METHODIST

Estd:2008 COLLEGE OF ENGINEERING AND TECHNOLOGY

(Affiliated to Osmania University& approved by AICTE, New Delhi)

LABORATORY MANUAL

TRANSPORTATION ENGINEERING LABORATORY

BE VI Semester (AMC): 2022-2023

NAME: ____________________

ROLL NO:____________________

BRANCH:__________ **SEM:**__________

DEPARTMENT OF CIVIL ENGINEERING

Empower youth- Architects of Future World

VISION

To produce ethical, socially conscious and innovative professionals who would contribute to sustainable technological development of the society.

MISSION

To impart quality engineering education with latest technological developments and interdisciplinary skills to make students succeed in professional practice.

To encourage research culture among faculty and students by establishing state of art laboratories and exposing them to modern industrial and organizational practices.

To inculcate humane qualities like environmental consciousness, leadership, social values, professional ethics and engage in independent and lifelong learning for sustainable contribution to the society.

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COLLEGE OF ENGINEERING AND TECHNOLOGY

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DEPARTMENTOFCIVIL ENGINEERING

LABORATORY MANUAL

TRANSPORTATION ENGINEERING LAB

Prepared
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&

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DEPARTMENT OF CIVIL ENGINEERING

VISION

To evolve into a centre of excellence for imparting holistic civil engineering education contributing towards sustainable development of the society.

MISSION

- To impart quality civil engineering education blended with contemporary and interdisciplinary skills.
- To provide enhanced learning facilities and professional collaborations to impart a culture of continuous learning.
- To involve in trainings and activities on communication skills, teamwork, professional ethics, environmental protection and sustainable development.

DEPARTMENT OF CIVIL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES

The Graduates of the programme shall be able to:

PEO 1: Engage in planning, analysis, design, construction, operation and maintenance of built environment.

PEO 2: Apply the knowledge of civil engineering to pursue research or to engage in professional practice.

PEO 3: Work effectively as individuals and as team members in multidisciplinary projects with organizational and communication skills.

PEO 4: Demonstrate the spirit of lifelong learning and career enhancement aligned to professional and societal needs.

METHODIST

Estd:2008

COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

PROGRAM OUTCOMES

Engineering Graduates will be able to:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and civil engineering specialization to the solution of complex civil engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex civil engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex civil 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.

PO4. 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.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex civil engineering activities with an understanding of the limitations.

PO6. 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 civil engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional civil engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the civil engineering practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. 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.

PO12. 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 OUTCOMES

Civil Engineering Graduates will be able to:

PSO 1. Investigate properties of traditional and latest construction materials using standard testing methods.

PSO 2. Use AutoCAD, STAAD Pro, ETABS, Revit Architecture and ANSYS software for computer aided structural analysis and design.

PSO 3. Describe the principles of sustainable development and green buildings for environmental preservation.

Laboratory Code of Conduct

1. Students should report to the concerned labs as per the time table schedule.
2. Studentswhoturnuplatetothelabswillinnocasebepermittedtoperformtheexperiment scheduled for the day.
3. Students should bring a note book of about 100 pages and should enter the readings/observations into the note book while performing the experiment.
4. After completion of the experiment, certification of the concerned staff in-charge in the observation book is necessary.
5. Staff member in-charge shall award 25 marks for each experiment based on continuous evaluation and will be entered in the continuous internal evaluation sheet.
6. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate last session should be submitted and certified by the staff member in-charge.
7. Not more than three students in a group are permitted to perform the experiment on a set-up for equipment-based labs. Only one student is permitted per computer system for computer-based labs.
8. The group-wise division made in the beginning should be adhered to, and no student is allowed to mix up with different groups later.
9. The components required pertaining to the experiment should be collected from the stores in-charge, only after duly filling in the requisition form/log register.
10. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.
11. Any damage of the equipment or burn-out of components will be viewed seriously by either charging penalty or dismissing the total group of students from the lab for the semester/year.
12. Students should be present in the labs for the total scheduled duration.
13. Students are required to prepare thoroughly to perform the experiment before coming to Laboratory.
14. Procedure sheets/data sheets provided to the students, if any, should be maintained neatly and returned after the completion of the experiment.

TRANSPORTATION ENGINEERING LABORATORY

DO'S

- Be familiar with your lab assignment before you come to lab.
- Follow all written and verbal instructions carefully.
- If you do not understand a direction or part of a procedure, ask the teacher before proceeding.
- Learn objective& significance of the practical.
- Maintain silence in the lab.
- Always perform the experiment or work precisely as directed by teacher/instructor
- Before performing experiment read instrument manual carefully.
- Leave the lab cleaner than you found it.

DON'Ts

- Enter laboratory without appropriate laboratory uniform and shoes
- Absolutely no running, practical jokes or horseplay is allowed in the laboratories.
- The use of personal audio or video equipment is prohibited in the laboratory.
- The performance of unauthorized experiments is strictly forbidden
- In the absence of instructor no student shall be allowed to work in the laboratory.
- Make sure that all equipment is clean and returned to its original place.
- Report all accidents to your teacher.
- Don't use mobile phones during lab hours.

B.E. VI Semester 2020-21

TRANSPORTATION ENGINEERING LAB (PC353CE)

EXP.NO.	Name of the Experiment	CO'S MAPPED	PO'S PSO'S
1	Tests on Bitumen	CO1	PO1,PO6, PO7,PO9
2	Tests on Road Aggregate	CO5	PO1,PO6, PO7,PO9
3	Experiments on Traffic	CO2,CO3&CO4	PO1,PO6, PO7,PO9
4	Miscellaneous Tests	CO6	PO1,PO6, PO7,PO9

<table>
<tr><td>Course Code</td><td colspan="6">Course Title</td><td>Core / Elective</td></tr>
<tr><td>PC – 353 CE</td><td colspan="6">TRANSPORTATION ENGINEERING LAB</td><td>Core</td></tr>
<tr><td rowspan="2">Prerequisite</td><td colspan="4">Contact Hours per Week</td><td rowspan="2">CIE</td><td rowspan="2">SEE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>D</td><td>P</td></tr>
<tr><td>Transportation Engineering (Co-Requisite)</td><td>0</td><td>0</td><td>0</td><td>2</td><td>25</td><td>50</td><td>1</td></tr>
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Course Objectives
- Know the properties of various road materials
- Create the awareness about various traffic studies in the field
- Impart knowledge on mix design of bitumen and CBR test etc.,

Course Outcomes
- Characterize the pavement materials.
- Perform quality control tests on pavement material and pavements.
- Conduct traffic studies for estimation of traffic flow characteristics.

A) Tests on Bitumen
1. Penetration Test.
2. Ductility Test
3. Softening point test
4. Specific gravity test
5. Viscosity test
6. Flash and fire point test

B) Tests on Road Aggregate

7. Aggregate crushing value test
8. Los Angeles abrasion test
9. Aggregate impact value test
10. Aggregate shape test (flakiness &elongation)
11. Specific gravity
12. Water Absorption
13. Soundness

C) Experiments on Traffic

14. Traffic Volume study (a) at mid-section (b) at intersection
15. Spot speed study
16. Speed and delay study
17. Origin and Destination Study

D) Miscellaneous Tests (Demonstration Only)

18. Marshal stability test
19. Determination of C.B.R.
20. Benkelman beam test
21. Bitumen extraction test
22. Exposure to Latest Software in the field of Transportation Engineering

<u>PENETRATION TEST</u>

(IS: 1203-1978)

Aim of the Experiment:

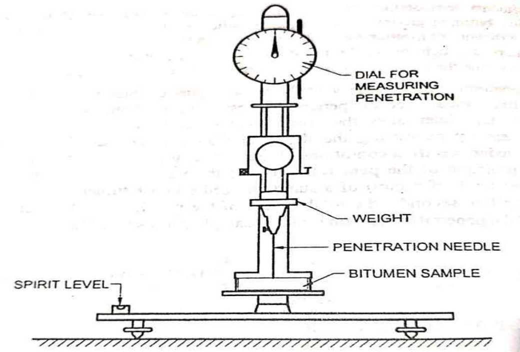
To determine the Penetration Value of the given sample (bitumen/tar)

Theory:

The consistency of bituminous materials varies based on many factors such as temperature, constituents, etc., Most of the paving bitumen grades remain in semi-solid or in plastic states at temperature ranges between 25 and 50 degree Centigrade. And they don't flow as liquid as there viscosity is very high. But the viscosity of most of the tars and cutbacks are sufficiently low at this temperature range to permit them to be in a liquid state. Finding the absolute viscosity of bituminous materials is not easy. Therefore the consistency of these materials is found out by indirect methods. The consistency of bitumen is determined by penetration test. Whereas the viscosity of tars and cutback bitumen are found out indirectly using an orifice viscometer. Various types and grades of bituminous materials are available depending on their origin and refining process. The penetration test determines the consistency of these materials for the purpose of grading them, by measuring the depth (in units of one tenth of a millimeter or hundredth of a centimeter) to which a standard needle will penetrate vertically under specified conditions of standard load, duration and temperature. Thus the basic principle of the penetration test is the measurement of the penetration (in units of one tenth of mm) of a standard needle in a bitumen sample maintained at 25 degree centigrade during 5 seconds, the total weight of the needle assembly being 100g. The softer the bitumen the greater will be the penetration. The penetration test is widely used world over for classifying the bitumen into different grades.

Specification of Equipment:

It consists of items like container, needle, water bath, penetrometer, stop watch etc., Following are the standard specifications as per ISI for the above apparatus.



Procedure:

The bitumen is softened to a pouring consistency between 75°and 100°Xabove the approximate temperature at which bitumen softens. The sample material is thoroughly stirred to make it homogenous and free from air bubbles and water. The sample material is then poured into the containers to a depth at least 15 mm more than the expected penetration. The sample containers are cooled in atmosphere of temperature not lower than 13°Xfor one hour. Then they are placed in temperature controlled water bath at a temperature of 25°Xfor a period of onehour.

The sample container is placed in the transfer tray with water from the water bath and placed under the needle of the penetrometer. The weight of needle, shaft and additional weight are checked. The total weight of this assembly should be 100

g. Using the adjusting screw, the needle assembly is lowered and the tip of the needle is made to just touch the top surface ofthe sample; the needle assembly is clamped in this position. The contact of the tip of the needle is checked using the mirror placed on the rear of the needle. The initial reading of the penetrometer dial is either adjusted to zero or the initial reading is taken before releasing the needle. The needle is released exactly for a period of 5.0 secs. By pressing the knob and the final reading is taken on the dial. At least three measurements are made on this sample by testing at a distance of not less than 10 mm apart. After each test the needle is disengaged and cleaned with benzene and carefully dried. The sample container is also transferred in the water bath before next testing is done so as to maintain a constant temperature of 25°C. The test is repeated with sample in the other containers.

Results:

The difference between the initial and final penetration readings is taken as the penetration value. The mean value of three consistent penetration measurements is reported as the penetration value. It is further specified by ISI that results of each measurement should not vary from the mean value reported above by more than the following

Penetration grade	Repeatability
0-80	4percent
80-225	5percent
Above2257percent	

Discussion:

It may be noted that the penetration value is influenced by any inaccuracy as regards:

(i) Pouring temperature

(ii) Size ofneedle

(iii) Weight placed on theneedle

(iv) Testtemperature

(v) Duration of releasing the penetrationneedle

It is obvious to obtain high values of penetration if the test temperature and / or weight (placed over the needle) are / is increased. Higher pouring temperatures than that specified may result in hardening of bitumen and may give lower penetration values. Higher test temperatures give considerably higher penetration values. The duration of releasing the penetration needle should be exactly 5.0 secs. It is also necessary to keep the needle clean before testing in order to get consistent results. The penetration needle should not be placed closer than 10 mm from the side of the dish.

Applications:

Penetration test is the most commonly adopted test on bitumen to grade the material in terms of the hardness. Depending upon the climatic condition and type of construction, bitumen's of different penetration grades are used. 80 / 100 bitumen denotes that the penetration value ranges between 80 and 100. The penetration values of various types of bitumen used in pavement construction in this country range between 20 and 225. For bituminous macadam and penetration macadam, Indian Roads Congress suggests bitumen grades 30/40, 60/70 and 80/100. In warmer regions lower penetration grades are preferred and in colder regions bitumen with higher penetration values areused.

The penetration test is not intended to estimate the consistency of softer materials like cutback or tar, which are usually graded by a viscosity test in an orifice viscometer.

The Indian Standards Institution has classified paving bitumen available in this country into the following six categories depending on the penetration values. Grades designated 'A' (such as A 35) are from Assam petroleum and those designated 'S' (such as S 35) are from other sources.

Bitumengrade	A25	A35 & S 35	A45 & S45	A65 & S65	A90 & S90	A200&S200
Penetration value	20 to 30	30to40	40to 50	60to 70	80 to100	175 to 225

DataSheet

PENETRATION TEST

(i) PouringTemperature,°C =

(ii) Period of cooling inatmosphere,minutes =

(iii) Roomtemperature,°C =

(iv) Period of cooling in waterbath,minutes =

(v) Actual testtemperature,°C =

SampleNo.					Sample No.			
Readings	Test 1	Test 2	Test 3	Mean value	Test 1	Test 2	Test 3	Mean value
Penetrometer dials reading								
(i) Initial								
(ii) Final								
Penetration Value								
Repeatability, percent								

Mean penetration value =

Result:

Inference:

Short Answer Questions:

1. How is penetration value of bitumen expressed?
2. What are the standard load, time and temperature specified for penetration test.
3. Briefly outline the penetration test procedure.
4. What do you understand by 80 / 100bitumen?
5. What are the effects of:
   (i) higher test temperature
   (ii) higher pouring
   (iii) Exposed bitumen, on penetration test results

DUCTILITY TEST
(IS: 1208-1978)

Aim of the Experiment:

To determine the Ductility Value of the given sample (bitumen/tar)

Theory:

In the flexible pavement construction where bitumen binders are used, it is of significant importance that the binders form ductile thin films around the aggregates. The binder material which does not possess sufficient ductility would crack and thus provide pervious pavement surface. The ductility is expressed as the distance in centimetres to which a standard briquette of bitumen can be stretched before the thread breaks. The test is conducted at 27 ± 0.5^{o} C. and a rate of pull of 50 ± 2.5 mm per minute.

Specification of Equipment's:

The ductility test apparatus consists of sample (briquette) moulds, water bath, and square-end trowel or putty knife sharpened on end and ductility machine. As per ISI following are the standard specifications of the above items:

a) Briquette mould: Mould is made of brass metal with shape and dimensions as indicated in the figure. Both ends called clips possess circular holes to grip the fixed and movable ends of the testing machine. Side pieces when placed together form the briquette of the following dimensions.

Length -	75mm
Distance between clips -	30mm
Width at mouth of clip -	20mm
Cross section at minimum width -	10mmx10mm

b) Ductility Machine: It is a equipment which functions at constant temperature water bath and a pulling device at a pre-calibrated rate. The central rod of the machine is threaded and through a gear system provides movement to one end where the clip is fixed during initial placement. The other clip end is hooked at the fixed end of the machine. Two clips are thus pulled apart horizontally at a uniform speed of 50 ± 2.5 mm per minute. The machine may have provision to fix two or more moulds so as to test these specimens simultaneously.

