JHARSUGUDA ENGINEERING SCHOOL

DEPARTMENT OF CIVIL ENGINEERING

Lab Manual

(Procedure For Conduct Of Practical)

Sub:- Highway & Transportation Engineering Lab

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AGGREGATE IMPACT VALUE

AIM OF THE EXPERIMENT:

To determine the aggregate impact value of coarse aggregate.

THEORY:

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

REFERENCE CODES:

IS:2386 (PartIV)-1963.

APPARATUS USED:

Impact testing machine:

The machine consists of a metal base.A detachable cylindrical steel cup of internal diameter 10.2 cm and depth 5cm. A metal hammer of weight between 13.5 to 14 Kg, 10 cm in diameter and 5 cm long. An arrangement for raising the hammer and allow it to fall freely between Vertical guides from a height of 38cm on the test sample in the cup.

PROCEDURE:

1. The test sample consists of aggregates passing 12.5mm sieve and retained on 10mm sieve and dried in an oven for 4 hours at a temperature of 100°C to 110°C.
2. The aggregates are filled up to about 1/3 full in the cylindrical measure and tamped 25times with rounded end of the tamping rod.
3. The rest of the cylindrical measure is filled by two layers and each layer being tamped 25times.
4. The overflow of aggregates in cylindrical measure is cut off by tamping rod using it has a straight edge. Then the entire aggregate sample in a measuring cylinder is weighted nearing to 0.01gm.
5. The aggregates from the cylindrical measure are carefully transferred into the cup which is firmly fixed in position on the base plate of machine. Then it is tamped 25times.
6. The hammer is raised until its lower face is 38cm above the upper surface of 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 being delivered at an interval of not less than one second. The crushed aggregate is then removed from the cup and the whole of it is sieved on 2.36mm sieve until no significant amount passes. The fraction passing the sieve is weighed accurate to 0.1gm. Repeat the above steps with other fresh sample.
7. Let the original weight of the oven dry sample be gm and the weight of fraction passing 2.36mm I.S sieve be gm. Then Aggregate Impact Value is expressed as the %of fines formed in terms of the total weight of the sample.

OBSERVATIONANDCALCULATION:

Sl.	Details of Sample	Trial 1	Trial 2	Average
1.	Total weight of aggregate sample filling the cylinder measure, w1gm			
2.	Weight of aggregate passing 2.36mm I.S sieve, w2 gm			
3.	Weight of aggregate retained on 2.36mm I.S sieve,w3 gm			
4.	Aggregate Impact Value, w1/w2×100%			

RESULT:

The mean A.I.V is_____%.

PRECAUTIONS:

Place the plunger centrally so that it falls directly on the aggregate sample and does not touch the walls of the cylinder in order to ensure that the entire load is transmitted on to the aggregates.

In the operation of sieving the aggregates through 2.36 mm sieve the sum of weights of fractions retained and passing the sieve should not differ from the original weight of the specimen by more than 1gm.

The tamping is to be done properly by gently dropping the tamping rod and not by hammering action. Also the tampering should be uniform over the surface of the aggregate taking care that the tamping rod does not frequently strike against the walls of the mould.

COMMENTS:

Aggregate impact value is used to classify the stones in respect of their toughness property as indicated below in Table1.

Table-1:Classification of aggregate based on the Aggregate Impact Value

Aggregate impact value(%)	**Quality of Aggregate**
<10	Exceptionally Strong
10-20	Strong
21-30	Satisfactory for road surfacing

>35	Weak for road surfacing

IRC has specified the following values of maximum allowable impact value of aggregate in different types of pavement material/layers.

Description	Maximum Allowable Aggregate Impact Value
Sub-Base Course	50%
Cement Concrete In Base Course	45%.
Water Bound Macadam With Bitumen Surface	40%
Bituminous Macadam Base Course	35%
All Surface Courses	30%

DETERMINATION OF LOS-ANGELES ABRASION VALUE

AIM OF THE EXPERIMENT:

To determine the abrasion value of the given aggregate sample.

THEORY:

Abrasion is a measure of resistance to wear or hardness . It is an essential property for road aggregates especially when used in wearing course. Due to the movements of traffic, the road stones used in the surfacing course are subjected to wearing actions at the top. When traffic moves on the road the fine particle (dust, soil etc) which comes between the wheel and road surface causes abrasion on the road stone.

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

REFERENCE CODES:

IS : 2386 (PartIV)-1963.

APPARATUS USED:

- Los Angeles Machine : It consists of a hollow steel cylinder , closed at both the ends with an internal diameter of 700mm and length 500mm and capable of rotating about its horizontal axis. A removable steel shaft projecting radially 88mm into cylinder and extending full length (i.e.500mm) is mounted firmly on the interior of cylinder. The shelf is placed at a distance 1250mm minimum from the opening in the direction of rotation.
- Abrasive charge: Cast iron or steel balls, approximately 48mm in diameter and each weighing between 390 to 445g; 6 to 12balls are required.
- Sieve : The 1.70mm IS sieve
- Balance of capacity 5kg or 10kg
- Drying oven

PROCEDURE:

a) Clean and dry aggregate sample confirming to one of the grading A to G is used for the test (Refer table)

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	Weight 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

b) Aggregates weighing 5Kg 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.

c) The abrasive charge is also chosen in accordance with the above table and placed in the cylinder of the machine, and cover is fixed to make dust tight.

d) The machine is rotated at speed of 30 to 33 revolutions per minute.

e) The machine is rotated for 500 revolutions for gradingsA, B, C and D, for gradings E, F and G, it shall be rotated for 1000 revolutions.

f) 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.

g) Using a sieve of size larger than 1.70mm I.S sieve, the material is first separated into two parts and the finer position is taken out and sieved further on a 1.70mm I.S sieve.

h) Let the original weight of aggregate be gm , weight of aggregate retained on 1.70mm I.S sieve after the test be gm.

Los Angeles abrasion value (%)={(w1-w2)/w1} X 100

Sl. No.	Details of sample	Trial 1	Trial 2	Trial 3	Average
1.	Weight of Specimen, W1 gm				
2.	Weight of specimen after abrasion test, coarser than 1.70mm IS sieve, W2gm				
3.	Percentage wear= $(w1-w2)/w1 \times 100$				

RESULT:

The average value of Los Angeles abrasion test on given aggregate sample is_____%

COMMENTS:

Los Angeles abrasion test has been standardized by the ASTM, AASHO and also by the ISI. Standard specification of Los Angeles abrasion value is also available for various types of pavement constructions.

Sl. No.	**Types of pavement layer**	**Los Angeles abrasion value, maximum%**
1.	Water Bound Macadam(WBM), sub-base course	60
2.	a)WBM base course with bituminous surfacing b)Bituminous Macadam base course	50
3.	a)WBM surfacing course b)Bituminous Macadam binder course c)Bituminous penetration Macadam d)Built-up spray grout binder course	40
4.	a)Bituminous carpet surface course b)Bituminous surface dressing, single or two coats c)Bituminous surface dressing, using precoated aggregates d)Cement concrete surface course	35
5.	a)Bituminous Asphaltic concrete surface course	30

SPECIFIC GRAVITY AND WATER ABSORPTION

AIM OF THE EXPERIMENT:

To determine water absorption of the given aggregate sample.

