List of Experiments

Name of laboratory : Transportation Engg.

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EXPERIMENT – __
CBR Test

AIM:

To determine the California Bearing Ratio (CBR) of soil specimen.

THEORY:

The California Bearing Ratio test is conducted for evaluating the suitability of the sub-grade and the material used in sub-base and base of a flexible pavement.

The plunger in the CBR test penetrates the specimen in the mould at the rate of 1.25 mm per minute. The load required for the penetration of 2.5 mm is determined. The penetration load is expressed as a percentage of the standard loads at the respective penetration level of 2.5 mm or 5.0 mm.

$$\text{CBR Value} = \frac{\text{Penetration load}}{\text{Standard load}} * 100$$

The CBR value is determined corresponding to both penetration levels. The greater of these values is used for the design of the pavement.

APPARATUS:

1) CBR mould, inside diameter = 150 mm, total height = 175 mm, with detachable extension collar, 50 mm high and detachable base plate, 10 mm thick.
2) Space disc, 148 mm diameter and 47.7 mm high.
3) Rammers, for light compaction : 2.6 kg, drop 310 mm; for heavy compaction : 4.8 kg, drop 450 mm.
4) Slotted masses, angular, 2.5 kg each, 147 mm diameter, with a hole of 53 mm diameter in centre.
5) Cutting collar, steel, which can fit flush with mould both outside and inside.
6) Expansion measuring apparatus, consisting of a perforated plate, 148 mm diameter with a thread screw in the center and an adjustable contact head to be screwed over the stem, and a metal tripod.
7) Penetration piston, 50 mm diameter, and 100 mm long.
8) Loading device, capacity 50 kN equipped with a movable head at a uniform rate of 1.25 mm per minute
9) Two dial gauges, accuracy 0.01 mm.
10) IS sieve, 4.75 mm and 19 mm size.

CBR TEST APPARATUS

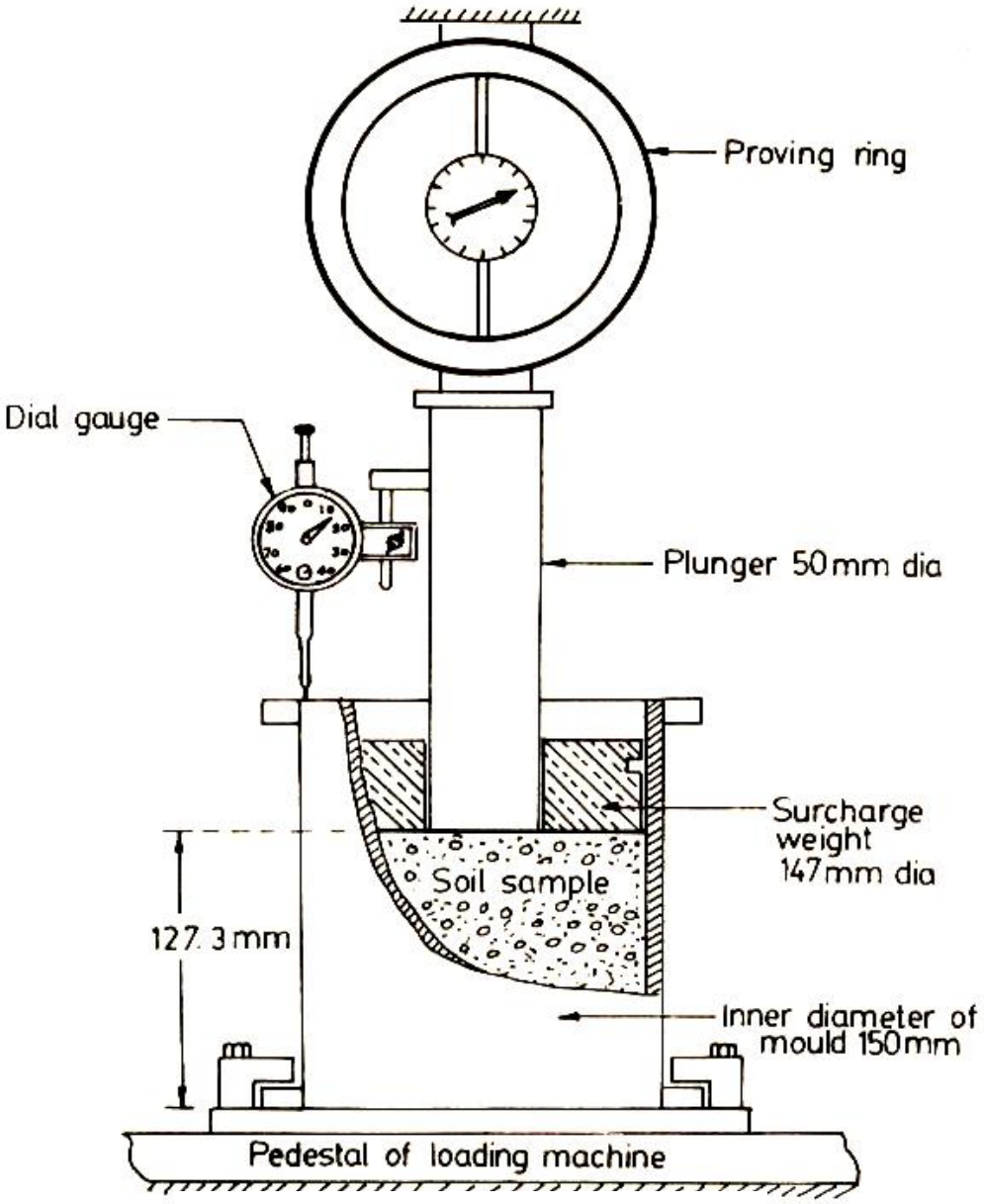


Fig. 1.8 CBR Test Set up

PROCEDURE:

As per the ISI, the CBR test may be performed either on undisturbed soil specimen or on remoulded specimens. Remoulded soil specimens may be compacted either by static compaction or by dynamic compaction. The preparation of soil specimens by dynamic compaction or ramming is more commonly adopted and is explained below. The soil specimen may be tested in unsoaked or soaked condition.

- Sieve the sample through **19 mm** IS sieve. Take the material passing 19 mm IS sieve for the test. However, make allowance for large size material by an equal amount which passes 19 mm IS sieve, but retained on 4.75 mm IS sieve.
- Take about 4.5 to 5.0 kg of the material, as obtained in step (1). Mix it thoroughly with the required quantity of water.
- Fix the extension collar to the top of the mould. Also fix, the base plate to the bottom.
- Insert the spacer disc over the base, with the central hole of the disc at the lower face. Place coarse filter paper on the top of the displacer disc.
- Take the soil sample in the mould. Compact it using either the light compaction rammer or heavy compaction rammer, as desired. **For light compaction**, the soil is to be compacted in **3 equal layers**, each layer is given **25 blows** by **2.6 kg** rammer with drop of **310 mm**. **For heavy compaction** the soil is compacted in **5 equal layers**, each layer is given **25 blows** by **4.89 kg** rammer with drop of **450** mm.
- Remove the extension collar. Trim even the excess compacted soil carefully with a straight edge with the top of the mould. Any hole that may form on the surface of the compacted soil by the removal of the coarse particles should be patched with small size particles and leveled. Loosen the base plate. Remove the base plate and the spacer disc.
- Weigh the mould with the compacted soil.
- Place a filter paper disc on the base plate. Invert the mould with the compacted soil. Clamp the base plate. Place a perforated disc fitted with an extension stem on the specimen top after placing a filter disc.
- Place annular masses to produce a surcharge equal to the mass of the base material and wearing coat of the pavement expected.
- Each 2.5 kg annular mass is equivalent to 70 mm of construction material. However, a minimum of two annular masses should be placed.
- Immerse the mould assembly in a tank full of water. Allow free access of water on the top and bottom of the specimen.
- Mount the tripod of the expansion measuring device on the edge of the mould and take the initial reading of the dial gauge.

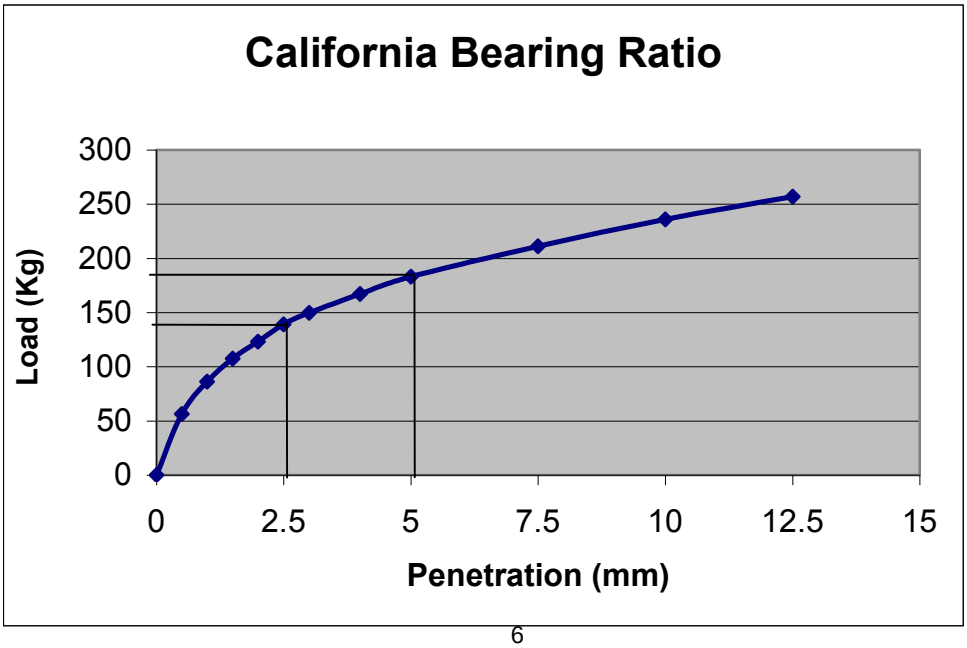
- Keep the mould in the tank undisturbed for 4 days. Take the reading of the dial gauge everyday and note the time of reading. Maintain water level constant in the tank. Take the final reading at the end of the 4 days.
- Remove the tripod. Take out the mould from the tank. Allow the specimen to drain off for 15 minutes. Remove all the free water on the mould, without disturbing the surface of the specimen.
- Weigh the mould with the soaked specimen.
- Place the mould containing the specimen, with the base plate in position but the top face exposed on the lower plate of the loading machine. Place the required surcharge masses on the top of the soaked specimen.
- To prevent upheaval of soil into the hole of the surcharge mass, one 2.5 kg annular mass shall be placed on the soil surface prior to seating the penetration plunger. After that the remaining masses are placed.
- Seat the penetration plunger at the centre of the specimen to establish full contact between the plunger and the specimen. The seating load should be about 40 N.
- Set the load gauge and the displacement dial gauge to zero. The initial load already applied to the plunger should be considered to zero.
- Apply the load on the plunger. Keep the rate of penetration as 1.25mm / min. Record the load corresponding to penetration of 0.5,1.0,1.5,2.0,2.5,3.0,4.0,5.0,7.5,10.0,12.5 mm. However, record the maximum load and the corresponding penetration if it occurs at a penetration of less than 12.5 mm.
- At the end of the test, raise the plunger and remove the mould from the loading machine.
- Take about 20 to 50 g of soil specimen from the top 30 mm layer for the water content determination. If the water content of the whole specimen is required, take soil specimen from the entire depth.