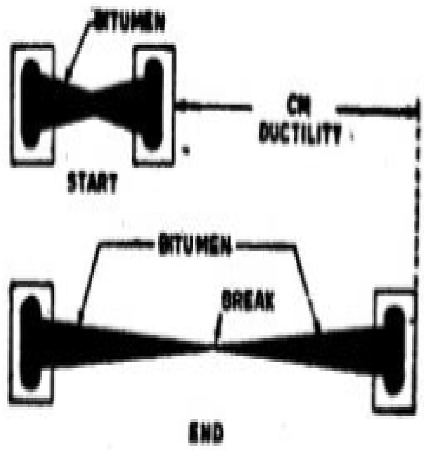


Figure 18.1 Ductility Test Concept

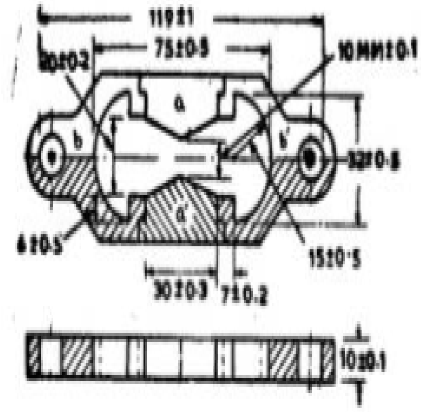


Figure 18.2 Briquette Mould

Initial Position of Bitumen

Final position of Bitumen

Procedure:

The bitumen sample is melted to a temperature of 75 to 100°C above the approximate softening point until it is fluid. It is strained through IS sieve 30 poured in the mould assembly and placed on a brass plate, after a solution of glycerin and dextrin is applied at all surfaces of the mould exposed to bitumen. Thirty to forty minutes after the sample is poured into the moulds, the plate assembly along with the sample is placed in water bath maintained at 27°C for 30 minutes. The sample and mould assembly are removed from water bath and excess bitumen material is cut off by levelling the surface using hot knife. After trimming the specimen, the mould assembly containing sample is replaced in water bath maintained at 27°C for 85 to 95 minutes. The sides of the mould are now removed and the clips are carefully hooked on the matching without causing any initial strain. Two or more specimens may be prepared in the moulds and clipped to the machine so as to conduct these tests simultaneously.

The pointer is set to read zero. The machine is started and the two clips are thus pulled apart horizontally. While the test is in operation, it is checked whether the sample is immersed in water at depth of at least 10 mm. The distance at which the bitumen thread of each specimen breaks, is recorded (in cm) to report as ductility value.

Results:

The distance stretched by the moving end of the specimen up to the point of breaking of thread measured in centimeters is recorded as ductility value. It is recommended by ISI that test results should not differ from mean value by more than the following:

Repeatability : 5%

Reproducibility : 10 %

Discussion:

The ductility value gets seriously affected if any of the following factors are varied:

i Pouring temperature

ii Dimensions of briquette

iii Improper level of briquette placement

iv Test temperature

v Rate of pulling

Increase in minimum cross section of 10 sq. mm and increase in test temperature would record increased ductility value.

Applications:

A certain minimum ductility is necessary for a bitumen binder. This is because of the temperature changes in the bituminous mixes and the repeated deformations that occur in flexible pavements due to the traffic loads. If the bitumen has low ductility value, the bituminous pavement may crack, especially in cold weather. The ductility values of bitumen vary from 5 to over 100. Several agencies have specified the minimum ductility values for various types of bituminous pavement. Often a minimum ductility value of 50 cm is specified for bituminous construction.

The minimum ductility values specified by the Indian Standards Institution for various grades of bitumen available in India are given below.

Source of paving bitumen And penetration grade value, cm	Minimum ductility
Assam petroleum A 25	5
A 35	10
A 45	12
A 65, A 90 & A 200	15
Bitumen from sources other Than Assam Petroleum S 35	50
S 45, S 65 & S 90	75

Observations & Calculations:

Ductility test

(i) Grade of bitumen: =

(ii) Pouring temperature, °C =

(iii) Test temperature, °C =

(i) Periods of cooling, minutes

(a) in air =

(b) in water bath before trimming =

In water bath after trimming

	Briquette Number			
Test property	(I)	(ii)	(iii)	Mean value
1. Ductility value (cm)				
2. Repeatability%				
3. Reproducibility %				

Result:

Inference:

Short Answer Questions:

1. Explain ductility of Bitumen and its significance.
2. How is ductility value expressed?
3. Outline the ductility test procedure.
4. What is the minimum area of cross section of the ductility specimen?
5. What are the precautions to be taken while finding the ductility value?
6. What are the factors affecting the ductility test results?

SOFTENING POINT TEST
(IS : 1205 – 1978)

Aim of the Experiment:

To determine the softening point of the given sample (bitumen/tar)

Theory:

Bitumen does not suddenly change from solid to liquid state, but as the temperature increases it gradually becomes softer until it flows readily. All semi-solid state bitumen grades need sufficient fluidity before they are used in pavement construction. The softening point is the temperature at which the substance attains particular degree of softening under specified condition of test for bitumen; it is generally determined by Ring and Ball test. A brass ring containing the test sample of bitumen is suspended in liquid like water or glycerin at a given temperature. A steel ball is placed upon the bitumen and liquid medium is then heated at a specified rate. The temperature at which the softened bitumen touches the metal plate placed at specified distance below the ring is recorded as the softening point of particular bitumen. Harder grade bitumen possesses higher softening point than softer grade bitumen.

Specification of Equipment's:

It consists of Ring and Ball apparatus.

(1) Steel Balls: They are two in number. Each has a diameter of 9.5mm and weighs 2.5 ± 0.05g.

(2) Brass Rings: There are two rings of the following dimensions,

Depth 6.4mm; inside diameter at top 17.5mm
Inside diameter at bottom 15.9mm

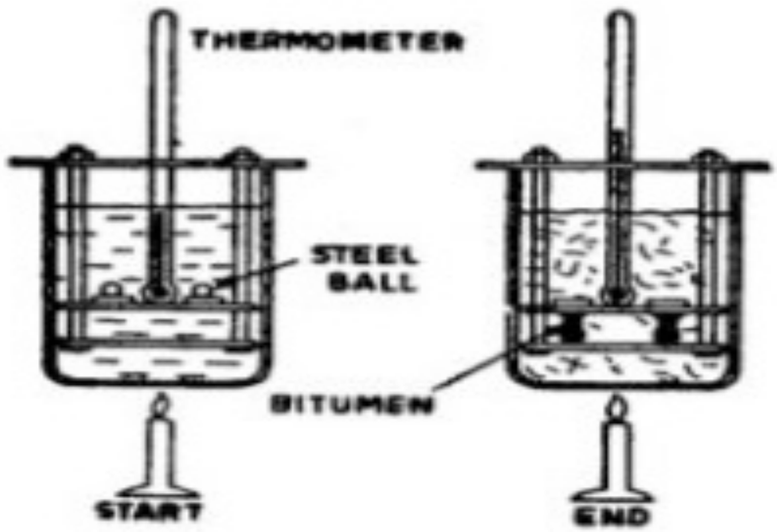
Outside diameter 20.6mm

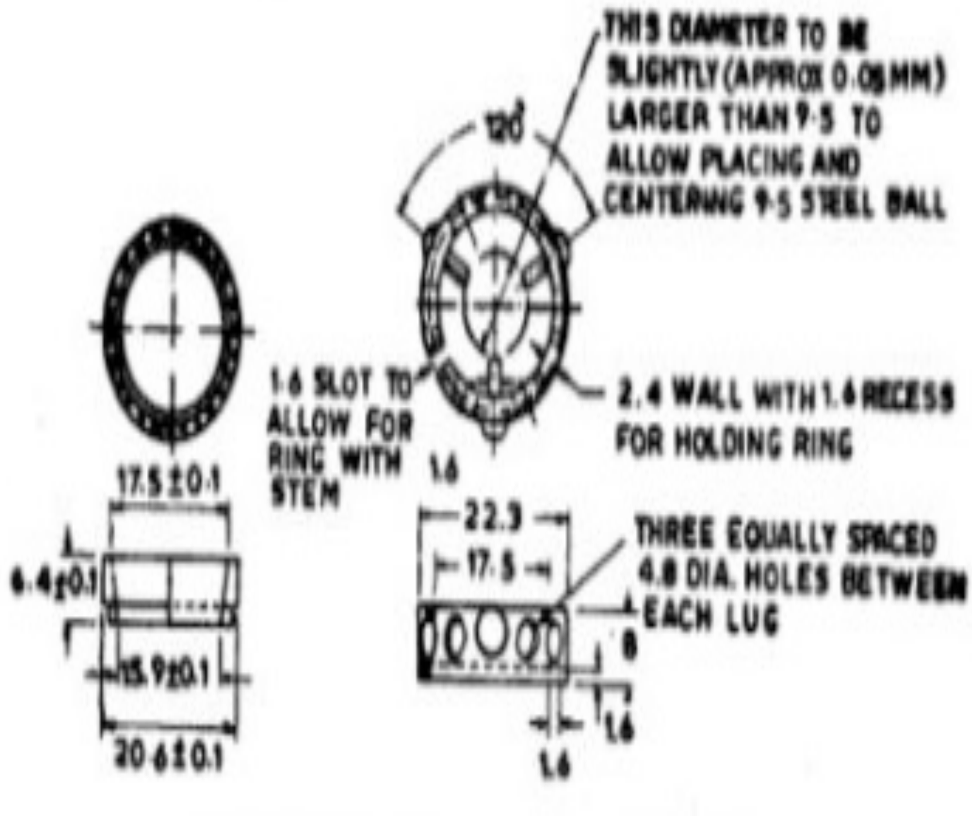
Brass rings are also placed with ball guides as shown in the figure.

(3) Support: The metallic support is used for placing pair of rings.

The upper surface of the rings is adjusted to be 50mm below the surface of water or liquid contained in the bath. A distance of 25mm between the bottom of the rings and top surface of the bottom plate of support is provided. It has housing for a suitable thermometer.

(4) Bath and stirrer: A heat glass container of 85 mm diameter and 120 mm depth is used. Bath liquid is water for material having softening point below 80°C and glycerin for materials having softening point above 80°C. Mechanical stirrer is used for ensuring uniform heat distribution at all times throughout the bath.


THERMOMETER
STEEL BALL
BITUMEN
START
END


THIS DIAMETER TO BE SLIGHTLY (APPROX 0.05 MM) LARGER THAN 9.5 TO ALLOW PLACING AND CENTERING 9.5 STEEL BALL
120°
1.6 SLOT TO ALLOW FOR RING WITH STEM
2.4 WALL WITH 1.6 RECESS FOR HOLDING RING
17.5±0.1
6.4±0.1
15.9±0.1
20.6±0.1
1.6
22.3
17.5
THREE EQUALLY SPACED 4.8 DIA. HOLES BETWEEN EACH LUG
8
1.6
1.6

Procedure:

Sample material is heated to a temperature between 75 and 100°C above the approximate softening point until it is completely fluid and is poured in heated rings placed on metal plate. To avoid sticking of the bitumen to metal plate, coating is done to this with a solution of glycerin and dextrin. After cooling the rings in air for 30 minutes, the excess bitumen is trimmed and rings are placed in the support as discussed in item (3) above. At this time the temperature of distilled water is kept at 5°C. This temperature is maintained for 15min after which the balls are placed in position. The temperature of water is raised at uniform rate of 5°Cper minute with a controlled heating unit, until the bitumen softens and touches the bottom plate by sinking of balls. At least two observations are made. For material whose softening point is above 80°C, glycerine is used as a heating medium and the starting temperature is 35°C instead of 5°C.

Results:

The temperature at the instant when each of the ball and sample touches the bottom plate of support is recorded as softening value. The mean of duplicate determinations is noted. It is essential that the mean value of the softening point (temperature) does not differ from individual observations by more than the following limits.

Softening point	Repeatability	Reproducibility
Below 305°C	2°C	4°C
30°Cto 80°C	1°C	2°C
Above 80°C	2°C	4°C

Discussion:

As in the other physical tests on bitumen, it is essential that the specifications are strictly observed. Particularly any variation in the following points would affect the result considerably:

i quality and type of liquid

ii weight of balls

iii distance between bottom of ring and bottom base plate

iv Rate of heating.

Applications:

Softening point is essentially the temperature at which the bituminous binders have an equal viscosity. The softening point of a tar is therefore related to the equi-viscous temperature (e.v.t.). The softening point found by the ring and ball apparatus is approximately 20°C lower than the e.v.t

Softening point, thus gives an idea of the temperature at which the bituminous material attains a certain viscosity. Bitumen with higher softening point may be preferred in warmer places. Softening point is also sometimes used to specify hard bitumen's and pitches.

Bitumen grades	Softening Point, ºC
*A 25 & A 35	55 to 70
*S 35	50 to 65
A 45, S 45 & A 65	45 to 60
S 65	40 to 55
A 90 & S 90	35 to 50
A 200 & S 200	30 to 45

Observations &Calculations:

(i) Bitumen grade =

(ii) Approximate softening = °C

(iii) Liquid used in the bath = water / glycerine

(iv) Period of air cooling, minutes =

(v) Period of cooling in water bath, minutes =

Sample no.1 Sample no.2

Test Property Ball no. Ball no. Mean value Ball no. Ball no. Mean value

(i) (ii) (i) (ii) (i) (ii) (i) (ii)

Temperature (°C) at which

Sample touches bottom

Plate

Repeatability

Reproducibility

Result:

Inference:

Short Answer Questions:

1. What is softening point?

2. What are the applications of this test?

3. When glycerin should be used as medium?

4. What are the factors which affect the ring and ball test results.

SPECIFIC GRAVITY TEST FOR BITUMEN
(IS: 2386 – (Part IV))

Aim of the Experiment:

To determine the specific gravity of the given sample (Bitumen/Tar)

Theory:

The density of a bitumen binder is a fundamental property frequently used as an aid in classifying the binders for use in paving jobs. In most applications, the bitumen is weighed, but finally in use with aggregate system, the bitumen content is converted on volume basis. Thus an accurate density value is required for conversion of weight to volume. The specific gravity is greatly influenced by the chemical composition of binder. Increased amount of aromatic-type compounds can cause an increase in the specific gravity. The test procedure has been standardized by the ISI.

The specific gravity is defined by ISI as the ratio of the mass of a given volume of the bituminous material to the mass of an equal volume of water, the temperature of both being specified as 27°C ± 0.1°C.

Specification of Equipment's:

There are two methods (I) Pycnometer method (ii) Balance method. For Pycnometer method, the apparatus are specific gravity bottle of 50 ml capacity, ordinary capillary type with 6 mm diameter neck or wide mouthed capillary type bottle with 25 mm diameter neck can be used. For balance method, an analytical balance equipped with a pan straddle is used.

