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BABU BANARASI DAS
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Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

LAB MANUAL

OF

Transportation Engineering Lab

[BCE 652]

B.TECH, 3rd Year, 6th Semester

Dr. A.P.J. Abdul Kalam Tech. University
Uttar Pradesh

2025-26

Department of Civil Engineering

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(Assistant Professor)

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(Associate Professor)

Head of the Department

MANUAL CONTENTS

This manual is intended for the 3rd year students of Civil Engineering in the subject of Transportation Engineering Lab (BCE-652). This manual typically contains practical/lab sessions related to highway materials testing, pavement engineering, traffic studies, and mix design practices, covering various aspects to enhance understanding of aggregate properties, bitumen characteristics, pavement materials, traffic analysis, and field applications. The laboratory experiments are designed in accordance with IRC and MoRTH specifications to provide students with practical exposure to transportation engineering concepts used in real-world highway construction and traffic engineering projects.

The manual includes experiments such as Aggregate Crushing Value Test, Aggregate Impact Value Test, Specific Gravity Test, Shape Tests, Los Angeles Abrasion Test, Penetration Test on Bitumen, Marshall Mix Design, Job Mix Formula for WMM and DBM, California Bearing Ratio (CBR) Test, Traffic Volume Study, and Traffic Speed Study. These experiments help students understand the behavior and performance of pavement materials and traffic characteristics under field and laboratory conditions.

Students are advised to thoroughly go through this manual rather than only the topics mentioned in the syllabus, as practical exposure is essential for understanding and visualizing the theoretical concepts related to highway materials, pavement design, traffic engineering, and transportation infrastructure development. The laboratory work will also help students develop analytical skills, observation techniques, data interpretation abilities, and report writing practices essential for professional civil engineering applications.

Good luck, and we wish you an engaging, practical, and insightful laboratory experience in the field of Transportation Engineering.

PREFACE

This manual has been prepared for the 3rd year Civil Engineering students to provide practical knowledge of Transportation Engineering and highway material testing. It includes important laboratory experiments related to aggregates, bitumen, pavement design, and traffic studies as per IRC standards. The experiments help students understand the behavior and performance of pavement materials under laboratory and field conditions. Students are advised to perform all experiments carefully to develop practical skills and better understanding of transportation engineering concepts.

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VISION OF THE DEPARTMENT

To impart academic excellence in civil engineering field with emphasis on holistic development of the professional, while inculcating ethics, socially and professionally responsive technocrats.

MISSION OF THE DEPARTMENT

M1: To provide a comprehensive platform for academic expertise and proficiency

M2: To develop civil engineering professionals with creative skills and leadership qualities in order to face regional and global challenges.

M3: To develop ethics in students in order to promote socially responsible environmental awareness with innovative thinking.

Program Educational Objectives (PEOs) of Department

PEO 1: To enhance skill and expertise in field of civil engineering with aim of boosting employability and entrepreneurship.

PEO 2: To develop multidisciplinary approach of civil engineering system with lifelong learning solutions.

PEO 3: To develop the potential to pursue higher education and research in field of civil engineering

Program Outcomes :(PO)

Graduates will be able to achieve

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

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

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

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

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

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

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

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

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

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

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

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

Program Specific Outcome (PSO)

PSO 1: Graduates shall be able to apply critical thinking in research, design, analysis and implementation of civil engineering problems

PSO 2: Graduates shall be able to inculcate the idea of sustainability in engineering solution to meet real world challenges.

Course Evaluation Scheme

Sr No	Subject Code	Subject Name	Periods			Evauation Scheme				Total	Credit
						Sessional Assessment			PE		
			L	T	P	CT	TA	PS			
1.	BCE652	Transportation Engineering Lab	0	0	2	-	-	50	50	100	1

Lab Objectives:

1.	To provide hands-on experience with standard testing procedures for highway materials.
2.	To develop practical skills in conducting traffic studies and analyzing data.
3.	To understand the application of Job Mix Formula (JMF) and mix design in pavement construction.
4.	To evaluate material performance through laboratory tests as per IRC guidelines.
5	To apply laboratory findings for real-world highway engineering solutions.

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Lab Outcomes (LOs)

Lab Outcomes: The students should be able to:		**Knowledge Level**
LO1	Recall standard procedures for material testing as per IRC guidelines.	K1, K2
LO2	Apply standard methods to test aggregates, bitumen, and subgrade materials.	K1, K2, K3
LO3	Analyze traffic survey data, material test results, and mix designs.	K1, K2, K4
LO4	Evaluate pavement quality based on laboratory and field test data.	K2, K4, K5
LO5	Create Job Mix Formulas (JMF) and comprehensive lab reports for highway materials.	K3, K6

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

CO-PO-PSO Mapping

LOs /POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
LO1	2	1	–	–	2	–	1	–	–	–	–	–	2	1
LO2	2	2	1	–	3	–	–	–	–	–	–	–	3	1
LO3	1	2	2	2	2	–	1	–	–	–	–	–	2	1
LO4	1	2	2	2	2	–	1	–	–	–	–	–	2	2
LO5	1	1	3	2	3	–	2	–	1	1	–	–	2	2
AVERAGE	1.40	1.60	2.00	2.00	2.40	-	1.25	-	1.00	1.00	-	-	2.20	1.40

The extent of mapping is as follows: 1 for low, 2 for moderate, 3 for high &"-" for No correlation between CO & PO.

List of Experiments

S. No.	Experiment
1	Determination of Crushing & Impact Value of Aggregates
2	Determination of Density and specific gravity of Aggregates
3	Flakiness and Elongation Index of Aggregates
4	Los Angeles Abrasion Test
5	Penetration and viscosity grade Test on Bitumen
6	Marshall Mix Design for Bituminous Concrete (BC) as per IRC:111-2009
7	Job Mix Formula (JMF) for Wet Mix Macadam (WMM)
8	Mix Design for Dense Bituminous Macadam (DBM) and Derivation of JMF
9	California Bearing Ratio (CBR) Test (Lab and Field)
10	Traffic Volume Study Using Manual and Automated Counters
11	Traffic Speed Study Using Radar Speed Gun

Beyond Syllabus:

S. No.	**Experiments**
1	To determine the Stripping Value of Coarse Aggregates.
2	To determine the Flash and Fire Point of Bituminous material.
3	To determine the Ductility Value of Bituminous material.

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S.No.	Name of the Experiment	CO	BTL	Lab Conduction Date	Remark/ Grade/ Marks	Faculty Signature with Date

Softwares & Hardwares Required

Software Requirements

- MS Excel / Google Sheets (for calculations and graphical analysis)
- AutoCAD (for pavement and transportation-related drafting work)

Hardware Requirements

Peripherals / Lab Equipment

I. Aggregate Tests

- Aggregate Crushing Value Apparatus
- Aggregate Impact Testing Machine
- Los Angeles Abrasion Testing Machine
- Thickness Gauge and Length Gauge
- Standard IS Sieves with Sieve Shaker
- Weighing Balance
- Drying Oven
- Compression Testing Machine (CTM)
- Metal Tamping Rods
- Cylindrical Measures and Trays

II. Bitumen Tests

- Penetrometer Apparatus
- Water Bath with Temperature Control
- Thermometer
- Bitumen Heating Oven / Hot Plate
- Marshall Stability Testing Machine
- Dial Gauge
- Mixing Trays and Mixing Tools

III. Pavement Material & Mix Design Tests

- CBR Testing Machine (Lab and Field Type)
- CBR Moulds with Loading Frame
- Moisture Content Containers
- Measuring Cylinders and Graduated Cylinders
- Mixing Equipment and Trowels
- Standard Weights

IV. Traffic Engineering Experiments

- Manual Traffic Counting Sheets
- Stopwatch / Digital Timer
- Endoscope Mirror Setup
- Laptop / Mobile Device for Data Recording
- Measuring Tape

Laboratory Safety Instructions (DO's)

- Read the experiment procedure carefully before starting the experiment.
- Ensure all equipment is clean, calibrated, and in proper working condition before use.
- Handle aggregates, bitumen, and pavement materials carefully to avoid contamination.
- Follow all laboratory safety instructions and wear proper PPE such as gloves, and safety shoes whenever required.
- Record all observations and calculations neatly in the practical file.
- Maintain proper labeling of test samples and data sheets.
- Operate testing machines such as Marshall Stability Machine, CBR Apparatus, and Abrasion Machine carefully as per guidelines.
- Work in coordination with lab partners and follow instructor directions.
- Switch off all electrical equipment after use and maintain cleanliness in the laboratory.
- Report damaged equipment or abnormal test results to the lab instructor immediately.

Laboratory Precautions (Don'ts)

- Do not operate laboratory equipment without proper instruction or supervision.
- Do not disturb prepared specimens during testing.
- Avoid guessing or manipulating readings; always use actual observations.
- Do not overload testing machines or use them improperly.
- Do not leave ovens, heating devices, or testing machines unattended while operating.
- Avoid spilling water, bitumen, or aggregates near electrical equipment.
- Do not mix different material samples or observation records.
- Do not ignore safety precautions while handling hot bitumen, ovens, or heavy equipment.
- Avoid careless handling of delicate instruments such as balances, gauges, and thermometers.
- Do not leave the laboratory untidy after completion of experiments.

