III
YEAR
I SEM

GEOTECHNICAL ENGINEERING LAB MANUAL

DEPARTMENT OF CIVIL ENGINEERING

MLRS
EMPOWERING THROUGH INNOVATIONS

MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY AND MANAGEMENT
(AN AUTONOMOUS INSTITUTION)
(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)
Accredited by NBA and NAAC with 'A' Grade & Recognized Under Section2(f) & 12(B)of the UGC act,19

2020 - 2021

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CERTIFICATE

This is to certify that this manual is a bonafide record of practical work in the **geotechnical engineering Laboratory** in **first Semester of Third Year B. Tech (Civil) programme** during the academic year **2021-22**. The book is prepared by **Mrs B. Lavanya Asst. prof. and Mr. Basavaraj.v.deshmukh Department of Civil Engineering,**

Signature of HOD   Signature of Director   Signature of Principal

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PREFACE

This book entitled "geotechnical engineering Lab Manual" is intended for the use of third semester (i.e, III-II) B.Tech(civil) students of Marri laxman Reddy Institute of Technology and Management, Dundigal, Hyderabad. The main objective of the Soil Mechanics Lab Manual is to teach the student basic soil fundamentals in various civil engineering applications, especially in soil properties This book lays foundation of certain basic concepts and skills that can be repeatedly employed by the students in their future endeavours. The main aim of this book is to develop the habit of scientific reasoning and providing answers to all the doubts that arise during the course of conducting experiments. The book was written as per the new syllabus prescribed by the JNTUH university in a simple language. Some of the additional experiments apart from the syllabus also included in the book. These experiments will help the students to expertise in the analysis and reporting the soil quality for construction purpose. Hence, we hope this book serve for better understanding by the student community with all details of experiments

By,

Mr. B.Lavanya, Asst.professor

Mr. Basavaraj.v.deshmukh , Asst. Professor

Department of civil engineering

ACKNOWLEDGEMENT

It was really a good experience, working at Soil Mechanics lab. First I would like to thank Mr. A. Sudhakar, Asst. Professor, Department of Civil Engineering, Marri Laxman Reddy Institute of technology & Management for giving the technical support in preparing the document.

I express my sincere thanks to Mr. K. Murali, Head of the Department of Civil Engineering, Marri Laxman Reddy Institute of technology & Management, for his concern towards me and gave me opportunity to prepare Soil Mechanics laboratory manual.

I am deeply indebted and gratefully acknowledge the constant support and valuable patronage of Dr. R. Kotaiah, Director, Marri Laxman Reddy Institute of technology & Management. I am unboundedly grateful to him for timely corrections and scholarly guidance.

I express my hearty thanks to Dr. K. Venkateswara Reddy, Principal, Marri Laxman Reddy Institute of technology & Management, for giving me this wonderful opportunity for preparing the Soil mechanics laboratory manual.

At last, but not the least I would like to thanks the entire Civil Department faculties those who had inspired and helped me to achieve my goal.

By,

Mr. B.Lavanya, Asst.professor

Mr. Basavaraj.v.deshmukh Asst. Professor

Department of civil engineering

GENERAL INSTRUCTIONS

1. Students are instructed to come to Soil Mechanics laboratory on time. Late comers are not entertained in the lab.

2. Students should be punctual to the lab. If not, conducted experiments will not be repeated.

3. Students are expected to come prepared at home with the experiments which are going to performed.

4. Students are instructed to display their identity cards and apron before entering into the lab.

5. Students are instructed not to bring mobile phones to the lab.

6. The computers and other accessories used in Soil Mechanics lab should be handled with care and responsibility.

7. Any damage to the computers during the lab session is student's responsibility and penalty or fine will be collected from the student.

8. Students should update the records and lab observation books session wise. Before leaving the lab the student should get his lab observation book signed by the faculty.

9. Students should submit the lab records 2/3 days in advance to the concerned faculty members in the staffroom for their correction and return.

10. Students should not move around the lab during the lab session.

11. If any emergency arises, the student should take the permission from faculty member concerned in written format.

12. The faculty members may suspend any student from the lab session on disciplinary grounds.

SAFETY PRECAUTIONS

1. While working in the laboratory suitable precautions should be observed to prevent accidents.
2. Always follow the experimental instructions strictly.
3. Use the first aid box in case of any accident/mishap.
4. Never work in the laboratory unless a demonstrator or teaching assistant in present.

INSTITUTION VISION AND MISSION

VISION

To establish as an ideal academic institution in the service of the nation, the world and the humanity by graduating talented engineers to be ethically strong, globally competent by conducting high quality research, developing breakthrough technologies, and disseminating and preserving technical knowledge.

OUR MISSION

To fulfill the promised vision through the following strategic characteristics and aspirations:

1. Contemporary and rigorous educational experiences that develop the engineers and managers.
2. An atmosphere that facilitates personal commitment to the educational success of students in an environment that values diversity and community.
3. Prudent and accountable resource management.
4. Undergraduate programs that integrate global awareness, communication skills and team building.
5. Leadership and service to meet society's needs.
6. Education nad research partnerships with colleges, universities, and industries to graduate.
7. Education and training that prepares students for interdisciplinary engineering research and advanced problem solving abilities.
8. Highly successful alumni who contribute to the profession in the global society.

DEPARTMENT VISION, MISSION, PROGRAMME EUCATIONAL OBJECTIVES AND SPECIFIC OUTCOMES

VISION

The Civil Engineering department strives to impart quality education by extracting the innovative skills of students and to face the challenges in latest technological advancements and to serve the society.

MISSION

M-I Provide quality education and to motivate students towards professionalism

M-II Address the advanced technologies in research and industrial issues

PROGRAMME EDUCATIONAL OBJECTIVES

The Programme Educational Objectives (PEOs) that are formulated for the civil engineering programme are listed below;

PEO-I solving civil engineering problems in different circumstances PEO-II Pursue higher education and research for professional development.

PEO-III Inculcate qualities of leadership for technology innovation and entrepreneurship.

PROGRAM SPECIFIC OUUTCOMES

PSO 1 - UNDERSTANDING: Graduates will have ability to describe, analyse and solve problems using mathematical, scientific, and engineering knowledge.

PSO 2 - ANALYTICAL SKILLS: Graduates will have an ability to plan, execute, maintain, manage, and rehabilitate civil engineering systems and processes.

PSO 3 - EXECUTIVE SKILLS: Graduates will have an ability to interact and work effectively in multi disciplinary teams.

PROGRAMME OUT COMES

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE STRUCTURE, OBJECTIVES & OUTCOMES

COURSE STRUCTURE

Soil Mechanics lab will have a continuous evaluation during 5th semester for 25 sessional marks and 50 end semester examination marks.

Out of the 25 marks for internal evaluation, day-to-day work in the laboratory shall be evaluated for 15 marks and internal practical examination shall be evaluated for 10 marks conducted by the laboratory teacher concerned.

The end semester examination shall be conducted with an external examiner and internal examiner. The external examiner shall be appointed by the principal / Chief Controller of examinations

COURSE OBJECTIVE

The objective of this lab is to teach the student basic fundamentals in soil and its properties which is suitable for different types of constructions and their uses.

COURSE OUTCOME

CE318.1	Evaluate different properties of soil.
CE318.2	Evaluate different field methods in lab.
CE318.3	Analyze the water-soil interaction and properties associated with it
CE318.4	Analyze the porosity of soil and its impact on soil properties
CE318.5	Analyze the behaviour of soil subjected to direct and shear stresses.

COURSE ARTICULATION MATRIX (CO - PO / PSO MAPPING):

Program outcomes	1	2	3	4	5	6	7	8	9	10	11	12	PSO 1	PSO 2	PSO 3
CE318.1	3	3	3	3	3	3	0	0	0	0	0	3	3	3	3
CE318.2	3	3	3	3	3	3	0	0	0	0	0	3	3	3	3
CE318.3	3	3	3	3	3	3	0	0	0	0	0	3	3	3	3
CE318.4	3	3	3	3	3	3	0	0	0	0	0	3	3	3	3
CE318.5	3	3	3	3	3	3	0	0	0	0	0	3	3	3	3
Total	15	15	15	15	15	15	0	0	0	0	0	15	15	15	15
Average	3	3	3	3	3	3	0	0	0	0	0	3	3	3	3

LIST OF EXPERIMENTS

1. Atterberg Limits (Liquid Limit, Plastic Limit, and shrinkage limit)
2. a) Field density by core cutter method and

   b) Field density by sand replacement method
3. Determination of Specific gravity of soil Grain size distribution by sieve analysis
4. Permeability of soil by constant and variable head test methods
5. Standard Proctor's Compaction Test
6. Determination of Coefficient of consolidation (square root time fitting method)
7. Unconfined compression test
8. Direct shear test
9. Vane shear test
10. Differential free swell index (DFSI) test

OBJECTIVES

1. To determine the specific gravity of coarse and fine-grained soils
2. To measure the water content of soil samples using different devices
3. To classify the soil as per Indian standards
4. To calculate the number of fines available in a soil sample
5. To compute the field density and natural moisture content of soils
6. To prepare disturbed and undisturbed soil specimens
7. To draw the flow curve for a fine-grained soil sample
8. To measure the Atterberg's limits and indices of soil
9. To determine the soil parameters by conducting shear tests
10. To draw the Mohr-Coulomb failure envelope
11. To analyze the advantages and disadvantages of different shear tests
12. To know the compaction characteristics of different soils
13. To consolidate the soil sample and to calculate the coefficient of consolidation
14. To determine the specific gravity of coarse and fine-grained soils
15. To measure the water content of soil samples using different devices

OUTCOMES

After completion of this Lab Students will be able to

1. Remove the air voids from fine grained soil sample
2. Understand the importance of specific gravity in identification of soils
3. Describe the advantage of conical brass cap in removing air voids from soil sample
4. Describe the advantage of conical brass cap in removing air voids from soil sample
5. Estimate the water content of soil sample using specific gravity
6. Analyze the necessity of semi-log sheet for plotting GSD curve
7. Assess the coefficient of permeability of soil using effective diameter
8. Build the knowledge about the inter relation between the shape of GSD curve and type of soil
9. Calculate the proportions of different grain sizes
10. Able to classify the soil
11. Say the importance of dolly for getting good quality soil samples
12. Know the types of soil water and the process of removing them from soil
13. Describe the use of conical portion at the bottom of sand pouring cylinder
14. Analyze the advantage of sand replacement method over core cutter method
15. Understand different states of existence of soil in nature
16. Assess the engineering properties (i.e compressibility, shear strength and permeability) of cohesive soils roughly
17. Differentiate the index properties for cohesive and cohesion less soils
18. Say the importance of grooving plates in conducting the test
19. Differentiate the stress controlled and strain controlled devices
20. Prepare a cylindrical soil specimen of standard size and density

EXPERIMENT NO: 1

ATTERBERG LIMITS(LIQUID LIMIT, PLASTIC LIMIT, AND SHRINKAGE LIMIT)

LIQUID LIMIT

AIM: To determine the liquid limit of the given soil sample.