OBSERVATION TABLE:

Dial Guage Reading	Proving Ring reading	Load (Kg)
0.0		
0.5		
1.0		
1.5		
2.0		
2.5		
3.0		
4.0		
5.0		
7.5		
10.0		
12.5		

RESULTS:

The CBR values at 2.5 mm and 5.0 mm penetrations are calculated for each specimen from the corresponding graphs. Generally the CBR value at 2.5 mm penetration is higher and this value is adopted. However if higher CBR value is obtained at 5.0 mm penetration, the test is to be repeated. If the value at 5.0 mm is again higher, this is adopted as CBR value of the soil sample. The average CBR value of three specimens is reported to the first decimal place and a plot is made between Load v/s. Penetration (As shown in figure below).



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

Maximum permissible variation in CBR values , %	Range of CBR valu1es, %
3.0	Upto 10
5.0	10 to 30
10.0	30 to 60
Not significant	Above 60

$$\text{CBR (2.5 mm)} = \frac{\text{Corrected load at 2.5 mm} * 100}{1370} =$$

$$\text{CBR (5.0 mm)} = \frac{\text{Corrected load at 5.0 mm} * 100}{2055} =$$

DISCUSSIONS:

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

REFERENCES:

(1) IS: 2720 (Part 16), 1987
(2) Punmia B.C. (1980), “Soil Mechanics and Foundations”
(3) Khanna S.K. and Justo C.E.G., “Manual of Highway Material Testing”

EXPERIMENT – ___
Aggregate Crushing Test

AIM:

★ To determine crushing value of the road aggregate
★ To assess suitability of aggregates for use different types of road pavements.

CONCEPT AND SIGNIFICANCE OF THE TEST:

The principal mechanical properties required in road stones are:

- Satisfactory resistance to crushing under the roller during construction.
- Adequate resistance to surface abrasion under traffic.

The 'Aggregate crushing value' gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. It is the percentage by weight of the crushed material obtained when the test aggregate are subjected to a specified load under standard conditions, and is the numerical index of the strength of the aggregates used in the road construction.

Aggregates used in road construction, should be enough to resist crushing under traffic wheel loads. If the aggregates are weak, the stability of the pavement structure is likely to be adversely affected. The strength of coarse aggregates is assessed by aggregates crushing test. Aggregate possessing low crushing value should be preferred.

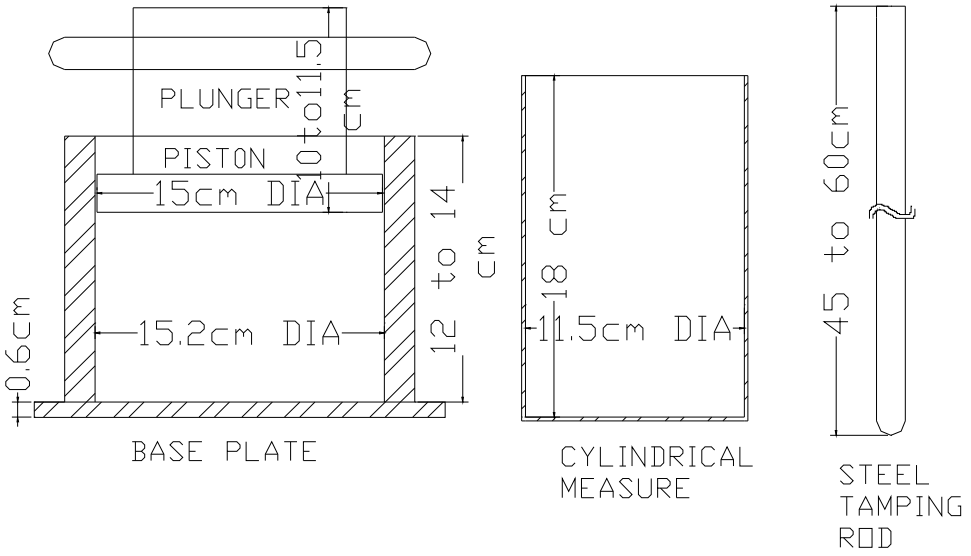
APPARATUS:

The apparatus for the standard aggregate crushing as per IS: 2386 (Part – IV) – 1963 consists of the following:

1) A test mould of 15.2 cm. Diameter open-ended cylinder with a square base plate, plunger having a piston of dia. 15 cm. with a hole provided across the stem of the plunger so that a rod could be inserted for lifting or placing the plunger in the cylinder.
2) A straight metal tamping rod of circular cross section 16 mm in diameter and 45 to 60 cm long, rounded at one end.
3) A balance of capacity not less than 500 g, readable and accurate up to 0.1 g.
4) IS sieves of sizes 12.5 mm, 10mm and 2.36 mm.

5) A compression testing machine capable of applying load up to 40 tonnes at a Uniform rate of 4 ton per minute.

6) A cylindrical measure having inter diameter of 11.5cm and height 18 cm.



AGGREGATE CRUSHING TEST APPARATUS

PROCEDURE:

The material for standard test sample consists of aggregates size 10 mm to 12.5 mm. The aggregates should be in the surface dry condition before testing. The aggregates may be dried by heating at100 – 110°C for not more than 4 hours and cooled to room temperature before testing, if necessary.

1) Sieve the material through 12.5 mm and 10.0 mm IS sieves. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.
2) Take about 3.25 kg of this sample.
3) Pour the aggregate to fill about 1/3rd depth of measuring cylinder.

4) Compact the material by giving 25 gentle blows with rounded end of the tamping rod.
5) Add two layers in similar manner, so that cylinder is full.
6) Remove the excess material with a straight edge. The quantity contained in the measuring cylinder is that amount of aggregates which will be used to prepare the test specimen.
7) Empty the cylinder and weight the aggregates, accurate up to 1 gram.
8) Transfer the whole of this weighed the quantity to the test mould by filling it in three layers in the same manner as for cylindrical measure. The total depth of the sample is about 10 cms and the surface a little below the top of mould.
9) Level off the surface and place the plunger over it so that it rests horizontally on the surface of the aggregate.
10) Place this assembly on the pedestal of compression testing machine.
11) Apply the load at a uniform rate of 4 tonnes per minutes until the total applied load is 40 tonnes.
12) Release the load.
13) Take the aggregates out of cylinder and sieve them through 2.36 mm IS sieve. weight this fraction is a measure of loss of material due to crushing.
14) Note down the observations in the proforma and compute the aggregate crushing value. The mean of two observations, rounded to nearest whole number is reported as the 'Aggregate Crushing Value'.

INTERPRETATION OF RESULTS:

The suitability of aggregates is adjudged, dependent upon its proposed use in the pavement layers. The table given below lays down specified limits of percent aggregate crushing value, for different types of road construction.

Sr. no.	Type of Pavement	Max. Aggregate Crushing Value %
1.	**Flexible pavements**	
a.	Soling	50
b.	Water Bound Macadam	40
c.	Bituminous Macadam	40
d.	Bituminous surface dressing / thin premix carpet	30
e.	Dense mix carpet	30
2.	**Rigid pavements**	
a.	Cement concrete base course	45
b.	Surface or wearing course	30

OBSERVATION:

Sr. No.	Description	1	2	3
1.	Total Weight of the Aggregate taken W1 (gm)			
2.	Weight of aggregate retained on 2.36 mm IS sieve, W2 (gm)			
3.	Weight of aggregate passing through 2.36 mm IS sieve W3 = W1 – W2 (gm)			
4.	Aggregate Crushing Value = (W3 / W1) x 100 in %			
	Average			

CALCULATIONS (For Sample 1):

Weight of the dry sample W_1 gm = gm
Weight of fraction retained on 2.36 mm IS sieve W_2 gm = gm
Aggregate passing through 2.36 mm sieve weight $W_1 – W_2$ = gm

Crushing value percentage = $(W_3 / W_1) * 100$

= **%**

PRECAUTION:

- The plunger should be placed centrally and rest directly on the aggregates. Care should be taken that it 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 aggregate through 2.36 mm sieve and weighing Care should be taken to avoid loss of fines. The sum of weights of fractions retained and passing the sieve should not differ from the original weight of the specimen by more than 1 gm.
- The tamping should be done properly by gentle dropping the tamping rod and not By hammering action. Also the tamping should be uniform over the surface of the aggregate taking care that the tamping rod does not frequently strike against the walls of the road.

EXPERIMENT – 4
Impact Test

AIM:

★ To determine the impact value of the road aggregate
★ To assess their suitability in road construction on the basis of impact value

CONCEPT AND SIGNIFICANCE OF THE TEST:

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

APPARATUS:

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

- A testing machine weighting 45 to 60 kg and having a metal base with a plane lower surface of not less than 30 cm in diameter. It is supported on level and plane concrete floor to minimum 45 cm thickness. The machine should also have provision for fixing its base.
- A cylindrical steel cup of internal diameter 102 mm, depth 50mm and minimum thickness 6.3 mm
- A metal hammer or cup weighting 13.5 to 14.0 kg the lower end is cylindrical in shape, is 50 mm long, 100 mm in diameter, with a 2 mm chamfer at the lower edge and case hardened. The hammer should slide freely between vertical guide and be concentric with the cap. The free fall of the hammer should be within 380 $\pm$ 5 mm.
- A cylindrical metal measure having internal diameter of 75 mm and depth 50 mm for measuring aggregates.
- Tamping rod 10 mm in diameter and 230 mm long, rounded at one end.
- A balance of capacity not less than 500 g, readable and accurate up to 0.1 g. I.S.sieves of sizes 12.5 mm, 10 mm, and 2.36 mm.
- A thermostatically controlled drying oven capable of maintaining constant temperature between 100º C and 110° C.

PROCEDURE:

The test sample consists of aggregates size 10 mm to 12.5 mm. The aggregates should be dried at 100 – 110°C for a period of 4 hours and cooled.

- Sieve the material through 12.5 mm and 10.0 mm IS sieves. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.
- Pour the aggregate to fill about $1/3^{rd}$ depth of measuring cylinder.
- Compact the material by giving 25 gentle blows with rounded end of the tamping rod.
- Add two layers in similar manner, so that cylinder is full.Strike off the surplus aggregates.
- Determine the net weight of the aggregates to the nearest gram (w_1).
- Bring the impact machine to rest without wedging or packing upon the level plate, back or floor, so that it is rigid and the hammer guide columns are vertical.
- Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.
- Raise the hammer until its lower face is 380 mm above the surface or the aggregate sample in the cup and allow it to fall freely on the aggregate sample. Give 15 such blows at an interval of not less than 1 second between successive falls.
- Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieve until no further significant amount passes in one minute. Weight the fraction passing the sieve to an accuracy of 1 gm (w_1). Also weigh the friction retained in the sieve.
- Note down the observations in the proforma and compute the aggregate impact value.
- The mean of two observations, rounded to nearest whole number is reported as the 'Aggregate Impact Value'.