Experiment No.1 (a)

DETERMINATION OF AGGREGATE CRUSHING VALUE

1. OBJECTIVE

1) To determine the aggregate crushing value of coarse aggregates
2) To assess suitability of aggregates for use in different types of road pavement

2. PRINCIPLE

The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. Crushing value is a measure of the strength of the aggregate. The aggregates should therefore have minimum crushing value.

3. APPARATUS

The apparatus of the aggregate crushing value test as per IS: 2386 (Part IV) – 1963 consists of:

1) A 15cm diameter open ended steel cylinder with plunger and base plate, of the general form and dimensions as shown in Fig 1.
2) A straight metal tamping rod of circular cross-section 16mm diameter and 45 to 60 cm long, rounded at one end.
3) A balance of capacity 3k, readable and accurate up to 1 g.
4) IS Sieves of sizes 12.5,10 and 2.36 mm
5) A compression testing machine capable of applying a load of 40 tonnes and which can be operated to give a uniform rate of loading so that the maximum load is reached in 10 minutes. The machine may be used with or without a spherical seating
6) For measuring the sample, cylindrical metal measure of sufficient rigidity to retain its form under rough usage and of the following internal dimensions:

Diameter 11.5cm

Height 18.0cm

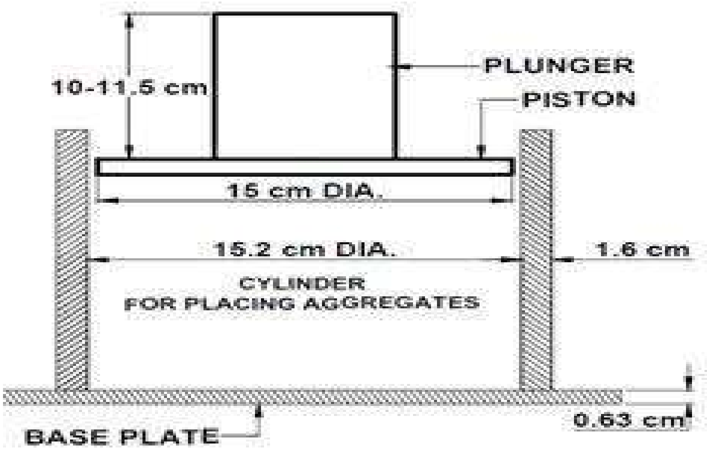


Fig 1 AGGREGATE CRUSHING TEST APPARATUS

4. PROCEDURE

The test sample: It consists of aggregates sized 12.5 mm - 10.0 mm (minimum 3kg). The aggregates should be dried by heating at 100-110° C for a period of 4 hours and cooled.

1) Sieve the material through 12.5 mm and 10.0 mm IS sieve. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.
2) The cylinder of the test shall be put in position on the base-plate and the test sample added in thirds, each third being subjected to 25 strokes with the tamping rod.
3) The surface of the aggregate shall be carefully leveled.
4) The plunger is inserted so that it rests horizontally on this surface, care being taken to ensure that the plunger does not jam in the cylinder
5) The apparatus, with the test sample and plunger in position, shall then be placed between the plates of the testing machine.

6) The load is applied at a uniform rate as possible so that the total load is reached in 10 minutes. The total load shall be 40 tones.
7) The load shall be released and the whole of the material is removed from the cylinder and sieved on 2.36mm IS Sieve.
8) The fraction passing the sieve shall be weighed and recorded.

5. REPORTING OF RESULTS

The mean of the two results shall be reported to the nearest whole number as the 'aggregate crushing value' of the size of the material tested.

6. CONCLUSION

Aggregate Crushing test value =

Record of Observation

	Sample I	**Sample II**
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 2.36 mm sieve= W_2 gm		
Aggregate crushing Value (per cent) = $(W_2/W_1)*100$		

Aggregate Crushing Mean Value =

Experiment No. 1(b)

DETERMINATION OF AGGREGATE IMPACT VALUE

1. OBJECTIVE

1) To determine the impact value of the road aggregates
2) To assess suitability of aggregates for use in different types of road pavement

2. PRINCIPLE

The property of a material to resist impact is known as toughness. Due to movement of vehicles on the road the aggregates are subjected to impact resulting in their breaking down into smaller pieces. The aggregates should therefore have sufficient toughness to resist their disintegration due to impact. This characteristic is measured by impact value test. The aggregate impact value is a measure of resistance to sudden impact or shock, which may differ from its resistance to gradually applied compressive load.

3. APPARATUS

The apparatus of the aggregate impact value test as per IS: 2386 (Part IV) – 1963 consists of:

1)A testing machine weighing 45 to 60 kg and having a metal base with a plane lower surface of not less than 30 cm in diameter. It is supported on level and plane concrete floor of minimum 45 cm thickness. The machine should also have provisions for fixing its base.

2) A cylindrical steel cup of internal diameter 102 mm, depth 50 mm and minimum thickness 6.3 mm.

3) A metal hammer p weighing 13.5 to 14.0 kg the lower end is cylindrical in shape, is 50 mm long, 100.0 mm in diameter, with a 2 mm chamfer at the lower edge and case hardened. The hammer should slide freely between vertical guides and be concentric with the cup. The free fall of the hammer should be within 380 ± 5 mm.

4) A cylindrical metal measure having internal diameter of 75 mm and depth 50 mm for measuring aggregates.

5) Tamping rod 10 mm in diameter and 230 mm long, rounded at one end.

6) A balance of capacity not less than 500 g, readable and accurate up to 0.1 g.

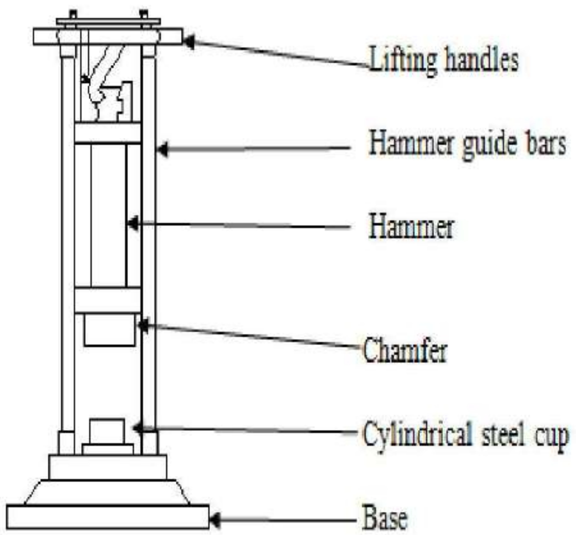


Fig 2 AGGREGATE IMPACT TESTING MACHINE

4. PROCEDURE

The test sample: It consists of aggregates sized 12.5 mm - 10.0 mm. The aggregates should be dried by h eating at 10 0-110º C for a period of 4 hours and cooled.

1) Sieve the material through 12.5 mm and 10.0 mm IS sieve. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.

2) Pour the aggregates to fill about 1/3rd depth of measuring cylinder.

3) Compact the material by giving 25 gentle blows with the rounded end of the tamping rod.

4) Add two more layers in similar manner, so that cylinder is full.

5) Strike off the surplus aggregates.

6) Determine the net weight of the aggregates to the nearest gram (W).

7) Bring the impact machine to rest without wedging or packing up on the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.

8) Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.

9) Raise the hammer until its lower face is 380 mm above the surface of the aggregate sample in the cup and allow it to fall freely on the aggregate sample. Give 15 such blows at an interval of not less than one second between successive falls.

10) Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieves until no further significant amount passes in one minute. Weigh the fraction passing the sieve to an accuracy of 1 gm (W_2). Also weigh the fraction retained in the sieve.

11) Note down the observations in the Performa and compute the aggregate impact value. The mean of two observations, rounded to nearest whole number is reported as the Aggregate Impact Value.

5. PRECAUTIONS

1) Place the plunger centrally so that it falls directly on the aggregate sample and does not touch the walls of the cylinder in order to ensure that the entire load is transmitted on to the aggregates.
2) In the operation of sieving the aggregates through 2.36 mm sieve the sum of weights of fractions retained and passing the sieve should not differ from the original weight of the specimen by more than 1 gm.
3) The tamping is to be done properly by gently dropping the tamping rod and not by hammering action. Also the tampering should be uniform over the surface of the aggregate taking care that the tamping rod does not frequently strike against the walls of the mould.

6. REPORTING OF RESULTS

The mean of the two results shall be reported to the nearest whole number as the aggregate impact value of the tested material.

Aggregate impact value is used to classify the stones in respect of their toughness property as indicated below in Table 1.

Table 1: Classification of aggregate based on aggregate impact value

Aggregate impact value (%)	**Quality of aggregate**
< 10	Exceptionally strong
10 – 20	Strong
20 – 30	Satisfactory for road surfacing
>35	Weak for road surfacing

Table 2: Maximum allowable impact values of aggregate in different types of Pavement material/ layers

Sl. No	**Types of pavement material /layer**	**Aggregate impact value (%)**
1	Water bound macadam, sub-base course	50
2	Cement concrete, base course	45
3	i) WBM base coarse with bitumen surfacing ii) Built-up spray grout, base course	40

4	Bituminous macadam, base course	35
5	i) WBM, surfacing course ii) Built-up spray grout, surfacing course iii) Bituminous penetration macadam iv) Bituminous surface dressing v) Bituminous macadam, binder course vi) Bituminous carpet vii) Bituminous/Asphaltic concrete viii) Cement concrete, surface course	30

7. CONCLUSION

Record of Observation	Sample I	Sample II
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 2.36 mm sieve = W_2 gm		
Aggregate impact = $(W_2/W_1)*100$ Value (per cent)		

Aggregate Impact Mean Value =

Experiment No. 2

SPECIFIC GRAVITY OF AGGREGATE

1. OBJECTIVE

This method of test lays down the procedure for determining the specific gravity of coarse and fine aggregates.