APPARATUS:

1. Balance
2. Liquid limit device (Casagrendes)
3. Grooving tool
4. Mixing dishes
5. Spatula 6. Electrical Oven

PROCEDURE:

1. About 120 gm of air-dried soil from thoroughly mixed portion of material passing 425 micron I.S sieve is to beobtained.
2. Distilled water is mixed to the soil thus obtained in a mixing disc to form uniform paste. The paste shall have a consistency that would require 30 to 35 drops of cup to cause closer of standard groove for sufficient length.
3. A portion of the paste is placed in the cup of LIQUID LIMIT device and spread into portion with few strokes of spatula.
4. Trim it to a depth of 1cm at the point of maximum thickness and return excess of soil to the dish.
5. The soil in the cup shall be divided by the firm strokes of the grooving tool along the diameter through the centre line of the follower so that clean sharp groove of proper dimension is formed.
6. Lift and drop the cup by turning crank at the rate of two revolutions per second until the two halves of soil cake come in contact with each other for a length of about 1 cm by flow only.
7. The number of blows required to cause the groove close for about 1 cm shall be recorded.
8. A representative portion of soil is taken from the cup for water content determination.
9. Repeat the test with different moisture contents at least three more times for blows between 10 and 40.

OBSERVATIONS:

Details of the sample: ________________

Naturalmoisturecontent: _____________ Roomtemperature: __________________

Determination Number	1	2	3	4
Container number				
Weight of container				
Weight of container + wet soil				
Weight of container + dry soil				
Weight of water				
Weight of dry soil				
Moisture content (%)				
No. of blows				

CALCULATION:

Draw a graph showing the relationship between water content (on y-axis) and number of blows (on x- axis) on semi-log graph. The curve obtained is called flow curve. The moisture content corresponding to 25 drops (blows) as read from the represents liquid limit. It is usually expressed to the nearest whole number.

RESULT Liquid limit = ________________.

PLASTIC LIMIT

AIM: To determine the plastic limit of the given soil sample.

APPARATUS:

1. Porcelain dish.
2. Glass plate for rolling thespecimen.
3. Air tight containers to determine the moisture content.
4. Balance of capacity 200gm and sensitive to0.01gm
5. Oven thermostatically controlled with interior of non-corroding material to maintain the temperature around 105^0 and 110^0C.

PROCEDURE:

1. Take about 20gm of thoroughly mixed portion of the material passing through 425 micron I.S. sieve obtained in accordance with I.S. 2720 (part1).
2. Mix it thoroughly with distilled water in the evaporating dish till the soil mass becomes plastic enough to be easily moulded withfingers.
3. Allow it to season for sufficient time (for 24 hrs) to allow water to permeate throughout the soilmass
4. Take about 10gms of this plastic soil mass and roll it between fingers and glass plate with just sufficient pressure to roll the mass into a threaded of uniform diameter throughout its length. The rate of rolling shall be between 60 and 90 strokes per minute.
5. Continue rolling till you get a threaded of 3 mmdiameter.
6. Kneed the soil together to a uniform mass andre-roll.
7. Continue the process until the thread crumbles when the diameter is 3mm.
8. Collect the pieces of the crumbled thread in air tight container for moisture content determination.
9. Repeat the test to atleast 3 times and take the average of the results calculated to the nearest whole number.

OBSERVATIONS:

Compare the diameter of thread at intervals with the rod. When the diameter reduces to 3 mm, note the surface of the thread for cracks.

Container No.			
Wt. of container + lid,W_1			
Wt. of container + lid + wet sample,W_2			
Wt. of container + lid + dry sample,W_3			
Wt. of dry sample = W_3 - W_1			
Wt. of water in the soil = W_3 - W_2			

Water content (%) = $(W_3 - W_2) / (W_3 - W_1) \square 100$			

Average Plastic Limit = ________________

Plasticity Index(Ip) = (LL-PL) = ____________

Toughness Index=I_p/I_F

Volume of calibrating container (V) in cc.

SHRINKAGE LIMIT

AIM: To determine the shrinkage limit of the given soil sample.

APPARATUS:

1. Evaporating Dish. Porcelain, about 12cm diameter with flatbottom.
2. Spatula
3. Shrinkage Dish. Circular, porcelain or non-corroding metal dish (3 no's) having a flat bottom and 45 mm in diameter and 15 mm in heightinternally.
4. Straight Edge. Steel, 15 cm inlength.
5. Glass cup. 50 to 55 mm in diameter and 25 mm in height, the top rim of which is ground smooth andlevel.
6. Glass plates. Two, each 75 □ 75 mm one plate shall be of plain glass and the other shallhaveprongs.
7. Sieves. 2mm and 425- micron ISsieves.
8. Oven-thermostatically controlled.
9. Graduate-Glass, having a capacity of 25 ml and graduated to 0.2 ml and 100 cc one markflask.
10. Balance-Sensitive to 0.01 gminimum.
11. Mercury. Clean, sufficient to fill the glass cup to over flowing. 12.Wash bottle containingdistilled water.

PROCEDURE:

Preparation of soil paste

1. Take about 100 gm of soil sample from a thoroughly mixed portion of the material passing through 425-micron I.S.sieve.
2. Place about 30 gm the above soil sample in the evaporating dish and thoroughly mixed with distilled water and make a creamypaste.
3. Use water content somewhere around the liquid limit.

Filling the shrinkage dish

1. Coat the inside of the shrinkage dish with a thin layer of Vaseline to prevent the soil sticking to thedish.
2. Fill the dish in three layers by placing approximately 1/3 rd of the amount of wet soil with the help of spatula. Tap the dish gently on a firm base until the soil flows overtheedgesandnoapparentairbubblesexist.Repeatthisprocessfor2ndand3rdlayers also till the dish is completely filled with the wet soil. Strike off the excess soil and make the top of the dish smooth. Wipe off all the soil adhering to the outside of the dish.
3. Weigh immediately, the dish with wet soil and record theweight.
4. Air- dry the wet soil cake for 6 to 8hrs, until the colour of the pat turns from dark to light.

Then oven-dry theto constant weight at 105^0C to 110^0C say about 12 to 16hrs.

5. Remove the dried disk of the soil from oven. Cool it in a desiccator. Then obtain the weight of the dish with drysample.
6. Determine the weight of the empty dish andrecord.
7. Determine the volume of shrinkage dish which is evidently equal to volume of the wet soil as follows. Place the shrinkage dish in an evaporating dish and fill the dish with mercury till it overflows slightly. Press it with plain glass plate firmly on its top to remove excess mercury. Pour the mercury from the shrinkage dish into a measuring jar and find the volume of the shrinkage dish directly. Record this volume as the volume of the wet soilpat.

Volume of the Dry Soil Pat

1. Determine the volume of dry soil pat by removing the pat from the shrinkage dish and immersing it in the glass cup full of mercury in the followingmanner.
2. Place the glass cup in a larger one and fill the glass cup to overflowing with mercury. Remove the excess mercury by covering the cup with glass plate with prongs and pressing it. See that no air bubbles are entrapped. Wipe out the outside of the glass cup to remove the adhering mercury. Then, place it in another larger dish, which is, clean and emptycarefully.
3. Place the dry soil pat on the mercury. It floats submerge it with the pronged glass plate which is again made flush with top of the cup. The mercury spills over into the larger plate. Pour the mercury that is displayed by the soil pat into the measuring jar and find the volume of the soil patdirectly.

CALCULATION:

Do not touch the mercury with gold rings.

S.No	Determination No.	1	2	3
1	Wt. of container in gm,W_1			
2	Wt. of container + wet soil pat in gm,W_2			
3	Wt. of container + dry soil pat in gm,W_3			
4	Wt. of oven dry soil pat, W_0 in gm			
5	Wt. of water in gm			
6	Moisture content (%), W			
7	Volume of wet soil pat (V), in cm			
8	Volume of dry soil pat (V_0) in cm^3			
9	By mercury displacement method a) Weight of displacedmercury b) Specific gravity of the mercury			
10	Shrinkage limit(W_S)			
11	Shrinkage ratio (R)			

VIVA:

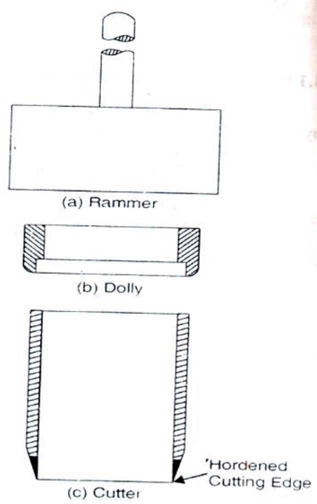
1. What is the degree of saturation at LL and PL?
2. How does oven dried soil affect the value of plastic limit?
3. If a thread of 5mm is made instead of 3mm, what is the effect on PL?
4. Define consistency of the soil. How is it measured?
5. What is liquid limit of soil?
6. What is the apparatus used to determine the liquid limit?
7. When a soil sample is given, what is the procedure to determine the liquid limit of the sample?
8. In a liquid limit test, the moisture content at 10 blows was 70% and that at 100 blows was 20%. The liquid limit of the soil, is?
9. What is the purpose of computing liquid limit of the soil?
10. With the organic matter in the soil, will the liquid limit increase or decrease?
11. Define plastic limit of soil
12. How is plastic limit computed in laboratory?
13. What is the practical significance of determining plastic limit of the soil?
14. What is plasticity index?
15. What is toughness index?
16. What is meant by unified soil classification?
17. What is A-line and U-line?
18. What is liquidity index and consistency index?
19. How to measure shrinkage limit of soil?
20. Why is mercury used to determine the shrinkage limit of soil?
21. What is the density of mercury?
22. What is the difference between undisturbed and remoulded soil?
23. Is the dry unit and unit weight of soil the same? 6. What is meant by Thixotropy?
24. What is shrinkage limit of soil?
25. If water content is increased above shrinkage limit, what is the effect?
26. Instead of Mercury can we use any other substance as mercury may cause health hazard.
27. What is liquid limit of soil?
28. What is the apparatus used to determine the liquid limit?
29. When a soil sample is given, what is the procedure to determine the liquid limit of the sample?
30. In a liquid limit test, the moisture content at 10 blows was 70% and that at 100 blows was 20%. The liquid limit of the soil, is?

