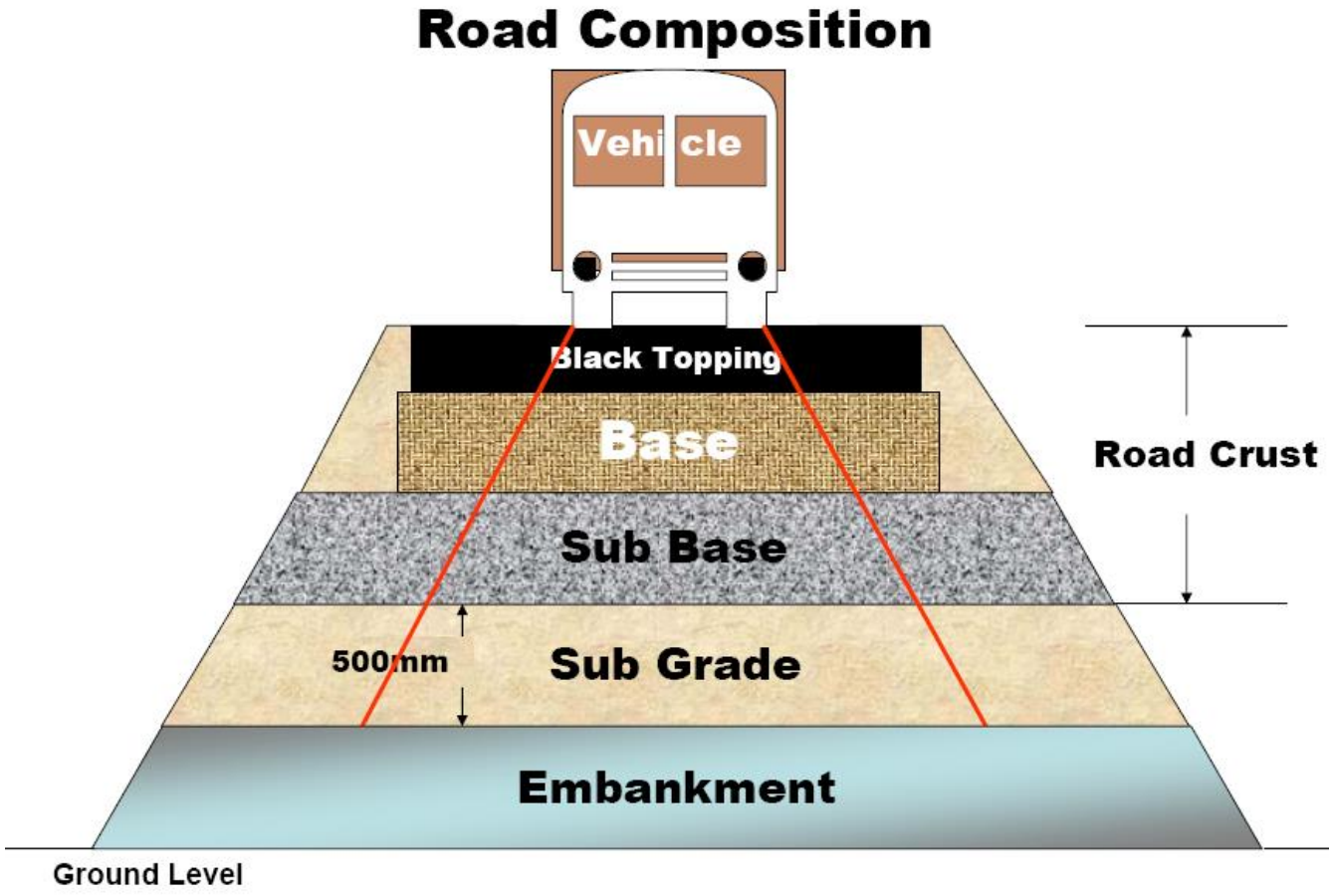
DEPARTMENT OF CIVIL ENGINEERING

TRANSPORTATION ENGINEERING LABORATORY

MANUAL AND OBSERVATION BOOK

COURSE: **B.E VI - SEMESTER (CIVIL ENGINEERING),**



MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

ROAD NO: 3, BANJARA HILLS, HYDERABAD-500 034.

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

TRANSPORTATION ENGINEERING LABORATORY

Name of the Student :_____

Class :_____

Roll No :_____

Semester :_____

Academic Year :_____

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

TRANSPORTATION ENGINEERING LABORATORY

Name of the Student:

Class : B.E VI Semester, Civil Engineering.

Roll No : Academic Year:

INDEX

S.No	Name of the Experiment	Date	Initial of Staff

CONTENTS

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 1

AGGREGATE CRUSHING VALUE TEST

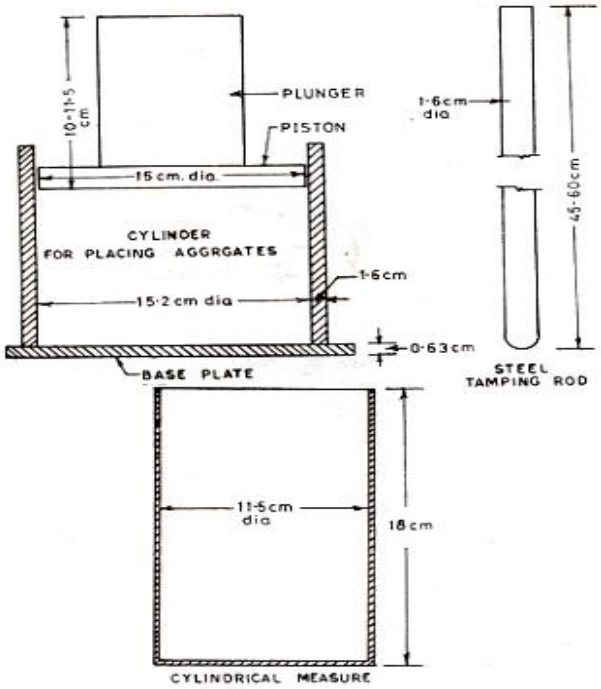
(IS: 2386(PART IV) 1963)

CONCEPT AND SIGNIFICANCE OF THE TEST:-

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 crushing (or finer) material obtained when the test aggregates are subjected to a specified load under standardized conditions. It is a numerical index of the strength of the aggregate used in road construction. Aggregate with lower crushing value indicates a lower crushed fraction under load and would give a longer service life to the road and hence a more economical performance. Weaker aggregates if used would get crushed under traffic loads and would produce smaller pieces not coated with binder and these would be easily displaced and loosened out resulting in loss of the surface layer. In short the aggregate used in road construction must be strong enough to withstand crushing under roller and traffic.

OBJECTIVES:-

1. To determine crushing value of given road aggregates.
2. To assess the suitability of aggregates for use in different types of road pavements.



Aggregate Crushing Test Apparatus

APPARATUS:-

The apparatus for the standard aggregate crushing test as per IS: 2386 – 1963 (PART IV) consist of the following.

1. The test mould 15.2 cm diameter open – ended steel cylinder with square base plate, plunger having a piston of diameter 15 cm, with a hole provided across the stem of the plunger so that a rod could be inserted for lifting or placing the plunger in the cylinder.

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 5 kg. readable and accurate up to 1 gm.
4. IS sieves of size of 12.5 mm, 10 mm, and 2.36 mm.
5. A compression test machine capable of applying load up to 40 tonnes at a uniform rate of 4 tonnes per minute.
6. A cylinder measure having internal diameter of 11.5 cm and height 18 cm.

PROCEDURE:-

a) **PREPARATION OF TEST SAMPLE**:-

The material for the standard test consists of aggregate passing a 12.5 cm IS sieve and retained on a 10 mm IS sieve and shall be thoroughly separated on these sieves before testing. The aggregate should be in surface dry condition before testing.

b) **TESTING**:-

1. Sieve the material through 12.5 mm and 10 mm IS sieve. The aggregates passing through 12.5 mm sieves and retained on 10 mm sieve comprise the test material.
2. Take about 3.25 kg of this material.
3. Pour the aggregate to fill about just more than 1/3 depth of the measuring cylinder.
4. Compact the material by giving 25 gentle blows with the rounded end of tamping rod.
5. Add two more layers in similar manner, such that the 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 weigh the aggregates, accurate up to 1 gram.
8. Transfer the whole of this weighted quantity to the test mould by filling it in three layers in the same manner as for cylindrical measure.
9. Level off the surface and a place the plunger over it so that it rests horizontally on the surface of the aggregates.
10. Place this assembly on the pedestal of compression testing machine.
11. Apply the load at a uniform rate of 4 tonnes per minute 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, weigh this fraction passing through it to an accuracy of 0.1 gram. This fraction is a measure of loss of material due to crushing.

PRECAUTIONS:-

1. The plunger should be placed centrally and rest directly on the aggregates. Care should be taken that it doesn't touch the walls of the cylinder so as to ensure that the entire load is transferred on to the aggregates.
2. The tamping should be done properly by gently 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 mould.

RECORD OF OBSERVATIONS:

Particulars	Sample - I	Sample II
1. Weight of the measuring cylinder = W_1 grams.		
2. Weight of the measuring cylinder + aggregates = W_2 grams.		
3. Weight of the aggregates taken for the test, W = ($W_2 - W_1$) grams.		
4. Weight of aggregates ***retained*** on IS Sieve 2.36mm = $\mathbf{W_R}$ grams.		
5. Weight of aggregates ***passing*** through IS Sieve 2.36mm = $\mathbf{W_P} = (W - W_R)$.		
6. Aggregate crushing value (%) = (W_P / W) x 100.		
W_P = Weight of aggregate passing through IS Sieve 2.36mm.		
W = Weight of aggregate taken for the test.		

RESULT: - The mean (average) crushing value of aggregates is _____%.

INTERPRETATION OF RESULTS:

The aggregate crushing value is an indirect measure of crushing strength of the aggregates. Low value indicates strong aggregates. This test can be used to assess the suitability of aggregates with reference to the crushing strength for different types of pavement components. The aggregates used

for the surface course of pavements should be strong enough to with stand the high stresses due to wheel loads, including the steel tyres of loaded bullock carts. As the stresses at the base and sub-base courses are low, aggregates with lesser crushing strength may be used at the lower layers of the pavement.

As per IRC and Indian Standards Institution, the limits of percent aggregate crushing value for different types of road construction is as specified in tabular form.

Types of road construction	**Aggregate crushing value (%) (not more than)**
1**. Flexible Pavement**	
a) Soling	60
b) Water – bound macadam (WBM)	40
c) Bituminous macadam	40
d) Bituminous surface dressing	30
e) Dense mix carpet	30
2 **Rigid Pavement**	
a) Other than wearing course	45
b) Surface or wearing course	30

REMARKS:

Short Questions:

1) Which property of aggregates is measured by this test?
2) How is aggregate crushing value expressed?
3) What are the uses and applications of Aggregate Crushing Value?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 2

AGGREGATE IMPACT TEST

(IS: 2386 (PART IV) 1963)

CONCEPT AND SIGNIFICANCE OF THE TEST:-

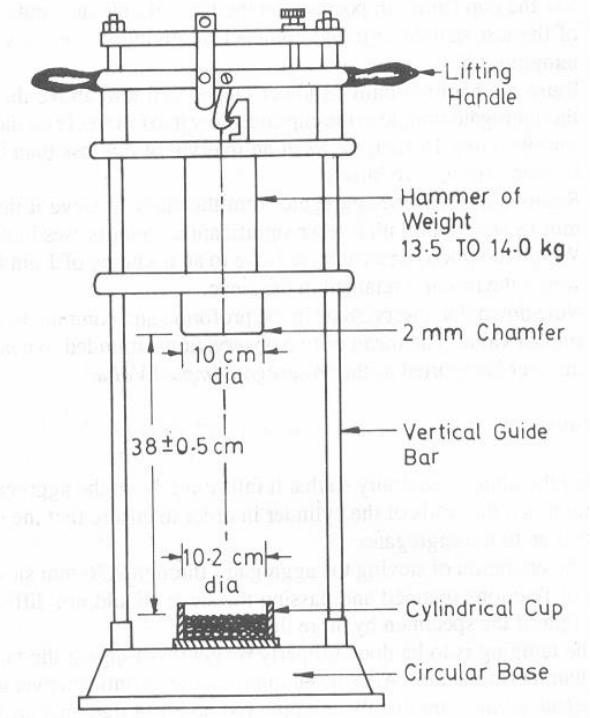
The property of a material to resist impact is known as toughness. Due to movement of vehicles on the road, the aggregates are subjected to impact resulting in their breaking down into smaller pieces. This characteristic is measured by impact value test. The aggregate impact value is a measure of resistance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

OBJECTIVE: - To determine the impact value of the given road aggregate.

APPARATUS:-

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

1. Impact testing machine: The machine consists of a metal base. A detachable cylindrical sheet cup of internal diameter 10.2 cm and depth 5 cm. 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 38 cm on test sample in the cup.
2. A tamping rod of circular cross section, 1 cm in diameter and 23 cm long rounded at one end.
3. IS sieve of sizes 12.5 mm, 10 mm and 2.36 mm.
4. A cylindrical metal measure having internal diameter of 7.5 cm and depth of 5 cm for measuring aggregates.
5. A balance of capacity not less than 500 grams, readable and accurate up to 0.1 gram.



Impact Test Apparatus

PROCEDURE:-

1. Sieve the material through 12.5 mm and 10 mm IS sieve. The aggregates passing through 12.5 mm sieve and retained on 10 mm IS sieve comprises the test material.
2. Pour the aggregates to fill about just 1/3rd depth of measuring cylinder.
3. Compact the material by giving 25 gently blows with rounded end of the tamping rod.
4. Add two more layers in similar manner, so that cylinder is full.
5. Strike off the surplus aggregates.
6. Determine the net weight of the aggregates to the nearest gram.
7. 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 25 times.
8. The hammer is raised until its lower face is 38 cm 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 than removed from the cup and the whole of it is sieved on 2.36 mm sieve until no significant amount passes. The fraction passing the sieve is weighed accurately to 0.1 gm. Repeat the above steps with other fresh sample.

PRECAUTIONS:-

1. Place the plunger centrally so that it falls directly on the aggregate sample and does not touch the walls of the cylinder in order to ensure that the entire load is transmitted on to the aggregates.
2. In the operation of sieving the aggregate through 2.36 mm IS sieve the sum of weights of fraction retained and passing the sieve should not differ from the original weight of the specimen by more than 1 gram.
3. The tamping is to be done properly gently 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 mould.