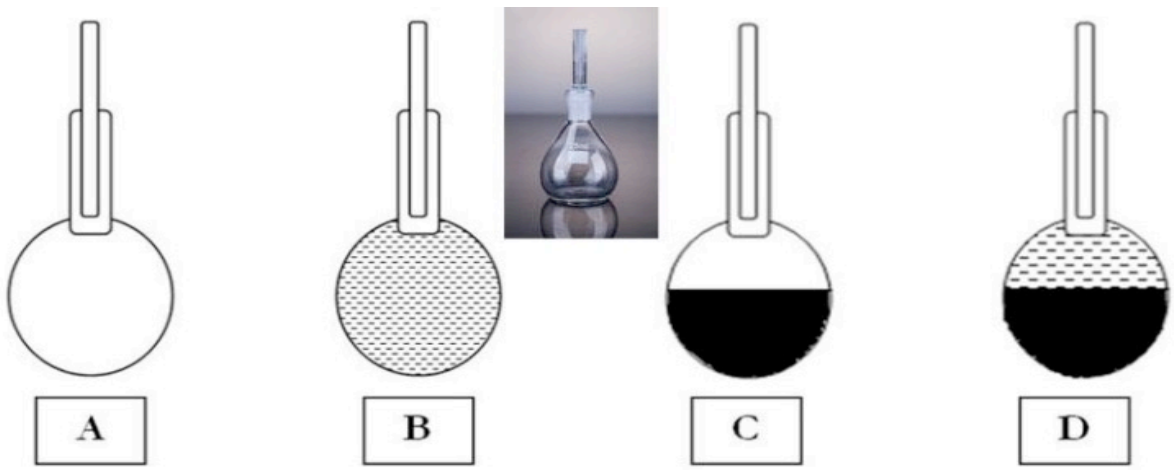
Procedure:

Method I (Pycnometer method)

The specific gravity bottle is cleaned, dried and weighed along with the stopper. It is filled with fresh distilled water, stopper placed and the same is kept in water container for at least half an hour at temperature 27°C ± 0.1°C. The bottle is then removed and cleaned from outside. The specific gravity bottle containing distilled water is now weighed.

The bituminous material is heated to a pouring temperature and is poured in the above empty bottle taking all the precautions that it is clean and dry before filling sample materials. The material is filled up to the half taking care to prevent entry of air bubbles. To permit an escape of air bubbles, the sample bottle is allowed to stand for half an hour at suitable temperature cooled to 27°C and then weighed. The remaining space in the specific gravity bottle is filled with distilled water at 27°C; stopper placed and is placed in water container at

27°C. The bottle containing bituminous material and remaining water is removed, cleaned from outside and is again weighed.



Method 2 (Balance method)

In balance method the bitumen test specimen is cube shaped, about 12 mm on each edge. It is prepared by pouring the liquefied bitumen sample in brass mould to provide the sample of required dimension and is cooled. The sample is weighed in air and is then weighed in distilled water maintained at 27°C +/- 0.1°C to the nearest 0.1 mg.

Calculation

The specific gravity of the bituminous material is calculated as follows:

(i) Pycnometer method

Specific gravity = weight of bituminous material / weight of equal volume of water at 27°C

= (c-a) / ((b-a) - (d-c))

a = Weight of the specific gravity bottle

b = weight of the specific gravity bottle filled with distilled water.

c = weight of the specific gravity bottle about half filled with Bituminous material.

d = weight of the specific gravity bottle about half filled with the Material and the rest with distilled water.

(ii) Balance Method

Specific Gravity = e / (e-f)

Where

e = weight of the dry specimen

f = weight of the specimen when immersed in distilled water.

Discussion

It is necessary that all precautions are taken in making the specific gravity bottles thoroughly cleaned and dried in the first weighing. The surface of the specific gravity bottle should be cleaned dry after filling with water, before weighing. The test temperature should be firmly adhered to. Inaccurate balance would never give reproducible results. At least three measurements should be made for determining value of the specific gravity.

The specific gravity of all types of bituminous materials could be determined by the Pycnometer method. However, only the bitumen which is in semi-solid state at 27°C can be tested by the balance method. If the bituminous material is in liquid form at 27°C, specific gravity may be found by the Pycnometer method by completely filling the specific gravity bottle with the liquid material.

7. Applications

Knowledge of the correct specific gravity of bituminous materials has mainly two applications. First to convert the specified bitumen content by weight to volume basis when the binder is measured by volume. Here it is necessary to know the coefficient of expansion or the specific gravity values at different temperatures.

Second, the specific gravity is useful to identify, the source of a bituminous binder. Pure bitumen has a specific gravity in the range 0.97 to 1.02. (Higher penetration grade bitumen and cut back bitumen have lower range of specific gravity values). In case the bitumen contains mineral impurity, the specific gravity will be higher. Thus it is possible for a qualitative estimation of mineral impurity in bitumen. The specific gravity of tars depends on the type of carbonization process used for their production. Vertical - retort tars have a specific gravity range 1.10 to 1.15 whereas horizontal - report and production. Vertical-retort tars have a specific gravity range 1.10 to 1.15 whereas horizontal - retort and coke-oven tars have values in the range 1.18 to 1.25.

The Indian Standards Institution specifies that the minimum specific gravity values of paving bitumen at 27°C shall be 0.99 for grades A 25, A 35, A 45, A 65, S 35, S 45, 0.98 for A 90 and S 90 and 0.97 for A 200 and S 200.

Observations & Calculations:

(i) Bitumen grade =

(ii)Test temperature =

A. Pycnometer Method

Sample No.	Weight of bottle, g	Weight of bottle + distilled water, g	Weight of bottle + half filled material, g	Weight of bottle + half filled material, g	Specific gravity
	A	B	C	D	
1					
2					
3					

Result :

Inference:

Sample No.	**Weight of dry sample**	**Weight of sample In distilled water, g**	**Specific gravity**
	E	F	
1			
2			
3			

Average value =

Specific gravity at the testing temperature =

Short Answer Questions:

1. Explain the two methods of finding specific gravity of bituminous materials.

2. What precautions should be taken while finding the specific gravity?

3. What are the applications of specific gravity test results?

VISCOSITY TEST

(IS: 1206 – 1978)

Aim of the Experiment:

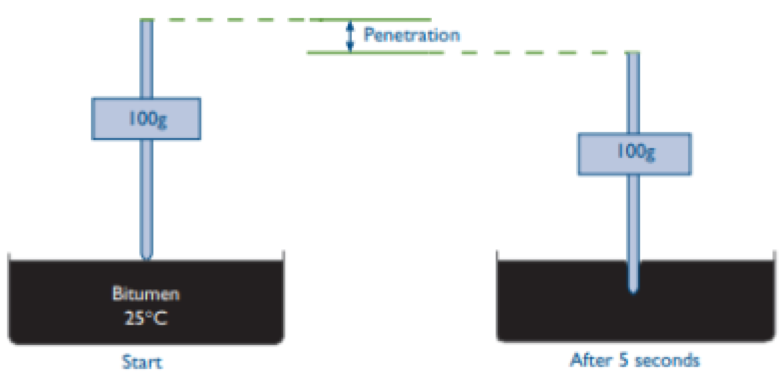
To determine the viscosity of the given sample (Tar/Bitumen)

Theory:

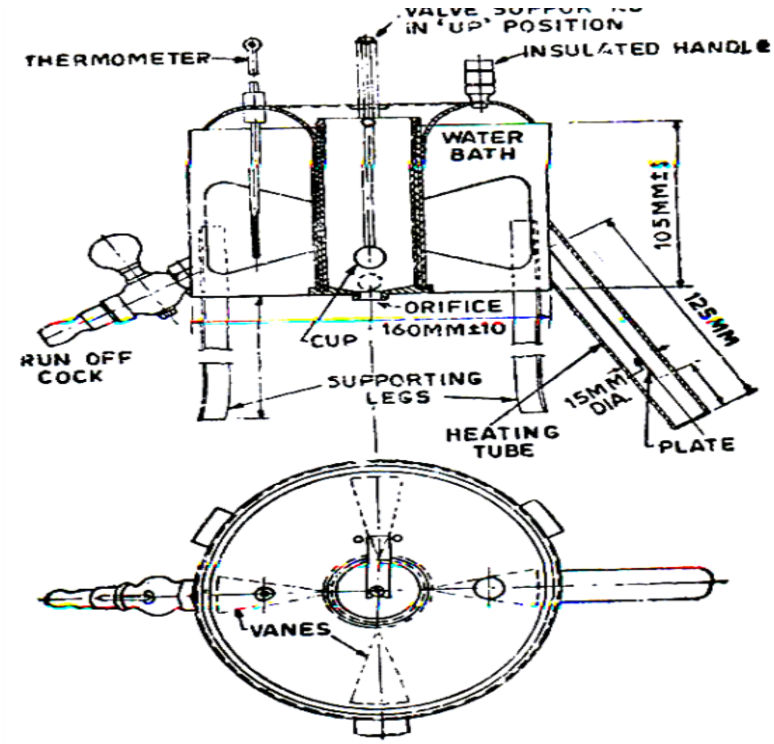
Viscosity is defined as inverse of fluidity. The degree of fluidity at the application temperature greatly influences the ability of bituminous material to spread, penetrate into the voids and also coat the aggregates and hence affects the strength characteristics of the paving mixes. There is an optimum value of fluidity or viscosity for mixing and compacting for each aggregate gradation for the mix and bitumen grade. At low viscosity, the bituminous binder simply lubricates aggregate particles instead of providing a uniform film thickness for binding action. Similarly, high viscosity doesn't enable the bitumen to coat the entire surface of aggregates in the mix easily and also resists the compaction process and the resulting mix is heterogeneous in character exhibiting low stability values. In this method the viscosity is determined by the time taken by 50cc of the material to flow from a cup through specified orifice at a given temperature**.**

Specification of Equipment's:

Ten millimetre orifice viscometer is specified for testing road tar and is called tar viscometer. 4.0 mm orifice is used to test cutback grades and 10 mm orifice to test all other grades. The apparatus consists of main parts like cup, valve, water bath, sleeves, stirrer, receiver and thermometers, etc. Figure shows the details of this apparatus.



Viscosity concept



Tar Viscometer

Tar Viscometer apparatus

Procedure:

The tar cup is properly leveled and water in the bath is heated to the temperature specified for the test and is maintained throughout the test. Stirring is also continued. The sample material is heated at the temperature 20°C above the specified test temperature, and the material is allowed to cool. During this the material is continuously, stirred. When material reaches slightly above test temperature, the same is poured in the tar cup, until the leveling peg on the valve rod is just immersed. In the graduated receiver (cylinder), 20 ml of mineral oil or one percent by weight solution of soft soap is poured. The receiver is placed under the orifice. When the sample material reaches the specified testing temperature within +/- 0.1°C and is maintained for 5 minutes, the valve is opened. The stop watch is started, when cylinder records 25 ml. The time is recorded for flow up to a mark of 75 ml. (i.e. 50 ml of test sample to flow through the orifice).

The viscosity test on road tar is carried out using 10 mm orifice and the standard test temperature for road tar grades RT1, RT2, RT3, and RT4 are 35, 40, 45 and 55°C respectively. (See Table 21.1 and also Table 23.3 under requirements of road tar). In case the viscosity test is being carried out to classify a given sample of road tar, i.e., 35°C; if the time taken for 50 ml of the tar sample to flow through the 10 mm orifice is more than 55 secs. Or if the sample does not flow freely, the test may be repeated at the next higher temperature, till the viscosity value falls in the specified range.

The viscosity test on cutback bitumen is carried out using 4.0 mm orifice for grades 0 and 1 (SC-0, MC-0, RC-0, SC-1, MC-1, RC-1), at 25°C. The tests for cutback grades 32 and 3 are carried out at 25°C using 10 mm orifice and those for grades 4 and 5 are carried out at 40°C using 10 mm orifice. For details of requirements of cutbacks, see Tables. If the viscosity of an unknown grade of cutbacks is to be determined, the orifice size and the trial test temperature may be chosen using judgment. If the viscosity value of the trial test does not fall within the specified range, the test should be repeated by altering the test temperature or orifi**ce size or both suitably.**

Results:

The time in seconds for 50 ml of the test sample to flow through the orifice is defined as the viscosity at a given test temperature. Therefore the temperature at which the test was conducted and the diameter of the orifice used should also be mentioned. The viscosity values of repeat tests should not vary by more than 4.0 percent from the mean value.

Discussions:

The results of the viscosity test will get affected greatly if the test temperature of the sample is not correctly maintained throughout the test. Erratic results are obtained due to clogging of the orifice and due to the presence of lumps in the sample of bituminous material.

Applications:

Orifice viscometer test gives an indirect measure of viscosity of road tars and cutbacks in seconds. Higher the duration, more viscous is the material. The determination of viscosity by orifice viscometer in seconds is an indirect measure of viscosity. The absolute unit of viscosity is dyne seconds per cm2 or poise. The following are the test temperatures and viscosity values of road tars of grades 1 to 5, using 10 mm orifice.

Viscosity values of Road Tars

Road tar grades RT-1 RT-2 RT-3 RT-4 RT-5

Test temperature 35 40 45 55 -
Viscosity range, sec 30 to 55 30 to 55 35 to 60 40 to 60

Viscosity values of Cut back Bitumen

Cutback types	0	1	2	3	4	5
Orifice size, mm	4	4	10	10	10	10
Test temp, C	25	25	25	25	40	40
Viscosity, sec	25-75	50-150	10-20	25-75	14-45	60-140

Observations & Calculations:

i i) Material :

ii ii) Grade :

iii iii) Specified test temperature, °C =

iv iv) Size of orifice, mm =

v v) Actual test temperature, °C =

Test run

Test property	1	2	3	Mean value
Viscosity in Seconds				
Repeatability, percent				

Result:

Inference:

Short Answer Questions:

1. Explain the term viscosity.
2. What are the different methods in determining the viscous characteristics of bituminous materials?
3. What is absolute unit for viscosity?
4. What are the uses of viscosity test?
5. Write a note on float test.
6. What are the precautions to be taken during viscosity test using orifice viscometer?
7. How is the grade of Tar / Cutback determined?

FLASH AND FIRE POINT TEST

(IS: 1209 – 1978)

Aim of the Experiment:

To determine the flash and fire point of the given sample (Bitumen/Tar)

Theory:

Bituminous materials leave out volatiles at high temperatures depending upon their grade. These volatile vapours catch fire causing a flash. This condition is very dangerous and it is therefore essential to know this temperature for each bitumen grade, so that the paving engineers may restrict the mixing or application temperature well within the limits. The flash point is the lowest temperature at which flash occurs due to the ignition of the volatile vapors when a small flame is brought in contact with the vapours of a bituminous product, gradually heated under standardized conditions. When the bituminous material is further heated to a higher temperature, the material itself catches fire and continues to burn; the lowest temperature causing this condition is the fire point.

Flash point: "The flash point of a material is the lowest temperature at which the vapor of substance momentarily takes fire in the form of a flash under specified condition of test".

Fire Point: "The fire point is the lowest temperature at which the material gets ignited and burns under specified condition of test".

4. Specification of Equipment's:

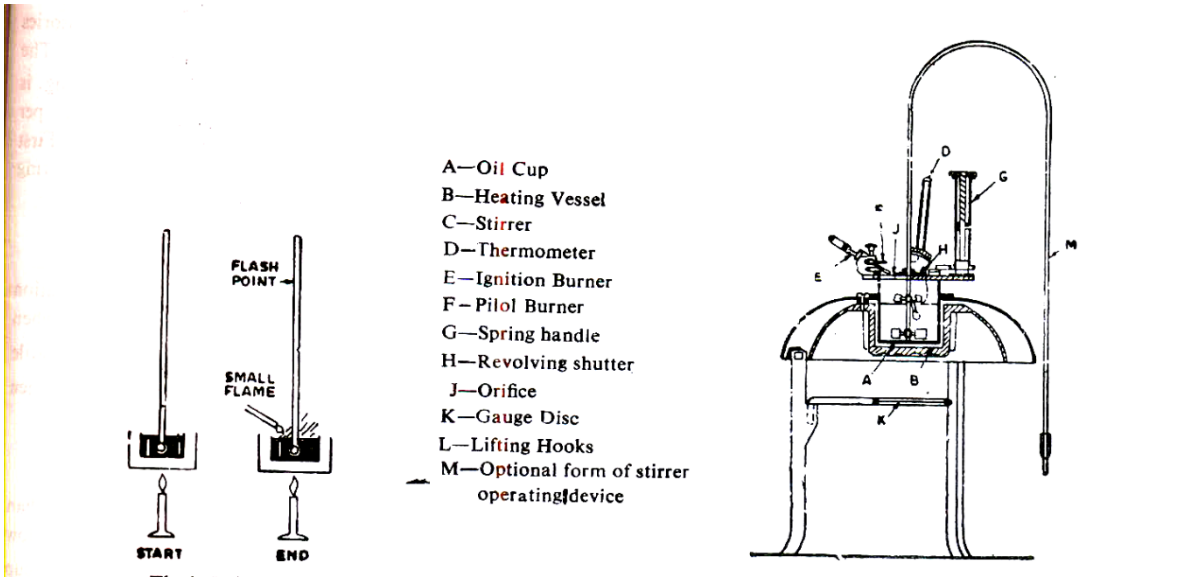
(i) Pensky - Martens Closed Tester consist of cup, lid, stirring device, cover, shutter, flame exposure device etc. (as given in the figure)

(ii) Pensky - Marten open Tester as above with the modification, that the cover of the cup is replaced by a clip which encircles the upper rim of the cup and carries the thermometer and test flame.

