Terna Public Charitable Trust's
College of Engineering, Osmanabad
Dept. of Civil Engineering

Class:- T.Y.B Tech **Sub:- Transportation Engineering**

INDEX

Sr. No.	Content	Page No.
i.	Determination of Shape Test of Aggregates	02
ii.	Determination of Specific Gravity of Aggregates	08
iii.	Determination of Stripping Value of Aggregate	11
iv.	Determination of Soundness Test of Aggregate	13
v.	Determination of CBR Test on soil and Aggregate	16
vi.	Determination of Penetration Value of bitumen	20
vii.	Determination of Softening Point of Bitumen	24
viii.	Determination of Flash & Fire Point Test for Bituminous Sample	27
ix.	Determination of Ductility of Bitumen	32
x.	Determination of Viscosity of Bituminous Material	36
xi.	Determination of Specific Gravity of Bituminous Sample	40
xii.	Determination of Marshall Stability Test	42
xiii.	Pavement design exercise based on flexible pavement consisting of bituminous concrete	50
xiv.	Visit to road construction site for studying different construction equipments.	53
3	Quiz	56
4	Conduction of Viva-Voce Examinations	61
5	Evaluation and marking system	62

Experiment No. 01

Shape Test

A. FLAKINESS INDEX

AIM:

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

THEORY:

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

APPARATUS:

The apparatus shall consist of the following:

1) A balance – The balance shall be of sufficient capacity and sensitivity and shall have an accuracy of 0.1 percent of the weight of the test sample
2) Metal Gauge – The metal gauge shall be of the pattern as shown in Fig. 1.1.
3) Sieves – The sieves of sizes as shown in Table 1.1.

PROCEDURE:

1) A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
2) The sample shall be sieved with sieves specified in Table 1.1.
3) Then each fraction shall be gauged in turn for thickness on a metal gauge of the pattern shown in Fig 1.1 or in bulk on sieves having elongated slots. The width of the slot used in the gauge or sieve shall be of the dimensions specified in column 3 of Table 1.1 for the appropriate size of material.
4) The total amount of aggregate passing the gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

Table No.1.1 Dimensions of Thickness and Length gauge

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

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

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

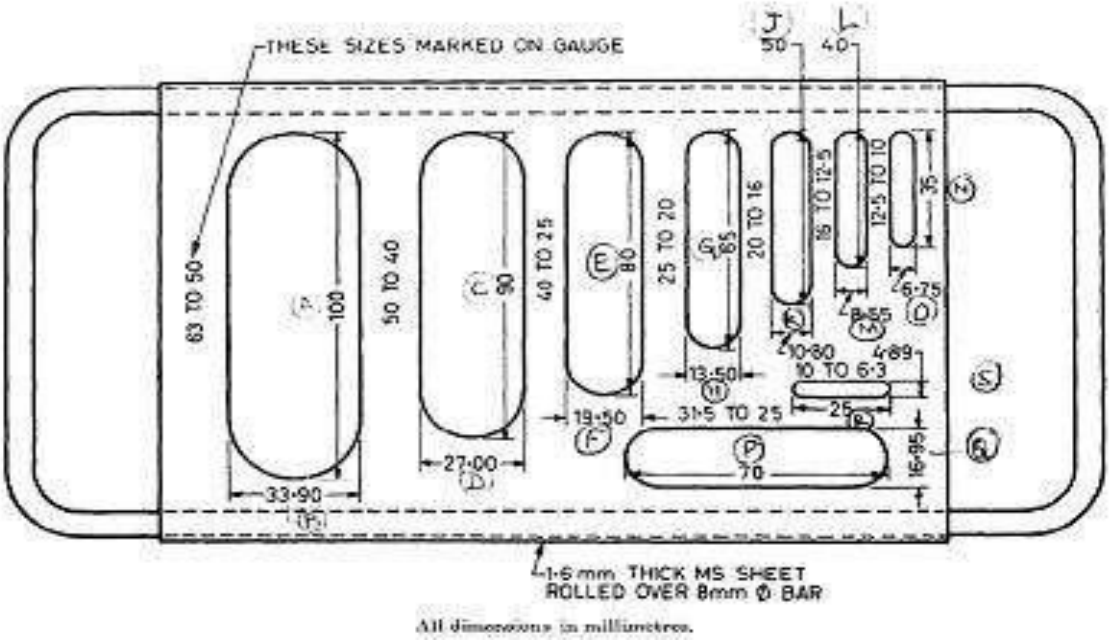


Fig 1.1. THICKNESS GAUGE

OBSERVATION TABLE:

SIZE OF AGGREGATE (mm)		THICKNESS GAUGE(mm)	Wt. of fraction containing at least 200 pieces W (gm)	Wt. of fraction passing the thickness gauge (w) (gm)
Passing through IS sieve	Retained on IS sieve			
63	50	33.90		
50	40	27.00		
40	31.5	19.50		
31.5	25	16.95		
25	20	13.50		
20	16	10.80		
16	12.5	8.55		
12.5	10	6.75		
10	6.3	4.89		

CALCULATION:

—

—

Where, w is the weights of material passing the various thickness gauges and W is the total weights of aggregate containing at least 200 pieces.

REPORTING OF RESULTS:

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

RESULT

Flakiness index = %

B. ELONGATION INDEX

AIM:

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

THEORY:

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

APPARATUS:

The apparatus shall consist of the following:

1) A balance – The balance shall be of sufficient capacity and sensitivity and shall have an accuracy of 0.1 percent of the weight of the test sample.
2) Metal Gauge – The metal gauge shall be of the pattern as shown in Fig. 1.2.
3) Sieves – The sieves of sizes as shown in Table 1.2.

PROCEDURE:

1) A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
2) The sample shall be sieved with sieves specified in Table 1.2.
3) Each fraction shall be gauged in turn for length on a metal gauge of the pattern shown in Fig 1.2. The gauge length used shall be of the dimensions specified in column 4 of Table1.2 for the appropriate size of material.
4) The total amount of aggregate retained by the length gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

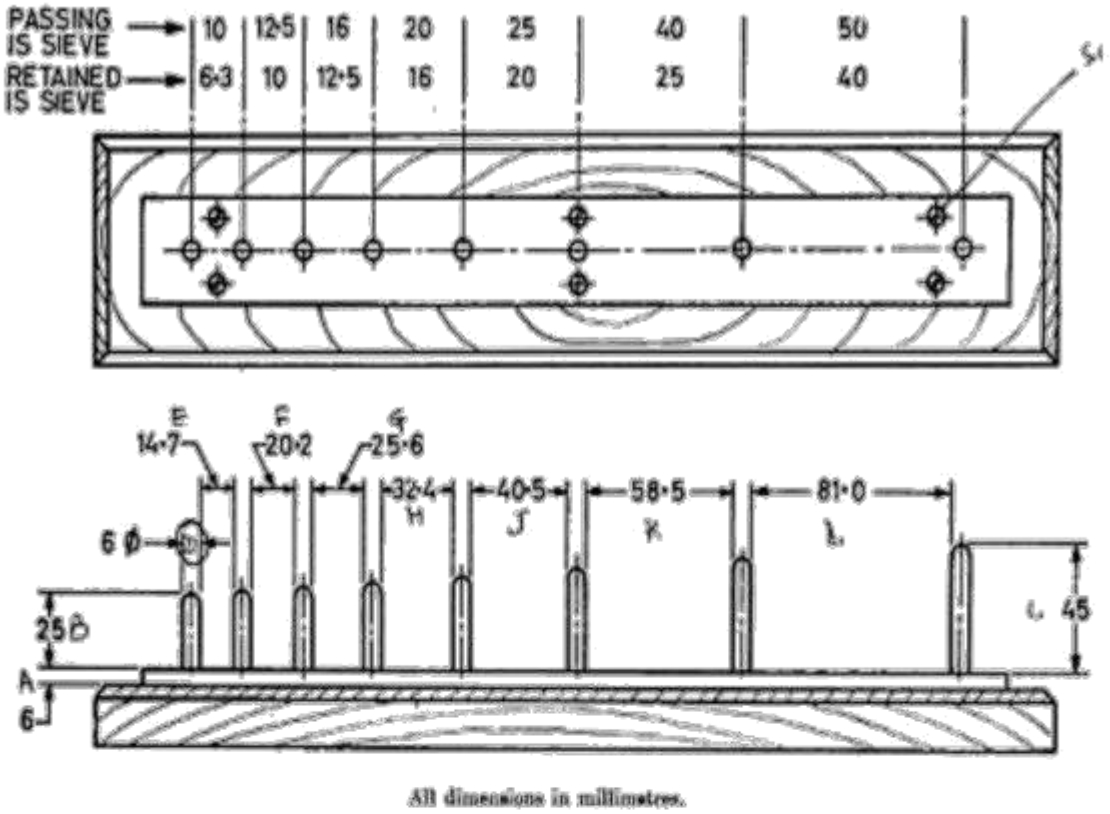


Fig 1.2. LENGTH GAUGE

OBSERVATION TABLE:

SIZE OF AGGREGATE (mm)		LENGTH GAUGE(mm)	Wt. of fraction containing at least 200 pieces W (gm)	Wt. of pieces retained on the length gauge w (gm)
Passing through IS sieve	Retained on IS sieve			
63	50	-		
50	40	81.0		
40	31.5	58.5		
31.5	25	-		
25	20	40.5		
20	16	32.4		
16	12.5	25.6		
12.5	10	20.2		
10	6.3	14.7		

CALCULATION:

—

Where, w is the weight of materials retained on length gauge. W is the total weights of aggregate containing at least 200 pieces.

REPORTING OF RESULTS:

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

RESULT

Elongation index = %

CONCLUSION:

Experiment No. 02

Specific Gravity And Water Absorption Tests of Aggregates

AIM: To determine the specific gravity and water absorption of the given aggregate.

THEORY:

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Aggregates having low specific gravity are generally weaker than those with high specific gravity. This property helps in a general identification of aggregates.

Water absorption also gives an idea on the internal structure of aggregate. Aggregates having more absorption are more porous in nature and are generally considered unsuitable, unless found to be acceptable based on strength, impact and hardness tests.

