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Department of Civil Engineering
School of Engineering & Technology
Session (2024-2028)

Fundamentals of Geotechnical Engineering (CEL0408)

PBL
"Soil Investigation"

Submitted To:
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CERTIFICATE

This is to certify that the Project-Based Learning (PBL) report entitled **"Soil Investigation"** has been successfully completed and submitted by Vikram (BETN1CE240009), Mukul Sharma (BEN1CE25D02), Subhankar Sharma (BEN1CE25D01)

This project work embodies the original efforts and findings of the above-mentioned students and has been carried out during the academic session 2025, as part of the curriculum prescribed by ITM University, Gwalior.

Under the Guidance of

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ACKNOWLEDGEMENT

We would like to express our deepest gratitude to Dr. Rakesh Gupta, *Associate Professor, Department of Civil Engineering, School of Engineering and Technology, ITM University, Gwalior*, for his constant guidance, encouragement, and invaluable support throughout the course of this Project-Based Learning (PBL) work titled

"Soil Investigation."

His expert supervision, constructive suggestions, and insightful feedback have been instrumental in the successful completion of this report.

We also extend our sincere thanks to the Department of Civil Engineering and School of Engineering and Technology (SOET), ITM University, Gwalior, for providing us with the necessary facilities and a conducive academic environment to carry out this project effectively.

Lastly, we are grateful to our teammates, classmates and friends for their continuous support, motivation, and cooperation during every phase of this work.

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Session: JAN-MAY 2026

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1.INTRODUCTION

Soil is a natural material whose engineering behavior depends on its composition, structure, and moisture condition. Before carrying out detailed strength and deformation analysis, it is essential to understand the basic characteristics of soil. These basic characteristics are described by **soil index properties**, which serve as a preliminary tool for evaluating soil behavior.

Soil index properties are fundamental physical properties that help in the **identification, classification, and comparison of soils**. Although these properties do not directly provide information about the strength or load-bearing capacity of soil, they offer valuable insight into how a soil is likely to behave under different engineering conditions. Parameters such as particle size distribution, consistency limits, and natural moisture content play a crucial role in understanding soil plasticity, compressibility, and permeability.

In geotechnical engineering practice, soil index properties form the **first stage of soil investigation**. They assist engineers in selecting appropriate laboratory and field tests, predicting general soil behavior, and making preliminary design decisions for foundations, embankments, pavements, and earth-retaining structures. Therefore, the determination of soil index properties is an essential step in any geotechnical investigation program.

2. AIM & OBJECTIVE

The aim of this Project-Based Learning (PBL) is to study and understand the **soil index properties** through various laboratory experiments and to evaluate their importance in geotechnical engineering applications. This project focuses on determining basic soil properties that help in the **identification, classification, and preliminary assessment of soil behavior**.

The objectives of this PBL include:

- To perform different laboratory tests to determine soil index properties
- To understand the significance of each index property in soil investigation
- To classify soil based on standard classification systems
- To develop practical knowledge of soil testing procedures and interpretation of results

Through this PBL, we gain a fundamental understanding of soil behavior, which forms the basis for safe and economical design of civil engineering structures.

3. OBJECTIVES

The objectives of this Project-Based Learning (PBL) on soil investigation are as follows:

- To collect **representative soil samples** from the selected site for laboratory testing.
- To determine the **index properties of soil** through standard laboratory experiments.
- To classify the soil according to the **Indian Standard Soil Classification System (IS).**
- To interpret the **engineering behavior of soil** based on the obtained index properties.
- To understand the **importance of soil index properties in foundation design** and other geotechnical engineering applications.

4. SCOPE OF THE PROJECT

The scope of this Project-Based Learning (PBL) includes the **field and laboratory investigation of soil index properties to** understand their role in geotechnical engineering. The project is limited to preliminary soil investigation and does not include advanced strength or consolidation testing.

This PBL covers the following aspects:

- Field collection of **representative soil samples** from the selected site
- Laboratory determination of **soil index properties** using standard testing procedures
- Analysis and interpretation of **experimental results**
- Classification of soil based on the **Indian Standard Soil Classification System**
- Study of the **engineering significance** of index properties in geotechnical applications

The outcomes of this project provide a basic understanding of soil behavior, which is essential for preliminary foundation design and other civil engineering works.

Soil Sample Collection

Soil sample is taken from the area near the Tapti hostel of ITM University Gwalior

EXPERIMENT 1 MOISTURE CONTENT (OVEN DRYING)

OBJECTIVE

Determine the natural water content of the given soil sample.

DEFINITION

The natural water content, also called the natural moisture content, is the ratio of the weight of water to the weight of the solids in a given mass of soil. This ratio is usually expressed as percentage.

THEORY

Moisture content is one of the most fundamental and important index properties of soil. It is defined as the ratio of the weight of water present in the soil to the weight of dry soil solids, expressed as a percentage. The presence of water in soil significantly influences its engineering properties such as strength, compressibility, permeability, and compaction behavior.