Specific Gravity is defined as the ratio of the weight of an aggregate to the weight of an equal volume of water. It is considered a measure of strength or quality of the material. Aggregates with low specific gravity are generally weaker than those with high specific gravity.

2. PRINCIPLE

The specific gravity of an aggregate sample is determined either by using a wire basket (for aggregate coarser than 6.3 mm) or a pycnometer (for aggregate finer than 6.3 mm). This test measures the bulk and apparent specific gravity, and water absorption of aggregates.

3. APPARATUS

The apparatus shall consist of the following:

1. **Wire Basket** – Not more than 6.3 mm mesh for immersion and weighing in water.
2. **Pycnometer** – Of 1000 ml capacity for aggregates finer than 6.3 mm.
3. **Balance** – Sufficiently sensitive to measure weight to an accuracy of 0.1 percent.
4. **Container for Water** – Large enough for immersion of basket.
5. **Airtight Container** – For cooling the oven-dried aggregates.
6. **Dry Absorbent Cloths** – For drying the saturated aggregates.
7. **Oven** – Capable of maintaining temperature at 110°C ± 5°C..

4. PROCEDURE

Procedure for Aggregate Coarser than 6.3 mm:

1. Take about 2 kg of the aggregate sample. Wash to remove fines and place it in the wire basket.
2. Immerse the basket with aggregate in water at a temperature of 22°C to 32°C.
3. Immediately after immersion, remove entrapped air by raising and dropping the basket 25 mm above the tank base, 25 times at one-second intervals.
4. Keep the basket and aggregate completely immersed for 24 ± 0.5 hours.
5. Weigh the basket and aggregate while suspended in water (W1).
6. Remove the basket from water, and transfer the aggregate to a dry absorbent cloth. Dry thoroughly to a saturated surface dry (SSD) condition.
7. Weigh the SSD aggregates in air (W3).
8. Place the aggregate in an oven at 110°C for 24 hours. Cool in an airtight container and weigh (W4).

Procedure for Aggregate Finer than 6.3 mm:

1. Weigh the empty, clean, and dry pycnometer (W1).
2. Add about 1000 g of clean, dry aggregate and weigh the pycnometer again (W2).
3. Add water to just cover the aggregate, remove air by shaking.
4. Fill the pycnometer completely with water, ensuring no air remains. Weigh (W3).
5. Empty and clean the pycnometer, fill it completely with water, and weigh (W4).

5. CALCULATION

S. No.	Description	Observed values
1	Weight of saturated aggregate and basket in water: W1 g	
2	Weight of basket in water: W2 g	
3	Weight of saturated aggregates in air: W3 g	
4	Weight of oven dry aggregates in air: W4 g	
5	Apparent Specific Gravity: W4 / [W4 – (W1 - W2)]	

6	Bulk Specific Gravity: W4 / [W3 – (W1 - W2)]	

Table 1 : Observation Table for Specific gravity of Aggregate coarser than 6.3 mm

S. No.	Description	Observed values
1	Weight of Pycnometer in air: W1 g	
2	Weight of aggregates and Pycnometer: W2 g	
3	Weight of aggregates, Pycnometer and water: W3 g	
4	Weight of water and Pycnometer in air: W4 g	
5	Apparent Specific Gravity: (W2 – W1) / [(W4 – W1) - (W3 -W2)]	

Table 2 : Observation Table for Specific gravity of Aggregate finer than 6.3 mm

6. REPORTING OF RESULTS

The specific gravity values (apparent and bulk) and water absorption percentage shall be recorded to the nearest 0.01. Values outside the normal range (2.5 to 3.0) should be carefully investigated.

7. CONCLUSION

Specific gravity of aggregate =

Water absorption =

Experiment No. 3

SHAPE TEST

A. FLAKINESS INDEX

1. OBJECTIVE

This method of test lays down the procedure for determining the flakiness index of the coarse aggregate.

2. PRINCIPLE

The flakiness index of an aggregate is the percentage by weight of particles in it whose least dimension (thickness) is less than three-fifths of their mean dimension. The test is not applicable to sizes smaller than 6.3mm.

3. APPARATUS

The apparatus shall consist of the following:

1) A balance – The balance shall be of sufficient capacity and sensitivity and shall have an accuracy of 0.1 percent of the weight of the test sample
2) Metal Gauge – The metal gauge shall be of the pattern as shown in Fig 4
3) Sieves – The sieves of sizes as shown in Table 6.

4. PROCEDURE

1) A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
2) The sample shall be sieved with sieves specified in Table 6.
3) Then each fraction shall be gauged in turn for thickness on a metal gauge of the pattern shown in Fig 4 or in bulk on sieves having elongated slots. The width of the slot used in the gauge or sieve shall be of the dimensions specified in column 3 of Table 6 for the appropriate size of material.

4)The total amount of aggregate passing the gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample

SIZE OF AGGREGATE (mm)		THICKNESS GAUGE(mm)	LENGTH GAUGE(mm)
Passing through IS sieve	Retained on IS sieve	*	#
63	50	33.90	-
50	40	27.00	81.0
40	31.5	19.50	58.5
31.5	25	16.95	-
25	20	13.50	40.5
20	16	10.80	32.4
16	12.5	8.55	25.6
12.5	10	6.75	20.2
10	6.3	4.89	14.7

Table 6. Dimensions of Thickness and Length gauge

*This dimension is equal to 0.6 times the mean sieve size.

This dimension is equal to 1.8 times the mean sieve size.

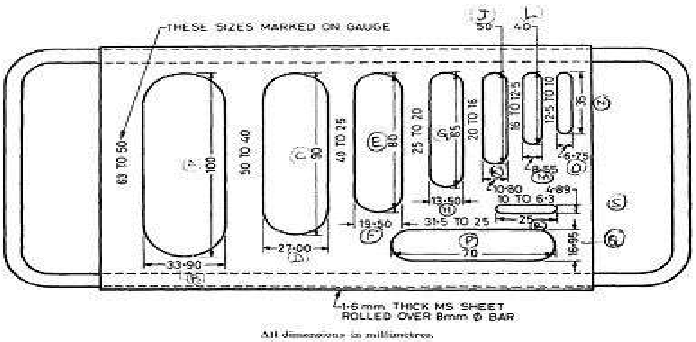


Fig4. THICKNESS GAUGE

5. CALCULATION

Flakiness index = 100 %

—

Where, *w* is the weights of material passing the various thickness gauges and **W** is the total weights of aggregate passing and retained on the specified sieves.

6. REPORTING OF RESULTS

The flakiness index is the total weight of the material passing the various thickness gauges, expressed as the percentage of the total weight of the sample gauged.

7. CONCLUSION

Flakiness index =

B. ELONGATION INDEX

1. OBJECTIVE

This method of test lays down the procedure for determining the elongation index of the coarse aggregate.

2. PRINCIPLE

The elongation index of an aggregate is the percentage by weight of particles in it whose greatest dimension (thickness) is greater than one and four-fifths of their mean dimension. The test is not applicable to sizes smaller than 6.3mm.

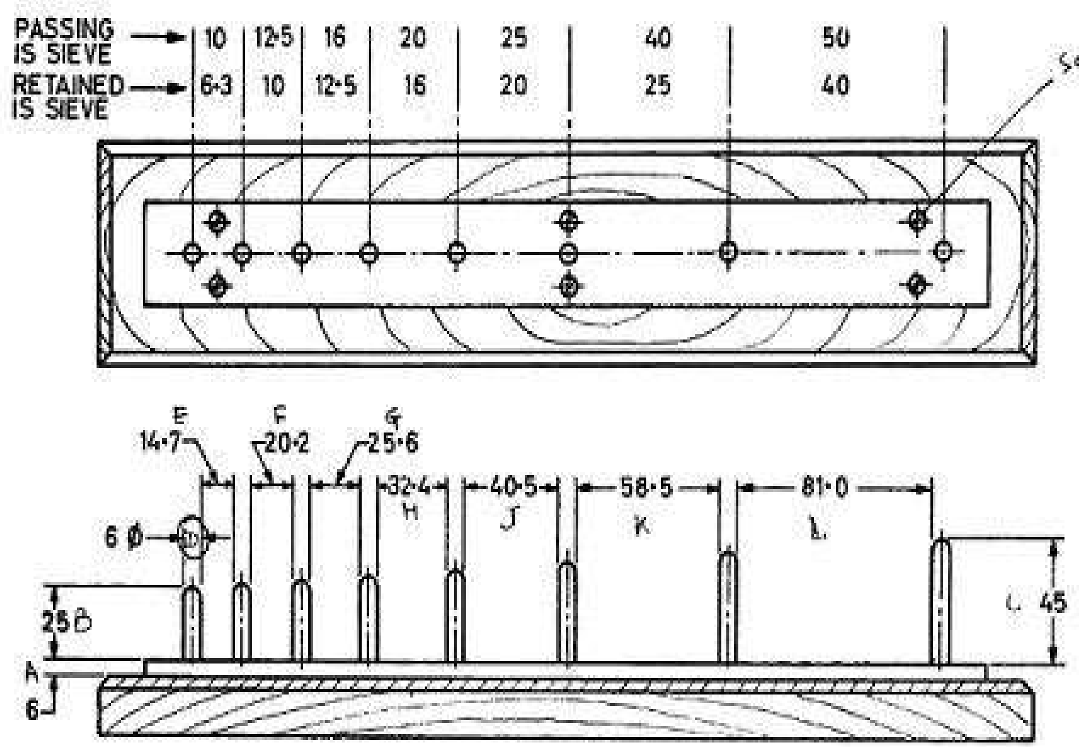
3. APPARATUS

The apparatus shall consist of the following:

1. A balance – The balance shall be of sufficient capacity and sensitivity and shall have an accuracy of 0.1 percent of the weight of the test sample
2. Metal Gauge – The metal gauge shall be of the pattern as shown in Fig 5
3. Sieves – The sieves of sizes as shown in Table 6.

