I

Name ______________________

Roll No. ____________ Year 20______ 20______

Exam Seat No. ______________________

CIVIL GROUP | SEMESTER - IV | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL FOR GEO-TECHNICAL ENGINEERING (22404)

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Practical Manual
for

Geotechnical Engineering

(22404)

Semester – (IV)

(CE, CR, CS)

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education,
(Autonomous) (ISO 9001 : 2015) (ISO/IEC 27001 : 2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on November 2018)

Maharashtra State
Board of Technical Education
Certificate

This is to certify that Mr. / Ms. ……………………………………. Roll No ………………………. of Fourth Semester of Diploma in …………………………………………………………….. of Institute ……………………………………………………….. (Code………………..) has attained predefined practical outcomes (PROs) satisfactorily in course **Geotechnical Engineering (22404)** for the academic year 20…….to 20…..... as prescribed in the curriculum.

Place ………………. Enrollment No……………………

Date:…................... Exam Seat No. …………………......

Course Teacher **Head of Department** **Principal**

Seal of the Institute

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-base education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practicals to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practicals to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Geotechnical engineering is the important for every structure, since all structures rest on soil. The stability of these structures depends upon behavior of soil and bearing capacity of soil to carry loads under different loading conditions. Formation of soil and rocks, defects in rocks, soil behavior, and soil as an engineering material are essential parameter to an engineer. The design of foundation of buildings, dams, towers, embankments, roads, railways, retaining walls, bridges is mainly governed by these above stated parameters. The content of this subject are also useful in designing basement, underground tank and underwater structures. Knowledge of geology, soil characteristics, and stress distribution under loading on soil, bearing capacity of soil is also useful to every engineer in the design, execution and stability analysis of structures.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Programme Outcomes (POs) to be achieved through practicals of this course:

PO 1. Basic knowledge: An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.

PO 2. Discipline knowledge: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.

PO 3. Experiments and practice: An ability to plan and perform experiments and practices and to use the results to solve engineering problems.

PO 4. Engineering tools: Apply relevant civil technologies and tools with an understanding of the limitations.

PO 8. Individual and Team Work: Function effectively as leader and team member in Diverse /multidisciplinary team.

PSO 1 Construction Planning and Designing: Perform optimal civil engineering construction, planning and designing activities of desired quality at optima cost.

PSO 2 Construction Execution and Maintenance: Execute civil engineering construction and maintenance using relevant materials and equipments.

Practical- Course Outcome Matrix

Course Outcomes (COs)

a. Identify types of rocks and sub soil strata of earth.
b. Interpret the physical properties of soil related to given construction activities.
c. Use the results of permeability and shear strength test for foundation analysis.
d. Interpret the soil bearing capacity results.
e. Compute optimum values for moisture content for maximum dry density of soil through various tests.

S. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.
1.	Identification of rocks from the given specimen	√	--	--	--	--
2.	Determine water content of given soil sample by oven drying method as per IS 2720 part- II	--	√	--	--	--
3.	Determine specific gravity of soil by pycnometer method as per IS 2720 part- III.	--	√	--	--	--
4.	Determine dry unit weight of soil in field by core cutter method as per IS 2720 (Part- XXIX).	--	√	--	--	--
5.	Determine dry unit weight of soil in field by sand replacement method as per IS 2720 (Part- XXVIII).	--	√	--	--	--
6.	Determine Plastic Limit & Liquid Limit along with Plasticity Index of given soil sample as per IS 2720 I(Part- V).	--	√	--	--	--
7.	Determine Shrinkage limit of given soil sample as per IS 2720 (Part- V).	--	√	--	--	--
8.	Determine grain size distribution of given soil sample by mechanical sieve analysis as per IS 2720 (Part- IV).	--	√	--	--	--
9.	Use different types of soil Identify and classify soil by conducting field tests-Through Visual inspection, Dry strength test, Dilatancy test and Toughness test .	--	√	--	--	--
10.	Determine co efficient of permeability by constant head test as per IS 2720 (Part- XVII)	--	√	√	--	--
11.	Determine co efficient of permeability by falling head test as per IS 2720 (Part- XVII)	--	√	√	--	--
12.	Determine shear strength of soil by direct shear test as per IS 2720 (Part-XIII)	--	√	√	--	--
13.	Determine shear strength of soil by vane shear test as per IS 2720 (Part-XXX)	--	√	√	--	--
14.	Determine bearing capacity of soil using liquid limit and plastic limit	--	√	--	√	√
15.	Determine MDD and OMC by standard proctor test of given soil sample as per IS 2720 (Part- VII).	--	√	--	√	√
16.	Determination of CBR value on the field as IS.	--	√	--	√	√

List of Industry Relevant Skills

The following industry relevant skills of the competency **'Evaluate soil properties for determining stability of foundation'** are expected to be developed in you by undertaking the practicals of this laboratory manual.

1. Identify the rocks based on its physical properties.
2. Perform the tests on soil at construction sites as per requirement.
3. Interpret the results of test performed stating the correlation of soil properties.
4. Judge/Check the suitability of field soil for the proposed or ongoing foundation works.
5. Undertake the improvement/modification techniques for weak field soil.

Brief Guidelines to Teachers

Hints regarding strategies to be used:

1. For difficult practical if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
2. Teachers should give opportunity to students for hands-on after the demonstration.
3. Teacher should give relevant information (including safety measures) to students prior to visit arranged for effective utilization of time and understanding.
4. Teachers shall ensure that required equipment are in working condition before start of each experiment, also keep operating instruction manual available.
5. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which is not mentioned in the printed practicals.
6. Assess the skill achievement of the students and COs of each unit.
7. One or two questions ought to be added in each practical for different batches. For this teachers can maintain various practical related question banks for each course.
8. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
9. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
10. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
11. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines.

12. Teacher should ensure that the different types of soil samples should be available in the laboratory except for the field tests.
13. The alternative methods of water content determination like rapid moisture meter method, infrared moisture meter method can be used to determine the water content of soil for the practicals except practical no. 2.
14. Teacher should distribute all the questions among all the three batches so as to attempt all questions. It is recommended that every year the combination of question must be changed for each batch.
15. As far as possible, show the videos from NPTEL website before performance of practical.

Instructions for Students

1. For effective implementation and attainment of practical outcomes, in the beginning it-self of each practical, students need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
2. Student ought to refer the data books, IS codes, safety norms, internet websites etc.
3. Student should not hesitate to ask any difficulties they face during the conduct of practicals/visits.
4. Student should develop the habit of pear discussions/group discussion related to the experiment/exercise so that exchanges of knowledge /skills could take place.
5. Student shall attempt to develop related hands-on skills and gain confidence.
6. Students shall visit the nearby construction site, technical exhibitions, trade fair etc. even not included in the lab manual.
7. Students should develop the habit of not to depend totally on teachers but to develop self-learning techniques.
8. Student should develop habit to submit the practical exercise continuously and progressively on the scheduled dates and should get the assessment done.
9. It is necessary to take all type of precautionary measures by students during site visit.
10. Students should take photographs (which may be different for each student) on their own for deep understanding of the concepts and same should be attached (pasted in separate sheet) in respective practical/visit.

Content Page

List of Practicals and Progressive Assessment Sheet

Name of the Student- ___________________________________ Roll No. __________________

Sr. No	Title of the Practical	Page No.	Date of Performance	Date of Submission	Assessment Marks (25)	Dated Sign. of Teacher	Remarks (If Any)
9	Use different types of soil Identify and classify soil by conducting field tests-Through Visual inspection, Dry strength test, Dilatancy test and Toughness test .	78					
10	Determine co efficient of permeability by constant head test as per IS 2720 (Part- XVII)	88					
11*	Determine co efficient of permeability by falling head test as per IS 2720 (Part-XVII).	96					
12	Determine shear strength of soil by direct shear test as per IS 2720 (Part-XIII)	104					
13*	Determine shear strength of soil by vane shear test as per IS 2720 (Part-XXX)	115					
14	Determine bearing capacity of soil using liquid limit and plastic limit.	123					
15*	Determine MDD and OMC by standard proctor test of given soil sample as per IS 2720 (Part- VII).	131					
16	Determination of CBR value on the field as IS.	142					
				Total			

Note: A judicial mix of minimum 12 or more more practical need to be performed , out of which practicals marked as * are compulsory.

Note: To be transferred to Proforma of CIAAN-2017.

Practical No. 1: Identification of Rocks from the Given Specimen

I. Practical Significance

Rock identification is a systematic process, requiring concise, accurate descriptions of its physical characteristics. Petrographic descriptions of rock elaborate physical characteristics for future reference. Systematic petrographic descriptions give necessary information of rock specimen. Geologists need to be able to determine the physical properties of rocks based on observations and simple tests that can be conducted in the field. This particular practical is able to identify the rocks by visual observation at construction site.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 8.Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Identify types of rocks and subsoil strata of the earth.

IV. Practical Outcome

Identification of rocks from the given specimen.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate rock properties for determining suitability for foundation."***

a. Observation skill.
b. Ability of identification of the physical properties of rock.
c. Ability of identification of types of rock structure.

VI. Relevant Affective domain related

a. Follow safety practices.
b. Practice good housekeeping.

VII. Minimum Theoretical Background

Rock: The rock is the aggregate of minerals. Basically the rock is classifies as per geological classification i.e. 1. Igneous rocks
2. Sedimentary rocks
3. Metamorphic rocks.

The details of such rocks are given below in Table No. 1.

Table No. 1. : Physical Properties of Rock

Type of Igneous Rock	**Rock Examples**	**Physical Properties**
Plutonic	Granite	Light colour, acidic in nature, Coarse grained texture
	Syenites	Light colour, acidic and basic in nature, Coarse grained to medium grained texture
	Diorites	Light colour, acidic and basic in nature, Coarse grained to medium grained texture
	Gabbros	Dark colour, basic in nature, medium grained texture
	Peridotites	Dark colour, Ultra-basic in nature, Coarse grained to medium grained texture
Hypabyssal	Dolerites	Dark colour, Ultra-basic in nature, fine grained texture, highly tough
Volcanic	Rhyolites	Light in colour, light in weight,acidic in nature,fine grained texture
	Andesites	Light in coloured,acidic to basic in nature, fine grained texture
	Basalt	Dark colour, Ultra-basic in nature, fine grained texture, tough stone
Type of Sedimentary Rock	**Rock Examples**	**Physical Properties**
Clastic	Conglomerates	More than 2 mm particle size, rounded ,heterogeneous,harder and dense in nature
	sandstones	Cemented sand grains, Coarse to fine grained particle sizes
	breccias	Mechanically formed, large angular fragments, More than 2 mm particle size, rounded ,heterogeneous
	shales	Composed of clays, more alumina contents
Non Clastic or chemical	Lime stone	Contains Calcium Carbonates, fine grained compact texture
	Dolostones	Contains magnesium corbonate, fine grained compact texture, heavy in weight, harder than limestone
	Rock Gypsum	Contains gypsum mineral, white in colour which may turn to yellow red or dark grey, microcrystalline texture,
	Chert,Jasper and Flint	Dense hard and brittle in nature, Chert is white to buff. Jasper is red and Flint is dark grey to balck in colour.

Type of Metamorphic Rock	Rock Examples	Physical Properties
Foliated	Gneisses	White to balck in colour, available in various shades, other properties are similar to igneous rocks
	Schist	Variety of colours, coarse grained crystalline texture, exhibits uniform bands
	Phyallites	Fine grained texture, more lusterous, crumpled arwraped
	Slate	Very fine grained texture, soft, bedding plane appear as bands called ribbons, cuts into sheets and pieces
Non- Foliated	Quartzite	Hard and tough, compact and dense, fine to coarse grained texture, white grey, yellowish, greenish or reddish in colour, difficult to be drilled and dressed, low absorption property, high strength
	Marble	fine to coarse grained texture, abrasion resistant, low water absorption, white hard

VIII. Experimental Set-up

		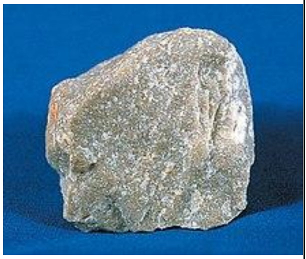	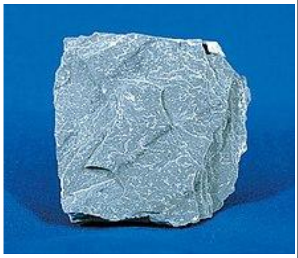
Dolomite-Morocco	Phyllite	Quartzite	Slate
			
Conglomerate	Mica-schist	White Marble	Teidepumice

Figure 1: Types of Rocks

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Magnifying glass	---	1 No.	Per batch
2	Measurement scale	15 or 30 cm length	1 No.	Per batch

X. Procedure

1. Collect the information of various types of rock from sources like wall charts, internet website, journals or books etc.
2. Discuss the rock and its physical properties with batch mates.
3. Teacher should display various rock specimens in the laboratory to identify its type and subtype if any.
4. Students should observe the rock type by handling properly and note down the same in observation table provided.

XI. Precautions to be followed

1. Handle the particular specimen very carefully so that it will not break at any stage.
2. There should not be any marking with pen or pencil on the given rock specimen.

XII. Actual procedure followed *(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					
3					
4					

XIV. Precautions followed

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XV. Observations

Sr. No.	Rock Specimen No.	Physical properties observed like colour, texture, streak, luster etc.	Type of Rock
1			
2			
3			

4			
5			

XVI. Results

The observed majority of rock specimens are mostly ………………………. (Igneous / Sedimentary / Metamorphic) type.

XVII. Interpretation of results*(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations*(Actions/decisions to be taken based on the interpretation of results)*

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XIX. Practical Related Questions

Note*: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. State the nos. of rock samples available in your laboratory.
2. Mention two sites where the……………… rocks are found.(*Teacher should mention the type of rock).*
3. Describe the luster and streak property of any one rock sample in your laboratory.
4. Name the rock specimen having fine grained and coarse grained texture from laboratory specimens.
5. Name the rock which is used generally for decorative purpose in constructions.
6. State practical applications……………..of rock. *(Teacher should mention the type of rock).*
7. Compare the compressive strength of …………………....rock with ……………..……. rock. *(Teacher should mention the type of rock).*
8. State four properties of minerals.
9. State the four types rocks giving the name of heritage structure for which it is used.

(Space to Write Answers)

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://www.youtube.com/watch?v=7MvXv66b5h4	--	--
4.	nptel.ac.in/courses/105105106/40	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Identification of rock	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40%**
3	Interpretation of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……………………………………………
2. ……………………………………………
3. ……………………………………………
4. …………………………………………….

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 2: Determine Water Content of Given Soil Sample by Oven Drying Method as per IS 2720 (Part- II)

I. Practical Significance

The water content of soil is the basic fundamental property of soil which is used to determine other physical properties of soil. The behavior of soil changes according to variation in water content. Therefore the load carrying capacity i.e. soil strength of soil may fluctuate as per water content of soil. The stability of various foundations and structures depends on water content percentage. The knowledge of the natural moisture content is essential in all studies of soil mechanics. The natural moisture content will give an idea of the state of soil in the field. This particular practical helps to know the methodology to determine the water content of soil from actual field/site.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Interpret the physical properties of soil related to given construction activities.

IV. Practical Outcome:

Determine water content of given soil sample by oven drying method as per I.S. 2720 Part- II.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Selection of soil sample.
b. Selection of suitable method of water content determination.
c. Ability of handling of instruments.

VI. Relevant Affective domain related

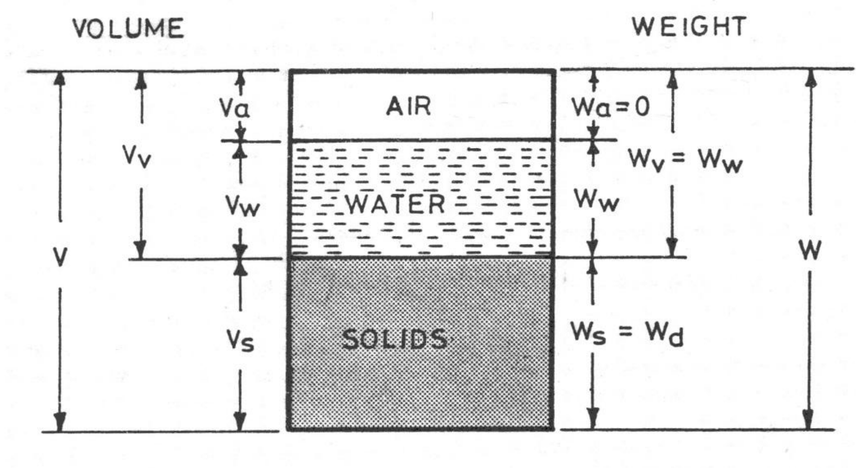
a. Follow safety practices.
b. Practice good housekeeping.
c. Maintain tools and equipment.

VII. Minimum Theoretical Background

Water content of soil: It is defined as the ratio of mass of water to mass of soil solids, which is expressed in percentage. Water content or moisture content of soil is present in its voids. It is expressed with respective of mass of dry soil.

Depending upon water content the soil can be classified as follows.

1. *Dry soil*- contains only air in its voids. But natural moisture may present in it.
2. *Partially saturated soil*- contains water and air in its voids.
3. *Fully or completely saturated soil*- contains only water in its voids. No air remains in it.
4. *Submerged soil*- contains excess amount of water in it having buoyancy effect.



THREE PHASE DIAGRAM

VIII. Experimental Set-up

Thermostatically Controlled Oven Containers in oven Desiccators

Figure 1: Oven Drying Method

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Oven-thermostatically controlled	Temperature of 110^0C to 115^0C	1 No.	Per batch
2	Weighing balance	With an accuracy of 0.01 gm	1 No.	Per batch
3	Desiccators	--	1 No.	Per batch
4	Non-corrodible air tight container	Minimum 25 to 1000 gm capacity	3 Nos.	Per group
5	Hand gloves/ Clinch	--	1 set	Per batch

X. Procedure

1. Measure the mass of empty container and record it as 'W_1' gm.
2. Collect the moist soil sample as per the IS recommendations and put it in the container.
3. Measure the mass of container filled with moist soil sample. Record it as 'W_2' gm.
4. Keep the filled container in thermostatically controlled oven at a temperature 105^0- 110^0C for 24 hours, so as to evaporate the water completely.
5. Take out the container from oven and cool it in desiccators for 5 minutes.
6. Measure the mass of container with dry soil and record it as 'W_3' gm.
7. Calculate the % water content as % w = $(W_2–W_3) / (W_3–W_1)$ x 100.
8. Repeat all above steps two more times to calculate average water content of given soil sample.

XI. Precautions to be followed

1. Record the mass of soil samples accurately up to 0.01 gm to get accurate results.
2. Use the hand gloves while handling soil samples in the oven.
3. Keep the lid of container at its bottom side to facilitate the evaporation process.
4. Keep the temperature of oven always in prescribed range continuously.

XII. Actual procedure followed *(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					
3					
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XIV. Precautions followed

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XV. Observations

Sr. No.	Particulars	Observation No.		
	Sample No.	1	2	3
1	Container No.			
2	Mass of empty container with lid (W_1) gm			

3	Mass of container with lid and moist soil (W_2) gm			
4	Mass of container with lid and dry soil (W_3) gm			
5	Mass of water (W_w) = (W_2 -W_3) gm			
6	Mass of dry soil (W_s) = (W_3 -W_1) gm			
7	Water content in % w = (W_w / W_s) x 100			

Sample Calculation

For Observation No.……….

% w = (W_w/ W_s) x 100

% w = ……………………………………………

% w = ……………………………………………

Average water content in percentage of three samples w_{avg} .= ………………………

w_{avg} = ……………………… %

XVI. Results

The average water content of given soil sample by oven drying method is found to be …………….. %

XVII. Interpretation of results *(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results)*

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XIX. Practical Related Questions

***Note**: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. State the maximum range of temperature of oven in your laboratory.
2. Give the least count of weigh balance you have used and cost of it.
3. 'The lid of container should be kept at its bottom during oven drying', give reasons.
4. Name the instruments used for water content determination faster than thermostat oven.
5. State the location from where the sample is collected.
6. Give the reason. The oven drying method is the most accurate to determine water content of soil.
7. If the temperature of oven is less than 105^0c (Say 70^0c), explain the effect on the value of water content of soil.
8. Write the unit of measurement of water content of soil.
9. If the sample is handed over to you on first day of the month, state the date on which you can give result of the test.

(Space to Write Answers)

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book/website Links	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN:9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://www.youtube.com/watch?v=O1xUKGcS728	--	--
4.	https://www.youtube.com/watch?v=GlPa_zxwV5I	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60 %**
1	Measurement of mass of soil samples	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40 %**
3	Calculations of result	10 %
4	Answers to practical related questions.	20 %
5	Submission of report in time.	10 %
Total: 25 Marks		**100 %**

List of Student Team Members (Roll No.)

1. ……………………………………………
2. …………………………………………….
3. …………………………………………….
4. …………………………………………….