RECORD OF OBSERVATIONS:

	Sample 1	Sample 2
Total wt. of dry sample taken = W_1 gm =	gm	gm
Wt. of portion passing through 2.36 mm sieve = W_2 gm =	gm	gm
Aggregate Impact Value = (W_2 / W_1)* 100=	%	%

Average Aggregate Impact Value = %

INTERPRETATION OF RESULTS:

Aggregate Impact Value is used to classify the stones in respect of their toughness property as indicated below:

Aggregate Impact Value	Classification
< 10 %	Exceptionally strong
10 – 20 %	Strong
20 – 30 %	Satisfactory for road surfacing
> 30%	Weak for road surfacing

Indian Roads Congress has recommended the following values for different types of road construction.

Sr. no.	Type of Pavement	Max. aggregate impact Value %
1)	Bituminous surface dressing penetration Macadam, Bituminous carpet	30
2)	Bitumen – bound – Macadam, base course	35
3)	WBM base course with bitumen surfacing	40
4)	Cement concrete base course	45

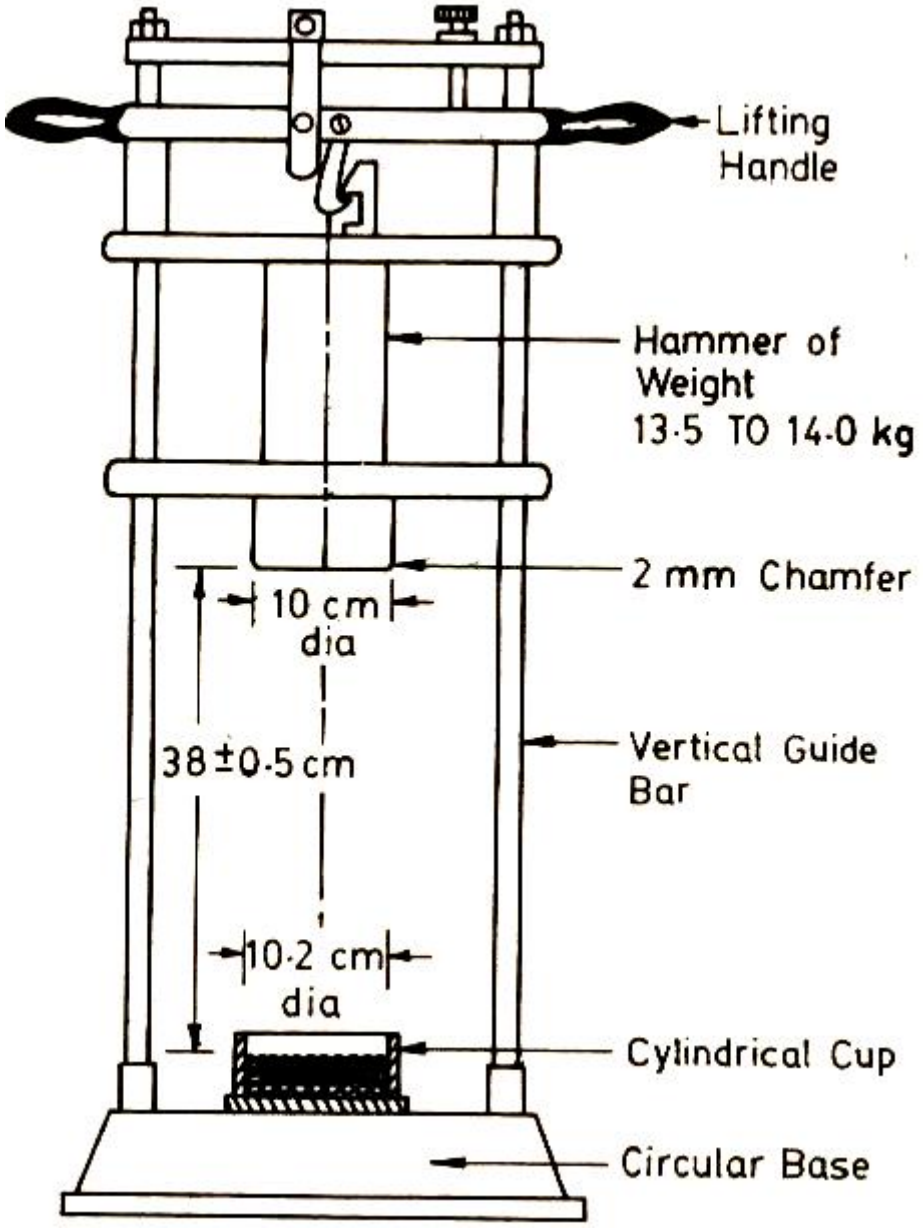


Fig. 2.1 Aggregate Impact Testing Machine

PRECAUTION:

- 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 aggregate through 2.36 mm sieve the sum of weight of fractions retained and passing the sieve should not differ from the original weight of the specimen by more than 1 gm.
- The tamping is to be done properly by gentle dropping the tamping rod and not by hammering action. Also the tamping should be uniform over the surface of the aggregate taking care that the tamping rod does not frequently strike against the walls of the road.

EXPERIMENT - ___
Shape Test

AIM:

- To determine the flakiness index of aggregate.
- To ascertain the suitability of road aggregate for bitumen road construction.

ELONGATION INDEX:

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

FLAKINESS INDEX:

The flakiness index of an aggregate is the percentage by weight of aggregate particles whose least dimension (thickness) is less than three fifth times (0.6 times) their mean dimension. The test is applicable to sizes larger than 6.3 mm.

CONCEPT AND SIGNIFICANCE:

The flakiness index of aggregate is percentage by weight of aggregate particle whose least dimension\thickness is less then three fifth or 0.6 of their mean dimension.

The particle shape of aggregate is determined by the percentage of flaky and elongated particles contained in it. In case of gravel it is determine by its angularity number. For base course and construction of bituminous and cement concrete types, the presence of flaky and particles are undesirable as they may case inherent weakness with possibilities 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 desirable for granular base course due to increased stability derived from the elongated angularity is necessary.

APPARATUS:

1) **Thickness gauge:** The apparatus consists of a standard thickness gauge as shown in fig.
2) **IS sieve:** IS sieve of size 63,50,40,31.5,20,16,12.5,10 and 6.3 mm
3) **Balance:** balance to weight sample size specified in the table and a balance.

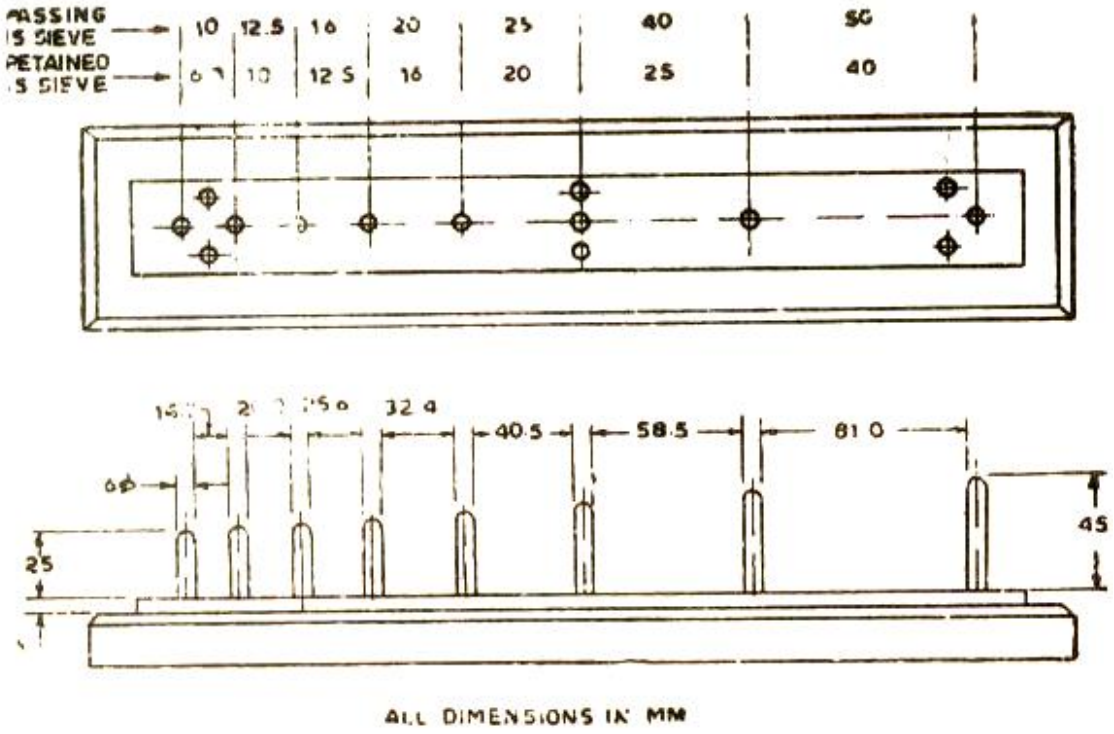


Fig. 2.4 Length gauge

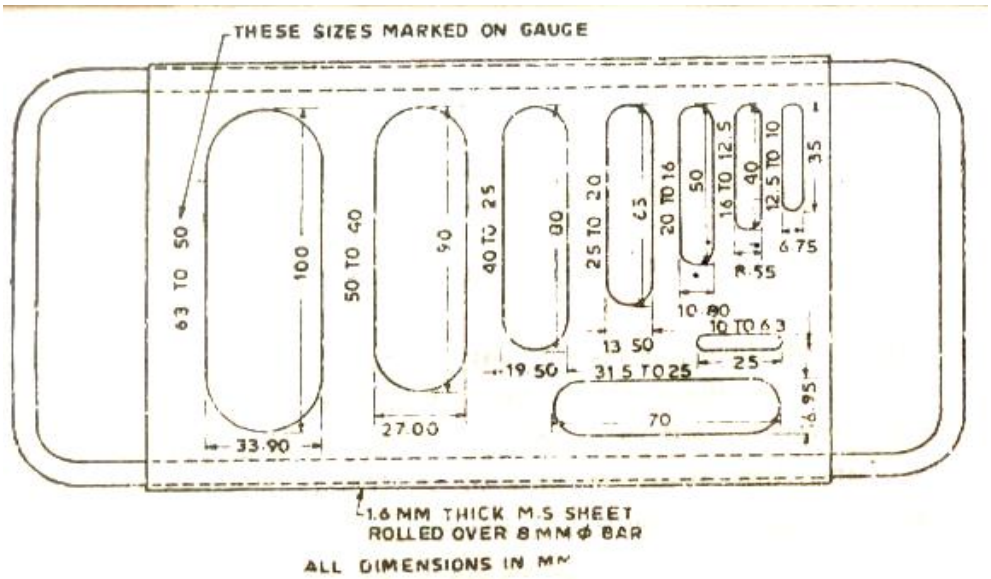


Fig. 2.5 Thickness Gauge

PROCEDURE:

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

DIMENSION OF THICKNESS AND LENGTH GAUGE

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

OBSERVATION:

Sr. No.	Passing through IS sieve (mm)	Retained on IS sieve (mm)	FLAKINESS INDEX		ELONGATION INDEX	
			Wt. of aggregate taken in each fraction (g)	Wt. of aggregate in each fraction passing thickness gauge (g)	Wt. of Non – flaky aggregate taken in each fraction (g)	Wt. of aggregate in each fraction not passing length gauge (g)
1.	63	50				
2.	50	40				
3.	40	31.5				
4.	31.5	25				
5.	25	20				
6.	20	16				
7.	16	12.5				
8.	12.5	10				
9.	10	6.3				
			w/W x 100 =	%	w1/W1 x 100 =	%

CALCULATION:

Flakiness Index = w / W x 100 = **%**
Elongation Index = w1 / W1 x 100 = **%**
Combined Flakiness Index and Elongation Index = **%** < 30%

EXPERIMENT – 6
Los Angeles Abrasion Test

AIM:

To find the hardness property of the aggregate.