4. PROCEDURE

1. A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
2. The sample shall be sieved with sieves specified in Table 6.
3. Each fraction shall be gauged in turn for length on a metal gauge of the pattern shown in Fig 5. The gauge length used shall be of the dimensions specified in column 4 of Table 6 for the appropriate size of material.
4. The total amount of aggregate retained by the length gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample



All dimensions in millimetres.

Fig5. LENGTH GAUGE

5. CALCULATION

Elongation index = 100 %

–

Where, *x* is the weight of materials retained on specified gauges

W is the total weights of aggregate passing and retained on the specified sieves.

6. REPORTING OF RESULTS

The elongation index is the total weight of the material retained on various length gauges, expressed as the percentage of the total weight of the sample gauged.

7. CONCLUSION

Elongation index =

Experiment No. 4

DETERMINATION OF LOS ANGELES ABRASION VALUE

1. OBJECTIVE

1) To determine Los Angeles abrasion value.
2) To find out the suitability of aggregates for its use in road construction.

2. PRINCIPLE

The aggregates used in surface course of the highway pavements are subjected to wearing due to movement of traffic. When vehicles move on the road, the soil particles present between the pneumatic tyres and road surface causes abrasion of road aggregates. The steel reamed wheels of animal driven vehicles also cause considerable abrasion of the road surface. Therefore, the road aggregate should be hard enough to resist the abrasion. Resistance to abrasion of aggregates is determined in laboratory by Los Angeles test machine.

The principle of Los Angeles abrasion test is to produce the abrasive action by use of standard steel balls which when mixed with the aggregates and rotated in a drum for specific number of revolutions also causes impact on aggregates. The percentage wear of the aggregates due to rubbing with steel balls is determined and is known as Los Angeles Abrasion Value.

3. APPARATUS

The apparatus as per IS: 2386 (Part IV) – 1963 consists of:

1) Los Angeles Machine: It consists of a hollow steel cylinder, closed at both the ends with an internal diameter of 700 mm and length 500 mm and capable of rotating about its horizontal axis. A removable steel shaft projecting radially 88 mm into cylinder and extending full length (i.e. 500 mm) is mounted firmly on the interior of cylinder. The

shelf is placed at a distance 1250 mm minimum from the opening in the direction of rotation.

2) Abrasive charge: Cast iron or steel balls, approximately 48 mm in diameter and each weighing between 390 to 445 g; 6 to 12 balls are required.

3) Sieve: The 1.70 mm IS sieve
    a. Balance of capacity 5 kg or 10 kg
    b. Drying oven

1) Miscellaneous like tray etc

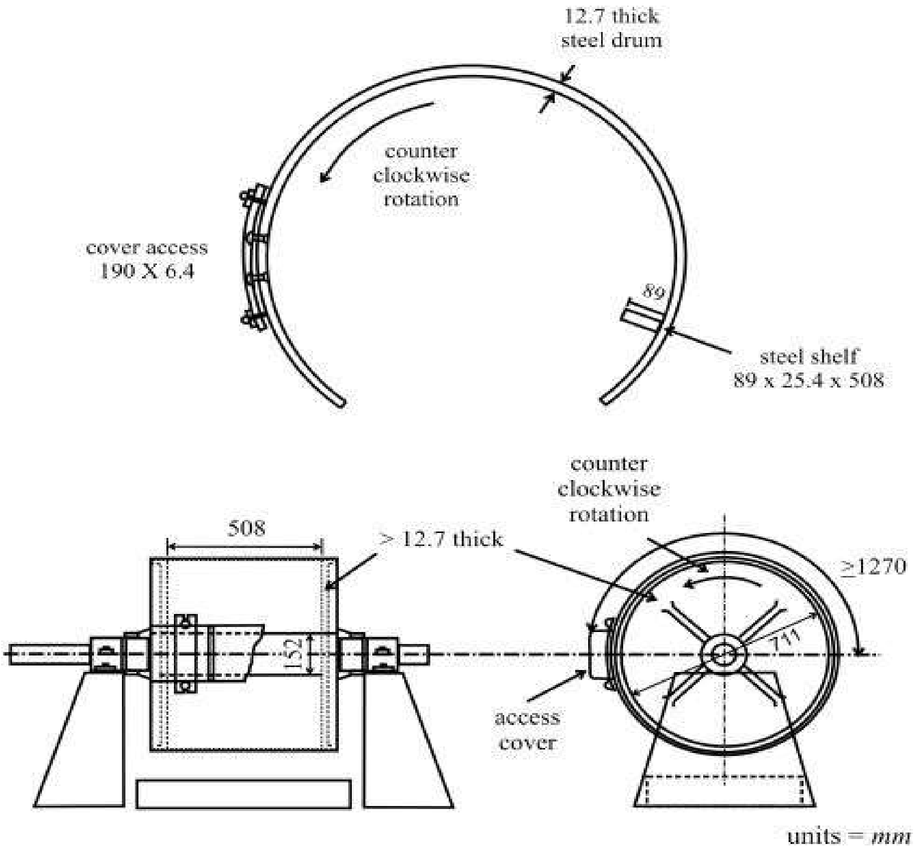


Fig 3 LOS ANGELES ABRASION TESTING MACHINE

4. PROCEDURE

Test Sample: It consists of clean aggregates dried in oven at 105 - 110° C and coarser than 1.70 mm sieve size. The sample should conform to any of the grading shown in table.

Table 3 Grading of Test Samples

Sieve size (square hole)		Weight in g of Test Sample for Grade						
Passing mm	Retained on mm	A	B	C	D	E	F	G
80	63	-	-	-	-	2500*	-	-
63	50	-	-	-	-	2500*	-	-
50	40	-	-	-	-	5000*	5000*	-
40	25	1250	-	-	-	-	5000*	5000*
25	20	1250	-	-	-	-	-	5000*
20	12.5	1250	2500	-	-	-	-	-
12.5	10	1250	2500	-	-	-	-	-
10	6.3	-	-	2500	-	-	-	-
6.3	4.75	-	-	2500	-	-	-	-
4.75	2.36	-	-		5000	-	-	-

*Tolerance of ±12 percent permitted.

1) Select the grading to be used in the test. It should be chosen such that it conforms

to the grading to be used in construction, to the maximum extent possible.

2) Take 5 kg of sample for grading A, B, C or D and 10 kg for grading E, F and G.

3) Choose the abrasive charge as per Table 2.

Table 4 Selection of Abrasive Charges

Grading	No. of Steel balls	Weight of charge, g
A	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 25
D	6	2500 ± 25
E	12	5000 ± 25
F	12	5000 ± 25

The test sample and the abrasive charge shall be placed in the Los Angles abrasion testing machine.

1) The machine is rotated at a speed of 20 to 33 rev/min for grading A, B,C and D, the machine shall be rotated for 500 revolutions; for grading E, F and G, it shall be rotated for 1000 revolutions

2) The material is discharged from the machine after the completion of the test and is sieved through 1.7 mm IS sieve.

3) The weight of the aggregate passing through 1.7mm sieve is taken and recorded

5. REPORTING OF RESULTS

The difference between the original weight and the final weight of the test sample shall be expressed as a percentage of the original weight of the test sample. This value is reported as the percentage wear.

Table 5. Maximum L A Abrasion values of aggregates in different types of pavement layers

Sl no.	Types of pavement layer	Maximum Los Value (%)
1	Water bound macadam ,sub-base course	60
2	i) WBM base course with bituminous surfacing	50

	ii) Bituminous macadam base course iii) Built-up spray grout base course	
3	i) WBM surfacing course ii) Bituminous macadam binder course iii) Bituminous penetration macadam iv) Built-up spray grout binder course	40
4	i) Bituminous carpet surface course ii) Bituminous surface dressing, single or two coats iii) Bituminous surface dressing, using pre-coated aggregates	35
5	i) Bituminous concrete surface course ii) Cement concrete pavement surface course	30

6. CONCLUSION

Los Angeles Abrasion value =

	Sample I	**Sample II**
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 1.7 mm sieve= W_2 gm		
Aggregate abrasion value = $(W_2/W_1)*100$ Value (per cent)		

Mean Los Angeles Abrasion value =

Experiment No. 5

DETERMINATION OF PENETRATION VALUE OF BITUMEN

1. OBJECTIVE

To determine the consistency of bituminous material

2. PRINCIPLE

Penetration value is a measurement of hardness or consistency of bituminous material. It is the vertical distance traversed or penetrated by the point of a standard needle in to the bituminous material under specific conditions of load, time, and temperature. This distance is measured in one tenth of a millimeter. This test is used for evaluating consistency of bitumen. It is not regarded as suitable for use in connection with the testing of road tar because of the high surface tension exhibited by these materials and the fact that they contain relatively large amount of free carbon.