THEORY:

Water absorption gives an idea of strength of aggregate. Aggregates 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.

REFERENCE CODES:

IS: 2386 (PartIII)-1963.

APPARATUS USED:

- A wire basket of not more than 6.3mm mesh or a perforated container of convenient size with thin wire hangers for suspending it from the balance.
- A thermostatically controlled oven to maintain temperature of 100° to 110°C.
- A container for filling water and suspending the basket.
- An air tight container of capacity similar to that of the basket.
- A balance of capacity about 5kg to weigh accurate to 0.5g and of such a type and shape as to permit weighing of the sample container when suspended in water.
- A shallow tray and two dry asorbent clothes, each not less than750×450mm.

PROCEDURE:

a) 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° to 32° C with a cover of atleast 50 mm of water above the top of the basket.

b) 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 25times at the rate of about one drop per second.

c) The basket and the aggregate should remain completely immersed in water for a period of 24 ± 0.5 hours afterwards.

d) The basket and the sample are then weighed while suspended in water at a temperature of 22° 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 25times as described above in the new tank to remove air before weighing.

e) This weight is noted while suspended in water W1g. 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.

f) The empty basket is then returned to the tank of water, jolted 25 times and weight in water W2g.

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. 10 to 50 minutes drying may be needed.

h) The aggregates should not be exposed to the atmosphere, direct sunlight or any other source of heat while surface drying.

i) A gentle current of unheated air may be used during the first ten minutes to accelerate the drying of aggregate surface.

j) The surface dried aggregate is then weighed W3g. The aggregate is placed in a shallow tray and kept in an oven maintained at temperature of 110°C for 24hours.

k) It is then removed from the oven, cooled in an air tight container and weighed W4 should be carried out, but not concurrently.

OBSERVATIONS:

Sl. No.	**Description**	**Trial 1**	**Trial 2**	**Average**
1.	Weight of saturated aggregate suspended in water With the basket, W1gm			
2.	Weight of basket suspended in water, W2gm			
3.	Weight of saturated aggregate in water, WS= (W1-W2) gm			
4.	Weight of saturated surface dry aggregate in air, W4gm			
5.	Weight of water equal to the volume of the aggregate= (W3-WS)gm			
6.	Specific Gravity=			
7.	Water absorption=			

RESULT:

a) The Specific Gravity of given aggregate sample is found to be_____.

b) The water absorption of given aggregate sample is found to be_____%.

FLAKINESS INDEX AND ELONGATION INDEX

AIM OF THE EXPERIMENT:

To determine the flakiness Index and elongation index of a given aggregates sample.

THEORY:

The particle shape of aggregate is determined by the percentages of flaky and elongated particles contained in it. In case of gravel it is determined by its Angularity Number. Flakiness and Elongation tests are conducted on coarse aggregates to assess the shape of aggregates.

Aggregates which are flaky or elongated are harmful to higher workability and stability of mixes. They are not favorable to good interlocking and hence the mixes with an excess of such particles are difficult to compact to the required degree. For base coarse 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 probabilities of breaking down under heavy loads. Rounded aggregates are preferred in cement concrete road construction as the workability of concrete improves. Angular shape of particles are desirable for granular base coarse due to increased stability derived from the better interlocking when the shape of aggregates deviates more from the spherical shape, as in the case of angular, flaky and elongated aggregates, the void content in an aggregate of any specified size increases and hence the grain size distribution of the graded aggregates has to be suitably altered in order to obtain minimum voids in the dry mix or the highest dry density.

Flakiness Index:

The flakiness index of aggregates is the percentage by particles whose least dimension (thickness) is less than 3/5th(0.6) of their mean dimension. The test is not applicable to sizes smaller than 6.3mm.

Elongation Index:

The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than $9/5^{th}$ times (1.8times) their mean dimensions. The elongation test is not applicable to sizes smaller than 6.3 mm.

APPARATUS USED:

- Standard thickness gauge
- I.S. sieves of sizes 63, 50, 40, 31.5, 25, 20, 16, 12.5, 10 and 6.3mm and a balance to weigh the samples.
- Length gauge
- A balance of accuracy 0.01gm

PROCEDURE:

a) The sample is sieved with the sieves mentioned above.

b) A minimum of 200pieces of each fraction to be tested are taken and weighed (w1gm).

c) In order to separate flaky materials, each fraction is then gauged for thickness on thickness gauge, or in bulk on sieve having elongated slots as specified in the table.

d) Then the amount of flaky material passing the gauge is weighed to an accuracy of at least 0.1% of test sample.

e) Let the weight of the flaky or elongated materials passing the gauge be gm. Similarly the weights of the fractions passing and retained on the specified sieves be w1,w2,w3,etc. are weighed and the total weight w1+w2+w3+…….w=gm is found. Also the weights of the materials passing each of the specified thickness gauges are found =W1,W2,W3… and the total weight of the material passing the different thickness gauges=W1+W2+W3+…….=Wgm is found.

f) Then the flakiness index is the total weight of the flaky material passing the various thickness gauges expressed as a percentage of the total weight of the sample gauged.

$$\text{Flakiness Index} = \frac{w1+w2+w3+\ldots\ldots}{W1+W2+W3+\ldots\ldots} \times 100$$

g) Also the weights of material from each fraction retained on the specified gauge length are found = x1,x2,x3…. And the total weight retained is determined=x1+x2+x3+…….=x gm.

h) 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.

$$\text{Flakiness Index} = \frac{x1+x2+x3+\ldots\ldots}{W1+W2+W3+\ldots\ldots} \times 100$$

OBSERVATION:

Size of Aggregate passing						
Through Sieve, mm	**Retained on I.S. Sieve,mm**	**ThicknessGauge(0.6 times the mean sieve)mm**	**Length Gauge(1.8 times the mean sieve)mm**	**Weight of the fraction consisting of atleast 200 pieces in gm.**	**Weight of aggregates in each fraction passing thicknessgauge ,gm** Wi	**Weight of aggregates in each fraction retained on length gauge, gm**
63	**50**	**33.90**	**-**			
50	**40**	**27.00**	**81.00**			
40	**31.5**	**19.50**	**58.50**			
31.5	**25**	**16.95**	**-**			
25	**20**	**13.50**	**40.50**			
20	**16**	**10.80**	**32.40**			
16	**12.5**	**8.55**	**25.60**			
12.5	**10**	**6.75**	**20.20**			
10	**6.3**	**4.89**	**14.70**			

Flakiness index= %

Elongation Index= %

RESULT

a) The flakiness index of the given sample of aggregates is_____%.

b) The elongation index of a given sample of aggregate is_____%.