INTRODUCTION:

Due to the movement of traffic the road stones used in the surface course are subjected to wearing action at the top. Hence road stones should be hard enough to resist the abrasion due to the traffic. Abrasion tests are carried out to test the hardness property of stones and to decide whether they are suitable for the different road construction works. The abrasion test on aggregate may be carried out using anyone of the following three tests:

1) Los Angeles abrasion test
2) Deval abrasion test
3) Dorry abrasion test

APPARATUS:

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

1. **Los Angeles Machine:** It consists of a hollow steel cylinder, closed at both the
2. ends
   with an internal diameter of 700 mm (see Fig.3.1) and capable of rotating about its horizontal axis**.** A removable cover for introducing sample is provided which when clamped is dust tight. A removable steel shaft projecting radially 88 mm into cylinder and extending full length (i.e.500mm) is mounted firmly on the interior of the cylinder. The shelf is placed at a distance 1250 mm minimum from the opening in the direction of rotation.
3. **Abrasive Charge:** Cast iron or steel balls, approximately 48 mm in diameter and each weighting between 390 to 445g; 6 to 12 balls are required
4. **Sieve:** The 1.70 mm IS sieve.
5. Balance of capacity 5kg or 10 kg.
6. Drying oven
7. Miscellaneous like tray etc.

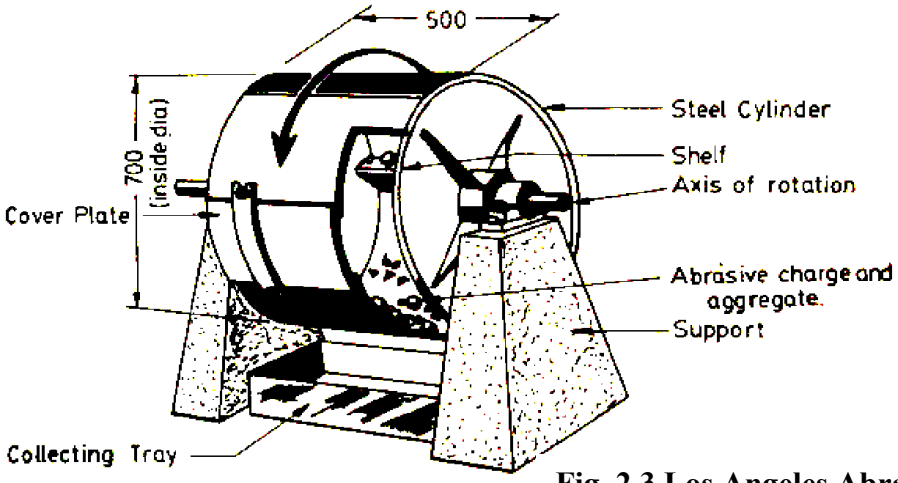


Fig. 2.3 Los Angeles Abrasion Testing

Table Grading of Test Sample

Sieve size (Square Hole)								
Passing mm	Retained on mm	A	B	C	D	E	F	G
80	63	-	-	-	-	2500*	-	-
63	50	-	-	-	-	2500*	-	-
50	40	-	-	-	-	5000*	5000*	-
40	25	1250	-	-	-	-	5000*	5000*
25	20	1250	-	-	-	-	-	5000*
20	12.5	1250	2500	-	-	-	-	-
12.5	10	1250	2500	-	-	-	-	-
10.0	6.3	-	-	2500	-	-	-	-
6.3	4.75	-	-	2500	-	-	-	-

PROCEDURE :

1. Select the grading to be used in test. It should be chosen such that it conforms to the grading to be used in construction, to the maximum extent possible.
2. Take 5 kg of sample for grading A,B,C or D and 10 kg for E,F, or G.
3. Choose abrasive charges as per Table below

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

4. Open the cover and feed the aggregate and steel balls in the cylinder. Replace the cover tightly.
5. Rotate the machine at a uniform seed of a 30 to 33 revolutions per minute.
6. Allow the machine to run for 500 revolutions for gradings A, B, C or D and 1000 revolutions for gradings E, F ,or G.
7. Stop the machine after desired no of revolutions.
8. Remove the dust cover and take out material.
9. Separate the steel balls and sieve the material on 1.70mm IS sieve.
10. Wash the material courser then 1.70mm size.
11. Dry it in oven to a constant rate and weigh to an accuracy of 1g.
12. Calculate the percentage of loss of material.
13. Take another sample and repeat the experiment. Find the mean of two values and report it as Los Angeles Abrasion Value.

OBSERVATION:

Grading selected	Sample 1	Sample 2
Original Weight of the dry sample (W_1)gm=		
Weight of fraction retained on 1.7 mm IS sieve (W_2)gm=		
Loss in weight due to shear $W_1 - W_2$		
Percentage wear $\left[\frac{W1 - W2}{W1} \times 100\right]$		
Los Angeles Abrasion Value =		

INTERPRETATION OF RESULTS:

Los Angeles abrasion test is commonly used to evaluate the hardness of the aggregates. The test has more acceptability because of resistance to abrasion and impact is determined simultaneously. Depending upon the numerical value, the suitability of aggregates for different road constructions can be judged as per Indian Roads Congress specifications given below:

Sr. no.	Type of Pavement	Max. Permissible abrasion value %
1.	Water Bound Macadam, sub base course	60
2.	WBM base course with bituminous course	50
3.	Bituminous Macadam	50
4.	WBM surfacing course	40
5.	Bituminous penetration Macadam	40
6.	Bituminous surface dressing, cement concrete surface course	35
7.	Bituminous concrete surface course	30

PRECAUTION:

- The cover should be fixed tightly before rotating the machine.
- All material should be discharged from the cylinder after the conduct of test.

EXPERIMENT N0 _____

DEVAL ABRASION TEST

7.1 AIM : To study the abrasion on given aggregates.

7.2 APPARATUS

The apparatus consists of the Deval machine and standard sieve.

7.2.1 *Deval Machine* : The Deval abrasion testing machine consists of one or more (generally two) hollow cast iron cylinders closed at one end and provided with iron cover at the other end, capable of fitting tightly. The inside diameter of the cylinder is 20 cm and length is 34 cm. The cylinders are mounted on a shaft at an angle of 30 degrees with the axis of rotation. Cast iron or steel spheres of about 4.8 cm dia. and 390 to 445 g weight are used as abrasive charge. Six such spheres are used as abrasive charge, their total weight being 2500 ± 10 g.

7.2.2. *Sieves* : IS sieves of 50,40,25,20,12.5,10 and 4.75 mm sizes are used. IS sieve having 1.70 mm square holes are used for sieving the materials after the abrasion test.

7.3 PROCEDURE

The procedure of Deval abrasion test is as follows :

7.3.1 Test sample consists of dry coarse aggregates made of different percentages of the various sizes conforming to any one of the gradings given in table.

7.3.2 The material is washed, dried and separated to different sizes by sieving. The grading adopted for the test should be the one which most nearly represents the coarse aggregate to be used for a particular construction project. Crushed gravel conforming to the above specifications can also be used.

7.3.3 The sample and the abrasive charge of 6 spheres of total weight 2,500 ± 10 grams are placed in the Deval abrasion testing machine and the cover is tightly fixed.

7.3.4 The machine is rotated at a speed of 30 to 33 r.p.m. for 10,000 revolutions.

7.3.5 At the completion of the above number of revolutions, the material is removed from the machine and is sieved on a 1.70 mm IS sieve.

7.3.6 The material retained on the sieve is washed, dried and weighed to the nearest gram.

Grading of Aggregates for Deval Abrasion Test

Grading	Passing IS sieve, mm	Retained on IS sieve, mm	Percentage of sample
A	20	12.5	25
	25	20.0	25
	40	25.0	25
	50	40.0	25
B	20	12.5	25
	25	20.0	25
	40	25.0	50
C	20	12.5	50
	25	20.0	50
D	12.5	4.75	50
	20	12.5	50
E	10	4.75	50
	12.5	10.00	50

The weight of the sample to be taken for the test depends on its average specific gravity and is given in table below.

Weight of Sample for Deval Abrasion Test.

Range of specific gravity	Weight of sample.g
Over 2.8	5,500
* 2.4 to 2.8	5,500
2.2 to 2.39	4,500
less than 2.2	4,000

7.4 OBSERVATION TABLE

(1) Type of aggregate =

(2) Percent crushed fragments

(3) Grading of the sample =

(4) Specific gravity of the sample =

	Test Number			Mean value
	1	2	3	
Original weight of the sample = W_1 g Weight of material retained on 1.7 mm Sieve after abrasion = W_2 g Percentage wear = $\frac{(W_1 - W_2)}{W_1}$ 100				

7.5 CALCULATION

7.5.1 The loss in weight by abrasion is the difference between the original weight of the test sample and the weight of material retained on the 1.70 mm IS sieve after the test. The percentage of wear is the loss in weight by abrasion expressed as a percentage of the original weight of the test sample.

Let the original weight of the sample be = W_1 g
Weight of the material retained of 1.70 mm IS sieve after the Abrasion test = W_2 g

Therefore percentage wear = $\frac{(W_1-W_2)}{W_1}$ 100

7.5.2 In the case of crushed gravel (*i.e.*, fragment of the gravel having atleast one fractured face) the percentage by weight of crushed fragments should be determined and the permissible percentage wear is calculated as given below.

$$W = \frac{A \times L + (100 - A) \times L}{100}$$

Where,

W = permissible percentage of wear
A = percentage of uncrushed fragments
L = maximum percentage of wear permitted by the. specifications for gravel consisting entirely of crushed aggregate.

(100-A) = percentage of crushed fragments.
And L = maximum percentage of wear permitted by the specification of gravel consisting entirely of crushed fragments

7.6 RESULTS

Duplicate test may be carried out simultaneously by placing similar specimens in the second cylinder and the average values of the two tests may be calculated. The report includes (a) percentage of wear, (b) percentage of crushed fragments in the test sample and (c) weight and grading of the test samples.

7.7 APPLICATION OF DEVAL ABRASION TEST

It has been recommended by the ISI that where ever possible the Los Angeles abrasion test should be preferred to the Deval abrasion test. The desirable limits of percentage wear by the Deval abrasion test have not been specified by the agencies, as this is not a common test. Thus the test has limited uses and applications.

EXPERIMENT – ____
Specific Gravity and Water Absorption Test

AIM:

To find out Specific Gravity of Aggregate.