RECORD OF OBSERVATIONS:-

Particulars	Sample I	Sample II
1. Weight of the empty measuring cylinder = W_1 grams. 2. Weight of the measuring cylinder + aggregate = W_2 grams. 3. Weight the aggregates taken for the test = $W = (W_2 - W_1)$ grams. 4. Weight of the aggregate retained on IS Sieve 2.36mm = $\mathbf{W_R}$ grams. 5. Weight the aggregate ***passing*** through IS Sieve 2.36mm = $\mathbf{W_P} = (W - \mathbf{W_R})$ grams. 6. Aggregate impact value (%) = $(\mathbf{W_P} / W) \times 100$, where $\mathbf{W_P}$ = Weight of aggregates passing through 2.36mm IS Sieve. W = Weight of aggregates taken for the test.		

RESULT: - Mean aggregate impact value is _____%.

INTERPRETATION OF RESULT:-

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
10 – 30%	Satisfactory for road surfacing
>35%	Weak for road surfacing

The IRC has recommended the following values for different types of road construction

Type of pavement	Maximum aggregate impact value (%)
1. Bituminous surface dressing penetration macadam, bituminous carpet concrete, and cement concrete wearing course.	30
2. Bituminous macadam, base course.	35
3. WBM base course with bitumen surfacing.	40
4. Cement concrete base course.	45
5. WBM sub – base course.	50

DISCUSSIONS:

The main advantage of aggregate impact test is that the procedure and the test equipment are quite simple and this test can be done in a short time even at the construction site at the stone quarry.

APPLICATIONS OF AGGREGATE IMPACT VALUE:-

The aggregate impact test is considered to be an important test to assess the suitability of the aggregate as regards the toughness for using the pavement construction. It has been found that for majority of aggregates, the aggregate crushing and aggregate impact values are numerically similar within close limits. But in case of finely grained highly silicons aggregate which are less resistant to impact values are higher (on the average, by about 5%) than the aggregate crushing values. For knowing the suitability of soft aggregates in base course construction, this test has been commonly used.

REMARKS:-

Short Questions:

1) What is meant by toughness of the aggregates?
2) How does toughness differ from compressive strength?
3) What are the uses of impact test?
4) How is the aggregate impact value expressed?
5) If the weight of the hammer is increased, what is the effect on impact value?
6) If the height of fall is increased, what is the effect on impact value?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 3

LOS ANGELES ABRASION TEST

(IS : 2386(PART IV) 1963)

CONCEPT AND SIGNIFICANCE OF THE TEST:-

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

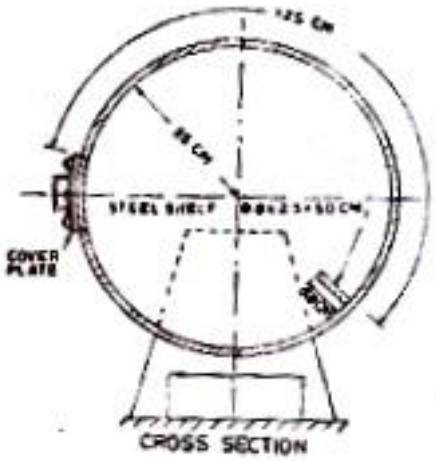
The principle of Los Angeles abrasion test is to produce the abrasive action by use of standard steel balls used as abrasive charge which when mixed with the aggregates and rotated in a drum for specific number of revolutions also cause impact on aggregates. The percentage wear of the aggregates due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

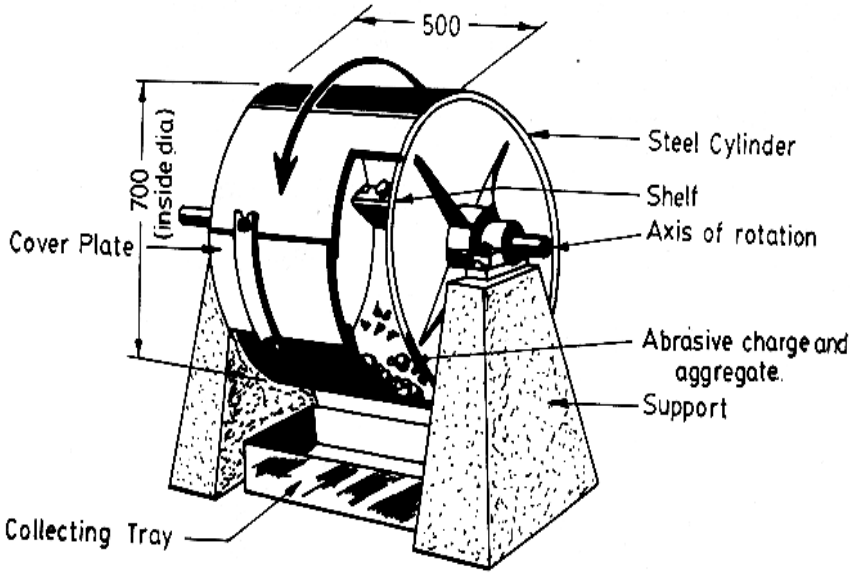
OBJECTIVES: -

To determine the abrasion value of given aggregate sample by conducting Los Angeles abrasion test.

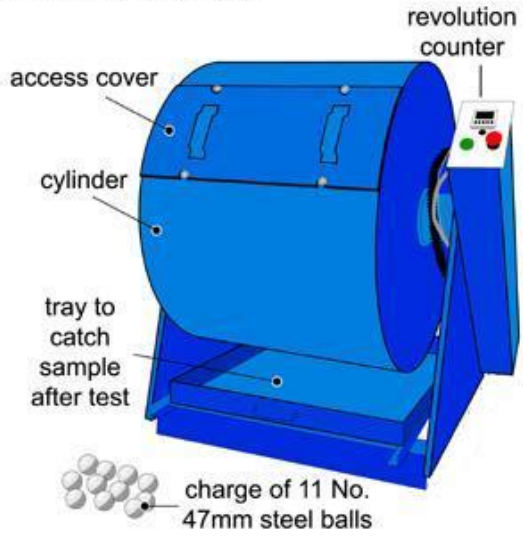
APPARATUS:-

1. Los Angeles machine: It consists of a hollow steel cylinder, closed at both the ends with an internal diameter of 70 cm and length of 50 cm and capable of rotating about its horizontal axis.
2. Abrasion charge: Cast iron or steel balls approximately 4.8 cm in diameter and each weighing between 300 to 445 grams. Six to twelve balls are required.
3. 1.70 mm IS sieve
4. Balance of capacity 5 kg or 10 kg.
5. Miscellaneous like tray etc.





Los Angeles machine



Los Angeles Abrasion Test Apparatus

PROCEDURE:-

1. Select the grading to be used in the test. It should be chosen such that it confirms 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 gradings E, F and G
3. Choose the abrasive charge as per Table (2).
4. Open the cover and place the aggregates and steel balls in the cylinder. Repeat the cover tightly
5. Rotate the machine at a uniform rate of speed of 30 to 33 revolutions per minute.
6. Allow the machine to run 500 revolutions for grading A,B,C or D and 1000 revolutions for gradings E, F, or G
7. Stop the machine after desired number of revolutions.
8. Remove the dust cover and take out material.
9. Separate the steel balls and sieve the material on 1.70 mm IS sieve.
10. Calculate the percentage of loss of material.
11. Take another sample and repeat the experiment. Find the mean of two values and reports it as Los Angeles Abrasion Value.

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
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

TABLE (2)

Grading	No. of Steel Balls	Weight of charge (Grams)
A	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 20
D	12	2500 ± 15
E	12	5000 ± 15
F	12	5000 ± 25
G	12	5000 ± 25

PRECAUTIONS:-

1. The cover should be fixed tightly before rotating the machine.
2. All materials should be discharged from the cylinder after the conduct of test.

RECORD OF OBSERVATIONS:-

Particulars	Sample- I	Sample- II
1. Weight of the aggregates taken for the test = W grams. 2. Weight of the aggregates ***retained*** on IS Sieve 1.70mm = $\mathbf{W_R}$ grams. 3. Weight of the aggregates ***passing*** through IS Sieve 1.70mm = $\mathbf{W_P} = (W - \mathbf{W_R})$ grams. 4. Percentage of Wear (%) = $(\mathbf{W_P} / W) \times 100$, where $\mathbf{W_P}$ = Weight of aggregate ***passing*** through 1.70mm IS Sieve. W = Weight of aggregate taken for the test.		

RESULT:-

The mean (average) abrasion value of aggregate by Los Angeles test is _____%.

INTERPRETATION OF RESULTS:-

Los Angeles Abrasion test is commonly used to evaluate the hardness of the aggregates. The test has more acceptability because the resistance to abrasion and impact is determined simultaneously. Depending upon to numerical value the suitability of aggregates for different road construction can be judged as per India Road Congress (IRC) specifications given below.

Types of pavement layer	Max. Permissible Abrasion value in %
1. Water bound macadam, sub-base course	60
2. WBM base course with bituminous surfacing	50
3. Bituminous Bound Macadam	50
4. WBM surfacing course	40
5. Bituminous carpet	35
6. Bituminous surface dressing, cement concrete surface course (as per IRC)	35
7. Cement concrete pavement surface course (as per ISI)	30

APPLICATION OF LOS ANGELES TEST:-

1. Used to evaluate the quality of aggregates for use in pavements construction, especially to decide the hardness of stones.
2. It is considered to be acceptable since the resistance to both abrasion and impact of aggregate may be obtained simultaneously due to the presence of abrasive charges.
3. The test condition is considered more representative of field conditions and the results obtained on stone aggregates are highly reproducible.

Short Questions:

1) What properties of aggregates are determined by Los Angeles test?
2) How does impact occur in the test?
3) Why Los Angeles Abrasion Test is considered supreme to others?
4) What is abrasion and attrition?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 4

DEVAL ABRASION TEST

(IS: 2386(PART IV) 1963)

CONCEPT AND SIGNIFICANCE OF THE TEST:-

Abrasion value of the aggregates is determined in order to determine their resistance against wearing. In this test the aggregate is mixed with abrasive consisting of six standard balls and rotated in closed inclined cylinder for specific number of revolutions. The abrasion value is then expressed as the percentage of abraded material with reference to the original weight of the test sample.

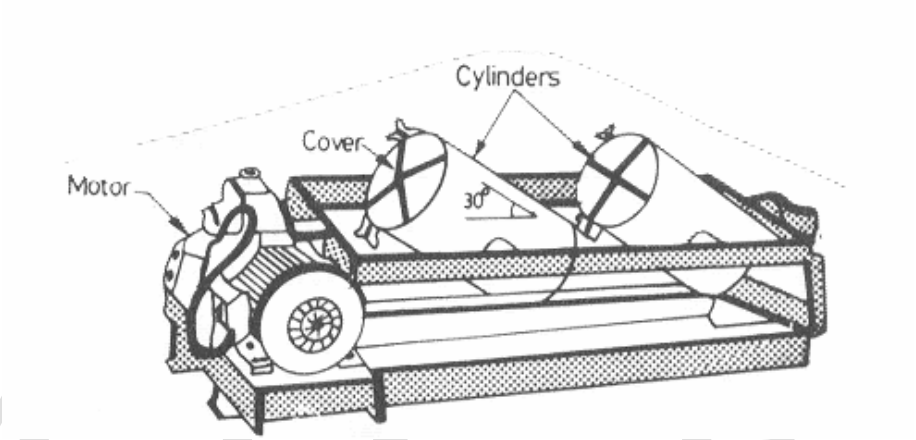
OBJECTIVES: - To determine the abrasion value of road aggregate.

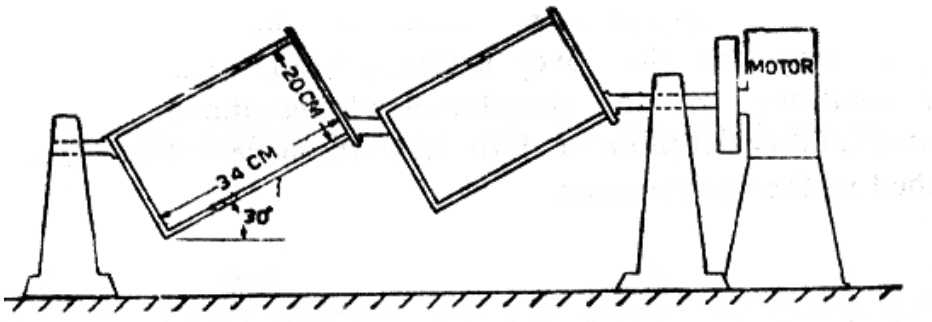
APPARATUS:-

1. Deval machine: it consists of one or more (usually two) hollow cast iron cylinder having an internal diameter of 20 cm and depth 34 cm. the cylinders are closed at the bottom and provided with a tightly fitted cover. The cylinders are mounted on a shaft at an angle of 30° with the axis of rotation.
2. IS sieve of size 1.70 mm.
3. Abrasive charge – 6 cast iron or steel balls each having an approximate diameter of 4.8 cm and weighing between 390 to 445 grams.
4. Balance or capacity 10 kg.
5. Drying oven and tray.

PROCEDURE:-

Preparation of test sample: - The test consists of dry and clean aggregates made up of percentage of different sizes conforming to one of the grading given in table (1). The grading adapted should be one which most closely represents the coarse aggregates to the used in construction.





Deval's Abrasion Apparatus

Table 1. Grading of Aggregate for Deval Abrasion Test.

Grading	Passing IS Sieve	Retained IS Sieve	Percentage of sample (%)
A	20 25 40 50	12.5 20 25 40	25 25 25 25
B	20 25 40	12.5 20 25	25 25 50
C	20 25	12.5 20	50 50
D	12.5 20	4.75 12.5	50 50
E	10 12.5	4.75 10	50 50

The weight of test sample depending upon the specific gravity is chosen from the following table (2).

Table (2). Weight of sample for Deval Abrasion Test.

Range of specific gravity	Weight of the sample (gm)
More than 2.8	5500
2.4 to 2.8	5000
2.2 to 2.39	4500
Less than 2.2	4000

TESTING:-

1. Choose the grading and weigh the material as per Tables 1 and 2.
2. Place the material in the cylinder.
3. Place the abrasive charge in the cylinder. The total weight of steel balls should be 2500 $\pm$ 10 grams.
4. Fix the cover tightly.
5. Rotate the machine for 10,000 revolutions at a speed of 30 – 33 rpm.
6. After completion, stop the machine and remove the material.
7. Sieve the material through 1.70 mm IS sieve.
8. Wash, dry and weigh the material on this sieve.
9. Calculate the Abrasive value. Find the average of two readings.

Note: - Most of the machines have two cylinders, there two samples can be tested simultaneously.

PRECAUTIONS:- The lid of the cylinder should be fixed.