CBR TEST

AIM OF THE EXPERIMENT:

To determine California Baring Ratio (C.B.R.)value of a given aggregate/soil sample.

THEORY:

The California Bearing Ratio (C.B.R.) test was developed by California Division of Highway as a method of classifying and evaluating soil subgrade and base course materials for flexible pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers.

The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The CBR test may be conducted in remoulded or undisturbed specimen in the laboratory. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement. The test is conducted by causing a cylindrical plunger of some diameter to penetrate a pavement component material at 1.25 mm/minute. The loads ,for 2.5 mm and 5mm are recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain C.B.R. value.

REFERENCECODES:

IS: 2720 part XVI

IS: 2720 part XXXI

APPARATUS USED:

C.B.R Testing Apparatus

a) Cylindrical mould with inside dia. 150mm and height 175mm, provided with a detachable extension collar 50mm height and a detachable perforated base plate 10mm thick.

b) Spacer disc: 148mm in dia and 47.7 mm in height along with handle.

c) Metal rammers: Weight 2.6 kg with a drop of 310mm (or) weight 4.89 kg a drop 450mm.

d) Weights: One annular metal weight and several lotted weights weighing 2.5 kg each , 147 mm in dia., with a central hole 53mm in diameter.

e) Loading machine: With a capacity of at least 5000 kg and equipped with a movable head or base that travels at an uniform rate of 1.25mm/min. Complete with load indicating device.

f) Metal penetration piston 50mm dia .and minimum of 100mm in length.

g) Two dial gauges reading to 0.01mm.

k) Sieves: 4.75mm and 20mm I.S .Sieves.

l) Miscellaneous apparatus, such as a mixing bowl, straight edge, scales soaking tank or pan, drying oven, filter paper and containers.

PROCEDURE:

a) Each batch of soil is(of at least 5.5kg for granular oils and 4.5 to 5kg weight for fine grained soils) mixed with water up to the optimum moisture content or the field moisture content if specified so.

b) 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.

c) The moist soil sample is to be compacted over this in the mould by adopting either the I.S. light compaction or the I.S. heavy compaction. For light compaction, compact the soil in 3 equal layers, each layer being given 55 blows by the 2.6kg rammer. For heavy compaction compact the soil in 5layers, 56 blows to each layer by the 4.89kg rammer.

d) 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 straightedges.

e) The clamps are removed and the mould with the compacted soil is lifted leaving below the base plate and the spacer disc is removed.

f) A filter paper is placed on the base plate, the mould with compacted soil is inverted and placed in position over the base plate and clamps of the base plate are tightened.

g) Weights of 2.5 to 5kg are placed over the soil sample in the mould. Then the whole mould is placed in water tank for soaking.

h) A swelling measuring device consisting of tripod and the dial gauge are placed on top edge of the mould and the spindle of the dial gauge is placed touching the top of the sample.The initial dial gauge reading is recorded and the test set up is kept undisturbed in the water tank to allow soaking of the soil specimen for four full days or 96hours.

i) After 96 hours of soaking, the mould with specimen is clamped over the base plate and the same surcharge weights are placed on the specimen centrally such that the penetration test can be conducted. The mould with base plate is placed under penetration plunger of the loading machine.

j) 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.

k) The dial gauge for the measuring the penetration values of the plunger is fitted in position. The dial gauge of the proving ring and the penetration dial gauge are set to zero. The load is applied through the penetration plunger at a uniform rate of 1.25mm/minute. 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, 12.5mm penetration. The maximum load value and the corresponding penetration value are recorded.

l) After the final reading, the load is released and the mould is removed from the loading machine. The proving ring calibration factor is noted so that the load dial values can be converted in to load in kg.

m) The load values noted for each penetration level are divided by the area of the loading

plunger (19.635 cm) to obtain the pressure.

n) A graph is plotted by penetration in mm on x-axis and the pressure in kg/cm on y-axis.

o) Then the unit pressure values corresponding to 2.5 and 5.0 mm penetration values are found from the graph. Then the CBR value is calculated from the formula:

CBR in %age = (load corresponding to chosen penetration/Standard load) x 100

p) The CBR values at 2.5mm and 5.0mm penetrations are calculated for each specimen from the corresponding graphs. Generally the CBRvalue at 2.5mm penetration is higher and the value is adopted. However if higher CBR value is obtained at 5.0mm penetration, the test is to be repeated to verify the results. If the value at 5.0mm penetration is again higher, this is adopted as the CBR value of the soil sample.

OBSERVATION AND CALCULATION:

Calibration factor of the proving ring 1Div.=_____kg

Least count of penetration dial 1Div.=_____mm

Load-Penetration curve:

The load penetration curve is plotted taking penetration value on x-axis and Load values onY-axis. Corresponding to the penetration value at which the CBR is desired, corrected load value is taken from the load-penetration curve and the CBR is calculated as follows:

CBR= (P_T /P_S) x 100

where

P_T= Corrected unit (or total)test load corresponding to the chosen penetration curve, and

P_S=Unit(or total) standard load for the same depth of penetration as for P_S taken from standard code. 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.

PenetrationDial		**LoadDial**		**CorrectedLoad P_T**
Readings	**Penetration (mm)**	**Proving Ring Reading**	**Load in kg**	

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

RESULT:

The CBR value of the given soil sample is_____%.

COMMENTS:

The values are given in the table. As per IRC recommendation the minimum value of C.B.R. required for a subgrade should be 8%.

FLASH & FIRE POINT TEST OF BITUMEN

AIM OF THE EXPRERIMENT:

To determine the flash point and the fire point of bitumen.

SCOPE OF THE TEST:

The determination of the flash point is helpful in assessing the safe limits of heating the bitumen.

THEORY:

At high temperatures, the bituminous materials emit volatile hydrocarbon vapours depending upon their quality or grade, which are susceptible to catch fire. Therefore, the heating temperature of bituminous materials is restricted to avoid hazardous conditions and the paving engineers are required to restrict the mixing or application temperatures of bitumen well within the limits. The flash point and fire point tests are used to determine the temperature to which bituminous material can safely be heated.

The flash point is the lowest temperature at which flash occurs due to the ignition of volatile vapours when a small flame is brought in contact with the vapors of a bituminous product, gradually heated under standardized conditions. Thus, this test gives an indication of the critical temperature at and above which suitable precautions should be taken to eliminate fire hazards during its application. When the bituminous material is further heated to a still higher temperature, the material itself catches fire and continues to burn, the lowest temperature causing this condition is the fire point. So the fire point is always higher than the flash point of the material.

The flash point and fire point are precisely defined as under

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

Fire point: - The fine point is the lowest temperature at which the application of the test flame causes the material to ignite and burn at least for 5 seconds under specified condition of test.

There are two methods available for their determination (I) Closed method (II) Open method.