THEORY:

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

APPARATUS:

The apparatus consists of the following

1) A balance of capacity about 3 kg, to weigh accurate to 0.5 g, and of such a type and shape as to permit weighing of the sample container when suspended in water
2) A thermostatically controlled oven to maintain temp of 100º to 110ºC
3) 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.
4) A container for filling water and suspending the basket.
5) An air tight container of capacity similar to that of the basket
6) A shallow tray and two dry absorb rent clothes, each not less than 75*45 cm.

PROCEDURE:

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

The basket and sample are then weighed well suspended in water at a temp of 22º to 32 ºC in case it is necessary to transfer the basket and the sample to a different tank for weighing, they should be jolted 25 times a described above in the new tank to remove air before weighing. The weight is noted while suspended in water =w1 gm .the basket and the aggregate are then remove from water and allowed to drained for a few minutes, after

which the aggregate are transferred to one of the dry absorbent clothes. The empty basket is then return to the tank of water, jolted 25 times and weighed in water =w2 gm.

The aggregate placed on the absorbent clothes are surface dried till no further moisture could be removed by this cloth. Then the aggregate are transfer to the second dry cloth spread in single layer, covered and allowed to dry for at least 10 minutes until the aggregate are completely surface dry.10 to 60 min drying may be needed. The aggregate should not be exposed to the atmosphere, direct sunlight or any other source of heat while surface drying.
A gentle current of unheated air may be used during the first 10 min. to accelerate the drying of aggregate surface. The surface dried aggregate is then weighed=w3 gm. the aggregate is placed in a shallow tray and kept in an oven maintain at a temp of 110ºC for 24 hrs. It is then removed from the oven, cooled in an airtight container and weighed=w4 gm.

OBSERVATION:

Weight of saturated aggregate suspended in water with the basket=w1 gm
Weight of basket suspended in water =w2 gm
Weight of saturated aggregate in water =(w1-w2)=w5 gm
Weight of saturated surface dry aggregate in air =w3 gm
Weight of water equal to the volume of the aggregate =(w3-w5) gm

CALCULATION:

1) Specific gravity= dry weight of aggregate / weight of equal volume of water
=w4 / (w3-w5)
=w3 / w3-(w1-w2)

2) Apparent sp. Gr.=$\frac{\text{dry weight of aggregate}}{\text{(Weight of equal volume of water excluding air voids in aggregate)}}$
$=\frac{w4}{(w4 - w5)}$
=w4 / w3-(w1-w2)

3) Water absorption= percent by weight of water absorbed in terms oven dried wt of. aggregate = (w3-w4) / w4 percent

OBSERVATION :

Details	Test number		
	1	2	3
1. Weight of saturated aggregate and basket in water=w1g			
2. Weight of basket in water =w2g			
3. Weight of saturated dry aggregate in air =w3g			
4. Weight of oven dried aggregate in air =w4g			
5. Specific gravity = $\frac{w4}{W3-(W1-W2)}$			
6. Apparent specific gravity = $\frac{W4}{W4-(W!-W2)}$			
7. Water absorption = $\frac{(W3-W4)*100}{W4}$ percent			

1. Mean value Specific gravity =
2. Mean value of apparent specific gravity =
3. Mean value of water absorption =

Conclusion:

EXPERIMENT – ___
Penetration Test

AIM:

- ★ To find out consistency of bitumen
- ★ To assess the suitability of bitumen for its use under different climatic condition and type of construction.

THEORY:

The consistency of bituminous materials varies depending upon several factors such as constituent, temperature, etc. at temperature 25° to 50°C most of the paving bitumen grades remains in semi-solid states and their viscosity is so high that they do not flow as liquid. Determination of absolute viscosity of bitumen is not so simple. Therefore the consistency of bitumen is determined by indirect method. Penetration test is one of such type of test.

APPARATUS:

1) Standard container.
2) Needle
3) Water bath.
4) Penetrometer.

PROCEDURE:

The bitumen is softened to a pouring consistency between 75° and 100°C above the approximate temperatures at which bitumen soften. The sample material is thoroughly stirred to make it homogeneous and free from air bubbles and water. The sample material is then poured into a container to a depth at least 15 mm more than the expected penetration. The sample containers are cooled in atmosphere of temperature not lower than 13°C for one hour. Then they are placed in temperature controlled water – bath at a temperature 25°C for one hour. The sample container is placed under the needle of penetrometer. The weight of the needle should be 100 g. the needle assembly is lowered and the tip of the needle is made to just touch the top surface of the sample. The initial reading of penetrometer dial is adjusted to zero. The needle is released exactly for a period of 5 second and final reading is taken on the dial. At least three readings are taken on this sample at distance not less than 10 mm apart. After each test the needle is disengaged and cleaned with benzene and carefully dried.

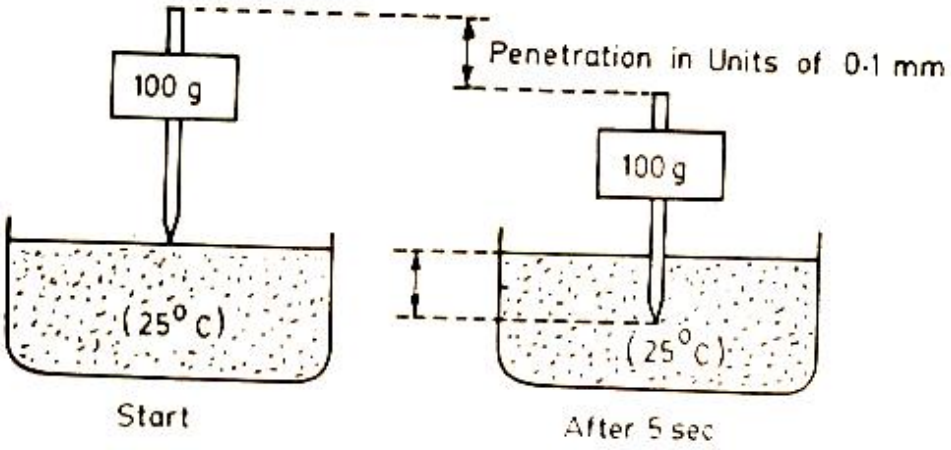


Fig. 3.1 Concept of Penetration test

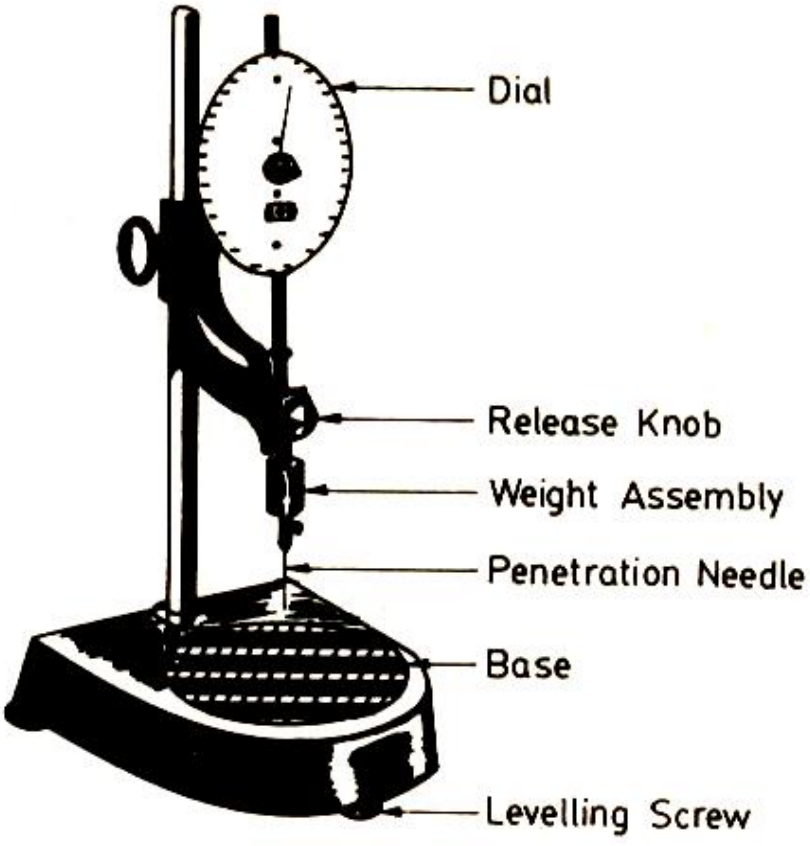


Fig. 3.2 Penetration Apparatus

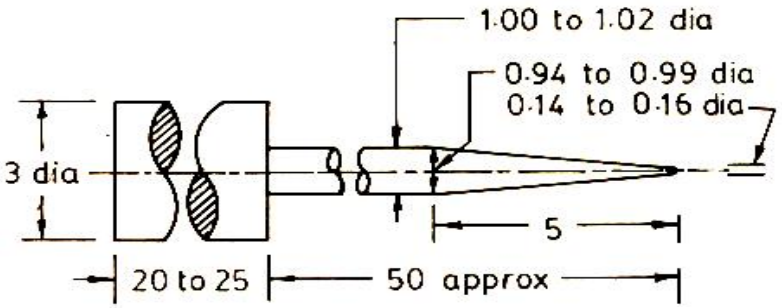


Fig. 3.3 Penetration Needle

All dimensions in millimetres

REPORTS:

The value of the penetration reported shall be the mean of not less than three determinations whose values do not differ by more than the amount given below:

Penetration grade	Maximum Difference
0 – 49	2
50 – 149	4
150 – 249	6
250 and Above	8

OBSERVATION TABLE (PENETRATION TEST-BITUMEN):

Sr. No.	Initial Reading	Final Reading	Difference	Average

INTERPRETATION OF RESULTS:

Penetration test is commonly adopted test on bitumen to grade the material in terms of its hardness. 80 / 100 grade bitumen indicates that its penetration value lies between 80 and 100. The grading of bitumen helps to assess its suitability for use in different climatic conditions and types of construction. For bituminous macadam and penetration macadam, IRC suggests bitumen grades 30 / 40, 60 / 70 and 80 / 100. in warmer regions lower penetration grades are preferred to avoid softening whereas higher penetration grades like 80 / 100 are used in colder regions so that excessive brittleness does not occur. Highest penetration grade is used in spray application works.

PRECAUTION:

- There should be no movement of the container while needle is penetrating into the sample
- The sample should be free from any extraneous matter.
- The needle should be cleaned with benzene and dried before each penetration

REFERENCE:

(1) Indian Standard Methods of testing Tar and Bituminous Materials I.S. 1203 – 1978

EXPERIMENT – ___
Softening Point Test

AIM: To find the softening point of bitumen.

THEORY:

Bitumen 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 condition of test. For bitumen, it is usually determine by Ring and Ball test. Higher grades of bitumen possess higher softening point.

APPARATUS:

1) Steel ball.
2) Brass ring
3) Water – bath.