EXPERIMENT NO: 2

FIELD DENSITY TEST

A) FIELD DENSITY BY CORE CUTTER METHOD

AIM: Determination of in situ density of soil by core cutter method.



APPARATUS:

1. Cylindrical core cutter
2. Straight edge
3. Steel dolly
4. Oven
5. Steel rule
6. Steel rammer
7. Balance

Fig. 2.1 Core Cutter

PROCEDURE:

1. Measure the height and internal diameter of the core cutter and calculate its volume.
2. Weigh the core cutter without dolly.
3. Clean and level the place where density is to be determined.
4. Put the dolly on the top of the cutter and drive the assembly in to the soil with the help of rammer until the top of the dolly protrude about 1.5 cm above the surface.
5. Dig out the assembly from the surrounding soil and take out the dolly.
6. Trim the top and bottom surface of the cutter and clean the outside surface of the cutter.
7. Weigh the cutter with soil.
8. Remove the soil core cutter and keep some representative soil sample in the oven for24 hours to determine the moisture content.

OBSERVATIONS:

Internal diameter of cutter (cm) =

Volume of cutter, V (cm^3) =

Height of cutter (cm) =

Mass of core cutter, W_1(gm)	=
Mass of cutter + Soil, W_2 (gm)	=
Mass of wet soil, $W_2 - W_1$(gm)	=
Moisture content bin no.	=
Mass of empty bin, M_1(gm)	=
Mass of bin + wet soil, M_2(gm)	=
Mass of bin + dry soil, M_3(gm)	=
Mass of water = M_2 - M_3(gm)	=
Mass of dry soil = M_3 - M_1(gm)	=
Moisture content, $\mathbf{m} = \dfrac{\mathbf{M_2 - M_3}}{\mathbf{M_3 - M_1}} \times 100$	=

CALCULATIONS:

Wet density of soil, $\gamma_{wet} = \dfrac{W_2 - W_1}{V}$

Dry density, $\gamma_{dry} = \dfrac{\gamma_{wet}}{1+m}$

RESULT:

VIVA:

1. What is the difference between the air dried and oven dried soil?
2. Why do you dry the soil at 105^0 to 110^0? Why not less or more than this range?
3. What do you understand by dry, wet, saturated and submerged densities? Explain
4. Out of these various types of densities, which is maximum and minimum? Explain.
5. Beside density what other properties can be obtained from the above test?
6. Which type of soils are suitable for finding density by core cutter?
7. In fully saturated soils, what is the degree of saturation?
8. What is the degree of saturation in oven dried soils?
9. Out of wet density, dry density, and saturated density, which one of them is maximum and minimum? Explain.
10. What are the main factors which affect in-situ density of soil? Explain.
11. Beside the density, what other properties do you need to calculate the void ratio and degree of saturation of soils?
12. What are the other methods to calculate the field density of soil?
13. Which is the most accurate method to determine the field density?
14. Can we use core cutter method on stony or non-cohesive soils?
15. Which method is more accurate, sand replacement method or core cutter method?
16. What is the practical application of the current test?
17. Do we get undisturbed sample using core cutter?
18. Why is field density required?
19. Out of wet density, dry density, and saturated density, which one of them is maximum and minimum? Explain
20. What is the objective of sand replacement method?
21. What is the relationship that can be established between the dry density with known moisture content?
22. What are the apparatus that are needed in this test?
23. What is the significance of determining the in-situ density of the soil?
24. Depth of hole is kept to 15 cm in the field. Why?
25. Why we need to determine the unit weight of sand to determine the unit weight of soil?
26. Which method is the accurate one, core cutter or sand replacement method as per you? And why?
27. What are the other methods to calculate the field density of soil?
28. Which is the most accurate method to determine the field density?
29. Can we use core cutter method on stony or non-cohesive soils?
30. Which method is more accurate, sand replacement method or core cutter method?
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48. What do you understand by dry, wet, saturated and submerged densities? Explain
49. Out of these various types of densities, which is maximum and minimum? Explain
50. Beside density what other properties can be obtained from the above test?

B) FIELD DENSITY BY SAND REPLACEMENT METHOD

AIM: Determine the in-situ density of natural or compacted soils using sand pouring cylinders.

APPARATUS:

1. Sand pouring cylinder of 3 litre/16.5 litre capacity, mounted above a pouring come and separated by a shutter coverplate.
2. Tools for excavating holes; suitable tools such as scraper tool to make a level surface.
3. Cylindrical calibrating container with an internal diameter of 100 mm/200 mm and an internal depth of 150 mm/250 mm fitted with a flange 50 mm/75 mm wide and about 5 mm surrounding the openend.
4. Balance to weigh unto an accuracy of1g.
5. Metal containers to collect excavatedsoil.
6. Metal tray with 300 mm/450 mm square and 40 mm/50 mm deep with a100 mm/200 mm diameter hole in thecentre.
7. Glass plate about 450 mm/600 mm square and 10mmthick.
8. Clean, uniformly graded natural sand passing through 1.00 mm I.Ssieve and retained on the 600micron I.Ssieve. It shall be free from organic matter and shall have been oven dried and exposed to atmospherichumidity.
9. Suitable non-corrodible airtightcontainers.
10. Thermostatically controlled oven with interior on non-corroding material to maintain the temperature between 105^0C to110^0C.
11. A desiccator with any desiccating agent other than sulphuricacid.

PROCEDURE:

Calibration of the Cylinder

1. Fill the sand pouring cylinder with clean sand so that the level of the sand in the cylinder is within about 10 mm from the top. Find out the initial weight of the cylinder plus sand (W_1) and this weight should be maintained constant throughout the test for which the calibration isused.
2. Allow the sand of volume equal to that of the calibrating container to run out of the cylinder

by opening the shutter, close the shutter and place the cylinder on theglass

3. sand takes place in the cylinder close the shutter and remove the cylinder carefully. Weigh the sand collected on the glass plate. Its weight(W_2) gives the weight of sand filling the cone portion of the sand pouring cylinder.Repeat this step at least three times and take the mean weight (W_2) Put the sand back into the sand pouring cylinder to have the same initial constant weight (W_1)
4. Determination of Bulk Density of Soil
5. Determine the volume (V) of the container be filling it with water to thebrim. Check this volume by calculating from the measured internal dimensions of the container.
6. Place the sand poring cylinder centrally on the of the calibrating container making sure that constant weight (W_1) is maintained. Open the shutter and permit the sand to run into the container. When no further movement of sand is seen close the shutter, remove the pouring cylinder and find its weight(W_3).

Determination of Dry Density of Soil In Place

7. Approximately 60 sqcm of area of soil to be tested should be trimmed down to a level surface, approximately of the size of the container. Keep the metal tray on the level surface and excavate a circular hole of volume equal to that of the calibrating container. Collect all the excavated soil in the tray and find out the weight of the excavated soil (W_w). Remove the tray, and place the sand pouring cylinder filled to constant weight so that the base of the cylinder covers the hole concentrically. Open the shutter and permit the sand to run into the hole. Close the shutter when no further movement of the sand is seen. Remove the cylinder and determine its weight(W_3).
8. Keep a representative sample of the excavated sample of the soil for water content determination.

OBSERVATIONS AND CALCULATIONS:

S. NO.	CALIBRATION	1	2	3
1	Weight of sand in cone (of pouring cylinder) W_2 gm			
2	Volume of calibrating container (V) in cc			
3	Weight of sand + cylinder before pouring W_3gm			
4	Weight of sand + cylinder after pouring W_3gm			
5	Weight of sand to fill calibrating containers $W_a = (W_1 - W_3 - W_2)$ gm			
6	Bulk density of sand $g_s = W_a / V$ gm/cc			

S. NO.	MEASUREMENT OF SOIL DENSITY	1	2	3
1	Weight of wet soil from hole W_w gm			
2	Weight of sand + cylinderbefore pouring W_1 gm			
3	Weight of sand + cylinder after pouring W_4gm			
4	Weight of sand in hole $W_b = (W_1 - W_2 - W_4)$ gm			

5	Bulk density $g_b = (W_w / W_b)\ g_s$ gm/cc			
6	Water content determination			
7	Container number			
8	Weight of wet soil			
9	Weight of dry soil			
10	Moisture content (%) Dry density $g_d = g_b / (1+w)$ gm/cc			

REMARKS:

1.While calibrating the bulk density of sand great care has to betaken.
2.The excavated hole must be equal to the volume of the calibratingcontainer.

VIVA:

1. Why do we keep the depth of the excavated hole equal to the height of calibrating can?
2. What happens if the conical portion is not there at the bottom of pouring cylinder?
3. What is the range of bulk density of sand in loose state?
4. What is the difference between the air dried and oven dried soil?
5. Why do you dry the soil at 105^0 to 110^0? Why not less or more than this range?
6. What do you understand by dry, wet, saturated and submerged densities? Explain
7. Out of these various types of densities, which is maximum and minimum? Explain.
8. Beside density what other properties can be obtained from the above test?
9. Which type of soils are suitable for finding density by core cutter?
10. In fully saturated soils, what is the degree of saturation?
11. What is the degree of saturation in oven dried soils?
12. Out of wet density, dry density, and saturated density, which one of them is maximum and minimum? Explain.
13. What are the main factors which affect in-situ density of soil? Explain.
14. Beside the density, what other properties do you need to calculate the void ratio and degree of saturation of soils?
15. What are the other methods to calculate the field density of soil?
16. Which is the most accurate method to determine the field density?
17. Can we use core cutter method on stony or non-cohesive soils?
18. Which method is more accurate, sand replacement method or core cutter method?
19. What is the practical application of the current test?
20. Do we get undisturbed sample using core cutter?
21. Why is field density required?
22. Out of wet density, dry density, and saturated density, which one of them is maximum and minimum? Explain
23. What is the objective of sand replacement method?
24. What is the relationship that can be established between the dry density with known moisture content?
25. What are the apparatus that are needed in this test?
26. What is the significance of determining the in-situ density of the soil?
27. Depth of hole is kept to 15 cm in the field. Why?
28. Why we need to determine the unit weight of sand to determine the unit weight of soil?