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 3: Determine Specific Gravity of Soil by Pycnometer Method as per IS 2720 (Part-III)

I. Practical Significance

In dealing with soils testing, the value of specific gravity is necessary to compute the soil's void ratio and for determining the grain-size distribution in hydrometer analysis. Generally, geotechnical engineers need the soil's specific gravity to perform additional testing of soil. A soil's specific gravity largely depends on the density of the minerals making up the individual soil particles. This practical helps to know the specific gravity of soil which is useful for grain size and voids ratio of soil.

II. Relevant Program Outcomes:

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and team work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Interpret the physical properties of soil related to given construction activities.

IV. Practical Outcome

Determine specific gravity of soil by pycnometer method as per I.S. 2720 part- III.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Ability of handling instruments.
b. Selection of suitable method of specific gravity determination.
c. Measurement of soil weights accurately.

VI. Relevant Affective domain related

a. Follow safety practices.
b. Practice good housekeeping.
c. Maintain tools and equipment.

VII. Minimum Theoretical Background

Specific Gravity of soil: It is defined as the ratio of unit weight of soil solids of any specific volume to the unit weight of distilled water of equal volume measured at 27^0c.

OR

It is the ratio of density of soil sample to density of distilled water measured at 27^0c.

The knowledge of specific gravity is required in calculation of soil properties like void ratio, degree of saturation and also weight-volume relationship. The specific gravity of soil solids is used to calculate the density of the soil solids. This is done by multiplying its specific gravity by the density of water (at proper temperature).The term soil solids is typically assumed to mean naturally occurring mineral particles or soil like particles that are not readily soluble in water. Therefore, the specific gravity of soil solids containing extraneous matter, such as cement, lime, and the like, water-soluble matter, such as sodium chloride, and soils containing matter with a specific gravity less than one.

Table for temperature correction to calculate specific gravity of soil at 27^0c.

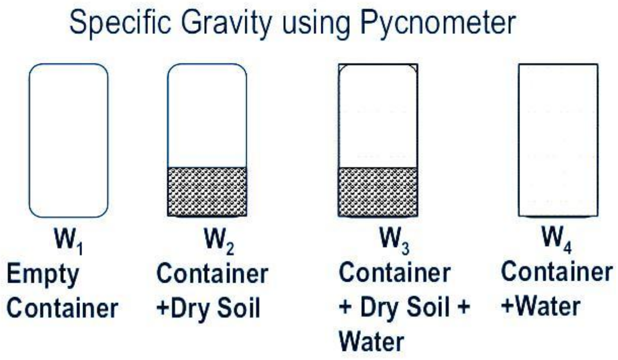
Temp ^{0}C	Density	Temp ^{0}C	Density	Temp ^{0}C	Density
0	0.99987	14	0.99927	28	0.99626
1	0.99993	15	0.99913	29	0.99597
2	0.99997	16	0.99897	30	0.99567
3	0.99999	17	0.99880	31	0.99537
4	1.00000	18	0.99862	32	0.99505
5	0.99999	19	0.99843	33	0.99473
6	0.99997	20	0.99823	34	0.99440
7	0.99993	21	0.99802	35	0.99406
8	0.99988	22	0.99780	36	0.99371
9	0.99981	23	0.99756	37	0.99336
10	0.99973	24	0.99732	38	0.99299
11	0.99963	25	0.99707	39	0.99262
12	0.99952	26	0.99681	40	0.99224
13	0.99940	27	0.99654	41	0.99186

The typical values of specific gravity of various soils are as follows.

Type of soil	Typical Specific Gravity
Gravel, Sand	2.65 – 2.68
Silty sand, Silt	2.66 – 2.70
Clay	2.68 – 2.80
Organic soil	Variable may fall below 2.00

VIII. Experimental Set-up

Pycnometer Bottle with Conical cap



Experimental Flow Diagram

Figure 1: Pycnometer Method

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Pycnometer bottle	As per IS 2720 part- III.	1 No.	Per batch
2	Glass rod or Stirrer	--	1 No.	Per batch
3	Pipette	--	1 No.	Per batch
4	Oven	Temperature range 105-110^{0}C	1 No.	Per batch
5	Weighing balance	With accuracy 0.01 gm	1 No.	Per batch

X. Procedure

1. Clean the pycnometer bottle and dry it. Take the weight of empty pycnometer with conical cap as 'W_1' gm.
2. Oven dry the given soil sample passing through 4.75 mm and retained on 75 micron IS sieve, in oven at temperature 105-110^{0}C for 24 hours to get dry soil.
3. Place this soil sample about 150-200 gms in the pycnometer and take its weight as 'W_2' 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.
5. Fill the distilled water up to top of conical cap using pipette.
6. Take the weight of pycnometer filled with distilled water as 'W_3' gm.
7. Remove all content from the pycnometer bottle. Wash and clean it with water.
8. Fill the pycnometer bottle with distilled water only up to top of conical cap.

9. Take the weight of pycnometer completely filled with water as W_4 gm.
10. Calculate the specific gravity G, as $(W_2 – W_1) / [(W_4 – W_1) – (W_3 – W_2)]$
11. Repeat all above steps two more times to calculate average specific gravity of given soil sample.

XI. Precautions to be followed

1. The soil sample should be completely dry in this test; even small amount of moisture may give erroneous result.
2. While handling the pycnometer bottle, one should take more care.
3. Ensure that the distilled water is filled up to top of conical cap for the particular measurement, so that errors can be minimized.
4. Appropriate correction should be applied as per room temperature during test.

XII. Actual procedure followed *(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					
3					
4					

XIV. Precautions followed

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XV. Observations

- Room temperature at the time of test: ……………. ^{0}C.

Sr. No.	Particulars	Observation No.		
	Sample No. →	1	2	3
1	Mass of empty pycnometer (W_1) gm			
2	Mass of pycnometer with dry soil (W_2) gm			
3	Mass of pycnometer with soil and water (W_3) gm			
4	Mass of pycnometer with water (W_4) gm			
5	Specific Gravity $G = (W_2 – W_1) /((W_4 – W_1) – (W_3 – W_2))$			

Sample Calculation

For Observation No. …………..

$$G = (W_2 – W_1) / [(W_4 – W_1) – (W_3 – W_2)]$$

G = …………………………………………………….

G = …………………………………………………….

Average specific gravity of soil three samples G_{avg} = ……………………………

$G_{avg.}$ = ……………………………

Specific gravity shall be calculated at 27^0C., the following correction shall be done.

G_{27}= K x G_{avg}

Where $G_{27}{}^0$= corrected specific gravity at 27^0C

K= Relative density of water at room temperature / Relative density of water at 27^0C

G_{27} = …………………………………………………

G_{27} = …………………………………………………

XVI. Results

a. The average specific gravity of given soil sample is ………………………………
b. Specific gravity of soil at 27^0C is …………………………………………………….

XVII. Interpretation of results *(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

***Note**: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. State the PH value of distilled water used in experiment.
2. State the maximum capacity, least count and cost of weigh balance you have used.
3. State the effect of variation in room temperature on the value of specific gravity of soil.
4. Give the reason for using oven dried soil sample in this test.
5. Sate two physical properties where specific gravity required for its determination.
6. State two field application where soil having specific gravity less than 2.70 can be used.
7. State two field application where soil having specific gravity more than 2.70 can be used.
8. State the unit of specific gravity of soil.
9. Write the time required to obtain the results of pycnometer test.

(Space to Write Answers)

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://www.youtube.com/watch?v=hNNilk-OKaw	--	--
4.	nptel.ac.in/courses/105103097/web/exp-2-final/s1.htm	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60 %**
1	Measurement of mass of soil with pycnometer	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40 %**
3	Calculations of result	10 %
4	Answers to practical related questions.	20 %
5	Submission of report in time.	10 %
Total: 25 Marks		**100 %**

List of Student Team Members (Roll No.)

1. ....
2. ....
3. ....
4. ....

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 4: Determine Dry Unit Weight of Soil in Field by Core Cutter Method as per IS 2720(Part- XXIX)-1975 Reaffirmed in 2010.

I. Practical Significance

In-situ density of soil is an important parameter for soil engineers. This is needed for determination of bearing capacity of soil, stability analysis and natural slopes and for determining the degree of compaction of fields. The density is used in calculating the stresses in the soil due to overburden pressure. The permeability of soil depends upon its density. This practical is able to know the dry unit weight i.e. dry density of soil which further helps to determine voids ratio, porosity, degree of saturation of soil.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team.*

III. Relevant Course Outcomes

a. Interpret the physical properties of soil related to given construction activities.

IV. Practical Outcome

Determine dry unit weight of soil in field by core cutter method as per IS 2720

(Part- XXIX)-1975 reaffirmed in 2010.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Soil sampling technique
b. Selection of suitable method of soil density determination
c. Handling of instruments

VI. Relevant Affective domain related

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

VII. Minimum Theoretical Background

Bulk Density of Soil (γ): It is defined as the ratio of bulk weight of soil (i.e. including weight of soil and weight of voids) to the volume of soil, is called as Bulk Density of Soil.

$\gamma = (W / V) = [(W_S + W_V) / V]$ in gm/cc; where W_S= weight of soil solids and W_V= weight of voids.

Dry Density of Soil (γ_d): It is defined as the ratio of dry weight of soil (i.e. weight of completely dry soil) to the volume of soil, is called as Dry Density of Soil.

$\gamma = (W_d / V_d) = (W_S / V)$ in gm/cc; where W_S = weight of soil solids

Relation between Bulk Density and Dry Density of Soil:

$$\gamma_d = (100 \times \gamma) / (100 + w)$$

Where, γ_d=dry densityof soil (gm/cc)

γ = bulk densityof soil(gm/cc)

w = water content of soil (%)

VIII. Experimental Set-up

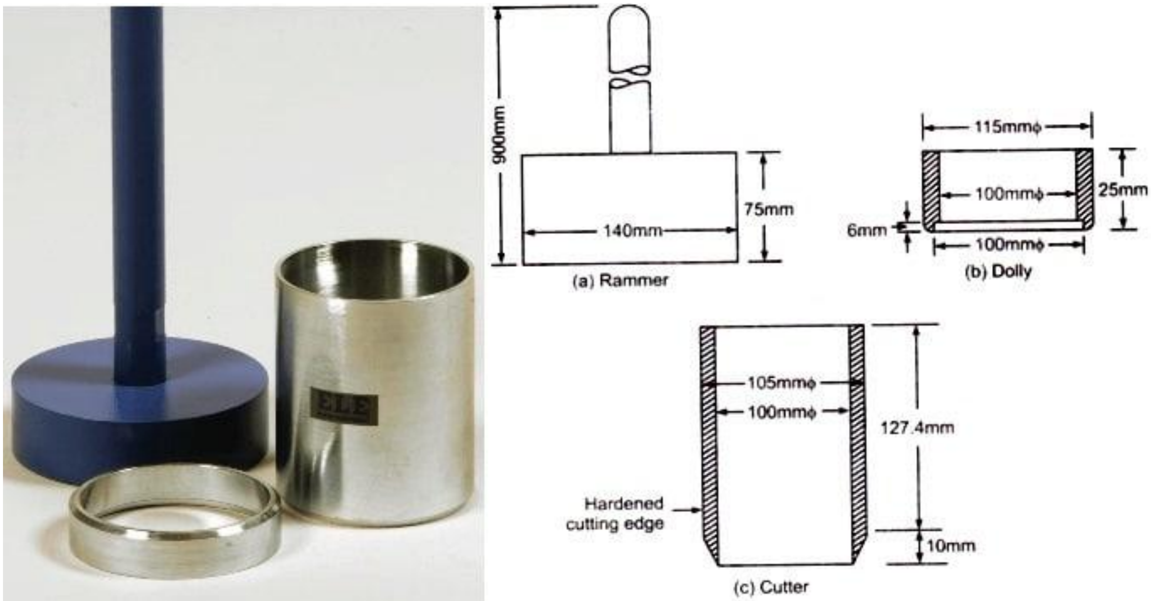

Figure1: Core Cutter with Dolly and Hammer

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Core cutter with dolly	As per IS 2720 part- III.	1 No.	Per batch
2	Pick axe / crow bar	--	1 No.	Per batch
3	Measuring scale	15 or 30 cm in length	1 No.	Per batch
4	Thermostatically controlled Oven	Temperature range 105-110^{0}C	1 No.	Per batch
5	Weighing balance	With accuracy 0.01 gm	1 No.	Per batch
6	Non-corrodible air tight container	--	3 Nos.	Per batch

X. Procedure

1. Measure the height (h) and internal diameter (d) of the core cutter and apply grease to the inside of the core cutter to calculate its volume in cc.
2. Weigh the empty core cutter without dolly as (W_1) gm.
3. Clean and level the place where density is to be determined.
4. Drive the core cutter, with a steel dolly on its top, into the soil to its full depth with the help of a steel rammer, so that half of dolly will remain above the ground.
5. Excavate the soil around the cutter with a crow bar/pick-axe and gently lift the cutter filled with soil without disturbing the soil in it.
6. Trim the top and bottom surfaces of the sample and clean the outside surface of the cutter.
7. Weigh the core cutter with filled with soil (W_2) gm.
8. Calculate bulk density of field soil as $\gamma = (W_2 - W_1) / V$ in gm/cc.
9. Remove the soil from the core cutter, using a sample extractor and take representative soil sample from it to determine the moisture content using any one method as w %.
10. Calculate dry density of field soil as $\gamma_d = (100 \times \gamma) / (100 + w)$ in gm/cc.
11. Repeat all above steps two more places in the field to determine average dry density of soil.

XI. Precautions to be followed

1. Ensure that this method should be used in soft or fine grained soils e.g. clay, silt etc.
2. Core cutter should be driven into the ground till the steel dolly penetrates into the ground half way only so as to avoid compaction of the soil in the core.
3. Before lifting the core cutter, soil around the cutter should be removed to minimize the disturbances.

XII. Actual procedure followed*(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
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XIV. Precautions followed

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XV. Observations

i. Internal diameter of core cutter d= ………………cm.
ii. Height of core cutter h = …………………………cm.
iii. Volume of core cutter V = ………………………..cm^3.

Sr. No.	**Particulars**	**Observation No.**		
	Sample No. →	**1**	**2**	**3**
	Bulk Density Determination			
1	Mass of empty core cutter (W_1) gm			
2	Mass of core cutter filled with field soil (W_2) gm			
3	Bulk Density of soil $\gamma = (W_2 - W_1) / V$ in gm/cc.			
	Water Content Determination			
4	Container No.			
5	Mass of empty container with lid (W_3) gm			
6	Mass of container with lid and moist soil (W_4) gm			
7	Mass of container with lid and dry soil (W_5) gm			
8	Mass of water (W_w) = W_4-W_5			
9	Mass of dry soil (W_s) = W_5-W_3			
10	Water content in % w = (W_w/ W_s) x 100			
	Bulk Density Determination			
11	Dry Density of soil $\gamma_d = (100 \times \gamma) / (100 + w)$ in gm/cc.			

Sample Calculation

For Observation No. 1

Bulk Density of soil $\gamma = (W_2 - W_1) / V$

γ= ……………………………………..

γ= ……………………………………..gm/cc.

Dry Density of soil$\gamma_d = (100 \times \gamma) / (100 + w)$ in gm/cc.

γ_d = ……………………………………..

γ_d=…………………………………….. gm/cc.

Average dry density of soil three samples $(\gamma_d)_{avg.}$ = ……………………………

$(\gamma_d)_{avg.}$= ………………………………gm/cc.

XVI. Results

The average dry density of given soil sample by core cutter method is ……………gm/cc.

XVII. Interpretation of results*(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

Note: *Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. State the suitability of core cutter method and sand replacement method.
2. State the capacity of mould used in this practical in litres.
3. State the wall thickness of core cutter.
4. State the diameter and height of dolly used on the Core cutter.
5. Give reason for application of oil/grease on inside wall surface of core cutter.
6. State the name of tool used to trim the soil after sampling.
7. Give the reason for providing dolly over core cutter during driving in ground.
8. State the unit of density and unit weight of soil.
9. Give the time required to obtain the dry density of soil from date of sampling.

Space to Write Answers

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Soil Mechanics andFoundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://www.youtube.com/watch?v=5rDHjZ_RJq0	--	--
4.	https://www.youtube.com/watch?v=DrA79GEMLf4	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Measurement of mass of soil samples	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40%**
3	Calculations of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ....
2. ....
3. ....
4. ....

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.5: Determine Dry Unit Weight of Soil in Field by Sand Replacement Method as per IS 2720 (Part- XXVIII).

I. Practical Significance

Determination of field density of cohesion less soil is not possible by core cutter method, because it is not possible to obtain a core sample. In such situation, the sand replacement method is employed to determine the unit weight. In-situ density of soil is an important parameter for soil engineers. This is needed for determination of bearing capacity of soil, stability analysis and natural slopes and for determining the degree of compaction of fields. The density is used in calculating the stresses in the soil due to overburden pressure. The permeability of soil depends upon its density. This practical is able to know the dry unit weight i.e. dry density of soil which further helps to determine voids ratio, porosity, degree of saturation of soil.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and team work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Interpret the physical properties of soil related to given construction activities.

IV. Practical Outcome

Determine dry unit weight of soil in field by sand replacement method as per I.S. 2720 (Part- XXVIII).

V. Competency and Practical Skill:

This practical is expected to develop the following skills for the industry identified competency, **"Evaluate soil properties for determining stability of foundation."**

a. Soil sampling technique
b. Selection of suitable method of soil density determination
c. Handling of instruments

VI. Relevant Affective domain related

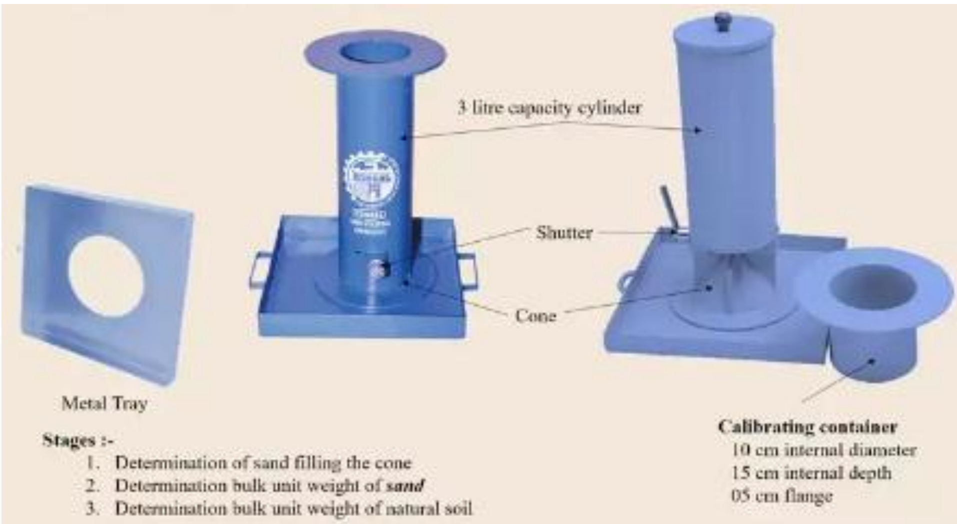
a. Follow safety practices.
b. Demonstrate working as a leader/a team member.
c. Maintain tools and equipment.

VII. Minimum Theoretical Background

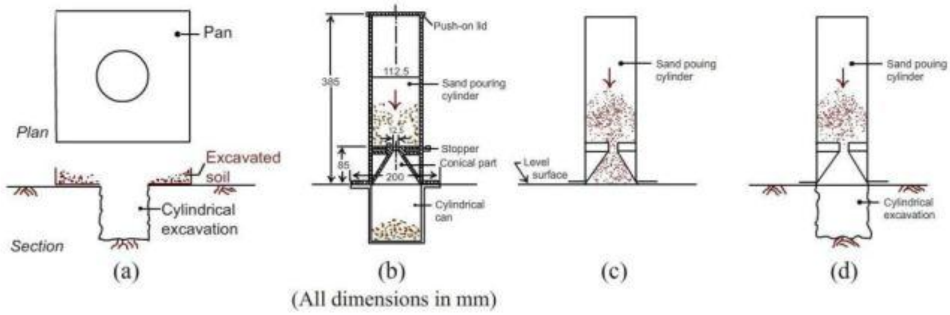
Sand Replacement Method: In sand replacement method, a small cylindrical pit is excavated and the weight of the soil excavated from the pit is measured. Sand whose density is known is filled into the pit. By measuring the weight of sand required to fill the pit and knowing its density the volume of pit is calculated. Knowing the weight of soil excavated from the pit and the volume of pit, the density of soil is calculated. Therefore, in this experiment there are two stages, namely, Calibration of apparatus and measurement of soil density.