(I) CLOSED METHOD

APPARATUS REQUIRED:

1) Pensky – Marten`s closed tester consisting of following major parts.
   a) Cup –It is made up of brass, the inside of the cup is 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 device for locating the position of the lid on the cup and the cup itself in the stove. A handle is attached to the flange of the cup.
   b) Lid- It includes a stirring device, cover proper, shutter and flame exposure device.

   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 proper: is made of brass and fits the outside of the cup closely. It has four openings. 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- 2.5 mm 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, the openingsA, B and C ofthe lid are completely closed and when in the other 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 frame for automatic relighting of the exposure flame is to 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 so as to leave an air gap.

d) Thermometers – For low range values, it has measurement range from – 7°C to 110°C and readable upto 0.5°C.For expected higher values of flash and fire point, thermometer having a range of 90°Cto 370°C and readable to 2°C should be used.

PROCEDURE:

[A] For bitumen other than cut back bitumen

1) All parts of the cup and its accessories are cleaned and dried thoroughly before the test is started.
2) The cup is filled with the material to be tested upto the level indicated by the filling mark.
3) The lid is placed to close the cup taking care that the locating devices are properly engaged.(All accessories including the thermometer of specified range are suitably fixed)
4) The cup is set in the stove and the bitumen sample is heated.
5) Also the test flame is lit and adjusted in such a way that it is of the size of a bead of 4mm in diameter.
6) The heat is applied at such a rate that the temperature recorded by the thermometer increases between 5 to 6°c per minute.
7) The stirrer is turned at a rate of approximately 60 revolutions per minute.
8) The test flame is applied by operating the device controlling the shutter and test flame burner so that the flame is lowered in 0.5 seconds, left in its lower position for one second and quickly raised to its high position. The stirring is discontinued during the application of test flame.

9) Initially, the test flame is applied at a temperature 17°C below the expected flash point. There after it is applied at an interval of 1°C for the range up to 104°C. For the temperature range above 104°C, this interval is increased to 2°C at the time of flame application that causes a bright flash in the interior of the cup.

10) The flash point is taken as the temperature read on the thermometer.

11) The barometric pressure is also observed and recorded.

CALCULATION:

Correction to the flash point reading:

Depending upon the barometric pressure, the flash point figure is corrected according to the following rules;

a) For each 25 mm below 760 mm barrometric reading, 1°C is added to the flash point.

b) For each 25mmabove 760mm barometric reading, 1°C is subtracted from the flash point.

Precision:

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

Flash point	Repeatability	Reproducibility
104°C & below	2°C	3.5°C
Above 104°C	5.5° C	8.5°C

PRECAUTION:

1) Particular care is to be taken to remove all traces of solvent used to clean the apparatus.

2) The test flame is to be neither larger than stipulated nor to be applied more frequently than specified as the surface layer is liable to be more super heated.

3) The bluish halo that sometimes surrounds the test flame should not be confused with the true flash.

[B] For cut back bitumen.

PROCEDURE:

1) The material to be tested and the tester are brought to a temperature of 17°c lower than the expected flash point.
2) The air space between the cup and the interior of the air bath is to be completely filled with water at the temperature of the tester and material.
3) Procedure to be followed is same as for bitumen other than cut back bitumenexcept for the following changes.

   a) the rate of heating to be not less than 1° C and not more than 1.5° C per minute.

   b) the rate of stirring to be 70 – 80 rev/min.

   c) Low range thermometer is to be used and the test flame is to be applied at each 0.5° C rise in temperature.

(II) OPEN METHOD

APPARATUS REQUIRED:

The standard Pensy –Martens tester and thermometers as described in the previous methods is used with the following modifications.

The coper of the cup is replaced by a clip which encircles the upper rim of the cup and carries the thermometer and the test flame. The thermometer is so positioned that its bulb remains in the vertical axis of the cup and 12mm below the filling line. The test flame is fixed a t the vertical axis of the cup and in level with the upper edge of the cup.

PROCEDURE:

1) The same steps as mentioned for closed method are followed.
2) Heat is applied at such a rate that the temperature recorded by the thermometer increases between 5 to 6°C per minute.
3) The surface of the material is carefully observed during heating.
4) The open flash point is taken as the temperature when a flash first appears at any point on the surface of the material.
5) The heating is continued until the oil ignites and continuous to burn for 5 seconds. The temperature of the material when this occurs is recorded as fire points.

PRECAUTIONS:

1) Care is taken to remove all traces of solvent used to clean the apparatus.

2) The apparatus is to be shielded from the droughts of air.

Precision:

The duplicate test results should fall within this the following range

Test property	Repeatability	Reproducibility
Flash point	8°C	11°C
Fire point	8°C	14°C

Observation Sheet

Type of material ; Bitumen grade/ Cutback type & grade_____

Type of equipment : Closed Cup / open Cup

Rate of heating

Time, minutes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Temp., °C																	

Test property/ Particulars	Test Number	Mean Value

	1	2	3	
1. Flash point 2. Fire point 3. Variation from mean				

RESULTS:

The flash point and fire point of given sample of bitumen is _____

CONCLUSION:

(Comment on the result by comparing withstandard values).

DISCUSSION:

Different bituminous materials have quite different values of flash and fire points. The minimum value of flash point by Pensky Marten`s close type apparatus is 175°C for all grades of bitumen (both Assam petroleum and those from the other sources.

The minimum specified flash point for rapid curing cut back bitumen of all grades is 26°C and that for medium curing type is 38° C for grades 0 to 1 and 65°C for grades 2 to 5.Slow curing cut backs& have minimum values ranging from 65 to121°C.

It is essential from the safety point of view that the heating temperature of bituminous materialsshould be limited well below the flash point.

In closed cup system, the test result should not differ from the mean by more than 3° c for materials flashing above 104°c and not more than 1°C from the mean for materials flashing below 104° C. For open cup system, the mean value should not differ from individual values bymorethan 3° C for flash & by 6°C for fire point.

REFERENCE:

IS: 1209 –Method for testing tar and bituminous materials –Determination of the flash and fire point.

DUCTILITY TEST OF BITUMEN

AIM OF THE EXPERIMENT:

To determine the ductility value of a given sample of bitumen.

SCOPE OF THE TEST:

To assess the suitability of bitumen for its use in road construction.

THEORY:

The ductility is a measure of cohesive property of bitumen and thus in turn its ability to stretch. In flexible pavement construction, where bitumen binders are used, it is essential that the binders from a thin ductile film around the aggregate so that the physical interlocking of the aggregates is improved. The binder material which does not possess sufficient ductility gets cracked when subjected to repeated traffic loads resulting in pervious pavement surface and finally leading to damaging effect on the pavement structure. The ductility of a bituminous material is measured by the distance in centimeters to which it will elongate before breaking when two ends of a standard briquette specimen of the material are pulled apart at a specified speed and at a specified temperature .Normally, the test is conducted at 27 ± 0.5°C and a rate of pull of 50 ± 2.5 mm per minute. However, when a low temperature ductility tests is required the test is made at a temperature of (4± 0.5°C) and at a rate of pull of 10.0 ± 0.5 mm/min.