In geotechnical engineering, the moisture content plays a vital role in determining the consistency and state of soil. For example, a soil with low moisture content behaves more like a solid, whereas a soil with high moisture content behaves like a plastic or even liquid material. Therefore, accurate determination of moisture content is essential for proper soil classification and analysis.

The oven drying method is the most commonly used and reliable laboratory method for determining the natural moisture content of soil. In this method, a soil sample is weighed before and after drying in an oven at a temperature of 100°C to 105°C. The loss in weight is considered as the weight of water present in the soil.

This method is simple, accurate, and widely adopted in standard testing procedures. However, care must be taken while testing soils containing organic matter or gypsum, as they may lose structural water at high temperatures, leading to inaccurate results.

Moisture content is particularly important in field applications such as compaction control in road construction, determination of optimum moisture content, and stability analysis of slopes and embankments.

APPARATUS REQUIRED

1. Non-corrodible air-tight container.
2. Electric oven, maintain the temperature around 100C.
3. Desiccator.
4. Balance of sufficient sensitivity.

PROCEDURE

1. Clean the container with lid, dry it and weigh it (W1).

2. Take a specimen of the sample in the container and weigh with lid (W2).

3. Keep the container in the oven with the lid removed. Dry the specimen to constant weight maintaining the temperature between 100 C to 105 C for a period varying with the type of soil but usually 16 to 24 hours.

4. Record the final constant weight (W3) of the container with a dried soil sample. Peat and other organic soils are to be dried at lower temperature (say 600) possibly for a longer period.

Certain soils contain gypsum which on heating loses its water if crystallization. If it is suspected that gypsum is present in the soil sample used for moisture content determination it shall be dried at not more than 800 C and possibly for a longer time.

Observation and Readings

Sl. No.	Observations & Calculations	Weight
1.	Weight of container with lid W1gm.	20.37 gm
2.	Weight of container with lid + wet soil W2 gm.	50.45 gm
3.	Weight of container with lid + dry soil W3 gm.	46.01 gm
4.	Water/Moisture content :- W = [(W2-W3)/(W3-W1)] x 100	17.33%

Important Considerations

- Temperature should not exceed **110°C**, as it may cause loss of structural water in some soils.
- For **organic soils or gypsum soils**, lower temperatures (60–80°C) are used.
- The sample must be cooled in a **desiccator** to prevent absorption of moisture from air.

Significance of Moisture Content

Moisture content plays a crucial role in:

- Determining **soil strength and stability**
- Compaction characteristics
- Shear strength
- Settlement behavior
- Classification of soil

Advantages of Oven Drying Method

- Highly accurate and reliable
- Simple and widely accepted
- Standard method (used in IS codes)

Limitations

- Time-consuming (requires 24 hours)
- Not suitable for soils containing **volatile substances**
- Requires controlled laboratory conditions

Conclusion

The oven drying method provides an accurate measurement of soil moisture content by removing water through controlled heating. It is a fundamental test in geotechnical engineering and forms the basis for many other soil property determinations.

Photographs of the experiment 1


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Experiment 2 - Specific Gravity of Soil

OBJECTIVE

Determination of specific gravity of soil by pycnometer method

THEORY

The pycnometer method can be used for the determination of the specific gravity of solid particles of both fine-grained and coarse-grained soils. The specific gravity of solids is determined using the relation

$$G = (M2 - M1)/[(M2 - M1) - (M3 - M4)]$$

where M1 = mass of empty pycnometer;
M2 = mass of pycnometer and dry soil;
M3 = mass of pycnometer, soil, and water;
M4 = mass of pycnometer filled with water only.

Specific gravity of soil solids is defined as the ratio of the unit weight (or density) of soil solids to that of water at a specified temperature. It is a dimensionless quantity and is usually denoted by "G". It provides information about the mineral composition and density characteristics of soil particles.

The specific gravity of soil generally ranges from 2.6 to 2.8 for most inorganic soils. Lower values may indicate the presence of organic matter, while higher values may suggest heavy minerals.

The pycnometer method is commonly used for determining the specific gravity of soil particles, especially for fine-grained soils. The method is based on measuring the mass of soil and water in a calibrated container (pycnometer) and comparing it with the mass of water alone.

The principle behind this method is the displacement of water by soil particles. By measuring different mass combinations, the volume of soil solids can be determined indirectly, which helps in calculating specific gravity.

Specific gravity is an important parameter used in various calculations such as:

- Void ratio and porosity determination
- Degree of saturation
- Unit weight of soil
- Soil classification

It also helps in understanding the compaction characteristics and behavior of soil under different loading conditions.

APPARATUS REQUIRED

(1) Pycnometer of about 1 litre capacity
(2) Weighing balance, with an accuracy of 1g
(3) Glass rod
(4) Vacuum pump.