PROCEDURE:

Sample materials is heated to a temperature between 75 to 100°C above the approximate softening point, until it is completely fluid and is poured in heated rings placed on metal plate. To avoid sticking of the bitumen to the metal plate the coating of glycerine is done. After cooling the rings in air for 30 minutes, the excess bitumen is trimmed and rings are placed in support. At this time the temperature of water is kept 5°C and maintained for 15 minutes. The temperature of water is raised at uniform rate of 5°C per minute with a controlled heating unit, until the bitumen softens and touches the bottom plate. At least two observations are made. For material whose softening point is above 80°C glycerine is used as a heating medium and starting temperature is 35°C.

RESULTS:

Test results shall not differ from the mean by more than the following:

Softening Point	Repeatability	Reproducibility
40 – 60°C	1°C	5.5°C
61 – 80 °C	1.5°C	5.5°C
81 – 100°C	2.0°C	5.5°C
101 – 120°C	2.5°C	5.5°C
121 – 140°C	3.0°C	5.5°C

OBSERVATION TABLE:

Bitumen Grade :
Liquid used in bath :
Period of air cooling : min
Period of cooling in water bath : min
Rate of Heating : 5°C / min

	Sample 1	
	Ball No. 1	Ball No. 2
Temperature when the ball touches bottom °C		

Mean value of Softening Point = °C

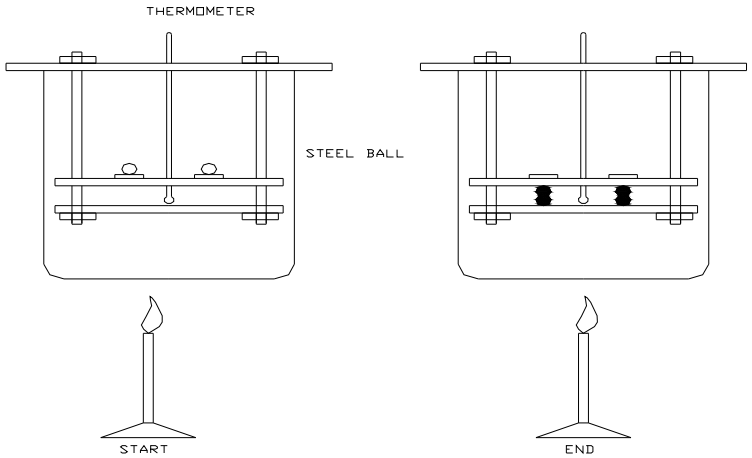


Fig. 3.4 Concept of Softening

INTERPRETATION OF RESULTS:

Softening point indicates the temperature at which binder 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. In general, the higher the softening point, the lesser the temperature susceptibility. Bitumen with higher softening point may be preferred in warmer place.

PRECAUTION:

- Only freshly boiled distilled water shall be used in the test, as otherwise air bubbles may form on the specimen and affect the accuracy of the results.
- The prescribed rate of heating shall be rigidly adhered to for ensuring accuracy of results.
- The bulb of the thermometer should be at about the same level as the rings.
- A sheet of filter paper or thin amalgamated sheet, placed on the bottom of the glass vessel and conveniently weighed would prevent the material from sticking to the glass vessel and considerable time and trouble in cleaning would thereby be saved.

REFERENCE:

(1) Indian Standard Methods of testing Tar and Bituminous Materials I.S. 1205 – 1978

EXPERIMENT – ___
Ductility Test

AIM:

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

THEORY:

In the flexible pavement construction where bitumen binders are used, it is significant importance that the binders from ductile thin films around the aggregates. The binder material, which does not possess sufficient ductility, would crack and thus provide pervious pavement surface. This results in failure of pavements. So the bitumen paving engineer wants the both of the penetration and ductility satisfactory. Penetration or ductility cannot replace each other.

APPARATUS:

1) Briquette mould
2) **Ductility machine:** It is equipment, which function as constant temperature water bath and a pulling device at a precallibrate 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 clip are thus pulled apart horizontally at uniform speed of **50 ± 2.5 mm per minute**. The machine may have provision to fix two or more mould so as to test this specimen simultaneously.

PROCEDURE:

The bitumen sample is melted to a temperature of 75°C to 100°C above the approximate softening point until it is fluid. it is strained through IS sieve 30, poured in the mould assembly and placed on a brass plate, after a solution of glycerin and dextrin is applied at all surface of the mould exposed to bitumen. Thirty to forty minutes after the sample is poured into the moulds, the plate assembly along with the sample is placed in water bath maintained at 27°C for 30min. the sample and mould assembly are removed from water bath and excess bitumen material is cut off by leveling the surface using hot knife. After trimming the specimen, the mould assembly containing sample is replaced in water bath

maintained at **27°C** for 85 to 95 minutes. The sides of the mould are now removed and the clips are carefully booked on the machine without causing any initial strain. Two or more specimens may be prepared in the moulds and clipped to the machine so as to conduct these test simultaneously.

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

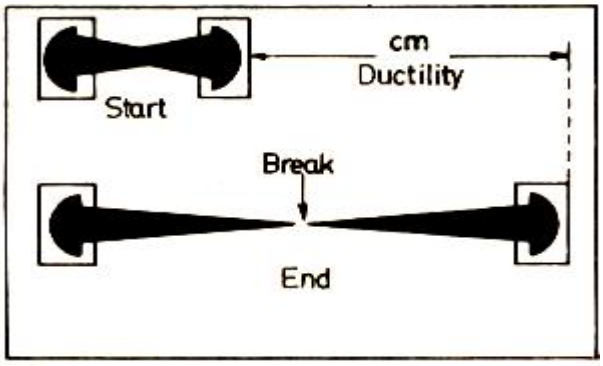


Fig. 3.5 Concept of Ductility Test

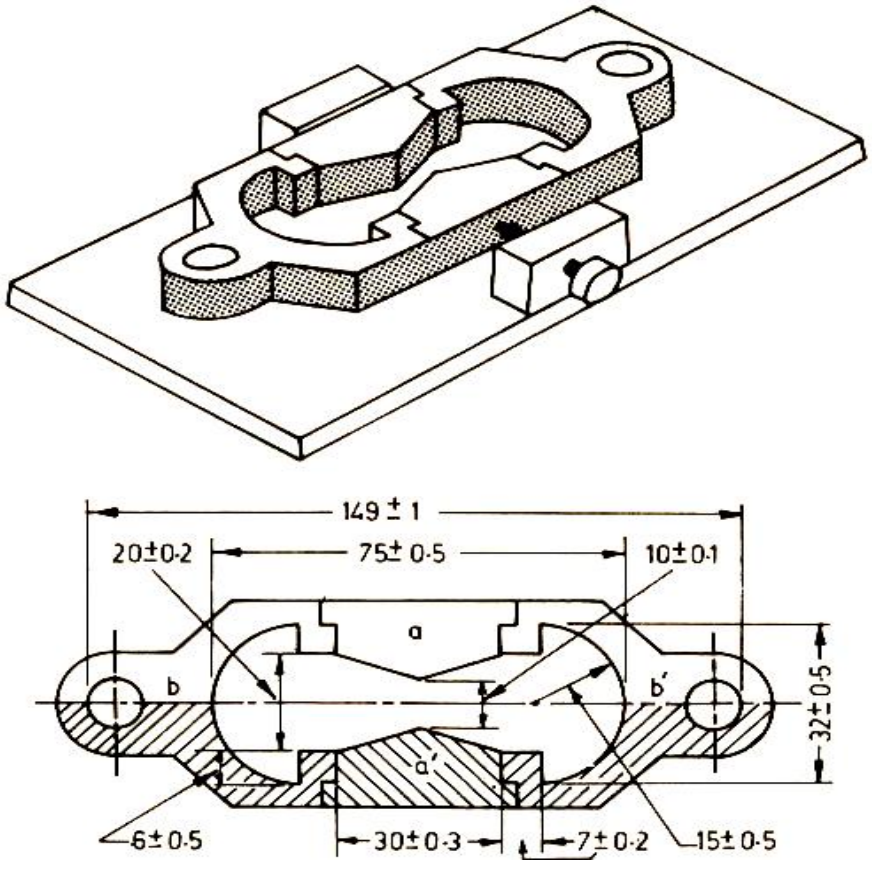


Fig. 3.6 Briquette Mould

RESULTS:

The distance stretched by the moving end of the specimen up to the point of breaking of thread measured in centimeters is recorded as ductility value. Following value are recommended by ISI.

Repeatability **10% of the mean**
Reproducibility **20% of the mean**

OBSERVATION TABLE:

1. Bitumen Grade :
2. Pouring temperature : °C
3. Test temperature : 27°C

	Sample No. 1
Initial Reading	cm
Final Reading	cm
Ductility	cm

INTERPRETATION OF RESULTS:

The suitability of bitumen is judged, depending upon its type and proposed use. Bitumen with low ductility value may get cracked especially in cold weather. ISI has specified following values of minimum ductility for various grades of Bitumen as follows:

Sources of paving bitumen and penetration grade	Minimum ductility value in cms
Assam Petroleum A 25	5
A 35	10
A 45	12
A 65, A 90 and A 200	15
Bitumen from sources other than Assam Petroleum S 35	50
S 45, S 65 and S 90	75

PRECAUTION:

- 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 moulded sample.

REFERENCE:

(1) Indian Standard Methods of testing Tar and Bituminous Materials I.S. 1208 – 1978

EXPERIMENT – 13
Flash and Fire Test

AIM:

To find out flash point and fire point of bitumen.

THEORY:

Bituminous material leaves out volatiles at high temperature depending upon their grade. These volatile vapors catch fire causing a flash. This condition is very hazardous and it is therefore essential to qualify this temperature for each bitumen grade, so that the paving engineer may restrict the mixing temperatures well within the limits.

Flash point:

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

Fire point:

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

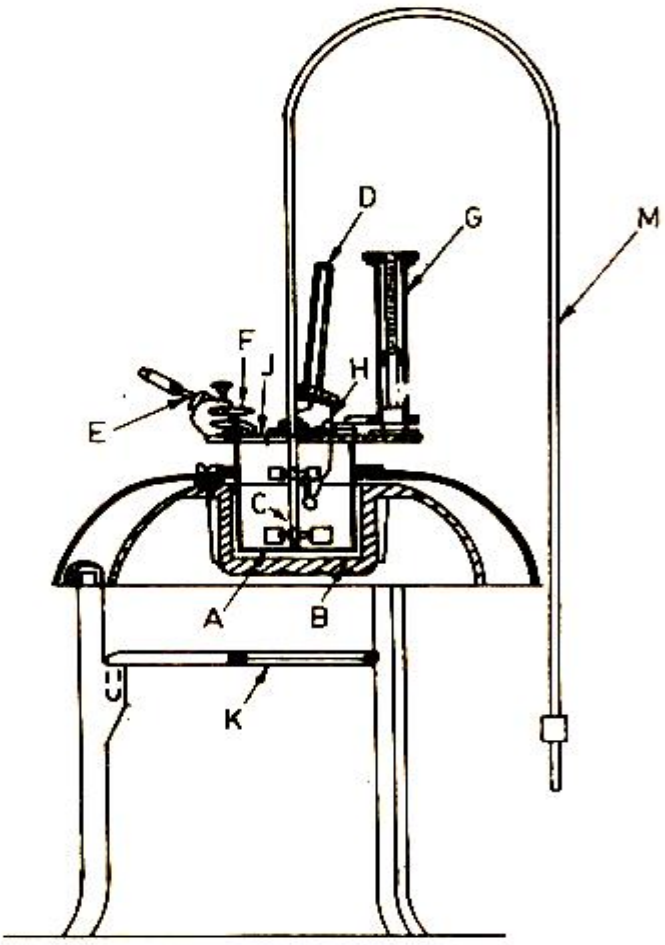
APPARATUS:

1) Pensky – Martens closed tester

PROCEDURE:

All parts of the cup and its accessories shall be thoroughly cleaned and dried before the test is started. Particular care shall be taken to remove all the traces of solvent used to clean the apparatus. The cup shall be filled with the materials to be tested up to the level indicated by the filling mark. The clip carrying the thermometer and test-flame shall be placed on the cup and the latter set in the stove. Care shall be taken to have the locating devices properly engaged. Insert the thermometer, high or low range as required. Light and adjust the test-flame so that the size of the bid is of 4 mm diameter. Apply heat at such a rate that the temperature recorded by the thermometer increases between 5 to 6°C

per minute. Turn the stirrer at a rate approximately 6o revolutions per minute. Apply the test flame at each temperature reading, which is a multiple of 1°C up to 104°C. for the temperature above 104°C, apply the flame at each temperature reading which is multiple of 2°C, the first application of the test flame being made at a temperature at least 17°C below the actual flash point.