APPARATUS:

The apparatus required for these tests are:

1) A balance of at least 3 kg capacity, with a accuracy to 0.5 g.
2) An oven to maintain a temperature range of 100 to 110^0 C.
3) 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.
4) A container for filling water and suspending the wire basket in it.
5) An airtight container of capacity similar to that of basket, a shallow tray and two dry absorbent clothes.
6) Pycnometer of 100ml for aggregates finer than 6.3 mm and Specific gravity bottle.

PROCEDURE FOR AGGREGATE COARSER THAN 6.3 mm:

1) About 2 kg of aggregate sample is taken, washed to remove fines and then placed in the wire basket. The wire basket is then immersed in water, which is at a temperature of 22^0 C to 32^0 C.
2) Immediately after immersion the entrapped air is removed from the sample by lifting the basket 25 mm above the base of the tank and allowing it to drop, 25 times at a rate of about one drop per second.
3) The basket, with aggregate are kept completely immersed in water for a period of 24 ± 0.5 hour.
4) The basket and aggregate are weighed while suspended in water, which is at a temperature of 22^0 C to 32^0 C.
5) The basket and aggregates are removed from water and dried with dry absorbent cloth.
6) The empty basket is suspended back in water tank and weighed.
7) The surface dried aggregates are also weighed.

8) The aggregate is placed in a shallow tray and heated to about 110 ^{0}C in the oven for 24 hours. Later, it is cooled in an airtight container and weighed.

PROCEDURE FOR SPECIFIC GRAVITY OF AGGREGATE FINER THAN 6.3 mm:

1) A clean, dry pycnometer is taken and its empty weight is determined.
2) About 1000g of clean sample is taken into the pycnometer, and it is weighed.
3) Water at 27 ^{0}C is filled up in the pycnometer with aggregate sample, to just immerse sample.
4) Immediately after immersion the entrapped air is removed from the sample by shaking pycnometer, placing a finger on the hole at the top of the sealed pycnometer.
5) Now the pycnometer is completely filled up with water till the hole at the top, and after confirming that there is no more entrapped air in it, it is weighed.
6) The contents of the pycnometer are discharged, and it is cleaned.
7) Water is filled up to the top of the pycnometer, without any entrapped air. It is then weighed.
8) For mineral filler, specific gravity bottle is used and the material is filled upto one-third of the capacity of bottle. The rest of the process of determining specific gravity is similar to the one described for aggregate finer than 6.3 mm.

OBSERVATION TABLE:

1. Aggregate coarser than 6.3 mm

Sr.No	**Details**	**Observed Values**
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 aggregates in air: W_3 g	
4	Weight of oven dry aggregates in air: W_4 g	
5	Apparent Specific Gravity: $W_4 / [W_4 – (W_1 - W_2)]$	
6	Bulk Specific Gravity: $W_4 / [W_3 – (W_1 - W_2)]$	
7	Water Absorption: $[(W_3 – W_4) \times 100]/ W_4$	

2. Aggregate of size finer than 6.3 mm

Sr.No	Details	Observed Values
1	Weight of Pycnometer in air: W_1 g	
2	Weight of aggregates and Pycnometer: W_2 g	
3	Weight of aggregates, Pycnometer and water: W_3 g	
4	Weight of water and Pycnometer in air: W_4 g	
5	Apparent Specific Gravity: $(W_2 - W_1) / [(W_4 - W_1) - (W_3 - W_2)]$	

RESULTS:

Bulk Specific Gravity =

Apparent Specific Gravity =

Water Absorption = %

Apparent Specific Gravity (Aggregate of size finer than 6.3 mm) =

SPECIFICATIONS:

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. Water absorption value ranges from 0.1 to about 2.0 percent for aggregates normally use in road surfacing.

APPLICATIONS:

Specific gravity of aggregates is considered as an indication of strength. Material having higher specific gravity is generally considered as having higher strength. Water absorption of aggregate is a measure of porosity. This value is considered as a measure of resistance to frost action, and as a measure of sustaining weathering action.

CONCLUSION:

Experiment No. 03

Determination of Stripping Value of Aggregate

AIM:

1) To determine the stripping value of aggregates used in road construction.
2) To ascertain the suitability of road aggregates for bituminous road construction.

THEORY:

This test is conducted to determine the effects of moisture upon the adhesion of the bituminous film to the surface particles of the aggregate. This test is of significant value to ascertain the suitability of the two materials i.e. bitumen (binder) and aggregates, because one particular aggregate may be satisfactory with one binder and unsatisfactory with another; and the same being true for the binders. The specifications of Ministry of Transport and Shipping recommend the determination of stripping value by the static immersion method in accordance with IS:6241-1971.

APPARTUS:

1) Thermostatically controlled water bath.
2) Beakers of capacity 500 ml.

PROCEDURE:

The aggregate sample: The test sample consists of aggregate of size passing 25mm sieve and retained on 12.5mm.

1) Obtain the material that passes through 25mm sieve and is retained on 12.5mm sieve.
2) Dry, clean and heat the binder and aggregates to 150-175ºC and 120-150ºC respectively and mix with 5percent binder by weight of aggregate.
3) After complete coating, allow the mixture to cool at room temperature in clean dry beaker.
4) Add distilled water to immerse the coated aggregates.
5) Cover the beaker and keep it undisturbed in a thermostatic water bath at a temperature of 40ºC for a period of 24 hours.
6) Estimate the extent of stripping by visual examination while the specimen is still under water and express as the average percent area of aggregate surface uncoated.

Note: Three samples may be tested simultaneously so as to arrive at an average value. The stripping value is expressed to the nearest whole number.

PRECAUTIONS:

1) The aggregate should be thoroughly dried before mixing with binder.
2) Distilled water should be used for the test.
3) Mix-up of the two separate samples should be uniform.

OBSERVATION TABLE:

	Sample I (%)	**Sample II (%)**	**Sample III (%)**
Percentage of area of aggregate uncoated by immersion in water			

Average stripping value = %

RESULT:

The Stripping value of aggregate =

CONCLUSION:

Experiment No. 04

Determination of Soundness Test of Aggregate

AIM: To determine soundness of aggregate sample used in road construction.

THEORY:

This method covers the testing of aggregates to determine their resistance to disintegration in saturated solutions of magnesium sulphate. It furnishes information helpful in judging the sound-ness of aggregates subject to weathering action, particularly when adequate information is not available from service records.

APPARTUS:

1. SULPHATE TANK: A suitably constructed three-compartment tank, one compartment for solution make-up, one for the test solution, and the third for washing the completed test samples. The test solution compartment shall contain suitable refrigeration and heating units capable of controlling the temperature of the magnesium sulphate solution within ±1.0°C of the required temperature.

Note 1: Immersion type mercury contact thermo-regulators reading to 0.05°C controlling Jumo electronic relays are suitable for this purpose.

2. SIEVES: With square openings of the following sizes conforming to OPSS specifications, Table 4.1.

Table 4.1

Coarse Series	Fine Series
4.75 mm	300 µm
9.50 mm	600 µm
13.2 mm	1.18 mm
16.0 mm	2.36 mm
19.0 mm	4.75 mm

3. WIRE BASKETS: For immersing the samples of aggregates in the solution. The baskets shall bear a number or other means of identification. The baskets shall be made of copper wire or stainless steel and of appropriate mesh size for the aggregate under test (19 - 9.5 mm aggregate use sieve mesh 6.7 mm, 9.5 - 4.75 mm aggregate use sieve mesh 2.36 mm).

4 BALANCES: For fine aggregate, a balance or scale accurate within 0.1 g over the range required for this test; for coarse aggregate, a balance or scale accurate within 0.1% or 1 g, whichever is greater, over the range required for this test.

5 MECHANICAL CONVECTION OVEN: The oven shall be capable of being continuously heated at 110 ± 5.0°C, and the rate of evaporation at this range of temperature shall be at least 25 g/h for 4 h, during which period the doors of the oven shall be kept closed. This rate shall be determined by the loss of water from 1-litre Griffin low-form beakers, each initially containing 500 g of water at a temperature of 21 ± 2.0°C, placed at each corner and the centre of each shelf of the oven. The evaporation requirement is to apply to all test locations when the oven is empty except for the beakers of water.

6 HYDROMETER: Capable of determining the relative density of the test solution

PROCEDURE:

1) COARSE AGGREGATE: Place the 9.5 mm to 4.75 mm fraction in a suitable wire basket. Place the combined 19.0 mm to 9.5 mm fraction in another wire basket. Place combined fractions larger than 19 mm in one or more baskets as required.

2) STORAGE OF SAMPLES IN SOLUTION: Immerse the samples in the prepared solution of magnesium sulphate for not less than 16 h or more than 18 h in such a manner that the solution covers them to a depth of at least 15 mm. Maintain the samples immersed in the solution at a temperature of 21 ± 1.0°C for the immersion period. The volume of solution shall be at least 20 times greater than the total sample volume.

3) DRYING SAMPLES AFTER IMMERSION: After the immersion period, remove the samples from the solution, drain for 30 ± 5 min., and place in drying oven. Dry at 110 ± 5.0°C until constant mass has been achieved, usually 6 to 8 h. Drying time may be established as follows: with oven containing the maximum sample load expected, check the loss in mass of samples by removing and weighing them in the baskets, without cooling, at intervals of 2 to 4 h. Make enough checks to establish required drying time for the least favorable oven location and sample condition. Constant mass will be considered to be achieved when the loss is less than 0.1% of sample mass in 4 h of drying. When constant mass is achieved, allow samples to cool to room temperature and immerse in solution.

OBSERVATION TABLE:

Basket No.	**Due date**	**Grading**	**Mass retained on**			
			300 micron	1.18 mm	2.36 mm	4.75 mm

CALCULATION:

$$\text{percent loss} = \frac{\text{original mass - mass retained after test}}{\text{original mass}} \times 100$$

RESULT:

The Soundness of aggregate =

CONCLUSION:

Experiment No. 05

Determination of CBR Test on Soil and Aggregate

AIM: To determine CBR value of aggregate sample used in road construction.

THEORY:

CBR is the ratio expressed in percentage of force per unit area required to penetrate a soil mass with a standard circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material. The ratio is usually determined for penetration of 2.5 and 5 mm . When the ratio at 5 mm is consistently higher than that at 2.5 mm, the ratio at 5 mm is used.