3. APPARATUS

1. Container A flat bottomed cylindrical metallic dish 55 mm in diameter and 35 mm in depth is required. If the penetration is of the order of 225 or more deeper dish of 70 mm diameter and 45 mm depth is required.
2. Needle: A straight, highly polished, cylindrical hard steel rod, as per standard dimensions
3. Water bath: A water bath maintained at 25.0±0.1^{0}C containing not less than 10 litres of water, the sample being immersed to a depth not less than 100 mm from the top and supported on a perforated shelf not less than 50 mm from the bottom of the bath.

[illegible]

6. Penetration apparatus: It should be such that it will allow the needle to penetrate without much friction and is accurately calibrated to give results in one tenth of a milli metre
7. Thermometer: Range 0- 44^0 C and readable up to 0.2^{0}C
7. Time measuring device: With an accuracy ± 0.1 sec

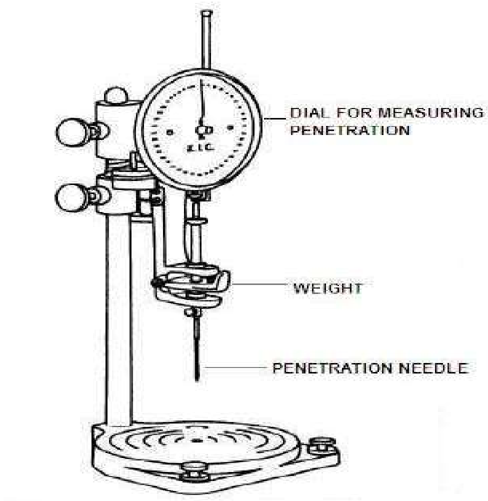


Fig6. PENETROMETER

4. PROCEDURE

1) Preparation of test specimen: Soften the material to a pouring consistency at a temperature not more than 60^0C for tars and 90^0C for bitumen's above the approximate softening point and stir it thoroughly until it is homogeneous and is free from air bubbles and water. Pour the melt into the container to a depth at least 10 mm in excess of the expected penetration. Protect the sample from dust and allow it to

cool in an atmosphere at a temperature between 15 to 30^0C for one hour. Then place it along with the transfer dish in the water bath at 25 ±0.1^0C, unless otherwise stated.

2) Fill the transfer dish with water from the water bath to depth sufficient to cover the container completely, place the sample in it and put it upon the stand of the penetration apparatus.

3) Clean the needle with benzene, dry it and load with the weight. The total moving load required is 100 +0.25gms, including the weight of the needle, carrier and super-imposed weights.

4) Adjust the needle to make contact with the surface of the sample. This may be done by placing the needle point in contact with its image reflected by the surface of the bituminous material

5) Make the pointer of the dial to read zero or note the initial dial reading.

6) Release the needle for exactly five seconds

7) Adjust the penetration machine to measure the distance penetrated.

8) Make at least 3 readings at points on the surface of the sample not less than 10 mm apart and not less than 10 mm from the side of the dish. After each test return the sample and transfer dish to the water bath and wash the needle clean with benzene and dry it. In case of material of penetration greater than 225, three determinations on each of the two identical test specimens using a separate needle for each determination should be made, leaving the needle in the sample on completion of each determination to avoid disturbance of the specimen.

5. CONCLUSION

Penetration value of given sample is =

Record of Observations

Actual Test Temperature =

		Test 1	Test 2	Test 3	Mean
Penetrometer dial reading	Initial				
	Final				
Penetration value					

Penetration value =

Experiment No. 6

MARSHALL MIX DESIGN FOR BITUMINOUS CONCRETE (BC)

1. OBJECTIVE

To determine the optimum binder content for bituminous concrete using the Marshall Mix Design method, by evaluating the stability, flow value, density, voids, and voids filled with bitumen (VFB).

2. PRINCIPLE

The Marshall Method involves the preparation of specimens of bituminous mixtures with varying binder contents, followed by compaction using a standard Marshall compactor. These specimens are tested for stability and flow by loading them diametrically at a constant rate of deformation. The results are used to determine the binder content at which the mix gives the desired stability and flow values, density, and air voids as per specifications.

3. APPARATUS

1. **Marshall Compaction Moulds** – Cylindrical moulds of 102 mm diameter and 64 mm height with base plate and collar.
2. **Compaction Hammer** – Weighing 4.5 kg and falling from a height of 457 mm.
3. **Heating Oven** – Capable of maintaining the temperature up to 200°C.
4. **Water Bath** – Maintained at 60 ± 1°C.
5. **Marshall Stability Testing Machine** – Equipped with a proving ring (capacity 50 kN) and a flow meter (accuracy 0.01 mm).
6. **Mixing Apparatus** – Mechanical or manual mixing tools for preparing bitumen mixes.
7. **Balance** – Accurate to 0.1 gram.
8. **Thermometer** – Measuring up to 250°C.
9. **Graduated Cylinder** – For measuring bitumen and other materials.
10. **Dial Gauge** – To record flow values.

4. PROCEDURE

A. Preparation of Specimens

1. **Sample Preparation**
   Heat aggregates and bitumen to the mixing temperature (approximately 160–170°C for aggregates, 150–165°C for bitumen). Mix thoroughly at five different bitumen contents with 0.5% increments (e.g., 4.0%, 4.5%, 5.0%, 5.5%, 6.0%).
2. **Compaction**
   Place the mixed material in a pre-heated Marshall mould. Compact with 75 blows on each face using the Marshall hammer. Allow the specimen to cool.
3. **Conditioning**
   Place the specimen in a water bath at 60 ± 1°C for 30–40 minutes before testing.

B. Marshall Test

4. Place the specimen centrally in the Marshall testing machine. Apply load at a deformation rate of 50.8 mm/min until failure.
5. Record the **maximum load (stability)** and **flow value** from the dial gauge.
6. Conduct tests for all specimens at different bitumen contents.

5. CALCULATIONS

Calculate the following for each specimen:

- **Bulk Density (Gb)** = Wd / V
- **Theoretical Maximum Specific Gravity (Gmm)**
- **Air Voids (Va)** = [(Gmm - Gb)/Gmm] × 100
- **Voids in Mineral Aggregate (VMA)** = [1 - (Gb/Gsb)] × 100
- **Voids Filled with Bitumen (VFB)** = [(VMA - Va)/VMA] × 100

Where:

- Wd = Weight of dry specimen in air
- V = Volume of specimen
- Gsb = Specific gravity of aggregate

6. CONCLUSION

Optimum Binder Content (OBC) is determined by plotting the following curves against binder content:

- Marshall Stability
- Flow Value
- Bulk Density
- Air Voids
- VMA
- VFB

The OBC corresponds to:

- Maximum stability
- Design air voids (~4%)
- Acceptable flow value (2–4 mm for BC)
- Voids filled with bitumen (~65–75%)

Record of Observations

Bitumen Content (%)	Stability (kN)	Flow (mm)	Bulk Density (g/cc)	Air Voids (%)	VMA (%)	VFB (%)
4.0						
4.5						
5.0						
5.5						
6.0						

Experiment No. 7

JOB MIX FORMULA (JMF) FOR WET MIX MACADAM (WMM)

1. OBJECTIVE

To determine the Job Mix Formula (JMF) for Wet Mix Macadam (WMM) by blending suitable aggregates and ensuring the mix meets specifications for gradation, water content, and compaction, as per relevant standards.

2. PRINCIPLE

The Job Mix Formula is prepared to achieve a dense, well-graded mix of crushed aggregates that meet the design requirements of strength, stability, and durability for sub-base or base course layers. The WMM material must comply with gradation limits, and the optimal moisture content must be determined to ensure maximum dry density during compaction. This is essential for ensuring a stable pavement structure.

3. APPARATUS

1. **Sieve Set and Shaker** – To determine the gradation of aggregates.
2. **Weighing Balance** – Accuracy up to 0.1% of the sample weight.
3. **Oven** – Capable of maintaining temperature at 110 ± 5°C.
4. **Moisture Content Containers** – Airtight containers for moisture testing.
5. **Proctor Compaction Apparatus** – For Standard/Modified Proctor Test.
6. **Mixing Tray** – For blending aggregate fractions manually.
7. **Water Sprayer** – To control moisture addition during mixing.
8. **Gradation Chart** – For plotting and verifying compliance with specifications.
9. **Measuring Cylinder or Burette** – For accurate water addition.
10. **Straight Edge and Scoop** – For leveling and transferring mix.