RECORD OF OBSERVATIONS:-

Particulars	Sample I	Sample II
1. Weight of the aggregate sample = W grams 2. Weight of aggregate ***retained*** on IS sieve 1.70mm = $\mathbf{W_R}$ grams. 3. Weight of the aggregate ***passing*** through 1.70mm sieve, $\mathbf{W_P}$ = (W – $\mathbf{W_R}$) grams. 4. Percentage of wear (%) = ($\mathbf{W_P}$ / W) x 100, where $\mathbf{W_P}$ = Weight of the aggregate ***passing*** through 1.70mm IS Sieve. W = Weight of aggregate taken for the test.		

RESULT:-

The mean (average) of Deval Abrasion value of aggregate by Deval Abrasion Test is _____%.

INTERPRETATION OF RESULT:-

Deval Abrasion test enables to get an idea of the hardness of the aggregates. However, no specifications to assess suitability for road construction have been laid by standard agencies. Therefore, this test has limited use and applications. Sometimes the test may be carried out without adding abrasive charge in which case it is known as "Deval Attrition Test".

Short Questions:

1) What is the principle of determination of abrasion value by Deval's machine?
2) What are the short comings of obtaining abrasion value by Deval's machine as compared to Los Angeles machine?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 5

SHAPE TEST

(IS : 1963 (PART IV))

CONCEPT AND SIGNIFICANCE OF THE TEST:-

The particle shape of aggregates is determined by the percentages of flaky and elongated particles contained in it. In the case of gravel it is determined by its angularity number. For base course and construction of bituminous and cement concrete types, the presence of flaky and elongated particles are considered undesirable as they may cause inherent weakness with possibilities of breaking down under heavy loads. Rounded aggregates are preferred in cement concrete construction as the workability of concrete improves.

Angular shape of particles are desirable for granular base course due to increased stability derived from the better interlocking, when the shape of aggregate deviated 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 increased and hence the grain size distribution of graded aggregate has to be suitably alter in order to obtain minimum voids in the dry mix as the highest dry density.

The angularity number denotes the void content of single sized aggregates in excess of that obtained with spherical aggregates of the same size. Thus angularity number has considerable important in the gradation requirements of various types of mixes such as bituminous concrete and soil-aggregate mixes.

Thus evaluation of shape of the particle, particularly with reference to flakiness, elongation and angularity is necessary.

DETERMINATION OF FLAKINESS INDEX OF AGGREGATES

OBJECTIVE:-

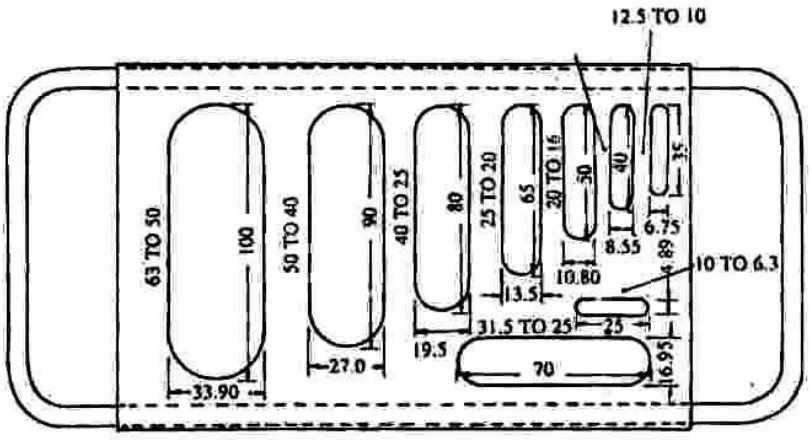
To determine the flakiness index of given coarse aggregate sample.

(**Note**: Flakiness index of an aggregate is the percentage by weight or particles whose least dimension (thickness) is less than three fifth $3/5^{th}$ (0.6) of their mean dimension the test is not applicable to sizes smaller than 6.3 mm)

APPARATUS:-

The apparatus for the standard flakiness index value test as per IS : 2386 (PART IV) 1963, consists of the following,

1. A balance of enough capacity and sensitivity. It should have an accuracy of 0.1% of the weight of test sample
2. Standard thickness gauge confirming to IS : 2386 (PART IV).
3. IS Sieves – 63 mm, 50 mm, 40 mm, 31.5 mm, 25 mm, 50 mm, 16 mm, 12.5 mm, 10 mm, and 6.3 mm.



All dimensions are in mm

Thickness Gauge

PROCEDURE:-

PREPARATION OF SAMPLE:

Sufficient quantity of sample in needed so that it consists of at least 200 pieces of any fraction to be tested.

TESTING:-

1. The sample has to be carefully and properly sieved.
2. The fraction are to be collected with the following specifications

Size of aggregate	
Passing through IS Sieve	**Retained on IS Sieve**
63 mm	50 mm
50 mm	40 mm
40 mm	31.5 mm
31.5 mm	25 mm
25 mm	20 mm
20 mm	16 mm
16 mm	12.5 mm
12.5 mm	10 mm
10 mm	6.3 mm

3. Every piece of each fractional sieve shall be gauged for the minimum thickness with the help of ISI gauge as shown in figure (1). The width of the slot used should be of the dimension specified in column (3) of table (1) for the appropriate size of the material.

Table (1): Dimensions of Thickness gauge

Size of aggregate		
Passing through IS Sieve. mm	**Retained on IS Sieve. mm**	**Thickness gauge (0.6 times the mean sieve) mm**
63	50	33.9
50	40	27
40	31.5	19.5
31.5	25	16.95
25	20	13.5
20	16.5	10.8
16	12.5	8.55
12.5	10	6.75
10	6.3	4.89

4. Thus each fraction is to be separated in two parts: one consisting of pieces which pass through the corresponding slot in the standard gauge and the other consisting of pieces which do not pass through the corresponding slot in standard thickness gauge.
5. Weight of each part is separately weighted to an accuracy of at least 0.1 percent of the sample.

RECORD OF OBSERVATIONS:-

Size of aggregate		Weight of the fraction consisting of least 200 pieces (gm)	Thickness gauge size, mm (0.6 times the mean sieve)	Weight of aggregates in each fraction passing through thickness gauge (gm)
Passing through IS Sieve, mm	**Retained on IS sieve, mm**			
63	50	W_1 =	33.90	Y_1 =
50	40	W_2 =	27	Y_2 =
40	31	W_3 =	19.5	Y_3 =
31	25	W_4 =	16.95	Y_4 =
25	20	W_5 =	13.5	Y_5 =
20	16	W_6 =	10.8	Y_6 =
16	12.5	W_7 =	8.55	Y_7 =
12.5	10	W_8 =	6.75	Y_8 =
10	6.3	W_9 =	4.89	Y_9 =
	Total	**W_T** =		**Y_P** =

RESULT:-

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.

Flakiness index = $\dfrac{\text{Total weight of aggregate in each fraction passing through thickness gauge (grams)}}{\text{Total weight of the fraction consisting of at least 200 pieces (grams)}}$

= (Y_P / W_T)

Percentage flakiness index, **(Y_P / W_T) x 100** = _____ %.

INTERPRETATION OF RESULTS:-

The suitability of aggregates is assessed by adopting the value as recommends maximum allowable limits of flakiness index value for various types of construction of pavement layers.

Type of pavement construction	Maximum limit of flakiness index, %
1. Bituminous carpet.	30
2. Bituminous i) Carpet. ii) Surface dressing. iii) Penetration macadam.	25
3. Bituminous macadam and WBM base and surface sources	15

APPLICATIONS OF FLAKINESS INDEX VALUE TEST:-

In pavement construction flaky particles are to be avoided, particularly in surface course. If flaky aggregates are present in appreciable proportion, the strength of the pavement layer would be adversely affected due to possibility of breaking down under loads. In cement concrete the workability is also reduced. However, the reduction in strength in cement concrete depends on the cement content and water – cement ratio.

REMARKS:-

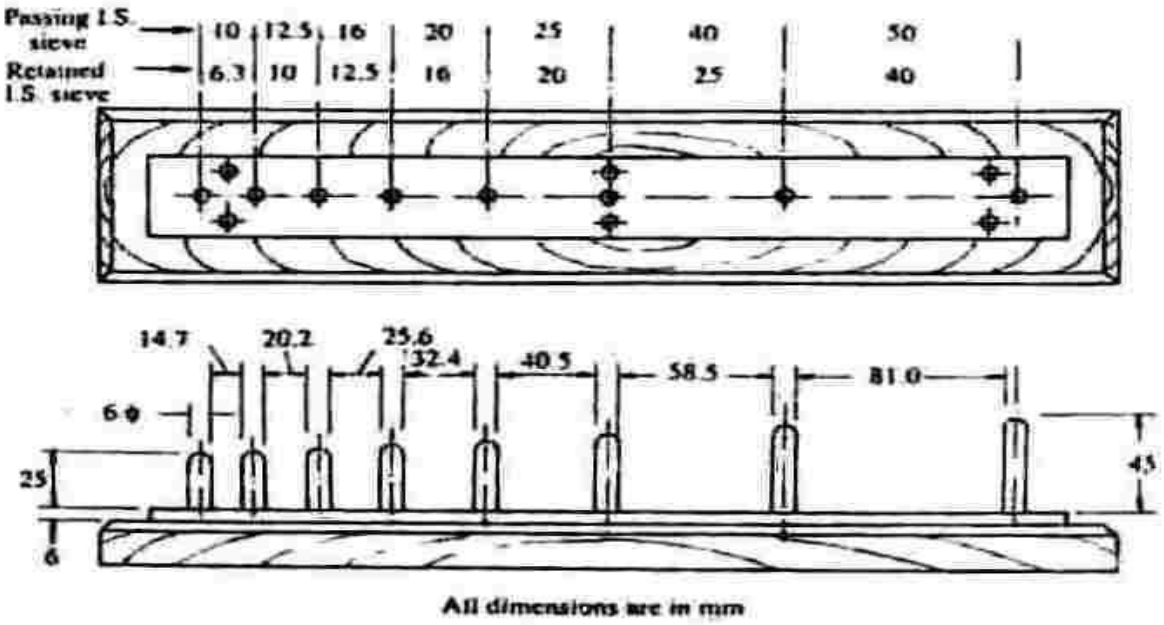
DETERMINATION OF ELONGATION INDEX VALUE OF AGGREGATES

OBJECTIVE:-

To determine the Elongation index of given coarse aggregate sample.

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

APPARATUS:-



Length Gauge

1. A balance of enough capacity and sensitivity. It should have an accuracy of 0.1% of the weight of test sample.
2. Standard length gauge confirming the IS:2386 (part I).
3. IS Sieve – 63 mm, 50 mm, 40 mm, 31.5 mm, 25 mm, 20 mm, 16 mm, 12.5 mm,10 mm, 6.3 mm.

PROCEDURE:-

PREPARATION OF SAMPLE:- Sufficient quantity of sample is needed so that it consist of at least 200 pieces of many fraction to be tested.

TESTING:-

1. The sample has to be carefully and properly sieved.
2. The fraction are to be collected with the IS sieve specification as indicated in flakiness index test.
3. Every piece of each fractional sieve shall be gauged for the length with the help is ISI gauge. The length of the slot used should be of the dimensions specified in column (3) of table (2) for the appropriate size of the material.

4. Thus, each fraction is to be separate. Consisting of piece which passes through and retained on the corresponding slot in the standard length gauge and weighed separately with an accuracy of 0.1% of the test sample.

Table (2) Dimensions of Length Gauge.

Size of aggregates passing through IS Sieve (mm)	Retained on IS Sieve (mm)	Length gauge, mm (1.8 times the mean sieve)
60	50	-
50	40	81
40	31.5	58.5
31.5	25	-
25	20	40.5
20	16	32.4
16	12.5	25.6
12.5	10	20.2
10	6.3	14.7

RECORD OF OBSERVATIONS:-

Sieve Sizes		Weight of the fraction consisting of least 200 pieces (gm)	Length gauge size, mm (1.8 times the mean sieve)	Weight of each fraction retained on length gauge (gm)
Passing through IS Sieve, mm	**Retained on IS Sieve, mm**			
51	40	W_1 =	81	X_1 =
40	31.5	W_2 =	58	X_2 =
25	20	W_3 =	40.5	X_3 =
20	16	W_4 =	32.4	X_4 =
16	12.5	W_5 =	25.5	X_5 =
12.5	10	W_6 =	20.2	X_6 =
10	6.3	W_7 =	14.7	X_7 =
	Total	**W_T =**		**X_R =**

RESULT:-

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

$$\textbf{Elongation Index} = \frac{(X_1 + X_2 + \text{---------})}{(W_1 + W_2 + \text{---------})} = \frac{\Sigma X}{\Sigma W} = \frac{X_R}{W_T} * 100$$

Total of weight aggregate in each fraction retained on length gauge (grams) = $\frac{X_R}{W_T}$.
Total weight of the fraction consisting of at least 200 pieces (grams)

Percentage Elongation Index = (X_R / W_T) x **100** = ____%

INTERPRETATION OF RESULTS:-

Through elongated shape of aggregates also affect the compaction and the construction of pavements, there are no specified limits of elongation index value as in the case of flakiness index of different methods of pavement constructions.

REMARKS:-

Short Questions:

1) What are the applications of shape test?
2) Why flaky and elongated aggregates should not be used?
3) What is Flakiness Index and Elongation Index?
4) Discuss the advantages and limitations of rounded and angular aggregates in different type of pavements.
5) Explain Angularity Number .How it is determined?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 6

SPECIFIC GRAVITY OF AGGREGATE AND WATER ABSORPTION TEST

(IS: 2386 PART III 1963)

CONCEPT AND SIGNIFICANCE:-

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

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

OBJECTIVE:-

To determine the specific gravity, apparent specific gravity and water absorption of aggregates of sizes as specified by ISI.

APPARATUS:- The apparatus shall consists of following.

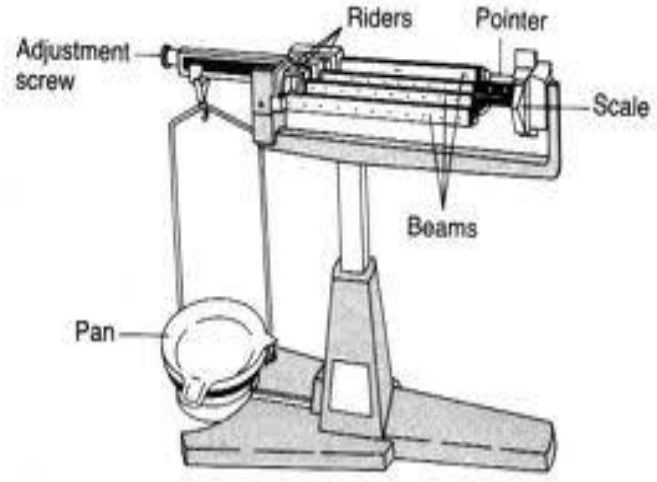
1. Balance – Capacity not less than 3 kg.
2. Oven – A well ventilated oven, thermostatically controlled to maintain a temperature of $100^{\circ}C - 110^{\circ}C$.
3. A wire basket of not more than 6.3 mm mesh as a perforated container of convenient size with thin wire hangers for suspending it from the balance.
4. A container for filling water and suspending the basket.
5. An air tight container of capacity similar to that of the wire basket.
6. A shallow tray and two dry absorbent clothes, each not less than 75 x 45 mm.