The in-situ density refers to the mass per unit volume of a soil in the undisturbed state or of a compacted soil in-place. During the construction of the compacted fills, it is standard practice to make in-situ determination of density of the soil after it is placed to ensure that the compaction effort has been adequate. Core cutter method has limitation in the case of soil containing coarse grained particles such as gravel, stone and aggregates. Under such circumstances, field density test by sand replacement method is advantageous. In sand replacement method a hole of specified diameter is excavated in the ground. The mass of the excavated soil is measured. The volume of the hole is determined by filling it with clean, uniform sand whose dry density is determined separately by calibration.

VIII. Experimental Set-up



Metal cylinder with tray and Calibrating container



Measurement of field density

Figure1: Sand Replacement Method

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Sand pouring cylinder ,mounted above the pouring cone separated by shutter	380 mm height, 100mm diameter, 3-litre capacity	1 No.	Per batch
2	Cylindrical calibrating container	10 cm internal diameter and 15 cm internal depth	1 No.	Per batch
3	Metal tray with central hole	Approx. 30cmx30cm; 40mm deep, 10mm dia. central hole.	1 No.	Per batch
4	Auger for excavating hole	--	1 No.	Per batch
5	Weighing balance	With accuracy 0.01 gm	1 No.	Per batch
6	600 µ -300µ IS sieve	--	3 Nos.	Per batch

X. Procedure

Calibration of apparatus:

1. Remove the cap of sand pouring cylinder, close the shutter, fill the test sand passing through 1mm and retained on 600 micron from the top and replace the cap.
2. Find the mass of sand pouring cylinder with sand nearest to 1.0 gm as (W_1).
3. Place the sand pouring cylinder over the calibration container, open the shutter and allow the sand to flow out for filling the calibration container. Close the shutter.
4. Place this sand pouring cylinder now on a clean and plane surface. Open the shutter and allow the sand to flow out for filling cone fully. Close the shutter, remove the sand pouring cylinder, collect the sand which occupied in the cone and weigh it nearest to 1.0 gm as (W_2).
5. Refill the sand pouring cylinder with sand such that it weighs equal to initial mass W_1.

6. Place the sand pouring cylinder centrally on the calibration container. Open the shutter and allow the sand to fill in the calibration container and cone completely. Close the shutter and find the mass of cylinder with remaining sand as (W_3).
7. Repeat above steps two more times and determine the average value of (W_2) and (W_3).
8. Determine the volume of calibrating container as V_1 either by measuring the internal dimensions or by filling with water and weighing.

Measurement of density in soil in field:

9. Refill the sand pouring cylinder with sand such that it weighs equal to initial mass W_1.
10. Go to the site where field density is to be determined with sand pouring cylinder full of sand, metal tray having central hole and trowel.
11. Expose and level small area, approximately 45cm x 45 cm on the ground where field density is to be determined.
12. Place metal tray having central hole on the prepared ground using central hole as pattern, excavate the soil using trowel up to 150 mm (approximately) depth, remove loose soil carefully and collect it in the metal container (Later on, find the mass of soil collected nearest to 1.0 gm (W) in the laboratory).
13. Remove the metal tray having central hole, place the sand pouring cylinder full of sand centrally over excavated hole. Open the shutter and allow sand to fill in excavated hole and cone completely. Close the shutter and take it to laboratory to find the mass of cylinder with remaining sand as (W_4).
14. Determine water content of collected soil by oven drying method as w%.
15. Repeat step no. 12, 13 and 14 two times more to get average value of dry density of field soil.

XI. Precautions to be followed

1. While calibrating the bulk density of sand, one should take intensive care while observations.
2. The excavated hole must be equal to the volume of the calibrating container.
3. Ensure the shutter of sand pouring cylinder is closed while filling the sand in it. Also open the shutter completely for smooth flow of sand.
4. Sand used in this test should be dry.
5. Excavated soil should be collected as the whole.
6. Sample collected for determination of water content should be kept covered.
7. Calibration of cone apparatus should be done before starting the test.

XII. Actual procedure followed:*(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
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XIV. Precautions followed

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XV. Observations

Calibration of apparatus:

i. Internal diameter of calibrating container (d) = ……………….cm.
ii. Internal height of calibrating container (h)= …………………. cm.
iii. Volume of calibrating container (V_1)= ………………………..cm^3 or cc.

Sr. No.	Particulars	Observation No.		
	Sample No.	**1**	**2**	**3**
1	Mass of sand pouring cylinder full of sand (W_1) gm			
2	Mass of sand in cone (W_2) gm			
3	Mass of cylinder after pouring sand in calibrating container and cone (W_3) gm			
4	Mass of sand filled in calibrating container (W_s) = (W_1 - W_3 – W_2) gm			
5	Density of sand γ_s = (W_s/ V_1) gm/ cc			

Measurement of density in soil in field:

Sr. No.	Particulars	Observation No.		
	Sample No.	**1**	**2**	**3**
1	Mass of sand pouring cylinder full of sand (W_1) gm			
2	Mass of collected soil (W) gm			
3	Mass of cylinder after pouring sand in excavated hole and cone (W_4) gm			
4	Mass of sand filled in excavated hole (W_5) = (W_1 – W_4 – W_2) gm			
5	Volume of collected soil = Volume of hole = Volume of sand filled in excavated hole V = (W_5 / γ_s) cc			
6	Bulk density γ = (W/V) gm/cc			
Measurement of water content of soil:				
7	Container No.			
8	Mass of empty container with lid (W_6) gm			
9	Mass of container with lid and moist soil (W_7) gm			
10	Mass of container with lid and dry soil (W_8) gm			
11	Mass of water (W_w) = W_7 -W_8			
12	Mass of dry soil (W_s) = W_8 -W_6			
13	Water content in % w = (W_w/ W_s) x 100			
14	Dry Density of soil γ_d= (100 x γ) / (100 + w) in gm/cc.			

Sample Calculation:-

(1) Calibration of apparatus

For observation No.………..

Average mass of sand in cone(W_2) gm = ………………….gm

Mass of sand filled in calibrating container (W_s) = (W_1 - W_3 – W_2)

(W_s) = …………………

(W_s) =…………………….gm

Density of sandγ_s= (W_s/ V_1)

γ_s=………………………………………

γ_s=………………………………………gm/cc.

Calculate average density of sand(γ_s)$_{avg.}$ = ………………………….

(γ_s)$_{avg.}$ = ………………………….gm/cc.

(2) Measurement of density of soil in field

For observation No.…………….

Mass of sand filled in excavated hole (W_5) = (W_1 – W_4 – W_2)

(W_5) =………………………………

(W_5) = ……………………………...gm

Volume of collected soil =Volume of hole = Volume of sand filled in excavated hole

V = (W_5 / γ_s)

V =……………………….

V =………………………. cc

Bulk Density of soil γ= Mass of soil mass(W) / Volume of soil mass (V)

γ =…………………………..

γ =…………………………..gm/cc.

Water content (w) = [Mass of water (W_s) / Mass of dry soil mass (W_d)] x 100

Dry density (γ_d)= [(100 x γ) / (100 + w)]

$(\gamma_d) =$ ……………………………………..

$(\gamma_d) =$ …………………………………….gm/cc.

Average dry density of soil three samples $(\gamma_d)_{avg.} =$ …………………………………

$(\gamma_d)_{avg.} =$ …………………………….gm/cc.

XVI. Results

The average dry density of given soil sample by sand replacement method is ……………... gm/cc.

XVII. Interpretation of results:*(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

Note: *Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. State the capacity of cylinder used in this experiment.
2. State the type of sand used for experiment.
3. Give reason for calibrating the cone before starting the experiment.
4. State the suitability of sand replacement method.
5. State the dimension of tray used in experiment.
6. State the method used for determination of water content for this experiment.
7. 'Uniformly graded clean sand is recommended for in-field density measurement', justify the statement.
8. The density of wet and dry soil will differ, give reasons.
9. Give the time required to determine the dry density of soil by this method.

(Space to Write Answers)

XX. References / Suggestions for further Reading

Sr. No	Title of Book	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://www.youtube.com/watch?v=C10dklH12W0	--	--
4.	https://www.youtube.com/watch?v=5rDHjZ_RJq0	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Measurement of mass of soil samples	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40%**
3	Calculations of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……………………………………………
2. ……………………………………………
3. ……………………………………………
4. ……………………………………………

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 6: Determine Plastic Limit & Liquid Limit along with Plasticity Index of given Soil Sample as per IS 2720 (Part- V)-1985 reaffirmed in 2010.

I. Practical Significance:

Liquid and plastic limit have been widely used all over the world, primarily for soil identification and classification. Liquid limit is sometimes used to estimate settlement in consolidation problems. This practical is helpful to know the water percentage of soil to change its state and soil behavior under varying water content. Further the values of liquid limit and plastic limit is useful for deciding the suitability of soil for proposed construction.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Interpret the physical properties of soil related to given construction activities.

IV. Practical Outcome

Determine Plastic Limit & Liquid Limit along with Plasticity Index of given soil sample as per IS 2720 (Part- V)-1985 reaffirmed in 2010.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Soil sampling technique.

b. Selection of suitable method of water content determination.

c. Handling of instruments.

VI. Relevant Affective domain related

a. Follow safety practices.
b. Practice good housekeeping.
c. Maintain tools and equipment.

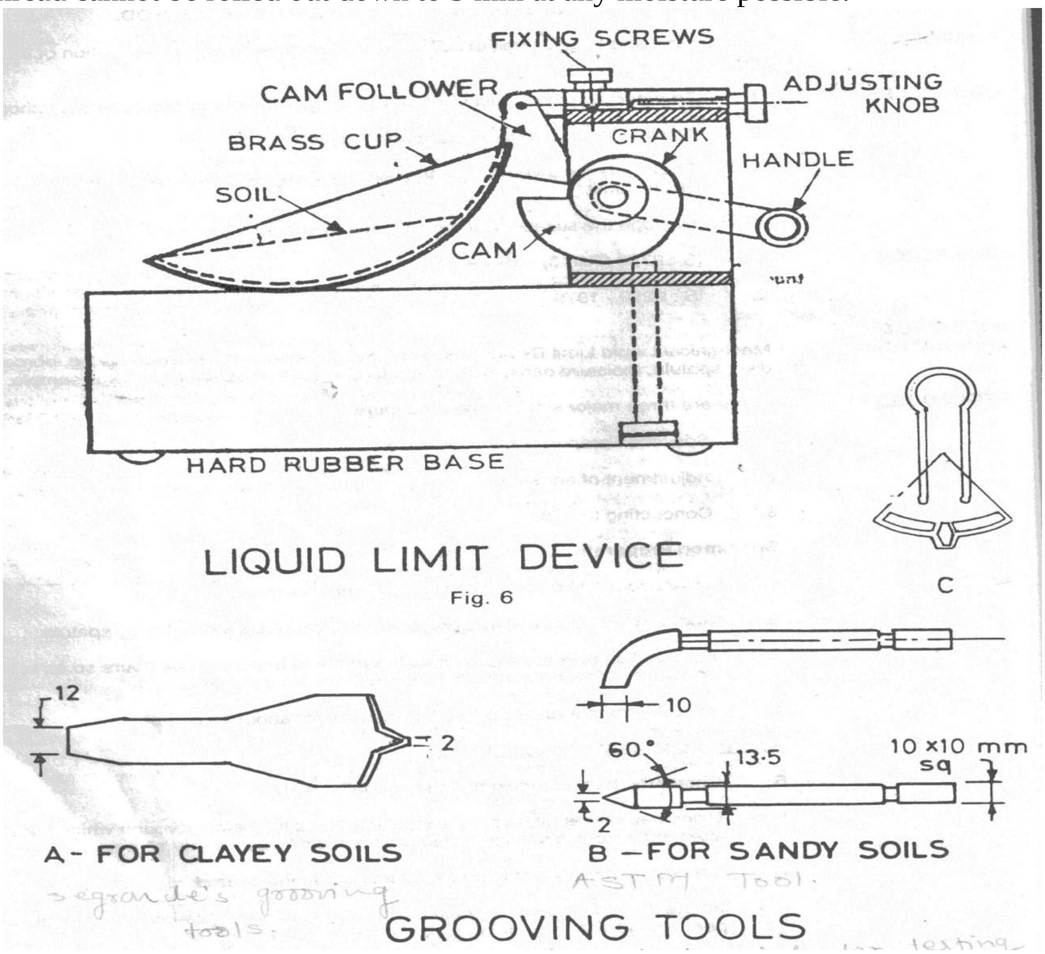
VII. Minimum Theoretical Background

At high moisture content, fine grained soils form suspensions and behave like fluids. As moisture content gradually reduces, the flow properties changes to those of paste like materials up to this stage, soil is said to be in a liquid state. On further drying, the soil can moulded and develops the plastic behavior. This is Plastic state. Further the reduction of water content, plasticity is lost and soil starts crumbling on application of pressure, then it is said to be semisolid state. At still lower moisture content, the soil takes on the properties of a solid or attains solid state.

Atterberg's consistency limits: The numerical values assigned to boundaries of four states: solid, semi-solid, plastic and liquid, is called Atterberg's consistency limits.

Liquid limit (W_L): The liquid limit is conceptually defined as the water content at which the behavior of a clayey soil changes from plastic to liquid. But experimentally it is defined as the minimum water content at which two separated grooved soil parts mixed together under 25 blows of Casagrande's Liquid Limit Apparatus.

Plastic limit (W_P): The plastic limit is defined as the minimum water content where the soil thread breaks when it is rolled into 3mm diameter. A soil is considered non-plastic if a thread cannot be rolled out down to 3 mm at any moisture possible.



LIQUID LIMIT DEVICE

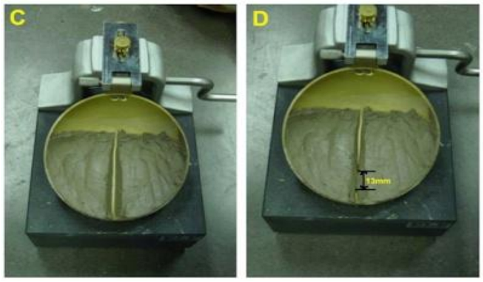
Fig. 6

GROOVING TOOLS

VIII. Experimental Set-up

Casagrande's Liquid Limit Apparatus

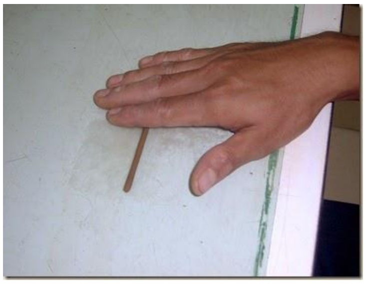
Grooving tools



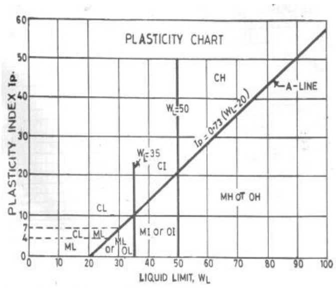
Soil cake before and after rotation

Figure1: Liquid Limit Test

Bowl, spatula, containers



Rolling of soil thread



Plasticity Chart

Figure 2: Plastic Limit Test

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Casagrande's Liquid Limit Apparatus	380 mm height, 100mm diameter, 3-litre capacity	1 No.	Per batch
2	Grooving tools (Casagrande's or ASTM grooving tool)	10 cm internal diameter and 15 cm internal depth	1 No.	Per batch
3	Thermostatically controlled oven	Temperature 100^0c - 115^0c	1 No.	Per batch
4	Metal tray with spatula	30x30 cm	1 No.	Per batch
5	Non-porous glass or marble plate	20 x 15 cm	1 No.	Per batch
6	Non-corrodible air tight container	--	3 Nos.	Per batch

7	Weighing balance	With accuracy 0.01 gm	1 No.	Per batch
8	IS sieve	425µ size	1 No.	Per batch
9	Metal rod	3mm diameter, 10 cm long	1 No.	Per batch

X. Procedure

Liquid Limit Test:

1. Take about 120 gm. of air dried soil sample passing through 425 micron IS sieve in metal tray.
2. Add 20 % distilled water to the soil sample to form uniform soil paste.
3. Put this soil paste in the brass cup of Casagrande's apparatus and spread horizontally into portion with few strokes of spatula.
4. Trim the soil up to a depth of 1 cm maximum thickness and remove excess of soil if any.
5. Divide the soil sample in two parts by the firm strokes of the grooving tool along the diameter through the centreof brass cup so that clean sharp groove of proper dimension is formed.
6. Rotate the handle of Casagrande's apparatus at a rate of 2 revolutions per second until two parts of the soil will come in contact with each other for a length of about 12 mm by flow only.
7. Count the number of blows required to close the groove close for about 12 mm. It is recorded as N.
8. Take representative portion of soil for water content determination as w %.
9. Repeat all above steps by changing water in soil sample to get number of blows between10 to 50. Record the number of blows and corresponding water content for various trials.
10. Draw the flow curve i.e. Number of blows required as abscissa (log scale) versus water content determined as ordinate (natural scale) on semi-logarithmic graph paper.
11. Find out the water content corresponding to 25 blows from graph as liquid limit (W_L)of given soil sample.

Plastic Limit Test:

1. Take 20-25 gm air dried soil sample passing through 425 micron IS sieve.
2. Add distilled water in soil and mix it thoroughly for 10-15 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.)
3. 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.
4. Continue the rolling process till soil starts crumbling and it resembles a uniform thread.
5. Compare the prepared soil thread with metal rod of same diameter, then stop the rolling; where soil thread crumbles into different parts.
6. Determine the water content of crumbled soil parts by oven drying method as w %.
7. Repeat all above steps two more tones to get average water content as plastic limit (W_P)given soil sample.

XI. Precautions to be followed

1. Soil used for liquid limit determination should not be oven dried prior to testing.
2. In liquid limit test the groove should be closed by the flow of soil and not by slippage between the soil and the cup.
3. After mixing the water to the soil sample, sufficient time should be given to permeate the water throughout out the soil mass.
4. Wet soil taken in the container for moisture content determination should not be left open in the air; the container with soil sample should either be placed in desiccators or immediately be weighed.
5. The dropping height of brass cup should be maintained exactly 10mm.

XII. Actual procedure followed:*(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					
3					
4					
5					
6					
7					
8					

XIV. Precautions followed

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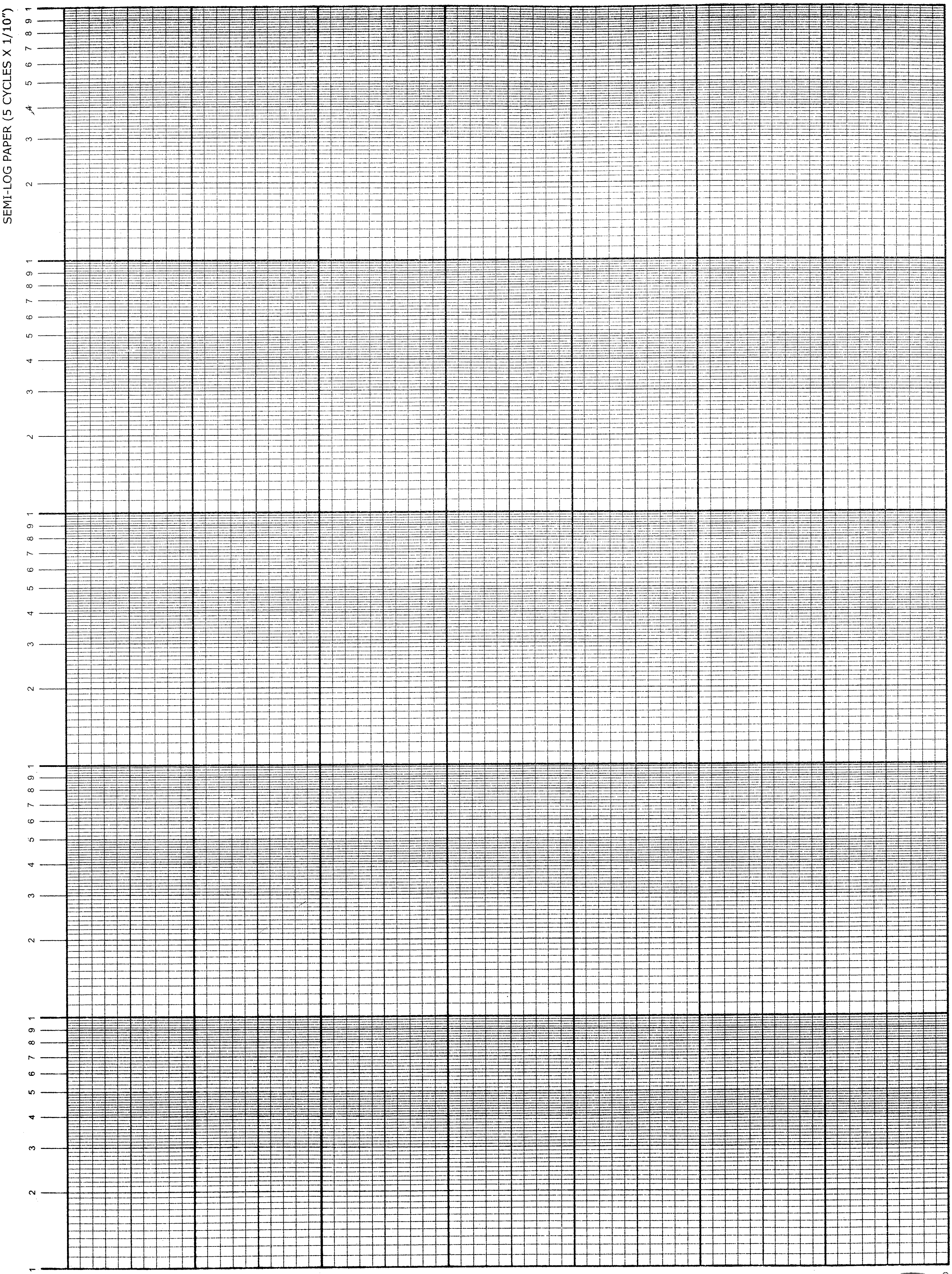
XV. Observations

Liquid Limit Test:

Sr. No.	Particulars	Observation No.				
		1	2	3	4	5
1	No. of blows (N)					
2	Container No.					
3	Mass of empty container with lid (W_1) gm					
4	Mass of container with lid and moist soil (W_2) gm					
5	Mass of container with lid and dry soil (W_3) gm					
6	Mass of water (W_w) = $W_2 - W_3$					
7	Mass of dry soil (W_s) = $W_3 - W_1$					
8	Water content in % $w = (W_w / W_s) \times 100$					

Plastic Limit Test:

Sr. No.	Particulars	Observation No.		
		1	2	3
1	Container No.			
2	Mass of empty container with lid (W_1) gm			
3	Mass of container with lid and moist soil (W_2) gm			
4	Mass of container with lid and dry soil (W_3) gm			
5	Mass of water (W_w) = W_2 -W_3			
6	Mass of dry soil (W_s) = W_3 -W_1			
7	Water content in % w = (W_w/ W_s) x 100			


SEMI-LOG PAPER (5 CYCLES X 1/10")

Sample Calculation:

Liquid limit test:

For Observation No. 1

% w = (W_w/ W_s) x 100

= ……………………………………

= ………………………………….. %

Plastic limit test:

For Observation No. 1

% w = (W_w/ W_s) x 100

= ……………………………………

= …………………………………… %

Average water content in percentage of three samples = …………………………………

= …………………………………%

Plasticity Index of given soil $I_P = W_L - W_P$

= ……………………..