4. PROCEDURE

A. Gradation Analysis

1. Collect representative samples of each aggregate fraction (e.g., 40 mm, 20 mm, 10 mm, and dust).
2. Perform sieve analysis for each size and record individual weight retained.

3. Calculate percentage passing for each sieve.
4. Blend aggregates in trial proportions and check whether combined gradation falls within the WMM grading envelope (as per MORTH Table 400-10).

B. Moisture-Density Relationship

1. Mix the combined aggregates in dry condition.
2. Add water in increments and prepare at least 4 to 5 moisture contents for the Proctor compaction test.
3. Compact each mix in three layers in the Proctor mold with 25 blows per layer (Standard or Modified method as per project specification).
4. Record the wet weight, determine moisture content, and calculate dry density for each sample.
5. Plot the moisture vs. dry density curve and determine the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD).

C. Finalizing JMF

1. Select the combination of aggregates that satisfies the gradation limits and gives the highest MDD at OMC.
2. Record the final percentages of each aggregate size in the mix.
3. Note the OMC and MDD as part of the JMF report.

5. CONCLUSION

The Job Mix Formula (JMF) for Wet Mix Macadam has been determined by optimizing the blend of aggregate sizes to meet the gradation envelope and ensuring maximum dry density at Optimum Moisture Content (OMC). This mix design will be used for field implementation and quality control.

RECORD OF OBSERVATIONS

Sieve Size (mm)	Individual Fraction Passing (%)	Combined Mix Passing (%)	Limits (as per spec)
53.0			100
45.0			95–100
22.4			60–80

Sieve Size (mm)	Individual Fraction Passing (%)	Combined Mix Passing (%)	Limits (as per spec)
11.2			40–60
4.75			25–40
2.36			15–30
0.600			8–22
0.075			0–8

MOISTURE-DENSITY RELATIONSHIP

Water Content (%) Wet Density (g/cc) Dry Density (g/cc)

- **OMC (%) =**
- **MDD (g/cc) =**

Experiment No. 8

Mix Design for Dense Bituminous Macadam (DBM) and Derivation of Job Mix Formula (JMF)

1. OBJECTIVE

To design a Dense Bituminous Macadam (DBM) mix and determine the Job Mix Formula (JMF) to achieve a durable, strong, and workable bituminous layer that satisfies the requirements of gradation, stability, voids, and binder content as per MoRTH or IRC standards.

2. PRINCIPLE

DBM mix design involves the selection and proportioning of aggregates and bitumen to achieve specified properties, such as stability, flow, voids in mix (VIM), voids filled with bitumen (VFB), and air voids. The Marshall method is commonly used, where various bitumen contents are tested to determine the optimum binder content that provides desired performance characteristics.

3. APPARATUS

1. **Oven** – Thermostatically controlled up to 200°C
2. **Marshall Stability Test Apparatus** – With breaking head, loading frame, and dial gauge
3. **Compaction Mould Assembly** – Including base plate, collar, and hammer
4. **Bitumen Hot Plate or Melting Pot** – For heating binder
5. **Water Bath** – Maintained at 60 ± 1°C
6. **Balance** – Accuracy of 0.1 g
7. **Measuring Cylinder / Pipette** – For measuring bitumen
8. **Mixing Tray and Trowel** – For sample mixing
9. **Thermometer** – Range up to 300°C
10. **Sieve Set** – For gradation of aggregates
11. **Caliper or Vernier Scale** – For measuring specimen dimensions

4. PROCEDURE

A. Selection and Gradation of Aggregates

1. Obtain aggregate samples in different sizes (e.g., 26.5 mm, 13.2 mm, 5.6 mm, and filler).

2. Perform sieve analysis to determine individual and blended gradation.
3. Mix aggregate fractions to satisfy DBM grading requirements (Grading 1 or 2 as per MORTH Table 500-9).

B. Preparation of Specimens

1. Heat aggregates to 170°C–180°C and bitumen to 150°C–160°C.
2. Mix the aggregates and heated binder at different bitumen contents (e.g., 4.0%, 4.5%, 5.0%, 5.5%, 6.0% by weight of mix).
3. Compact each mix using 75 blows per face (for heavy traffic) with a Marshall hammer.
4. Allow specimens to cool, then immerse in water bath at 60°C for 30–40 minutes.

C. Testing and Observations

1. Test each specimen for **Marshall Stability and Flow**.
2. Record dimensions and weights (bulk density).
3. Calculate:
    - **Air Voids (VIM)**
    - **Voids in Mineral Aggregate (VMA)**
    - **Voids Filled with Bitumen (VFB)**

D. Determination of Optimum Bitumen Content (OBC)

Plot the following graphs:

- Bitumen content vs. Stability
- Bitumen content vs. Flow
- Bitumen content vs. Bulk Density
- Bitumen content vs. Air Voids
- Bitumen content vs. VFB

Determine **Optimum Bitumen Content (OBC)** at:

- Maximum stability
- 4% air voids
- Maximum bulk density
- Acceptable VFB range

The average of the above is considered the OBC.

5. DERIVATION OF JOB MIX FORMULA (JMF)

The JMF includes:

- **Aggregate Gradation:** Final % passing for each sieve size
- **Binder Content:** Optimum Bitumen Content (OBC)
- **Mix Properties at OBC:** Stability, Flow, VIM, VFB, VMA
- **Temperature:** Mixing and compaction temperatures

6. CONCLUSION

The mix design for DBM has been successfully completed using the Marshall Method. The derived Job Mix Formula ensures required stability, flow, density, and durability as per standard specifications and can be used for field production and quality control.

RECORD OF OBSERVATIONS

Aggregate Gradation

Sieve Size (mm)	% Passing	MoRTH Limits (Grading 1)
37.5		100
26.5		90–100
19.0		71–95
13.2		56–80
9.5		45–70
4.75		28–58
2.36		19–45
1.18		13–35
0.600		7–28
0.300		4–20
0.150		2–10
0.075		0–8

Marshall Test Results

Bitumen Content (%)	Stability (kN)	Flow (mm)	Bulk Density (g/cc)	VIM (%)	VMA (%)	VFB (%)

- **Optimum Bitumen Content (OBC):**

- **Final JMF Gradation and Mix Properties at OBC:**

Experiment No. 9

California Bearing Ratio (CBR) Test (Lab and Field)

1. OBJECTIVE

To determine the California Bearing Ratio (CBR) value of a soil subgrade or base material in the laboratory and field, which helps assess the strength of the ground for pavement design purposes.

2. PRINCIPLE

The CBR test evaluates the strength of subgrade soil and base materials by measuring the pressure required to penetrate a soil specimen with a standard plunger compared to the pressure required for a standard crushed stone. The result is expressed as a percentage and helps in determining pavement thickness. The CBR value is calculated from the ratio of force per unit area required to penetrate the soil to that required for standard material.

3. APPARATUS

For Laboratory CBR Test:

1. **CBR Testing Machine** – With proving ring or load cell, and penetration piston (50 mm diameter)
2. **CBR Mould** – With a collar, base plate, and perforated spacers
3. **Compaction Rammer** – 2.6 kg weight, 310 mm drop
4. **Loading Frame** – Motorized or hand-operated, capable of 1.25 mm/min
5. **Soaking Tank** – For soaking specimens
6. **Dial Gauge** – 0.01 mm least count
7. **Penetration Plunger** – 50 mm diameter, cylindrical
8. **Balance** – Accuracy 0.01 g
9. **Mixing tools, trays, measuring cylinders**

For Field CBR Test:

1. **Field CBR apparatus with Proving Ring**
2. **Penetration Plunger** – 50 mm diameter
3. **Dial Gauge** – To measure penetration
4. **Loading Jack** – 5–10 tonnes capacity

5. **Reaction Frame or Truck for Counterweight**
6. **Steel Plates, Spacer Discs, Annular Weights**
7. **Tools for excavation and trimming surface**

4. PROCEDURE

A. Laboratory CBR Test

1. **Sample Preparation**
   - Take a representative soil sample (preferably passing 19 mm sieve).
   - Determine the optimum moisture content (OMC) using Proctor compaction.
   - Mix soil at OMC and compact it in a CBR mould in 3 layers (56 blows per layer with 2.6 kg rammer).
2. **Soaking (If Required)**
   - Place the specimen in a soaking tank for 4 days with surcharge weights (equal to pavement layers).
3. **Penetration Test**
   - Place the mould in the loading machine.
   - Apply load through the penetration plunger at 1.25 mm/min.
   - Record load corresponding to 0.5 mm intervals up to 12.5 mm penetration.
4. **Calculations**
   - Determine the pressure at 2.5 mm and 5.0 mm penetrations.
   - CBR (%) = (Test Load / Standard Load) × 100
   - Standard Load:
     - At 2.5 mm = 1370 kg
     - At 5.0 mm = 2055 kg
   - Report higher of the two as CBR value unless 5 mm value is consistently higher.

B. Field CBR Test

1. **Test Pit Preparation**
   - Excavate a hole to expose subgrade/base layer.
   - Trim and level the surface. Place surcharge weights to simulate pavement load.
2. **Test Execution**
   - Place the plunger and apply load using jack at 1.25 mm/min.
   - Record load vs. penetration at 0.5 mm intervals up to 12.5 mm.
3. **Calculations**
   - Same as for lab test. Compare with standard loads to get field CBR value.