The following table gives the standard loads adopted for different penetrations for the standard material with a C.B.R. value of 100%.

Penetration of Plunger (mm)	Standard Load (kg)
2.5	1370
5.0	2055

Table 5.1 : Standard Load Values at Penetration

For Railway Formation purpose, the test is performed on remoulded specimens which are compacted dynamically.

The methodology covers the laboratory method for the determination of C.B.R. of remoulded /compacted soil specimens in soaked state.

APPARATUS:

1) Consisting of Loading machine with capacity of atleast 5000 kg and equipped with a movable head or base which enables Plunger of 50 mm dia. to penetrate into the specimen at a rate of 1.25 mm/ minute.
2) Cylindrical mould: Inside dia. 150mm and height 175mm with a detachable perforated base plate of 235mm dia. and 10mm thickness. Net capacity - 2250 ml; conforming to IS-9669:1980 (Reaffirmed-2016).
3) Collar - A detachable extension collar of 60 mm height.
4) Spacer Disc 148 mm in diameter and 47.7 mm in height along with handle.
5) Weights -One annular metal weight and several slotted weights weighing 2.5 kg each, 147 mm in diameter, with a central hole 53 mm in diameter.
6) Compaction Rammer Weight - 4.89 kg with a drop 450 mm.

CBR Test Apparatus

PROCEDURE:

1) Remoulded specimen: The test material should pass 19 mm IS sieve and retained on 4.75 mm IS sieve. The dry density for a remoulding shall be either the field density or the value of the maximum dry density estimated by the compaction test (Heavy Compaction Test as per IS 2720 (Part-8) - 1983, for Railway Formation). The water content used for compaction shall be the optimum water content or the field moisture as the case may be.
2) Dynamic Compaction: A representative sample of the soil weighing approximately 4.5 kg or more for fine grained soil and 5.5 kg or more for granular soil shall be taken and mixed thoroughly with water. If the soil is to be compacted to the maximum dry density at the optimum moisture content, the exact mass of the soil required shall be taken and the necessary quantity of water added so that the water content of the soil sample is equal to the determined optimum moisture content.
3) Fix the extension collar and the base plate to the mould. Insert the spacer disc over the base. Place the filter paper on the top of the spacer disc.
4) Apply Lubricating Oil to the inner side of the mould. Compact the mix soil in the mould using heavy compaction. i.e. compact the soil in 5 layers with 55 blows to each layer by the 4.89 kg rammer.
5) Remove the extension collar and trim the compacted soil carefully at the level of top of mould, by means of a straight edge. Any holes developed on the surface of the compacted soil by removal of the coarse material, shall be patched with the smaller size material. Remove the perforated base plate, Spacer disc and filter paper and record the mass of the mould and compacted soil specimen. Place a disc of coarse filter paper on the perforated base plate, invert the mould and compacted soil and clamp the perforated base plate to the mould with the compacted soil in contact with the filter paper.
6) Place a filter paper over the specimen and place perforated plate on the compacted soil specimen in the mould. Put annular weights to produce a surcharge equal to weight of base material and pavement, to the nearest 2.5 kg.
7) Immerse the mould assembly and weights in a tank of water and soak it for 96 hours. Mount the tripod for expansion measuring device on the edge of the mould and record initial dial gauge reading. Note down the readings every day against time of reading. A constant water level shall be maintained in the tank throughout the period.

8) At the end of soaking period, note down the final reading of the dial gauge and take the mould out of water tank.

9) Remove the free water collected in the mould and allow the specimen to drain for 15 minutes.
10) Remove the perforated plate and the top filter paper. Weigh the soaked soil sample and record the weight.

Procedure For Penetration Test

1) Place the mould assembly with test specimen on the lower plate of penetration testing machine. To prevent upheaval of soil into the hole of the surcharge weights, 2.5 kg annular weight shall be placed on the soil surface prior to seating the penetration plunger after which the remainder of the surcharge weights shall be placed.
2) Seat the penetration piston at the center of the specimen with the smallest possible load, but in no case in excess of 4 kg so that full contact of the piston on the sample is established.
3) Set the load and deformation gauges to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/min.
4) Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 4.0, 5.0, 7.5, 10 and 12.5 mm.
5) Raise the plunger and detach the mould from the loading equipment. Take about 20 to 50 g of soil from the top 30 mm layer and determine the moisture content.

OBSERVATION TABLE:

Penetration(mm)	Applied Load (kg)
0.50	
1.00	
1.50	
2.00	
2.50	
4.00	
5.00	
7.50	
10.00	
12.50	

CALCULATION:

1. If the initial portion of the curve is concave upwards, apply correction by drawing a tangent to the curve at the point of greatest slope and shift the origin. Find and record the correct load reading corresponding to each penetration.

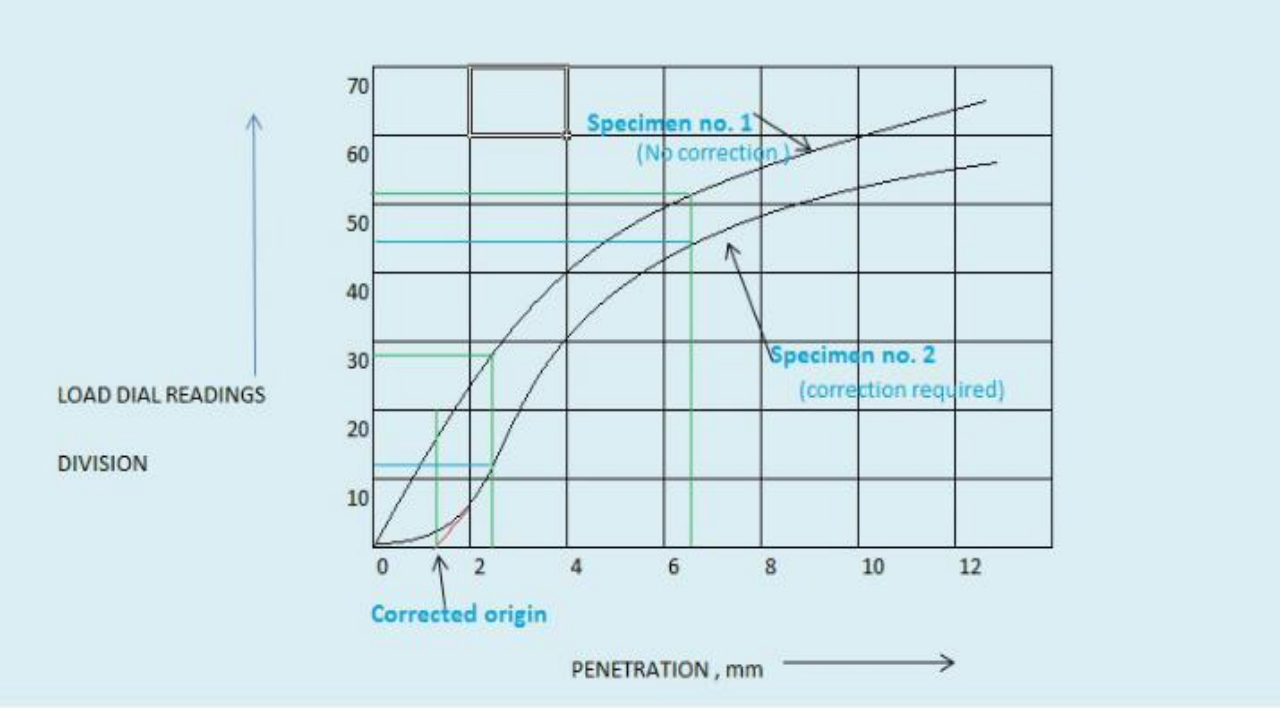
$$\textbf{C.B.R.} = (P_T/P_S) \times 100$$

where P_T = Corrected test load corresponding to the chosen penetration from the load penetration curve.
P_S = Standard load for the same penetration taken from the table above.

2. C.B.R. of specimen at 2.5 mm penetration =
3. C.B.R. of specimen at 5.0 mm penetration =
4. The C.B.R. values are usually calculated for penetration of 2.5 mm and 5 mm. Generally the C.B.R. value at 2.5 mm will be greater than at 5 mm and in such a case/the former shall be taken as C.B.R. for design

purpose. If C.B.R. for 5 mm exceeds that for 2.5 mm, the test should be repeated. If identical results follow, the C.B.R. corresponding to 5 mm penetration should be taken for design.

GRAPH: Draw graph between Load versus Penetration



RESULT:

The CBR Value of sample is

CONCLUSION:

Experiment No. 06

Determination of Penetration Value of bitumen

AIM: To determine the consistency of bituminous material

THEORY:

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

APPARATUS:

1) Container: A flat bottomed cylindrical metallic dish 55 mm in diameter and 35 mm in depth is required. If the penetration is of the order of 225 or more deeper dish of 70 mm diameter and 45 mm depth is required.
2) Needle: A straight, highly polished, cylindrical hard steel rod, as per standard dimensions.
3) Water bath: A water bath maintained at 25.0±0.1 ^{0}C containing not less than 10 liters of water, the sample being immersed to a depth not less than 100 mm from the top and supported on a perforated shelf not less than 50 mm from the bottom of the bath.
4) Transfer dish or tray: It should provide support to the container and should not rock the container. It should be of such capacity as to completely immerse the container during the test.
5) Penetration apparatus: It should be such that it will allow the needle to penetrate without much friction and is accurately calibrated to give results in one tenth of a millimeter.
6) Thermometer: Range 0- 44 ^{0}C and readable up to 0.2 ^{0}C
7) Time measuring device: With an accuracy ± 0.1 sec