A – Oil-cup
B – Heating vessel
C – Stirrer
D – Thermometer
E – Ignition burner
F – Pilot burner
G – Spring handle
H – Revolving Shutter
J – Orifice
K – Gauge disc
L – Lifting hooks
M – Optional form of stirrer operating device

Fig. 3.7 Pensky – Marten Apparatus (Closed type)

REPORT:

The flash point shall be taken as the temperature read on the thermometer at the time of the flame application that causes a distinct flash in the interior of the cup.

The heating shall be continued until the oil ignites and continues to burn for 5 seconds. The temperature of the material, when this occurs, shall be recorded as the fire point.

PRECISION:

The following criteria should be followed for the acceptability of the test results:

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

RESULTS:

Flash point of the bitumen = °C
Fire point of the bitumen = °C

As the bitumen was used for several times and was heated many times, the volatility was evaporated so due to this the flash point and fire point increased.

INTERPRETATION OF RESULTS:

The determination of flash point is helpful in assessing the safe limits of heating the bitumen. The heating temperature of bitumen should be limited well below the flash point.

PRECAUTION:

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

REFERENCE:

(1) Indian Standard Methods of testing Tar and Bituminous Materials I.S. 1209 – 1978

EXPERIMENT NO _____

SPECIFIC GRAVITY TEST FOR BITUMEN

14.1 AIM : To determine the specific gravity for the given material.

14.2 APPARATUS : There are two methods *i.e.* Pyknometer and Balance method.

14.2.1 *Pyknometer method* : The apparatus are specific gravity bottle of 50 ml capacity: ordinary capillary type with 6 mm diameter neck or wide mouthed capillary type bottle with 25 mm diameter neck can be used.

14.2.2 *Balance method* : An analytical balance equipped with a pan straddle is used.

14.3 INTRODUCTION

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

The specific gravity is defined by the ISI as the ratio of the mass of a given volume of the aggregate material to the mass of an equal volume of water, the temperature of both being specified as 27^0 C $\pm$ 0.1^0 C.

14.4 PROCEDURE

The procedure consists of two methods which are as follows.

Pyknometer Method

14.4.1 The specific gravity bottle is cleaned, dried and weighed along with the stopper.

14.4.2 It is filled with fresh distilled water, stopper placed and the same is kept in water container for at least half an hour at temperature 27^0 C $\pm$ 0.1^0 C.

14.4.3 The bottle is then removed and cleaned from outside.

14.4.4 The specific gravity bottle containing distilled water is now weighed.

14.4.5 The aggregate material is heated to a pouring temperature and is poured in the above empty bottle taking all the precautions that it is clean and dry before filling sample materials.

14.4.6 The material is filled up to the half taking care to prevent entry of air bubbles.

14.4.7 To permit an escape of air bubbles, the sample bottle is allowed to stand for half an hour at suitable temperature cooled to 27^0 C and then weighed.

14.4.8 The remaining space in the specific gravity bottle is filled with distilled water at 27^0 C ; stopper placed and is placed in water container at 27^0 C.

14.4.9 The bottle containing aggregate material and containing water is removed Cleaned from outside and is again weighed.

Balance method

14.4.1 In balance method the aggregate test specimen is cube shaped, about 12 mm on each edge.

14.4.2 It is prepared by pouring the liquified aggregate sample in brass mould to provide the sample of required dimension and is cooled.

14.4.3 The sample is weighed in air and is then weighed in distilled water maintained at 27^0 C $\pm$ 0.1^0 C to the nearest 0.1 mg.

14.5 CALCULATION

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

Pyknometer method

$$\text{Specific gravity} = \frac{\text{Weight of Aggregate material}}{\text{Weight of equal volume of water at } 27^0\text{C}} = \frac{(c-a)}{(b-a)-(d-c)}$$

a = weight of specific gravity bottle

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

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

d = weight of the specific gravity bottle about one third with the material and the rest with distilled water.

Balance Method

$$\text{Specific gravity} = \frac{c}{(e-f)}$$

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

14.6 OBSERVATION SHEET

(1) Aggregate Grade =
(2) Test temperature =

Pyknometer method

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

Balance method

Sample no	Weight of dry sample	Weight of sample in distilled water, g	Specific gravity
	e	f	
1 2 3			
		Average value	

Specific gravity at the testing temperature =

14.7 DISCUSSION

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

If the bituminous material is in liquid form at 27^0 C , the specific gravity may be found by the pyknometer method by completely filling the specific gravity bottle with the liquid material.

14.8 APPLICATION OF SPECIFIC GRAVITY TEST ON BITUMINOUS MATERIALS

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

Second, the specific gravity is useful to identify the source of a bituminous binder. Pure bitumen has a specific gravity in the range 1.00 to 1.05. (cutback bitumen has a lower range of specific gravity value). In case the bitumen contains mineral impurity the specific gravity will be higher. Thus it is possible for a qualitative estimation of mineral impurity in bitumen. The specific gravity of tars depends on type of carbonization process used for their production. Vertical-retort tars have a specific gravity range 1.10 to 1.15 whereas horizontal-retort and cake-oven tars have values in the range 1.18 to 1.25.

EXPERIMENT – 14
Viscosity Test

AIM:

To find out the viscosity of bitumen.

THEORY:

Viscosity is defined as the inverse of fluidity. The degree of fluidity at the application temperature greatly influences the ability of bituminous material to spread, penetrate and coating the aggregate and hence affect the strength characteristics of the paving mixes. It is necessary to have optimum value of fluidity. At higher fluidity the bitumen binder simply lubricates the aggregates and similarly at lower fluidity does not enable to bitumen to coat the entire surface of aggregate.

APPARATUS:

1) Tar viscometer
2) Receiver
3) Thermometer

PROCEDURE:

The tar cup is properly cleaned and water in the bath is heated to temperature specified for the test and maintain through out the test. Stirring is also continued. The sample material is heated at the temperature 20°C above the specified test temperature and is allowed to cool. Then material, which is slightly above the test temperature the same, is poured in the tar cup until the leveling peg on the value road is just immerged. In the graduated cylinder, 20 ml of mineral oil for one percent by weight solution of soft soap is poured; the receiver is placed under the orifice. When the sample material reaches the specified testing temperature within $\pm$ 0.1°C and is maintained for 5 minutes, the valve is open. The stopwatch is started; when cylinder records 25 mm the time is recorded up to mark of 75 mm.

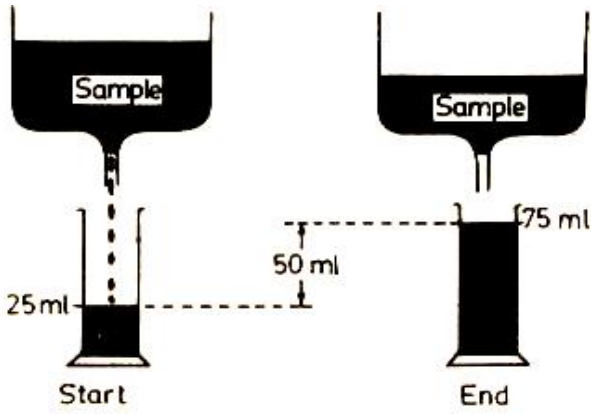
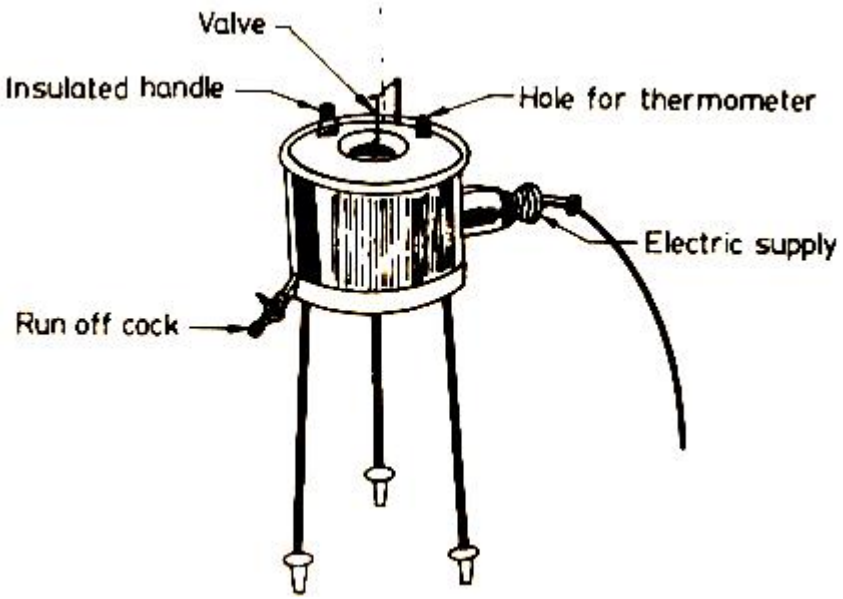