Procedure:

All parts of the cup are cleaned and dried thoroughly before the test is started. The material is filled in the cup up to a filling mark. The lid is placed to close the cup in a closed system. All accessories including thermometer of the specified range are suitably fixed. The bitumen sample is then heated. The test flame is lit and adjusted in such a way that the size of a beed is of 4 mm diameter. The heating is done at the rate of 5°C to 6°C per minute. The stirring is done at a rate of approximately 60 revolutions per minute. The test flame is applied at intervals depending upon the expected flash and fire points. First application is made at least

17°C below the actual flash point and then at every 1°C to 3°C. The stirring is discontinued during the application of the test flame.



Flash Point Test Concept

Pensky-Martens closed Tester

Results

The flash point is taken as the temperature read on the thermometer at the time of the flame application that causes a bright flash in the interior of the cup in closed system. For open cup it is the instance when flash appears first at any point on the surface of the material. The heating is continued until the volatile ignites and the material continues to burn for 5 seconds. The temperature of the sample material when this occurs is recorded as the fire point.

Discussion:

It is specified that in closed cup system, the test results should not differ from the mean by more than 3ºC for materials flashing above 104°C and not more than 1°C from the mean for material flashing below 104°C. Sometimes bluish halo that surrounds the test flame is confused with true flash. For open cup system, it is specified by ISI that the mean value should not differ from the individual values by more than 3°C for flash point, and by 6°C for fire point.

Applications:

Different bituminous materials have quite different values of flash and fire points. When the bitumen or cutback is to be heated before mixing or application, utmost care is taken to see that heating is limited to a temperature well below the flash point. This is essential from safety point of view.

The minimum value of Flash point by PenskyMortens' closed type apparatus specified by the ISI is 175ºC for all the grades of bitumen's (for both Assam petroleum and those from other sources).

The minimum specified flash point for rapid curing cutback bitumen of all grades is 26°C and that for medium curing type is 38°Cfor grades 0 and 1 and 65°C for grades 2 to 5. Slow curing cutbacks have minimum values ranging from 65 to 121°Cas given in Table.

Observations & Calculations:

Flash and Fire Point Tests

i (i) Bitumen grade / Cutback type & grade :

ii (ii) Type of equipment : Closed cup/Open cup

Rate of heating

Time, minutes 12 3 4 5 67 89 101112

Temperature, °C

Test property	Test number 1	2	3	Mean value
1. Flash point				
2. Fire point				
3. Variations from mean value				

Result :

Inference:

Short Answer Questions:

1. Define flash and fire points.
2. Briefly outline the flash point test procedure.
3. What is the significance of flash point test? Differentiate between flash point and fire point.

AGGREGATE CRUSHING VALUE TEST
(IS: 2386 – (Part IV))

Aim of the Experiment:

To determine the aggregate crushing value of the given sample.

Theory:

Aggregates used in road construction, should be strong enough to resist crushing under traffic wheel loads. If the aggregates are weak, stability of the pavement structure is likely to be adversely effected. The strength of coarse aggregates is assessed by aggregate crushing test. The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load. To achieve a high quality of pavement, aggregates possessing low aggregate crushing value should be preferred.

Specification of Equipment's:

The apparatus for the standard aggregate crushing test consists of the following:

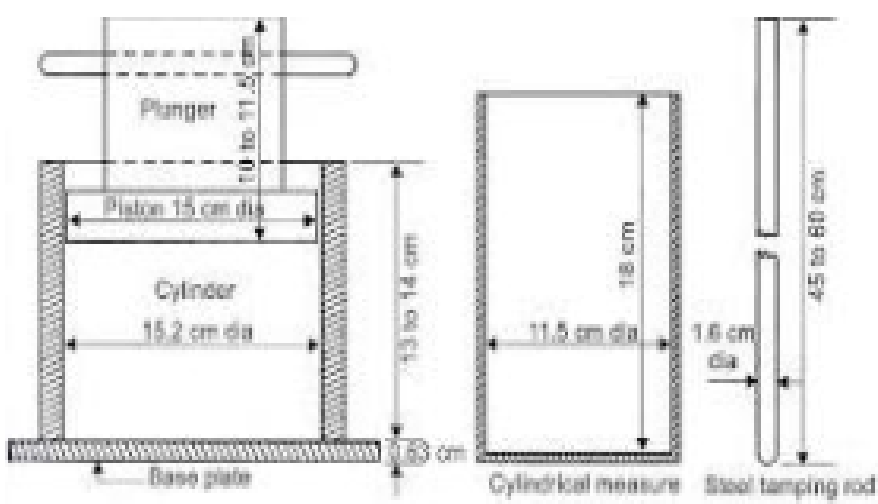
(i) Steel cylinder with open ends, and internal diameter 15.2 cm, square base plate, plunger having a piston of diameter 15 cm, with a hole provided across the stem of the plunger so that a rod could be inserted for lifting or placing the plunger in the cylinder.

(ii) Cylindrical measure having internal diameter of 11.5 cm and height 18 cm.

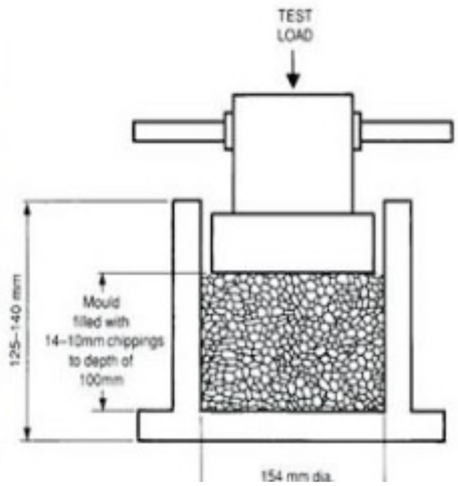
(iii) Steel tamping rod with one rounded end, having a diameter of 1.6 cm and length 45 to 60 cm.

(iv) Balance of capacity 3 Kg with accuracy up to 1 g.

(v) Compression testing machine capable of applying load of 40 tonnes, at a uniform rate of loading of 4 tonnes per minute.



Aggregate Crushing Value Test



Test Procedure

Precautions:

The aggregate sample for conducting the aggregate crushing test for the first time is to be taken by tamping in a specified manner and the weight of this sample is determined.

Comments:

IRC and ISI have specified that the aggregate crushing value of the coarse aggregates used for cement concrete pavement at surface should not exceed 30%. For aggregates used for concrete other than for wearing surfaces, the aggregate crushing value shall not exceed 45% according to the ISS. However aggregate crushing values have not been specified by the IRC for coarse aggregates to be used in bituminous pavement construction methods

Procedure:

The aggregate passing 12.5 mm IS sieve and retained on 10 mm IS sieve is selected for standard test. The aggregate should be in surface dry condition before testing. The aggregate may be dried by heating at a temperature of 100°C to 110°C for a period of 4 hours and is tested after being cooled to room temperature.

The cylindrical measure is filled by the test sample of aggregate in three layers of approximately equal depth, each layer being tamped 25 times by the rounded end of the tamping rod. After the third layer is tamped, the aggregates at the top of the cylindrical measure leveled off by using the tamping rod as a straight edge. About 6.5 kg of aggregate is required for preparing two test samples. The test sample thus taken is then weighed. The same weight of the sample is taken in the repeat test.

The cylinder of the test apparatus is placed in position on the base plate; one third of the test sample is placed in this cylinder and tamped 25 times by the tamping rod. Similarly, the other two parts of the test specimen are added, each layer being subjected to 25 blows. The total depth of the material in the cylinder after tamping shall however be 10 cm. The surface of the aggregates is leveled and the plunger is inserted so that it rests on this surface in level position. The cylinder with the test sample and the plunger in position is placed on compression testing machine. Load is then applied through the plunger at a uniform rate of 4 tonnes per minute until the total load is 40 tonnes, and then the load is released. Aggregates including the crushed portion are removed from the cylinder and sieved on a 2.36 mm IS sieve. The material which passes this sieve is collected.

The above crushing test is repeated on second sample of the same weight in accordance with above test procedure. Thus two tests are made for the same specimen for taking an average value.

Calculations:

Total weight of dry sample taken = W1 g.

Weight of the portion of retained material on 2.36 mm IS sieve = W2 g.

Weight of the portion of material passing through 2.36 mm IS sieve = (W1 – W2) g.

The aggregate crushing value is defined as a ratio of the weight of fines passing the specified IS sieve to the total weight of the sample expressed as a percentage. The value is usually recorded up to the first decimal place.

Aggregate crushing value = 100 (W1 – W2) / W1

Results:

The mean of the crushing value obtained in the two tests is reported as the aggregate crushing value.

Determination of Ten Percent Fines Value

The 'ten percent fines' value is a measure of resistance of the aggregates to the crushing. The apparatus and materials used are the same as for the standard aggregate crushing test. The test sample in the cylinder with the plunger in position is placed in the compression testing machine. The load is applied at a uniform rate so as to cause a total penetration of the plunger of about 20 mm for normal crushed aggregates in 10 minutes. But for rounded or partially rounded aggregates, the load required to cause a total penetration of 15 mm is applied whereas for honeycombed aggregate like expanded shale's or slag's that for a total penetration of 24 mm is applied in 10 minutes. After the maximum specified penetration is reached, the load is released and the aggregates from the cylinder are sieved on a 2.36 mm IS sieve. The fines passing through the sieve is weighed and is expressed as a percentage by weight of the test sample. This percentage normally falls in the range of 7.5 to 12.5; but if it does not fall in this range, the test is repeated with necessary adjustment of the load.

Discussion

In general large size of aggregate used in the test results in higher aggregates crushing value. The relationship between the aggregate sizes and the crushing values will however vary with the type of specimens tested. The aggregate sample for conducting the aggregate crushing test for the first time is to be taken by tamping in a specified manner and the weight of the sample is determined. When the test is repeated using the same aggregate, it is sufficient to directly weigh and take the same weight of sample. This is because it is necessary to keep the volume and height of the test specimen's in the aggregate crushing mould constant when testing any aggregate sample by weight, the volume and hence the height may vary depending on the variation in specific gravity and shape factors of different aggregates. When aggregates are not available, crushing strength test may be carried out on cylindrical specimen prepared out of rock sample by drilling, sawing and grinding. The specimen may be subjected to a slowly increasing compressive load until failure to find the crushing strength in kg/sq cm. However this test is not preferred generally, the reason being difficulty in preparing specimens and not getting reproducible results.

Applications

The aggregate crushing value is an indirect measure of crushing strength of the aggregates. Low value indicates strong aggregates. This test can be used to assess the suitability of aggregates with reference to the crushing strength for different types of pavement components. The aggregate used for the surface course of pavements should be strong enough to with stand the high stresses due to wheel loads, including the steel tyres of loaded bullock-carts. As the stresses at the base and sub–base courses are low, aggregates with lesser crushing strength may be used at the lower layers of the pavement.

IRC and BIS have specified that the aggregate crushing value of the coarse aggregates used for cement concrete pavement at surface should not exceed 30%. For aggregates used for concrete other than for wearing surfaces, the aggregate crushing value shall not exceed 45% according to the BIS. However aggregate crushing values have not been specified by the IRC for coarse aggregates to be used in bituminous pavement construction methods.

Observations &

Sample Number	Total Weight of dry Sample, W1 g	Weight of Material retained on 2.36mm IS Sieve, W2 g	Weight of fines passing 2.36mm IS Sieve, (W_1-W_2) g	Aggregate crushing value = 100 * $(W_1-W_2)/W_1$
1				
2				

Calculations:

Result:

Inference:

Short Answer Questions:

1. Why is the test carried out on cylindrical stone specimen is not generally used?

2. Aggregate crushing value of material A is 35% and that of B is 20%. Which one is better and why?

3. What is the specified standard size of aggregates?

4. What are the recommended maximum values of aggregate crushing value for the aggregates to be used in base and surface courses of cement concrete?

5. What are the applications of aggregate crushing test?

LOS ANGELES ABRASION TEST
(IS : 2386 – (Part IV))

Aim of the Experiment :

To determine the Los Angeles Abrasion Value of the given aggregate sample.

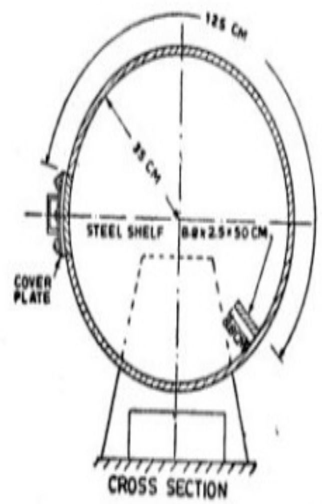
Theory:

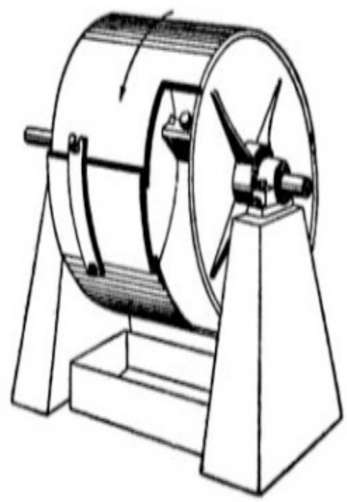
The principle of Los Angeles abrasion test is to find the percentage wear due to the relative rubbing action between the aggregates and steel balls used as abrasive charge. Pounding action of these balls also exist while conducting the test. This test is more dependable as rubbing and pounding action simulate the field conditions, where both abrasion and Impact occur. This test has been standardized by the ASTM, AASHO and also by the ISI. Standard specifications of Los Angeles Abrasion values are also available for various types of pavement construction.

Specifications of Equipment:

The apparatus consists of Los Angeles Machine and sieves.

Los Angeles machine consists of a hollow steel cylinder, closed at both ends, having an inside diameter 70cm and an inside length of 50cm, mounted on stub shafts about which it rotates on a horizontal axis. An opening is provided in the cylinder for the introduction of the test sample. A removable cover of the opening is provided in such a way that when closed and fixed by bolts and nuts, it is dust-tight and the interior surface is perfectly cylindrical. A removable steel shelf projecting radially 8.8 cm into the cylinder and extending to the full length of it, is mounted on the interior surface of the cylinder rigidly, parallel to the axis. The shelf is fixed at a distance of 125 cm form the opening, measured along the circumference in the direction of rotation. Abrasive charge, consisting of cast iron spheres approximately 4.8 cm in diameter and 390 to 445 g in weight are used. The weight of the sphere used as the abrasive charge and the number of spheres to be used are specified depending on the gradation of the aggregates tested. The aggregate grading have been standardized as A, B, C, D, E, F and G for this test and the IS specification for the grading and abrasive charge to be used are given in table. IS sieve with 1.70 mm opening is used for separating fines after the abrasion test.