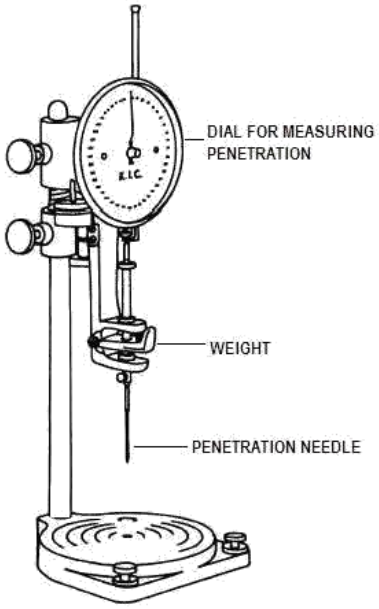


Fig 6.1. PENETROMETER

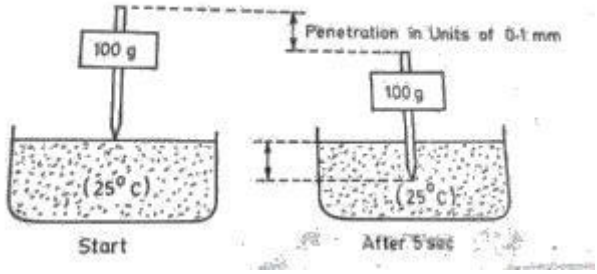


Fig 6.2. Penetration Test Concept

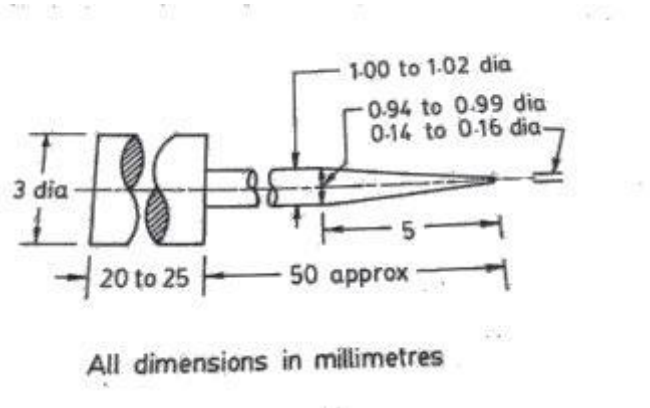


Fig 6.3. Penetration Needle

PROCEDURE:

1) Preparation of test specimen: Soften the material to a pouring consistency at a temperature not more than 60^0C for tars and 90^0C for bitumen's above the approximate softening point and stir it thoroughly until it is homogeneous and is free from air bubbles and water. Pour the melt into the container to a depth at least 10 mm in excess of the expected penetration. Protect the sample from dust and allow it to cool in an atmosphere at a temperature between 15 to 30^0C for one hour. Then place it along with the transfer dish in the water bath at 25 $\pm 0.1^0$C for one and one and half hour, unless otherwise stated.

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

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

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

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

6) Release the needle for exactly five seconds

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

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

PRECAUTIONS:

1) There should be no movement of the container while needle is penetrating into the sample.

2) The sample should be free from any extraneous matter.

3) The needle should be cleaned with benzene and dried before each penetration.

OBSERVATION TABLE:

Actual Test Temperature =

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

Mean Penetration value =

RESULT:

Penetration value of given sample is =

CONCLUSION:

Experiment No. 07

Determination of Softening Point of Bitumen

AIM: To determine the softening point of bitumen or tar.

THEORY:

The softening point of bitumen or tar is the temperature at which the substance attains a particular degree of softening. As per IS:334-1982, it is the temperature (in ^{o}C) at which a standard ball passes through a sample of bitumen in a mould and falls through a height of 2.5 cm, when heated under water or glycerin at specified conditions of test. The binder should have sufficient fluidity before its applications in road uses. The determination of softening point helps to know the temperature up to which a bituminous binder should be heated for various road use applications. Softening point is determined by ring and ball apparatus.

APPARATUS:

1) Steel balls-two numbers each of 9.5 mm dia. and weighing $\pm$ 0.05g.
2) Brass rings-two numbers each having depth of 6.4 mm. The inside diameter at bottom and top is 15.9 mm and 17.5 mm respectively.
3) Ball guides to guide the movement of steel balls centrally.
4) Support- that can hold rings in position and also allows for suspension of a thermometer. The distance between the bottom of the rings and the top surface of the bottom plate of the support is 25 mm.
5) Thermometer that can read up to 100 ^{o}C with an accuracy of 0.2 ^{o}C
6) Bath- A heat resistant glass beaker not less than 85 mm in diameter and 1220 mm in depth.
7) Stirrer.

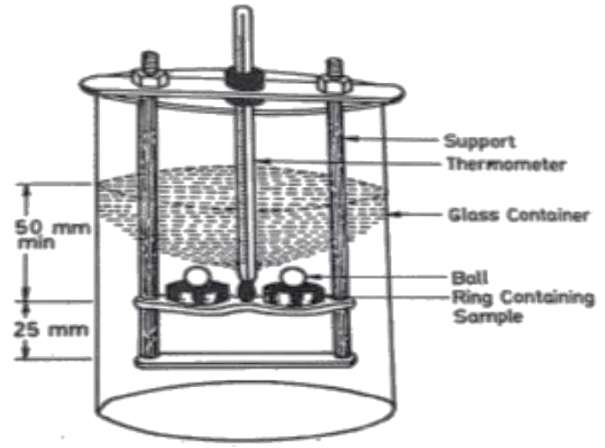


Fig 7.1. Ring and Ball Apparatus

PROCEDURE:

1) Preparation of test sample: Heat the material to a temperature between 75-100 ^{0}C above its softening point stir until, it is completely fluid and free from air bubbles and water. If necessary filter it through IS Sieve 30. Place the rings, previously heated to a temperature approximating to that of the molten material, on a metal plate which has been coated with a mixture of equal parts of glycerin and dextrin. After cooling for 30 minutes in air, level the material in the ring by removing the excess with a warmed, sharp knife.
2) Assemble the apparatus with the rings, thermometer and ball guides in position.
3) Fill the bath with distilled water to a height of 50 mm above the upper surface of the rings. The starting temperature should be 5 ^{o}C.

   Note: Use glycerin in place of water if the softening point is expected to be above 80 ^{o}C the starting temperature may be kept 35 ^{o}C.
4) Apply heat to the bath and stir the liquid so that the temperature rises at a uniform rate of 5±0.5 ^{o}C per minute.
5) As the temperature increases the bituminous material softens and the ball sinks through the ring, carrying a portion of the material with it.
6) Note down the temperature when any of the steel ball with bituminous coating touches the bottom plate.
7) Record the temperature when the second ball also touches the bottom plate. The average of the two readings to the nearest 0.5 ^{o}C is reported as the softening point.

PRECAUTIONS:

1) Distilled water should be used as the heating medium.
2) During the conduct of test the apparatus should not be subjected to vibrations.
3) The bulb of the thermometer should be at about the same level as the rings.

OBSERVATION TABLE:

Temperature when the ball touches bottom in C	Test 1	Test 2	Average

Softening point of the bituminous material =

RESULT:

The softening point of given sample is =

CONCLUSION:

Experiment No. 8

Flash & Fire Point Test for Bituminous Sample

AIM: To determine the flash and fire point for the given bituminous sample.

THEORY:

The flash point of a material is the lowest temperature at which the application of test flame causes the vapours from the material momentarily catches fire in the form of a flash under specified conditions of test. The fire point is the lowest temperature at which the application of test flame causes the material to ignite and burn at least for 5s under specified conditions of test.

At high temperatures, bituminous materials emit hydrocarbon vapours which are susceptible to catch fire. Therefore the heating temperature of bituminous material should be restricted to avoid hazardous conditions. Flash point and Fire Point tests are used to determine the temperature to which bituminous material can safely be heated.

APPARATUS:

The apparatus as per IS: 1209-1978 consists of :

1) Pensky-Marten tester consisting of the following major parts:

a) **Cup:** It is made of brass, the inside of the cup may be turned to a slightly larger diameter above the filling mark and the outside may be tapered above the flange. The flange is about 12mm in width and approximately 3mm in thickness. It is equipped with devices for locating the position of the lid o the cup and the cup itself in the stove. A handle is attached to the flange o f the cup.

b) **Lid:** it includes a stirring device, cover proper, shutter and flame exposure device. The stirring device consists of a vertical steel shaft of 2.5mm to 3mm diameter and mounted in the center of the cup. It carries two bladed brass propellers. Cover is made of brass and fits the outside of the cup closely. It has four Openings as shown in following fig.

Opening A has an area defined by area of two concentric circles. Openings B and C are of equal areas and approximately half the angular width of opening A. Opening D is provided to grip the thermometer collar.

Shutter 2.5mm thick and made of brass. It is so shaped and mounted that it rotates on the axis of the horizontal center of the lid. On one extreme position, these orifices are completely opened.

Flame exposure device having a tip with an opening 0.7 to 0.8 mm in diameter. The device is equipped with an operating mechanism which, when the shutter is in open position, depresses the tip so that the center of orifice is between the planes of the under and the

upper surfaces of the lid proper. A pilot flame for automatic relighting of the exposure flame should be provided.

c) Stove: It consists of an air bath and a top plate on which the flange of the cup rests. Air bath has a cylindrical interior; 41.3 to 42.2mm in depth. The air bath may be either a flame heated metal casting or an electric resistance element. The top plate is made of metal and it can be attached to the air bath with the help of three screws in such a manner to leave an air gap.

d) **Thermometers**: For low range values, it has measurement range from -7ºC to 110ºC and readable up to 0.5ºC. For expected higher values of flash and fire point, thermometer having a range of 90º to 370º and readable to 2ºC should be used.