29. Which method is the accurate one, core cutter or sand replacement method as per you? And why?
30. What are the other methods to calculate the field density of soil?
31.
32. What is the degree of saturation in oven dried soils?
33. Out of wet density, dry density, and saturated density, which one of them is maximum and minimum? Explain.
34. What are the main factors which affect in-situ density of soil? Explain.
35. Beside the density, what other properties do you need to calculate the void ratio and degree of saturation of soils?
36. What are the other methods to calculate the field density of soil?
37. Which is the most accurate method to determine the field density?
38. Can we use core cutter method on stony or non-cohesive soils?
39. Which method is more accurate, sand replacement method or core cutter method?
40. What is the practical application of the current test?
41. Do we get undisturbed sample using core cutter?
42. Why is field density required?
43. Out of wet density, dry density, and saturated density, which one of them is maximum and minimum? Explain
44. What is the objective of sand replacement method?
45. What is the relationship that can be established between the dry density with known moisture content?
46. What are the apparatus that are needed in this test?
47. What are the main factors which affect in-situ density of soil? Explain.
48. Beside the density, what other properties do you need to calculate the void ratio and degree of saturation of soils?
49. What are the other methods to calculate the field density of soil?
50. Which is the most accurate method to determine the field density?
51. Can we use core cutter method on stony or non-cohesive soils?
52. Which method is more accurate, sand replacement method or core cutter method?
53. What is the practical application of the current test?
54. Do we get undisturbed sample using core cutter?
55. Why is field density required?

EXPERIMENT NO: 3

DETERMINATION OF SPECIFIC GRAVITY OF SOIL GRAIN SIZE DISTRIBUTION BY SIEVE ANALYSIS

A) DETERMINATION OF SPECIFIC GRAVITY

AIM: Determine the specific gravity of soil fraction passing 4.75 mm I.S sieve by density bottle.

APPARATUS REQUIRED: Density bottle of 50 ml with stopper having capillaryhole, Balance to weigh the materials (accuracy10gm), Wash bottle with distilledwater, Alcohol andether.

PROCEDURE:

1. Clean and dry the densitybottle
   a. wash the bottle with water and allow it todrain.
   b. Wash it with alcohol and drain it to removewater.
   c. Wash it with ether, to remove alcohol and drainether.

Fig 1.1 Density bottle

2. Weigh the empty bottle with stopper(W_1).
3. Take about 10 to 20 gm of oven soil sample which is cooled in a desiccator. Transfer it to the bottle. Find the weight of the bottle and soil(W_2).
4. Put 10ml of distilled water in the bottle to allow the soil to soak completely. Leave it for about 2hours.
5. Again, fill the bottle completely with distilled water put the stopper and keep thebottle under constant temperature water baths (T_x^0).
6. Take the bottle outside and wipe it clean and dry note. Now determine the weight of thebottle and the contents(W_3).
7. Now empty the bottle and thoroughly clean it. Fill the bottle with only distilled waterand weigh it. Let it be W_4 at temperature$_x$(T ^{0}C).

8. Repeat the same process for 2 to 3 times, to take the average reading ofit.

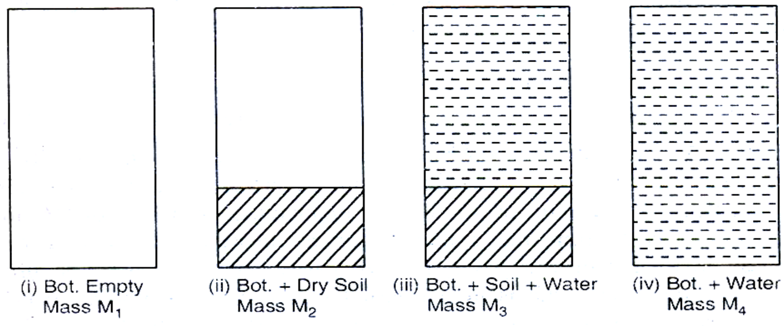

Fig.1.2 Specific Gravity Computation.

OBSERVATIONS:

S.NO	OBSERVATION NUMBER	1	2	3
1	Weight of density bottle (W_1 g)			
2	Weight of density bottle + dry soil (W_2g)			
3	Weight of bottle + dry soil + water (W_3 g)			
4	Weight of bottle + water (W_4 g)			

RESULT: specific gravity of soil -------------

Unless or otherwise specified specific gravity, values reported shall be based on water at 27^{0}C.

The specific gravity of the soil particles liewithin the range of 2.65 to 2.85. Soils containing organic matter and porous particles may have specific gravity values below
2 0. Soils having heavy substances may have values above 3.0.

VIVA:

1. What is the difference between air dried and oven dried soil?
2. How do you remove entrapped air in specific gravity test?
3. What is the range of specific gravity for fine grained soils?
4. If specific gravity is determined using kerosene, what modifications should we make in the experiment?
5. Is there any advantage in using kerosene in place of water? State, if any.
6. If the entrapped air is not completely removed, how will it effect the value of specific gravity?
7. What are the standard values of specific gravity?
8. Do we need to conduct this test? Why?
9. What is your inference on the result obtained?
10. Can we use this method for all types of soils?

11. Write phase diagrams for a) Dry soil b) Saturated soil
12. Why we need to compute the specific gravity of soil?
13. What is the unit of specific gravity?
14. What is specific gravity of water?
15. Explain the steps required to determine specific gravity by Pycnometer method
16. What are the calculations required in computing specific gravity by Pycnometer method?
17. Which method is accurate in determining specific gravity of soil solids?
18. What are the steps involved in determining specific gravity using density bottle method?
19. How much grams of soil need to be taken for the test?
20. What is the specification required for the test?
21. What is the equation to determine the specific gravity?
22. Can we use kerosene instead of water to determine specific gravity of soil?
23. Could we do classification of soil based on the specific gravity of soil?
24. Could there be entrapped air in the soil sample?
25. What are the various sources of error in this experiment, if any?
26. What are the applications in geotechnical engineering where the specific gravity is used?
27. Water content is also called?
28. Which method is mostly used to determine the water content in field?
29. What is water content for clay soil?
30. Can we use this method for all types of soils?
31. Write phase diagrams for a) Dry soil b) Saturated soil
32. Why we need to compute the specific gravity of soil?
33. What is the unit of specific gravity?
34. What is specific gravity of water?
35. Explain the steps required to determine specific gravity by Pycnometer method
36. What are the calculations required in computing specific gravity by Pycnometer method?
37. Which method is accurate in determining specific gravity of soil solids?
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41. What is the equation to determine the specific gravity
42. Is there any advantage in using kerosene in place of water? State, if any.
43. If the entrapped air is not completely removed, how will it effect the value of specific gravity?
44. What are the standard values of specific gravity?
45. Do we need to conduct this test? Why?
46. What is your inference on the result obtained?
47. Can we use this method for all types of soils
48. What is specific gravity of water?
49. Explain the steps required to determine specific gravity by Pycnometer method
50. What are the calculations required in computing specific gravity by Pycnometer method?

B) GRAIN SIZE DISTRIBUTION BY SIEVE ANALYSIS

AIM: To determine therelative proportions of different grain sizes which make up a given soil mass.

APPARATUS: Balance**,** I.S sieves**,** Rubber pestle andmortar, mechanical SieveShaker

PROCEDURE:

1. For soil samples of soil retained on 75 micron I.Ssieve

(a) The proportion of soil sample retained on 75 micron I.S sieve is weighed, and recorded weight of soil sample is as per I.S 2720.
(b) I.S sieves are selected and arranged in the order as shown in thetable.
(c) The soil sample is separated into various fractions by sieving through above sieves placed in the above-mentionedorder.
(d) The weight of soil retained on each sieve isrecorded.
(e) The moisture content of soil if above 5% it is to be measured andrecorded.

2. No particle of soil sample shall be pushed through thesieves.

OBSERVATIONS:

Weight of soil sample: Moisture content:

I.S sieve number or sizein mm	Wt. Retained in each sieve (gm)	Percentage on each sieve	Cumulative %age retained on each sieve	% finer	Remarks
4.75					
4.00					

3.36					
2.40					
1.46					
1.20					
0.60					
0.30					
0.15					
0.075					

CALCULATION:

1. The percentage of soil retained on each sieve shall be calculated on the basis of total weight of soil sampletaken.
2. Cumulative percentage of soil retained on successive sieve isfound.

VIVA:

1. What is the purpose of sieve analysis?
2. Can you classify all types of soils by sieve analysis?
3. What do you understand by well graded and uniformly graded soils?
4. Why do you use semi – log graph for plotting GSD curve?
5. Draw the GSD curves for poorly, well and uniformly graded soils?
6. What do you understand by GW, GP, GM, GC, SW, SP, SM, and SC in soil classification?
7. What are the considerations to fix the quantity of soil to be taken for sieve analysis?
8. What is meant by gap graded soil?
9. What is the effective diameter of soil? Why does it consider as effective diameter?
10. How many samples are to be collected and why?
11. What is the advantage of sand replacement method over core cutter method?
12. What is the practical application of the test?
13. Define the grain size analysis and what is the silt size?
14. What is uniformity coefficient? What is the significance on computing the same?
15. What is the most basic classification of soil?
16. What are the methods of soil gradation or grain size distribution?
17. How to compute D10, D30 and D60 of soil using sieve analysis?
18. How to compute CC and Cu?
19. What is poorly graded, gap graded and well graded soil?
20. Does grain distribution affect the voids ratio of the soil?
21. Could the quality of concrete have enhanced by the grade of the sand?
22. If soil is uniformly graded, voids ratio is high or low?
23. Well graded aggregates require less cement or more?
24. What is the practical significance of Grain Size Distribution Analysis?
25. What is the practical application of the test?
26. Define the grain size analysis and what is the silt size?
27. What is uniformity coefficient? What is the significance on computing the same?
28. What is the most basic classification of soil?
29. What are the methods of soil gradation or grain size distribution?

30. Does grain distribution affect the voids ratio of the soil?
31. How many samples are to be collected and why?
32. What is the advantage of sand replacement method over core cutter method?
33. What is the practical application of the test?
34. Define the grain size analysis and what is the silt size?
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44. Well graded aggregates require less cement or more?
45. What is the practical significance of Grain Size Distribution Analysis?
46. What is the practical application of the test?
47. What is the purpose of sieve analysis?
48. Can you classify all types of soils by sieve analysis?
49. What do you understand by well graded and uniformly graded soils?
50. Why do you use semi – log graph for plotting GSD curve?
51. Draw the GSD curves for poorly, well and uniformly graded soils?
52. What do you understand by GW, GP, GM, GC, SW, SP, SM, and SC in soil classification?