PROCEDURE:-

PREPARATION OF SAMPLE:-

A sample of about two kg of the aggregate in any of the following three sizes ranges as specified by ISI is selected.

1. Aggregate more than 10 mm.
2. Between 10 mm and 40 mm.
3. Smaller than 10 mm.



Tri-Beam Balance

TESTING:-

1. The aggregate sample as selected above is washed thoroughly to remove fines, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22° C and 32° C and with a cover of at least 5 cm of water above the top of the basket. Immediately after immersion the entrapped air is removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop 25 times at the rate of above one drop per second. The basket and the aggregate should remain completely immersed in water for a period of 24 ± ½ hours afterwards.
2. The basket and the sample are then weighed while suspended in water at a temperature of 22° C. In case it is necessary to transfer the basket and the sample to a different tank for weighing, they should be jolted 25 times as described above in the new tank to remove air before weighing. This weight is noted while suspended in water = W_1 grams. The basket and the aggregate are then removed from the water and allowed to drain for a few minutes, after which the aggregates are transferred to one of the dry absorbent clothes. The empty basket is then returned to the tank of water, jolted 25 times and weighed in water = W_2 grams.
3. 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 are transferred to 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 60 minutes drying may be needed. The aggregate should not be exposed to the atmosphere, directly sunlight or any other source of heat while surface drying. A gentle current of unheated air may be used during the first ten minutes to accelerate the drying of aggregate surface.
4. The surface dried aggregate is then weighed = W_3 grams. The aggregate is placed in a shallow tray and kept in an oven. Maintained at a temperature of 100 to 110° C for 24 hrs. It is then removed from the oven, cooled in an airtight container and weighed = W_4 grams. At least two tests should be carried out, but not concurrently.

RECORD OF OBSERVATIONS:-

Particulars	Sample - I	Sample -II
1. Weight of wire basket suspended in water = W_1 grams. 2. Weight of the wire basket + ***saturated*** aggregate suspended in water = W_2 grams. 3. Weight of the ***saturated*** aggregates in water = $W_S = (W_2 - W_1)$ grams. 4. Weight of the saturated ***surface*** dried aggregates in air = W_3 grams. 5. Weight of the ***oven*** dried aggregates = W_4 grams. 6. ***Specific gravity*** = $\frac{\text{Weight of the dry aggregate}}{\text{Weight of the equal volume of water}} = \frac{\mathbf{W_4}}{\mathbf{(W_3 - W_S)}}$ 7. ***Apparent specified gravity*** = $\frac{\text{Weight of the dry aggregate}}{\text{Weight of equal volume of water excluding air void}} = \frac{W_4}{(W_4 - W_S)} = \frac{\mathbf{W_4}}{\mathbf{W_4 - (W_2 - W_1)}}$ 8. ***Water absorption*** = $\frac{\text{Weight of the water absorbed x 100}}{\text{Weight of the dry aggregate}} = \frac{\mathbf{(W_3 - W_4)\ x\ 100}}{\mathbf{W_4}}$		

RESULTS:-

1. Aggregate **specified gravity** mean value =
2. Aggregate **apparent specific gravity** mean value =
3. Aggregate **water absorption** mean value = _____%.

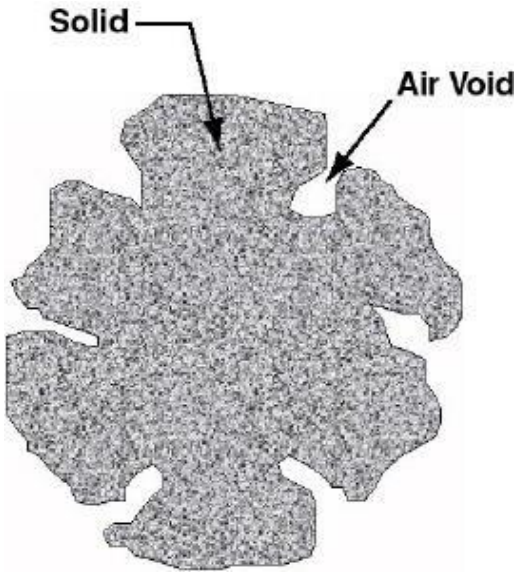
INTERPRETATION OF RESULTS:-

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

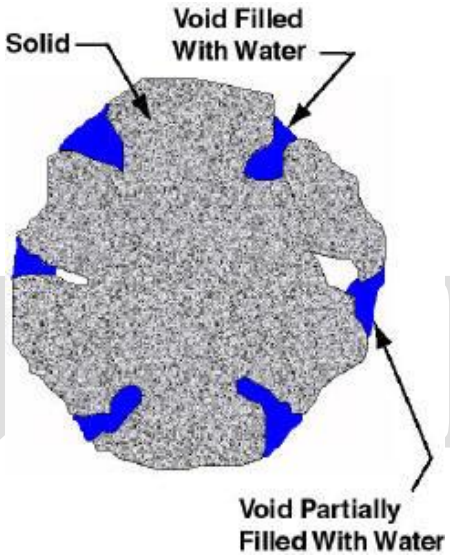
ii) Water absorption of an aggregate is accepted as measure of its porosity. Water absorption value ranges from 0.1 to about 2.0 percent for aggregates normally used in road surfacing. Stones with water absorption up to 4.0 percent have been used in base courses. Generally a value of less than 0.6 percent is considered desirable for surface course, though slightly higher values are allowed in bituminous constructions. IRC has specified the maximum water absorption value as 1.0 percent for aggregates used in bituminous surface dressing and built up spray grouts.

Apparent Specific Gravity: - The volume measurement only includes the volume of the aggregate particle, it does not include the volume of any water permeable voids. The mass measurement only includes the aggregate particle. Apparent specific gravity is intended to only measure the specific gravity of the solid volume; therefore it will be the highest of the aggregate specific gravities.

It is formally defined as the ratio of the mass of a unit volume of the impermeable portion of aggregate (does not include the permeable pores in aggregate) to the mass of an equal volume of gas-free distilled water at the stated temperature.



Bulk Specific Gravity (Bulk Dry Specific Gravity):- The volume measurement includes the overall volume of the aggregate particle as well as the volume of the water permeable voids. The mass measurement only includes the aggregate particle. Since it includes the water permeable void volume, bulk specific gravity will be less than apparent specific gravity. It is formally defined as the ratio of the mass of a unit volume of aggregate, including the water permeable voids, at a stated temperature to the mass of an equal volume of gas-free distilled water at the stated temperature.



REMARKS:-

Short Questions:

1) Discuss the importance of specific gravity test on road aggregates?
2) Define bulk and apparent specific gravity of aggregates?
3) What is the significance of water absorption test on aggregates?
4) Which specific gravity values are preferred? Why?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 7

DETERMINATION OF PENETRATION VALUE OF BITUMINOUS MATERIAL

(IS: 1203 – 1978)

CONCEPT AND SIGNIFICANCE OF THE TEST:-

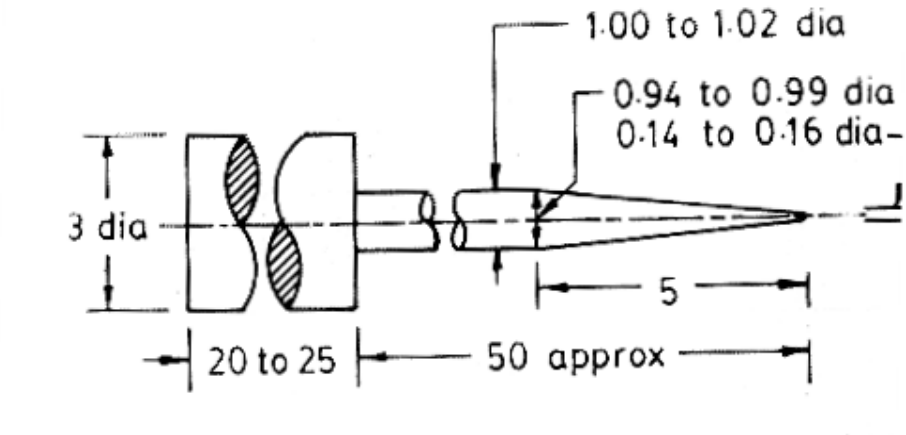
Penetration is a measurement of hardness or consistency of bituminous material. It is the vertical distance traversed or penetrated by the point of a standard needle in to the bituminous material under specific condition of load (100 gm), time (5 sec) and temperature ($25^{\circ}C$). This distance is measured in one – tenth of a millimeter. The softer the bitumen, the greater will be the penetration. The test is used for evaluating consistency of bituminous materials, it is not regarded as suitable for use in connection with the test of road tar because of the high surface tension exhibited by these materials and the fact that they contain relatively large amount of free carbon.

OBJECTIVES:-

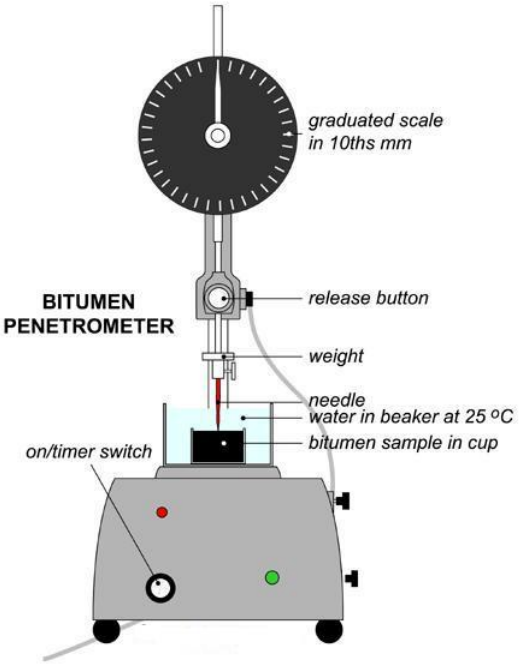
1. To determine the grade of a given blinder
2. To assess the suitability of bitumen for its use under different climatic condition and types of road construction.

APPARATUS:-

It consists of items like container, needle, water bath, penetrometer, stop watch etc. Container is a flat bottomed cylindrical metallic disc with 55 mm in diameter and 35 mm in depth. If the penetration is of the order of 225 or more deeper dish of 70 mm diameter and 45 mm depth is required. The needle is provided with a shank approximately 3 mm in diameter into which it is immovable fixed.



All dimensions in millimetres



Penetrometer

PROCEDURE:-

PREPARATION OF TEST SAMPLE:-

Soften the material to pouring consistency at a temperature not more than 60° C for tars and 90°C for bitumen above the approximate softening point and stir it thoroughly until it is homogeneous and is free from air bubbles and water. Pour the melted material into the container to a depth at least 15 mm in excess of the expected penetration. Protect the sample from dust and allow it to cool in an atmosphere at a temperature between 15° to 30° C for one hour. Then place it along with the transfer dish in the water bath at 25.0° ± 0.1° C, and allow it to remain for 1 to ½ hour. The test is carried out at 25 ± 0.1° C unless otherwise stated.

TESTING:-

1. Fill the transfer dish water from the water bath to depth sufficient to cover the container completely, place the sample in it and put it upon the stand of the penetration apparatus.
2. Clean the needle with benzene, dry it and load with the weight. The total moving load required is 100 ± 0.25 gm, including the weight of the needle, carrier and super imposed weights.
3. Adjust the needle to make contact with the surface of the sample. This may be done by placing the needle point in contact with it image reflected by the surface of the bituminous material.
4. Make the pointer of the dial to read zero or note the initial dial reading.
5. Release the needle for exactly five seconds.
6. Adjust the penetration machine to measure the distance penetrated.
7. Make at least 3 readings at points on the surface of the sample not less than 10 mm apart and not less than 100 mm from the side of the dish. After each test return the sample and transfer dish to the water bath and wash the needle clean with benzene and dry it. In case of material of penetration greater than 225, three determinations on each of the two identical test specimens using a separate needle for each determination should be made, leaving the needle in the sample on completion of each determinations to avoid disturbance of the specimen.

PRECAUTIONS:-

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

OBSERVATIONS AND CALCULATIONS:-

Readings	Trials			Mean value
	1	2	3	
Penetrometer dial initial reading				
Penetrometer dial final reading				
Penetration Value				

RESULT:-

Mean penetration value =

Note: The value of 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	MAXIMUM DIFFERENCE
0 to 49	2
50 to 149	4
150 to 249	6
250 and above	8

INTERPRETATION OF RESULTS:-

1. Penetration test is a commonly adopted test on bitumen to grade the materials in terms of its hardness. Depending upon the climatic condition and type of construction, bitumen of different penetration grades are used. A 80/100 grade bitumen indicates that its penetration value ranges between 80 and 100. The penetration value of various types of bitumen used in pavement construction in this county ranges between 20 and 225. In warmer regions lower penetration grades are preferred to avoid softening whereas higher penetration grades like 180/200 are used in colder region so that excessive brittleness does not occur. Higher penetration grade is used in spray application works.
2. The penetration test is not intended to estimate the consistency of softer materials like cutback or tar, which are usually graded by a viscosity test in an orifice viscometer.
3. IRC suggests bitumen grades 30/40, 60/70, and 80/100 for bituminous and penetration macadam.
4. The ISI has classified paving bitumen available in this county into the following six categories depending upon the penetration values. Grading designated 'A' (such as A35) are from Assam petroleum and those designated 'S' (such as S35) are from other sources.

Bitumen grade	A 25	A 35 & S 35	A 45 & S 45	A 65 & S 65	A 90 & S 90	A200 & S 200
Penetration value	20 to 30	30 to 40	40 to 50	60 to 70	80 to 100	175 to 225

REMARKS:-

Short Questions:

1) How is penetration value of bitumen expressed?
2) What are the standard load, time and temperature specified for penetration test?
3) What do you understand by 80 /100 bitumen?
4) What are the effects of (i) higher test temperature (ii) higher pouring.
5) Which property of bitumen is related to penetration value?
6) If the penetration value of a binder is 65, what is the distance in mm which the needle has penetrated through?
7) Which bitumen grades are commonly used in warmer regions and why?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 8

DETERMINATION OF SOFTENING POINT OF BITUMINOUS MATERIAL

(IS: 1205 – 1978)

CONCEPT AND SIGNIFICANCE OF THE TEST:-

Bitumen does not suddenly change from solid to liquid state, but as the temperature increase, it gradually becomes soften until it flows readily. The softening point of bitumen or tar is the temperature at which the substance attains a particular degree of softening, as per IS : 334 – 1982, it is the temperature (in $^{\circ}$C) at which a standard ball passes through a sample of bitumen in a mould and falls through a height of 2.5 cm, when heated under water or glycerin at specified conditions of test. The binder should have sufficient fluidity before its applications in road uses. The determination of softening point helps to know the temperature up to which a bituminous blinder should be heated for various road use applications. Softening point is determined by ring and ball apparatus.