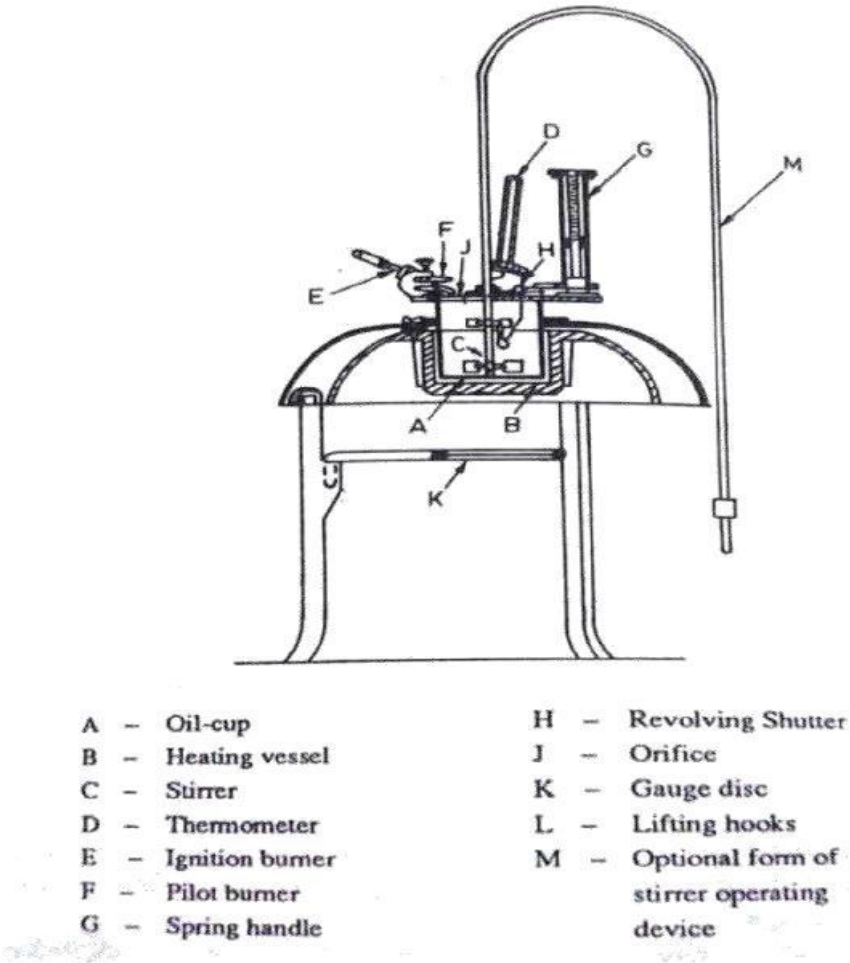


Fig. 8.1 Pensky-Martens closed Tester

PROCEDURE:

A. FOR BITIMEN OTHER THAN CUT BACK BITUMEN

1) Clean and dry all parts of the cup and its accessories thoroughly.
2) Fill the cup with the material to be tested up to the level indicated by the filling mark.
3) Place the lid on the cup and set the latter in the stove.
4) Insert the thermometer.
5) Light and adjust the test flame so that it is of the size of bead of 4mm in diameter. Apply heat such that the temperature rises at a rate of 5º to 6ºC per minute.
6) Turn the Stirrer at a rate of approximately 60 revolutions per minute. Apply the test-flame by operating the device controlling the shutter and test flame burner so that the flame is lowered in 0.5 second, left in its lowered position for one second, and quickly raised to its high position. Discontinue stirring during the application of the test flame.
7) Apply the test flame initially at a temperature 17ºC below the expected flash point. Therefore apply the test flame at an interval of 1ºC for the range above 104ºC. For the temperature range above 104ºC increase this interval to 2ºC.
8) Note down the flash point as the temperature at which the flame application causes a distinct flash in the interior of the cup.

The duplicate test results should not differ by more than the following:

Flash point range	Repeatability	Reproducibility
104ºC and below	2ºC	3.5ºC
Above 104ºC	5.5ºC	8.5ºC

B. FOR CUT-BACK BITUMEN

1) Fill the cup with the material to be tested.
2) Completely fill the air space between the cup and the interior of the air bath with water having the same temperature as of the material.
3) Light and adjust the test flame so that it is of the size of bead of 4mm in diameter. Apply heat such that the temperature rises at a rate of 1º to 1.5ºC per minute.
4) Turn the Stirrer at a rate of approximately 70-80 revolutions per minute. Apply the test-flame by operating the device controlling the shutter and test flame burner so that the flame is lowered in 0.5 second, left in its lowered position for one second, and quickly raised to its high position. Discontinue stirring during the application of the test flame.

5) Apply the test flame initially at a temperature 17ºC below the expected flash point. Therefore apply the test flame at each 0.5ºC rise in the temperature.
6) Note down the flash point as the temperature at which the flame application causes a distinct flash in the interior of the cup.

The duplicate test results should not differ by more than the following:

Flash point range	Repeatability	Reproducibility
104ºC and below	2ºC	3.5ºC
Above 104ºC	5.5ºC	8.5ºC

C. FOR OPEN FLASH POINT AND FIRE POINT

The standard Pensky-Martens tester and thermometers as prescribed in previous method is used slight modifications. The cover of the cup is replaced by a clip which encircles the upper rim of the cup carries the thermometer and test flame. The test flame is fixed at the vertical axis of the cup and in le with the upper edge of the cup. Follow the following procedure.

1) Clean and dry all parts of the cup and its accessories thoroughly.
2) Fill the cup with the material to be tested up to the level indicated by the filling mark.
3) Place the lid on the cup and set the latter in the stove.
4) Insert the thermometer.
5) Light and adjust the test flame so that it is of the size of bead of 4mm in diameter. Apply heat such that the temperature rises at a rate of 5º to 6ºC per minute.
6) Note the temperature at which a flash first appears at any point on the surface of the material.
7) Continue heating until the oil ignites and burns for 5 minutes. Record this temperature as fire point.
8) The duplicate test results should fall within the following range.

	Repeatability	Reproducibility
Flash Point	8ºC	11ºC
Fire Point	8ºC	14ºC

PRECAUTIONS:

1) The test flame should neither be larger than stipulated nor be applied more frequently than specified as the surface layer may get super heated.
2) The bluish halo that sometimes surrounds the test flame should not be confused with the true flash.

OBSERVATION TABLE:

Type of Material:

Type of Test: Closed/Open

Property	Test 1	Test 2	Test 3	Mean
Flash Point				
Fire Point				

RESULT: Flash point =
Fire point =

CONCLUSION:

Experiment No. 9

Determination of Ductility of Bitumen

AIM:

1) To measure the ductility of a given sample of bitumen.
2) To determine the suitability of bitumen for its use in road construction.

THEORY:

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

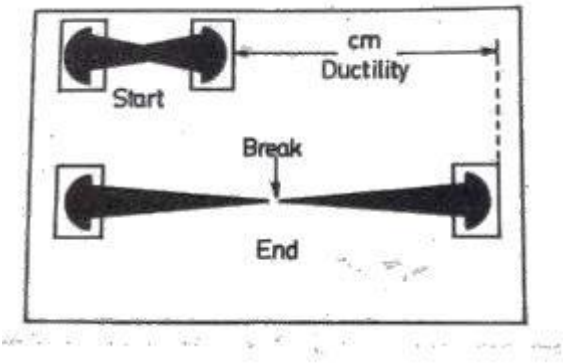


Fig. 9.1 Ductility Test Concept

APPARATUS:

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

   Total length 75.0 ± 0.5 mm
   Distance between clips 30.0 ± 0.3 mm
   Width at mount of slip 20.0 ± 0.2 mm
   Width at minimum cross-section (half way between clips) 10.0 ± 0.1 mm
   Thickness throughout 10.0 ± 0.1 mm

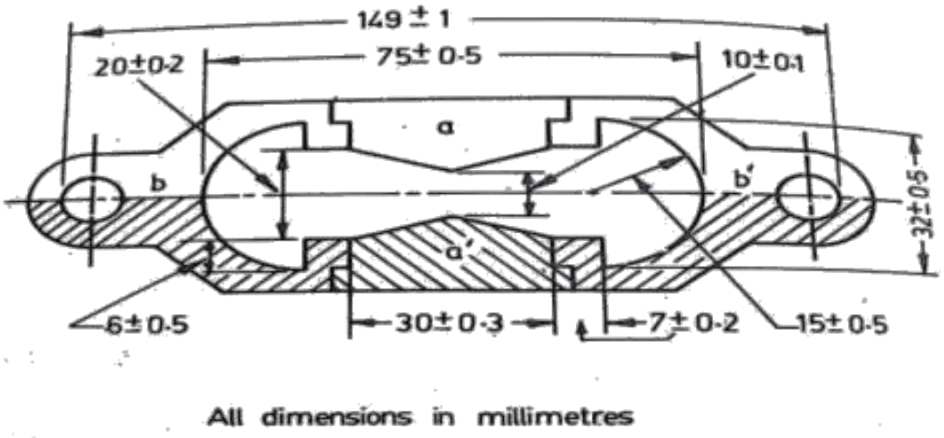


Fig. 9.2 Briquette Mould

O

1) Water bath: A bath maintained within ±0.1 C of the specified test temperature, containing not less than 10 liter of water, the specimen being submerged to a depth of not less than 10cms and supported on a perforated shelf and less than 5cms from the bottom of the bath.
2) Testing Machine: For pulling the briquette of bituminous material apart, any apparatus may be used which us so constructed that the specimen will be continuously submerged in water while the two clips are being pulled apart horizontally at a uniform speed of ±2.5mm per minute.

3) Thermometer: Range 0-44ºC and readable upto 0.2ºC.

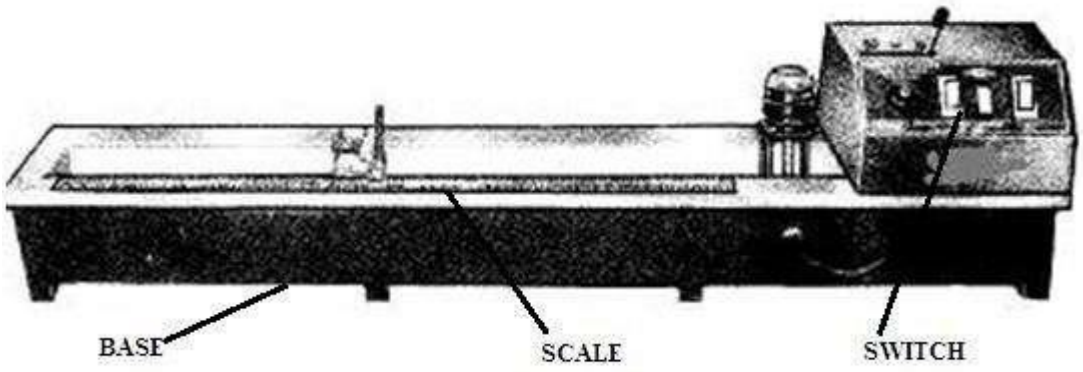


Fig 9.3. DUCTILITY TESTING MACHINE

PROCEDURE:

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

2) Strain the fluid. Through IS sieve 30.