PROCEDURE

1. Clean and dry the pycnometer. Tightly screw it's cap. Take its mass (M1) to the nearest 0.1 g.
2. Mark the cap and pycnometer with a vertical line parallel to the axis of the pycnometer to ensure that the cap is screwed to the same mark each time.
3. Unscrew the cap and place about 200g of oven-dried soil in the pycnometer. Screw the cap. Determine the mass (M2).
4. Unscrew the cap and add a sufficient amount of de-aired water to the pycnometer so as to cover the soil. Screw on the cap.
5. Shake the contents well. Connect the pycnometer to a vacuum pump, to remove the entrapped air, for about 20 minutes for fine- grained soils and for about 10 minutes for coarse-grained soils.
6. Disconnect the vacuum pump. Fill the pycnometer with water, about three fourths full. Reapply the vacuum for about 5 minutes, till air bubbles stop appearing on the surface of the water.

7. Fill the pycnometer with water completely, upto the mark. Dry it from outside. Take its mass (M3).
8. Record the temperature of contents.
9. Empty the pycnometer. Clean it and wipe it dry.
10. Fill the pycnometer with water only. Screw on the cap upto the mark. Wipe it dry. Take its mass (M4).

SL. No	Observations and Calculations	Trail
	Observations	
1.	Pycnometer No.	3
2.	Room temperature	26 C
3.	Mass of empty pycnometer (M1)	635.11g
4.	Mass of empty pycnometer and dry soil (M2)	812.02g
5.	Mass of empty pycnometer, dry soil & water	1422g
6.	(M3)	
	Mass of pycnometer and water (M4)	1330g
7.	*Calculations*	
8.	M2 - M1	176.91g
9.	M3 - M4	112g
	G = 176.91/(176.91-112)	2.76

RESULT Specific gravity of solids at 26 C = 2.76

Important Considerations

- Soil must be **completely dry** before the test.
- All **air bubbles must be removed**, as they affect volume measurement.
- Use **distilled water** to avoid impurities.
- Temperature should be constant, as water density changes with temperature.

Significance of Specific Gravity

Specific gravity is important for:

- Determining **void ratio, porosity, and degree of saturation**
- Soil classification
- Compaction and settlement analysis
- Design of foundations and earth structures

Advantages of Pycnometer Method

- Suitable for **coarse-grained soils**
- Simple and fairly accurate
- Requires basic laboratory equipment

Limitations

- Not suitable for **fine-grained soils** (use density bottle instead)
- Errors due to **air bubbles**
- Requires careful handling and precise measurements

Conclusion

The pycnometer method is a reliable technique for determining the specific gravity of soil solids by measuring displaced water. It is widely used in geotechnical engineering for evaluating fundamental soil properties.

Photographs of Experiment 2


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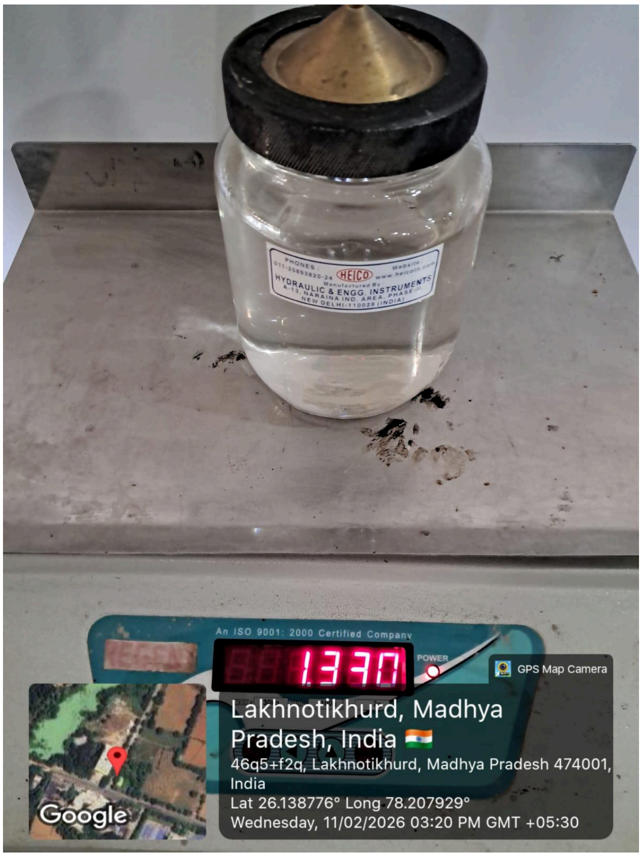
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EXPERIMENT 3 - LIQUID LIMIT OF SOIL

OBJECTIVE

Determination of liquid limit of soil sample

THEORY

The liquid limit of a soil is the water content at which the soil behaves practically like a liquid, but has a small shear strength. It flows to close the groove in just 25 blows in Casagrande's liquid limit device:
As it is difficult to get exactly 25 blows in a test, 3 to 4 tests are conducted, and the number of blows (N) required in each test is determined. A semi-log plot is drawn between log N and the water content (w). The liquid limit is the water content corresponding to N= 25, as obtained from the plot.