= ………….. %

XVI. Results

a. The liquid limitof given soil sample from flow curve is ………….. %.

b. The plastic limit of given soil sample is ………….. %.

c. The plasticity index of given soil sample is ………….. %.

XVII. Interpretation of results*(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

<u>Note</u>*: Below given are few sample questions for reference. Teachers <u>must design</u> more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. Oven dried soil is not used for liquid limit determination. Justify it.
2. State the size of sieve used for taking soil sample in liquid limit test.
3. Mention the suitability of grooving tools used for clayey/ peat/ silty soil.
4. State the capacity and least count of measuring cylinder used during experiment.
5. State the use of Casagrande's plasticity chart.
6. State the dropping height of brass cup while performing test.
7. Suggest the No. of blows at which liquid limit can be determined from flow curve.
8. State the time required to complete the liquid limit and plastic limit test.
9. Give the unit of liquid and plastic limit of soil.

(Space to Write Answers)

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Soil Mechanics andFoundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://www.youtube.com/watch?v=EcXJ961qjGA	--	--
4.	https://www.youtube.com/watch?v=pM-w_cvk1nA	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Preparation of soil samples	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40%**
3	Calculations of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ………………………………………………
2. ………………………………………………
3. ………………………………………………
4. ………………………………………………

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 7: Determine Shrinkage Limit of given Soil Sample as per IS 2720 (Part- V).

I. Practical Significance

As the soil looses moisture, either in its natural environment, or by artificial means in laboratory it changes from liquid state to plastic state to semi-solid state and then to solid state. The volume is also reduced by the decrease in water content. But, at a particular limit the moisture reduction causes no further volume change. A shrinkage limit test gives a quantitative indication of water content produces no further reduction in soil volume. This practical is important in areas where soils undergo large volume changes when going through wet and dry cycles (e.g. earth dams). The shrinkage limit of fine-grained soils is used for predicting the volume stability of soils in the field.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Interpret the physical properties of soil related to given construction activities.

IV. Practical Outcome

Determine Shrinkage limit of given soil sample as per I.S. 2720 (Part- V).

V. Competency and Practical Skills:

This practical is expected to develop the following skills for the industry identified competency, **"Evaluate soil properties for determining stability of foundation."**

a. Soil sampling technique.
b. Selection of suitable method of water content determination.
c. Handling of instruments

VI. Relevant Affective domain related

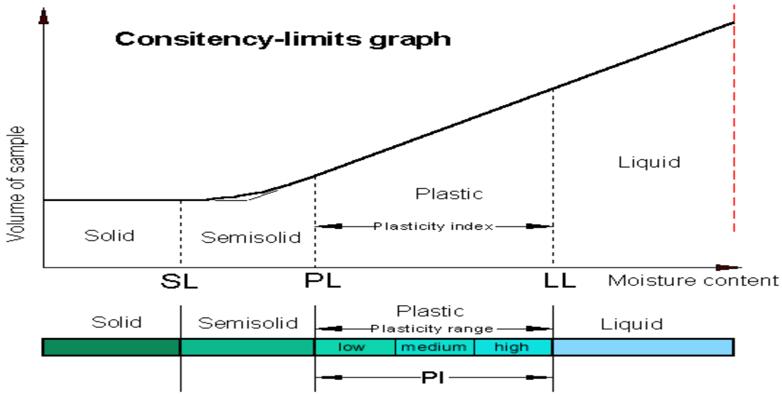
a. Follow safety practices.
b. Practice good housekeeping.
c. Maintain tools and equipment.

VII. Minimum Theoretical Background

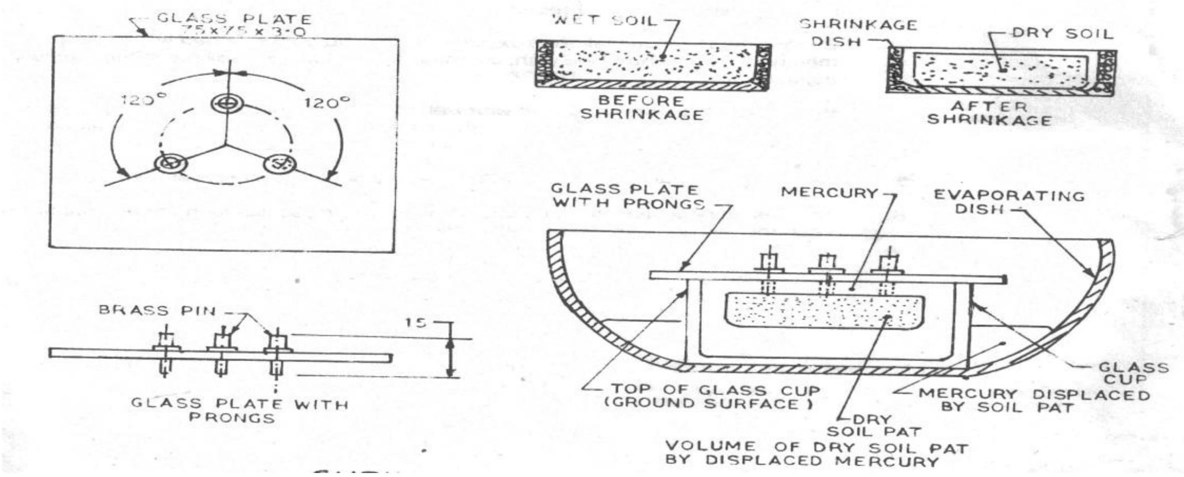
Atterberg'sLimits: There are various consistency limits of soil based on its water holding capacity and soil flow. The shrinkage limit is one of the Atterberg's limits.

Shrinkage Limit(W_S): The shrinkage limit is defined as maximum water content at which there is no reduction in volume of soil due to further decrease in its water content.

The shrinkage limit is the water content of the soil when the water is just sufficient to fill all the pores of the soil and the soil is just saturated. The volume of the soil does not decrease when the water content is reduced below the shrinkage limit.



VIII. Experimental Set-up



Shrinkage dish with prongs plate

Accessories required : Evaporating Dish, Spatula, Glass plate with prong

Figure1: Shrinkage Limit Test

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Evaporating Dish of Porcelain	about 120mm diameter with a pour out and flat bottom.	1 No.	Per batch
2	Spatula and Straight Edge	10 cm internal diameter and 15 cm internal depth	1 No.	Per batch
3	Shrinkage Dish. porcelain or non-corroding metal dish	Circular, having flat bottom, 45mm diameter and 15 mm height	1 No.	Per batch
4	Glass cup	50mm diameter and 25mm height	1 No.	Per batch
5	Glass plates	one plain and one with 3 prongs, 75mm x 75mm x 3mm size	2 Nos.	Per batch
6	Thermostatically controlled oven	Temperature of 110^{0}Cto 115^{0}C	1 No.	Per batch
7	Weighing balance	With minimum accuracy 0.01 gm	1 No.	Per batch
8	IS sieve	425µ size	1 No.	Per batch
9	Wash bottle containing distilled water	3mm diameter, 10 cm long	1 No.	Per batch
10	Mercury Dish	60mm diameter	1 No.	Per batch

X. Procedure

1. Take a sample of mass about 100g from a thoroughly mixed soil passing 425 μ sieve.
2. Take about 30g of soil sample in a large evaporating dish. Mix it with distilled water to make a creamy paste which can be readily worked without entrapping the air bubbles.
3. Take the shrinkage dish. Clean it and determine its mass.
4. Fill the mercury in the shrinkage dish. Remove the excess mercury by pressing the plain glass plate over the top of the shrinkage dish. The plate should be flush with the top of the dish. And no air should be entrapped.
5. Transfer the mercury of the shrinkage dish to a mercury weighing dish and determine the mass of the mercury to an accuracy of 0.1g. the volume of the shrinkage dish is equal to the mass of mercury in grams divided by the specific gravity of the mercury (i.e. 13.6).
6. Coat the inside of the shrinkage dish with a thin layer of silicon grease or Vaseline. Place the soil specimen in the center of the shrinkage dish equal to about one-third the volume of the shrinkage dish. Tap the shrinkage dish on a firm cushioned surface and allow the paste to flow to the edges.
7. Add more soil and continue the tapping till the shrinkage dish is completely filled and excess soil paste projects out about its edge. Strike out the top surface of the plate with a straight edge. Wipe of all soil adhering to the outside of the shrinkage dish. Determine the mass of the wet soil (M_1).
8. Dry the soil in the shrinkage dish in air until the colour of the pat turns from dark to light. Then dry the pat in the oven at 105 to 110 ^{0}C to constant mass for 24 hours.
9. Cool the dry pat in a desiccator. Remove the dry pat from the desiccator after cooling, and weight the shrinkage dish with the dry pat to determine the dry mass of the soil (M_S).
10. Place a glass cup in a large evaporating dish and fill it with mercury. Remove the excess mercury by pressing the glass plate with prongs firmly over the top of the cup. Wipe off any mercury adhering to the outside of the cup. Remove the glass cup full of mercury and place it in another evaporating dish taking care not to spill any mercury from the cup.
11. Take out the dry pat of the soil from the shrinkage dish and immerse it in the glass cup full of mercury. Take care not to entrap air under the pat. Press the plate with prongs on the top of the cup firmly.
12. Collect the mercury displaced by the dry pat in the evaporating dish and transfer it to the mercury weighing dish. Determine the mass of the mercury to an accuracy of 0.1g. The volume of the dry pat (V_2)is equal to the mass of the mercury divided by the specific gravity of the mercury.
13. Repeat the test atleast 3 times

XI. Precautions to be followed

1. Handle the mercury very carefully while using it in this test.
2. Record the observations as per sequential steps enumerated as above.
3. Maintain the temperature of the oven as prescribed above.

XII. Actual procedure followed:*(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					
3					
4					

XIV. Precautions followed

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XV. Observations

Sr. No.	Particulars	Observation No.		
		1	2	3
1	Mass of empty mercury dish (M_1) gm			
2	Mass of mercury dish, with mercury equal to volume of the shrinkage dish (M_2) gm			
3	Mass of mercury (M_m) = (M_2) – (M_1)gm			
4	Volume of shrinkage dish V1= (M_m)/13.6			
5	Mass of shrinkage dish (M_3) gm			
6	(Mass of shrinkage dish + wet soil) (M_4) gm			
7	Mass of wet soil M_5 = (M_4) – (M_3)			
8	(Mass of shrinkage dish + dry soil) (M_6) gm			
9	Mass of dry soil M_s= (M_6) – (M_5)gm			
10	Mass of mercury dish + mercury equal to in volume of dry pat (M_7) gm			
11	Mass of mercury displaced by dry pat (M_{md})=(M_7) – (M_1) gm			
12	Volume of dry pat V_2= (M_{md})/13.6			
13	Shrinkage Limit $W_S =(((M_1 - M_s) / (V_1 – V_2)\ \gamma_w) / M_s) \times 100$			

Sample Calculation:

For Observation No. 1

Shrinkage Limit $W_S= ((M_1 - M_s) / (V_1 – V_2)\ \gamma_w) / M_s) \times 100$

= ……………………………………………………

= ……………………………………………… %

Average Shrinkage Limit in percentage of three samples = ……………………………

= ………………………………….%

XVI. Results

The shrinkage limit of given soil sample is ………….. %.

XVII. Interpretation of results*(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

Note*: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. State the diameter of evaporating dish that you used in this test.
2. Write the density of mercury.
3. Mention the way of preventing inclusion of air bubbles in shrinkage dish.
4. State the necessity of dry pat used in experiment.
5. State the density of distilled water in KN/m^3 and gm/cm^3.
6. State the alternate method to determine shrinkage limit of soil.
7. State the practical applications of shrinkage limit of soil.
8. State the shrinkage value of four different type of soils.
9. Give the time required to determine shrinkage limit of soil in days.

Space to Write Answers

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Soil Mechanics andFoundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://www.youtube.com/watch?v=nTW12RvU77Q	--	--
4.	https://www.youtube.com/watch?v=h5gaAvHD-bI	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Preparation of soil samples	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40%**
3	Calculations of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……………………………………………
2. ……………………………………………
3. ……………………………………………
4. …………………………………………….

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 8: Determine Grain Size Distribution of Given Soil Sample by Mechanical Sieve Analysis as per IS: 2720 (Part- IV).

I. Practical Significance

A sieve analysis (or gradation test) is a practice or procedure used (commonly used in civil engineering) to assess the particle size distribution (also called gradation) of a granular material by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the amount of material that is stopped by each sieve as a fraction of the whole mass.The size distribution is often of critical importance to the way the material performs in use. This practical is important as grain size analysis is widely used in classification of soils. The data obtained from grain size distribution curves is used in the design of filters for earth dams and to determine suitability of soil for road construction, air field etc. It can predict soil water movement although permeability tests are most generally used.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Interpret the physical properties of soil related to given construction activities.

IV. Practical Outcome

Determine grain size distribution of given soil sample by mechanical sieve analysis as per

I.S. 2720 (Part- IV).

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Measurement of soil fractions accurately.
b. Ability of analyzing the obtained weights of soils.
c. Handling of instruments.

VI. Relevant Affective domain related

a. Practice good housekeeping.
b. Demonstrate working as a leader/a team member.
c. Maintain tools and equipment.

VII. Minimum Theoretical Background

Soil consists of an assemblage of discrete particles of various shape and sizes. In this experiment, the soil particles are categorized into different size ranges. Two separate procedures, sieving and sedimentation are used for grain size analysis to span very wide range of particle sizes. One procedure sieving, is used for gravel and sand size particles, which can be separated into different size range with a series of sieves of standard aperture openings. Other procedure is sedimentation (Hydrometer Test) used for silt and clay size particles.

Coefficient of Uniformity (C_u): This is the indicator of spread of the range of the particles sizes and defined as the ratio of D_{60} to D_{10} particle sizes.

Mathematically, $C_u = (D_{60} / D_{10})$

Coefficient of Curvature (C_c): This is the measure of the shape of curve between D_{60} and D_{10}grain sizes and defined as the ratio of square of D_{30} to product of D_{10} and D_{60}.

Mathematically, $C_c = (D_{30})^2 / (D_{10} \times D_{60})$

Particle Size Distribution Curve (PSDC): It is the curve drawn to analyze the soil sample based on its nature. It is sieve size or particle size versus cumulative % finer of particles.

Depending upon the nature of graph drawn, the soil tested is classified as follows.

1. *Well graded soil*-which contains particles of all sizes in it i.e. finer to coarser. The nature of graph is S-shaped.
2. *Poorly graded soil-* which contains large amount of particles of any specific size and deficiency of other sizes in it. The nature of graph is undulating or wavy type.
3. *Uniformly graded soil*- which contains particles of same or equal sizes. The graph will be approximately vertical line parallel to Y-axis.
4. *Fine grained soil*- which contains maximum amount of finer particles in it. The line on PSDC will be cutting to X-axis
5. *Coarse grained soil*- which contains maximum amount of coarse particles in it. The line on PSDC will be cutting to Y-axis

Criteria grading of soil as per the Unified Soil Classification System:

For a gravel to be classified as well graded, the following criteria must be met:

$$Cu > 4 \ \& \ 1 < Cc < 3$$

If both of these criteria are not met, the gravel is classified as poorly graded (GP). If both of these criteria are met, the gravel is classified as well graded (GW).

For a sand to be classified as well graded, the following criteria must be met:

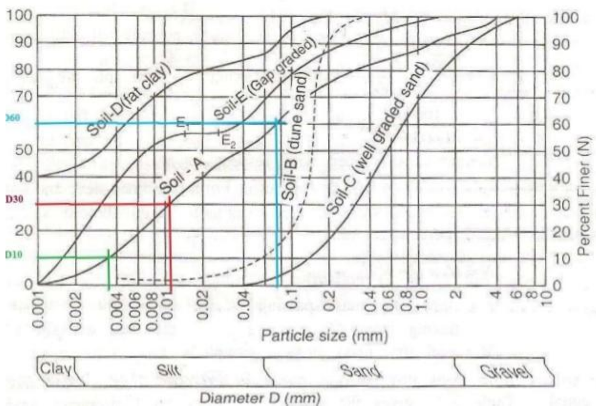
$$Cu \geq 6 \ \& \ 1 < Cc < 3$$

If both of these criteria are not met, the sand is classified as poorly graded or SP. If both of these criteria are met, the sand is classified as well graded or SW.

VIII. Experimental Set-up

Measurement and filling of soil sample

Mechanical Sieve Shaker



Measurement of soil fraction after sieving

Particle Size Distribution Curve (PSDC)

Figure 1: Sieve Analysis Test

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	IS Sieve Set	10mm, 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 212µ, 150µ, 75µ sizes	1 No.	Per batch
2	Mechanical Sieve Shaker	--	1 No.	Per batch
3	Weighing balance	With minimum accuracy 0.01 gm	1 No.	Per batch
4	Thermostatically controlled oven	Temperature of 110^0Cto 115^0C	1 No.	Per batch
5	Metal Tray	30x30cm approx..	1 No.	Per batch
6	Steel brush	--	1 No.	Per batch

X. Procedure

1. 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.
2. Arrange the set of IS sieves mentioned above in the descending order with coarser sieve at top and finer sieve at bottom.
3. Take the soil sample about 500-1000 gm and put it on topmost sieve.
4. Place lid and pan at top and bottom of IS sieve set respectively.
5. Keep this assembly on Mechanical Sieve Shaker for sieving. Continue the shaking the sieve set for minimum10-15 minutes as recommended.
6. Take out the soil from each sieve using steel brush. Measure the weight of soil fraction retained on each sieve separately. Record the same in observation table.
7. Calculate the cumulative percentage finer in tabular format given below.
8. Draw the Particle Size Distribution Curve (PSDC) on semi logarithmic graph as particle size as abscissa (log scale) versus cumulative percentage finer as ordinate (natural scale).
9. From nature of PSDC, classify the given soil in above mentioned categories.

XI. Precautions to be followed

1. Ensure that the soil sample is completely in dry state only.
2. Break the soil lumps before placing it on sieve for sieving.
3. Weigh the soil fraction very accurately retained on each sieve by removing all particles using steel brush.
4. The care should be taken to clean the sieve by brush, so that it will not damage wire fabric of sieve.

XII. Actual procedure followed:*(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					
3					
4					
5					
6					

XIV. Precautions followed

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XV. Observations

- Total mass of dry soil sample taken (W_1) = ………………gm.