OBJECTIVES:-

1. To determine the softening point of bitumen / tar.
2. To assess the suitability of bitumen for its use under different climatic conditions and type of construction.

APPARATUS:-

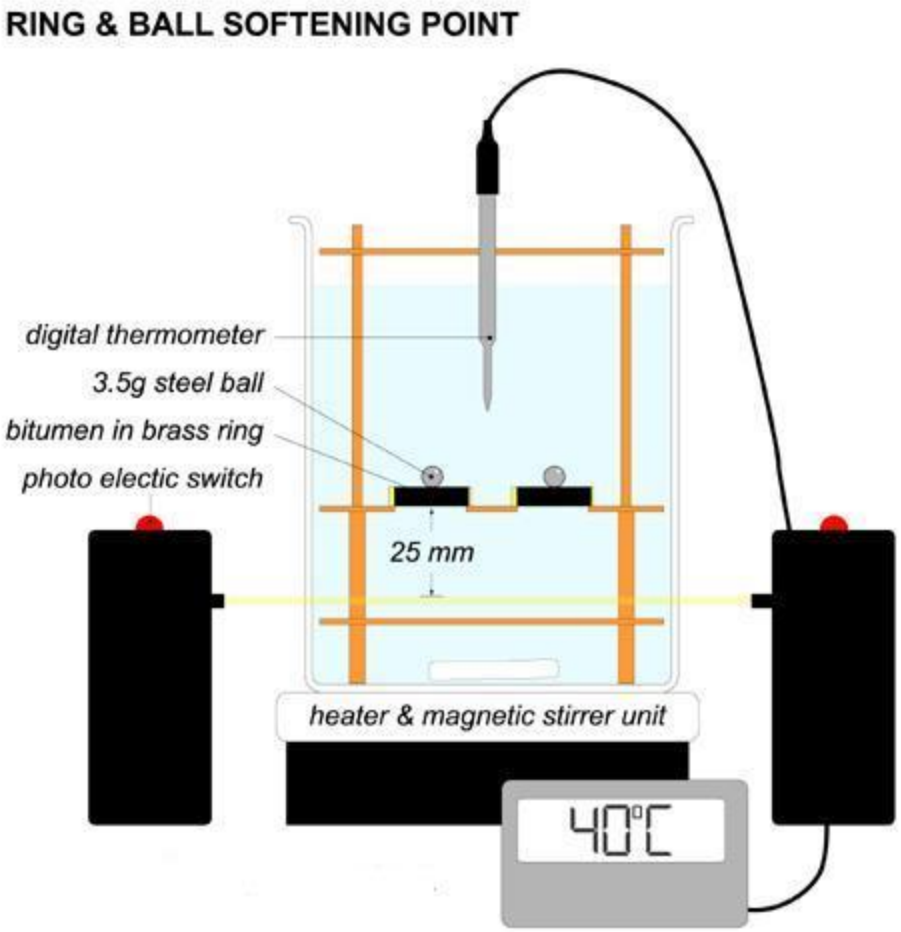
i) The ring and ball apparatus consists of following.

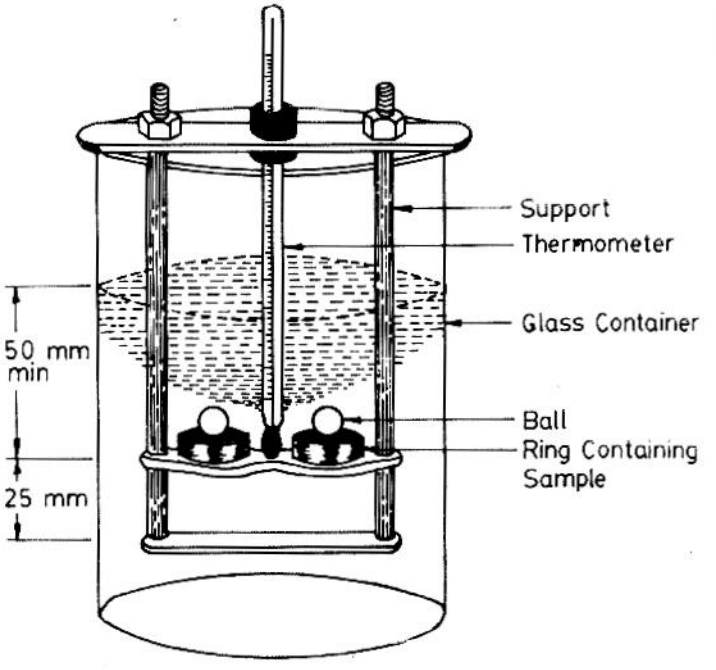
1. Steel balls – two numbers each of 9.5 mm diameter and weighing 2.5 $\pm$ 0.05 gm.
2. Brass rings – two numbers each having depth of 6.4 mm, the inside diameter at bottom and top is 15.9 mm and 17.5 mm respectively.
3. Ball guides to guide the movement of steel balls centrally.
4. Support – that can hold rings in position and also allows for suspension of a thermometer. The distance between the bottom of the rings and the top surface of the bottom plate of the support is 25 mm.

ii) Thermometer that can read up to 100°C with an accuracy of 0.2°C.

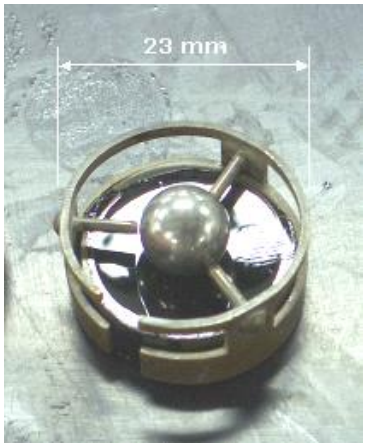
iii) Bath – a heat resistant glass beaker not less than 85 mm in diameter and 120 mm in depth.

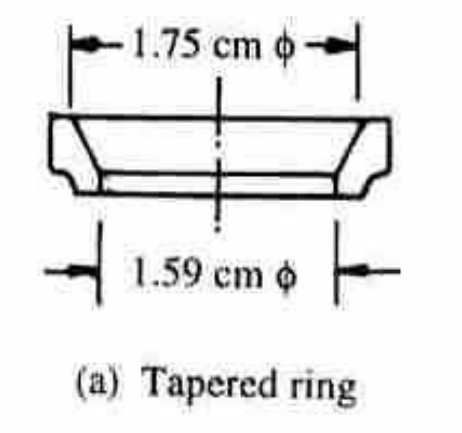
iv) Stirrer.



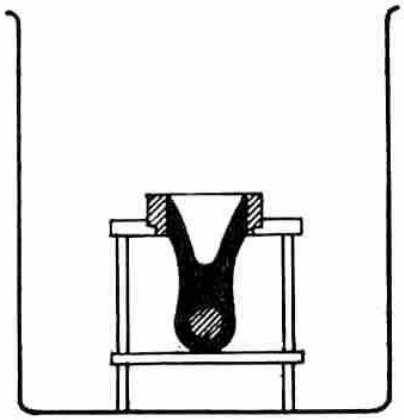


Softening Point Test





(a) Tapered ring



(c) End point of test

Ring and Ball Test Apparatus

PROCEDURE:-

PREPARATION OF TEST SAMPLE: -

Heat the material to a temperature between 75° – 100°C above its softening point stir until it is completely fluid and free from air bubbles and water. Place the rings on a metal plate which has been coated with a mixture of equal parts of glycerine and dextrin. Pour the material in the rings and after cooling for 30 minutes in air, level the material in the ring by removing the excess with warmed, sharp knife.

TESTING:-

1. Assemble the apparatus with the rings, thermometer and ball guides in position.
2. Fill the bath with distilled water to a height of 50 mm above the upper surface of the rings. The stating temperature should be 5°C. Use glycerin in place of water if the softening point is expected to be above 80°C the starting temperature may be kept at 35°C.
3. Apply heat to the bath and stir the liquid so that the temperature rises at a uniform rate of 5 ± 0.5°C per minute.
4. As the temperature increases the bituminous material softens and the ball sinks through the ring, carrying a portion of the material with it.
5. Note down the temperature when any of the steel ball with bituminous coating touches the bottom plate.
6. Record the temperature when the second ball also touches the bottom plate. The average of the two readings to the nearest 0.5°C is reported as the softening point.

PRECAUTIONS:-

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

RECORDS OF OBSERVATIONS:-

Test Property	**Trial**			**Mean value**
	1	2	3	
Temperature (°C) at which **Ist ball** touches the bottom plate.				
Temperature (°C) at which **IInd ball** touches the bottom plate.				
Final Softening Point Temperature = _____ °C.				

RESULTS:-

The softening point of given bitumen sample is _____ **°C.**

It is essential that the mean value of the softening point (temperature) does not differ from individual observation by more than the following limits.

SOFTENING POINT	REPEATABILITY	REPRODUCIBILITY
Below 30°C	2°C	4°C
30°C to 80°C	1°C	2°C
Above 80°C	2°C	4°C

INTERPRETATION OF RESULTS:-

Softening point indicates the temperature at which binders possess the same viscosity. The softening point of a tar is therefore related to the equiviscous temperature (e.v.t). The softening point found by the ring and ball apparatus is approximately 20°C lower than the equiviscous temperature. Softening point, thus gives an idea of the temperature at which the bituminous material attains a certain viscosity. Bituminous material does 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 crack filler. Higher softening point ensures that they will not flow during service. In general, higher the softening point, the lesser the temperature susceptibility. Bitumen with higher softening point may be preferred in warmer places.

DISCUSSION:-

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

(i) quality and type of liquid

(ii) weight of balls

(iii) distance between bottom of ring and bottom base plate

(iv) rate of heating.

Impurity in water or glycerin has been observed to affect the result considerably. It is logical to observe lower softening point if the weight of ball is excessive. On the other hand, increased distance between bottom of ring and bottom plate increases the softening point.

The ranges of softening point specified by ISI for various grades of bitumen are given below.

BITUMEN GRADES	SOFTENING POINT($^{\circ}$C)
A 25 & A 35	55 TO 70
S 35	50 TO 65
A 45 S 45 & A 65	45 TO 60
S 65	40 TO 55
A 90 & S 90	35 TO 50
A 200 & S 200	30 TO 45

Note: - '**A**' denotes bitumen from **Assam Petroleum** and '**S**' denotes bitumen from **source other than from Assam Petroleum.**

REMARKS:-

Short Questions:

1) What is softening point? What is the importance of this test in road constructions?

2) What is the criteria of selection of medium used for heating the specimen?

3) What will happen to softening point if (a) Aluminum balls are used in place of steel balls?

(b) the distance between rings and bottom place is increased?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 9

DETERMINATION OF DUCTILITY OF BITUMEN

(IS: 1208 – 1978)

CONCEPT AND SIGNIFICANCE OF THE TEST:

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

OBJECTIVES:-

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

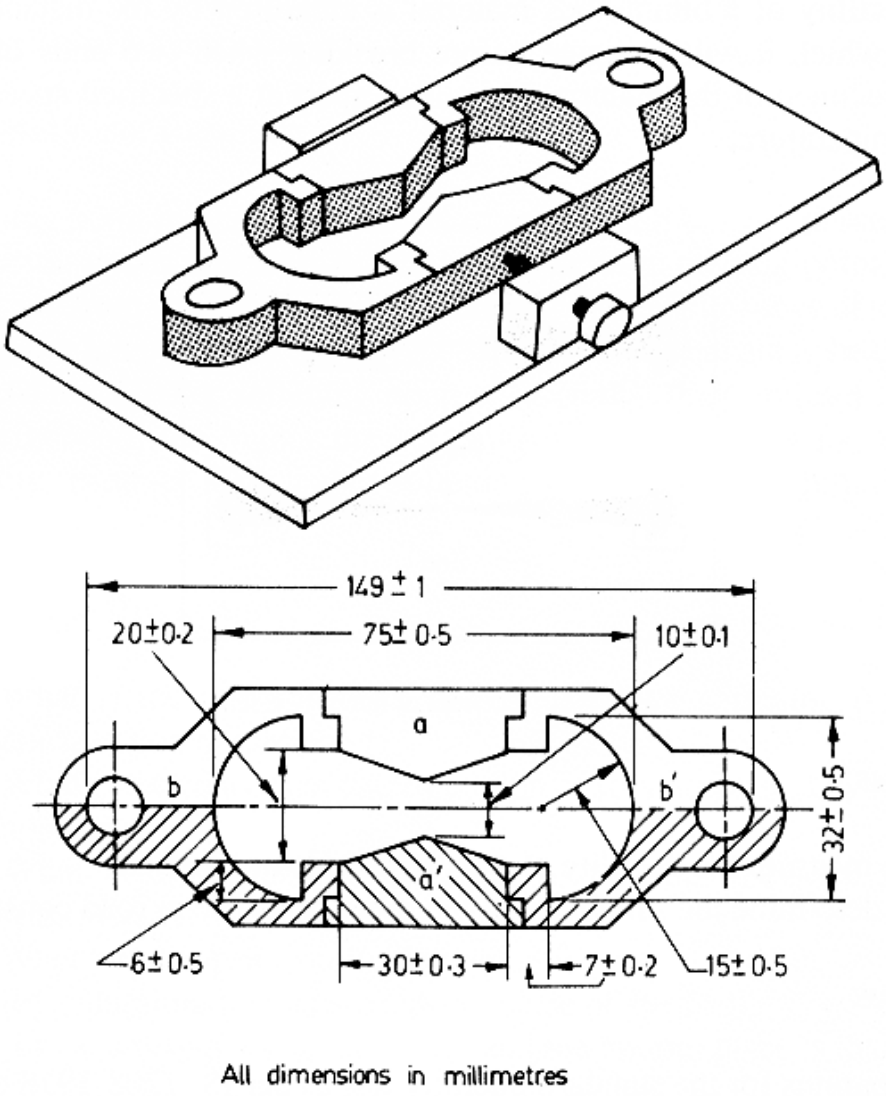
APPARATUS:-

The apparatus for the standard ductility test as per IS : 1208 – 1978 consists of the following.