The liquid limit is one of the Atterberg limits and represents the water content at which soil changes from a plastic state to a liquid state. At this limit, the soil begins to flow under its own weight and possesses very little shear strength.

The liquid limit is determined using Casagrande's liquid limit apparatus. In this method, a soil paste is placed in a standard cup, divided by a groove, and subjected to repeated blows. The number of blows required to close the groove is recorded, and the corresponding moisture content is determined. The liquid limit is defined as the moisture content at which the groove closes in 25 blows.

The liquid limit provides valuable information about the consistency and compressibility of soil. Soils with high liquid limits are generally more compressible and have lower strength, while soils with low liquid limits are relatively more stable.

This property is widely used in:

- Soil classification systems (IS classification)
- Predicting settlement behavior
- Assessing workability of soil
- Evaluating shear strength characteristics

It is especially important for clayey soils, where changes in moisture content can significantly alter soil behavior.

APPARATUS REQUIRED

(1) Casagrande's liquid limit device
(2) Grooving tools of both Standard and ASTM types
(3) Oven
(4) Evaporating dish or glass sheet
(5) Spatul;
(6) 425 p IS sieve
(7) Weighing balance, accuracy 0.01 g
(8) Wash bottles.

PROCEDURE

1. Adjust the drop of the cup of the liquid limit device by releasing the two screws at the top and by using the handle of the grooving tool or a gauge. The drop should be exactly 1cm at the point of contact on the base. Tighten the screw after adjustment.

2. Take about 120g of the air-dried soil sample passing 425 u IS sieve.
3. Mix the sample thoroughly with distilled water in an evaporating dish or a glass plate to form a uniform paste. Mixing should be continued for about 15 to 30 minutes, till a uniform mix is obtained.
4. Keep the mix under humid conditions for obtaining uniform moisture distribution for a sufficient period. For some fat clays, this maturing time may be upto 24 hours.
5. Take a portion of the matured paste and remix it thoroughly. Place it in the cup of the device by a spatula and level it by a spatula or a straight edge to have a maximum depth of the soil as 1cm at the point of the maximum thickness.
6. The excess soil, if any, should be transferred to the evaporating dish. (6) Cut a groove in the sample in the cup by using the appropriate tool. Draw the grooving tool through the paste in the cup along the symmetrical axis,

along the diameter through the centre line of the cam. Hold the tool perpendicular to the cup.

7. Tum the handle of the device at a rate of 2 revolutions per second. Count the number of blows until the two halves of the soil specimen come in contact at the bottom of the groove along a distance of 12mm due to flow and not by sliding.
8. Collect a representative specimen of the soil by moving spatula width-wise from one edge to the other edge of the soil cake, at right-angles to the groove. This should include the portion of the groove in which the soil flowed to close the groove. Place the specimen in an air-tight container for the water content determination. Determine the water
9. Remove the remaining soil from the cup. Mix it with the soil left in the evaporating dish.
10. Change the water content of the mix in the evaporating dish, cither by adding more water if the water content is to be increased, or by kneading the soil, if the water content is to be decreased. In no case, the dry soil should be added to reduce the water content.
11. Repeat steps 4 to 10, and determine the number of blows (N) and the water content in cach case.
12. Draw the flow curve between log N and w, and determine the liquid limit corresponding to N= 25.

Data Sheet for Liquid Limit Test

S.No.	Observation and calculation	Trail 1	Trail 2	Trail 3
	Observations			
1.	Number of blows	15	22	30
2.	Mass of empty can (M1)	25.15g	25.60	24.95
3.	Mass of can + wet soil (M2)	36.93g	38.20	37.10
4.	Mass of can + dry soil (M3)	33.81g	34.85	34.20
	Calculations			
5.	Mass of water = M2 - M3	3.12g	3.35	2.90
6.	Mass off dry soil = M3 - M1	8.66	9.25	9.25
7.	Water content w	36%	36.2%	31.4%

RESULT = The average liquid limit of the given sample is 34.55%

Important Considerations

- Grooves should be cut uniformly and correctly.
- The rate of blows should be 2 blows per second.
- Soil paste must be uniformly mixed.
- Avoid excessive drying during the test.

Significance of Liquid Limit

Liquid limit is used for:

- Soil classification (IS classification system)
- Determining plasticity index (PI)
- Assessing compressibility and settlement
- Evaluating shear strength behavior
- Predicting engineering behavior of clays

Advantages

- Simple and widely used method
- Standardized procedure (IS: 2720 Part 5)
- Useful for engineering analysis

Limitations

- Operator-dependent results
- Not suitable for coarse-grained soils
- Errors due to improper groove cutting or blow rate

Conclusion

The liquid limit test determines the water content at which soil transitions from plastic to liquid state. It is a fundamental property used in soil classification and plays a vital role in understanding the engineering behavior of fine-grained soils.