INSTRUMENTS/EQUIPMENTS/APPARATUS REQUIRED:

The apparatus for the standard ductility test consists of the following:

1) Briquette mould: - It is made up of brass metal with the shape and dimensions as shown in the fig. Both ends called clips (b & b′) possess circular holes to grip the fixed and movable ends of the testing machine. Side pieces (a & a′) placed together for the briquette of the following dimensions:

Length----------75mm

Distance between the clips----------30mm

Width at mouth of the clip----------20mm

Cross section at minimum width--------10mm x 10mm

2)Water bath –A bath (preferably thermostatically controlled) maintained within ± 0.1°C of the specified test temperature, containing not less than 10 liters of water ,the specimen being submerged to a depth of not less than 10cm and supported on a perforated shelf not less than 5cm from the bottom of the bath.

3)Testing machine-It is an equipment which functions as a constant temperature water bath with suitable arrangement for stirring the water for attaining uniformity in temperature and a pulling device at a precalibrated 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 mould so as to test these specimens simultaneously.

4) Thermometer –Range 0 – 44° C and readable upto 0.2° C.

MATERIAL REQUIRED:

Sample of bitumen.

PROCEDURE:

[**A] Sample preparation**

1) The bitumen sample is melted to a temperature of 75 °C to 100°C above the approximate softening point until it becomes thoroughly fluid.
2) If the sample contains extraneous matter, the fluid may be strained through IS sieve 30.
3) The mould is assembled on a brass plate and in order to prevent the material under test from sticking, the surface of the plate and interior surfaces of the sides of mould are thoroughly coated with a mixture of equal parts of glycerin and dextrine.
4) The sample is poured in the mould assembly and while filling the material is poured in a thin stream back and fourth from end to end of the mould until it is more than level full.
5) Then, it is left to cool at room temperature for 30 to 40 minutes and after that placed in a water bath maintained at the specified temperature for 30mins.
6) The sample and mould assembly are removed from the water bath and excess bitumen material is cut off by leveling the surface by means of a hot, straight edged putty knife or spatula.

[B] Testing proper:

1) The brass plate and mould with the briquetle specimen is placed in the water bath and kept at the specified temperature for about 85 to 95 minutes.
2) Then the briquette is removed from the plate, the side pieces are detached and the rings at each end of the clips are attached to the pins or hooks in the testing machine without causing any initial strain.
3) Two or more specimens may be prepared in the moulds and clipped to the machine so as to conduct these tests simultaneously.
4) The pointer is set to read zero. The machine is started and the two clips are pulled apart horizontally at a uniform speed until the sample reptures.
5) While the test is being made, itis to be ensured that the water in the tank of the testing machine covers the specimen both above and below it by at least 25mm and is maintained continuously within ≠ 0.5°c of the specified temperature.
6) The distance in centimeters through which the clips have been pulled to produce repture (i.e. the distance at which the bitumen thread of each specimen breaks is measured or noted).

PRECAUTIONS:

1) The plate upon which the mould is placed is tobe perfectly flat and level so that the bottom surface of the mould touches it throughout.
2) In filling the mould, care is taken not to disarrange the parts and thus disort the briquette and to see that no air pockets are within the moulded sample.

3) If the bituminous material comes in contact with the surface of the water or the bottom of the bath, the test is notconsidered to be normal and in that case the specific gravity of the water in the bath is adjusted by addition of either methyl alcohol or sodium chloride, so that these situations do not happen.

OBSERVATION AND REPORT:

The average of three normal tests is reported as the ductility of the sample, provided the three determinations are within ±5 percent of their mean value. If the value of the three determinations do not lie within ±5 percent of their mean value but the two higher values are within ±5 percent of their mean, then the mean of the two higher values are recorded as the tests result. However, if a normal test is not obtainable on three successive tests, the ductility is reported as unobtainable under the conditions of the test.

The repeatability and reproducibility of test results is to be within 10 and 20 percent of the mean.

Observation Sheet

(i) Grade of bitumen_____ (ii) Pouring temperature_____

(iii)Test temperature_____

(iv) Period of cooling, minutes (a) in air_____

(b) In water bath before trimming_____

(c) In water bath after trimming_____

Sl. No.	Particulars	Briquette the number			Mean
		1	2	3	
1	Initial reading				
2	Final reading				
3	Ductility				

RESULT: The ductility of the sample = _____.

Repeatability percent =_____.

Reproducibility = _____.

CONCLUSION:

(Comment on the result by comparing with standard values).

DISCUSSION:

The ductility value gets seriously affected if any of the factors like

i) Pouring temperature

ii) Dimension of briquette

iii) Test temperature

iv) Rate of pulling etc. are varied .Increase in minimum cross section of 10 sq.mm and increase in the test temperature would record increased ductility value.

In view of the temperature changes in bituminous mixes and repeated deformation that occur in flexible pavements due to the traffic loads, a certain minimum ductility is necessary for a bitumen binder, Bitumen with low ductility value may get cracked especially in cold weather. The ductility values of bitumen may vary from 5 to over 100. Often a minimum ductility value of 50cm is specified for bituminous consruction.However, the suitability of bitumen is judged depending upon its type and proposed use.

The minimum ductility values specified by BIS for various grades of bitumen available in India are as follows:

Source of paving bitumen	Penetration Grade	Minimum ductility value, cm
Assam petroleum	A25	5
	A35	10
	A45	12
	A65,A90 and A200	15
Bitumens from sources other than Assam petroleum	S35	50
	S45,S65 & S90	75

REFERENCE:

IS: 1208 – Methods for testing tar and bituminous materials; Determination of ductility.

DETERMINATION OF VISCOSITY OF BITUMINOUS MATERIAL

AIM: To determine the viscosity of road tar and cut back bitumen

SCOPE OF THE TEST:

To assess the suitability of the bituminous material to be used in road constructions in different tempera zones.

THEORY:

Viscosity may be defined as inverse of fluidity and it is that properly of a fluid by virtue of which it offers resistance to flow due to internal friction.

Higher the value of viscosity, the slower will be the movement of fluid and vice versa. The viscosity at the application temperature greatly influences the ability of a binder (bituminous material) to spread, penetrate into the voids as well as coat the aggregates thus affecting the strength characteristics of the paving mixes. There is always an optimum value of viscosity for mixing and compaction of each aggregate gradation of the mix and bitumen grade beyond which paving mix has been observed to result in lower stability values. Highly viscous binders may not fill up the voids completely there by resulting in poor density of the mix. At lower viscosity, the binder does not hold the aggregates, together but just acts as lubricants.