4. OBSERVATIONS AND CALCULATIONS

Penetration (mm)	Load (kg)	CBR (%) at each point
0.5		
1.0		
1.5		
2.0		
2.5		
3.0		
4.0		
5.0		
7.5		
10.0		
12.5		

6. CONCLUSION

The **CBR value** of the given soil is found to be:

- **Laboratory CBR at 2.5 mm =** _____ %
- **Laboratory CBR at 5.0 mm =** _____ %
- **Final CBR Value (Higher of the two) =** _____ %
- **Field CBR Value (if applicable) =** _____ %

CBR values are used in flexible pavement design to select layer thicknesses based on the strength of subgrade and base materials.

Experiment No. 10

Traffic Volume Study Using Manual and Automated Counters

1. OBJECTIVE

To conduct a traffic volume study using manual counting methods and automated traffic counters in order to determine the number, classification, and patterns of vehicles over a specified time and location for traffic engineering analysis and planning.

2. PRINCIPLE

Traffic volume studies quantify the number of vehicles passing a specified point or section of a road during a particular time interval. The study helps evaluate road usage, determine design parameters, plan signal timings, and assess the need for expansion. Manual counting involves human observers classifying and recording vehicles, while automated methods use sensors and data loggers for continuous and objective measurements.

3. APPARATUS

A. Manual Counting:

1. Tally sheets or traffic counting forms
2. Stopwatch or wristwatch
3. Hand-held tally counters
4. Clipboards, pens/pencils
5. Vehicle classification chart
6. Safety vest (for roadside data collection)

B. Automated Counting:

1. Pneumatic tube counters
2. Inductive loop detectors (embedded in pavement)
3. Infrared or radar sensors
4. Automatic Traffic Recorders (ATRs)
5. Data logger and analysis software
6. Laptop or mobile device (for download/analysis)

4. PROCEDURE

A. Manual Traffic Volume Count

1. **Selection of Site and Time Period**
   - Choose the survey location such as intersections or mid-blocks.
   - Decide on the survey period (e.g., morning/evening peak hours or 24-hour count).
2. **Vehicle Classification**
   - Classify vehicles into categories:
     - 2-wheelers
     - 3-wheelers
     - Cars
     - Buses
     - Light commercial vehicles (LCVs)
     - Heavy trucks
     - Tractors/others
3. **Data Collection**
   - Assign observers to specific lanes or directions.
   - Use tally marks or mechanical counters to count and classify vehicles at specified time intervals (typically every 15 minutes).
4. **Data Summarization**
   - Convert tally data into hourly and total volumes.
   - Plot traffic volume vs. time to identify peak periods.

B. Automated Traffic Volume Count

1. **Installation of Equipment**
   - Deploy pneumatic tubes or radar sensors across the selected roadway.
   - Ensure proper placement to capture vehicle axles or metal signatures.
2. **System Configuration**
   - Set up the counter to log data continuously or at specified intervals.
   - Program vehicle classification (if supported).
3. **Data Logging**
   - Let the system record for desired period (typically 24 hours or more).
   - Retrieve data from device using laptop or mobile interface.
4. **Data Processing**
   - Use software tools to classify and summarize vehicle volumes.
   - Generate hourly, daily, and vehicle-type-specific statistics.

5. OBSERVATIONS & DATA RECORDING

Sample Tally Sheet (Manual)

Time Interval	2-Wheelers	3-Wheelers	Cars	LCVs	Buses	Trucks	Tractors	Total
08:00–08:15	56	12	88	13	4	9	2	184
08:15–08:30	…	…	…	…	…	…	…	…
…								

6. CALCULATIONS

- **Total Volume (vehicles/hour)** = Sum of vehicles in 1 hour
- **Peak Hour Volume (PHV)** = Maximum volume observed in any hour
- **Directional Distribution (DD)** =

$$DD = \frac{\text{Volume in one direction}}{\text{Total volume}} * 100$$

- Vehicle Composition (%) =

$$\frac{\textbf{Number of specific type}}{\textbf{Total vehicles}} \times 100$$

- **PCU (Passenger Car Unit)** values may be used for standardization.

7. CONCLUSION

From the traffic volume study conducted using manual and automated methods:

- **Peak Hour Traffic Volume** = ______ vehicles/hour
- **Most Dominant Vehicle Type** = ______
- **Vehicle Composition** = ______% 2-wheelers, ______% cars, etc.
- **Average Daily Traffic (ADT)** from automated count = ______ vehicles/day

This data is essential for traffic planning, intersection design, and capacity analysis.

Experiment No. 11

Traffic Speed Study Using Endoscope Mirror

1. Objective

To measure the speed of vehicles on a selected roadway section using an endoscope mirror setup and analyze the collected data to determine traffic speed characteristics such as average speed, 85th percentile speed, and pace.

2. Apparatus and Tools Required

- Endoscope mirror (attached to smartphone or tablet)
- Measuring tape (minimum 50 meters)
- Stopwatch or timer app
- Tripod or stable stand for mirror placement
- Data recording sheet or notebook
- Calculator or spreadsheet software (e.g., Excel)

3. Principle

Speed is defined as the distance traveled by a vehicle per unit time. The basic speed equation is:

$$\text{Speed (km/h)} = (\text{Distance (m)}/\text{Time (s)}) \times 3.6$$

An **endoscope mirror** setup enables unobtrusive observation of a fixed roadway segment, allowing for accurate start and stop timing of vehicle passage over a known distance.

4. Site Selection Criteria

- Straight and level section of road (minimum 100 meters)
- Free flow of traffic without interruptions (signals, intersections)
- Adequate lighting and safety for observers
- Legal permissions if needed for roadside setup

5. Procedure

1. **Setup:**

- Select a straight road section and mark two fixed points (A and B) with a known distance apart (e.g., 30 meters).
- Fix the endoscope mirror in a discreet and stable position with clear visibility of both points A and B.
- Connect the mirror to a mobile device for live observation and recording.

2. **Measurement:**
   - As a vehicle crosses point A, start the stopwatch.
   - As the same vehicle crosses point B, stop the stopwatch.
   - Record the time taken and compute speed using the formula above.
   - Repeat the process for at least 100 vehicles to get a statistically significant sample.
3. **Data Recording:**
   - Prepare a sheet with the following format:

Vehicle No.	Time Taken (s)	Distance (m)	Speed (km/h)

6. Data Analysis

1. Calculate:
   - **Mean speed:** Average of all vehicle speeds.
   - **85th percentile speed:** Speed below which 85% of the vehicles are moving.
   - **Standard deviation:** Measures variation in vehicle speeds.
2. Plot:
   - Speed distribution histogram
   - Cumulative frequency curve to determine percentile speeds

7. Precautions

- Ensure endoscope view is stable and clearly captures the marked points.
- Calibrate the stopwatch before use.
- Avoid observer bias in start-stop timing by training personnel or using video recording.

8. Result Format

- Average speed of observed traffic = ____ km/h
- 85th percentile speed = ____ km/h
- Speed standard deviation = ____ km/h

9. Conclusion

Summarize key findings related to traffic flow characteristics. Comment on whether the observed speeds indicate safe and efficient operation or suggest need for enforcement/intervention.

Experiments beyond the Syllabus

Experiment No. 12

FLASH & FIRE POINT TEST FOR BITUMINOUS SAMPLE

1. OBJECTIVE

To determine the flash and fire point for the given bituminous sample

2. PRINCIPLE

The flash point of a material is the lowest temperature at which the application of test flame causes the vapours from the material momentarily catch fire in the form of a flash under specified conditions of test.

The fire point is the lowest temperature at which the application of test flame causes the material to ignite and burn at least for 5s under specified conditions of test.

3. APPARATUS

1) Open Cup Tester is same as standard Pensky-Marten tester with the modification that cover of the cup is replaced by a clip which encircles the upper rim of the cup and carries a test flame
2) Thermometer
3) A stove / heating device with provision to adjust the rate of heating

4. PROCEDURE

1) All the parts of the open cup tester and the accessories are cleaned and dried.
2) The cup is filled with the sample of bituminous binder up to the level of the filling mark.
3) The clip supporting the thermometer and test flame is placed in position on the cup.
4) The thermometer is inserted and the open cup tester is set on the stove.
5) The test flame is lighted and adjusted to size 4 mm bead and it is fixed in the vertical axis

of the cup, level with the upper edge of the cup.

6) The bitumen sample in the tester is heated and the rate of heating is adjusted such that the temperature of the test specimen increases at the rate of 5°C to 6°C per minute.
7) A burning match stick is placed at the binder surface from time to time and the appearance of flash, if any, is observed.
8) When the flash occurs the first time, the temperature at that instance is recorded as the flash point.