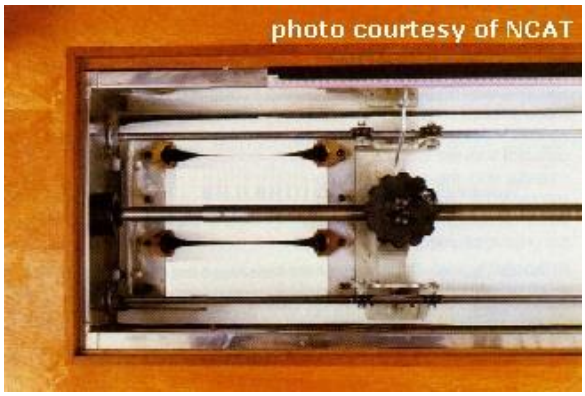
1. Briquette mould: It is made up of brass with the shape dimensions and tolerances as shown in figure. The ends **b** and **b'** being known as clips and parts **a** and **a'** are sides of the mould, the circular holes are provided in the clips to grip the fixed and movable ends of the testing machine. The mould when properly assembled form briquette specimen of following dimensions.

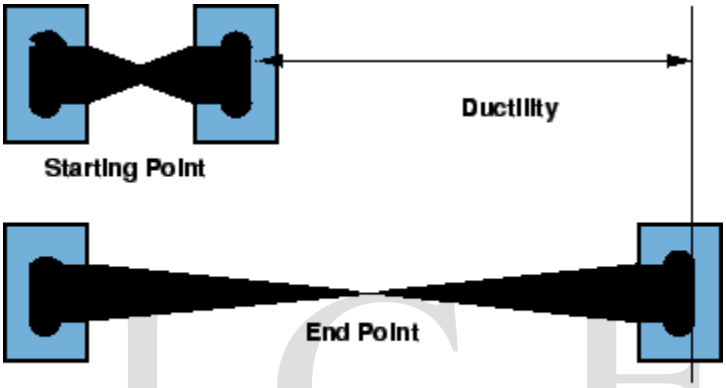
Total length	75.0 + 0.5 mm
Distance between clips	30.0 + 0.3 mm
Width at mouth of the clip	20.0 + 0.2 mm
Width at minimum cross section (half way between clip)	10.0 + 0.1 mm
Thickness throughout	10.0 + 0.1 mm

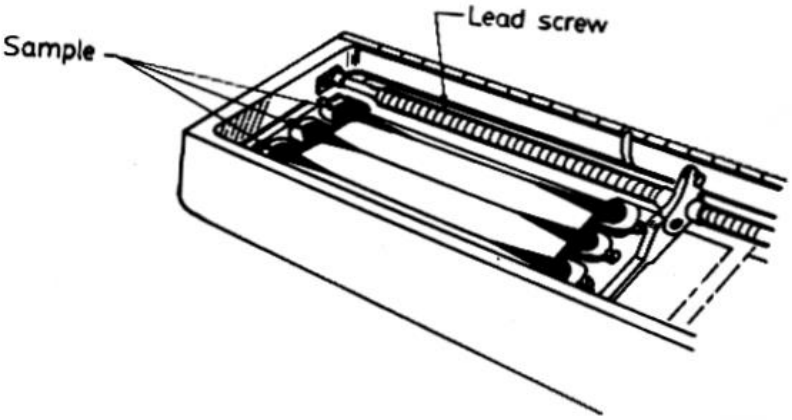
2. Water Bath: A bath maintained with + 0.1°C of the specified test temperature, containing not less than 10 liters of water, the specimen being submerged to a depth of not less than 10 cm and supported on a perforated shelf and less than 5 cm from the bottom of the bath.
3. Testing Machine: For pulling the briquette of bituminous material apart pulled apart horizontally at a uniform speed of 50 + 2.5 mm per minute.
4. Thermometer: Range 0 – 44°C and readable up to 0.2°C.



Ductility Test Apparatus







Ductility Test Apparatus

PROCEDURE:-

1. Melt the bituminous test material completely at temperature at 75°C to 100°C above the approximate softening point until it becomes thoroughly fluid.
2. Pour it in the mould assembly and place it on a brass plate.
3. In order to prevent the material under test from sticking, coat the surface of the plate and interior surface of the sides of the mould with mixture of equal parts of glycerine and dextrine.
4. After about 30 – 40 minutes, keep the plate assembly along with the sample in a water bath. Maintain the temperature of the water bath at 27°C for half an hour.
5. Remove the sample and mould assembly from the water bath and trim the specimen by leveling the surface using a hot knife.
6. Replace the mould assembly in water bath maintained at 27°C for 80 to 90 minutes.
7. Remove the sides of the mould.
8. Hook the clip carefully on the machine without causing any initial strain,
9. Adjust the pointer to read zero.
10. Start the machine and pull two clips horizontally at a speed of 50 mm per minute.
11. Note the distance at which the bitumen thread of specimen breaks.
12. Record the observation in the proforma and computer the ductility value. Report the mean of two observations, rounded to nearest whole number as the "Ductility Value". Machine may have a provision to fix two or more moulds so as to test these specimens simultaneously.

PRECAUTIONS:-

1. The plate assembly upon which the mould is placed shall be perfectly flat and level so that the bottom surface of the mould touches it throughout.
2. In filling the mould, care should be taken not to disarrange the parts and thus distort the briquette and to see that no air pocket shall be within the moulded sample.

RECORD OF OBSERVATIONS:-

Test Particulars	**Briquette Number**		
	1	**2**	**3**
1. Initial Reading, **a** cm.			
2. Final Reading, **b** cm.			
3. **Ductility = (b – a)** cm.			

RESULTS:-

The ductility value of the given bitumen sample is _____cm.

INTERPRETATION OF RESULTS:-

A certain minimum ductility is necessary for a bitumen binder. This is because of the temperature changes in the bituminous mixes and the repeated deformations that occur in flexible pavements due to the traffic loads. If the bitumen has low ductility value, the bituminous pavement may crack, especially in cold weather. The ductility values of bitumen vary from 5 to over 100. Several agencies have specified the minimum ductility values for various types of bituminous pavement. Often a minimum ductility value of 50 cm is specified for bituminous construction. The suitability of bitumen is judged, depending upon its type and proposed use. Bitumen with low ductility valve may get cracked especially in cold weather. ISI has specified following values of minimum ductility for various grades of bitumen as follows.

Source of paving bitumen and penetration grade	Minimum ductility value (cms)
Assam Petroleum	
A 25	5
A 35	10
A 45	12
A65, A 90, A 200	15
Bitumen from source other than Assam Petroleum	
S 35	50
S 45, S 65 and S90	75

REMARKS:-

Short Questions:

1) Explain ductility of bitumen and its significance.
2) How is the ductility value expressed?
3) What is the minimum area of cross section of the ductility specimen?
4) What are the precautions to be taken while finding the ductility value?
5) What are the factors affecting the ductility test results?
6) What id standard test temperature and standard rate of pull?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 10

SPECIFIC GRAVITY TEST FOR BITUMEN (PYCNOMETER METHOD)

(IS : 1202 – 1978)

CONCEPT AND SIGNIFICANCE OF THE TEST:-

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

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

OBJECTIVES: - To determine the specific gravity for a semi – solid / solid bitumen sample.

APPARATUS: - Pycnometer, solid bitumen sample, wash bottle and balance.

PROCEDURE:-

1. Clean, dry and weigh the pycnometer. Let the weight be W_1 grams.
2. Fill the pycnometer more than half with given solid bitumen sample piece. Let the weight be W_2 grams.
3. Calculate the net weight of bitumen, $W_b = (W_2 – W_1)$ grams.
4. Fill the pycnometer containing bitumen sample with distilled water up to brim wipe the outer surface of the bottle with clean dry cloth and weigh it. Let the weight be W_3 grams.
5. Empty the pycnometer completely. Then fill it with distilled water up to the brim. Wipe all surplus moisture from the surface with clean dry cloth and weigh again. Let the weigh be W_4 grams.

Pycnometer

RECORD OF OBSERVATIONS:-

Particulars	Trial - I	Trial - II
1. Weight of the empty pycnometer = W_1 gm. 2. Weight of the pycnometer + half filled with given bitumen = W_2 gm. 3. Weight of the bitumen = $\mathbf{W_b}$ = ($W_2 - W_1$) gm. 4. Weight of pycnometer + bitumen + water = W_3 gm. 5. Weight of the pycnometer + water filled to the top = W_4 gm		

$$\textbf{Specific gravity of bitumen} = \frac{\textbf{Weight of the bitumen}}{\textbf{Weight of equal volume of water}}$$

$$\frac{\mathbf{W_b}}{(W_4 - W_1) - (W_3 - W_2)} = \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}$$

RESULT: - Specific gravity of bitumen is = _____.

PRECAUTIONS:-

Pycnometer should be thoroughly cleaned, dried in the weighing operations.

INTERPRETATION OF RESULT:-

Pure bitumen has a specific gravity in the range of 0.97 to 1.02.

APPLICATIONS OF SPECIFIC GRAVITY TEST:-

Knowledge of the correct specific gravity of bituminous materials has mainly two applications. First, to convert the specified bitumen content by weight to volume basis. Here it is necessary to know the co-efficient of expansion of the specific gravity values at different temperatures. Secondly, the specific gravity is useful to identify the source of a bituminous binder. Pure bitumen has a specific gravity in the range of 0.97 to 1.02 (higher penetration grade bitumen and cut back bitumen have lower range of specific gravity values). In case the bitumen contains minerals impurities, the specific gravity will be higher. Thus it is possible for a qualitative estimation of mineral impurities in bitumen. The specific gravity of tars depends on the type of carbonization process used for their production. Vertical-retort tars have a specific gravity range 1.10 to 1.15 and horizontal retort and coke-oven tars have values in the range of 1.18 to 1.25.

The specific gravity of bitumen can also be determined by **Balance method.**

Specific Gravity = **A / (A-B)**, where

A = weight of dry specimen

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

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

REMARKS:-

Short Questions:

1) What are the two methods for finding specific gravity of bituminous materials?

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

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

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 11

FLASH AND FIRE POINT TEST

CONCEPT AND SIGNIFICANCE OF THE TEST:-

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

Definition: - 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.

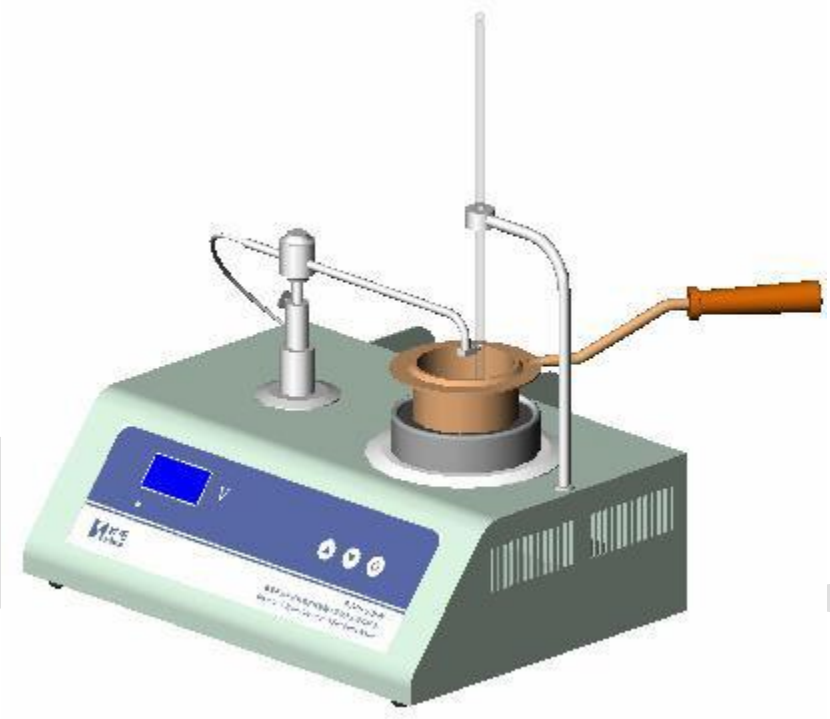
At high temperatures, bituminous materials emit hydrocarbon vapours which are susceptible to catch fire. Therefore the heating temperature of bituminous material should be restricted to avoid hazardous conditions. Flash point and fire point tests are used to determine the temperature to which bituminous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

OBJECTIVES: - To determine flash and fire point of the bituminous material.

PROCEDURE:-

1. Clean and dry all parts of the cup and its accessories thoroughly.
2. Fill the cup with the material to be tested up to the level indicated by the filling mark.
3. Place the lid on the cup and set the latter in the stove.
4. Insert the thermometer.
5. Light and adjust the test flame so that it is of the size of bead of 4 mm in diameter. Apply heat such that the temperature rises at a rate of 5° to 6°C per minute.
6. Turn the stirrer at a rate of approximately 60 revolutions per minute.
7. Apply the test-flame by operating the device controlling the shutter and test flame burner so that the flames is lowered in 0.5 seconds, left in its lowered position for one second, and quickly raised to its high position. Discontinue stirring during the application of test flame.

8. Apply the test flame initially at a temperature of 17°C below the expected flash point. Thereafter apply the test flame at an interval of 1°C for the range above 104°C for the temperature range above 104°C increase this interval to 2°C.Note down the flash point as the temperature at which the flame application causes a distinct flash in the interior of the cup.



Flash and Fire Point Apparatus

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

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

FOR CUTBACK BITUMEN

PROCEDURE:-

1. Fill the cup with the material to be tested.
2. Completely fill the air space between the cup and the interior of the air bath with water having the same temperature as of the material.
3. Proceed in same manner except that rate of heating is between 1°C to 1.5°C per minute, the rate of stirring is 70 - 80 revolutions per minute, and the test flame to be applied at each 0.5°C rise in the temperature. Note down the test results. The duplicate tests should be within the limits specified.

PRECAUTIONS:-

(i) The test flame should neither be large than stipulated nor be applied more frequently than specified as the surface layer may get super-heated.

(ii) Then bluish halo that sometimes surrounds the test flame should not be confused with the true flash.

RECORD OF OBSERVATIONS:-

Type of Material:

Type of test: Close / Open

Property	Test			Mean
	1	2	3	
Flash point, °C.				
Fire point, °C.				

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

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.

APPLICATIONS OF FLASH AND FIRE POINT TEST:-

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

The minimum value of Flash point by Pensky Marten's closed type apparatus specified by the ISI is 175°C for all the grades of bitumen, 26°C for rapid curing cutback bitumen of all grades, 38°C for medium curing grades 0 and 1 and 65°C for grades 2 to 5. Slow curing cutbacks have minimum values ranging from 65 to 121°C.