The viscosity of bituminous binders changes very rapidly as the temperature rises or falls. Since the bituminous binders exhibit viscosity over a wide range, it becomes necessary to use different methods for the determination of viscosity .For binders in liquid state the industrial viscosity is measured by determining the time taken by 50cc of the material to flow from a cup through a specified orifice under standard conditions. of test and at specified temperature. There are two types of orifice; 10mm cup is used to determine viscosity of road tar and 4mm cup is used to determine viscosity of cut back bitumen. Absolute & kinematic viscosity is also some times determined.

In the range of consistency of bituminous materials when neither orifice viscometer test nor penetration test could be conducted, float test may be carried out. Equipments like sliding plate micro-viscometer and Brook field viscometer may be used for all grades of bitumen irrespective of testing temperature. The viscosity of bitumen can also be measured by capillary tube viscometer.

APPARATUS REQUIRED:

Tar viscometer – It consists 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 etc. different parts and accessories as described below.

a) Cup- made up 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. (for road tar) or diameter 4mm and length 5mm(for cut back).

b) Valve – Serves to close the orifice of the cup and is made up of phosphor – bronze.

c) Water bath – made up of copper sheet, cylindrical in shape, about 160mm in diameter and 105 mm in depth mounted on three equidistant legs.

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

e) Stirrer – consisting of four vertical vanes.

f) Curved shield – fixed to the upper edge of the cylinder and extends to within about 5mm of the walls of the water bath, carries an insulated handle for rotating a stirrer, a support for a thermometer and a swivel support for the valve.

g)Receiver- A 100ml graduated measuring cylinder with graduations at 20ml,25ml and 75ml capacities having an internal diameter of not more than 29mm.

h) Thermometers– two nos, one for the bath and another for the cup. The measurement range should be 0 to 44°C or 37.8°C to 82°C or 76°C to 122°C for low, medium and high viscosity respectively. The thermometer should be readable and accurate up to 0.2°C.

i) A stop watch or other time measuring device capable of being read up to ½ second.

Note: - *The working range of tar viscometer with 10mm orifice is such that liquid having time of efflux between 10 seconds and 140 seconds is used. For 4mm orifice, it may be between 20 and 200 seconds.*

MATERIALS REQUIRED:

1) Sample of road tar or cut back bitumen.

2) Mineral oil or 1 percent soap solution.

PROCEDURE:

1) The tar viscometer is adjusted so that the top of the tar cup is level.
2) The water in the water bath is heated to the temperature specified for the test and it is maintained within ± 0.1°c of the specified temperature through out its bulk for the duration of the test, the stirrer being gently rotated at frequent intervals or preferably, continuously.
3) The cup orifice of the viscometer is cleaned with a suitable solvent and dried thoroughly.
4) The sample material is heated with stirring at a temperature of 20◦C above the specified test temperature and allowed to cool while continuing the stirring.
5) When the material reaches slightly above the test temperature, the same is poured in the cup until the leveling peg on the valve rod is just immersed when the later is vertical.
6) 20ml of mineral oil or a one percent by weight solution of soft soap is poured into the graduated receiver and it is placed under the orifice of the cup.
7) A second thermometer is placed in the sample material and the latter is stirred until the temperature is within ± 0.1°c of the specified temperature. When this temperature has been reached, the thermometer is coaxially suspended with the cup with its bulbs approximately at the geometric center of the sample material.
8) The assembled apparatus is allowed to stand for five minutes during which period the thermometer reading remains within 0.05°c of the specified temperature. The thermometer is

removed and any excess of sample material is quickly removed so that the final level is on the central line of the leveling peg when the valve is in vertical position.

9) The value is lifted to open and it is suspended on valve support.

10) The stop watch or the time recording device is started when the reading in the cylinder (receiver) is 25 ml and it is stopped when it is 75ml.The time is noted in seconds.

11) The time taken in seconds by 50ml of the sample material (tar or cut back) to flow out at the temperature specified for the test is reported as the viscosity.

PRECAUTIONS:

i) The temperature of the test is to be appropriate and should be a multiple of 5°c not lower than 20°c.

ii) The cup should be cleaned gently with non- corroding solvents such as light tar oils free from phenols.

iii) The orifice size should be tested at frequent intervals with a gauge having appropriate diameters.

iv) The results of the viscosity test is likely to be substantially affected if the test temperature of the sample is not correctly maintained throughout the test.

v) Erratic results are obtained due to clogging of the orifice or due to presence of lumps in the sample of bituminous material.

REPORT:

Whether the sample was dried or tested as received is clearly stated. The pressure of water, presence particularly in quantities less than 1 percent has a marked effect on the viscosity. The method of drying adopted is also reported.

Observation Sheet

i) Material: Road tar/cut back bitumen Grade:_____

iii) Specified test temperature, °c=_____ iv) Size of ……., mm=_____

v) Actual test temperature, °c=_____

Test properly	Test run			Mean
	1	2	3	
Time taken for flow of 50 ml binder				
i)Repeatability ii)Reproducibility				

RESULT:

The viscosity of the supplied sample of road tar/ cut back bitumen_____

CONCLUSION:

(Comment on the result by comparing with standard values)

PRECISION:

1) For road tar, the results of repeat determinations on portions of the same sample should fall within ± 4 percent of the average of several readings.

2) For cut back, the results of duplicate tests should not differ by more than the following amount.

Viscosity	Repeatability	Reproducibility
Below 20s	2s	2s
20 to 40s	2s	10% of the mean
>40s	5% of the mean	10% of the mean

DISCUSSION:

The determination of time of flow in seconds of binder through the orifice gives an indirect measure of viscosity of tars and cut backs whereas absolute unit of viscosity is dyne seconds per cm^2 or poise. Higher the duration of flow, greater is the viscosity. Viscosity of the binder is one of the criteria for their classification. The viscosity of a particular grade of road tar or cut back bitumen should fall within the range as given in Table 1 & 2.

In case, the viscosity test is carried out to classify a given sample of road tar or to find its grade, then the test is first conducted at the lowest temperature of testing road tar i.e. 35°c.If the time taken for 50ml of tar sample to flow through the 10mm orifice is more than 55 seconds 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. However ,if the viscosity of an unknown grade of cut back ,is to be determined ,the orifice size and trial test temperature is choosen using judgment .If the viscosity value of the trial test does not fall within the specified range, test should be repeated by altering the test temperature or orifice size or both suitably.

Table 1

Specifications for Test Temperature & Range of Viscosity for Road Tar (As per IS: 215)

Road tar type	RT-1	RT-2	RT-3	RT-4	RT-5
Test temp, °C	35	40	45	55	-
Viscosity in s	30 to 55	30 to 55	30 to 60	30 to 60	-

Table 2

Specifications for Test Temperature & Range of Viscosity for Cutback bitumen (As per IS: 217)

Grades – SC,MC,RC	1	2	3	4	5	6
Orifice size, mm	4.0	4.0	10	10	10	10
Test temp, °C	25	25	25	25	40	40
Viscosity in sec	25-75	30-150	10-20	25-75	14-45	60-140

Binders having very low viscosity can be advantageously used in exceptionally cold weather condition. High viscosity binders have to be heated before their application. There is a range of consistency of the bituminous materials for which neither an orifice viscometer test nor a penetration test could be used to define consistency of the material. The consistency of intermediate materials of this group is measured by the float test.