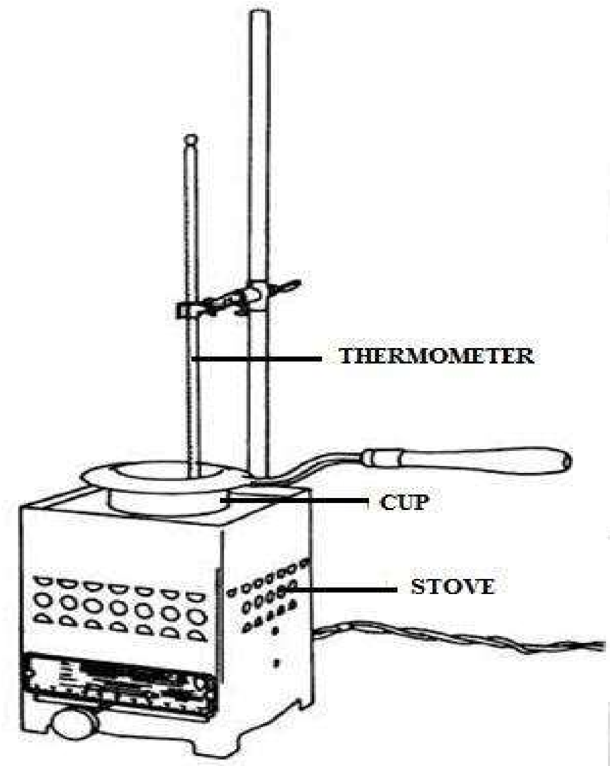


Fig.10 Fire and Flash Testing machine

5. REPORTING OF RESULTS

The temperature of the binder when flash first appears at any point on the surface of the material is noted and recorded as the flash point under open cup flash point test.

The heating is continued at the same rate until the binder itself gets ignited and continues to burn for five seconds. When it occurs, the temperature of the material is noted and is recorded as the fire point.

6. CONCLUSION

Flash point =

Fire point =

Experiment No. 13

STRIPPING VALUE OF AGGREGATE

1. OBJECTIVE

To find out the stripping value of the road aggregates

2. PRINCIPLE

The film stripping device is used to measure resistance of bituminous mixtures to stripping of the bitumen from the rock particles and is generally used to evaluate the mineral aggregate. However, it may be used to judge the adhesive capacity of the bituminous material. Stone screenings for use in seal coats or open graded mixes are usually subjected to this test. The test is applied to the aggregate fraction passing 10mm sieve and retained on 2.36mm sieve. Four specimens can be tested simultaneously.

3. APPARATUS

Film Stripping Apparatus: Four bottles are positioned in the rotating drum. The rotating drum is connected to a gear box which is coupled to a motor. The drum rotates at the rate of approximately 100rpm.

4. PROCEDURE

1) Coat 60g sample of aggregate which passes through 10mm IS Sieves and retained on 2.36mm IS Sieve with the bitumen to be tested.
2) Keep it in the bottle and cure the sample for 15hours at 60°C.
3) Allow it to cool to room temperature at 25°C.
4) Add 175ml of distilled water.
5) Similarly take the specimens in the other three bottles and screw on the caps to the

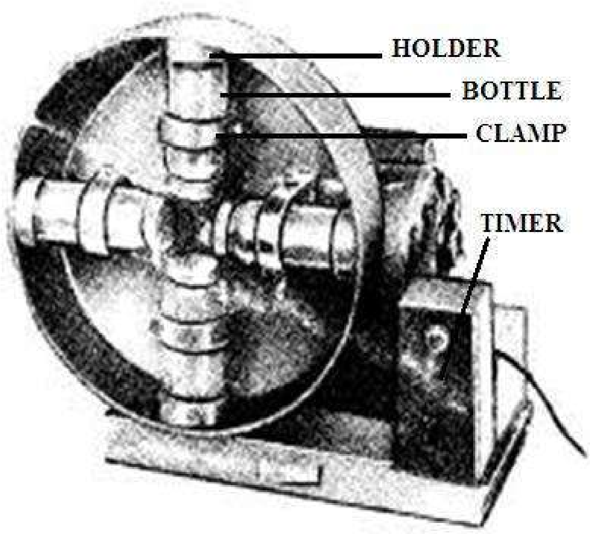
bottles having the rubber gasket in between the bottle top and the cap. Clamp the bottles to the disc.

6) Switch on the unit and agitate the mixture for 15 minutes.

7) Estimate the percentage of aggregate stripped by visual observation.

5. PRECAUTIONS

Keep the bottles and washers clean. When not in use keep the bottles mounted in the position as shown in Fig



Stripping Apparatus

6. CONCLUSION

The Stripping value of aggregate=

Experiment No. 14

DETERMINATION OF DUCTILITY OF BITUMEN

1. OBJECTIVE

1. To measure the ductility of a given sample of bitumen.

2. PRINCIPLE

The ductility test gives a measure of adhesive property of bitumen and its ability to stretch. In a flexible pavement design, it is necessary that binder should form a thin ductile film around the aggregates so that the physical interlocking of the aggregates is improved. Binder material having insufficient ductility gets cracked when subjected to repeated traffic loads and it provides pervious pavement surface. Ductility of a bituminous material is measured by the distance in centimeters to which it will elongate before braking when two ends of standard briquette specimen of the material are pulled apart at a specified speed and at a specified temperature.

3. APPARATUS

1. Briquette mould: It is made up of brass. The circular holes are provided in the clips to grip the fixed and movable ends of the testing machine. The moulds when properly assemble form a briquette specimen of the following dimensions.

Total length 75.0 ± 0.5 mm

Distance between clips 30.0 ± 0.3 mm

Width at mount of slip 20.0 ± 0.2 mm

Width at minimum cross-section (half way between clips) 10.0 ± 0.1 mm

Thickness throughout 10.0 ± 0.1 mm

2. Water bath. A bath maintained within ±0.1°C of the specified test temperature, containing not less than 10 litres of water, the specimen being submerged to a depth of not less than 10 cms and supported on a perforated shelf and less than 5 cms.from the bottom of the bath.

3. Testing machine. For pouring the briquette of bituminous material apart, any apparatus may be used which is so constructed that the specimen will be continuously submerged in water while the two clips are being pulled apart horizontally at a uniform speed of 50 ± 2.5 mm per minute.

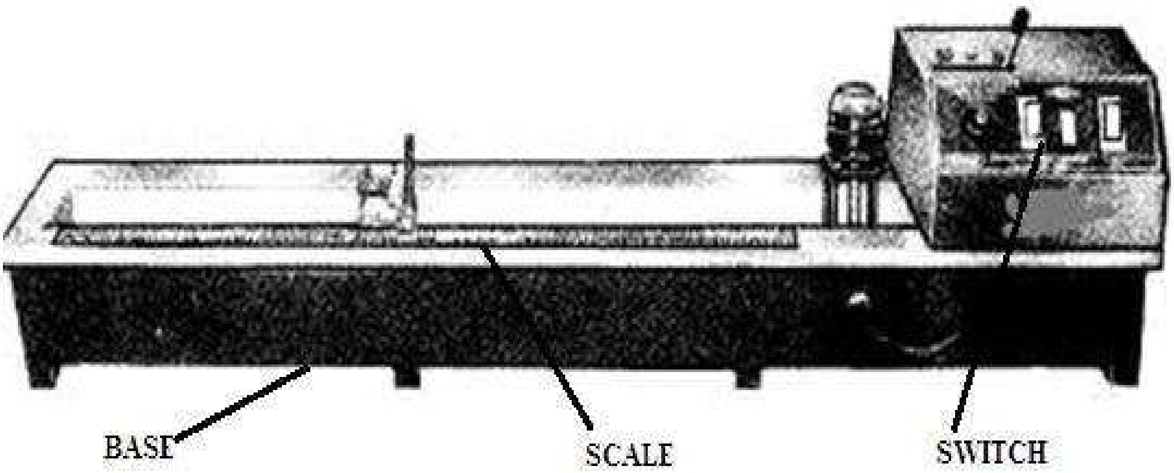


Fig 9. DUCTILITY TESTING MACHINE

4. PROCEDURE

1) Melt the bituminous test material completely at a temperature of 75^0 C to 100^0C

Above the approximate softening point until it becomes thoroughly fluid.

2) Strain the fluid. Through IS sieve 30.

3) After stirring the fluid, pour it in the mould assembly and place it on a brass plate.

4) In order to prevent the material under test from sticking, coat the surface of the plate and interior surfaces of the sides of the mould with mercury or by a mixture of equal parts of glycerine and dextrin.

5) After about 30-40 minutes, keep the plate assembly along with the sample in a water bath. Maintain the temperature of the water bath at 27 ^{O}C for half an hour.

7) Remove the sample and mould assembly from the water bath and trim the specimen by levelling the surface using a hot knife. Replace the mould assembly in water bath maintained at 27^{O} C for 80 to 90 minutes.

8) Remove the sides of the mould.

9) Hook the clips carefully on the machine without causing any initial stain.

10) Adjust the pointer to read zero.

11) Start the machine and pull two clips horizontally at a speed of 50 mm per minute.

12) Note the distance at which the bitumen thread of specimen breaks.

13) Record the observations in the Performa and compute the ductility value. Report the mean of two observation, rounded to nearest whole number as the 'Ductility Value'

Note: machine may have a provision to fix two or more moulds so as to test these specimens simultaneously.

5. PRECAUTIONS

1 The plate assembly upon which the mould is placed shall be perfectly flat and level so that the bottom surface of the mould touches it throughout.

2 In filling the mould, care should be taken not to disarrange the parts and thus distort the briquette and to see that no air pocket shall be within the molded sample.

6. CONCLUSION

The ductility value of given sample is =

Record of Observations

Bitumen grade =

Reading	Briquette No			Mean
	1	2	3	
Initial				
Final				
Ductility in cm				