Procedure:

Clean aggregates dried in an oven at 105 - 110□C to constant weight, conforming to any one of the grading A, to G, as per the specification Table is used for the test. The grading or gradings used in the test should be nearest to the grading to be used in the construction. Aggregates weighing 5 kg for grading A, B,C or D and 10 kg for gradings E,F or G may be taken as test specimen and placed in the cylinder. The abrasive charge is also chosen in accordance with the specified Table depending on the grading of the aggregate and is placed in the cylinder of the machine. The cover is then fixed dust-tight. The machine is rotated at a speed of 30 to 33 revolutions per minute. The machine is rotated for 500 revolutions for gradings A, B, C and D, for gradings E, F and G, it shall be rotated for 1,000 revolutions. The machine should be balanced and driven in such a way as to maintain uniform peripheral speed.

After the desired number of revolutions, the machine is stopped and the material is discharged from the machine taking care to take out entire stone dust. Using a sieve of size larger than 1.70 mm IS sieve, the material is first separated into two parts and the finer position is taken out and sieved further on a 1.7 mm IS sieve. The portion of material coarser than 1.7 mm size is washed and dried in an oven at 105°C to 110°C to constant weight and weighed correct to one gram.

Observations & Calculations:

The difference between the original and final weight of the sample is expressed as percentage of the original weight of the sample is reported as the percentage wear.

Specifications for Los Angeles Test

Grading	Weight in grams of each test sample in the size range, mm (passing and retained on square holes)										Abrasive Charge	
	80-63	63-50	50-40	40-25	25-20	20-12.5	12.5-10	10-6.3	6.3-4.75	4.75-2.36	No. of spheres	Wt. of charge, g
A	-	-	-	1250	1250	1250	1250	-	-	-	12	5000± 25
B	-	-	-	-	-	2500	2500	-	-	-	11	4584± 25
C	-	-	-	-	-	-	-	2500	2500	-	8	3330± 20
D	-	-	-	-	-	-	-	-	-	5000	6	2500± 15
E	2500*	2500*	5000*	-	-	-	-	-	-	-	12	5000± 25
F	-	-	5000*	5000*	-	-	-	-	-	-	12	5000± 25
G	-	-	-	5000*	5000*	-	-		-	-	12	5000± 25

*** Tolerance of ± 2 per cent is permitted.**

Results:

The result of the Los Angeles abrasion test is expressed as a percentage wear and the average value of two tests may be adopted as the Los Angeles abrasion value.

Discussion:

It is generally observed that the aggregates desired for a certain construction project would not be the same grading as that of the specified gradings. In all the cases, standard grading is gradings nearest to the gradation of the selected aggregates may be chosen. This test is very commonly used to evaluate the quality of aggregates for use in pavement construction, especially to decide the hardness of stones. The allowable limits of this test have been specified by different agencies based on extensive performance studies in the field. This test can be considered as one in which resistance to bothabrasion and impact of aggregate may be obtained simultaneously, due to the presence of abrasive charge. Also the test is considered more representative of field conditions. The results obtained on stone aggregates are highly reproducible.

Applications:

This test is very widely accepted as a suitable test to assess the hardness of aggregates used in pavement construction. Many agencies have specified the desirable limits of the test, for different methods of construction. The maximum allowable Los Angeles Abrasion values of aggregates as specified by IRC for different methods of construction are given in the following table.

Sl No.	Types of pavement Layer	Los Angeles Abrasion Value, maximum %
1.	Water Bound macadam(WBM), sub-base course	60
2.	(i) WBM base course with bituminous surfacing (ii) Bituminous Macadam base course (iii) Built-up spray grout base course	50
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 (ii) Bituminous surface dressing, single or two coats (iii)Bituminous surface dressing, using pre-coated aggregates (iv) Cement concrete surface course(as per IRC)	35
5.	(i) Bituminous/Asphalt concrete surface course (ii) Cement concrete pavement surface course (as per ISI)	30

Observations & Calculations:

i) Type of aggregate =

ii) Grading =

iii) Number of spheres used =

iv) Weight of charge =

v) Number of revolutions =

Sl.No	Description	Test Number	
		1	2
1	Weight of specimen = W_1 g		
2	Weight of specimen after abrasion test, Coarser than 1.70 mm IS sieve = W_2 g		
3	Percentage wear = $(100(W_1-W_2)/W_1)$		

Average Los Angeles abrasion value =

Result :

Inference :

Short Answer Questions:

1. Why is Los Angeles abrasions test considered supreme to others?
2. What is attrition? What is abrasion?
3. If charge is removed from Los Angeles abrasion test, can it be considered as attrition test? If not why?
4. What are the desirable limits for different layers?

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AGGREGATE IMPACT TEST

(IS : 2386 – (Part IV))

Aim of the Experiment:

To determine the aggregate impact value of the given sample.

Theory:

Toughness is the property of a material to resist impact loads. Due to traffic loads, the road aggregates are subjected to the pounding action or impact, and there is a possibility of aggregates breaking into smaller pieces. The aggregates should therefore be tough enough to resist fracture under impact loads. A test designed may be called as impact test for road aggregates.

Impact test may either be carried out on cylindrical stone specimens as in page impact test or on stone aggregates as in Aggregate impact test. The page Impact test is not carried out now-a-days and has also been omitted from the revised British standards for testing mineral aggregates. The Aggregate Impact test has been standardized by the British Standards Institution and the Indian Standards Institution.

The aggregate impact value indicates a relative measure of the resistance of an aggregate to a sudden shock or an impact, which in some aggregates differs from its resistance to a slow compressive load. The method of test covers the procedure for determining the aggregate impact value of coarse aggregates.

Specifications of Equipment:

The apparatus consists of an impact testing machine, a cylindrical measure, tamping rod, IS sieves, balance and oven.

(a) Impact testing machine: The machine consists of a metal base with a plane lower surface supported well on a firm floor, without rocking. A detachable cylindrical steel cup of internal diameter 10.2 cm and depth 5 cm is rigidly fastened centrally to the base plate. A metal hammer of weight between 13.5 and 14.0 kg having the lower end cylindrical in shape, 10 cm in diameter and 5 cm long, with 2 mm chamber at the lower edge is capable of sliding freely between vertical guides, and fall concentric over the cup. There is an arrangement for raising the hammer and allowing it to fall freely between vertical guides from a height of 38 cm on the test sample in the cup, the height of fall being adjustable up to 0.5 cm. A key is provided for supporting the hammer while fastening or removing the cup. Refer Figure.

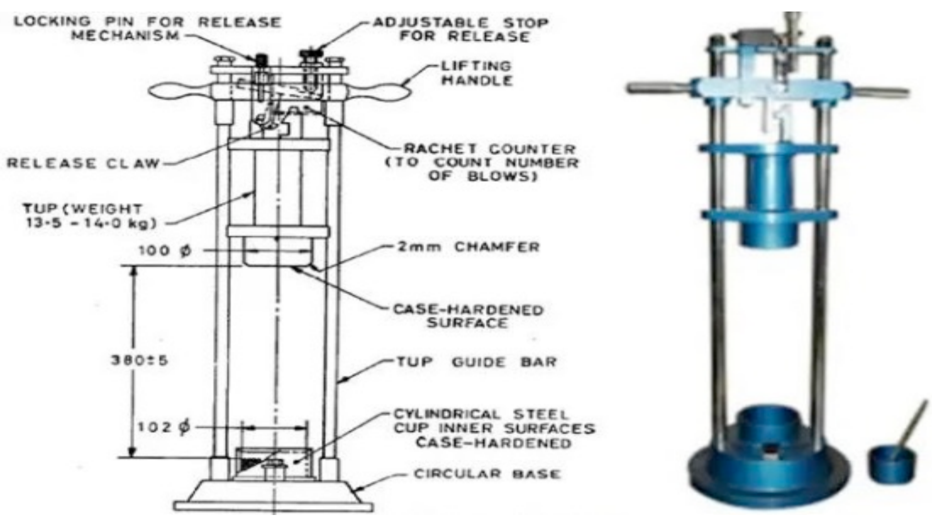
(b) Measure: A cylindrical metal measure having internal diameter 7.5 cm and depth 5 cm for measuring aggregates.

(c) Tamping rod: A straight metal tamping rod of circular cross section, 1 cm in diameter and 23 cm long, rounded at one end.

(d) Sieve: IS sieve of sizes 12.5 mm, 10 mm and 2.36 mm for sieving the aggregates.

(e) Balance: a balance of capacity not less than 500 g to weigh accurate up to 0.1 g.

(f) Oven: A thermostatically controlled drying oven capable of maintaining constant temperature between 100°C and 110°C.



Aggregate Impact Test Apparatus

Procedure:

The test sample consists of aggregates passing 12.5 mm sieve and retained on 10 mm sieve and dried in an oven for four hours at a temperature 100°C to 110°C and cooled. Test aggregates are filled up to about one-third full in the cylindrical measure and tamped 25 times with rounded end of the

tamping rod. Further quantity of aggregates is then added up to about two-third full in the cylinder and 25 strokes of the tamping rod are given. The measure is now filled with the aggregates to over flow, tamped 25 times. The surplus aggregates are struck off using the tamping rod as straight edge. The net weight of the aggregates in the measure is determined to the nearest gram and this weight of the aggregates is used for carrying out duplicate test on the same material. The impact machine is placed with its bottom plate flat on the floor so that the hammer guide columns are vertical. The cup is fixed firmly in position on the base of the machine and the whole of the test sample from the cylindrical measure is transferred to the cup and compacted by tamping with 25 strokes.

The hammer is raised until its lower face is 38 cm above the upper surface of the aggregates in the cup, and allowed to fall freely on the aggregates. The test sample is subjected to a total of 15 such blows, each the cup and the whole of it sieved on the 2.36 mm sieve until no further significant amount passes. The fraction passing the sieve is weighed accurate to 0.1 g. The he fraction retained on the sieve is also weighed and if the total weight of the fractions passing and retained on the sieve is added it should not be less than the original weight of the specimen by more than one gram; if the total weight is less than the original by over one gram the result should be discarded and a fresh test made.

The above test is repeated on fresh aggregate sample.

Calculation:

The aggregate impact value is expressed as the percentage of the fines formed in terms of the total weight of the sample.

Let the weight of dry sample taken = W1 g. Weight of the portion of retained material on 2.36 mm IS sieve = W2 g. Weight of the portion of material passing through 2.36 mm IS sieve = (W1 – W2) g.

Precautions:

It is essential that the first specimen to be tested from each sample of aggregates is equal in volume. This is ensured by taking the specimen in the measuring cylinder in the specified manner by tamping in three layers.

Results:

The mean of the two results is reported as the aggregate impact value of the specimen to the nearest whole number.

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

Aggregate impact values : < 10% - Exceptionally strong
10 - 20% - strong
20 - 30% - satisfactory for road surfacing
> 35% - weak for road surface

Discussion:

The main advantage of aggregate impact test is that the test procedure and the test equipment are quite simple and determine the resistance to impact of stones simulating the field conditions. This test also can be done in a short time even at construction site or at a stone quarry. Generally well-shaped cubical aggregates have higher resistance to impact when compared with elongated and flaky aggregates. It is essential that the first specimen to be tested from each sample of aggregate is equal in volume; taking the specimen in the measuring cylinder in the specified manner by tamping in three layers ensures this.

If all the test specimens are of equal volume, the height of the specimens will also be equal and hence the height of fall of the impact rammer on the specimens will be equal.

Applications:

This test is very important to ascertain the suitability of aggregate as regards the toughness for use in pavements construction. Generally for majority of aggregates the crushing and impact values are numerically similar within close limits. Various agencies have specified the maximum permissible aggregate impact values for the different types of pavements. For knowing the suitability of soft aggregates in base course construction, this test has been commonly used.

A modified impact test is also often carried out in the case of soft aggregates to find the wet impact value after soaking the test samples.

Observations & Calculations:

Sl.No	Details	Trial No.		
		1	2	3
1.	Total weight of aggregate sample filling the cylindrical measure = W_1 g			
2.	Weight of aggregate retained on 2.36 mm I S sieve after the test = W_2 g			
3.	Weight of aggregate passing through 2.36 mm I S sieve after the test = $(W_1 - W_2)$ g			
4.	Aggregate Impact value = percent fines = $100 (W_1 - W_2) / W_1$ %			

Average aggregate impact value =

Result :

Inference:

Short Answer Questions:

1. What are the advantages of Aggregate Impact test over page Impact test?

2. Briefly mention the procedure of aggregate impact test?

3. How is aggregate impact value expressed?

4. What are the desirable limits of aggregate impact value specified for different types of pavement surfaces?

5. Aggregate impact value of material A is 20% and of B are 45%. Which one is better for surface course? Why?

6. What do you understand by dry and wet impact values?

7. If the weight of the hammer is increased, what is the effect on impact value?

8. If the height of fall is increased, what is the effect on impact value?

SHAPE TESTS

(IS: 2386 – (Part IV))

Aim of the Experiment:

To determine the Flakiness index and Elongation index of the given aggregate sample.

Theory:

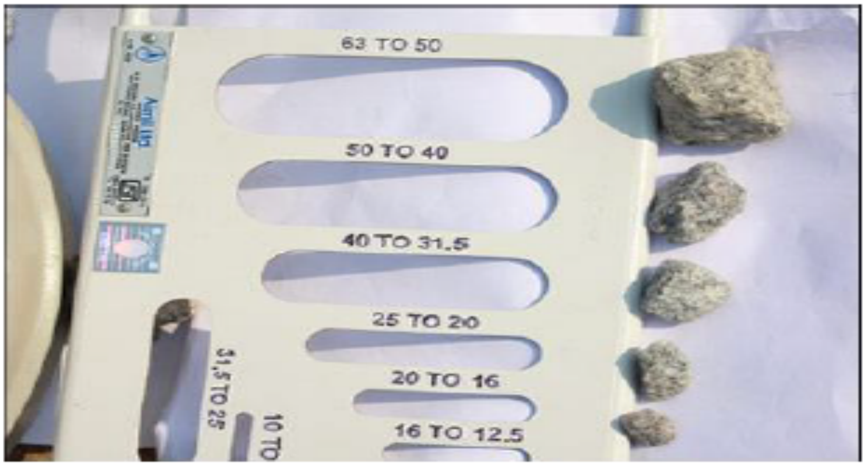
The particle shape of aggregates is determined by the percentage of flaky and elongated particles contained in it. In the case of gravel its angularity number determines it. For base course and construction of bituminous and cement concrete types, the presence of flaky and elongated particles are considered undesirable as they may cause inherent weakness with possibilities of breaking down under heavy loads. Rounded aggregates are preferred in rigid pavement construction as the workability of concrete improves. Angular shapes of particles are desirable for granular base course due to increased stability derived from the better inter-locking. The angularity number has considerable importance in the gradation requirements of various types of mixes such as bituminous concrete and soil aggregate mixes. Evaluation of shape of the particles, particularly with reference to flakiness, elongation and angularity is necessary.