Photographs of Experiment 3

EXPERIMENT - 4 Plastic Limit of Soil Specimen

Objective

To determine the liquid limit of soil sample

Theory

The plastic limit of a soil is the water content of the soil below which it ceases to be plastic. It
begins to crumble when rolled into threads of 3mm diameter.
Equipment. (1) Porcelain evaporating dish, about 120mm diameter or a flat glass plate, 450mm square and 10 mm thick; (2) Ground glass plate, about 200mm x 150 mm; (3) Metallic rod, 3mm dia. and 100 mm long; (4) Oven; (5) Spatula or palette knife; (6) Moisture content can.

The plastic limit is the water content at which soil changes from a plastic state to a semi-solid state. Below this limit, the soil loses its plasticity and starts to crumble when subjected to deformation.

The plastic limit is determined by rolling a soil sample into threads of 3 mm diameter. When the thread begins to crumble at this diameter, the corresponding moisture content is considered as the plastic limit.

This test helps in understanding the plastic behavior of soil and its ability to undergo deformation without cracking. It is particularly useful in identifying clayey soils and assessing their engineering properties.

The plastic limit, along with the liquid limit, is used to determine the Plasticity Index (PI), which is given by:

PI = Liquid Limit – Plastic Limit

The plasticity index indicates the range of moisture content over which the soil remains plastic. A higher PI indicates higher plasticity and compressibility, whereas a lower PI indicates less plastic and more stable soil.

Plastic limit is important in:

- Soil classification
- Stability analysis
- Road construction and subgrade evaluation
- Determining shrinkage and swelling behavior
-

Procedure

1. Take about 30g of air-dried soil from a thoroughly mixed sample of the soil passing
2. Mix the soil with distilled water in an evaporating dish or on a glass plate to make it plastic cough to shape into a small ball.
3. Leave the plastic soil mass for some time for maturing. For some fat clays, this period may be even upto 24 hours.
4. Take about 8g of the plastic soil, and roll it with fingers on a glass plate. The rate of the rolling should be about 80 to 90 strokes per minute to form a thread of 3mm diameter, counting one stroke when the hand moves forward and backward to the starting point.
5. If the diameter of the thread becomes less than 3mm without cracks, it shows that the water content is more than the plastic limit. Knead the soil to reduce the water content, and roll it again into thread.

Repeat the process of alternate rolling and kneading until the thread crumbles, and the soil can no longer be rolled into thread.
[**Note** If the crumbling occurs when the thread has a diameter slightly greater than 3 mm, it may be taken as the plastic limit, provided the soil had been rolled into a thread of 3mm diameter immediately before kneading. Do not attempt to produce failure exactly at 3mm diameter.]

6. Collect the pieces of the crumbled soil thread in a moisture content container.
7. Repeat the procedure at least twice more with fresh samples of plastic soil each time.

Data Sheet of the experiment

S.No.	Observation and calculation	Trail 1	Trail 2	Trail 3
	Observations			
1.	Mass of empty can (M1)	24.12g	24.50g	24.05g
2.	Mass of can + wet soil (M2)	30.28g	31.10g	30.60g
3.	Mass of can + dry soil (M3)	29.12g	29.85g	29.50g
	Calculations			
4.	Mass of water = M2 - M3	1.16g	1.25g	1.10g
5.	Mass off dry soil = M3 - M1	5.00g	5.35g	5.45g
6.	Water content w	23.2%	23.4%	29.50%

RESULT = The average plastic limit of the given sample is 22.3%

Important Considerations

- Rolling should be done **uniformly without excessive pressure**.
- Diameter must be approximately **3 mm**.
- Soil should not be over-dried during testing.
- Perform the test quickly to avoid moisture loss.

Significance of Plastic Limit

Plastic limit is important for:

- Determining **Plasticity Index (PI = LL − PL)**
- Soil classification
- Evaluating **workability of soil**
- Understanding **consistency and behavior of clay soils**

Advantages

- Simple and quick test
- Requires minimal equipment
- Useful for fine-grained soils

Limitations

- Results depend on **operator skill**
- Not suitable for **coarse-grained soils**
- Difficulty in identifying exact crumbling point

Conclusion

The plastic limit test determines the water content at which soil changes from plastic to semi-solid state. It is an essential parameter for soil classification and understanding the consistency characteristics of fine-grained soils.

