$	1	6

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	(c)	**A soil sample of volume 160 CC, weights 304 gms, when partially saturated. It weights 269.28 gms, when fully dry specific gravity of soil is 2.64. Determine porosity, voids ratio, water content, and degree of saturation.**		
	Ans.	Given: V = 160 *cc*, W_{wet} = 304 gms, W_{dry} = 269.28 gms, Calculate: $w, e, \eta, S = ?$ *To* find water content *w*, $w = \left(\frac{W_{wet} - W_{dry}}{W_{dry}}\right) \times 100$ $w = \left(\frac{304 - 269.28}{269.28}\right) \times 100$ $\boxed{w = 12.893\ \%}$	1	
		To find dry density γ_d, Assume specific gravity G = 2.7 Density of water $\gamma_w = 1 gm/cc$ $\gamma_d = \frac{W_{dry}}{V}$ $\gamma_d = \frac{269.28}{160}$ $\boxed{\gamma_d = 1.683\ \text{gm/cc}}$	1	
		To find voids ratio e, $\gamma_d = \frac{\gamma_w \times G}{1 + e}$ $1.683 = \frac{1 \text{ x } 2.64}{1 + e}$ $e = \frac{2.64}{1.683} - 1$ $\boxed{e = 0.568}$	1 1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	(c)	*To* find porosity η,		
	Ans.	$\eta = \frac{e}{1 + e}$		
		$\eta = \frac{0.568}{1 + 0.568}$		
		$\eta = 0.3622$		
		$\eta = 0.3622 \times 100$		
		$\boxed{\eta = 36.22\ \%}$	1	
		To find degree of saturation S,		
		$S = \frac{w \times G}{e}$		
		$S = \frac{0.1289 \times 2.64}{0.568}$		
		$S = 0.5992$		
		$S = 0.5992 \times 100$		
		$\boxed{S = 59.92\ \%}$	1	6

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6		**Attempt any TWO of the following:**		12
	(a)	**Explain with figure laboratory determination of shear strength of soil with direct shear test.**		
	Ans.	**Procedure for Direct Shear Test:** 1. Take 2.5 Kg air dried soil sample passing through 4.75 mm and retained on 2.36mm IS sieve**.** 2. Measure the internal dimensions of the shear box. Fix the upper part of the box to the lower part using the locking screws. Attach the base plate to the lower part. 3. For performing a UU test, Plain toothed grids (without perforations) are used at the top and bottom faces of samples. Place the porous stone over the grid plate. 4. Weigh the shear box with base plate, grid plate and porous stone. Place the soil specimen in the box. Tamp it directly in the shear box at the required density. 5. When the soil in the top half of the shear box is filled, weigh the box with soil specimen. Weigh the box inside the box contained and fix the loading pad on the box. Mount the box contained on the loading frame. 6. Bring the upper half of the box in contact with the proving ring. Check the contact by giving a slight movement. 7. Mount the loading yoke on the ball placed on the loading pad. Mount the dial gauge on the loading yoke to record the vertical displacement and another dial gauge on the container to record the horizontal displacement. 8. Place the slotted weights of 0.5 N/mm^2 on the loading yoke to apply a normal stress. Note the reading of the vertical displacement dial gauge. 9. Remove the locking screws. Using the spacing screws, raise the upper part slightly above the lower part such that the gap is slightly larger than the maximum particle size. Remove the spacing screws. 10. Apply the horizontal shear load at a constant rate of strain of 0.2mm/minute till shear failure of soil. Record the reading of the proving ring, the vertical displacement dial gauge and the horizontal displacement dial gauge at regular time intervals to know the shear stress at failure. 11. Repeat the test on identical specimens under the normal stresses of 1.0, 1.5, 2.0 N/mm^2 etc. Plot the graph by taking the value Normal Stress as abscissa and the maximum shearing stress as ordinate to find shear strength of soil.	**4**	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	(a)	 **Figure: Direct Shear Test Apparatus**	1	
		 **Figure: Graph of Normal stress vs. Shear stress**	1	6

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	(b)	**The following are the test results of standard compaction test performed on a sample of soil:**	2	

Water content %	5	10	15	20	25	30
Bulk density (gm/cc)	1.77	1.98	2.10	2.18	2.16	2.12

Plot the water content dry density curve and obtain the optimum water content (OMC) and its maximum dry density (MDD).

Ans. **Calculation of Dry density for each observation:**

For obs. no. 1; $\gamma_d = \left(\frac{\gamma}{1+w}\right) = \left(\frac{1.77}{1+\left(\frac{5}{100}\right)}\right) = 1.68$ gm/cc

For obs. no. 2; $\gamma_d = \left(\frac{\gamma}{1+w}\right) = \left(\frac{1.98}{1+\left(\frac{10}{100}\right)}\right) = 1.80$ gm/cc