Sr. No.	Sieve size/ Particle size	Mass of soil retained (W) gm	% Mass of soil retained $(Wx100)/W_1$	Cumulative % mass of soil retained	Cumulative % Finer (100- Col 5)
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
1	10 mm				
2	4.75 mm				
3	2.36 mm				
4	1.18 mm				
5	600µ				
6	300µ				
7	212µ				
8	150µ				
9	75µ				
10	Pan				

Sample Calculation:

For Observation No. 1

% Mass of soil retained $(Wx100)/W_1$ = …………………………………….

= ……………………………………..%

Cumulative % Finer= (100 - Cumulative % mass of soil retained**)**

= …………………………………….

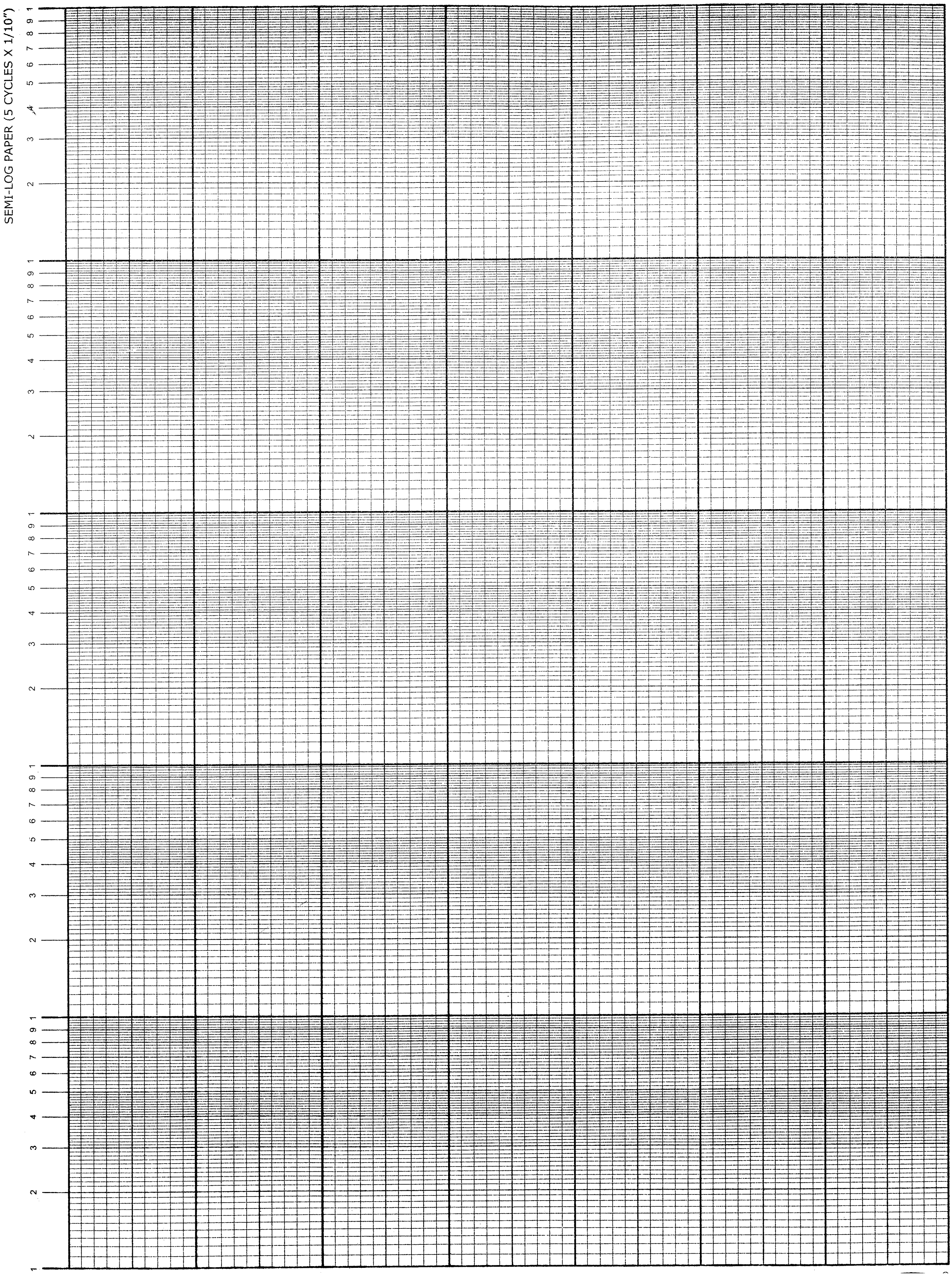
= …………………………………… %

Coefficient of Uniformity $Cu = (D_{60} / D_{10})$ = ……………………………………

= …………………………………….

Coefficient of Curvature $Cc = (D_{30})^2 / (D_{10} \times D_{60})$ = ………………………………

= ………………………………


SEMI-LOG PAPER (5 CYCLES X 1/10")

XVI. Results

i. Coefficient of Uniformity of given soil sample is ………………., hence it is designated as …………………………soil.
ii. Coefficient of Curvature of given soil sample is ………………., hence it is designated as …………………………soil.
iii. The given soil sample is classified as …………………………soil from particle size distribution curve.

XVII. Interpretation of results*(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

Note*: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. Compare mechanical and wet sieving.
2. State the different sizes of sieve used in this experiments.
3. Mention the sieve set range for coarse type of soil.
4. State the minimum time of sieving the soil sample.
5. Write the weight of soil sample taken in this test.
6. Is gradation affecting the soil properties? State properties.
7. State the use of pan/receiver in sieve analysis.
8. State the application of particle size distribution curve.
9. Give the time required to perform this test and to obtain the results.

Space to Write Answers

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Soil Mechanics andFoundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://www.youtube.com/watch?v=j5_6lXOwmv0	--	--
4.	https://nptel.ac.in/courses/105101160/	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Measurement of weight of soil samples	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40%**
3	Calculations/Interpretation of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……………………………………………
2. ……………………………………………
3. ……………………………………………
4. ……………………………………………

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 9 : Use Different Types of Soil and Identify and Classify Soil by Conducting Field Tests-through Visual Inspection, Dry Strength Test, Dilatancy Test and Toughness Test.

I. Practical Significance

The constituent parts of fine grained soil are silt and clay fractions. Both these constituents are microscopic in size; the properties other than grain size are used as criteria for field identification. The classification tests used in the field for preliminary identification are dry strength test dilatancy test, plasticity test and toughness test. These tests are done without use of major equipment. These field methods are used primarily to classify and describe the soil. Visual observations are employed in place of precise laboratory tests to define basic soil properties. This practical is useful to do general assessment of sites during field reconnaissance activities.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Interpret the physical properties of soil related to given construction activities.

IV. Practical Outcome

Use different types of soil Identify and classify soil by conducting field tests-Through Visual inspection, Dry strength test, Dilatancy test and Toughness test.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Soil sampling technique.
b. Ability to classify the soil.

VI. Relevant Affective domain related

a. Follow safety practices.

b. Practice good housekeeping.

c. Demonstrate working as a leader/a team member.

d. Follow ethical Practices.

VII. Minimum Theoretical Background:

1. **Dilatancy or Shaking Test_**: Since silts are considerably more permeable than clays, the dilatancy or shaking test may also be used to distinguish between the two materials. In this test a small amount of soil is mixed with water to a very soft consistency in the palm of the hand. The back of the hand is then lightly tapped. If the soil is silty, water rises quickly to its surface and gives it a shiny or glistening appearance. Then if the soil pat is deformed, in some instances by squeezing and in others by stretching, the water flows back into it and leaves the surface with a dull appearance. Usually, the greater is the proportion of clay in the sample, the slower the reaction to the test. The reaction is described as rapid, slow or none.

2. **Toughness / Plasticity Test** : The property of plasticity is characteristic of clays and may be used as the basis for a simple field test. At certain moisture contents a soil that contains appreciable quantities of clay can be deformed and remolded in the hand without disintegration. Thus, if a sample of moist soil can be manipulated between the palms of the hands and fingers and rolled out into a long thread, it unquestionably contains a significant amount of clay. As moisture is lost during continued manipulation, the soil approaches a non-plastic condition and becomes crumbly. Just before the crumbly state is reached, highly plastic clay can be rolled into a long thread, with a diameter of approximately 3mm, which has sufficient strength to support its own weight. Silt, on the other hand, can seldom be rolled into a thread with a diameter as small as 3mm without severe cracking, and is completely lacking in tensile strength unless small amounts of clay are present. The record of a simple plasticity test should indicate not only whether a plastic thread can be formed, but also the toughness of the thread as it nears the crumbling stage. This condition is described as weak and friable, medium, or tough.

3. **Dry Strength Test** : The dry strength provides one basis for distinction. A small briquette of the soil is molded and allowed to dry in the air. It is then broken and a small fragment about 1.0 cm in size is pressed between thumb and forefinger. The effort required to break the fragment provides a basis for describing the strength as ver low, low, medium, high or very high. A clay fragment can be broken only with great effort, where as a silt fragment crushes easily.

After conducting these tests we can use the table given below to classify the soil as silt or clay.

Typical Name of Soil	Dry Strength	Dilatancy Reaction	Toughness of plastic thread
Sandy silt	None to very low	Sandy silt	Weak to friable
Silt	Very low to low	Rapid	Weak to friable
Clayey silt	Low to medium	Rapid to slow	Medium
Sandy clay	Low to high	Slow to none	Medium
Silty clay	Medium to high	Slow to none	Medium
Clay	High to very high	None	Tough
Organic silt	Low to medium	Slow	Weak to friable
Organic clay	Medium to very high	none	Tough

VIII. Experimental Set-up

Visual Inspection Test

Dry Strength Test

Dilatancy or Shaking Test

Toughness Test

Figure 1: Field Tests on Soil

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Hand Gloves	--	2 Nos.	Per batch
2	Safety Shoes	--	1 No.	Per batch
3	First aid kit	--	1 No.	Per batch
4	Excavating tools	Pick Axe, pawrah	2-3 Nos.	Per batch

X. Procedure

The course teacher should organize the visit to nearby field of proposed construction work/open land to be developed to conduct the following field tests.

1. Visual Inspection Test :

1. Take the soil sample from the site or field in palms and spread it uniformly.
2. Check the various physical properties of soil taken i.e. colour, odour, gradation, grain size.
3. Fresh wet organic soils usually have a distinctive odour of decomposed organic matter.
4. This odour can be made more noticeable by heating the wet sample.
5. Another indication of the organic matter is the distinctive dark colour. In tropical soils, the dark colour may be or may not be due to organic matter; when not due to organic matter, it is associated with poor drainage. Dry organic clays develop an earthy odour upon moistening, which is distinctive from that of decomposed organic matter.

2. Dry Strength Test (Crushing Resistance):

1. Dry completely the prepared soil pat.
2. Then measure its resistance to crumbling and powdering between fingers.
3. This resistance, called dry strength, is a measure of the plasticity of the soil and is influenced largely by the colloidal fraction content.
4. The dry strength is designated as low, if the dry pat can be easily powdered; medium, if considerable finger pressure IS required and high, ifit cannot be powdered at all. Observe and record the dry strength as descriptive information.

3. Dilatancy Test:

1. Take a small representative sample in the form of a soil pat of the size of about 5 cubic centimeters.
2. Add enough water to nearly saturate it.
3. Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times.
4. Squeeze the pat between the fingers.

5. The appearance and disappearance of the water with shaking and squeezing is referred to as a reaction. This reaction is called quick, if water appears and disappears rapidly; slow, if water appears and disappears slowly; and no reaction, if the water condition does not appear to change. Observe and record type of reaction as descriptive information.

4. Toughness Test:

1. Dry the pat used in the dilatancy test by working and moulding, until it has the consistency of putty. The time required to dry the pat is the indication of its plasticity.
2. Roll the pat on a smooth surface or between the palms into a thread about 3 mm in diameter.
3. Fold and reroll the thread repeatedly to 3 mm in diameter so that its moisture content is gradually reduced until the 3 mm thread just crumbles.
4. The moisture content at this time is called the plastic limit and the resistance to moulding at the plastic limit is called the toughness. After the thread crumbles, lump the pieces together and continues light kneading action until the lump crumbles.
5. If the lump can be moulded slightly drier than the plastic limit and if high pressure is required to role the thread between the palms of the hand. The soil is described as having high toughness. Medium toughness is indicated by a medium thread and a lump formed of the threads slightly below the plastic limit will crumble; while low toughness is indicated by a weak thread that breaks easily and cannot be lumped together when drier than the plastic limit. Highly organic clays have very weak and spongy feel at the plastic limit. Non-plastic soils cannot be rolled into thread of 3 mm in diameter at any moisture content. Observe and record the toughness as descriptive information.

XI. Precautions to be followed

1. Take the safety shoes while visiting the particular site or field.
2. Use safety gloves while handling the soil sample on site itself.
3. Keep the first aid accessories during the site visit.
4. The recording of observations should be made very accurately.

XII. Actual procedure followed: *(Use blank sheet if provided space is not sufficient)*

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XIII. Observations

i. Date and time of Visit =……………………………………………………………

ii. Location of Visit = ……………………………………………………………

Sr. No.	Name of Field Identification Test	**Observations during Site Visit** (Physical properties, behavior of soil to test performed etc.)
1	Visual Inspection Test	
2	Dilatancy Test	
3	Toughness Test	
4	Dry Strength Test	

Actual site visit photographs (any two) showing the field tests should be pasted below.

XIV. Results

i. The type of soil based on visual inspection test is found ……………………….
ii. The type of soil based on dry strength test is found …………………………….
iii. The type of soil based on dilatancy test is found ……………………………….
iv. The type of soil based on toughness test is found ………………………………

XV. Interpretation of results*(Give meaning of the above obtained results)*

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XVI. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XVII. Practical Related Questions

Note*: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. State the texture of collected soil sample at visit.
2. State the color of collected soil sample at visit.
3. State the odor of collected soil sample at visit.
4. State the type of soil containing fine particles.
5. State the atmospheric temperature during visit approximately.
6. State two difficulties arise during site visit if any.
7. Name the various tools used by you during field identification of soil.
8. State whether the soil is organic or inorganic type, if its colour is dark grey.
9. State five properties of soil which can be determined in the lab only.

Space to Write Answers

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XVIII. References / Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629

XIX. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Performing the field tests	30 %
2	Recording of observations on field	30 %
Product related:10 Marks		**40%**
3	Interpretation of result	10%
4	Answers to practical related questions	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……………………………………………
2. ……………………………………………
3. ……………………………………………
4. ……………………………………………

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 10: Determine Coefficient of Permeability by Constant Head Test as per IS 2720 (Part- XVII)

I. Practical Significance

The purpose of this test is to determine the permeability (hydraulic conductivity) of a sandy soil by the constant head test method. The knowledge of this property is much useful in solving problems involving yield of water bearing strata, seepage through earthen dams, stability of earthen dams, and embankments of canal bank affected by seepage, settlement etc. Permeability (or hydraulic conductivity) refers to the ease with which water can flow through a soil. This property of soil is necessary for the calculation of seepage through earth dams or under sheet pile walls, the calculation of the seepage rate from waste storage facilities (landfills, ponds, etc.), and the calculation of the rate of settlement of clayey soil deposits. The permeability of soil is recommended for maximum particle size of 9.5mm and permeability of soil varying from the range 10^{-3} to 10^{-7} cm/seconds.

II. Relevant Program Outcomes:

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Use the results of permeability and shear strength test for foundation analysis.

IV. Practical Outcome

Determine coefficient of permeability by constant head test as per I.S. 2720 (Part- XVII)

V. Competency and Practical Skills:

This practical is expected to develop the following skills for the industry identified

competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Ability of preparing test soil specimen for the permeameter.
b. Observing the water flow at any instant.
c. Handling of instruments.

VI. Relevant Affective domain related

a. Practice good housekeeping.
b. Demonstrate working as a leader/a team member.
c. Maintain tools and equipment.

VII. Minimum Theoretical Background:

Permeability: Permeability is defined as the property of a porous material which permits the passage or seepage of water through its interconnecting voids. It is a very important engineering property. Gravels are generally highly permeable than that of stiff clay which are least permeable.

Darcy's law: It states that there is a linear relationship between flow velocity (v) and hydraulic gradient (i) for any given saturated soil under steady laminar flow conditions.
If the rate of flow is q (volume/time) through cross-sectional area (A) of the soil mass,

Darcy's Law can be expressed as

$$v = q/A = k.i$$

where k = permeability of the soil
q = discharge of water through soil
A = cross sectional area of soil
i = hydraulic gradient
$I = \Delta h/L$
Δh = difference in total heads
L = length of the soil mass

The purpose of constant head test is to determine the permeability (hydraulic conductivity) of a sandy soil. There are two general types of permeability test methods that are routinely performed in the laboratory:

1. The constant head test method. The constant head test method is used for permeable soils ($k > 10^{-4}$ cm/s) and
2. The falling head test method is mainly used for less permeable soils ($k < 10^{-4}$ cm/s).

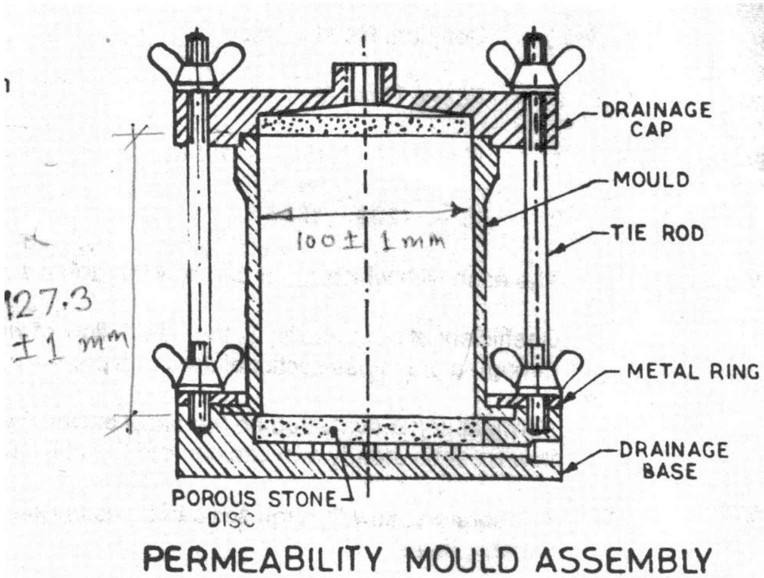
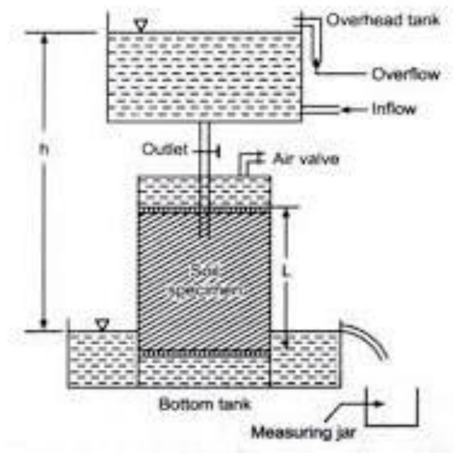


Figure 1: Permeability Mould

VIII. Experimental Set-up

Constant Head Test Apparatus



Schematic diagram of Constant Head Test

Figure 2: Constant Head Test

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Constant Head Test Apparatus	as per I.S. 2720 (Part- XVII)	1 No.	Per batch
2	Tamper	--	1 No.	Per batch
3	Balance	With minimum accuracy 0.01 gm	1 No.	Per batch
4	Scoop	--	1 No.	Per batch
5	Graduated cylinders	1000 mL	1 No.	Per batch
6	Watch (or Stopwatch)	Least count 0.01 seconds	1 No.	Per batch

X. Procedure

1. Take 2.5 Kg air dried soil sample passing through 9.5mm IS sieve**.**
2. Add the water in soil equals to its optimum moisture content (OMC) to get required density.
3. Apply grease to inside surface of mould, base plate and collar. Clamp the base plate with extension collar.
4. Fill the prepared soil sample in permeameter in three different layers. Compact each layer using 25 blows using rammer.
5. Remove the collar and trim the excess soil for mould. Remove compaction base plate.

6. Cover the soil with filter paper and porous stones on both sides.
7. Place the mould assembly in the drainage base. Fix the top cap on it using rubber sealing gasket.
8. Open air vent at top of permeameter mould to remove air from soil.
9. Immerse the mould with soil specimen in water tank for saturating it about 24 hours.
10. Connect the inlet nozzle of permeameter to outlet of constant head water tank. Close the air vent of mould.
11. Open outlet of permeameter and allow water to flow in the bottom water tank. Wait for some time to establish steady flow.
12. Measure head causing flow ‘h’. Collect quantity of water (Q) in the measuring cylinder for suitable time interval (t).
13. Calculate the coefficient of permeability of soil as K = (Q x L) / (A x h x t) in cm/s.
14. Repeat all above steps two more times to get average coefficient of permeability of given soil sample.