Photographs of the experiment


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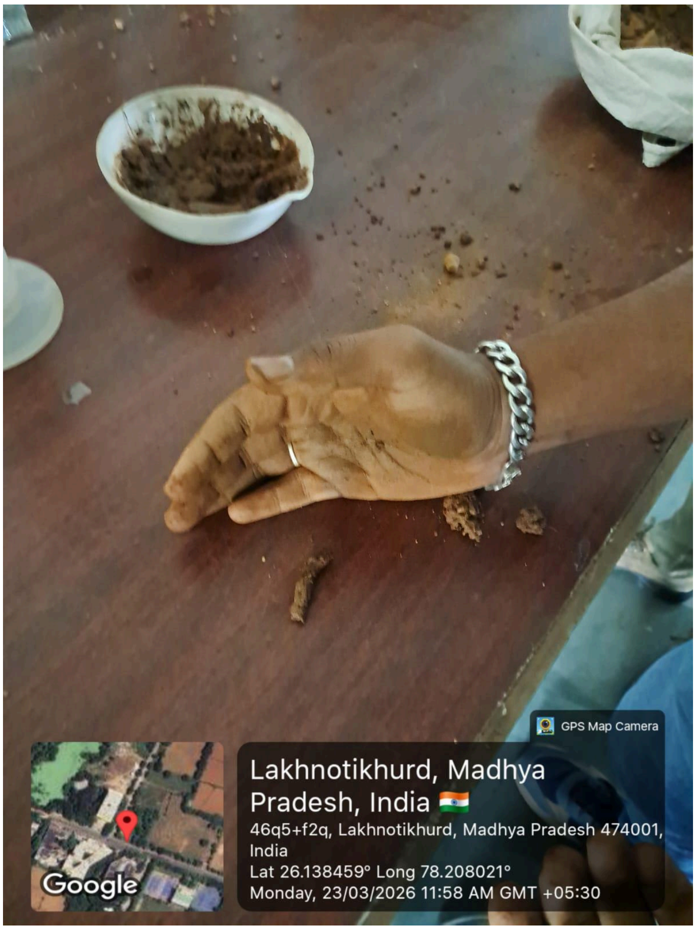
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EXPERIMENT - 5 Particle Size Distribution of soil by Sieving.

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OBJECTIVE

To determine the particle size distribution of soil by sieving.

THEORY

The soil is sieved through a set of sieves. The material retained on different sieves is determined.
The percentage of material retained on any sieve is given by

$$Pn = (Mn/M)*100$$

where M, = mass of soil retained on sieve 'n',
and M = total mass of the sample.
The cumulative percentage of the material retained,

C, = PI + P2 + ... + Pa

where p,P, etc, are the percentages retained on sieve '1', '2', etc. which are coarser than sieve n'. The percentage finer than the sieve 'n',

N, - 100 - Cn

Particle size distribution is an important index property that describes the proportions of different sizes of soil particles present in a soil sample. It is determined using sieve analysis for coarse-grained soils.

In this method, soil is passed through a series of standard sieves with decreasing mesh sizes. The amount of soil retained on each sieve is measured, and the percentage of particles passing through each sieve is calculated.

The results are used to plot a particle size distribution curve, with particle size on the logarithmic scale (x-axis) and percentage finer on the y-axis.

This analysis helps in:

- Classifying soil as coarse-grained or fine-grained
- Determining gradation (well-graded or poorly graded)

- Understanding permeability and drainage characteristics
- Assessing compaction and strength properties

Well-graded soils contain a wide range of particle sizes and exhibit better compaction and strength. Poorly graded soils have uniform particle sizes and generally have lower stability.

Particle size distribution is widely used in the design of:

- Foundations
- Pavements
- Earth dams
- Filter materials

APPARATUS REQUIRED

(1) Set of fine sieves, 2 mm, 1 mm, 600 u, 425u, 212u , 150u, and 75u
(2) Set of coarse sieves, 100 mm, 80 mm, 40 mm, 20 mm, 10mm and 4.75 mm
(3) Weighing balance, with accuracy of 0.1% of the mass of sample
(4) Oven
(5) Mechanical shaker
(6) Trays
(7) Mortar, with a rubber covered pestle
(8) Brushes
(9) Riffler

Part—I. Coarse sieve Analysis

Procedure.

(1) Take the required quantity of the sample. Sieve it through a 4.75 mm IS sieve. Take the soil fraction retained on 4.75mm IS sieve for the coarse sieve

analysis (part I) and that passing through the sieve for the fine sieve analysis (part II).

(2) Sieve the sample through the set of coarse sieves, by hand.
While sieving through each sieve, the sieve should be agitated such that the sample rolls in irregular motion over the sieve. The material retained on the sieves may be rubbed with the rubber pestle in the mortar, if necessary. Care shall be taken so as not to break the individual particles. The quantity of the material taken for sieving on each sieve shall be such that the maximum mass of material retained on each sieve does not exceed the specified value.

(3) Determine the mass of the material retained on each sieve.

(4) Calculate the percentage of soil retained on each sieve on the basis of the total mass of the sample, taken in step (1).