EXPERIMENT NO: 4

PERMEABILITY OF SOIL BY CONSTANT AND VARIABLE HEAD TEST METHODS

A) PERMEABILITY OF SOIL BY CONSTANT TEST METHODS

AIM: To determine the co-efficient of permeability of coarse grained soils.

APPARATUS:

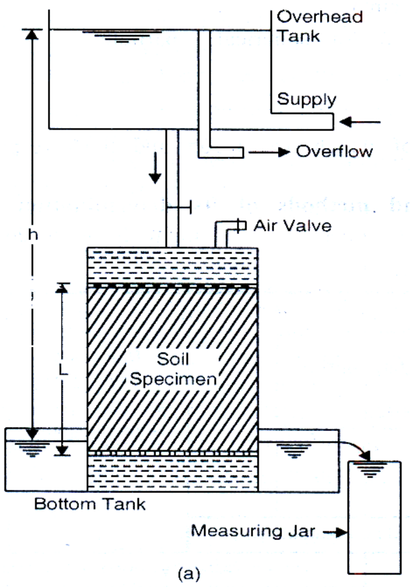
1. Permeability mould with a detachable base plate, removable extension collar, drainage base, dummy plate and drainage cap.
2. Porous plate
3. Compaction rammer
4. Constant head tank
5. Metal ring
6. Other – rubber, measuring jars, stop watch, balance etc.

THEORY:

If Q is the total quantity of flow in a time interval‘t’ through a soil sample of length ‘L’ and cross-sectional area ‘A’ under a hydraulic head ‘h’ then from Darcy’s Law:

$$q = \frac{Q}{t} = \mathrm{kiA}$$

$$\mathrm{k} = \frac{Q}{t} \times \frac{L}{h} \times \frac{1}{A}$$



When the steady state of flow is reached the total quantity of water Q collected in time‘t’ in jar is measured. L, h and A are constant for a particularset.

PREPARATION OF SPECIMEN:

REMOULDED SAMPLE:

1. Choose the moisture content (w) and dry density (γ_d) at which the specimen has to be remoulded from the compaction curve obtained from Proctor test.

Fig.4.1 Constant Head Permeameter

2. For a given volume (V) of the mould, calculate the weight (W) of the soil mix by the following expression

$$W = \gamma_d (1+w) V$$

3. Mix the soil with water thoroughly.
4. Place the permeameter mould upside down on the dynamic compaction base and put collar to the other end.
5. Fill the soil mix in the mould and compact it in three layers, giving 25 blows to each layer by rammer of wt. 2.6 kg and free fall of 310 mm
6. Remove the collar and trim off the excess soil.
7. Keep a filter paper on the top of the soil specimen and fix the perforated base plate to it.
8. Turn the assembly upside down and remove the compaction plate. Place the top perforated plate on the specimen and fix the top cap. The specimen is now ready for testing.

PROCEDURE:

1. Place the mould assembly in the bottom tank and connect the out let tube of the constant head tank to the nozzle of permeameter.
2. Open the outlet valve and allow the water to flow through the specimen till the steady state of flow is established.
3. Measure the quantity of water flowing out of the constant head tank in a convenient time intervals’.
4. Repeat steps 2 and 3 twice more for the same time interval‘t’.
5. Measure the head ‘h’ and temperature ‘T’ of the laboratory.

OBSERVATIONS AND CALCULATIONS:

Moulding water content = Dry density, γ_d =

Volume, V (cm^3) = Mass, M (gm) =

Hydraulic head, h (cm)	=
Length of the sample, L (cm)	=
Cross-sectional area, A (cm^2)	=
Quantity of flow (Q): I test, (ml) II test, (ml) III test, (ml)	= = =
Time interval, t(sec) =	
Hydraulic gradient, i	=
Co-efficient of permeability, (cm/sec) $k = \frac{Q}{t} \times \frac{L}{h} \times \frac{1}{A}$	=
Permeability at 27^0C, $K_{27} = K\frac{\eta}{\eta_{27}}$ (cm/sec)	=

B) PERMEABILITY OF SOIL BYVARIABLE HEAD TEST METHOD

AIM: To determine the co-efficient of permeability of fine grained soils**.**

APPARATUS:

1. Permeability mould with a detachable base plate, removable extension collar, drainage base, dummy plate and drainage cap.
2. Porous plate
3. Compaction rammer
4. Glass standpipes with measuring scales
5. Metal ring
6. Other – rubber, measuring jars, stop watch, balance etc.

THEORY:

In this method a standpipe pf cross-sectional area ‘a’ filled with water is fitted over the Permeameters and water is allowed to run down. If the hydraulic head falls down from ‘h_1’ to ‘h_2’ in time interval ‘t’, co-efficient of permeability ‘k’ is given by the following equation:

$$k = \frac{2.3aL}{At}\log_{10}\frac{h_1}{h_2}$$

PROCEDURE:

Place the mould assembly in the bottom tank and connect the water inlet nozzle of the mould to the standpipe.

Allow water to flow for some time till steady state of flow is reached

Note the time required for water level to fall down from a known initial head (h_1) to a known final head (h_2). Repeat this step at least twice and determine the time required for water level to fall from h_1 to h_2.

For determining the cross-sectional area 'a' of the standpipe, collect the quantity of water contained in between two graduations of known distance apart. The weight of water in grams divided by the distance in cm, between the graduations will give the area of cross section of standpipe.

OBSERVATIONS AND CALCULATIONS:

1	Length of the sample, L (cm)	
2	Cross-sectional area, A (cm^2)	
3	Initial head, h_1 (cm)	
4	Final head, h_2 (cm)	
5	Area of standpipe, a (cm^2)	
6	Time interval, t : I test, (sec) II test, (sec) III test, (sec)	
7	Co-efficient of permeability, (cm/sec) $k = \frac{2.3\text{aL}}{\text{A}} \log_{10} \frac{h_1}{h_2}$	
8	Permeability at 27^0C, $K_{27} = K \frac{\eta}{\eta_{27}}$ (cm/sec)	

DISCUSSION:

TYPE OF SOIL	VALUE OF 'k' (cm/sec)
1. Clean gravel	10^2 - 1.0
2. Clean sand, sand and gravel mix	1.0 – 10^{-2}
3. Fine sand, silt, mixture of silt and clay	10^{-3} - 10^{-7}

4.	Homogeneous clay	$<10^{-7}$

VIVA:

1. What type of flow do you expect in soils?
2. What is the effect of temperature of water on the coefficient of permeability?
3. What is the unit permeability?
4. What is the effect of entrapped air voids of soils on the permeability?
5. How do you ensure the removal of air during experiment?
6. For fine soils which method of permeability test is suitable and why?
7. How do the permeability effects the consolidation of a soil?
8. Define Permeability?
9. What are the units of Permeability?
10. Define Coefficient of Permeability?
11. Which soil will have more Permeability?
12. If the permeability of the soil is 0.8 mm/s, the type of soil is?
13. Constant head permeameter is used to test permeability of ______________ ?
14. Falling head permeameter is used to test permeability of _______________ ?
15. Coefficient of permeability of the soil increases with increase in _______?
16. Define MDD, OMC?
17. Application of Compaction test?
18. Name some Index & Engineering Properties of the soil?
19. Density is an Index or Engineering Property?
20. What is the difference between Dynamic Compaction an Modified Compaction test?
21. What are the uses of density?
22. List ‘k’ values for different types of soils.
23. How permeability test is done in the field?
24. Mention other permeability tests that can be done in the lab.
25. What is the application of permeability of soils?
26. Derive the expression for ‘k’ by falling head method.
27. Is hydraulic gradient constant in variable head test? Why?
28. How will you reduce observed permeability to permeability at standard temperature?
29. What is the necessity of two methods for determination of ‘k’ in lab?
30. Estimate discharge velocity in constant head test conducted. What is seepage velocity?
31. Time interval for flow from h1to h0 should be same as that from h0 to h2 Why?
32. For fine soils which method of permeability test is suitable and why?
33. How do the permeability effects the consolidation of a soil?
34. Define Permeability?
35. What are the units of Permeability?
36. Define Coefficient of Permeability?
37. Which soil will have more Permeability?
38. If the permeability of the soil is 0.8 mm/s, the type of soil is?
39. Constant head permeameter is used to test permeability of ______________ ?
40. Falling head permeameter is used to test permeability of _______________ ?
41. Coefficient of permeability of the soil increases with increase in _______?
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48. List ‘k’ values for different types of soils.
49. How permeability test is done in the field?
50. Mention other permeability tests that can be done in the lab.
51. What is the application of permeability of soils?
52. Derive the expression for ‘k’ by falling head method.

EXPERIMENT NO: 5

STANDARD PROCTOR’S COMPACTION TEST

AIM: To determine the maximum dry density and optimum water content of soil sample by using Proctor compaction equipment.

APPARATUS:

1. Cylindrical mould (capacity 1000 cm^3)
2. Rammer (2.6 kg)
3. Mould accessories(detachable base, plate with removable collar)
4. Other-IS sieve, balance, oven, moisture container, straight edge, mixing tools, etc.

THEORY:

It is a quantitative test developed by Proctor in 1933 in connection with the construction of an earthen dam. If the soil is properly mixed with water and compacted there is a marked improvement in engineering properties.

Compaction means rapid reduction in air voids by mechanical means with water leading to a consequent increase in dry density and the bearing capacity of a soil. It also reduces the compressibility and permeability of the soil.