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

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

5) After about 30-40 minutes, keep the plate assembly along with the sample in a water bath.

6) Remove the sample and mould assembly from the water bath and trim the specimen by levelling the surface using a hot knife.

7) Replace the mould assembly in water bath maintained at 27 ^{O}C for 80 to 90 minutes.

8) Remove the sides of the mould.

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

10) Adjust the pointer to read zero.

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

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

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

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

PRECAUTIONS:

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

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

OBSERVATION TABLE:

I. Bitumen grade =

II. Pouring Temperature in ^{o}C =

III. Test Temperature in ºC =

a) In air =
b) In water bath before trimming =
c) In water bath after trimming =

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

RESULT:

The ductility value of given sample is =

CONCLUSION:

Experiment No. 10

Determination of Viscosity of Bituminous Material

AIM: To determine the viscosity of bituminous binder.

THEORY:

Viscosity of a fluid is the property by virtue of which it offers resistance to flow. Higher the viscosity, the slower will be the movement of the liquid. The viscosity affects the ability of the binder to spread, move into and fill up the voids between aggregates. It also plays an important role in coating of aggregates. Highly viscous binder may not fill up the voids completely thereby resulting in poor density of the mix. At lower viscosity the binder does not hold the aggregates together but just acts as lubricant. The viscosity of bituminous binder s falls very rapidly as the temperature rises. Since binders' exhibit viscosity over a wider range, it is necessary to use different methods for the determination of viscosity. For binders in liquid state (road tars and cutback bituminous), the viscosity is determined as the time in seconds by 50 c.c. of the material to flow from a cup through a specified orifice under standard conditions of the test and at specified temperature.

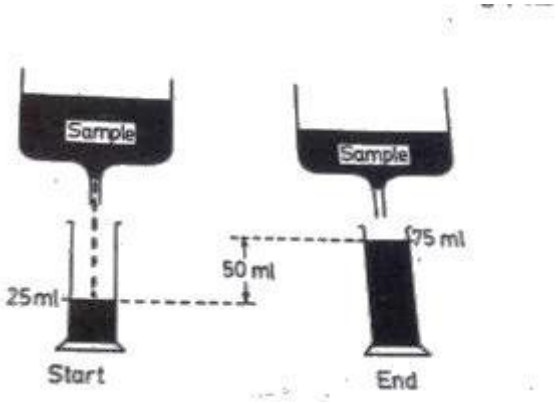


Fig. 10.1 Concept of Viscosity Test

APPARTUS:

As per IS: 1206(Part I)- 1978, following equipment is required:

1) Tar Viscometer: It consists essentially of a cup having a specified orifice and valve; a water bath mounted on three legs having a suitable sleeve for the cup, a stirrer and a shield. The following is the detailed description of the different parts and accessories of tar viscometer.

a. **Cup:** It is made of hard brass tube and fitted with an external brass collar at the upper end of the cylinder to support the cup. The bottom of the cup consists of a circular phosphor –bronze plate screwed into the cylinder and made conical to facilitate drainage of tar after use. It is provided with a perfectly cylindrical extension of diameter 10mm and length 5mm. Some viscometers have orifice of 4mm dia. Referring table 1and 2.

b. **Valve:** It serves to close the orifice of cup and is made of phosphor- bronze as per the dimensions.

c. **Water bath:** It is made of copper sheet, is cylindrical in shape, about 160 mm in diameter and 105 mm in depth. It is mounted on three equidistant legs.

d. **Sleeve** to receive the cup and to hold it in position.

e. **Stirrer** consists of four vertical vanes.

f. **Curved Shield:** It is fixed to the upper edge of the cylinder and extends to within about 5mm of the walls of the water bath. This shield carries an insulated handle for rotating the stirrer, a support for a thermometer, and a swiveled support for the valve.

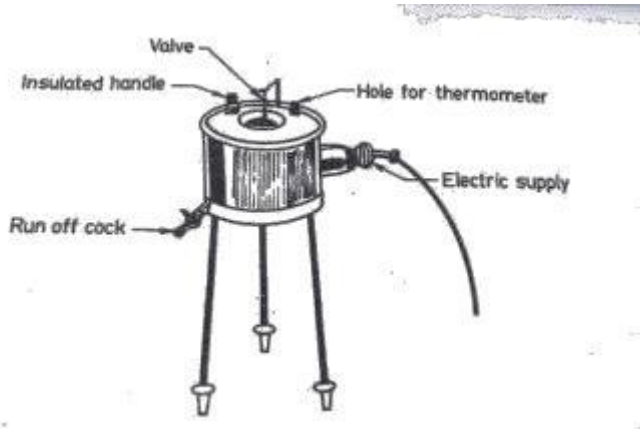


Fig. 10.2 Tar Viscometer

2) Receiver: A 100 ml graduated cylinder, having an internal diameter of not more than 29mm. it has markings on 25 ml and 75 ml levels.

3) Thermometers: Two thermometers, one for bath and another for cup. The measurement range should be 0º to 44ºC or 37.8ºC to 82ºC or 76ºC to 122ºC depending upon whether the viscosity is expected to be low, medium or high. The thermometer should be readable and accurate up to 0.2ºC.

4) A stop watch or other timing device capable of being read up to half second.

Road Tar Type	**RT-1**	**RT-2**	**RT-3**	**RT-4**	**RT-5**
Orifice size, mm	10	10	10	10	10
Test Temperature	35ºC	45ºC	45ºC	55ºC	65ºC
Viscosity in sec.	30-55	30-55	35-60	35-70	35-70

Table1. Specifications for Test Temperature and Range of Viscosity for Road Tar (as per IS: 215-1981)

Grades-SC,MC and RC	**0**	**1**	**2**	**3**	**4**	**5**
Orifice size, mm		4	4	10	10	10
Test Temperature	25ºC	25ºC	25ºC	25ºC	25ºC	25ºC
Viscosity in sec.	25-55	50-150	10-20	26-27	14-45	60-140

Table2. Specifications for Test Temperature and Range of Viscosity for Cutback Bitumen (as per IS: 215-1981)

PROCEDURE:

1) Adjust the tar viscometer so that the top of the tar cup is leveled. Select the test temperature from table 1. Heat the water in water bath to the temperature specified for the test and maintains it within ± 0.1ºC of the specified temperature throughout the duration of test. Rotate the stirrer gently at frequent intervals or perfectly continuously.
2) Clean the tar cup orifice of the viscometer with a suitable solvent and dry thoroughly.
3) Warm and stir the material under examination to 20ºC above the temperature specified for test and cool, while counting the stirring.
4) When the temperature falls slightly above the specified temperature, pour the tar into the cup until the leveling peg on the valve rod is just immersed when the latter is vertical.
5) Pour into the graduated receiver 20 ml of mineral oil,or one percent by weight solution of soft soap, and place it under the orifice of the tar cup.
6) Place the other thermometer in the tar and stir until the temperature is within ± 0.1ºC of the specified temperature. When this temperature has been reached, suspend the thermometer coaxially with the cup and with its bulb approximately at the geometric center of the tar.
7) Allow the assembled apparatus to stand for five minutes during which period the thermometer reading should remain within 0.05ºC of the specified temperature. Remove the thermometer and quickly remove any excess of tar so that the final level is on the central line of the leveling peg when the valve is in vertical position.
8) Lift the valve and suspend it on valve support.
9) Start the stop watch when the reading in the cylinder is 25ml and stop it when it is 75ml. Note the time in seconds.
10) Report the viscosity as the time taken in seconds by 50ml of tar to flow out at the temperature specified for the test.

PRECAUTIONS:

1) The tar cup should be cleaned gently with non-corroding solvents such as light tar oils free from phenols.
2) The orifice size should be tested at frequent intervals with a gauge having appropriate diameters.

OBSERVATION TABLE:

	Test 1	**Test 2**
Test Temperature		
Time taken to flow 50cc of the binder Viscosity		

Mean Viscosity = _____sec

RESULT:

Viscosity of given sample is =

CONCLUSION:

Experiment No. 11

Determination of Specific Gravity of Bituminous Material

AIM: To determine the specific gravity of bituminous binder.

THEORY: It is often required to know the specific gravity of straight run and cut-back bitumen for purposes of calculating rates of spread, asphaltic concrete mix properties. The standard specific gravity test is carried out at a temperature of 25^0C. However, if cooling facilities are not available, a temperature of 35^0C may be used, although this must be clearly stated in the result. For some purposes the specific gravity at elevated temperatures is required, as it is not possible to measure this directly an approximate value may be obtained by calculation using the value determined at a lower temperature.

APPARTUS:

- The apparatus for the test consists of a standard pycnometer as shown in Figure 10.3.1.