(5) Determine the percentage passing through each sieve.

Part—II. Fine sieve analysis

(6) Take the.portion of the soil passing 4.75 mm IS sieve. Oven dry it at 105° to 100°C. Weigh it to 0.1% of the total mass.

(7) Sieve the soil through the nest of fine sieves. The sieves should be agitated so that the sample rolls in irregular motion over the sieves. However, no particles should be pushed through the sieve.

(8) Take the material retained on various sieves in a mortar. Rub it with rubber pestle, but do not try to particles.

(9) Resieve the material through the nest of sieves.

A minimum of 10 minutes of shaking is required if a mechanical shaker is used.
(10) Collect the soil fraction retained on each sieve in a separate container. Take the mass.
on the total mass taken in step (1).

(11) Determine the percentage retained, cumulative percentage retained, and the percentage finer, based on the total mass taken in step (1)

DATA SHEET FOR SIEVE ANALYSIS

Total mass of dry soil = 400 g
Mass of soil retained on 4.75 mm sieve = 200g
Mass of soil passing 4.75 mm sieve = 200 g.

S. No.	**IS Sieve**	**Size of Opening**	**Mass of soil retained**	**Percentage retained**	**Cumulative % retained**	**% finer**
1	100 mm	100 mm	-	-	-	-
2	80 mm	80 mm	-	-	-	-
3	40 mm	40 mm	-	-	-	-
4	20 mm	20 mm	30.0 g	7.50	7.50	92.50
5	10 mm	10 mm	62.0 g	15.50	23.00	77.00
6	4.75 mm	4.75 mm	108.0 g	27.00	50.00	50.00
7	2 mm	2 mm	30.5 g	7.62	57.62	42.38

8	1 mm	1 mm	24.0 g	6.00	63.62	36.38
9	600 µ	0.600 mm	17.5 g	4.38	68.00	32.00
10	425 µ	0.425 mm	16.0 g	4.00	72.00	28.00
11	300 µ	0.300 mm	14.0 g	3.50	75.50	24.50
12	212 µ	0.212 mm	18.0 g	4.50	80.00	20.00
13	150 µ	0.150 mm	22.0 g	5.50	85.50	14.50
14	75 µ	0.075 mm	36.0 g	9.00	94.50	5.50
15	Pan	-	22.0 g	5.50	100.00	-

RESULT

Percentage finer given in the last column can be used to plot the particle size distribution curve with particle size as abscissa on log scale and the percentage finer as ordinate.
[**Note**. If the fine fraction contains an appreciable amount of clay particles, the wet sieve analysis is required.
Altematively, the following method may be used.
Before conducting step (7), add the water containing sodium hexa-metaphosphate at the rate of 2g per litre of water to the soil fraction. Stir the mix thoroughly and leave for soaking. Wash the soaked specimen on a 75p IS sieve until the water passing the sieve is clear. Take the fraction retained on the sieve and dry it in an oven. Sieve the oven dried soil through the nest of sieves as discussed in step (7). Perform further steps, as before.

Obviously, the mass of material which would have been retained on pan is equal to the original mass of the soil before washing minus the dry mass of the soil retained on 75u IS sieve after washing.]

Important Considerations

- Soil must be **completely dry** before testing.
- Sieves should be **clean and undamaged**.
- Avoid loss of fine particles during transfer.
- Proper shaking time should be maintained.

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10. Significance of Sieve Analysis

- Soil classification (coarse-grained soils)
- Determining **gradation of soil**
- Evaluating **permeability and drainage**
- Design of **filters, pavements, and foundations**

11. Advantages

- Simple and widely used method
- Provides detailed size distribution
- Standard procedure (IS: 2720 Part 4)

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12. Limitations

- Not suitable for particles **smaller than 75 µm** (use hydrometer analysis)
- Errors due to improper sieving or handling
- Time-consuming for large samples

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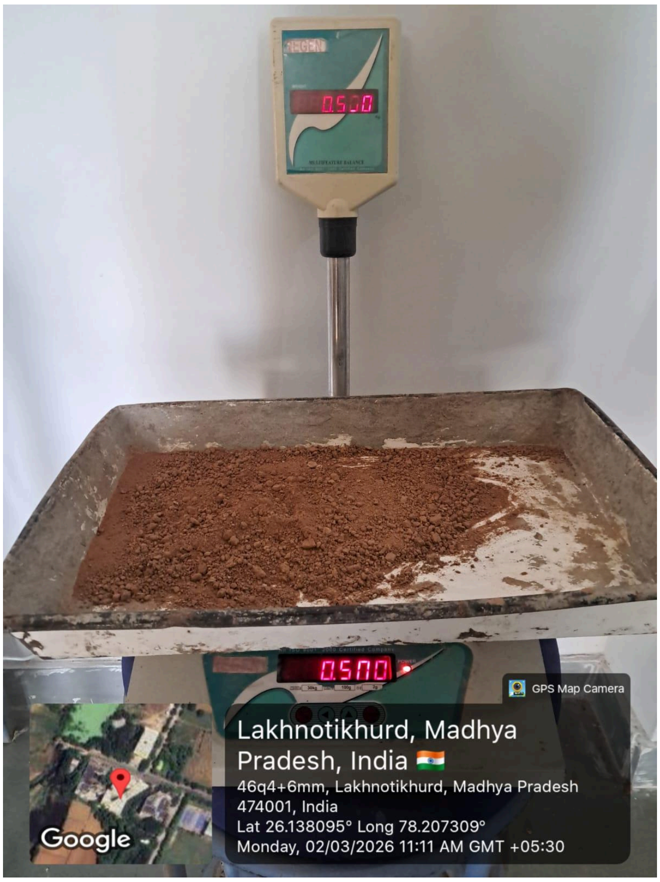
13. Conclusion