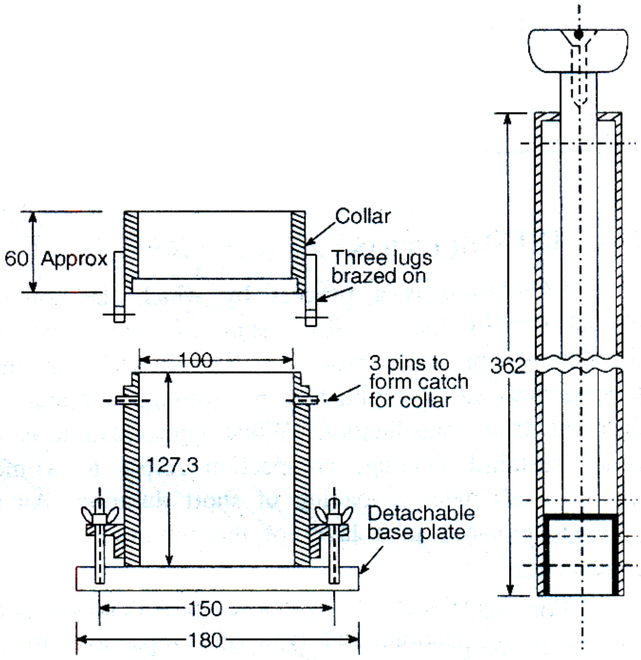

Fig.5.1 Proctor Compaction Mould and Rammer

PROCEDURE:

1. Take about 20kg of oven dried soil.
2. Sieve this soil through 4.75mm sieve. Take 2.5 kg of the soil and add water to it bringing its moisture content to about 4% in case of coarse grained soils and 8% in fine grained soils.
3. Clean, dry and grease the mould and base plate. Weigh the mould with base plate. Fit the collar
4. Compact the wet soil in three layers by the rammer with 25 evenly distributed blows in each layer.
5. Remove the collar and trim off the soil flush with the top of the mould. While removing the collar, rotate it to break the bond between it and soil before lifting it off the mould.
   Clean the outside of the mould and weigh the mould with soil and base plate.
6. Remove the soil from the mould.
7. Repeat the above procedure with 8, 12, 16 and 20% 0f water content for coarse grained fresh soil samples and 14, 18, 22 and 26 % of water content for fine grained fresh soil samples

OBSERVATIONS:

Height of mould, cm =   Diameter of mould, cm =

Volume of mould, cm^3 =

No.of trials	1	2	3	4	5
Empty weight of mould, W_1 Weight of mould + compacted soil, W_2 Water content (added), w (%) Wt of compacted soil, $W = W_2 - W_1$					

1. Plot a curve between percentage of water content water content and dry density and find optimum moisture content and maximum dry density.
2. Find void ratio, $e = \frac{G.\gamma_w}{\gamma_d} - 1$
3. Plot zero air voids (100% saturation) line.

VIVA:

1. Differentiate between compaction and consolidation of soils
2. What is OMC?
3. What are wet side and dry side of optimum? Which side is preferable for field compaction?
4. Write the differences between Standard and Modified Proctor's test
5. If water content is increased above shrinkage limit, what is the effect?
6. Instead of Mercury can we use any other substance as mercury may cause health hazard.
7. What is the difference between standard proctor test and modified proctor test?
8. What is relative density of soil?
9. What is voids ratio? What is zero air voids line?
10. What is the practical implication of conducting standard proctor test?
11. How to determine OMC of soil? Explain.
12. How is compaction different from consolidation?
13. Did you watch any civil engineering construction compaction is carried out? Explain.
14. Is there any other method other than standard proctor test to determine maximum density?
15. The standard proctor test was developed by___________
16. The compaction process can be accomplished by___________process.
17. The compaction energy used for standard proctor test is___________
18. A line showing the water content dry density relation for the compacted soil is___________
19. The initial percentage of water content taken for coarse-grained soil in proctor test is__________

20. The water content corresponding to the maximum density in compaction curve is called____________
21. The modified compactor test is also known as_________
22. In standard compactor test, soil is compacted into_____________layers.
23. If water content is increased above shrinkage limit, what is the effect?
24. Instead of Mercury can we use any other substance as mercury may cause health hazard.
25. What is the difference between standard proctor test and modified proctor test?
26. What is relative density of soil?
27. What is voids ratio? What is zero air voids line?
28. What is the practical implication of conducting standard proctor test?
29. How to determine OMC of soil? Explain.
30. How is compaction different from consolidation?
31. Did you watch any civil engineering construction compaction is carried out? Explain.
32. Is there any other method other than standard proctor test to determine maximum density?
33. The standard proctor test was developed by___________
34. The compaction process can be accomplished by___________process.
35. The compaction energy used for standard proctor test is___________
36. A line showing the water content dry density relation for the compacted soil is___________
37. The initial percentage of water content taken for coarse-grained soil in proctor test is__________
38. The water content corresponding to the maximum density in compaction curve is called____________
39. The modified compactor test is also known as_________
40. In standard compactor test, soil is compacted into_____________layers.
41. If water content is increased above shrinkage limit, what is the effect?
42. Instead of Mercury can we use any other substance as mercury may cause health hazard.
43. What is the difference between standard proctor test and modified proctor test?
44. What is relative density of soil?
45. What is voids ratio? What is zero air voids line?
46. What is the practical implication of conducting standard proctor test?
47. How to determine OMC of soil? Explain.
48. How is compaction different from consolidation?
49. What is OMC?
50. What are wet side and dry side of optimum? Which side is preferable for field compaction?

EXPERIMENT NO: 6

DETERMINATION OF COEFFICIENT OF CONSOLIDATION (SQUARE ROOT TIME FITTING METHOD)

AIM: To determine co-efficient of consolidation of given soil.

APPARATUS:

1. Consolidometer
2. Porous stones
3. Loading device consisting of loading frame, lever frame, loading yoke and loads
4. Water reservoir
5. Soil trimming tools
6. Other- balance, stopwatch, dial gauge, oven, desiccators, sample container etc.

THEORY:

The reduction in volume of soil mass under pressure is known as compression which occurs due to a decrease in the volume of voids. When voids are filled with air alone, the compression of soil occurs rapidly because air is compressible and can escape easily from the voids. In saturated soil mass having its voids filled with incompressible water, decrease in volume or compression can take place when water is expelled out of the voids. This reduction in volume of saturated soil mass which is due principally to a squeezing out of water from the voids is termed as primary consolidation.

Co-efficient of consolidation (C_v): the rate of settlement can be estimated with the help of C_v

Preparation of specimen:

1. Undistributed specimen:

The undistributed sample of required size from a large size block of undistributed soil sample obtained from field. For obtaining consolidation sample, insert carefully, the specimen ring into the large block of undistributed sample, by pressing it with hands. Trim the sample and flush it with the top and bottom of the ring. Take the weight of the ring containing soil sample. Keep three specimens of soil in the oven, for water content determination. If the undistributed sample is collected in the sampling tube of the same diameter of specimen ring, the sample is directly to the consolidation ring, with the help of extractor.

2. Remoulded sample:

For obtaining remoulded sample, compact the soil at desired water content and dry density in a separate mould and prepare the specimen as explained in undistributed spacemen preparation.

3. Assembling of mould and saturation of sample:

1. Immerse the porous stones in distilled water and boil it for fifteen minutes. Assemble the consolidometer and mount it on the loading platform of the load frame.
2. Position the dial gauge to measure vertical settlement of the specimen.
3. Connect the mould assembly to the water reservoir and saturate the specimen, by allowing the water to flow through it. Keep the level of water in the reservoir just above the level of the soil sample.
4. Apply an initial seating load of 0.05 kg/cm^2, for ordinary soils to prevent swelling of the sample during saturation and allow this load to stand till these is no change in dial gauge reading or maximum 24 hrs.

PROCEDURE:

1. Re-set the dial gauge to zero and apply a load to transmit a pressure of 0.25 kg/cm^{2}on the soil sample.
2. Start a stop watch and record the compression dial reading at various time interval
3. Keep this load for 24 hrs. and record the final settlements.
4. increase the pressure to 0.5 kg/cm^2 and repeat step 2 and 3
5. Similarly apply pressure of intensity of 1, 2, 4 and 8 kg/cm^2 or desired pressure intensity and take the settlement reading as explained in step 2 and 3
6. After the final reading for last load is taken, decrease the load in four equal stages to the initial seating load.

OBSERVATIONS:

a. Dimension of sample
b. Density of sample
c. Thickness of sample

Time (t) minutes	$\sqrt{t}$	Dial gauge readings

CALCULATION:

Plot a graph between $\sqrt{t}$ and on X-axis and dial gauge readings on y-axis.

The co-efficient of consolidation is calculated as follows:

$$Cv = \frac{0.848\,\mathrm{H}^2}{t_{90}}$$

H- Length of drainage path

t_{90}- time for 90% consolidation.

RESULT: co-efficient of consolidation $c_v =$

VIVA:

1. What is the use of Cv? When it is used?
2. Can permeability be determined from consolidation test indirectly?
3. Which type of permeability test can be done directly? Explain.
4. What result do you expect if a consolidation test is conducted on sand?
5. Suppose loading pad is placed such that it touches the sides of the ring. What will happen?
6. Define consolidation.
7. Differentiate consolidation and compaction.
8. What are the units of the coefficient of consolidation?
9. What are the methods for determination of coefficient of consolidation?
10. What is the formula for determination of coefficient of consolidation?
11. What is meant by compaction?
12. What are the factors effecting consolidation?
13. What is cv?
14. Differentiate between compaction and consolidation of soils
15. What is OMC?
16. What are wet side and dry side of optimum? Which side is preferable for field compaction?
17. Write the differences between Standard and Modified Proctor’s test
18. If water content is increased above shrinkage limit, what is the effect?
19. Instead of Mercury can we use any other substance as mercury may cause health hazard.
20. What is the difference between standard proctor test and modified proctor test?
21. What is relative density of soil?
22. What is voids ratio? What is zero air voids line?
23. What is the practical implication of conducting standard proctor test?
24. How to determine OMC of soil? Explain.
25. How is compaction different from consolidation?
26. Did you watch any civil engineering construction compaction is carried out? Explain.
27. Is there any other method other than standard proctor test to determine maximum density?
28. The standard proctor test was developed by____________
29. The compaction process can be accomplished by____________process.
30. The compaction energy used for standard proctor test is____________
31. If water content is increased above shrinkage limit, what is the effect?
32. Instead of Mercury can we use any other substance as mercury may cause health hazard.
33. What is the difference between standard proctor test and modified proctor test?
34. What is relative density of soil?
35. What is voids ratio? What is zero air voids line?

36. What is the practical implication of conducting standard proctor test?
37. How to determine OMC of soil? Explain.
38. How is compaction different from consolidation?
39. Did you watch any civil engineering construction compaction is carried out? Explain
40. Suppose loading pad is placed such that it touches the sides of the ring. What will happen?
41. Define consolidation.
42. Differentiate consolidation and compaction.
43. What are the units of the coefficient of consolidation?
44. What are the methods for determination of coefficient of consolidation?
45. What is the formula for determination of coefficient of consolidation?
46. What is meant by compaction?
47. What are the factors effecting consolidation?
48. What is cv?
49. Differentiate between compaction and consolidation of soils
50. What is OMC?

EXPERIMENT NO: 7

UNCONFINED COMPRESSION TEST

AIM: Determination of unconfined compressive strength of cohesive soil sample.

APPARATUS:

1. Unconfined compression apparatus(screw jack with load measuring device).
2. Sample extractor
3. Split mould of internal diameter 38 mm and 76mm long
4. Vernier callipers.