REFERENCE: IS: 1206 – (Part –I)-Method for testing tar and bituminous materials;

PENETRATION TEST OF BITUMEN

AIM: To determine the penetration value of bitumen.

SCOPE OF THE TEST:

To assess the suitability of bitumen for its use under different climatic conditions and type of constructions.

THEORY:

Penetration is measure of consistency of bituminous material. It is the distance in tenths of a millimeter that a standard needle penetrates vertically into a sample of the material under standard conditions of temperature, load and duration. Thus the basic principle of penetration test is the measurement of the penetration of a standard needle in a bitumen sample maintained at 25°C during 5 seconds, the total weight of the needle assembly being 100± 0.25 g. The softer the bitumen, the greater will be the penetration.

Various types and grades of bituminous materials are available depending on their origin and refining process. The consistency of bituminous materials vary depending upon several factors such as constituents, temperature etc. However, penetration test is widely used for the purpose of classifying bitumen into different grades.

EQUIPMENT/INSTRUMENTS/APPARATUS REQUIRED:

1) Containers –A metal or glass cylindrical, flat bottom container of following dimensions are used.

   For penetration below 225 ,diameter 55m & Internal depth 35mm.For penetration between 225 & 350 ,diameter 70mm & internal depth 45mm.

2) Needle –A straight, highly polished, cylindrical stainless steel needle with conical end, having the shape and dimension as given in the fig. The needle is provided with a shank approximately 3.0 mm in diameter into which it is immovably fixed.[fig.]

3) Water bath –A water bath thermostatically maintained at 25°±1°C containing not less than 10 liters of water ,the sample being immersed to a depth of 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- A small dish or tray to provide a firm bearing and prevent rocking of the container. It should be of such capacity as to completely immerse the container during the test.

5) Penetration apparatus (penetrometer) –It allows the needle assembly of grass weight 100g to penetrate without appreciable friction for the desired duration of time. The dial is accurately calibrated to give penetration value in units of one –tenth of a mm. Both manual & electrically operated automatic penetrometers are available.

6) Thermometer – Range 0– 44°C and readable up to 0.2°C.

7) Time measuring device- within accuracy of ± 0.1s.

MATERIALS /REAGENT/CHEMICAL REQUIRED:

Given sample of bitumen or fluxed native asphalt.

PROCEDURE:

[A] Preparation of test sample

1) The sample of bitumen is softened to a pouring consistency at a temperature not more than 60°C for tars and pitches and not more than 90°c for bitumens (above the respective approximate soften point) and it is stirred thoroughly until it is homogeneous and free from air bubbles and water.
2) The melt is poured into the container to a depth at least 10mm in excess of the expected penetration and the sample is protected from the dust and allowed to cool in an atmosphere at a temperature between 15 to 30° c for $1\frac{1}{2}$ to 2 hours for 45 mm deep container and 1 to $1\frac{1}{2}$ hours when the container of 35 mm depth is used.
3) Then the sample along with the transfer dish is placed in the water bath at 25 ≠ 1°c and it is allowed to remain for $1\frac{1}{2}$ to 2 hours or 1 to $1\frac{1}{2}$ hours for 45 mm and 35 mm deep container respectively.

[B] Testing proper:

1) The transfer dish is filled with water from the water bath to a depth sufficient to cover the container completely, the sample is placed in it and it is put upon the stand of the penetration apparatus.
2) The needle is washed clean with benzene, dried and loaded with the weight. The total moving load required is 100 ± 0.25 grams including the weight of the needle, carrier and super imposed weight.
3) The needle is adjusted 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.
4) The pointer of the dial is made to read zero or the initial dial reading is noted.
5) The needle is released exactly for five seconds and the penetration apparatus is adjusted to measure the distance penetrated. The difference between the initial and final penetration readings is taken as the penetration values.
6) At least three determinations are made at points on the surface of the sample not less than 10 mm apart and not less than 10mm from the side of the dish.
7) After each test, the sample and transfer dish is returned to the water bath and the needle is washed clean with benzene and dried.
8) In case of material of penetration greater than 225, three determinations on each of two identical test specimens using a separate needle for each determination is made ,leaving the needle in the sample on completion of each determination to avoid disturbance of the specimen.

PRECAUTIONS:

1) The sample should be free from the extraneous matter. If the sample contains extraneous matter, it should be sieved through IS sieve 30.

2) There should be no movement of the container while needle is penetrating in to the sample.

3) An air- oven or sand bath is to be used to avoid over- heating at the bottom of the container.

OBSERVATION AND REPORT:

The depth of penetration of the needle is expressed in tenths of millimeter and the mean value of three consistent penetration measurements is reported as the penetration value. The result of each measurement is not to differ from the mean by more than the amount given below.

Penetration	**Maximum difference**
0 to 49	2
50 to 149	4
150 to 249	6
250 and above	8

Also the duplicate results should not differ by more than the following.

Penetration	*Repeatability*	*Reproducibility*
Below 50	1 unit	4 units
Above 50	3% of their mean	8% of their mean

Actual test temperature =_____°C.

Sl. No.	Particulars of readings	Sample I				Sample II			
		Test 1	Test 2	Test 3	Mean	Test 1	Test 2	Test 3	Mean
1	Penetrometer dial reading (a)Initial (I) (b)Final (F)								
2	Penetration value								
3	Repeatability or reproducibility								

RESULT:

The penetration value of bitumen = _____.

CONCLUSION AND REMARKS:

(Comment on the result by comparing with standard values).

DISCUSSION:

Penetration test is the commonly adopted test on bitumen to grade the material in terms of its consistency (hardness or viscosity) .Depending upon the climatic condition and the type of construction ,bitumens of different penetrate grades are used. A 80/100 bitumen implies that its penetration value

ranges between 80 to 100 .The penetration values of various types of bitumen used in pavements construction in our country range between 20 to 225. As per IRC recommendations, for bituminous macadam and penetration macadam, bitumen grades 30/40, 60/70 and 80/100 are to be used. In warmer regions, lower penetration grades are preferred to avoid softening, whereas higher penetration grades like 80 / 200 etc. are used in colder regions so that excessive brittleness does not occur. Highest penetration grade bitumen is used in spray application works.

However, penetration test is not intended to estimate the consistency of softer materials like cutbacks or tars ,which are usually graded by a viscosity test in an orifice viscometer. Again ,these is a certain range of consistency of bituminous materials ,where- in the material is too soft for penetration test, but the viscosity of the material is so high that it cannot flow thorough the orifice of the viscometer; the consistency of such materials is measured by the 'float test.