XI. Precautions to be followed

1. Ensure that the soil sample taken for test should be completely in dry state only.
2. Break the soil lumps before placing it on sieve for sieving.
3. While the reading the head of water read at the lower meniscus.
4. Saturate the porous disc assembling in the mould.

XII. Actual procedure followed: *(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					
3					
4					
5					

XIV. Precautions followed

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XV. Observations

i. Length of soil specimen (L) = ……………………..cm.
ii. Diameter of soil specimen (d) = ……………………cm.
iii. C/S area of soil specimen (A) = ……………………cm^2.

Sr. No.	Head 'h' in cm	Quantity of water collected 'Q' in ml or cc	Time 't' in sec	Coefficient of permeability K = (QxL)/(Axhxt) in cm/sec
1				
2				
3				
4				

Sample Calculation:

For Observation No. 1

Coefficient of permeability K = (Q x L) / (A x h x t) **=** ……………………………………

= ……………………………………cm/s

Average Coefficient of permeability = ………………………………………..

= …………………………………… cm/s

XVI. Results

The average coefficient of permeability of the given soil by constant head method is ………………… cm/s.

XVII. Interpretation of results *(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

Note: *Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. Explain the function of porous stones on both side of soil sample.
2. State the capacity and least count of measuring cylinder used to measure discharge.
3. State the overall cost of apparatus required for constant head method.
4. State the practical applications of permeability of soil.
5. Give the values of coefficient of permeability of any two type of soil.
6. State the units of measurement of coefficient of permeability of soil.
7. State the type of soil for which the constant heat test is suitable or recommended.
8. Enlist the factors affecting permeability of soil.
9. State the total time required to perform this test.

Space to Write Answers

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XX References / Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://www.youtube.com/watch?v=dnLLUMW0j3I	--	--
4.	nptel.ac.in/courses/105101084/23	--	--

XX. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Measurement of time and discharge	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40%**
3	Calculations of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……………………………………………
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Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 11: Determine Coefficient of Permeability by Falling Head Test as per IS 2720 (Part- XVII)

I. Practical Significance

The purpose of this test is to determine the permeability (hydraulic conductivity) of a sandy soil by the constant head test method. The knowledge of this property is much useful in solving problems involving yield of water bearing strata, seepage through earthen dams, stability of earthen dams, and embankments of canal bank affected by seepage, settlement etc. Permeability (or hydraulic conductivity) refers to the ease with which water can flow through a soil. This property of soil is necessary for the calculation of seepage through earth dams or under sheet pile walls, the calculation of the seepage rate from waste storage facilities (landfills, ponds, etc.), and the calculation of the rate of settlement of clayey soil deposits. The permeability of soil is recommended for maximum particle size of 9.5mm and permeability of soil varying from the range 10^{-3} to 10^{-7} cm/seconds.

II. Relevant Program Outcomes:

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Use the results of permeability and shear strength test for foundation analysis.

IV. Practical Outcome

Determine coefficient of permeability by falling head test as per I.S. I.S. 2720 (Part- XVII).

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Ability filling test soil specimen mould.
b. Observing accurately the fall of head and corresponding time.
c. Handling of instruments.

VI. Relevant Affective domain related

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.

VII. Minimum Theoretical Background

The falling head permeability test involves flow of water through a relatively short soil sample connected to a standpipe which provides the water head and also allows measuring the volume of water passing through the sample. The diameter of the standpipe depends on the permeability of the tested soil. The test can be carried out in a Falling Head permeability cell or in an odometer cell. Before starting the flow measurements, the soil sample is saturated and the standpipes are filled with de-aired water to a given level. The test then starts by allowing water to flow through the sample until the water in the standpipe reaches a given lower limit. The time required for the water in the standpipe to to drop from the upper to the lower level is recorded. Often, the standpipe is refilled and the test is repeated. On the basis of the test results, the permeability of the sample can be calculated as

$K = [2.303 \, a \times L / (A \times t)] \, . \, \text{Log} \, (h_1 / h_2)$

Where, a = the cross section of the standpipe

L = the height of the soil sample column (cm)

A = cross sectional area of soil specimen (cm^2)

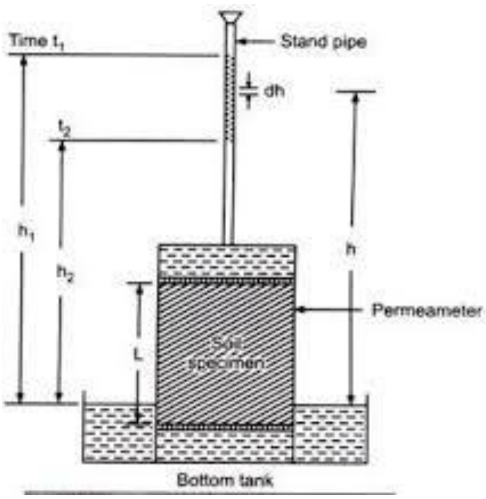
t = time reuired to fall the water head from h_1 to h_2. (sec.)

h_1 = initial water head (cm)

h_2 = final water head (cm)

The falling head test is mainly used for less permeable soils (k<10-4 cm/s).

VIII. Experimental Set-up



Falling Head Test Apparatus   Schematic diagram of Falling Head Test

Figure1: Falling Head Test

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Falling Head Test Apparatus	as per I.S. 2720 (Part- XVII)	1 No.	Per batch
2	Tamper	--	1 No.	Per batch
3	Balance	With minimum accuracy 0.01 gm	1 No.	Per batch
4	Scoop	--	1 No.	Per batch
5	Graduated cylinders	1000 mL	1 No.	Per batch
6	Watch (or Stopwatch)	Least count 0.01 seconds	1 No.	Per batch

X. Procedure

1. Take 2.5 Kg air dried soil sample passing through 9.5 mm IS sieve**.**
2. Add the water in soil equals to its optimum moisture content to get required density.
3. Apply grease to inside surface of mould, base plate and collar. Clamp the base plate with extension collar.
4. Fill the prepared soil sample in permeameter in three different layers. Compact each layer using 25 blows using rammer.
5. Remove the collar and trim the excess soil for mould. Remove compaction base plate.
6. Cover the soil with filter paper and porous stones on both sides.
7. Place the mould assembly in the drainage base. Fix the top cap on it using rubber sealing gasket.
8. Open air vent at top of permeameter mould to remove air from soil.
9. Immerse the mould with soil specimen in water tank for saturating it about 24 hours.
10. Connect inlet nozzle of permeameter to the stand pipe filled with water. Close air valve of permeameter.
11. Open outlet of permeameter and allow water to flow out. Wait for some time to establish steady flow.
12. Measure the head ‘h_1’ and time ‘t_1’.
13. Let the water level in stand pipe to fall to lower head. Note the head ‘h_2’ and corresponding time ‘t_2’.
14. Calculate the coefficient of permeability of soil as K= 2.303x a x L /(Ax t)] x Log_{10} ($h_{1\,/}\, h_2$).
15. Repeat all above steps two more times to calculate the average coefficient of permeability of given soil sample.

XI. Precautions to be followed:

1. Ensure that the soil sample taken for the test should be completely in dry state only.
2. Break the soil lumps before placing it on sieve for sieving.
3. Soils of low permeability require periods from a day to one week for saturation.
4. While reading the head of water, read at the lower meniscus.

XII. Actual procedure followed: *(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
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XIV. Precautions followed

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XV. Observations

i. Length of soil specimen (L) = …………………….cm.
ii. Diameter of soil specimen (D) = ………………….cm.
iii. C/S area of soil specimen (A) = …………………..cm^2.
iv. Diameter of stand pipe (d) = ………………………cm.
v. C/S area of stand pipe (a) =………………………..cm^2.

Sr. No.	**Internal dia. of stand pipe cm**	**Inside area of stand pipe (a) cm^2**	**Initial head h_1 cm**	**Initial time t_1 cm**	**Initial head h_2 cm**	**Initial time t_2 cm**	**Time interval t = $(t_2 - t_1)$ sec**	**Coefficient of Permeability K=[2.303xaxL/(Axt)]x $Log_{10}(h_1 / h_2)$ cm/s**
1								
2								
3								

Sample Calculation:

For Observation No. 1

Coefficient of permeability K= [2.303 x a x L/(A x t)] x $Log_{10}(h_1 / h_2$

= ………………………………………………

= ………………………………………………cm/s

Average Coefficient of permeability = ………………………………………….

= …………………………………………… cm/s

XVI. Results

The average coefficient of permeability of the given soil by falling head method is

………………… cm/s.

XVII. Interpretation of results: *(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

Note: *Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. Name the instrument used to measure dimensions of mould in this test.
2. State the type of soil that you have used in this test.
3. Explain the function of burette pipe of soil sample.
4. Explain the method of filling the soil sample in the permeameter.
5. State the purpose of air vent pipe in this method.
6. State the suitability to soil of the falling head method.
7. Compare the falling head method with constant head method. with respective to type of soil and discharge.
8. State the types of soil for which falling head method is suitable or preferable.
9. State the time required to perform this test.

(Space to Write Answers)

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	nptel.ac.in/courses/105101084/23	--	--
4.	https://www.youtube.com/watch?v=U7IGdFpVEoQ	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Measurement of time require and fall of head	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40%**
3	Calculations of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……………………………………………
2. ……………………………………………
3. ……………………………………………
4. ……………………………………………

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 12: Determine Shear Strength of Soil by Direct Shear Test as Per I.S. 2720 (Part-XIII)

I. Practical Significance

When soil is loaded, shearing stresses induced in it. When sharing stress is reaching limiting value, shear deformation takes place, leading to failure of soil mass. The failure may be in the form of sinking of a footing, or moment of a wedge of soil behind the retaining wall forcing it to move out, or the slide in an earth embankment. In many engineering problems such as design of foundation, retaining walls, slab bridges, pipes, sheet piling, the value of the angle of internal friction and cohesion of the soil involved are required for the design. Direct shear test is used to predict these parameters quickly. A direct shear test is a laboratory test used by geotechnical engineers to measure the shear strength properties of soil or rock material, all stability analysis in soil mechanics involved the basic knowledge of shearing properties and shearing resistance of soil.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes:

a. Use the results of permeability and shear strength test for foundation analysis.

IV. Practical Outcome

Determine shear strength of soil by direct shear test as per I.S. 2720 (Part-XIII) .

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, **"Evaluate soil properties for determining stability of foundation."**

a. Ability preparing test soil specimen mould.
b. Handling of instruments

VI. Relevant Affective domain related

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.

VII. Minimum Theoretical Background

Shear strength of soil: This standard (IS 2720: Part 13) covers the methods for determination of shear strength of soil with a maximum particle size of 4.75 mm in undrained, consolidated undrained and consolidated drained conditions.

The resistance of soil against its sliding or the ability of soil to remain stable even in sloping condition is known as *Shear Strength of Soil*.

The test can be performed under all the preconditions of drainage. To conduct undrained test, plain grids are used. For the drained test, perforated grids are used. The same is the first consolidated under the normal load, and then sheared sufficiently slowly so that complete dissipation of pore pressure takes place. The drains test is therefore also known as slow test, and the shearing of cohesive soil may sometimes require 2-5 days. Cohesion less soils are sheared in relatively less time. For the consolidated undrained test, perforated grids are used. The sample is permitted to consolidate under the normal load. After the completion of consolidation, the specimen is sheared quickly in about 5-10 minutes. The shear test is simple test. The relatively thin thickness of sample permits quick drainage and quick dissipation of pore pressure develops during the test.

Shear strength of a soil is its maximum resistance to shearing stresses. The shear strength is expressed as $s = c' + \sigma . \tan Ø$

Where c' = effective cohesion, $\overline{\sigma}$ = effective stress, ϕ' = effective angle of shearing resistance.

The shear tests can be conducted under three different drainage conditions. The direct shear test is generally conducted on sandy soils as a consolidated drained test.

VIII. Experimental Set-up

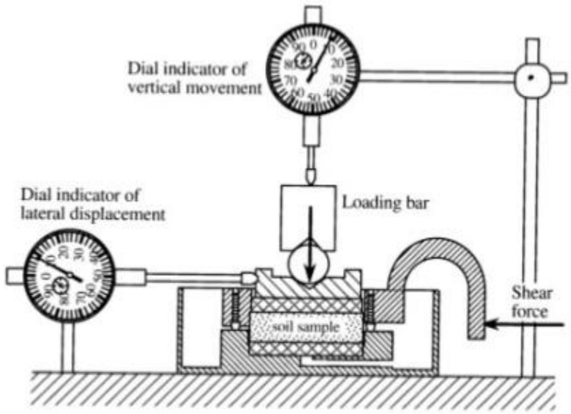

Figure 1: Shear Box Assembly

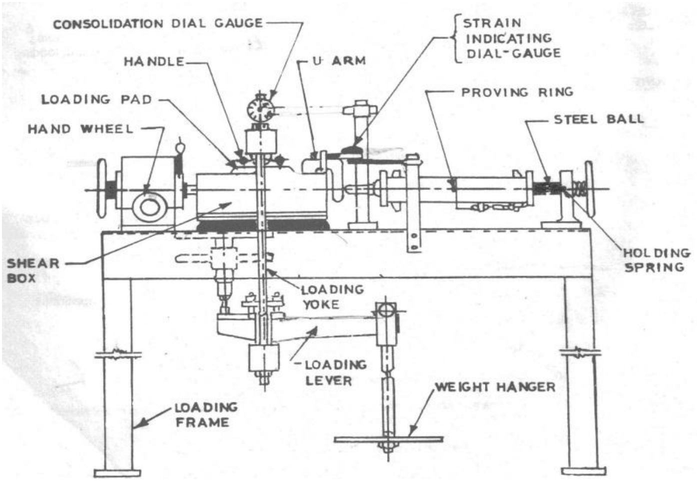

Figure 2: Direct Shear Test Apparatus

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Direct Shear Test Apparatus	as Per I.S. 2720 (Part-XIII)	1 No.	Per batch
2	Shear box	divided into two halves by a horizontal plane, and fitted with locking and spacing screws	1 No.	Per batch
3	Box container	to hold the shear box	1 No.	Per batch
4	Base plate	having cross grooves on its top surface	1 No.	Per batch
5	Grid plates	perforated	2 Nos.	Per batch
6	Porous stones	6mm thick	2 Nos.	Per batch
7	Loading frame with yoke	--	1 No.	Per batch
8	Proving ring	Capacity 2kN.	2 Nos.	Per batch
9	Dial gauges	Accuracy 0.01mm	2 Nos.	Per batch
10	Compaction devices	Static or dynamic	1 No.	Per batch
11	Spatula	--	1 No.	Per batch

X. Procedure

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. Also determine the average thickness of the grid plates.
3. Fix the upper part of the box to the lower part using the locking screws. Attach the base plate to the lower part.
4. 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.
5. Weigh the shear box with base plate, grid plate and porous stone.
6. Place the soil specimen in the box. Tamp it directly in the shear box at the required density. When the soil in the top half of the shear box is filled.
7. Weigh the box with soil specimen.
8. Weigh the box inside the box contained and fix the loading pad on the box. Mount the box contained on the loading frame.
9. Bring the upper half of the box in contact with the proving ring. Check the contact by giving a slight movement.
10. Fill the container with water if the soil is to be saturated, otherwise omit this step.
11. Mount the loading yoke on the ball placed on the loading pad.
12. 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.
13. 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.
14. 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.
15. Adjust all the dial gauges to read zero. The proving ring should also read zero.
16. Apply the horizontal shear load at a constant rate of strain of 0.2mm/minute.
17. Record the reading of the proving ring, the vertical displacement dial gauge and the horizontal displacement dial gauge at regular time intervals. Take the first few readings at closer intervals.
18. Continue the test till the specimen fails or till a strain of 20% is reached.
19. At the end of the test, remove the specimen from the box and take a representative sample for water content determination.
20. Repeat the test on identical specimens under the normal stresses of 50, 100, 200, 400 KN/m, etc. (The range of stresses selected should correspond to the actual field stress conditions.)
21. Plot the graph by taking the value Normal Stress as abscissa and the maximum shearing stress as ordinate.

XI. Precautions to be followed

1. Before starting the test, the upper half of the box should be brought in contact of the proving ring assembly.
2. Before subjecting the specimen to shear, the fixing pins should be taken out.
3. The rate of strain should be constant throughout the test.
4. The soil sample should be compacted carefully.
5. Dial of proving ring should be adjusted properly.
6. The soil specimen should be kept in wet condition throughout test.

XII. Actual procedure followed: *(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
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5					
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7					
8					

XIV. Precautions followed

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XV. Observations:

i. C/S area of soil specimen (A) = ……………………………cm^2.
ii. 20% Longitudinal Displacement (d) = ………………………..cm.

Sr. No.	Normal Stress in N/mm^2	Proving Ring Dial Gauge Reading in Divisions	Shear Force from Calibration Chart in N	Shear Stress in N/mm^2
1				
2				
3				

Observations from Graph of Normal Stress vs. Shear Stress:

The shear strength parameters of the given soil sample are

1. Cohesion ‘c’ = ………………… N/mm^2.
2. Angle of internal friction ‘Ø’ = ………………^{0}.

Calculations: The shear strength of soil is s = c + σ . tan Ø

= ……………………………………………………………………………..

= ……………………………………………………………………………N/mm^2.

Scale

X-axis -

Y-axis -

XVI. Results

a. The shear strength of given soil sample by direct shear test is ……………………….. N/mm^2.

b. The shear strength envelop for the given soil is ……………………………………… (horizontal line / starting from origin/intersecting Y-axis); hence it is classified as ………………………………………….. (purely cohesive soil/cohesion less soil / partially cohesive soil).

XVII. Interpretation of results *(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

Note*: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. State the dimensions of shear box assembly used in this test.
2. State whether the direct shear test apparatus is motorized or not.
3. Mention the constant of proving ring used by you.
4. State the rate of loading in horizontal direction.
5. Give the meaning of cohesion and angle of internal friction in case of shear strength of soil.
6. State any three advantages of direct shear test.
7. State any two limitations of direct shear test.
8. State the conditions in which direct shear test is conducted.
9. Name the soil for which this test is unsuitable.

Space to Write Answers

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book/ Website Links	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN:_9788123913629
3.	https://nptel.ac.in/courses/105101084/47	--	--
4.	https://www.youtube.com/watch?v=bmpn5oNDvOs	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Measurement of weight of soil samples	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40%**
3	Calculations of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……………………………………………
2. ……………………………………………
3. ……………………………………………
4. ……………………………………………

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 13: Determine Shear Strength of Soil by Vane Shear Test as per IS 2720 (Part-XXX)

I. Practical Significance

The structural strength of soil is basically deals with its shear strength. Vane shear test is a useful method of measuring the undrained shear strength of clay. It is a cheaper and quicker method. The laboratory vane shear test for the measurement of shear strength of cohesive soils is useful for soils of low shear strength (less than 0.05 N/mm^2) for which tri-axial or unconfined tests cannot be performed. The test gives the undrained strength of the soil. The results of undisturbed and disturbed soil samples are used to evaluate the sensitivity of soil.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Use the results of permeability and shear strength test for foundation analysis.

IV. Practical Outcome

Determine shear strength of soil by vane shear test as per I.S. 2720 (Part-XXX) .

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Ability preparing test soil specimen mould.

b. Handling of instruments.

VI. Relevant Affective domain related

a. Follow safety practices.

b. Practice good housekeeping.

c. Demonstrate working as a leader/a team member.

d. Maintain tools and equipment.

VII. Minimum Theoretical Background

The vane shear test apparatus consists of a torque head mounted on a bracket. A vane having four blades are fixed on a shaft and the shaft is fixed in the lower end of a circular disk graduated in degrees. These blades are at right angles to each other. A torsion spring is fixed between torque head and the circular disk. A maximum pointer is provided to facilitate reading the angle of torque. As the strain indicating pointer rotates when the torque is applied, it moves the maximum pointer, leaving it in position when the torque gets released at failure, the vane returns to its initial position.