Flakiness Index

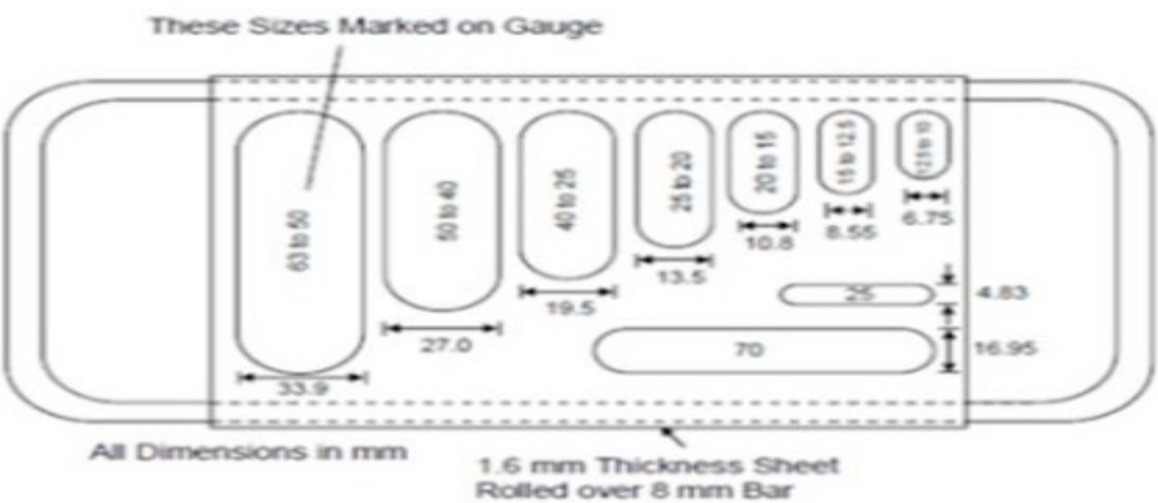
It is the percentage by weight of particles whose least dimension (thickness) is less than three-fifths (0.6) of their mean dimension. The test is not applicable to sizes smaller than 6.3mm

Specification of Equipment's:

The apparatus consists of a standard thickness gauge, IS sieves of sizes 63, 50, 40, 31.5, 25, 20, 16, 12.5, 10 and 6.3 mm and a balance.



Aggregate passed along the thickness



Thickness Gauge

Procedure:

The sample is sieved with the sieves as mentioned in the following 'Table'. A minimum of 200 pieces of each fraction to be tested are taken and weighed (W1 g). In order to separate flaky materials, each fraction is then gauged for thickness on a thickness gauge or in bulk on sieves having elongated slots. The width of the slot used should be of the dimensions specified in column (3) of Table for the appropriate size of material. The amount of flaky material passing the gauge is weighed to an accuracy of at least 0.1 percent of the test sample.

DIMENSIONS OF THICKNESS AND LENGTH GAUGES

Size of aggregate		(a) Thickness gauge (0.6 times the mean sieve), mm	(b) Length gauge (1.8 times the mean sieve), mm
Passing through IS sieve mm	Retained on IS sieve, mm		
1	2	3	4
63.0	50.0	33.90	-
50.0	40.0	27.00	81.0
40.0	25.0	19.50	58.5
31.5	25.0	16.95	-
25.0	20.0	13.50	40.5
20.0	16.0	10.80	32.4
16.0	12.5	8.55	25.6
12.5	10.0	6.75	20.2
10.0	6.3	4.89	14.7

Calculation And Result

In order to calculate the flakiness index of the entire sample of aggregates first the weight of each fraction of aggregate passing and retained on the specified set of sieves is noted. As an example let 200 pieces of the aggregate passing 50 mm sieve and retained on 40 mm sieve be = W1 g. Each of the particle from this fraction of aggregate is tried to be passed through the slot of the specified thickness of the thickness gauge; in this example the width of the appropriate gauge of the thickness gauge is = ((50 x 40) / (2)) x 0.6 = 27.0 mm gauge. Let the weight of the flaky material passing this gauge be w1 g. Similarly the weights of the fractions passing and retained on the specified sieves, W1, W2, W3 etc., are weighed and the total weight W1 + W2 + W3 +….. = W g is found. Also the weights of material passing each of the specified thickness gauges are found = w1, w2, w3 … and the total weight of material passing through the different thickness gauges = w1 + w2 + w3 + … = w g is found. Then the flakiness index is the total weight of the flaky material passing through the various thickness gauges expressed as a percentage of the total weight of the sample gauged.

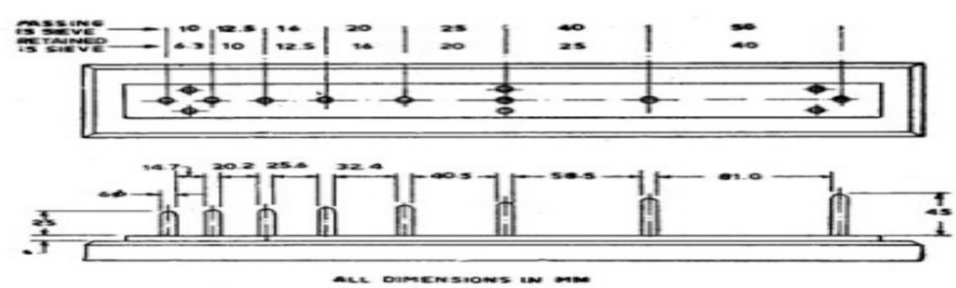
Flakiness Index = 100(w1 + w2 + w3 +…..) / (W1 + W2 + W3+)%or 100(w/W)%.

Elongation Index

The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four fifth times (1.8 times) their mean dimension. The elongation test is not applicable to sizes smaller than 6.3 mm.

Specification of Equipment:

The apparatus consists of the length gauge, sieves of the sizes as specified in the Table and a balance.



Procedure:

The sample is sieved through the IS sieves specified in Table. A minimum of 200 pieces of each fraction is taken and weighed. In order to separate elongated material, each fraction is then gauged individually for length in a length gauge. The gauge lengths used should be those specified in column 4 of the Table for the appropriate material. The pieces of aggregates from each fraction tested which could not pass through the specified gauge length with its long side are elongated particles and are collected separately to find the total weight of aggregates retained on the length gauge from each fraction. The total amount of elongated material retained by the length gauge is weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

Calculation and Result:

In order to calculate the elongation index of the entire sample of aggregates the weight of aggregates which is retained on the specified gauge length from each fraction is noted. As an example, let 200 pieces of the aggregate passing 40 mm sieve and retained on 25 mm sieve weigh W1 g. Each piece of these are tried to be passed through the specified gauge length of the length gauge, which in this example is = ((40 + 25) / 2) x 1.8 = 58.5 mm with its longest side and those elongated pieces which do not pass the gauge are separated and the total weight determined = w1 g. Similarly the weight of each fraction of aggregate passing and retained on specified sieve sizes are found, W1, W2, W3, and the total weight of sample determined = W1 + W2 + W3 + … = W g. Also the weight of materials from each fraction retained on the specified gauge length are found to be equal to x1, x2, x3 … and the total weight retained determined = x1 + x2 + x3 + … = x g.

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

Elongation Index = 100 (x1+x2+x3+---) / (W1+W2+W3+----)

= 100(x/W) %

Observations & Calculations

FLAKINESS INDEX AND ELONGATION INDEX

General description of the aggregate:

Size of aggregate		Weight of the fraction consisting of at least 200 pieces, g	Thickness gauge size, mm	Weight of aggregate in each fraction passing thickness gauge, g	Length gauge size, mm	Weight of **Non-Flaky** aggregate in each fraction retained on length gauge, g
Passing through IS sieve, mm	Retained on IS sieve mm					
1	2	3	4	5	6	7
63	50	W_1=	23.90	w_1=	-	-
50	40	W_2=	27.00	w_2=	81.0	x_1=
40	25	W_3=	19.50	w_3=	58.0	x_2=
31.5	25	W_4=	16.95	w_4=	-	-
25	20	W_5=	13.50	w_5=	40.5	x_3=
20	16	W_6=	10.80	w_6=	32.4	x_4=
16	12.5	W_7=	8.55	w_7=	25.6	x_5=
12.5	10	W_8=	6.75	w_8=	20.2	x_6=
10.0	6.3	W_9=	4.89	w_9=	14.7	x_7=
Total		W=		w=	x=	

Flakiness Index = 100 (w1 + w2 + w3 +) / (W1 + W2 + W3 + …) %

= 100(w / W) %

Combined Flakiness and Elongation indices (Total): To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The value of flakiness index and elongation index so found are added up.

(The elongation test to be done only on non-flaky aggregates in the sample)

Result:

Elongation Index = 100 (x1 + x2 + x3 + …) / (W1 + W2 + W3 + …)%

= 100 (x/W)%

Result:

Inference:

Discussion:

The shape tests give only a rough idea of the relative shapes of the aggregates.

Application:

Flaky and elongated particles are to be avoided in pavement construction particularly in surface course. If flaky and elongated aggregates are present in large proportions, the strength of the pavement layer would be adversely affected due to possibility of breaking down under traffic loads. In rigid pavements the workability is also reduced. However, the reduction in strength in rigid pavements depends on the cement content and water cement ratio. IRC has recommended the maximum allowable limits of flakiness index values for various types of construction, as given in the following table

Maximum Allowable Flakiness Index of Aggregates in Different Types of Pavement Construction

SL No.	Type of Pavement Construction	Maximum limit of combined Flakiness and Elongation index, % (as per MORTH)
1	Bituminous carpet	30
2	(i) Bituminous/Asphalt concrete (ii) Bituminous surface dressing(single coat, two coats and pre-coated) (iii) Bituminous penetration Macadam (iv) Built-up spray grout	30
3	(i) Bituminous Macadam (ii) WBM, base and surfacing courses	30

Though elongated shape of the aggregates also effects the compaction and the construction of pavements, there are no specified limits of elongation index values as in the case of flakiness index for different methods of pavement construction.

Short questions:

1. Explain Flakiness Index. How is it found?

2. What is Elongation Index? How is it determined in the laboratory?

3. Discuss the advantages and limitations of rounded and angular aggregate in different type of pavements

4. Explain Angularity Number. How is it found?

5. What are the applications of shape tests?

6. Why flaky and elongated material should not be used?

SPECIFIC GRAVITY AND WATER ABSORPTION TESTS

Aim of the Experiment:

To determine the Specific gravity and water absorption of the given aggregate sample

Introduction:

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Stones having low specific gravity are generally weaker than those with higher specific gravity values. The specific gravity test helps in the identification of stone.

Water absorption gives an idea of the strength of rock. Stones having more water absorption are more porous in nature and are generally considered unsuitable unless they are found to be acceptable based on strength, impact and hardness tests.

Specification of Equipment's:

The apparatus consists of the following:

(a) A balance of capacity about 3 kg, to weigh accurate to 0.5 g, and of such a type and shape as to permit weighing of the sample container when suspended in water.

(b) A thermostatically controlled oven to maintain temperature of 100□ to 110□C.

(c) A wire basket of not more than 6.3 mm mesh or a perforated container of convenient size with thin wire hangers for suspending it from the balance.

(d) A container for filling water and suspending the basket.

(e) An air tight container of capacity similar to that of the basket (referred to in 'c' above)

(f) A shallow tray and two dry absorbent clothes, each not less than 75 x 45 cm.

W1 W2 W3 W4

Specific Gravity Calculation Procedure

Procedure:

About 2 kg of the aggregate sample is washed thoroughly to remove fines, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22°C and 32°C with a cover of at least 5 cm of water above the top of the basket. Immediately after immersion the entrapped air is removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per second. The basket and the aggregate should remain completely immersed in water for a period of 24 ±1/2 hours afterwards.

The basket and the sample are then weighed while suspended in water at a temperature of 22°C to 32°C. In case it is necessary to transfer the basket and the sample to a different tank for weighing, they should be jolted 25 times as described above in the new tank to remove air before weighing. This weight is noted while suspended in water = W1 g. The basket and the aggregate are then removed from water and allowed to drain for a few minutes, after which the aggregates are transferred to one of the dry absorbent clothes. The empty basket is then returned to the tank of water, jolted 25 times and weighed in water = W2 g.

The aggregates placed on the absorbent clothes are surface dried till no further moisture could be removed by this cloth. Then the aggregates are transferred to the second dry cloth spread in a single layer, covered and allowed to dry for at least 10 minutes until the aggregates are completely surface dry. Ten to sixty minutes of drying may be needed. The aggregate should not be exposed to the atmosphere, direct sunlight or any other source of heat while surface drying. A gentle current of unheated air may be used during the first ten minutes to accelerate the drying of aggregate surface. The surface dried aggregates is then weighed = W3 g. The aggregate is placed in a shallow tray and kept in an oven maintained at a temperature of 110°C for 24 hours. It is then removed from the oven, cooled in an air-tight container and weighed = W4 g.

At least two tests should be carried out, but not concurrently.

Observations & Calculations:

Weight of saturated aggregate suspended in water with the basket = W1 g

Weight of basket suspended in water = W2 g

Weight of saturated aggregate in water = (W1 - W2) = Ws g

Weight of saturated surface fry aggregate in air = W3 g

Weight of water equal to the volume of the aggregate = (W3 - Ws) g

(1) Specific gravity = dry weight of aggregate / weight of equal volume of water

= W4 / (W3-Ws) = W4 / (W3-(W1-W2))

(2) Apparent specific gravity = (Dry weight of aggregate) / (Weight of equal volume Of water excluding air voids in aggregates)

= W4 / (W4 – Ws) = W4 / (W4 - (W1 - W2))

(3) Water absorption = %by weight of water absorbed in terms of oven dried weight of Aggregates

= 100 (W3 - W4) / W4 %

Discussion:

The size of the aggregates and whether it has been artificially heated should be indicated. The ISI specifies three methods of testing for the determination of the specific gravity and water absorption of aggregates, according to the size of aggregates. The three size ranges used are

(i) Aggregate larger than **40** mm

(ii) Between 10 mm and 40 mm, and

(iii) Smaller than 10 mm

The water absorption test does not always give reproducible results with aggregates of high porosity.

Applications:

The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0 with an average value of about 2.68. Though high specific gravity of an aggregate is considered as an indication of high strength, it is not possible to judge the suitability of a sample of road aggregate without finding the mechanical properties such as aggregate crushing, impact and abrasion values.

Water absorption of an aggregate is accepted as measure of its porosity. Some times this value is even considered as a measure of its resistance to frost action, though this has not yet been confirmed by adequate research. Water absorption value ranges from 0.1 to about 2.0 % for aggregates normally used in road surfacing. Stones with water absorption up to 4.0 % have been used in base courses. Generally a value of less than 0.6 % is considered desirable for surface course, though slightly higher values are allowed in bituminous constructions. Indian Roads Congress has specified the maximum water absorption value as 1.0 % for aggregates used in bituminous surface dressing and built-up spray grout.

Data Sheet

Determination of Specific Gravity And Water Absorption

(i) Size of the aggregates = ii) Aggregate Type =

S. No	Details	Test Number		
		1	2	Mean Value
1	Weight of saturated aggregate and Basket in water = W_1 g			
2	Weight of basket in water = W_2 g			
3	Weight of saturated surface dry aggregates in air = W_3 g			
4	Weight of oven dried aggregates in air = W_4 g			
5	Specific gravity = $W_4/(W_3-(W_1-W_2))$			
6	Apparent specific gravity = $W_4/(W_4-(W_1-W_2))$			
7	Water Absorption = $100((W_3-W_4)/W_4)$ %			

(i) Mean value of specific gravity =

(ii) Mean value of apparent specific gravity =

(iii) Mean value of water absorption =

Report on quality of stone

Result:

Inference:

Short Answer Questions:

1. Discuss the importance of specific gravity test on road aggregates?

2. Define true and apparent specific gravity of aggregates?

3. What is the significance of water absorption test on aggregates?

4. Which Specific gravity values are preferred? Why?

SOUNDNESS TEST

(IS: 2386 – (Part IV))

Aim of the Experiment:

To find out the resistance of aggregates to weathering action.