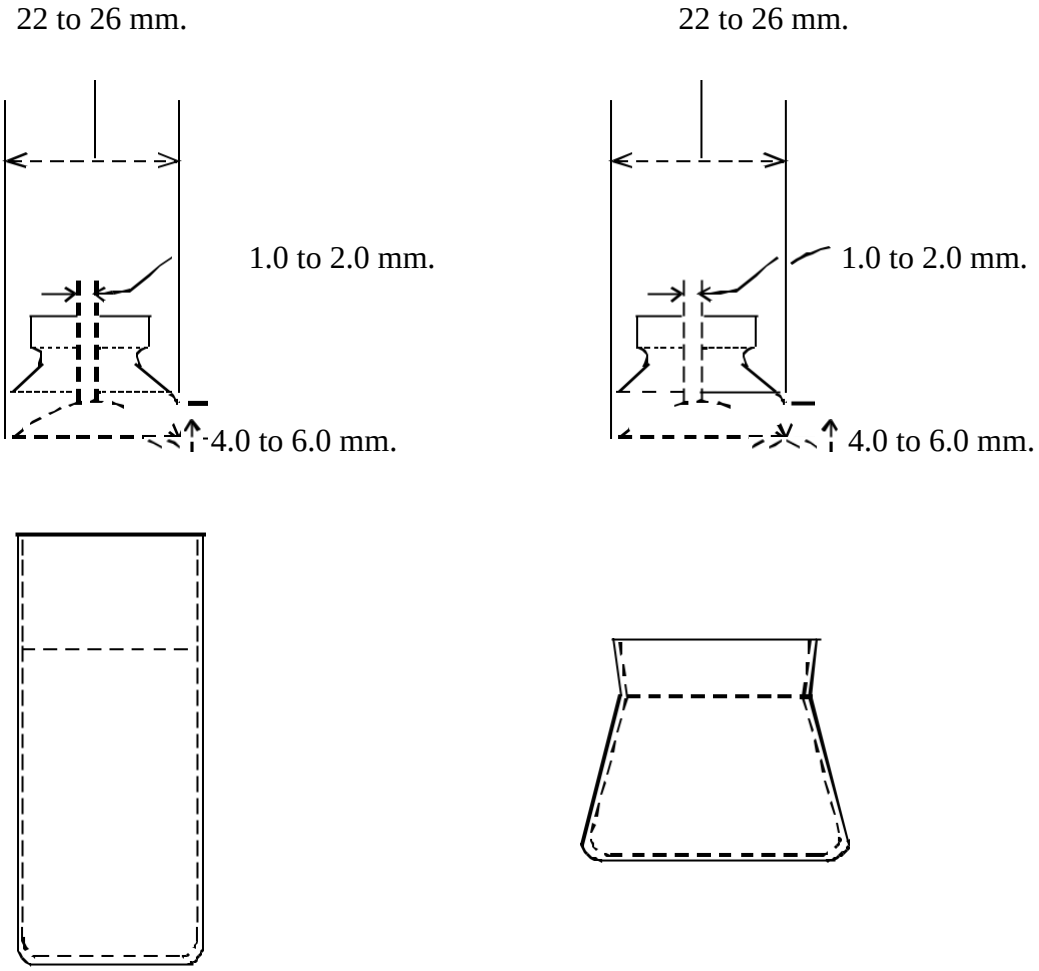


Figure 11.1 Suitable Pycnometers

1) A constant temperature water bath is also required.
2) A 600 ml glass beaker.

PROCEDURE:

1) The clean, dry pycnometer, complete with stopper, should be weighed to the nearest 0.001 gram., weight A.
2) A 600 ml glass beaker should be partly filled with freshly boiled distilled water which has been allowed to cool in a stoppered flask. The beaker should then be immersed to a depth of at least 100mm. in a water bath which is maintained at the required temperature ± 0.1^0C for a period of at least 30 minutes. The top of the beaker should be above the level of the water in the bath.
3) The weighed pycnometer should then be filled with the boiled distilled water and the stopper placed loosely in position, taking care to expel all air from the pycnometer. The pycnometer should then be submerged in the beaker of water to a depth above the stopper of at least 40mm and the stopper firmly pushed into position. The beaker and pycnometer must remain in the water bath for at least 30 minutes after which the pycnometer is removed. The top of the pycnometer should first be dried with one stroke of a dry clean cloth and the remainder of the pycnometer is then dried as quickly as possible prior to weighing, weight B. Note that if a droplet of water forms on the stopper after drying, the stopper should not be re-dried, the volume of water in the pycnometer on immediately, leaving the water is the required value, any subsequent changes should not affect the result. On completion of weighing the pycnometer should be thoroughly dried.
4) The pycnometer is then filled about three quarters full with the sample of bitumen. The bitumen should be carefully poured into the pycnometer ensuring that no air becomes trapped below the bitumen and there are no air bubbles in the sample. The sample should be poured into the center of the pycnometer so that the sides or neck of the pycnometer above the level of the bitumen are not contaminated. The pycnometer and bitumen should then be allowed to cool in air for a period of at least 40 minutes, after which the weight is determined, weight C.
5) The pycnometer is then topped up with the boiled distilled water and the stopper loosely placed in position, taking care to expel all air from the pycnometer. The pycnometer should then be submerged in the beaker of water to a depth above the stopper of at least 40mm and the stopper firmly pushed into position. The beaker and pycnometer must remain in the water bath for at least 30 minutes after which the top and sides of the pycnometer are dried as before, prior to weighing, weight D.
6) At least two separate determinations should be made.

Calculation

The specific gravity of the bitumen is given by:

$$S.G = \frac{(C-A)}{(B-A) - (D-C)}$$

RESULT:

Specific value of given sample is =

CONCLUSION:

Experiment No. 12

Marshall Stability Test

AIM:

1) To find out optimum bitumen content of given mix.
2) To determine the density –voids analysis for the given bituminous mixture.
3) To determine the strength (Marshall's Stability Value) and flexibility (Flow Value) for the given bituminous mixture.

THEORY:

Bruce Marshall, formerly bituminous engineer with Mississippi state highway department, USA formulated Marshall's method for designing bituminous mixes. Marshall's test procedure was later modified and improved upon by U.S.corps of engineers through their extensive research and correlation studies .ASTM and other agencies have standardized the test procedure. Generally, this stability test is applicable to hot-mix design using bitumen and aggregates with maximum size of 25mm.

Strength is measured in terms of the 'Marshall Stability' of the mix which is defined as the maximum load carried by a compacted specimen at a standard test temperature of 60ºC. This temperature represents the weakest condition for a bituminous pavement in use. The flexibility is measured in terms of the 'flow value' which is measured by the change in diameter of the sample in the direction of load application between the start of loading and the time of maximum load. In this test an attempt is made to obtain optimum binder content for the aggregate mix type and traffic intensity.

APPARATUS:

1) Mould assembly: Cylindrical moulds of 10cm diameter and 7.5cm height are required. It further consists of a base plate and collar extension. They are designed to be interchangeable with either end of cylindrical mould.
2) Sample Extractor: For extruding the compacted specimen from the mould, an extractor suitably fitted with a jack or compression machine.
3) Compaction pedestal and hammer: It consist of a wooden block capped with M.S. plate to hold the mould assembly in position during compaction. The compaction hammer consists of a flat circular tamping face 8.8 cm diameter and equipped with a 4.5 kg. Weight constructed to provide a free fall of 47.5cm. Mould holder is provided consisting of spring tension device designed to hold compaction mould in place on the compaction pedestal.
4) Breaking head: It consist of upper and lower cylindrical segments or test heads having an inside radius of curvature of 5cm. The lower segment is mounted on a base having two vertical guide rods which facilitate insertion in the holes of upper test head.

5) Loading machine: See fig. 17. The loading machine is provided with a gear system to lift the base in upward direction. On the upper end of the machine, a pre-calibrated proving ring of 5 tonne capacity is fixed. In between the base and the proving ring, the specimen contained in test head is placed. The loading machine produces a movement at the rate of 5cm per minute. Machine is capable of reversing its movement downward also. This facilitates adequate space for placing test head system after one specimen has been tested

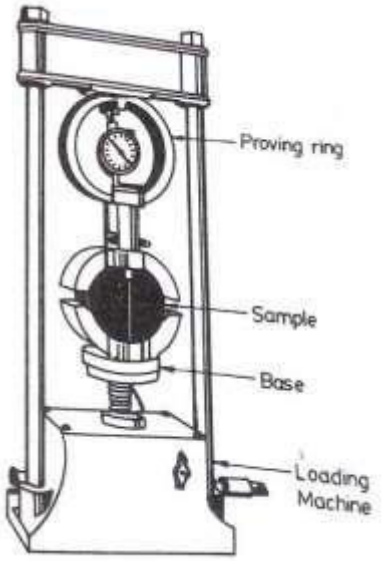


Fig. 12.1 Marshall Stability Testing Machine

6) Flow Meter: One dial gauge fixed to the guide rods of a testing machine can serve the purpose. Least count of 0.025 mm is adequate. The flow value refers to the total vertical upward movement from the initial position at zero load to a value at maximum load. The dial gauge or the flow meter should be able to measure accurately the total vertical movement upward.

Besides the above equipment, the following are also required:

a) Ovens on hot plate
b) Mixing apparatus
c) Water bath, thermometers of range up to 200^0C with sensitivity of 2.5^0C.

PROCEDURE:

In the Marshall method each compacted test in specimen is subjected to the following tests and analysis in the order listed below:

1. Bulk density determination
2. Stability and flow test
3. Density and voids analysis

At least three samples are prepared for each binder content.

PREPARATION OF TEST SPECIMENS:

The coarse aggregates, fine aggregates and the filter material should be proportioned and mixed in such a way that final mix after blending has the gradation within the specified range. The specified gradation of mineral aggregates and the bitumen binder as per IRC: 29-1968 are given in table 14.1

The aggregates and filter are mixed together in the desired proportion as per the design requirements are fulfilling the specified gradation. The required quantity of mix is taken so as to produce a compacted bituminous mix specimen of thickness 63.5mm approximately.

Approximately 1200g of aggregates and filter are taken and heated to a temperature of 175 to 190^0C. The compaction mould assembly and rammer are cleaned and kept pre heated to a temperature of 100 to 145^0C. The bitumen is heated to temperature of 121 to 138^0C and the required quantity of first trail percentage of bitumen (say 3.5% by weight of mineral aggregates) is added to the heated aggregate and thoroughly mixed using a mechanical mixer or by hand mixing with trowel. The mixing temperature for 80/100 grade bitumen may be around 154^0C and that for 60/70 grade about 160^0C. The mix is placed in a mould and compacted by rammer, with 75 blows on either side. The compacting temperatures may be about 138^0C for 80/100 grade bitumen and 149^0C for 60/70 grade. The compacted specimen should have a thickness of 63.5 mm. The weight of the aggregate taken may be suitably altered to obtain a thickness of 63.5 $\pm$ 3.0 mm. At least two specimens, but preferably three or four specimens should be prepared at each trail bitumen content which may be varied at 0.5 percent increments up to about 6.0 or 6.5 percent. The compacted specimens are allowed to cool to room temperature, the sample height and weight is determined, theoretical density is calculated. The specimen is then weighed in air and then in water for determining volume and later bulk density. The specimens are then transferred into a water bath, kept at 60^0C for 30 to 40 minutes. They are then removed, dried and placed in Marshall test head. Their Stability and flow values are noted. They are corrected for variation from average height.

TESTS:

Specific gravity of compacted specimens:

The specific gravity values of the different aggregates, filler, and bitumen used are determined first. The theoretical specific gravity Gt of the mix is given by;

Where, W1= percent of weight of coarse aggregates,

W2= percent of weight of fine aggregates,

W3= percent of weight of filler,

W4= percent by weight of bitumen in total mix,

G1, G2, and G3 are apparent specific gravity values of the coarse aggregates, fine aggregates and filler respectively and G4 is the specific gravity of bitumen.