The torque can be calculated using following formula.

$$T = [(\Theta_2 - \Theta_1) \times \pi \times K] / 180$$

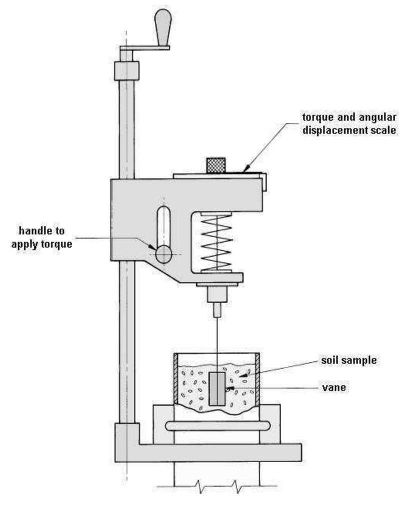
(where, T = Torque, $(\Theta_2 - \Theta_1)$ = Difference of angle (angle of torque, K = Spring stiffeness)

The Shear strength can be calculated using following formula.

$$\tau_f = T / \{\pi \times [(d^2H/2) + (d^3/6)]\}$$

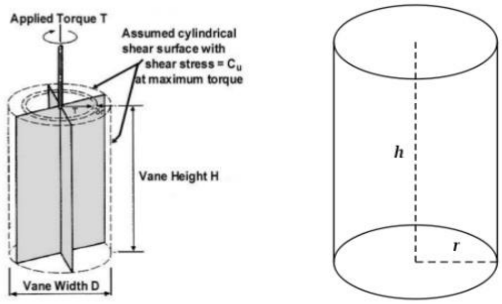
(where, d = Diameter of vane (cm), H = Height of the vane (cm), τ_f = Shear strength (kg/cm^2), T = Torque applied (kg-cm)

VIII. Experimental Set-up



Vane Shear Test Apparatus

Surface area of the cylinder = $2\pi rh = \pi dh$



Details of Vanes

Figure 1: Vane Shear Test

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Vane shear test apparatus with vanes	Hand operated or motorized, least 37.5 mm diameter and 75 mm length	1 No.	Per batch
2	Calibrated torque spring	--	1 No.	Per batch
3	Cylindrical soil container	--	1 No.	Per batch
4	Tray	--	1 No.	Per batch

X. Procedure

1. Take the fine cohesive soil passing through 425 micron IS Sieve in a tray and add water to have required moisture content. Mix it uniformly.
2. Compact the wet soil in the specimen container to required density. Level it flushing it with the top of container.
3. Mount the specimen container with soil on the base of vane shear apparatus and fix it securely to the base.
4. Attach required calibrated torque spring to connect torque applicator with vanes.
5. Lower the shear vanes in to the specimen gradually with minimum disturbance of the soil specimen so that the top of vanes is at least 10mm below the top of the soil specimen.
6. Note down spring stiffness.
7. Note the initial reading of the torque (Θ_1).
8. Rotate the vane at a uniform rate approximately 0.1^0/sec by suitably operating the torque applicator handle till the specimen fails.
9. Note the final reading of the torque (Θ_2).

10. Lift the vanes up remove the soil sample and clean the container.
11. Repeat the above steps for two more samples from same soil and at the same water content, calculate average shear strength.

XI. Precautions to be followed

1. The soil should be cohesive type only with optimum water content in it.
2. Ensure that, the spring should be calibrated for this test.
3. The vanes should penetrate vertically into the soil specimen.
4. The dimensions of vane should be checked to ensure that vane is not disturbed or worn.
5. Every time before inserting the vane into soil sample it should be properly clean.

XII. Actual procedure followed: *(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					
3					
4					
5					

XIV. Precautions followed

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XV. Observations:

Spring Constant (K) = …………………………..N-mm/radians.

i. Diameter of vanes (d) = ………………………………mm.
ii. Height of vanes (H) = …………………………………..mm.

Sr. No.	Initial Angle of Twist (Θ_1) in Radians	Final Angle of Twist (Θ_2) in Radians	Torque T in N-mm	Shear Stress in N/mm^2
1				
2				
3				

Calculation of torque:

$$T = [(\Theta_2 - \Theta_1) \times \pi \times K] / 180$$

(where, T = Torque, ($\Theta_2 - \Theta_1$) = Difference of angle, K = Spring Stiffness)

T = ……………………………………

T = ……………………………………

Calculate Shear Strength:

Shear strength of the soil, C is computed using the following formula

$\tau_f = T / \{\pi \times [(d^2H/2) + (d^3/6)]\}$

(where,D = Diameter of vane (cm), H = Height of the vane (cm), C = Shear strength (kg/cm2), T = Torque applied (kg-cm)

τ_f = ……………………………………..

τ_f = …………………………………… N/mm^2.

XVI. Results

The shear strength of given soil sample by vane shear test is ………………. N/mm^2.

XVII. Interpretation of result (*Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

Note*: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. Mention the number of blades in a vane used for this test.
2. State the rate of rotation of vanes in the soil sample.
3. Explain the method of preparation of soil specimen for this practical.
4. State the types of soil recommended for vane shear test.
5. Differentiate between direct and vane shear test.
6. State the drainage condition followed to conduct the vane shear test.
7. List out the other tests to determine shear strength of soil.

8. Mention the time required to failure of soil.
9. State the dimensions of mould used for the test.

(Space to Write Answers)

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://nptel.ac.in/courses/105101084/47	--	--
4.	https://www.youtube.com/watch?v=Jz4ir185iUE	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Filling the soil specimen in vane mould	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40%**
3	Calculations of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1……………………………………………

2……………………………………………

3……………………………………………

4…………………………………………….

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 14: Determine Bearing Capacity of Soil using Liquid Limit and Plastic Limit

I. Practical Significance

The bearing strength characteristics of foundation soil are a major design criterion for civil engineering structures. This experiment aims to estimate the bearing strength characteristics, namely California Bearing Ratio (CBR) and ultimate bearing capacity, from easily measured soil properties. This assignment is significant to know the correlation between soil properties like bearing capacity and consistency limits of soil.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 4. Engineering tools: *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

a. Interpret the physical properties of soil related to given construction activities.

IV. Practical Outcome

Determine bearing capacity of soil using liquid limit and plastic limit.

V. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Selection of suitable method of CBR and Bearing capacity determination
b. Calculation of soil properties using correlation.

VI. Relevant Affective domain related

a. Practice good housekeeping.
b. Demonstrate working as a leader/a team member.
c. Maintain tools and equipment.

VII. Minimum Theoretical Background

Civil engineering works in highways, buildings, dams and other structures have strong relationship with soil. These structures need a strong and stable layer of foundation soil to build on. Therefore, soil must be able to carry imposed loads from any structure placed upon it without shear failure or destructive unallowable settlements. In pavement design, the California Bearing Ratio (CBR) is a common test currently practiced to predict the bearing strength of sub-grade soil. Due to its simplicity and relatively low cost, this method has been widely used across the world for flexible pavement design. Even though, highway engineers encounter some difficulties in obtaining representative CBR value for pavement design.

The laboratory CBR test is not only laborious and time consuming, but, sometimes, the results are not accurate due to the sample disturbance and poor quality of the laboratory testing conditions. Therefore, the development of prediction correlations might be useful and become a base for the judgment of the validity of the CBR values. Many correlations have been developed by various researchers for the prediction of CBR.

(1)The National Cooperative Highway Research Program had developed a correlation for soils contain 12% fines and exhibit some plasticity. The soil index properties chosen to correlate CBR are the percentage passing 0.075mm size sieve (w) and plasticity index (PI). The suggestedequation by NCHRP is given below.

$$CBR = 75/[1+0.728(w \times PI)]$$

(2)The soil bearing capacity is defined as the capacity of the underlying soil to support the loads applied to the ground without undergoing shear failure and without accompanying large settlements The theoretical maximum pressure which can be supported without failure is called ultimate bearing capacity (UBC). While the allowable bearing capacity (ABC) is the UBC divided by the factor of safety (FS). The established theory on ultimate bearing capacity is based on ideal condition of soil profiles. In reality, the soil profiles are not always homogenous and isotropic. Therefore, rational judgment and experiences are always necessary in adopting proper soil parameters to be used in calculations of ultimate bearing capacity.

i) The ultimate bearing capacity expressed by Terzaghi, and it is calculated as,

$$q_u = CN_c + q\,N_q + 0.5\gamma\,BN\gamma$$

Where N_C, Nq, Nγ are Terzaghi bearing capacity coefficients.

ii) A correlation between the ultimate bearing capacity (qu) and the CBR of cohesive soil.

$$q_{u(kPa)} = 70 \times C.B.R$$

iii) A correlation between the CBR and the liquid limit, plastic limit or plasticity index.

$$CBR = 2-16 \log (OMC) + 0.07\,LL$$

Linear relationships fordifferent soils expressed by following equations

$$q_u(kpa) = 65 \times (CBR - 1.5)$$

VIII. Experimental Set-up

There is no need of separate experimental set up required for this practical.

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Scientific calculator	--	1 No.	Per student
2	Plain paper	A4 Size	1-2 Nos.	Per student

X. Procedure

Bearing capacity of soil using liquid limit and plastic limit:

1. Note down the results of plastic limit, Liquid limit and Plasticity Index as per the practical no. 6.
2. Note down the results of OMC and MDD value from standard proctor test practical no. 15.
3. Calculate the CBR and ultimate bearing capacity using above correlations discussed in minimum Theoretical background.
4. Refer the other similar research papers and calculate bearing strength characteristics and compare with results obtained in step 3 above.

XI. Precautions to be followed

1. Use appropriate correlation to determine CBR and bearing capacity of soil.
2. Correctly find the values using calculator.

XII. Actual procedure followed: *(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
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XIV. Precautions followed

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XV. Observations

Sr. No.	Particulars	Observation No.		
		1	2	3
1.	The percentage passing 0.075mm size sieve (w)			
2.	Liquid Limit			
2.	Plastic Limit			
3.	Plasticity Index			
4.	Optimum Moisture Content			

Sample Calculation:

1) CBR =75/[1+0.728(w x PI)]
   =……………………………………………………………………………
   =……………………………………………………………………………

2) CBR= 2-16 log (OMC) +0.07 LL

   =……………………………………………………………………………

=……………………………………………………………………………

3) $q_{u(kPa)}$= 70 x C.B.R

=……………………………………………………………………………
=……………………………………………………………………………

4) q_u(kpa) = 65 x (CBR -1.5)

= ……………………………………………………………………………
= ……………………………………………………………………………

XVI. Results

The bearing capacityof soil from its liquid and plastic limit ………………….%.

XVII. Interpretation of results: *(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

Note: *Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. State the value of liquid and plastic limit of soil that you have tested in the experiment no. 6.
2. State the correlation used between bearing capacity, liquid limit, and of plastic limit of soil.
3. Give the effect of variation in consistency limits (i.e. liquid and plastic limit) on bearing capacity of soil.
4. Give two more imperial / formulae to calculate the CBR using liquid limit and plastic limit.
5. State the CBR values of soils available in your area.
6. Define Safe bearing capacity of soil.
7. Define Ultimate bearing capacity of soil.
8. Give imperial formulae to determine CBR using water content of soil.

9. Define optimum moisture content.

Space to Write Answers

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book/Research papers	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629

3.	"Predicating Bearing Strength Characteristics From Soil Index Properties."	Magdi M.E. Zumrawi, HussamElnour, M.Sc.Student Civil Engineering Department,University of Khartoum,Sudan	Paper published in International Journal of Civil Engineering and Technology (IJCIET), Volume 7, Issue 2, March-April 2016,PP. 266-277.
4.	"A Study of Correlation Between California Bearing Ratio (CBR) Value with other properties of Soil."	Dr. Dilip Kumar Talukdar Lecture,Civil Engineering Department,NowgongPolytechnic,Nagaon, Assum.,India	Paper published in International Journal of Emerging Technology and Advanced Engineering,Volume4, Issue 1, January 2014,PP. 559-562.

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Collection of data required for calculation	30 %
2	Calculation of bearing capacity	30 %
Product related:10 Marks		**40%**
3	Calculations of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ....
2. ....
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Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 15: Determine MDD and OMC by Standard Proctor Test of Given Soil Sample as per IS 2720(Part-VII)

I. Practical Significance

Compaction is a method of improving mechanical method of improving density of soil. The purpose of laboratory compaction test is to determine the proper amount of mixing water to be used, when compacting the soil in the field and the resulting degree of denseness which can be expected from compaction. With knowledge of moisture density relation as determined by this test, ether control of the field compaction of soil fill is possible because the optimum moisture content and maximum dry density which should be obtained are known by using this test procedure and this can be checked by filed control test. This particular test helps to know the relationship of water content and dry density of soil, which further becomes beneficial to diploma engineer for compaction of soils in various construction works.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

e. Compute optimum values for moister content for maximum dry density of soil through various tests.

IV. Practical Outcome

Determine MDD and OMC by standard proctor test of given soil sample as per I.S 2720(Part-VII).

V. Competency and Practical Skills:

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Ability preparing test soil specimen.
b. Handling of instruments

VI. Relevant Affective domain related

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.

VII. Minimum Theoretical Background

The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. The test is developed by Ralph R. Proctor in 1933 showed that the dry density of a soil for a given compactive effort depends on the amount of water the soil contains during soil compaction. His original test is most commonly referred to as the standard Proctor compaction test; his test was later changed with some modifications to create the modified Proctor compaction test.

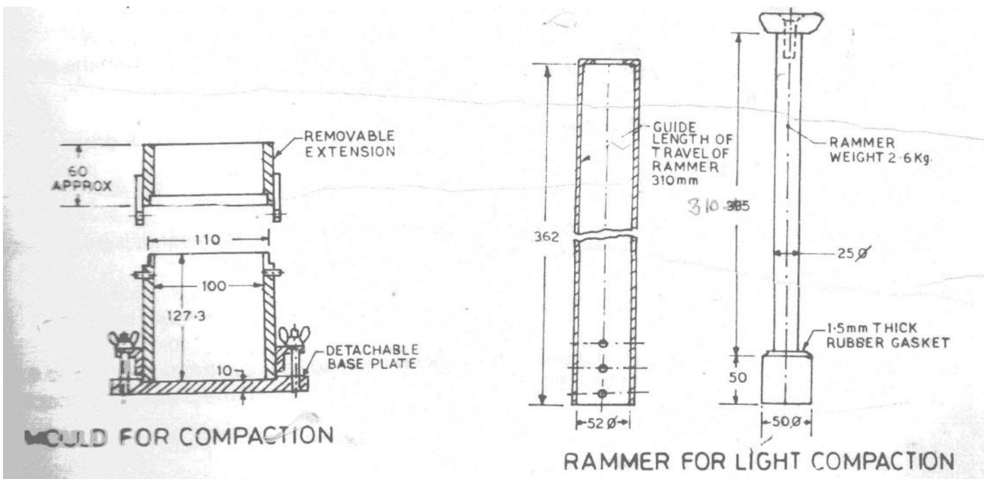
Compaction is the process of packing soil particles closely together thereby reducing voids and removing air from voids by dynamic load. There is an optimum amount of mixing water for a given soil and compaction process, which will give a maximum weight of soil per unit volume. This process increases dry density of soil.

Optimum Moisture Content (O.M.C): It is the water content corresponding to maximum dry density of soil, is called as Optimum Moister Content.

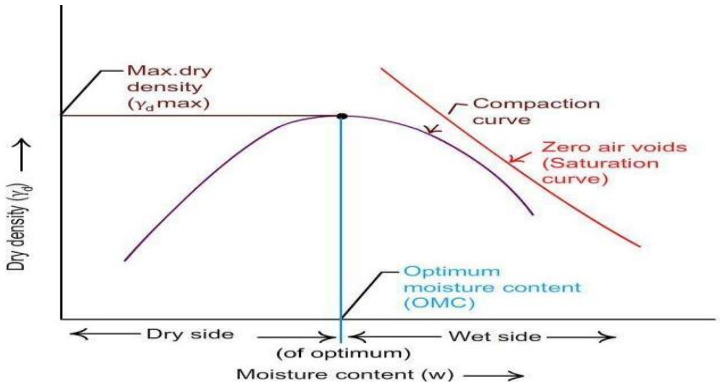
Maximum Dry Density (M.D.D): It is the Maximum value of dry density obtained in compaction curve, is known as Maximum Dry Density.

Compaction Curve: It is the curve plotted between water content as abscissa and corresponding dry density as ordinate.

VIII. Experimental Set-up



Standard Proctor Mould and Light Rammer



Typical Compaction Curve

Standard Proctor Mould and Light Rammer

Figure 1: Standard Proctor Test

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Compaction mould	capacity 1000ml, 10 cm internal dia., 12.73 cm height	1 No.	Per batch
2	Rammer	mass 2.6 kg	1 No.	Per batch
3	Detachable base plate	--	1 No.	Per batch
4	Collar	60mm high	1 No.	Per batch
5	I S sieve	20 mm	1 No.	Per batch
7	Oven	--	1 No.	Per batch
8	Desiccator	--	1 No.	Per batch
9	Weighing balance	accuracy 1g	1 No.	Per batch
10	Large mixing pan		1 No.	Per batch
11	Spatula		1 No.	Per batch
12	Mixing tools, spoons, trowel		1 No. each	Per batch

X. Procedure

1. Take about 5 Kg. of de-aired soil passing through sieve 20 mm in tray.
2. Add about 4% water (approximately 120 ml) to the soil and mix thoroughly with trowel and cover it with moist cloth for 24 hours to ensure thorough mixing of water with soil.
3. Note the dimension of proctor mould, collar and base plate.
4. Take the empty weight of the mould (without collar and base plate).
5. Apply a thin film of grease on inside of the mould.
6. Fix the mould to the base plate with the help of wing nuts, place collar on the mould.
7. To determine the Proctor density till the soil in mould in three equal layers and give 25 blows to each layer using standard hammer. Scrap the top surface of compacted layer before placing the next layer of a soil. Ensure that after compaction of the third layer, the level of compacted soil slightly above the top of the mould.
8. Remove the collar trim the soil with a straight edge, disconnect the mould from base plate and weigh it.
9. Extrude the compaction soil from the mould.
10. Collect sample from middle of the mould for water content determination.
11. Repeat step 5 to 10 taking fresh sample of same soil with addition of 3 to 4 % more water than previously added water. Repeat these steps for no. of times till a decrease in the weight of a soil is observed for at least two successive reading.
12. Calculate bulk density of compacted soil for each test.
13. Determine the maximum dry density and optimum moisture content corresponding to the standard proctor compaction by plotting graph water content v/s. dry density. Also plot constant degree of saturation lines for 100%, 90%,80% degree of saturation on same graph. Calculate the degree of saturation corresponding to the maximum dry density as OMC and MDD of given soil sample.

XI. Precautions to be followed

1. Use hand gloves & safety shoes while compacting.
2. The blows should be uniformly distributed over the surface of each layer.
3. Rammer should not be strike the collar while giving blows.
4. Fill mould with loose soil half the height of mould and compact it for the first layer. For second layer fill the mould to full height with loose soil and then compact. For the third layer fill the soil up to half of collar height and then compact it.

XII. Actual procedure followed: *(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
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XIV. Precautions followed

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XV. Observations

i. Internal diameter of mould (d) : ………………………cm
ii. Height of mould (H) : ………………………………….cm
iii. Volume of mould (V): …………………………………cm

Sr. No.	Particulars	Observation No.							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	Bulk Density Determination								
1	Mass of empty mould with base plate (W_1) gm								
2	Mass of compacted soil+ mass of mould with base plate (W_2) gm								
3	Mass of compacted soil M=(W_2 - W_1) gm								
4	Bulk density γ =M/V gm/cc								
	Water content Determination								
5	Container No.								
6	Mass of empty container with lid (W_3) gm								
7	Mass of container with lid and moist soil (W_4) gm								
8	Mass of container with lid and dry soil (W_5) gm								
9	Mass of water (Ww) = W_4-W_5								
10	Mass of dry soil (Ws) = W_5-W_3								
11	Water content in % w = (Ww/ Ws) x 100								
	Dry Density Determination								
12	Dry Density of soil γ_d= (100 x γ) / (100 + w) in gm/cc.								

Sample Calculations

For observation No. 1:

Bulk density γ =M/V

=……………………………….

= ………………………………gm/cc.

Dry Density of soil γ_d= (100 x γ) / (100 + w)

= ……………………………….

= ……………………………… gm/cc.

Scale

X-axis -

Y-axis -

XVI. Results

1. The optimum moisture content of given soil sample from the compaction curve is ……………………….. %.
2. The maximum dry density of given soil sample from the compaction curve is ……………………….. gm/cc.

XVII. Interpretation of results: *(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

Note*: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. State the volume of mould used in this test.
2. State the weight of hammer used in this test.
3. State the apparatus used giving compaction effort.
4. State no. of layers and no. of blows given to compact soil in standard compactor test.
5. State the practical applications of standard proctor test.
6. List any three factors affecting soil compaction.
7. Give the meaning of zero air void line.
8. Differentiate between standard proctor test and modified proctor test with respect to weight of rammer and height of fall.
9. State the time required to complete the Standard Proctor test.

Space to Write Answers

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XX. References / Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://www.youtube.com/watch?v=25z0MewBj0Q	--	--
4.	nptel.ac.in/courses/105104147/11	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Measurement of weight of soil samples	30 %
2	Recording of observations	30 %
Product related:10 Marks		**40%**
3	Calculations of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1. ……………………………………………
2. ……………………………………………
3. ……………………………………………
4. ……………………………………………

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 16: Determination of CBR value on the field as IS 2720 (Part-XXXI) -1990

I. Practical Significance

The California Bearing Ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method and is important for the design of flexible pavement. The determination of C.B.R. of undisturbed and remoulded /compacted soil specimens, both in soaked as well as unsoaked state can be performed.