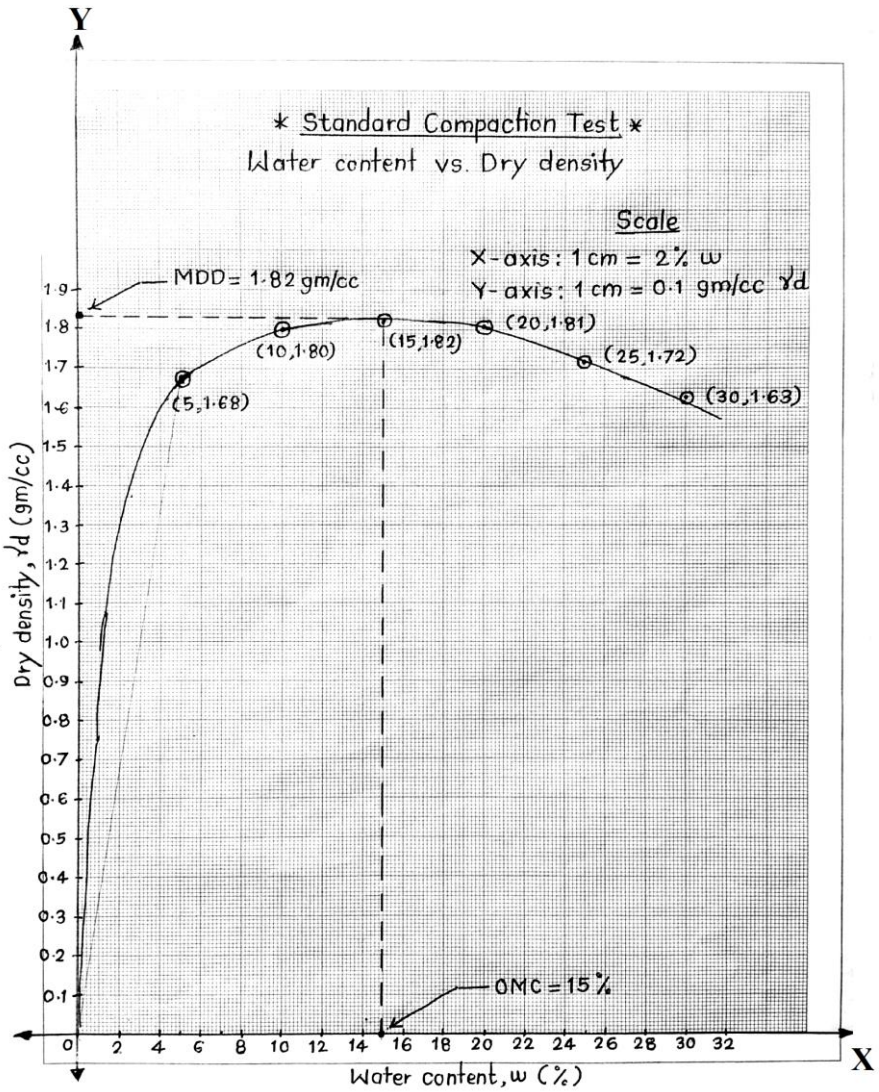
For obs. no. 3; $\gamma_d = \left(\frac{\gamma}{1+w}\right) = \left(\frac{2.10}{1+\left(\frac{15}{100}\right)}\right) = 1.82$ gm/cc

For obs. no. 4; $\gamma_d = \left(\frac{\gamma}{1+w}\right) = \left(\frac{2.18}{1+\left(\frac{20}{100}\right)}\right) = 1.81$ gm/cc

For obs. no. 5; $\gamma_d = \left(\frac{\gamma}{1+w}\right) = \left(\frac{2.16}{1+\left(\frac{25}{100}\right)}\right) = 1.72$ gm/cc

For obs. no. 6; $\gamma_d = \left(\frac{\gamma}{1+w}\right) = \left(\frac{2.12}{1+\left(\frac{30}{100}\right)}\right) = 1.63$ gm/cc

Water content %	5	10	15	20	25	30
Dry density (gm/cc)	1.68	1.80	1.82	1.81	1.72	1.63

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	(b)	**Compaction Curve : Water Content-Dry Density Curve:**		
			2	
		From above graph: 1. Optimum Moisture Content (OMC) = 15 %. 2. Maximum Dry Density (MDD) = 1.82 gm/cc.	1 1	6

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	(c)	**State field methods of compactions. Explain suitability of various compaction equipments.**		
	Ans.	**Field methods of compactions:** 1. Compaction by rolling 2. Compaction by ramming 3. Compaction by tamping 4. Compaction by vibration	½ each	
		Suitability of various compaction equipments. 1. **Smooth wheel roller:** It is suitable only for fine grained cohesive soil i.e. black cotton soil used for plinth filling, earthen dam, abutment of bridge, etc. 2. **Sheep foot roller:** These rollers are best suitable for compaction of cohesion less soils i.e. sandy soils used for sub grade or base course of road pavement. 3. **Pneumatic tyred roller:** Pneumatic tyred rollers are effective for compacting both cohesive as well as cohesion less soils. It is useful for mega projects of road, dam and bridge sites. 4. **Rammer:** Dropping weight type, internal combustion type and pneumatic type rammers are used to compact all types of soil used for light to medium structure i.e. for plinth filling, PCC etc. 5. **Tamping rod:** Tamping rod is used to compact coarse grained cohesion less soils of lesser thickness for less important construction work. 6. **Vibratory compactor:** Dropping weight type and pulsating hydraulic type vibrators compacts soil particles of sub grades and base course of both flexible and rigid pavement. It is also suitable for compacting granular soils with no fines.	1 each (any four)	6