Sieve analysis is an essential method for determining the particle size distribution of coarse-grained soils. The results help in soil classification and in understanding the engineering behavior of soils for construction purposes.

Photographs of Experiment

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CONCLUSION

The present study on soil investigation successfully fulfilled its objective of determining and analyzing the index properties of the collected soil sample. Various laboratory tests were conducted, including moisture content, specific gravity, liquid limit, plastic limit, and particle size distribution, which together provide a comprehensive understanding of the soil behavior.

From the experimental results, the natural moisture content of the soil was found to be approximately 17.33%, indicating moderate water presence in the soil mass. The specific gravity of soil solids was determined as 2.76, which falls within the typical range for mineral soils, suggesting the absence of unusual or highly organic materials. The consistency limits showed a liquid limit of 34.55% and a plastic limit of 22.3%, indicating that the soil possesses moderate plasticity characteristics. This implies that the soil can undergo deformation without cracking within a certain moisture range.

The particle size distribution analysis revealed the gradation characteristics of the soil, indicating a mix of coarse and fine particles. Such gradation plays a crucial role in determining permeability, compaction behavior, and strength characteristics. Based on these index properties, the soil can be broadly classified and its engineering behavior can be reasonably predicted for preliminary design purposes.

Overall, the soil exhibits properties of a moderately plastic soil, suitable for general construction purposes with proper consideration of moisture control and compaction. However, since this project is limited to index properties only , further advanced tests such as shear strength and consolidation tests are recommended for detailed foundation design and stability analysis.

This project highlights the importance of soil investigation as the first and most essential step in geotechnical engineering. Understanding soil properties helps engineers make safe, economical, and efficient decisions in the design of foundations, pavements, and other civil engineering structures.

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APPENDIX

Appendix A – Raw Observation Data

This section includes the original observations recorded during the laboratory experiments.

A1. Moisture Content Test (Oven Drying Method)

- Weight of container (W1) = 20.37 g
- Weight of container + wet soil (W2) = 50.45 g
- Weight of container + dry soil (W3) = 46.01 g

A2. Specific Gravity Test (Pycnometer Method)

- Mass of empty pycnometer (M1) = 635.11 g
- Mass of pycnometer + dry soil (M2) = 812.02 g
- Mass of pycnometer + soil + water (M3) = 1422 g
- Mass of pycnometer + water (M4) = 1330 g

A3. Liquid Limit Test Data

Trail	No. of blows	Water Content %
1	15	36%
2	22	36.2%
3	30	31.4%

A4. Plastic Limit Test Data

Trail	Water Content %
1	23.2%
2	23.4%
3	29.5%

A5. Sieve Analysis Data (Partial)

Total mass of soil = 400 g

Appendix B – Sample Calculations

B1. Moisture Content

W =[(W2 - W3)/(W3 - W1)] * 100

W =[(50.45 - 46.01)/(46.01 - 20.37)] * 100 = 17.33%

B2. Specific Gravity

G = (M2 - M1)./(M2 - M1) - (M3 - M4)

G = (176.91)/(176.91 - 112) = 2.76

B3. Liquid Limit

The liquid limit is determined from the flow curve by plotting water content versus log of number of blows.

At 25 blows, the corresponding water content is:
LL = 34.55%

B4. Plastic Limit

PL = (23.2 + 23.4 + 29.5)/3 = 22.3%

B5. Plasticity Index

PI = LL - PL = 34.55 - 22.3 = 12.25%

Appendix C – Additional Photographs

This section includes extra photographs of:

- Soil sample collection site
- Laboratory setup and apparatus
- Step-by-step procedures of experiments

(Refer to pages 5, 7, 12, 17, 20, and 27 of the report for visual documentation)

Appendix E – Equipment Details

The following equipment were used during the experiments:

- Oven (for drying soil samples)
- Weighing balance
- Pycnometer
- Casagrande liquid limit device
- Sieve set and mechanical shaker
- Glass plates and spatula