Short Questions:

1) Define flash and fire points.
2) What is the significance of flash point test?
3) What is the utility of determining flash point?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 12

VISCOSITY TEST

CONCEPT AND SIGNIFICANCE OF THE TEST:-

Viscosity of a fluid is the property by virtue of which it offers resistance to flow. Higher the viscosity, the slower will be the movement of the liquid. The viscosity affects the ability of the binder to spread, move into and fill up the voids between aggregates. It also plays an important role in coating of aggregates. Highly viscous binder may not fill up the voids completely thereby resulting in poor density of the mix. At lower viscosity the binder does not hold the aggregates together but just acts as lubricant. The viscosity of bituminous binders falls very rapidly as the temperature rises. Since binders exhibits viscosity over a wide range, it is necessary to use different methods for the determination of viscosity.

For binders in liquid state (road tars and cutback bituminous) the viscosity is determined as the time in seconds by 50 c.c of the material to flow from a cup through a specific orifice under standard conditions of test and at specified temperature.

OBJECTIVES: - To determine the viscosity of bituminous binder.

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

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

1. Cup: - it is made of hard brass tube and fitted with an external brass collar at the upper end of the cylinder to support the cup. The bottom of 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 10 mm and length 5 mm. some viscometers have orifice of 4 mm diameter (Refer Table 1 and 2)

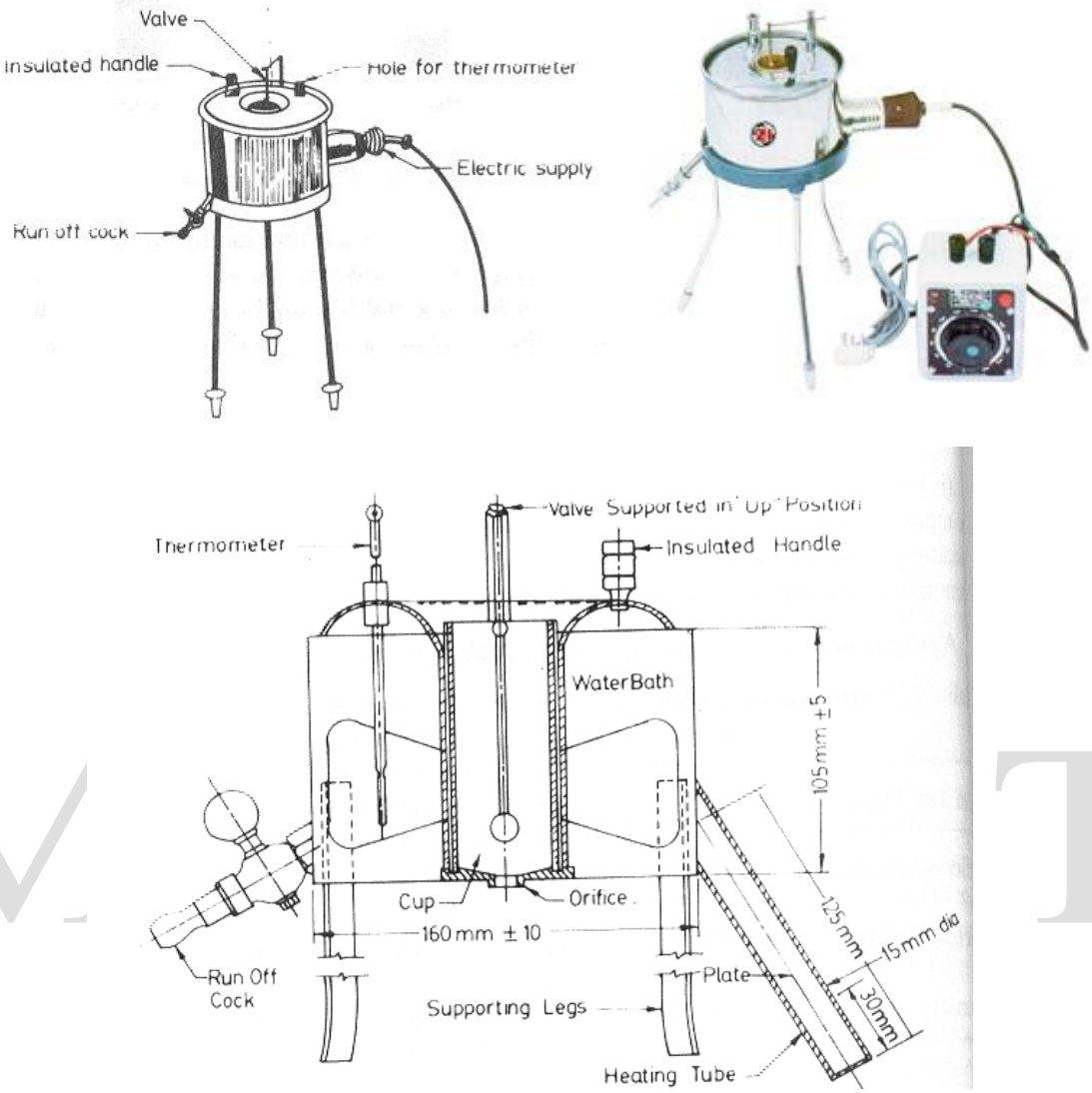
2. Valve: - it serves to close the orifice of cup.
3. Water bath:- It is made of copper sheet, is cylindrical in shape, about 160 mm in diameter and 105 mm in depth.
4. Sleeve to receive the cup and to hold it in position.
5. Stirrer.
6. Curved shield.
7. Receiver: A 100 ml graduated cylinder, having an internal diameter of not more than 29 mm. it has markings on 25ml and 75 ml levels.
8. Thermometers: - Two thermometers, one for bath and another for cup. The measurement range should be 0 to 44° C or 37.8°C or 76° to 122°C depending upon whether the viscosity is expected to be low, medium or high. The thermometer should be readable and accurate up to 0.2°C. A stop watch or other timing device capable of being read upto ½ second.

Table 1. Specifications for Test Temperature and Range of Viscosity for Road Tar (As per IS: 215 – 1981)

Road Tar Type	RT - 1	RT - 2	RT -3	RT -4	RT -5
Orifice size, mm	10	10	10	10	10
Test temperature, °C	35°C	40°C	45°C	55°C	65°C
Viscosity in sec	30-55	30-55	35-60	40-60	35-70

Table 2. Specifications for Test Temperature and Range of Viscosity for Cutback Bitumen (As per IS: 217 – 1961)

Grades (SC, MC and RC)	0	1	2	3	4	5
Orifice size, mm	4	4	4	10	10	10
Test temperature, °C	25	25	25	25	40	40
Viscosity in sec	25-75	50-150	10-20	26-27	14-45	60-140

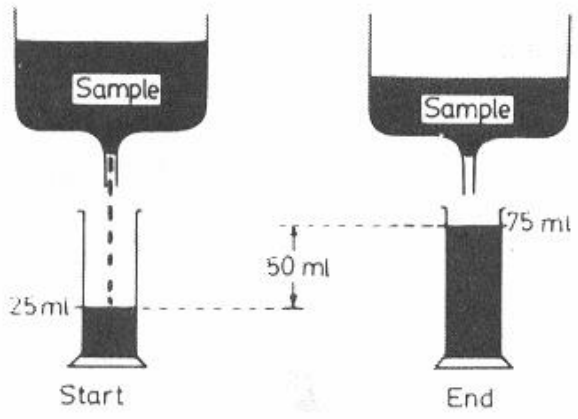


Viscometer

PROCEDURE:-

1. Adjust the tar viscometer so that the top of the tar cup is leveled. Select the test temperature from Table 1. Heat the water in water bath to the temperature specified for the test and maintain it within + 0.1°C of the specified temperature throughout the duration of test. Rotate the stirrer gently at frequent intervals or perfectly continuously.
2. Clean the tar cup orifice of the viscometer with a suitable solvent and dry thoroughly.
3. Warm and stir the material under examination to 20°C above the temperature specified for test and cool, while continuing the stirring.

4. When the temperature falls slightly above the specified temperature, pour the tar into the cup until the leveling peg on the valve rod is just immersed when the later is vertical.
5. Pour into the graduated receiver 20 ml of mineral oil, or one percent by weight solution of soft soap, and place it under the orifice of the tar cup.
6. Place the other thermometer in the tar and stir until the temperature is within + 0.1°C of the specified temperature. When this temperature has been reached, suspend the thermometer coaxially with the cup and with its bulb approximately at the geometric centre of the tar.
7. Allow the assembled apparatus to stand for five minutes during which period the thermometer reading should remain. Within 0.05°C of the specified temperature. Remove the thermometer and quickly remove any excess of tar so that the final level is on the ventral line of the leveling peg when the valve is in vertical position.
8. Lift the valve and suspend it on valve support.
9. Start the stop watch when the reading in the cylinder is 25 ml and stop it when it is 75 ml. Note the time in seconds.
10. Report the viscosity as the time taken in seconds by 50 ml tar to flow out at the temperature specified for the test.



Viscometer Test

PRECAUTIONS:-

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

RECORD AND OBSERVATIONS:-

Specification	Test 1	Test 2
Test temperature =		
Time taken to flow 50 cc of the binder (seconds) =		

Viscosity = _____ **seconds.**

INTERPRETATION OF RESULTS: -

The determination of time of flow 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 as given in tables 1 and 2. Binders having very low viscosity can be advantageously used in exceptionally cold weather conditions. High viscosity binders have to be heated before their application.

Short Questions:

1) Explain the term viscosity.
2) What are the different methods in determining the viscous characteristics of bituminous materials?
3) What is the absolute unit for viscosity?
4) What are the uses of viscosity test?
5) What are the precautions to be taken during viscosity test using orifice viscometer?
6) How is the grade of tar / cutback determined?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 13

BITUMEN EXTRACTION TEST

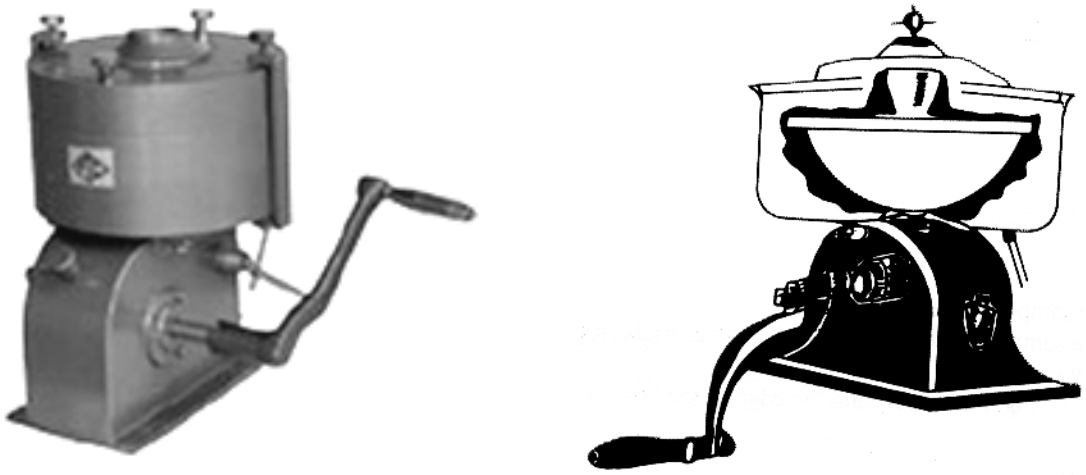
CONCEPT AND SIGNIFICANCE OF THE TEST:-

The centrifuge extractor is used for the quantitative determination of bitumen in hot-mixed paving and pavement samples, essentially as a field test to exercise quality control and ensure that the specified amount of bitumen has been used. The bitumen content and ash from the weight of the sample is taken for the test.

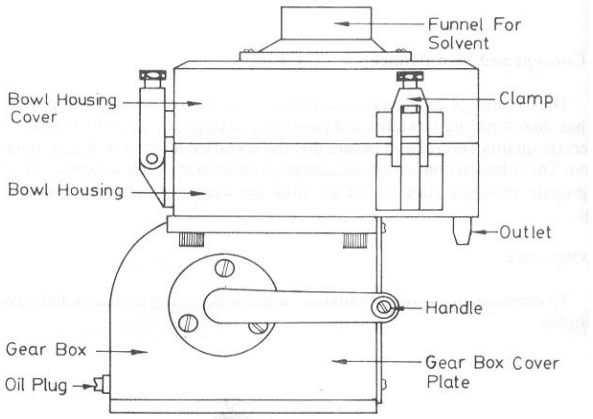
OBJECTIVE: - To determine quantity of bitumen in hot-mix paving mixtures and pavement samples.

APPARATUS:-

1. The Centrifuge Extractor consists of a revolving bowl inside housing. The bowl is provided with a cover plate and it is secured in position by tightening the nuts.
2. The bowl housing is provided with an outlet, the housing is mounted on an enclosed gear box. A cover is clamped to housing.
3. The gears are splash lubricated and the system is operated manually with the handle.



Bitumen Extractor



Bitumen Extractor

PROCEDURE:-

1. Weigh a 1000 g sample of asphalt mix.
2. With the fork break the sample down to small pieces and heat the sample to about 110°C.
3. Place the sample in the bowl and weigh it.
4. Cover the sample in the bowl with benzene or trichloroethane and allow it to soak for one hour.
5. Weigh filtering. Place it around the edge of the bowl and clamp a lid on the bowl
6. Place a beaker under the outlet.
7. Place the bowl in a centrifuge and rotate it gradually to increase the speed upto 3600 rpm. Rotate until the solvent ceases to flow from the outlet.
8. Stop the centrifuge, add 200ml of trichloroethane or benzene and rotate it again.
9. Repeat the procedure (not less than three washings) until the extract is no longer cloudy and is fairly light in colour.
10. Remove the filter from the bowl and dry in air.
11. Brush the loose particles from the filter into the bowl.
12. Dry the filter to constant weight in an oven at 98^{0}°C to 100°C.
13. Dry the contents of the bowl on a steam bath and then to constant weight in an oven at 98°C to 100°C.
14. Obtain the weight of the filter and bowl with dry aggregates.

PRECAUTIONS:-

1. Separate the particles of the mixture as uniformly as possible taking care not to fracture the mineral particles.
2. The cover plate should be fixed tightly on the bowl.

RECORD OF OBSERVATIONS:-

	SAMPLE 1	SAMPLE 2	SAMPLE 3

BEFORE TEST

Weight of bowl + sample (W_1)g

Weight of bowl (W_2)g

Weight of filter (W_3)g

AFTER TEST

Weight of bowl + sample (W_4)g

Weight of filter (W_5)g

Weight of sample ($W_1 – W_2$)g

Weight of aggregates in bowl ($W_4 – W_2$)g

Weight of aggregates in filter ($W_5 – W_3$)g

Weight of aggregates $W_A = (W_4 – W_2) + (W_5 – W_3)$

Weight of bitumen $W_B = (W_1 – W_2) – W_A$

$$\text{Bitumen content} = \frac{\text{Weight of bitumen}}{\text{Weight of aggregates}} * 100\%$$

INTERPRETATION OF RESULT:-

The result of the test is an indication regarding the quantity of bitumen that has been used in a bituminous mix. By performing this field test substantial saving in the cost of bitumen can be had by ensuring that the optimum quantity of bitumen has been provided. Also the performance of the road be affected if lesser or more quantity of bitumen is used.