Fig 3.8 Concept of Viscosity Test



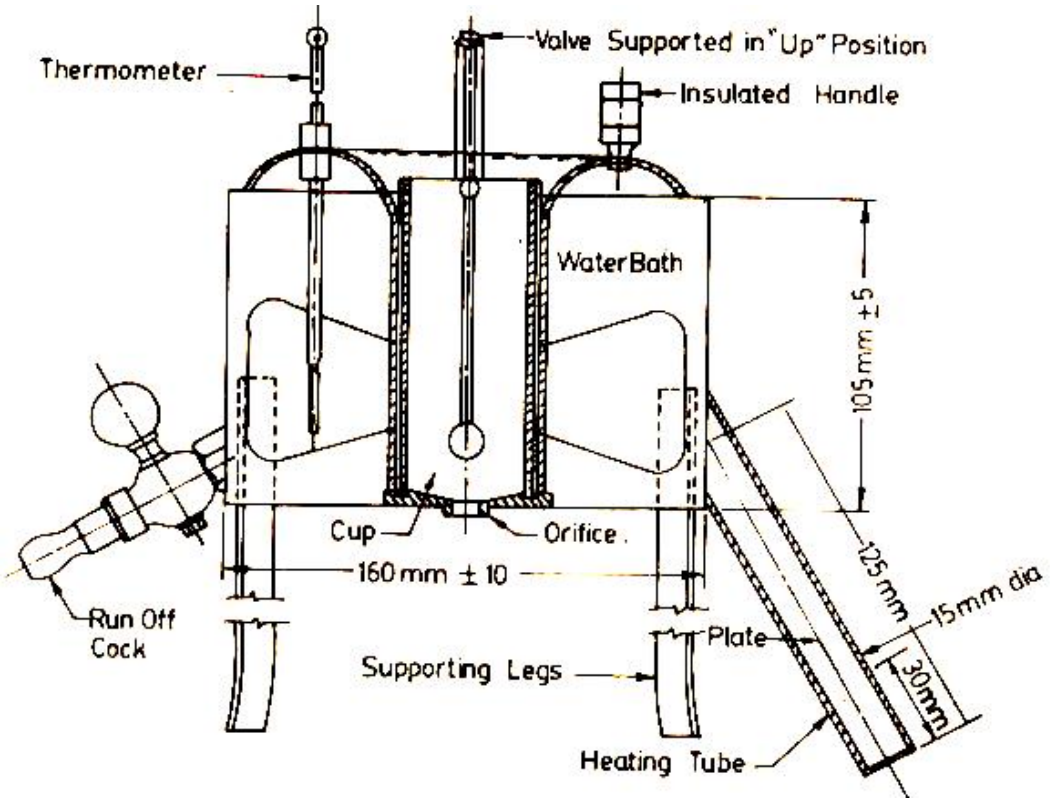


Fig. 3.9 Tar Viscometer

REPORT:

Report the time in seconds taken by 50 ml of the sample to flow out as the viscosity of the sample at the temperature specified for the test.

The results of repeat determination of portions of the same sample shall fall within $\pm$ 4 percent of the average of several readings.

INTERPRETATION OF RESULTS:

The determination of time of binder through the orifice gives an indirect measure of viscosity of tars and cutbacks. Higher the duration of flow, greater is the viscosity. Viscosity of binder is one of the criteria for their classification. The viscosity of a particular grade of road tar or cutback bitumen should fall within the range. Binders having very low viscosity can be advantageously used in exceptionally cold weather conditions. High viscosity binder have to be heated before their application.

PRECAUTION:

- The tar cup should be cleaned gently with non corroding solvents such as light tar oils free from phenols are recommended rather than mechanical means, such as dusters, which are liable to cause abrasion of the metal.

- If any material be used for rubbing the interior of the cup, it shall not be such as May disintegrate in use, leaving particles which may interfere with the free flow of sample through the orifice.

- The orifice size should be tested at frequent intervals with gauge having appropriate diameters.

REFERENCE:

(1) Indian Standard Methods of testing Tar and Bituminous Materials I.S. 1206 – 1978

EXPERIMENT –___
Marshall Stability Test

CONCEPT AND SIGNIFICANCE:

The test procedure is used in designing and evaluating bituminous paving mixes, and is widely applied in routine test programmes for the paving jobs. The major features of the Marshall method of designing mixes are to determine the two important properties of strength and flexibility.

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 60°C. 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.

OBJECTIVES:

i) To determine the density – voids analysis for the given bituminous mixture;
ii) To determine the strength (Marshall's Stability Value) and flexibility (flow value) for the given bituminous mixture;
iii) To determine the suitability of the bituminous mixture to meet the specified criteria for the surface course.

APPARATUS:

1) Mould Assembly: Cylindrical moulds of 10 cm diameter and 7.5 cm height base plate and extension collars.
2) Sample Extractor for extracting the compacted specimen from the mould.
3) Compaction Pedestal and Hammer
4) Breaking Head: It consist of upper and lower cylindrical segments or test head having an inside radius of curvature of 5 cm. the lower segment is mounted on a base having two perpendicular guide rods which facilitate insertion in the holes of upper test segment.
5) Loading Machine
6) Flow meter

In addition to above the following general equipments are also required:
a) Ovens or hot plates
b) Mixing apparatus
c) Water bath
d) Thermometers
e) Miscellaneous equipment like containers, mixing and handling tools etc.

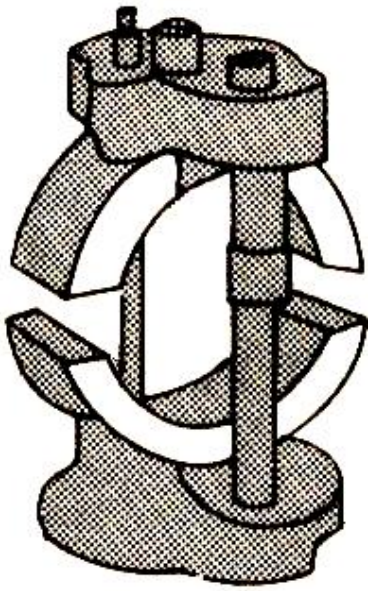


Fig. 5.1 Mould assembly for Marshall Test

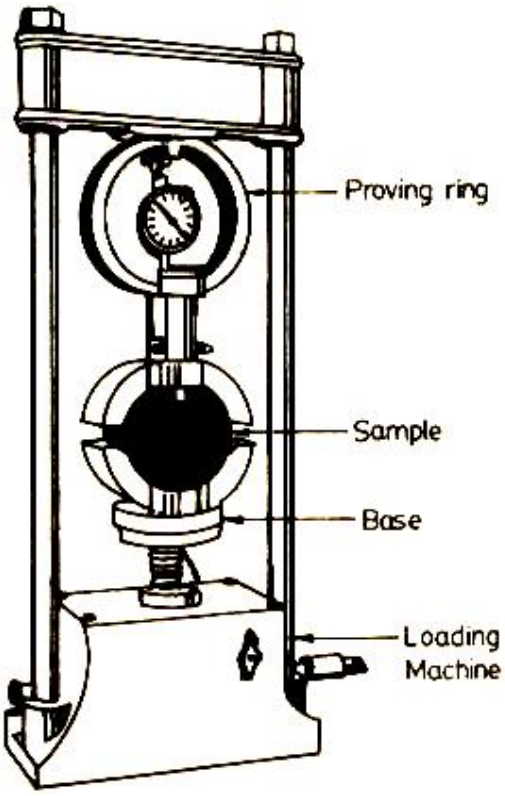


Fig. 5.2 Set up for Marshall Test

The proposed design steps for the design of bituminous mix are given below:

1) Select grading to be used.
2) Select aggregates to be employed in the mix.
3) Determine the proportion of the each aggregate required to produce the design grading.
4) Make up trial specimens with varying asphalt contents.
5) Determine the specific gravity of each compacted specimen.
6) Make stability tests on the specimens.
7) Calculate the percentage of voids, VMA and the percent voids filled with bitumen in each specimen.
8) Select the optimum bitumen content from the data obtained.
9) Check the values of the Marshall Stability, Flow, Voids in the total mix and Voids filled with Bitumen obtained at the optimum bitumen content, with the design requirements. The design may be repeated if necessary after altering the gradation so as to fulfill the design requirements.

Preparation of Test Specimen:

i) Measure out approximately 1200 g of aggregates blended in the desired proportion. Heat the aggregates in the oven to the mixing temperature (175° to 190°C)
ii) Add bitumen at the mixing temperature at various percentages both above and below the expected optimum content. (154° to 160° C)
iii) Mix the materials in a heated pan with heated mixing tools.
iv) Place the mixture in a heated Marshall mould with a collar and base. Spread the mixture around the sides of the mould. Place filter papers under the sample and on top of the sample.

v) Place the mould in the Marshall compaction pedestal.
vi) Compact the material with 50 blows of the hammer (or as specified), invert the sample, and compact the other face with the same number of blows.
vii) After compaction, invert the mould. With the collar on the bottom, remove the base and extract the sample by pushing it out with the extractor.
viii) Allow the sample for few hours to cool.
ix) Obtain the sample mass in air and submerged, to measure density of specimen, so as to allow, calculation of the voids properties.

Test Procedures:

i) Specimens are heated to 60±1°C either in a water bath for 30 – 40 minutes or in an oven for a minimum of two hours.
ii) Remove the specimen from the water bath (or oven) and place in the lower segment of the breaking head. Then place the upper segment of the breaking head on the specimen and place the complete assembly in position on the testing machine.
iii) Place the flow meter over one of the post and adjust it to read zero.
iv) Apply a load at a rate of 50 mm per minute until the maximum load reading is obtained.
v) Record the maximum load reading in Newtons (N). At the same instant obtain the flow as recorded on the flow meter in units of mm.

Specific Gravity of Compacted Specimens:

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

$$Gt = 100 / (W1+G1) + (W2/G2) + (W3/G3) + (W4/G4)$$

where, W1 = percent by weight of coarse aggregate
W2 = percent by weight of fine aggregate
W3 = percent by 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 Voids 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 also weighed in air and then in water. The bulk density value Gb of the specimen is calculated from the weight and volume. The voids analysis are made as given below:

$$V_v, \% = 100 (G_t – G_b) / G_t$$

$$V_b, \% = G_b * W4/G4$$

$$VMA, \% = V_v + V_b$$

VFB, % = $100V_b / VMA$

Where V_v = air voids in the mix, %

V_b = volume of bitumen

VMA = voids in mineral aggregates %

VFB = voids filled with bitumen, %

Design Requirements of the Mix:

As per **IRC: 29 – 1968**, when the specimens are compacted with **50** blows on either face, the designed **BC** mix should fulfill the following requirements.

i) Marshall stability value kg (minimum) = 340
ii) Marshall flow value, 0.25 mm units = 8 to 16
iii) Voids in total mix, V_v % = 3 to 5
iv) Voids in mineral aggregate filled with bitumen, VFB % = 75 to 85

Observation and Analysis:

Sieve Analysis of Coarse Aggregate
Sample: Kg

Sieve Size	Wt. Retained (gm)	Wt. Passing (gm)	% wt Retained	Cum. % wt retained	Cum % passing

Penetration Test
No. of Sample:

Sr. No.	Initial Reading	Final Reading	Difference	Average

Formula for Fuller's Grading:
$P = (d/D)^n \times 100$

d = sieve size in mm
D = Maximum sieve size in mm
n = depends on the shape of the aggregate (0.3 to 0.5)

Percentage of Coarse aggregate = %
Percentage of Fine aggregate = %
Percentage of Filler material = %

Specific Gravity of Coarse Aggregate =
Specific Gravity of Fine Aggregate =

Specific Gravity of Filler Material =
Specific Gravity of Bitumen =

BULK DENSITY CALCULATION

Sample No.	Wt. in Air (kg)	Wt. in water(kg)	Bulk Density	Average

MARSHALL STABILITY TEST

Sr. No.	Bitumen Content %	Theoretical	Bulk Density (Gb)	Air Voids Mix Vv	Vol. of Bit. Vb	VMA	VFB	Av. Stability Value	Av. Flow Value
1									
2									
3									
4									

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