II. Relevant Program Outcomes

PO 1. ***Basic knowledge:*** *An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.*

PO 2. ***Discipline knowledge****: An ability to apply discipline - specific knowledge to solve core and/or applied engineering problems.*

PO 3. ***Experiments and practice:*** *An ability to plan and perform experiments and practices and to use the results to solve engineering problems.*

PO 4. ***Engineering tools:*** *Apply relevant civil technologies and tools with an understanding of the limitations.*

PO 8. Individual and Team Work: *Function effectively as leader and team member in Diverse /multidisciplinary team*

III. Relevant Course Outcomes

b. Interpret the physical properties of soil related to given construction activities.

d. Interpret the soil bearing capacity results.

IV. Practical Outcome

Determination of CBR value on the field as IS.

V. Competency and Practical Skills:

This practical is expected to develop the following skills for the industry identified competency, ***"Evaluate soil properties for determining stability of foundation."***

a. Ability preparing test soil specimen mould.
b. Handling of instruments

VI. Relevant Affective domain related

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

VII. Minimum Theoretical Background

Definition of CBR: It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material. The California Bearing Ratio Test (CBR Test) is a penetration test developed by California State Highway Department (U.S.A.) for evaluating the bearing capacity of subgrade soil for design of flexible pavement.

Tests are carried out on natural or compacted soils in water soaked or un-soaked conditions and the results so obtained are compared with the curves of standard test to have an idea of the soil strength of the subgrade soil.

Standard Loads at Specified Penetrations:

Penetration depth(mm)	Unit Standard load (MPa)	Total Standard load(N)
2.50	6.86	13.43
5.00	10.30	20.15
7.50	13.10	25.79
10.00	15.90	31.18
12.50	17.90	35.30

CBR test can be performed not only in laboratory but also in-situ. One can proposes a dual purpose test assembly that, connected to the suitable accessories, can satisfy both needs:

i. For field testing includes all necessary components that, along with vehicle bracket can be used for in-situ determination of CBR of soils used in road construction.
ii. Alternatively, for laboratory testing, frame can be assembled with the main components of vehicle bracket, to create a hand operated CBR machine.

The CBR penetration test can be performed with a number of loading, some of them specifically designed for CBR tests, and others with multiple applications (Universal models), at different levels of sophistication: MULTISPEED digital automatic universal tester for displacement controlled tests

i. CBR motorized loading press
ii. Hand operated CBR loading press

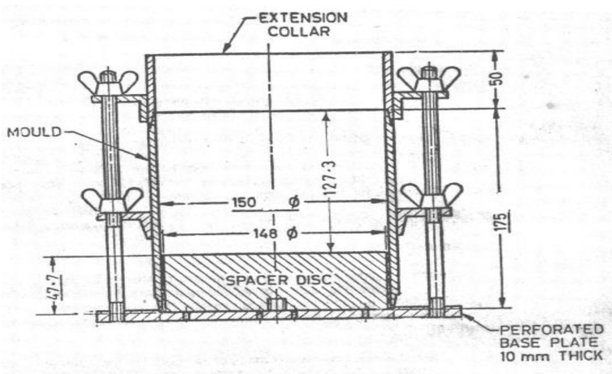
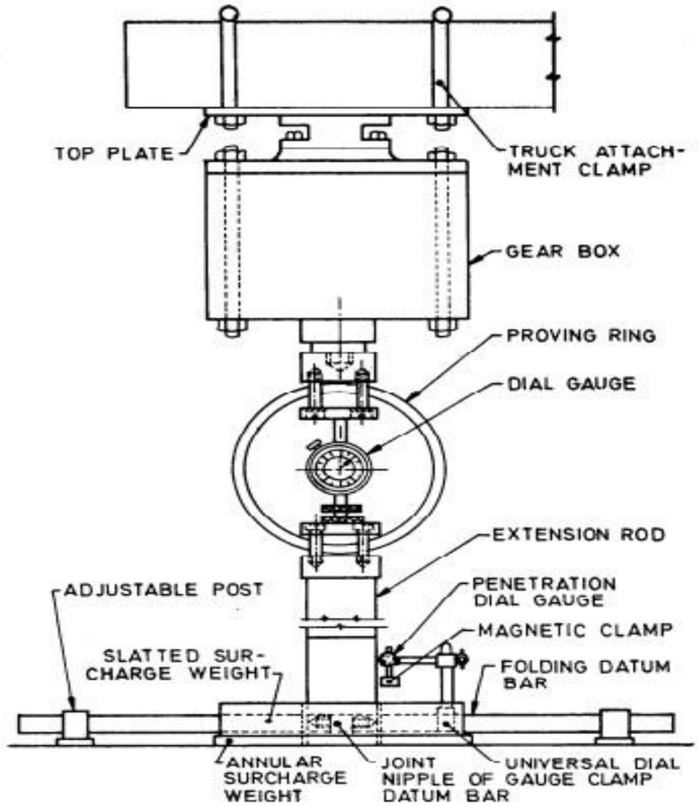
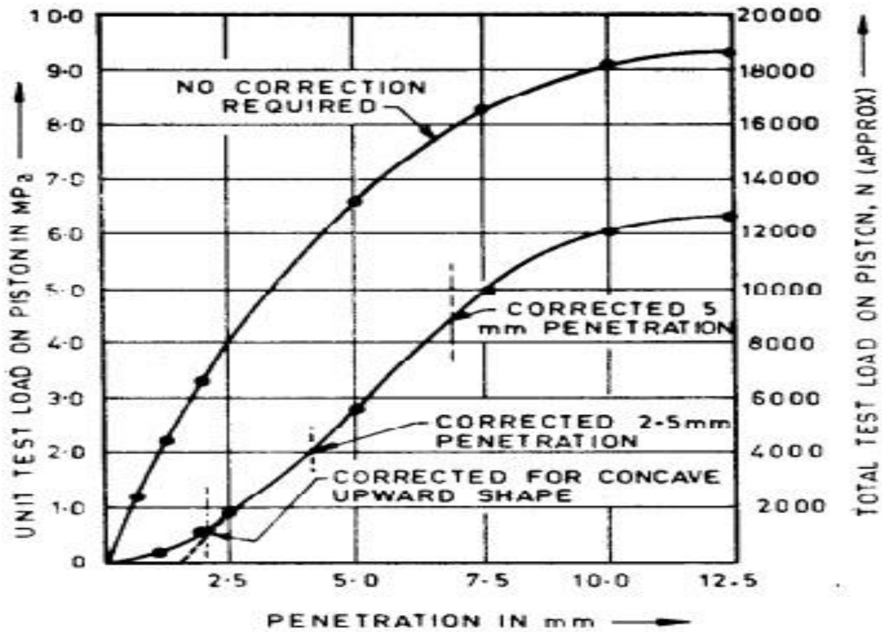


Figure 1: C.B.R. Test Mould

VIII. Experimental Set-up



CBR Test Apparatus with Accessories



Load Penetration Curve

Figure 1: ***California Bearing Ratio (CBR) Test***

IX. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Field CBR Test Apparatus	As per IS:2720 (Part-XXXI)-1990	1 No.	Per batch
2	Loading Device	Capacity 50KN, should have an arrangement for attachment to truck, tractor, truss or any other equipment	1 No.	Per batch
3	Jacks	track-type jacks of 50 to 120 kN capacity, having double acting combination trip and automatic lowering	2 No.	Per batch
4	Proving Ring	suitable capacity having an accuracy of not more than one percent of the anticipated load shall be used.	1 No.	Per batch
5	Metal Penetration Piston	50 +/- 0.1 mm in diameter and not less than 100 mm long.	1 No.	Per batch
6	Extensions	Internally threaded pipe or rod extensions not less than 200 cm long	1 No.	Per batch
7	Connectors	For coupling the penetration piston and proving ring assembly	1 No.	Per batch
8	Dial Gauge	Reading to 0.01 mm having a travel of 25 mm,	2 Nos.	Per batch
9	Dial Gauge Support	about 2 m long, of overall height 30 cm and 45 cm wide a	1 No.	Per batch
10	Surcharge Weight	circular slotted weights of mass 5 kg and of diameter 215 to 250 mm	1 No. each	Per batch
11	Miscellaneous Apparatus	such as spirit level, pick, spade, scoop and brush, apparatus for moisture	1 No. each	Per batch

X. Procedure

1. The general surface area to be tested should be exposed, cleaned of all loose and dried material and levelled. Extreme care shall be taken not to disturb the test surface. The spacing of the tests should be such that operations in one area do not disturb the soil in the other area. For testing operations this spacing may be 50 cm for the penetration piston used in the test.

2. If actual service conditions in the field warrant, the surface to be tested may be soaked to the desired degree. During the process of soaking the required surcharge weights should be kept in place. The test surface should be drained of all free water, levelled and allowed to stand for at least 15 minutes before starting further operations.
3. The equipment used to provide load reaction (truck, tractor, truss etc), should be so located that the centre of the beam against which the loading jack will work is over the centre of the surface to be tested. If loaded truck or tractor is used for providing the necessary reaction, the rear wheels of the truck or tractor should be completely raised by means of the track type jacks placed below the frame of the body near the wheels in order to avoid the loss of loading effort which would otherwise be spent on the flexing of the axial springs of the vehicle at the time of testing. In order to avoid accidents due to the failure of jacks near the wheels and the lifting of the vehicle at higher loads, the rear side of the body of the vehicle should be placed over two rigid supports.

   The screw jack with swivel should be installed to the underside of the equipment - providing reaction, at. the correct position for the test. The proving ring should be connected to the bottom end of the jack and the piston connector to the bottom of the proving ring. The piston should then, be connected using, if necessary, lengths of extension : pipes or rods. It should be ensured that the entire assembly is plumb and the loading jack should be clamped in position.
4. The surcharge annular weight of mass 5 kg should be kept in position on the surface to be tested so that when the piston is lowered, it will pass through the hole in the annular weight. The penetration piston should be seated with the smallest possible load not exceeding a total load of 40 N (or unit load of 0.02 MPa) so that full contact is established between the piston and the surface to be tested. For materials with irregular surface the piston may be seated on a thinnest practical layer of fine limestone screening or plaster of Paris spread over the surface.
5. While the seating load is on the piston, a 3 to 6 mm layer of clean sand should be spread over the surface to be covered by the surcharge annular weight. This helps in distributing the surcharge load over the surface uniformly.
6. Surcharge weights, sufficient to produce an intensity of loading, equal to the weight of the base material and pavement, except that the minimum weight applied should be 150 N including that of the annular weight [this weight gives an intensity of loading approximately equal to that in the laboratory bearing ratio test [see IS 2720 (Part 16) : 1987] should be applied. The penetration indicating dial should be suitably fixed for reading the penetration and the dial set to zero. A diagrammatic set up of the test is shown in Fig. 1.
7. Load shall be applied on the penetration piston so that the penetration is approximately 1.25 mm/min. The load readings shall be recorded at penetration of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5 mm. The maximum load and penetration shall be recorded if it occurs for a penetration less than 12.5 mm. The set up may then be dismantled.

8. After the completion of the test, a sample shall be collected from the point of penetration, for moisture content determination. The moisture content shall be determined in accordance with IS 2720 (Part 2) : 4973. Besides the moisture content, the in-place density shall be determined in accordance with IS 2720 (Part ~28) : 1974 or IS 2720 (Part 29) : 1975 about 15 cm away from the point of penetration.
9. The load penetration curve shall be plotted (see Fig. 2). This curve may be convex upwards although the initial portion of the curve may be concave upwards due to surface irregularities. A correction shall then be applied by drawing a tangent to the curve at the point of maximum slope. The corrected curve shall -be taken to be this tangent, together with the follows: convex portion of the original curve, with the .origin of strains shifted to the point where the tangent cuts the horizontal axis for penetration as illustrated in Fig. 2.
10. Bearing Ratio: Corresponding to the penetration value corresponding at which the bearing ratio is desired, corrected load values shall be taken from the load penetration curve and the bearing ratio calculated as Bearing ratio = (Pt / Ps) x 100; where, Pt = corrected unit (or total) test load corresponding to the chosen penetration value read from the load penetration curve in MPa or and Ps = unit (or total) standard load for the same depth of penetration as per Pt in in MPa or N.
11. The bearing ratios are usually calculated' for penetration of 2.5 mm and 5 mm. Generally the bearing ratio at 2.5 mm penetration will be greater than that at 5 mm penetration and m such a case the former shall be taken as the bearing ratio for design purposes. If the bearing ratio corresponding to a penetration of 5 mm exceeds that for 2.5 -mm, the test shall be repeated. If identical results follow, the bearing. ratio corresponding to 5 mm penetration shall be taken for design.

XI. Precautions to be followed

1. Follow all the safety precautions while performing this test on field.
2. Ensure the sufficient working area for the installation of the test set-up.
3. Record the observations instantly at the suggested particular penetration.

XII. Actual procedure followed: *(Use blank sheet if provided space is not sufficient)*

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XIII. Resources used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remark
		Make	Details		
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					

XIV. Precautions followed

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XV. Observations

Proforma for Field CBR Test:

i. Location of test = ………………………………………………
ii. Date of test = …………………………………………………..
iii. Depth of test point = ………………………………………..
iv. Condition of test = …………………………………… (soaked/unsoaked)
v. Period of soaking if any = ……………………………………..
vi. Surcharge weight used during soaking = ………………………
vii. Moisture content = ……………………………………………..
viii. Density = …………………………………………………….
ix. Method used for determination of density = …………………..
x. Surcharge weight used for penetration test = ………………………

Sr. No.	Penetration in mm	Proving Ring Dial Gauge Reading in Divisions	Load in N	Corrected Load from Load-Penetration Curve in N
1	0.5			
2	1.0			
3	1.5			
4	2.0			
5	2.5			
6	3.0			
7	4.0			
8	5.0			
9	6.0			
10	7.5			
11	10.0			
12	12.5			

Observations from Load Penetration Curve:

1. Test load at 2.5 or 5.0 mm penetration (P_t) = ……………………… N
2. Standard Load at corresponding 2.5 or 5.0 mm penetration (P_s) = ……………………..N

Calculations

The California Bearing Ratio of field soil is

% CBR = (Test Load / Standard Load) x 100

% CBR = (P_t / P_s) x 100

% CBR = ……………………………………….

% CBR = ………………………………………. %

XVI. Results

The percentage California Bearing Ratio of field soil tested is found to be ……….. %.

Scale

X-axis -

Y-axis -

XVII. Interpretation of results: *(Give meaning of the above obtained results)*

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XVIII. Conclusions and Recommendations *(Actions/decisions to be taken based on the interpretation of results).*

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XIX. Practical Related Questions

Note*: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.*

1. State the significance of C.B.R. Test.
2. State the hours required to soak specimen for soaked condition of C.B.R. Test.
3. State the maximum value of penetration up to which readings of loads are to be note down.
4. State two application of C.B.R. test in construction work.
5. Write the cost of Field CBR Test Apparatus.
6. State the physical features of field soil that you have tested.
7. Give the details of working area of field CBR test that you performed.
8. State the capacity and least count of proving ring used in this test.
9. Write the values of slotted weights used in this test.

Space to Write Answers

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XX. References / Suggestions for further Reading:

Sr. No.	Title of Book	Author	Publication
1.	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2.	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3.	https://www.youtube.com/watch?v=fCmMW73rP64	--	--
4.	https://www.youtube.com/watch?v=mZQIQRlQp3Q	--	--

XXI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related:15 Marks		**60%**
1	Installation of test set up	30 %
2	Recording of observations(Load,Penetartion)	30 %
Product related:10 Marks		**40%**
3	Calculations of result	10%
4	Answers to practical related questions.	20%
5	Submission of report in time.	10%
Total: 25 Marks		**100%**

List of Student Team Members (Roll No.)

1……………………………………………

2……………………………………………

3……………………………………………

4…………………………………………….

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

List Of Laboratory Manuals Developed by MSBTE

First Semester:

1	Fundamentals of ICT	22001
2	English	22101
3	English Work Book	22101W
4	Basic Science (Chemistry)	22102
5	Basic Science (Physics)	22102

Second Semester:

1	Bussiness Communication Using Computers	22009
2	Computer Peripherals & Hardware Maintenace	22013
3	Web Page Design with HTML	22014
4	Applied Science (Chemistry)	22202
5	Applied Science (Physics)	22202
6	Applied Machines	22203
7	Basic Surveying	22205
8	Applied Science (Chemistry)	22211
9	Applied Science (Physics)	22211
10	Fundamental of Electrical Engineering	22212
11	Elements of Electronics Engineering	22213
12	Elements of Electrical Engineering	22215
13	Basic Electronics	22216
14	C Language programming	22218
15	Basic Electronics	22225
16	Programming in C	22226
17	Fundamental of Chemical Engineering	22231

Third Semester:

1	Applied Multimedia Techniques	22024
2	Advanced Serveying	22301
3	Highway Engineering	22302
4	Mechanics of Structures	22303
5	Building Construction	22304
6	Concrete Technology	22305
7	Strength Of Materials	22306
8	Automobile Engines	22308
9	Automobile Transmission System	22309
10	Mechanical Operations	22313
11	Technology Of Inorganic Chemicals	22314
12	Object Oriented Programming Using C++	22316
13	Data Structure Using ‘C’	22317
14	Computer Graphics	22318
15	Database Management System	22319
16	Digital Techniques	22320
17	Principles Of Database	22321
18	Digital Techniques & Microprocessor	22323
19	Electrical Circuits	22324
20	Electrical & Electronic Measurment	22325
21	Fundamental Of Power Electronics	22326
22	Electrical Materials & Wiring Practice	22328
23	Applied Electronics	22329
24	Electrical Circuits & Networks	22330
25	Electronic Measurments & Instrumentation	22333
26	Principles Of Electronics Communication	22334
27	Thermal Engineering	22337
28	Engineering Matrology	22342
29	Mechanical Engineering Materials	22343
30	Theory Of Machines	22344

Fourth Semester:

1	Hydraulics	22401
2	Geo Technical Engineering	22404
3	Chemical Process Instrumentation & Control	22407
4	Fluid Flow Operation	22409
5	Technology Of Organic Chemical	22410
6	Java Programming	22412
7	GUI Application Development Using VB.net	22034
8	Microprocessor	22415
9	Database Managment	22416
10	Electric Motors And Transformers	22418
11	Industrial Measurement	22420
12	Digital Electronic And Microcontroller Application	22421
13	Linear Integrated Circuits	22423
14	Microcontroller & Applications	22426
15	Basic Power Electronics	22427
16	Digital Communication Systems	22428
17	Mechanical Engineering Measurments	22443
18	Fluid Mechanics and Machinery	22445
19	Fundamentals Of Mechatronics	22048
20	Micro Project & Industrial Training Assessment Manual	22049

Fifth Semester:

1	Network Management & Administration	17061
2	Solid Modeling	17063
3	CNC Machines	17064
4	Behavioral Science(Hand Book)	17075
5	Behavioral Science (Assignment Book)	17075
6	Windows Programming using VC++	17076
7	Estimation and Costing	17501
8	Public Health Engineering	17503
9	Concrete Technology	17504
10	Design of Steel Structures	17505
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18	Hydraulic & Pneumatics	17522
19	Advanced Automobile Engines	17523
20	Basic Electrical & Electronics	17524
21	Measurement and Control	17528
22	Power Engineering	17529
23	Metrology & Quality Control	17530
24	Computer Hardware & Networking	17533
25	Microcontroller	17534
26	Digital Communication	17535
27	Control System & PLC	17536
28	Audio Video Engineering	17537
29	Control System	17538
30	Industrial Electronics and applications	17541
31	Heat Transfer Operations	17560
32	Chemical Process Instrumentation & control	17561

Sixth Semester:

1	Solid Modeling	17063
2	Highway Engineering	17602
3	Contracts & Accounts	17603
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5	Industrial Fluid Power	17608
6	Design of Machine Elements	17610
7	Automotive Electrical and Electronic Systems	17617
8	Vehicle Systems Maintenance	17618
9	Software Testing	17624
10	Advanced Java Programming	17625
11	Mobile Computing	17632
12	System Programing	17634
13	Testing & Maintenance of Electrical Equipments	17637
14	Power Electronics	17638
15	Illumination Engineering	17639
16	Power System Operation & Control	17643
17	Environmental Technology	17646
18	Mass Transfer Operation	17648
19	Advanced Communication System	17656
20	Mobile Communication	17657
21	Embedded System	17658
22	Process Control System	17663
23	Industrial Automation	17664
24	Industrial Drives	17667
25	Video Engineering	17668
26	Optical Fiber & Mobile Communication	17669
27	Therapeutic Equipment	17671
28	Intensive Care Equipment	17672
29	Medical Imaging Equipment	17673

Pharmacy Lab Manual

First Year:

1	Pharmaceutics - I	0805
2	Pharmaceutical Chemistry - I	0806
3	Pharmacognosy	0807
4	Biochemistry and Clinical Pathology	0808
5	Human Anatomy and Physiology	0809

Second Year:

1	Pharmaceutics - II	0811
2	Pharmaceutical Chemistry - II	0812
3	Pharmacology & Toxicology	0813
4	Hospital and Clinical Pharmacy	0816

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