Short Questions:

1) What is the criteria for specifying benzene or trichloroethane as solvents to be use in the test?
2) How would the road surface be effected in case the test reveals use of
    (i) lesser quantity of bitumen,
    (ii) more quantity of bitumen, than the optimum quantity?

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

Transportation Engineering Laboratory

EXPERIMENT – 14

CALIFORNIA BEARING RATIO TEST

CONCEPT AND SIGNIFICANCE OF THE TEST:-

The California Bearing Ratio **(C.B.R.)** test was developed by California Division of Highway as a method of classifying and evaluating the strength of subgrade soil and base course materials for design of flexible pavement thickness. The test is empirical and the result cannot be related accurately with any fundamental properties of the material.

The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The procedure is standardized by Indian Standards Institution in two different categories. The first being test of soils **in laboratory**, determination of CBR, **IS: 2720 part XVI**. (Re-moulded specimen).The second being methods of test for soils, **field** determination of CBR, **IS: 2720 XXXI.** (Undisturbed specimen). The test is simple and has been extensively investigated for field correlated of flexible pavement thickness requirement. The test is conducted by causing a cylindrical plunger of 50mm diameter to penetrate a pavement component material at 1.25mm/minute. The loads for 2.5mm and 5mm are recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain CBR value. The standard load values are given in the table.

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

OBJECTIVE: - To determine California Baring Ratio (CBR) value of a given soil sample.

APPARATUS:-

Loading Machine: Any compression machine with a capacity of 5000 kg which can be operated at a constant rate of 1.25mm/minute can be used for this purpose.

Mould: A metallic cylindrical of 150mm internal diameter and 175mm height provided with a collar of about 50mm length and a detachable perforated base plate of 10mm thickness.

Steel cutting collar:

A spacer disc of 148mm diameter and 47.7mm thickness is used to obtain a specimen of exactly 127.3mm height.

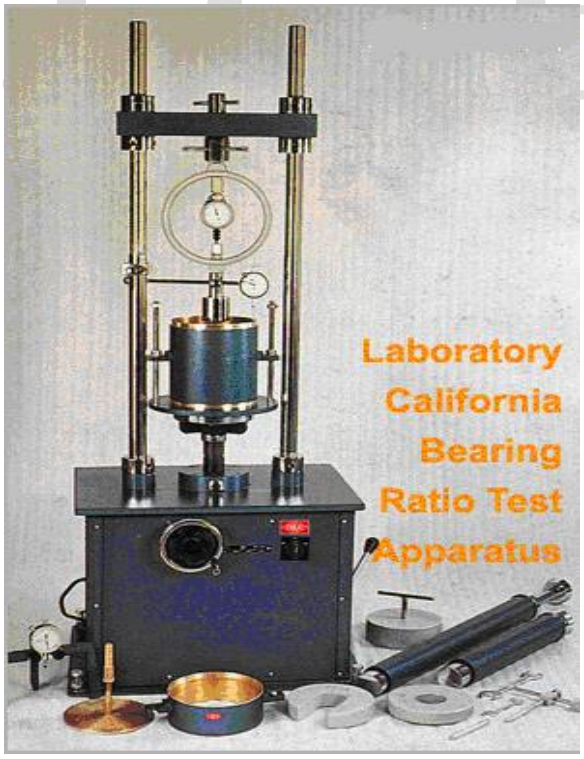
Surcharge weights: Annular metal weights each of 2.5 kg and 147mm diameter.

IS Sieves 4.75mm and 20mm.

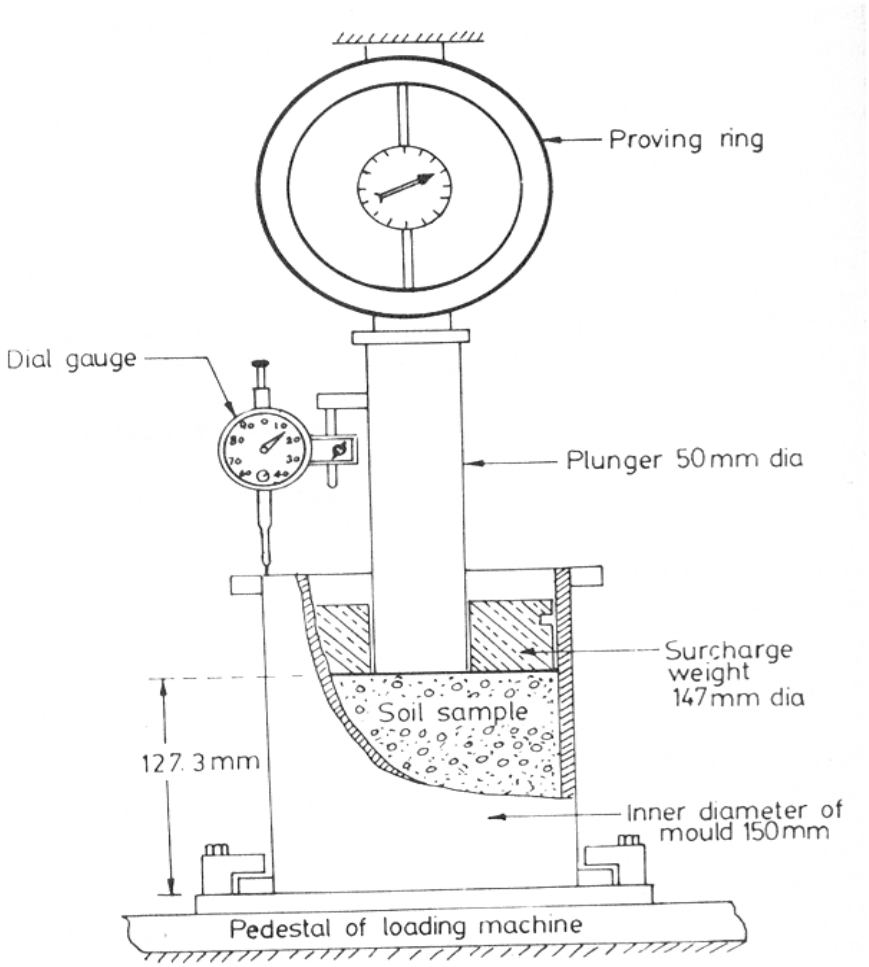
Penetration plunger: A metallic plunger of 50mm diameter and at least 100mm long.

Two dial gauges reading to 0.01mm.

Compaction rammer and miscellaneous apparatus like mixing bowl ,straight edge, soaking tank , drying oven, filter paper, dishes and measuring jar.



CBR Test Apparatus



CBR Test Apparatus

PROCEDURE:-

PREPARATION OF UNDISTURBED SPECIMEN:-

Fit to the mould, the steel cutting edge of 150mm internal diameter. Push the mould into the ground as gently as possible till the mould is full of soil. Remove the soil from the sides and bottom. Trim the excessive soil from top and bottom also.

PREPARATION OF REMOULDED SPECIMEN:-

Remoulded samples are prepared such that the dry density obtained from proctor compaction tests, the water content of remoulded samples is either the optimum water content or the field moisture as the case may be, the remoulded sample is compacted either statically or dynamically.

Statically Compacted Specimen:-

1. Calculate the amount of soil required such that if fills the mould (excluding collar) at the desired density after compaction.
2. Calculate the amount of water to be added to give desired water content.
3. Mix the soil thoroughly with water.
4. Fix the extension collar to the mould and clamp it o the base plate.
5. Fix the mould with soil, gently pressing it with hands so that it does not spill out of the mould.
6. Place a coarse filter paper over the levelled soil surface and then insert the space disc.
7. Place the assembly on the pedestal of compression machine and compact the soil until the top of the spacer disc is flush with the top of the collar.

Dynamically Compacted Specimen:-

1. Sieve the material through 20mm IS sieve.
2. Take about 4.5 kg or more of representative sample for fine grained soils about 5.5 kg for granular soils in a mixing pan.
3. Add water to the soil in the quantity such that the moisture content of the specimen is either equal to the field moisture content or OMC as desired.
4. Mix together the soil and water uniformly.
5. Clamp the mould along with the extension collar to the base plate.
6. Place the coarse filter paper on the top of the spacer disc.
7. Pour soil-water mix in the mould in such quantity that after compaction about $1/5^{th}$ of the mould is filled.
8. Give 56 blows with the rammer weighing 2.6 kg dropping through 310 mm in three layers (light compaction0 or 4.89 kg dropping through 450 mm in 5 layers (heavy compaction) evenly spread on the surface.
9. Scratch the top layer of compacted surface. Add more soil and compact in similar fashion. Fill the mould completely in % layers.
10. Remove the extension collar and trim off the excess soil by a straight edge.
11. Remove the base plate, spacer disc and filter paper and note down the weight of the mould and compacted specimen.
12. Place a coarse filter paper on the perforated base plate.
13. Invert the mould containing compacted soil and clamp it to the base plate.

TESTING THE SPECIMEN:-

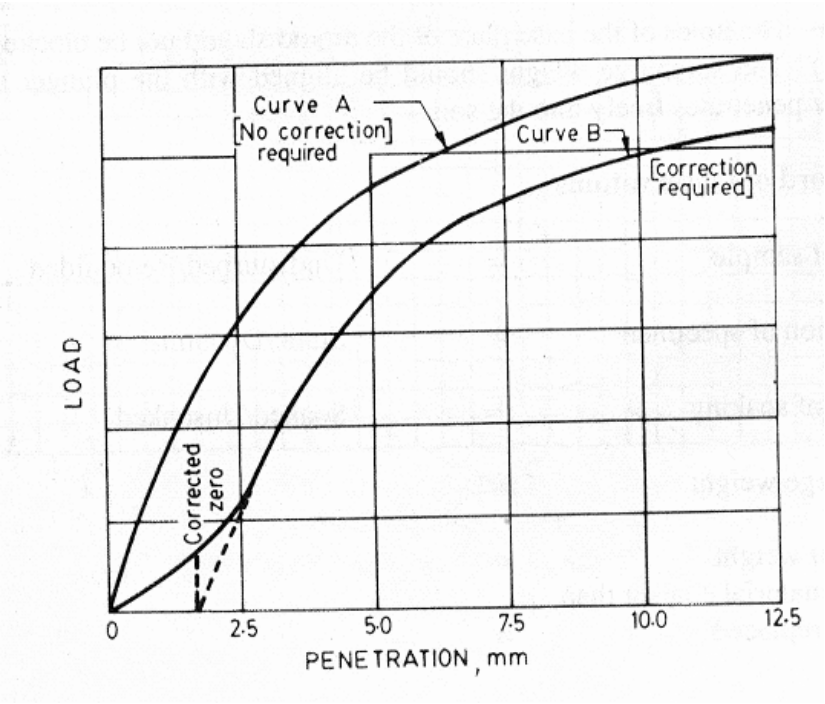
1. Place the mould containing the specimen, with base plate in position, on the testing machine.
2. Place the annular weight of 2.5 kg on the top of soil.
3. Bring the penetration plunger in contact with soil surface and apply a load of 4 kg so that full contact between soil and plunger is established. This should be taken as zero load.
4. Place the remainder surcharge weight so that total surcharge weight equals to 5 kg.
5. The dial gauge for the measuring the penetration value of the plunger is fitted in position. The dial gauge of the proving ring and the penetration dial gauge are set to zero.
6. 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.
7. 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 into load in kg.
8. The load values noted for each penetration level are divided by the area of the loading plunger (19.635cm^2) to obtain the pressure.

CBR TEST ON SOAKED SAMPLE:-

To perform CBR test on soaked sample specimen, the sample excluding base plate and spacer disc is weighed. A filter paper is placed on the sample with a perforated plate on it. Over it a surcharge weight 2.5 kg or 5 kg is placed and the sample is soaked in water for 4 days. The sample is then allowed to drain off water in a vertical position for about 15 minutes. The sample is weighed again to calculate the percentage of water absorbed. It is then tested following the normal procedure.

COMPUTATION OF TEST RESULTS:-

Plot the load-penetration curve with load as ordinate and penetration as abscissa. Sometime the initial portion of the curve is concave upwards due to the surface irregularities. In such a case apply a correction. Draw tangent at the point of steepest. A graph is plotted with penetration in mm on x-axis and the pressure in kg/cm^2 on y-axis. Then the unit pressure values corresponding to 2.5mm and 5.0mm penetration value are found from the graph.



Then the CBR value is calculated from the formula:

CBR in % = Unit pressure or load carried by soil sample at defined penetration level * 100
Unit pressure or load carried by standard crushed stones at above penetration level

Generally the CBR value at 2.5mm penetration if higher and the value are 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.

PRECAUTIONS:-

1. The holes of the base plate of the mould should not be blocked.
2. The surcharge weight should be aligned with the plunger so that the plunger penetrates freely into the soil.

RECORD OF OBSERVATIONS:-

Type of sample = Undisturbed / Remoulded.

Condition of specimen = Static / Dynamic.

Period of soaking = Soaked / Unsoaked.

Surcharge Weight =

Dry Unit Weight =

Weight of material coarser than 20 mm replaced =

OBSERVATION AND CALCULATIONS:

Penetration , mm	No. of divisions on proving ring	Corresponding load on plunger, kg(f)	Corrected load kg(f)	Unit load, kg / cm^2
0.0				
0.5				
1.0				
1.5				
2.0				
2.5				
3.0				
4.0				
5.0				
7.5				
10.0				
12.5				

C.B.R at 2.5 mm penetration =
C.B.R at 5.0 mm penetration =
C.B.R of the sample =

INTERPRETATION OF RESULTS:-

California Bearing Ratio is an empirical value and is useful in design of flexible pavements. Design curves evolved by Road Research Laboratory, U.K have been adopted by Indian Road Congress. Depending upon the expected traffic volume, the thickness of base course and sub-base course can be determined from their respective CBR values, the suitability of the soil tested for use as a subgrade material (or for other materials to be used as sub-base and base) in road construction may be interpreted from the curves giving the relationship between bearing value and penetration. 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.

RESULT:- The CBR value of the given soil sample is _____% .

Short Questions:

1) What is the CBR value?
2) What is the significance of surcharge weight?
3) Under what conditions would you recommend to conduct CBR test on the soaked specimen?
4) What are the field applications of CBR test results?
5) When it is necessary to apply correction to CBR value?
6) What are the reasons for concavity of load-penetration curve?