Specification of Equipment's:

1. Trays

2. I.S Sieves

3. Balance

4. Containers for aggregates

Procedure:

Saturated solution of Sodium Sulphate or Magnesium sulphate is prepared in water at a temperature of 25ºC to 30ºC. The specimen of coarse aggregate for the test is prepared after removing the fraction finer than 4.75mm I.S Sieve. The sample should be of such a size that it will yield not less than the following amounts of the different sizes, which should be available in amounts of 5 percent or more.

10mm to 4.75mm	300gms
20mm to 10.0mm	1000gms
Consisting of 12.5mm to 10mm	33%
20mm to 12.5mm	67%
40mm to 20mm	1500gms
Consisting of 25mm to 20mm	33%
40mm to 25mm	67%
63mm to 40mm	3000gms
Consisting of 50mm to 40mm	50%
63mm to 50mm	50%
80mm and larger sizes	
By 20mm spread in sieve size	3000gms

The sample of coarse aggregate should be thoroughly washed and dried. The proper weight of the sample for each fraction is weighed and placed in separate containers. The samples are then immersed in the prepared solution ofsodium sulphate or magnesium sulphate for 16 to 18 hours in such a manner that the solution cover them to a depth of at least 15mm. The containers are kept covered and temperature of the solution is maintained at 27ºC. After the immersion period, the aggregates are removed from the solution. Drained for about 15 minutes and placed in the drying oven maintained at a temperature of 105ºC to 110ºC. The aggregate are then weighed and the loss of weight is determined. The procedure can be repeated for number of cycles.

Observations:

Initial weight of aggregates = W1

Final weight of aggregates = W2

Calculations:

Loss of weight, % = ((W1 - W2)/W1) x 100

Discussions:

Indian Roads Congress has specified 12 % as the maximum permissible loss in soundness test after 5 cycles with sodium sulphate for the aggregates to be used in bituminous surface dressing, penetration macadam and bituminous macadam construction.

Result:

TRAFFIC VOLUME STUDIES

Theory:

Traffic volume is the number of vehicles crossing a section of Highway per unit time at any selected period. It is used as a quantity measure of flow and the commonly used units are vehicles per day and vehicles per hour.

A complete traffic volume study includes the classified volume study by recording the volume of various types and classes of traffic, their distribution by direction and turning movements and the distribution on different lanes per unit time.

There are variations in traffic flow from time to time. Hourly traffic volume varies considerably during a day, the peak hourly volume may be much higher than the average hourly volume. Daily traffic volumes vary considerably in week and there are variations with season also. In classified traffic volume study, the traffic is classified and the volume of each class of traffic – busses, truck, passenger cars, other light vehicles, rikshaws, tongas, bullock carts, cycles and pedestrians is found separately. The direction of each class of traffic is also to be noted. At intersections the traffic flow in each direction of flow including turning movements are recorded.

COUNTING OF TRAFFIC VOLUME

Traffic volume counts can be done by either mechanical counters or manual.

In mechanical counters, traffic count is recorded by electrically operated counters and recorders capable of recording the impulses.. Other methods of working of mechanical detectors are by photo electric cells, magnetic detector and radar detectors. The main advantage of this type of counters is they can work round the clock for the desired period. The disadvantage of this method is that the impulses caused by the vehicles of light weight may not be enough in some cases to actuate the counter. Also it is not possible to record classified traffic volume data and details of turning movements along with pedestrian traffic.

In manual counters, a field team is employed to record traffic volume on the prescribed record sheets by hand held counters. In this method it is possible to obtain data which cannot be obtained by mechanical counters such as vehicle classification, turning movements and the details regarding loading conditions and number of occupants. However it is not practicable to conduct manual counts round the clock and on all days round the year. Therefore it is necessary to resort to statistical sampling techniques so that we can cut down the manual hours involved in taking complete traffic counts.

First the fluctuations of traffic volume during the hours of the day and the daily variations are observed, than by selecting typical short count periods, the traffic volume study is made by manual counting after that by statistical analysis, the peak hourly traffic volumes as well as the average daily traffic volumes are calculated. This method is most commonly used because of the specific advantages over other methods.

The prescribed record sheet for traffic volume counts is as below. The traffic volume count is done for every 15 minutes period.

Road:					Location:				Date:			
Direction: From……………………….. To ……………………												
Weather condition: Rainy/Sunny/Cold												
Time		Motorized passenger vehicles					Motorized goods vehicles			Human powered vehicles		Total PCUs
From	To	Two wheeler	Three wheelers	Cars/ jeeps	Van/ mini bus	Buses	LCVs	2axle trucks	Multi axle trucks	Cycle	Cycle Rikshaw	

SPEED STUDIES

Theory:

The speed of vehicles over a particular stretch over a particular route may fluctuate widely depending on the following factors such as traffic conditions, pavement conditions, geometric features, time, place, environment, vehicular and driver characteristics.

Spot speed is the instantaneous speed of the vehicle at a specified section or location

Average speed is the average of the spot speeds of all the vehicles passing a given point on the highway.

The average of series of spot speed measurements can be divided into two types – space mean speed and time mean speed.

Space mean speed represents the average speed of vehicles in a certain road length at any time. It can be obtained from the observed travel time of the vehicles over a relatively long stretch of the road. The average travel time of all the vehicles can be obtained from the reciprocal of space mean speed

Time Mean speed represents the speed distribution of vehicles at a point on the road way and is the average of instantaneous speeds of observed vehicles at the spot.

Running speed is the average speed maintained by a vehicle over a particular stretch of road while the vehicle is in motion. This is obtained by dividing the distance covered by the time during which the vehicle is actually in motion.

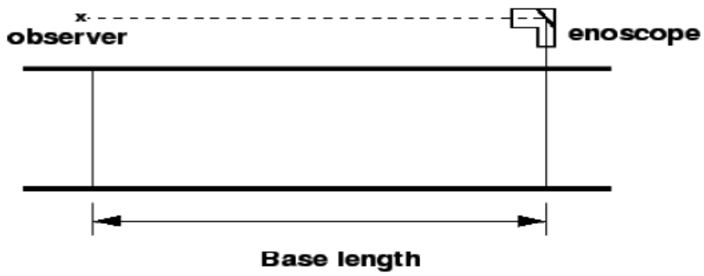
Over all speed / Travel speed is the effective speed with which the vehicle traverses a particular route between two points. This is obtained by dividing the total distance travelled by the total time taken including all delays and stoppages en route.

Procedure

SPOT SPEED STUDY

There are number of methods available to measure the spot speed. The spot speed can be obtained either by finding the running speed of vehicles over a short distance of less than 50m or by finding the instantaneous speed while crossing a section of road depending on the method used. The spot speeds of a few typical sample vehicles are found during the sampling periods of the day, days of the week and months of the year

One of the easiest methods of finding spot speed is by using **'ENOSCOPE'.** An ENOSCOPE comprises of mirror box supported on a tripod stand.



In this method the observer is stationed on one side of the road and starts a stop watch when a vehicle crosses that section AA. An enoscope is placed at a convenient distance of 50m in such a way that the image of the vehicle is seen by the observer when the vehicle crosses the section BB where the enoscope is fixed and at that instant the stop watch is stopped. Thus the time required for the vehicle to cross the known distance is found and is converted to the speed in km/hr [L/T]. the disadvantage of the method is the progress will be slow and it is difficult to spot out typical vehicles and also the number of samples observed will be less. Further there may be a possibility of human error. The other equipment used for spot speed measurement are graphic recorder, electronic meter, photo electric meter, radar, speed meter and photo graphic methods.

SPEED AND DELAY STUDY

The speed and delay studies give the running speeds, Overall speeds, and fluctuation in speeds and the delay between two terminals of a road spaced far apart. They also give the information such as the amount location duration frequency and causes of the delay in the traffic stream. The results of these studies are very much helpful in finding the spots of congestion, causes and to find the suitable remedial measures. The studies are also useful in finding the travel time and in benefit – cost analysis.

There are various methods available for carrying out speed and delay studies. They are floating car or riding check method, license plate or vehicle number method, interview technique, elevated observations and photographic technique.

Floating car method: In this method **a test vehicle** is driven over a given stretch of travel at approximately the average stretch of the stream, thus trying to float with the traffic stream. A number of test runs are made along the study stretch and a group of observers record the required details. One observer is seated in the test car with two stop watches. One of the stop watches is used to record the time at various control points like intersections, bridges or any other fixed points in each trip. The other stop watch is used to find the duration of individual delays. The time, location and cause of these delays is recorded by the second observer either on suitable tabular forms or by voice recording equipment.

The number of vehicles over taking the test vehicle and that over taken by the test vehicle are noted in each trip by a third observer. The number of vehicles travelling in the opposite direction in each trip is noted by a fourth observer. However in mixed traffic flow more number of observers are needed to count the vehicles of different classes.

In this method detailed information is obtained concerning all phase of speed and delay including location, duration and causes of delay.

The average journey time t'(minutes) for all the vehicles in a traffic stream in the direction of flow q is given by $t' = tw - (ny/q)$. and $q = (na + ny)/(ta + tw)$. Where q=flow of vehicles (volume /minute), in one direction of the stream. na = average number of vehicles counted in the direction of the stream when the test vehicle travels in the opposite direction. ny =the average number of vehicles overtaking the vehicle minus the number of vehicles overtaken when the test vehicle is run in the direction of q. tw is the average journey time, in minutes when the test vehicle is travelling with the stream q. ta is the average journey time in minutes when test vehicle is running against the stream q.

ORIGIN AND DESTINATION STUDIES

1. Theory:

The Origin and Destination study is one of the most important studies carried out to

1. Plan the road network and other facilities for vehicular traffic

2. Plan the schedule of different modes of transportation based on the trip demand of the commuters

This study determines their number, their origin and destination in each zone under the study. Further the data may also be supplemented by the number of passengers occupying each vehicle, purpose of each trip, intermediate stops made and reasons etc. this study gives comprehensive information like the actual direction of travel, selection of roads and length of the trip. These studies are very much essential in planning new highway facilities and improving the existing facilities. This study provides the basic data required in determining the desired directions of flow or the **Desire lines**. This is considered to be one of the most important traffic studies needed to solve many traffic problems in a zone and is most important to plan the highway system in a region.

Scientific planning of transportation system and mass transit facilities in urban areas should be based on O & D data of passenger trips. Further the future traffic needs may also be estimated by extrapolating the data from O & D study together with socio economic studies. Various methods for collecting O & D data are

(1) road side interview method

(2) license plate method

(3) return post card method

(4) tag-on –car method

(5) home interview method. The choice of the method is made based on the objective and location.

The various applications of O & D studies are as follows (a) planning new road networks (b) judge adequacy of the present roads (c) planning transportation system and mass transit facilities in urban areas including routes and schedules of operations (d) in locating expressways / major routes along the desire lines (e) arriving at preferential routes on categories of vehicles including by pass (f) in locating terminals and planning new terminal facilities (g) locating bridges (h) locating intermediate stops (j) in establishing design standards for roads, bridges and culverts along the route.

Questions on Traffic Studies

1. The traffic volume is usually expressed in __________
2. The number of vehicles that pass through a transverse line of road at a given time in a specified direction is called __________
3. Which method is more accurate for traffic analysis?
4. The 5 minute count at a traffic junction is 15 find the hourly count?
5. The traffic design in India is based on ________
6. How desire line is drawn
7. The PCU (passenger car unit) value for car on an urban road is
8. What is the first stage in traffic engineering studies?
9. The traffic flow is __________
10. The outgoing and incoming traffic are counted at?

Marshal stability test

Test Procedure of ASTM D6927 - 06 Standard Test:

The apparatus for the Marshall Stability test consists of the following:

1. Specimen mould assembly comprising mould cylinders 10.16 cm diameter by 6.35 cm height, base plate and extension collars.
2. Specimen extractor for extracting the compacted specimen from the mold. A suitable bar is required to transfer load from the extension collar to the upper proving ring attachment while extracting the specimen.
3. Compaction hammer having a flat circular tamping face 4.5 kg sliding weight constructed to provide a free fall of 45 cm.
4. Compaction pedestal consisting of a 20 × 20 × 45 cm wooden block capped with 30 × 30 × 2.5 cm MS plate to hold the mould assembly in position during compaction. Mold holder is provided consisting of spring tension device designed to hold compaction mould in place on compaction pedestal.
5. Breaking head: this consists of upper and lower cylindrical segments or test heads having a inside radius curvature of 5 cm. the longer segment is mounted on a base having two perpendicular guide rods which facilitate insertion in the holes of upper test segment.

Loading Machine:

It is provided with a gear system to lift the upward direction. Pre-calibrated proving ring of 5 tones capacity is fixed on the upper end of the machine, specimen contained in the test head is placed in between the base and the proving ring. The load jack produces a uniform vertical moment of 5 cm per minute. Machine is capable of reversing its moment downward also. This facilitates adequate space for placing test head system after one specimen has been tested.

Flow meter consists of guide, sieve and gauge. The activating pin of the gauge slides inside the guide sleeve with a slight amount of frictional resistance. Least count of 0.025 mm is adequate. The flow value refers to the total vertical upward movement from the initial position at zero loads to value at maximum load. The dial gauge of the flow meter should be able to measure accurately the total vertical moment upward.

In addition to above the following general equipment are also required:

1. Oven or hot plate
2. Water bath
3. Thermometers of range up to 200 °C with sensitivity of 2.5 °C and Miscellaneous equipment like containers, mixing and handling tools etc.

Preparation of Test Specimen

1. 1200 grams of aggregate blended in the desired proportions is measured and heated in the oven to the mixing temperature.
2. Bitumen is added at the mixing temperature to produce viscosity of 170 ± centi-stokes at various percentages.
3. The materials are mixed in a heated pan with heated mixing tools.
4. The mixture is returned to the oven and reheated to the compacting temperature (to produce viscosity of 280±30 centi-stokes).
5. The mixture is then placed in a heated Marshall mould with a collar and base and the mixture is spaded around the sides of the mould. A filter paper is placed under the sample and on top of the sample.
6. The mould is placed in the Marshall Compaction pedestal.
7. The material is compacted with 50 blows of the hammer (or as specified), and the sample is inverted and compacted in the the other face with same number of blows.
8. After compaction, the mold is inverted. With collar on the bottom, the base is removed and the sample is extracted by pushing it out the extractor.
9. The sample is allowed to stand for the few hours to cool.

10. The mass of the sample in air and when submerged is used to measure the density of specimen, so as to allow, calculation of the void properties.

Marshal Test Procedure

Specimens are heated to 60 ± 1 °C either in a water bath for 30 - 40 minutes or in an oven for minimum of 2 hours. The specimens are removed from the water bath or oven and place in lower segment of the breaking head. The upper segment of the breaking head of the specimen is placed in position and the complete assembly is placed in position on the testing machine. The flow meter is placed over one of the post and is adjusted to read zero. Load is applied at a rate of 50 mm per minute until the maximum load reading is obtained. The maximum load reading in Newton is observed. At the same instant the flow as recorded on the flow meter in units of mm was also noted.

CALIFORNIA BEARING RATIO TEST

Theory:

The California Bearing Ratio (CBR) test was developed by the California Division of Highway as a method of classifying and evaluating soil-sub grade and base course materials for flexible pavements. The test is empirical and results cannot be related accurately with any fundamental property of the material. The method of test has been standardized by the ISI also.