Density and void analysis:

Soon after the compacted bituminous mix specimens have cooled to room temperature, the weight, average thickness and diameter of the specimen are noted. The specimens are to be weight in air and then in water. The bulk density value G_b of the specimen if calculated from the weight and volume. The voids analysis is made as given below:

— %

VMA = Void in Mineral Aggregates = $V_v + V_b$ = %

VFB = Voids Filled with Bitumen,% =

Marshall Stability and flow values:

The specimens to be tested are kept immersed under water in a thermostatically controlled water bath maintained at 60^0C for 30 to 40 minutes. The specimens are taken one by one, placed in the marshall test head and the Marshall stability value (maximum head carried in kg. before failure load in o.25mm units) are noted.

The corrected Marshall stability value of each specimen is determined by applying the approximate correction factor, if the average height of the specimen is not exactly 63.5mm the correction factors are given in table 14.2.

DETERMINATION OF OPTIMUM BITUMEN CONTENT:

Five graphs are plotted with values of bitumen content against the value of:

1. Density G_b. g/cm^3,
2. Marshall stability S, kg,
3. Voids in total mix Vv %,
4. Flow value ,F (0.25mm units)
5. Voids filled with bitumen , VFB %,

Let the bitumen content corresponding to maximum density be B_1, corresponding to maximum stability be B_2 and that corresponding to the specified voids content Vv (4.0% in the case of dense AC mix) to B_3. Then the optimum bitumen content for deign mix is given by, $B_0 = (B_1+B_2+B_3)/3$.

The value of flow and VFB are found from the graphs, corresponding to the bitumen content B_0. All the design values of Marshall Stability, flow, voids and VFB are checked at the optimum bitumen content B_0, with the specified design requirements of the mix.

OBSERVATION SHEET:

Stability and flow value determination

Type of grading of aggregate :

Mixing temperature :

Number of blows on either side :

Grade of bitumen :

Compaction temperature :

Providing ring calibration factor :

Flow value dial, 1 division :

Table 12.1 Observation table for density and voids

Sample No	Bitumen content,%	Height of sample, mm	Weight (g) in air in water	Bulk Density G_b	G_t	V_v	V_b	VMA	VFB
1									
2									
3									
Average									
1									
2									
3									
Average									
1									
2									
3									
Average									
1									
2									
3									
Average									

Table 12.2 Observation table for Marshall Stability and flow value

Sample No	Bitumen content percent	Stability Value		Flow dial reading	Flow value 0.25mm units
		Measured	Corrected		
1					
2					
3					
Average					
1					
2					
3					
Average					
1					
2					
3					
Average					
1					
2					
3					
Average					

Optimum bitumen content determination:

B_1 = Bitumen content corresponding to maximum density =

B_2 = Bitumen content corresponding to maximum Stability =

B_3 = Bitumen content corresponding to 4% voids content =

B_o = Optimum bitumen content = (B_1 + B_2 + B_3) / 3 =

In addition to these, graphs are plotted between, with bitumen content on x axis, and:

1. Bulk density, G_b
2. Marshall Stability, M
3. % voids in total mix, V_v
4. Flow value, f
5. % voids filled with bitumen, VFB

RESULTS:

Optimum bitumen content = %

Marshall Stability at optimum bitumen content = kg

Marshall flow value at optimum bitumen content, 0.25 mm units = mm

Voids in total mix at optimum bitumen content, V_v = %

Voids in mineral aggregate filled with bitumen, VFB = %

CONCLUSION:

Experiment No. 13

Pavement design exercise based on flexible pavement consisting of bituminous concrete

Experiment No. 12

Visit to road construction site for studying different construction equipments

3.Quiz on the subject:-

Question No. 01

Group index method of design of flexible pavement is

(A) A theoretical method

(B) An empirical method based on physical properties of sub-grade soil

(C) An empirical method based on strength characteristics of sub-grade soil

(D) A semi empirical method

Answer: Option B

Question No. 02

Which of the following is considered to be the highest quality construction in the group of black top pavements?

(A) Mastic asphalt

(B) Sheet asphalt

(C) Bituminous carpet

(D) Bituminous concrete

Answer: Option D

Question No. 03

Los Angeles testing machine is used to conduct

(A) Abrasion test

(B) Impact test

(C) Attrition test

(D) Crushing strength test

Answer: Option A

Question No. 04

When the width of car parking space and width of street are limited, generally preferred parking system is

(A) Parallel parking

(B) 45° angle parking

(C) 65° angle parking

(D) 90° angle parking

Answer: Option A

Question No. 05

When the bituminous surfacing is done on already existing black top road or over existing cement concrete road, the type of treatment given is

(A) Seal coat

(B) Tack coat

(C) Prime coat

(D) Spray of emulsion

Answer: Option B

Question No. 06

In the penetration macadam construction, the bitumen is

(A) Sprayed after the aggregates are spread and compacted

(B) Premixed with aggregates and then spread

(C) Sprayed before the aggregates are spread and compacted

(D) None of the above

Answer: Option A

Question No. 07

The drain which is provided parallel to roadway to intercept and divert the water from hill slopes is known as

(A) Sloping drain

(B) Catch-water drain

(C) Side drain

(D) Cross drain

Answer: Option B

Question No. 08

The function of an expansion joint in rigid pavements is to

(A) Relieve warping stresses

(B) Relieve shrinkage stresses

(C) Resist stresses due to expansion

(D) Allow free expansion

Answer: Option D

Question No. 09

Select the correct statement.

(A) More the value of group index, less thickness of pavement will be required

(B) More the value of CBR, greater thickness of pavement will be required

(C) Minimum and maximum values of group index can be 0 and 20 respectively

(D) All of the above

Answer: Option C

Question No. 10

Penetration test on bitumen is used for determining its

(A) Grade

(B) Viscosity

(C) Ductility

(D) Temperature susceptibility Answer: Option A

Question No. 11

In soils having same values of plasticity index, if liquid limit is increased, then

1. Compressibility and permeability decrease and dry strength increases
2) Compressibility, permeability and dry strength decrease
3) Compressibility, permeability and dry strength increase
4) Compressibility and permeability increase and dry strength decreases Answer: Option D

Question No. 12

The maximum limit of water absorption for aggregate suitable for road construction is

(A) 0.4 %
(B) 0.6 %
(C) 0.8 %
(D) 1.0 % Answer: Option B

Question No. 13

The critical combination of stresses for corner region in cement concrete roads is

(A) Load stress + warping stress frictional stress
(B) Load stress + warping stress + frictional stress
(C) Load stress + warping stress
(D) Load stress + frictional stress
Answer: Option C

Question No. 14

In highway construction, rolling starts from

(A) Sides and proceed to center
(B) Center and proceed to sides
(C) One side and proceed to other side
(D) Any of the above Answer: Option A

Question No. 15

The most economical lighting layout which is suitable for narrow roads is

(A) Single side lighting
(B) Staggered system
(C) Central lighting system
(D) None of the above Answer: Option A

Question No. 16

The ideal shape of a transition curve, is

(A) Clothoid
(B) Cubic spiral
(C) Cubic parabola
(D) Lamniscate Answer: Option A

Question No. 17

The full width of land acquired before finalising a highway, alignment is known

(A) Width of formation

(B) Right of way

(C) Carriage way

(D) Roadway

Answer: Option B

Question No. 18

Tyre pressure influences the

(A) Total depth of pavement

(B) Quality of surface course

(C) Both the above

(D) None of the above

Answer: Option B

Question No. 19

Any gradient on a road is said to be an exceptional gradient, if it is

(A) More than ruling gradient

(B) Less than average gradient

(C) More than floating gradient

(D) Less than minimum gradient or more than maximum gradient Answer: Option D

Question No. 20

During last phase of the reconnaissance, details of the grade line is recorded on 2 metre poles to indicate

(A) Direction of the proposed alignment

(B) Distance between the previous and forward pegs

(C) Relative elevations of pegs

(D) All the above

Answer: Option D

Question No. 21

The most suitable equipment for compacting clayey soils is a

(A) Smooth wheeled roller

(B) Pneumatic tyred roller

(C) Sheep foot roller

(D) Vibrator

Answer: Option C

Question No. 22

Pick up the correct statement from the following:

(A) Seasonal cycle of traffic volume during April and November, is usually near the annual average
(B) Mid-winter seasonal cycle of traffic is least
(C) Mid-summer seasonal cycle of traffic is highest
(D) All the above

Answer: Option D

Question No. 23

Three points A, B and C 500 m apart on a straight road have 500 m, 505 m and 510 m as their reduced levels. The road is said to have

(A) No gradient between A and C
(B) A positive gradient between A and C
(C) A negative gradient between A and C
(D) A negative gradient between A and B Answer: Option D

Question No. 24

Select the correct statement.

(A) Quantity of binder required for tack coat is less than that required for prime coat
(B) Prime coat treatment is given for plugging the voids in water bound macadam during bituminous road construction
(C) Seal coat is the final coat over certain previous bituminous pavements
(D) A bitumen primer is a high viscosity cutback

Answer: Option D

Question No. 25

The minimum design speed of various types of highways in plain terrain is the same as the ruling design speed of

(A) Rolling terrain
(B) Mountainous terrain
(C) Steep terrain
(D) None of these

Answer: Option A

4. Conduction of Viva-Voce Examinations:

Teacher should conduct oral exams of the students with full preparation. Normally, the objective questions with guess are to be avoided. To make it meaningful, the questions should be such that depth of the students in the subject is tested. Oral examinations are to be conducted in cordial environment amongst the teachers taking the examination. Teachers taking such examinations should not have ill thoughts about each other and courtesies should be offered to each other in case of difference of opinion, which should be critically suppressed in front of the students.

5. Evaluation and marking system:

Basic honesty in the evaluation and marking system is absolutely essential and in the process impartial nature of the evaluator is required in the examination system to become. It is a primary responsibility of the teacher to see that right students who are really putting up lot of hard work with right kind of intelligence are correctly awarded.

The marking patterns should be justifiable to the students without any ambiguity and teacher should see that students are faced with just circumstances.