THEORY:

The unconfined compressive strength is defined as the ratio of failure load to cross-sectional area of the soil sample when it is subjected to any lateral pressure.

$$q_u = \frac{P}{A_c}$$

$$A_c = \frac{A_0}{1-\in}\ , \ \in = \frac{\Delta L}{L_0}$$

Where q_u =unconfined compressive strength P = failure load

A_c= corrected load at failure ΔL = change in length

A_0 = initial area L_0 = initial length of sample.

This test is un-drained, since the rate of loading does not allow dissipation of pore water pressure.

Sensitivity is defined as the ratio of unconfined compressive strength of undisturbed soil sample to the unconfined compressive strength of remoulded sample at constant moisture content.

$$\text{Sensitivity} = \frac{(q_u)\text{undisturbed}}{(q_u)\text{remoulded}}$$

Cohesion of the soil sample may be calculated by using the following relations:

$$\sigma_1 = \sigma_3 \tan^2\alpha + 2c\tan\alpha$$

$$\alpha = (45 + \phi/2)$$

In unconfined compression test $\sigma_3 = 0$, $\sigma_1 = q_u$

Hence $q_u = 2c \tan(45 + \phi/2)$

$$c = \frac{q_u}{2\tan(45+\varphi/2)}$$

If the soil is pure clay, then $\phi = 0$

therefore

$$c = \frac{q_u}{2}$$ Where

σ_1 =major principal stress

σ_3 = minor principal stress

α = failure angle with major principal plane

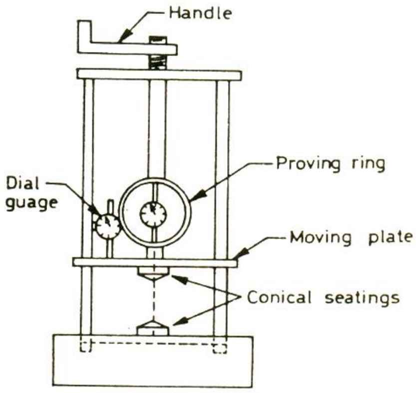

Fig6.1. Unconfined Compression Testing Machine

SAMPLE PREPARATION:

1. Corresponding maximum dry density of the soil, calculate the weight of the dry soil required for preparing a specimen of 38 mm diameter and 75 mm long.
2. Add moulding water content to this soil.
3. Mix the soil thoroughly with water.
4. Place the wet soil in thick polythene bag tightly in a humidity chamber for 24 hours.
5. After 24 hours take the soil from the humidity chamber and place the soil in a constant volume mould, having an internal height of 75mm and diameter 38 mm.
6. Place the lubricated mould with plunger in position in the load frame and remove the sample from mould.

PROCEDURE:

1. Measure the initial length and diameter of the specimen
2. Place the specimen on the lower plate and rise so that the specimen will have contact with the upper plate
3. Adjust the compression dial gauge and load dial gauge to read zero
4. Apply the compression load to produce an axial strain at a rate of 0.5 to 0.2 % per minute.
5. Record the readings of both the dial gauge at suitable time intervals
6. Continue the compression till the specimen fails or 20% vertical deformation is reached whichever occurs earlier.
7. Sketch the failure pattern and measure the failure angle with the horizontal plane

OBSERVATIONS AND CALCULATIONS:

Initial length of specimen, L_0 (mm) =

Diameter of specimen, d (mm) =

Area of specimen, A_0 (mm^2) =

Volume, V (mm^3) =

Mass, M (gm) =

S. No	Dial gauge readings	Proving ring readings	Deformations, (mm) ΔL	Load, P (kg)	Strain $\in = \frac{\Delta L}{L_0}$	Corrected area (mm^2) $A_c = \frac{A_0}{1-\in}$	Compressive stress, (kg/mm^2)

Failure angle =

1. Plot a curve between compressive stress as ordinate and axial strain as abscissa and find the compressive stress at failure.
2. Find un-drained cohesion $c_u = q_u/2$

VIVA:

1. What do you understand by unconfined compressive strength of the soil?
2. Can you determine the unconfined compressive strength for all type of soils? Explain.
3. What are the drainage conditions in unconfined compression test?
4. What do you understand by undistributed, distributed and remoulded soil samples?
5. Are you using stress controlled or strain controlled device?
6. What do you mean by sensitivity of clay?
7. Draw mohr’s circle for state of stress at failure in an unconfined compression test.
8. This test is used only for cohesive soils. Why?
9. Explain the relation between consistency and UCC value of clay
10. Will this test give reliable undrained strength?
11. What are the initial adjustments required for the equipment?
12. What is the proving ring capacity in direct shear test?
13. What are the steps taken to get accurate result?
14. What is the difference between unconfined compression test and triaxial test?
15. What is meant by unconfined compression strength of soil?
16. Plot roughly the Mohr circle for Unconfined Compressive Strength of soil.
17. Explain the procedure to determine the Unconfined compressive strength of soil
18. How is sensitivity determined?
19. Why we need Mohr’s circle for this experiment?
20. Is there any stress which cannot be determined in the case of UCC?
21. Could the drainage condition be handled in UCC?
22. Explain unconfined compressive?
23. Will this test give reliable undrained strength?
24. What are the initial adjustments required for the equipment?
25. What is the proving ring capacity in direct shear test?
26. What are the steps taken to get accurate result?
27. What is the difference between unconfined compression test and triaxial test?
28. Draw mohr’s circle for state of stress at failure in an unconfined compression test.
29. This test is used only for cohesive soils. Why?
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31. Will this test give reliable undrained strength?
32. What are the initial adjustments required for the equipment?
33. What is the proving ring capacity in direct shear test?
34. What are the steps taken to get accurate result?
35. What is the difference between unconfined compression test and triaxial test?
36. What is meant by unconfined compression strength of soil?
37. Plot roughly the Mohr circle for Unconfined Compressive Strength of soil.
38. Explain the procedure to determine the Unconfined compressive strength of soil
39. How is sensitivity determined?
40. What do you understand by unconfined compressive strength of the soil?
41. Can you determine the unconfined compressive strength for all type of soils? Explain.
42. What are the drainage conditions in unconfined compression test?
43. What do you understand by undistributed, distributed and remoulded soil samples?
44. Are you using stress controlled or strain controlled device?
45. What do you mean by sensitivity of clay?
46. Draw mohr’s circle for state of stress at failure in an unconfined compression test.

47. This test is used only for cohesive soils. Why?
48. Explain the relation between consistency and UCC value of clay
49. What are the steps taken to get accurate result?
50. What is the difference between unconfined compression test and triaxial test?
51. What is meant by unconfined compression strength of soil?

EXPERIMENT NO: 8

DIRECT SHEAR TEST

AIM: Determination of shear strength parameters of the given soil sample of known density by conducting direct shear test.

APPARATUS: Shear box (60mm x 60mm x 50mm), container for shear box, grid plate, base plate, porous plate, loading pad, proving ring with dial gauge, static compaction device.

THEORY:

Shear strength of a soil is its maximum resistance to shearing stresses. It is taken to be equal to the shearing stress at failure on the failure plane.

Shear strength of the soil is mainly due to the internal friction and cohesion.

Internal friction is the resistance due to friction between individual particles at their contact points and interlocking of particles.

Cohesion is the resistance due to inter particle forces which tend to hold the particles together in a soil mass. Coulomb has represented the shear strength of soils by the equation.

$$\mathbf{s = c + \sigma \tan\phi}$$

Where s- Shear strength of soil c - Cohesion ø -Angle of internal friction σ - Normal stress

The parameters c and Ø are not constant for a type of soil but depend on its degree of saturation and the conditions of laboratory testing.

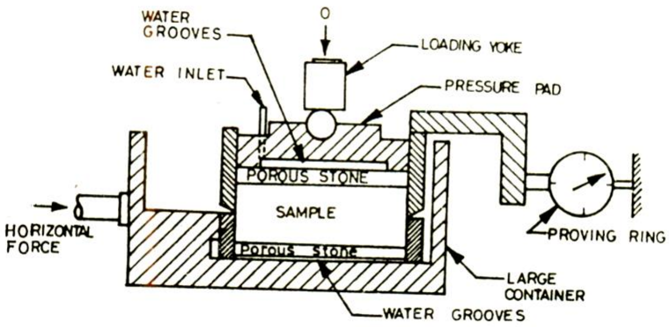

Fig.8.1 Direct Shear Box

PROCEDURE:

1. Prepare a soil specimen of size 60 mm x 60 mm x 25 mm either from undisturbed soil sample or from compacted and remoulded sample. Soil specimen may be directly prepared in the box by compaction.
2. Obtain the required density of soil specimen.
3. Fix the upper part of the box to the lower part by the fixing screws. Attach the base plate to the lower part.
4. Place the porous plate in the box.
5. For undrained test, place the grid on the porous stone keeping the serration of the grid at right angle to the direction of shear. For consolidated undrained and drained tests, use the perforated grid in place of plain grid.
6. Transfer the soil specimen prepared in step1, in the box.
7. Place the upper grid, porous stone and loading pad in the order on soil specimen.
8. Place the shear box inside the container and mount it on loading frame.
9. Bring the upper half of the box in contact with the proving ring assembly. Contact is observed by a slight movement of proving ring gauge.
10. Fill the container with water if soil is to be saturated.
11. Mount the loading yoke on the ball placed on the loading pad.
12. Put the weights on the loading yoke to apply a normal stress intensity of 0.5 kg/cm^2.
13. For consolidated undrained and drained test, allow the soil to consolidate fully under this normal load. This step should be avoided for un-drained test.
14. Remove the fixing screws from the box and raise slightly the upper half of the box with help of spacing screw. Remove the spacing screws.
15. Adjust the proving ring gauge to zero.
16. Shear load is applied at a constant rate of strain (For undrained test the rate of strain is 1 to 15 mm per minute in clays and 1.5 mm to 2.5mm per minute in sand. For drained test, the rate of strain is 0.005 to 0.02 mm per minute in clays and 0.2 to 1 mm minute in sand).
17. Observe the proving ring dial gauge; the reading will increase till soil fails. Record the proving ring dial gauge reading at failure.

18. Repeat the test on identical specimen under increasing normal stress of 1, 1.5 and 2 kg/cm^2

OBSERVATIONS AND CALCULATIONS:

Cross-sectional area, A (cm^2) =

Density of soil (gm/cc) =

Thickness of sample (cm) =

Volume of the sample, V (cm^3) =

Calibration Factor =

Mass of soil (gm) =

S. No	Normal Stress, kg/cm^2	Proving ring reading	Shear load, P (kg)	Shear Stress, kg/cm^2	Shear strength $s = c + \sigma \tan\phi$
1					
2					
3					

1. Plot a graph using normal stress on X-axis and corresponding shear stress at failure on Y-axis. Join the points by a straight line. This is defined as the shear strength envelop.
2. Read the slope of the line, which is defined as the angle of shearing resistance and the intercept of the line with Y-axis, the cohesion of the soil.