The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The test procedure should be strictly followed if high degree of reproducibility is desired. The CBR test may be conducted in re-moulded or undisturbed specimen in the laboratory. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement.

Briefly, the test consists of causing a cylindrical plunger of 50mm diameter to penetrate a pavement component material at 1.25mm per minute. The loads for 2.5mm and 5mm are recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain CBR value. The standard load values were obtained from the average of a large number of tests on different crushed stones and are given in the following table.

Standard Load Values on Crushed Stones for Different Penetration Values

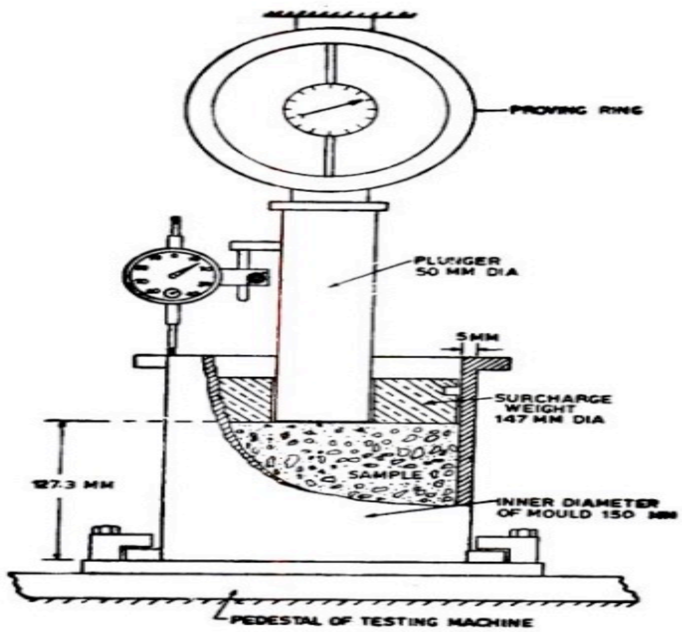
Penetration, mm	Standard Load, kg.	Unit Standard Load, kg/cm^2
2.5	1370	70
5.0	2055	105
7.5	2630	134
10.0	3180	162
12.5	3600	183

LABORATORY C.B.R. TEST VALUES

Specification of Equipment:

a) Loading Machine: Any compression machine which can operate at a constant rate of 1.25mm/minute can be used for this purpose. If such machine is not available then a calibrated hydraulic press with proving ring to measure load can be used (Following Figure). A metal penetration piston or plunger of diameter 50 mm is attached to the loading machine.

Cylindrical Moulds: Moulds of 150mm diameter and 175 mm height provided with a collar of about 50mm length and detachable perforated base are used for this purpose. A spacer disc of 148mm diameter and 47.7mm thickness is used to obtain a specimen of exactly 127.3mm height.



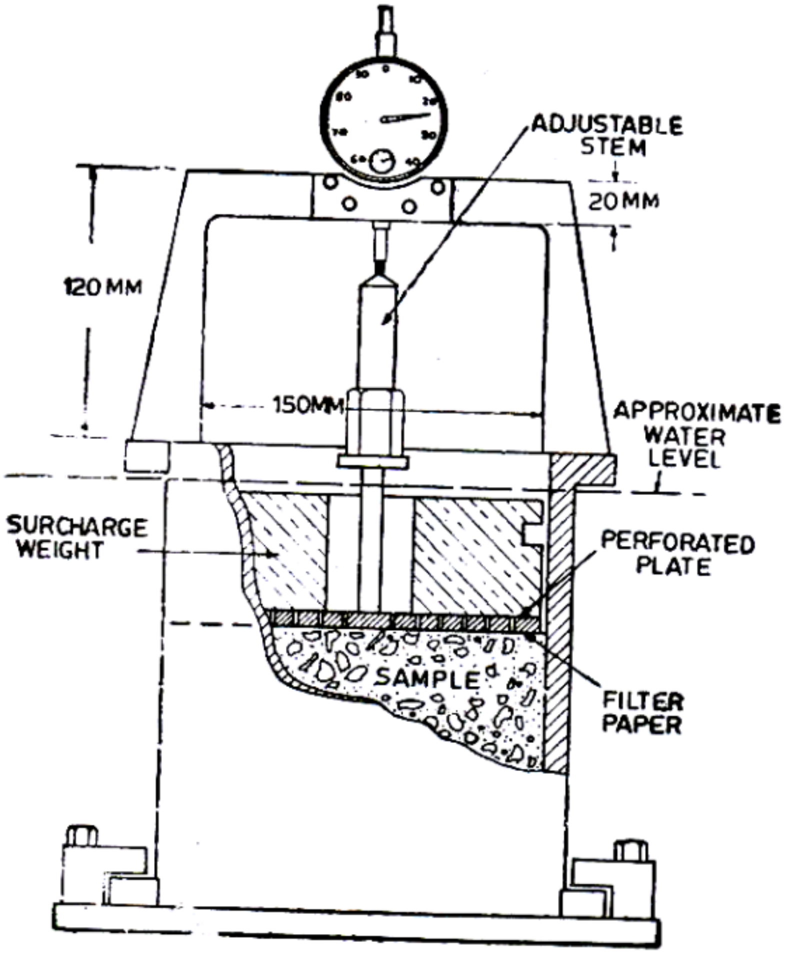
C.B.R. Test Apparatus

c) Compaction Rammer: The Material is usually compacted as specified for the work, either by dynamic compaction or by static compaction. The details for dynamic compaction suggested by the ISI are given in the following table:

Specifications for Dynamic Compaction

Type of compaction	No. of layers	Magnitude of blows		
		Weight of hammer, kg	Fall, cm	Number of blows
Light Compaction	2	2.6	31	56
Heavy Compaction	5	4.89	45	56

d) Adjustable stem, perforated plate, tripod and dial gauge: The standard procedure requires that the soil sample before testing should be soaked in water to measure swelling. For this purpose the above listed accessories are required. See the following diagram for the arrangement.



C.B.R. Mould with Swell Measuring Device

e) Annular weight: In order to simulate the effect of the overlying pavement weight, annular weights each of 2.5kg and 147mm diameter are placed on the top of the specimen, both at the time of soaking and testing the samples, as surcharge.

Besides above equipment, coarse filter paper, sieves, oven, balance etc., are required.

Procedure:

As per the ISI, the CBR test may be performed either on undisturbed soil specimens obtained by fitting a cutting edge to the mould or on re-moulded specimens. Re-moulded soil specimens may be compacted either by static compaction or by dynamic compaction. When static compaction is adopted, the batch of soil is mixed with water to give the required moisture content: the correct weight of moist soil to obtain the desired density is placed in the mould and compaction is attained by pressing in the spacer disc using a compaction machine or jack. The preparation of soil specimens by dynamic compaction or ramming is more commonly adopted and is explained below.

About 45 kg of material is dried and sieved through 20mm sieve. If there is note worthy proportion of materials retained on 20mm sieve, allowance for larger size materials is made by replacing it by an equal weight of material passing 20mm sieve and retained on 4.75mm sieve. The optimum moisture content and maximum dry density of the soil are determined by adopting either IS light compaction (Procter compaction) or IS heavy compaction (modified Procter or modified AASHO compaction) as per the requirement.

Each batch of soil (of at least 5.5kg weight for granular soils and 4.5 to 5.0kg weight for fine grained soils) is mixed with water up to the optimum moisture content or the field moisture content if specified so. The spacer disc is placed at the bottom of the mould over the base plate and a coarse filter paper is placed over the spacer disc. The moist soil sample is to be compacted over this in the mould by adopting either the IS light compaction or the IS heavy compaction.

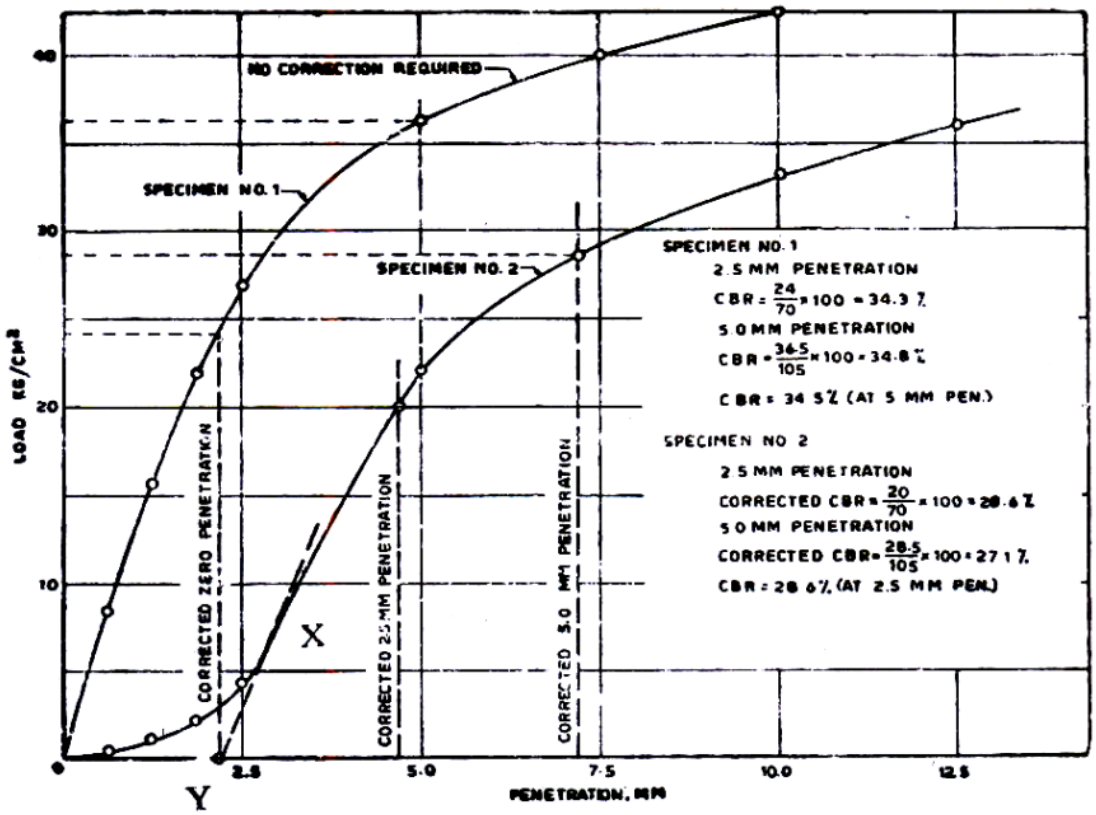
(i) For IS light compaction or Procter compaction, the soil to be compacted is divided into three equal parts, the soil is compacted in three equal layers, each of compacted thickness about 44mm by applying 56 evenly distributed blows of the 2.6kg rammer.

(ii) For IS heavy compaction or the modified Procter compaction, the soil is divided into five equal parts; the soil is compacted in five equal layers, each of compacted thickness about 26.5mm by applying 56 evenly distributed blows of the 4.89kg rammer. After compacting the last layer, the collar is removed and the excess soil above the top of the mould is evenly trimmed off by means of the straight edge. It is important to see if the excess soil to be trimmed off while preparing each specimen is of thickness about 5.0mm; if not the weight of soil taken for compacting each specimen is suitably adjusted for the repeat tests so that the thickness of the excess layer to be trimmed off is about 5.0mm. Any hole that develops on the surface due to the removal of coarse particles during trimming may be patched with smaller size material. Three such compacted specimens are prepared for the CBR test. About 100g of soil samples are collected from each mould for moisture content determination from trimmed off portion.

The clamps are removed and the mould with the compacted soil is lifted leaving below the perforated base plate and the spacer disc which is removed. The mould with the compacted soil is weighed. A filter paper is placed on the perforated base plate, the mould with the compacted soil is inverted and placed in position over the base plate (such that the top of the soil sample is now placed over the base plate) and the clamps of the base plate are tightened. Another filter paper is placed on the top surface of the sample and the perforated plate with adjustable stem is placed over it. Surcharge weights of 2.5 or 5.0 kg weight are placed over the perforated plate and the whole mould with the weights is placed in a water tank for soaking such that water can enter the specimen both from the top and bottom. The swell measuring device consisting of the tripod and the dial gauge are placed on the top edge of the mould and the spindle of the dial gauge is placed touching the top of the adjustable stem of the perforated plate(See the Figure). The initial dial gauge reading is recorded and the test setup is kept undisturbed in the water tank to allow soaking of the soil specimen for four full days or 96 hours. The final dial gauge reading is noted to measure the expansion or swelling of the specimen due to soaking.

The swell measuring assembly is removed, the mould is taken out of the water tank and the sample is allowed to drain in a vertical position for 15 minutes. The surcharge weights, the perforated plate with stem and the filter paper are removed. The mould with the soil sample is removed from the base plate and is weighed again to determine the weight of water absorbed. The mould with the specimen is clamped over the base plate and the same surcharge weights are placed on the specimen centrally such that the penetration test could be conducted. The mould with base plate is placed under the penetration plunger of the loading machine. The penetration plunger is seated at the centre of the specimen and is brought in contact with the top surface of the soil sample by applying a seating load of 4.0kg. The dial gauge for measuring the penetration values of the plunger is fitted in position. The dial gauge of the proving ring (for load readings) and the penetration dial gauge are set to zero. The load is applied through the penetration plunger at a uniform rate of 1.25mm/min. The load readings are recorded at penetration readings of 0.0,0.5,1.0,1.5,2.0,2.5,3.0,4.0,5.0,7.5,10.0 and 12.5mm. In case the load readings start decreasing before 12.5 mm penetration the maximum load value and the corresponding penetration

value are recorded. After the final reading, the load is released and the mould is removed from the loading machine. Theproving ring calibration factor is noted so that the load dial values can be converted into load in kg. About 50g of soil is collected from the top 3cm depth of the soil sample for the determination of moisture content.



C.B.R. Test Load-Penetration Curve

Results:

The expansion ratio of soil due to soaking and the other details of the test may be reported as given in the observation sheet.

The CBR values at 2.5mm and 5.0mm penetrations are calculated for each specimen from the corresponding graphs. Generally the CBR value at 2.5mm penetration is higher and this value is adopted. However, if higher CBR value is obtained as 5.0mm penetration; the test is to be repeated to verify the results; if the value at 5.0mm is again higher, this is adopted as the CBR value of the soil sample. The average CBR value of three specimens is reported to the first decimal place.

According to the IRC, if the maximum variation in the laboratory in CBR values between the three specimens exceeds the values given below for the different ranges, the CBR tests should be repeated on additional three specimens and the average value of six specimens is adopted.

Maximum permissible variation in CBR values, %	Range of CBR values %
3.0	Up to10
5.0	10 to 30
10.0	30 to 60
Not significant	Above 60

Discussion:

Undisturbed soil samples may be used for the CBR test by taking out samples from the field in the mould by attaching a core cutter. Due to high degree of disturbance in sample, this method is generally not adopted.

The CBR test is essentially an arbitrary strength test and hence cannot be used to evaluate the fundamental soil properties. Unless the test procedure is strictly followed, dependable results cannot be obtained. The compaction specifications such as total height of compacted specimen(before trimming off), the equality of thickness of the five compacted layers and the uniformity of distribution, the blows of the rammer in each layer (in the case of dynamic compaction) affect the test results. The initial upward concavity of the load- penetration curve calling for the correction may be due to (i) piston surface not being fully in contact with top of the specimen or (ii) the top layer of the soaked soil being too soft. The test is meant only for soil and granular base course materials and hence may not be suitable for semi-rigid materials like soil-cement.