It may be noted that the penetration value is influenced by any inaccuracy resulting from
(1)proving temperature(2)Size of the needle(3)Weight placed on the needle(4)Test temperature and
(5) Duration of release of the penetration needle. It is obvious that a high value of penetration is obtained if the test temperature or the weight placed over the needle is inversed. Higher pouring temperature than that specified may be result in hardening of bitumen and may be give lower penetration values.

REFERENCE:

IS: 1203 – Method for testing tar and bituminous materials; Determination of penetration.

DETERMINATION OF SOFTENING POINT OF BITUMEN

AIM: To determine the softening point of given sample of bituminous material.

SCOPE OF THE TEST:

Softening point test is required to assess temperature susceptibility & suitability of the bituminous material to be used under different temperate zones or climatic conditions i.e. warmer or colder place.

THEORY:

Generally bitumens tend to liquefy under the application of heat or rise of temperature. It does not suddenly change from solid to liquid state, but as the temperature increases, it gradually becomes softer until it flows readily. The softening point is the temperature at which the substance attains particular degree of softening under specified conditions of the test. For bitumen, it is usually determined by Ring and Ball test, where it refers to the temperature in ^{0}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 idea of softening point helps to know the temperature up to which a road structure will remain stable or a bituminous birder should be heated for various road use application. The softening point of various bitumen grades used in paving jobs vary between 35°c to 70°C .Hard grade bitumens possess higher softening point than soft grade bitumens. Generally higher softening point indicates lower temperature susceptibility and is preferred in warm climates.

APPARATUS /EQUIPMENT REQUIRED:

1) The ring and ball apparatus consisting of the following

   a) Steel balls-two numbers each of 9.5 mm dia and weighting (3.5 ±0.05) g.

   b) Brass rings - Two numbers each having depth of 6.4 mm. The inside diameter at top and bottom is 17.5mm & 15.9mm respectively.

   c) Ball guides- to guide the movement of steel balls centrally.

   d) 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 25mm.

2) Thermometer – that can read up to 100°C with an accuracy of 0.2 °C.
3) Bath and stirrer –A heat resistant glass vessel not less than 85 mm diameter and 120 mm depth. The bath liquid is fleshed boiled distilled water for materials 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.

The test set up:

The brass rings containing the test sample of bitumen remains suspended in liquid like water or glycerin at the given temperature. A steel ball can be placed up on the bitumen and liquid medium heated at a specified rate. The upper surface of the ring remains 50mm below the surface of the water or liquid contained in the bath. A distance of 25mm between the bottom of the rings and the top surface of the bottom plate of support is provided. It has a housing for a suitable thermometer.

MATERIAL REQUIRED:

1) Sample of bitumen
2) Distilled water or glycerin
3) Grease.

PROCEDURE:

1) The sample material is heated to a temperature between 75 °c to 100°C above its approximate softening point ,stirred until it is completely fluid and free from air bubbles and water.(If necessary ,it may be filtered through I.S sieve30.)
2) The rings are also heated to a temperature approximately to that of the molten material and placed on a metal plate which is coated with a mixture of equal parts of glycerin and dextrine.
3) The rings are filled with sufficient melted material to give an excess above the level of the ring when cooled.
4) After cooling for 30 minutes in air, the material in the ring is leveled by removing the excess with a warmed, sharp knife.
5) The apparatus is assembled with the rings, thermometer and ball guides in position and the bath is filled to a height of 50mm above the upper surface of the rings with freshly boiled distilled water glycerin depending upon the expected softening point at a temperature of 5° C/ 35°C as the case may be.
6) The bath is maintained at a temperature of 5°C for 15 minutes after which a ball previously cooled to a temperature of 5°C is placed by means of forceps in each ball guide.
7) Heat is applied to the bath and the liquid is stirred so that the temperature rises at a uniform rate of 5 ≠ 0.5°c per minute until the material softens and allows the ball to pass through the ring, carrying a portion of the material with it.
8) The rate of temperature rise is not to be averaged over the period of the test and any test in which the rate of temperature rise does not fall within the specified limits after the first three minutes, is rejected.
9) The temperature at the instant when each ball with bituminous coating touches the bottom plate is noted down.
10) The mean of the duplicate determinations to the nearest 0.5°C is reported as the softening point.

PRECAUTIONS:

1) During conduct of the test, the apparatus should not be subjected to any vibrations.
2) The bulb of the thermometer should be at about the same level as the rings.
3) Only freshly boiled distilled water are to be used in the test, as otherwise air bubbles may form on the specimen and affect the accuracy of the result.
4) The prescribed rate of heating is to be rigidly adhered to for ensuring accuracy of results.

5) A sheet of filter paper or thin amalgamated sheet is to be placed on the bottom of the glass vessel and conveniently weighed to prevent the material from sticking to the glass vessel and considerable time and trouble in cleaning can be avoided.

OBSERVATION AND PRECISION:

Determination of softening point is to be made in duplicate. The test result shall not differ from the mean by more than the following;

Softening point(°C)	Repeatability(°C)	Reproducibility(°C)
40 to 60	1.0	5.5
61 to 80	1.5	5.5
81 to 100	2.0	5.5
101 to120	2.5	5.5
121 to 140	3.0	5.5

Observation sheet

1) Bitumen grade_____ 2) Liquid used in the bath_____

3) Period our cooling, minutes_____

4) Period of cooling in water bath, minutes_____

Rate of heating

Time in minutes	1	2	3	4	5	6	7	8	9	10
Temperature in °C										
Time in minutes	11	12	13	14	15	16	17	18	19	20
Temperature in °C										

Test property or particulars	Sample No 1		Sample No 2		Mean value softening point
	Ball no 1	Ball no 2	Ball no 3	Ball no 4	
Temperature in °C at which the sample touches bottom plate					
Repeatability					
Reproducibility					

RESULT:

The softening point of given sample of bitumen_____.

CONCLUSION:

(Comment on the result by comparing with standard values)

REFERENCE:

IS: 1205-Method for testing tar& bituminous materials; Determination of softening point.

DISCUSSION:

Softening point indicates the temperature at which the binders possess the same viscosity .Bituminous materials do not have a definite melting point. Rather the change of state from solid to liquid is gradual and over a wide range of temperature. Softening point has particular significance for materials that are to be used as joint and crack fillers. Higher softening point ensures that they will not flow during service. It is used to specify hard bitumen and pitches. Softening point of bitumen to be used for pavement construction should not be less than 40.

Any variation in the

i) Quality and type of liquid

ii) Weight of balls

iii) Distance between bottom of ring and bottom base plate

iv) Rate of heating is likely to affect the softening point.

v) Impurity in water or glycerine has been observed to affect the result considerably. If the weight of the ball is excessive, lower softening point is observed. On the other hand, increased distance between bottom of the ring and bottom plate increases the softening point.

Bitumen grade	A25 & A35	S35	A45 S45 A65	S65	A90 & S90	A200 & S200	A-Assam petroleum
Sifting point, °C	55 to 70	50 to 65	45 to 60	40 to 55	35 to 50	30 to 45	S-Bitumen from other sources