RESULT:

Cohesion of the Soil, c (kg/cm^2) =

Angle of Internal Friction of the Soil, ø =

VIVA:

1. What do you understand by shear strength of soils?
2. What are Shear parameters? Are these constant or variable for a type of soil?
3. What is the effect of pore water pressure on shear strength of soil?
4. What are the other lab and field methods to determine Shear Parameters?
5. Are you using stress controlled or strain controlled device?
6. What is the rate of strain maintained in the test?
7. Shearing resistance can be determined in the laboratory by__________methods.
8. The direct shear test can also be called as____________
9. The commonly used apparatus used for performing shear box test is____________

10. To conduct un-drained test, which of the following is used?
11. The drained test is also known as___________
12. The shearing of cohesive soil in drained test requires___________days.
13. A major difference between the direct shear test and tri axial shear test is_____________
14. In direct shear test, the soil load is subjected to more stress at_____________
15. What are the limitations of this test?
16. Draw mohr's circle for failure for a direct shear test and mark the failure plane, major and minor principal plane.
17. If test is done under normal stress of 40 N/cm
18. Find the shear load at which this soil will fail.
19. What is the procedure for determination of shear strength parameters of clay using direct shear test?
20. Pour dry sand on horizontal surface and find angle of repose. Compare this angle with angle of shearing resistance
21. Are you using stress controlled or strain controlled device?
22. What is the rate of strain maintained in the test?
23. Shearing resistance can be determined in the laboratory by_________methods.
24. The direct shear test can also be called as___________
25. The commonly used apparatus used for performing shear box test is___________
26. To conduct un-drained test, which of the following is used?
27. What is the rate of strain maintained in the test?
28. Shearing resistance can be determined in the laboratory by_________methods.
29. The direct shear test can also be called as___________
30. The commonly used apparatus used for performing shear box test is___________
31. To conduct un-drained test, which of the following is used?
32. The drained test is also known as___________
33. The shearing of cohesive soil in drained test requires___________days.
34. A major difference between the direct shear test and tri axial shear test is_____________
35. In direct shear test, the soil load is subjected to more stress at_____________
36. What are the limitations of this test?
37. Draw mohr's circle for failure for a direct shear test and mark the failure plane, major and minor principal plane.
38. If test is done under normal stress of 40 N/cm
39. Find the shear load at which this soil will fail.
40. What do you understand by shear strength of soils?
41. What are Shear parameters? Are these constant or variable for a type of soil?
42. What is the effect of pore water pressure on shear strength of soil?
43. What are the other lab and field methods to determine Shear Parameters?
44. Are you using stress controlled or strain controlled device?
45. What is the rate of strain maintained in the test?
46. The shearing of cohesive soil in drained test requires___________days.
47. A major difference between the direct shear test and tri axial shear test is_____________
48. In direct shear test, the soil load is subjected to more stress at_____________
49. What are the limitations of this test?
50. Draw mohr's circle for failure for a direct shear test and mark the failure plane, major and minor principal plane.
51. If test is done under normal stress of 40 N/cm
52. Find the shear load at which this soil will fail.

EXPERIMENT NO: 9

VANE SHEAR TEST

AIM: To determine the measurement of shear strength of cohesive soils.

APPARATUS:

The vane shear test apparatus consists of a torque head mounted on a bracket. Four shear vanes are fixed on a shaft and the shaft is fixed in the lower end of a circular disk graduated in degrees. A torsion spring is fixed between torque head and the circular disk. A maximum pointer is provided to facilitate reading the angle of torque

Fig:9.1 Vane Shear test apparatus.

PROCEDURE:

1. Prepare two or three specimens of the soil sample of dimensions of at least 37.5 mm diameter and 75 mm long specimen.
2. Mount the specimen container with the specimen on the base of the vane shear apparatus. If the specimen container is closed at one end, it should be provided with a hole of about 1 mm diameter at the bottom.

3. Gently lower the shear vanes into the specimen to their full length without disturbing the soil specimen. The top of the vanes should be at least 10 mm below the top of the specimen. Note the readings of the angle of twist.
4. Rotate the vanes at an uniform rate say 0.10/s by suitably operating the torque applicator handle until the specimen fails.
5. Note the final reading of the torque indicator. Torque readings and the corresponding strain readings may also be noted at desired intervals of time as the test proceeds.
6. Just after the determination of the maximum torque rotate the vane rapidly through a minimum of 10 revolutions. The remoulded strength should then be determined within 1 minute after completion of the revolution.

OBSERVATIONS AND CALCULATIONS:

S.No	Initial Reading (Deg.)	Final Reading (Deg.)	Difference (Deg.)	T=Spring Constant/180 x Difference (Kg-cm)	G = 1/π (D2h/2 + D3/6)	S=TxG (Kg/cm2)	Average 'S' (Kg/cm2)	Spring Constant (Kg-cm)
1								
2								
3								
4								
5								

CALCULATION:

Torque, T = Ø * K/180

Where, T = Torque applied in cm kgf
Ø = Difference of angle (angle of torque)
K = Spring factor

G = 1/{π*[(d2h/2) + (d3/6)]}

Where, d = diameter of vane (cm)
h = height of the vane (cm)

Shear Strength, S = T * G or S = (3/19)*T

or

S = (3/19)*T

Where, S = Shear Strength in kgf/cm2
T = Torque applied in cm kgf.

VIVA:

1. Differentiate direct shear and vane shear.
2. What is the purpose of vane shear test?
3. Define spring factor.
4. Define torque.
5. What are the units of torque?

6. Define angle of torque.
7. What is spring constant?
8. What is the relation between spring constant and torque?
9. Define shear strength.
10. Define shear stress.
11. Write the purpose of the direct shear stress.
12. Differentiate unconfined and vane shear test.
13. Differentiate triaxial and vane shear test.
14. What do you understand by shear strength of soils?
15. What are Shear parameters? Are these constant or variable for a type of soil?
16. What is the effect of pore water pressure on shear strength of soil?
17. What are the other lab and field methods to determine Shear Parameters?
18. Are you using stress controlled or strain controlled device?
19. What is the rate of strain maintained in the test?
20. Shearing resistance can be determined in the laboratory by _________ methods.
21. The direct shear test can also be called as___________
22. The commonly used apparatus used for performing shear box test is___________
23. To conduct un-drained test, which of the following is used?
24. The drained test is also known as___________
25. The shearing of cohesive soil in drained test requires ___________ days.
26. A major difference between the direct shear test and tri axial shear test is_____________.
27. What is spring constant?
28. What is the relation between spring constant and torque?
29. Define shear strength.
30. Define shear stress.
31. What is spring constant?
32. What is the relation between spring constant and torque?
33. Define shear strength.
34. Define shear stress.
35. Write the purpose of the direct shear stress.
36. Differentiate unconfined and vane shear test.
37. Differentiate triaxial and vane shear test.
38. What do you understand by shear strength of soils?
39. What are Shear parameters? Are these constant or variable for a type of soil?
40. What is the effect of pore water pressure on shear strength of soil?
41. What are the other lab and field methods to determine Shear Parameters?
42. Are you using stress controlled or strain controlled device?
43. Differentiate direct shear and vane shear.
44. What is the purpose of vane shear test?
45. Define spring factor.
46. Define torque.
47. What are the units of torque?
48. Define angle of torque.
49. What is the effect of pore water pressure on shear strength of soil?
50. What are the other lab and field methods to determine Shear Parameters

.

EXPERIMENT NO: 10

DIFFERENTIAL FREE SWELL INDEX (DFSI) TEST

AIM: To determine Free Swell Index is the increase in volume of a soil, without any external constraints, on submergence in water.

APPARATUS:

1. 425 micron IS sieve.
2. Graduated glass cylinders 100 ml capacity 2Nos (IS: 878 -1956).
3. Glass rod for stirring.
4. Balance of capacity 500grams and sensitivity 0.01 gram.

Fig:10.1 Free swell index.

PROCEDURE:

1. Take two representative oven dried soil samples each of 10 grams passing through 425 micron sieve.
2. Pour each soil sample in to each of the two glass graduated cylinders of 100ml capacity.
3. Fill one cylinder with kerosene and the other with the distilled water up to the100ml mark.
4. Remove the entrapped air in the cylinder by gentle shaking and stirring with a glass rod.
5. Allow the samples to settle in both the cylinders.

6. Sufficient time, not less than 24 hours shall be allowed for soil sample to attain equilibrium state of volume without any further change in the volume of the soils.
7. Record the final volume of the soils in each of the cylinders.

CALCULATIONS:

Free Swell Index, (%) = Vd–Vk / Vk x 100

Vd = Volume of the soil specimen read from the graduated cylinder containing distilled water.

Vk = Volume of the soil specimen read from the graduated cylinder containing kerosene.

VIVA:

1. What is the purpose of free swell index test?
2. What is meant by free well index?
3. What are the apparatus to conduct this test?
4. What are the dimensions of the cylinder used in this test?
5. Write the formula for free swell index.
6. Which type of sieve is used in this test?
7. What are the types of soils?
8. What are the types of sieves?
9. What are the materials used in this test?
10. What is the use of Cv? When it is used?
11. Can permeability be determined from consolidation test indirectly?
12. Which type of permeability test can be done directly? Explain.
13. What result do you expect if a consolidation test is conducted on sand?
14. Suppose loading pad is placed such that it touches the sides of the ring. What will happen?
15. Define consolidation.
16. Differentiate consolidation and compaction.
17. What are the units of the coefficient of consolidation?
18. What are the methods for determination of coefficient of consolidation?
19. What is the formula for determination of coefficient of consolidation?
20. What is meant by compaction?
21. What are the factors effecting consolidation?
22. What is cv?
23. Differentiate between compaction and consolidation of soils
24. What is OMC?
25. What are wet side and dry side of optimum? Which side is preferable for field compaction?
26. If water content is increased above shrinkage limit, what is the effect?
27. Instead of Mercury can we use any other substance as mercury may cause health hazard.
28. What is the difference between standard proctor test and modified proctor test?
29. What is relative density of soil?
30. What is voids ratio? What is zero air voids line? Write the formula for free swell index.
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