GOVT CO-ED POLYTECHNIC

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TRANSPORTATION ENGINEERING,
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CONTENTS

Experiment No: 1

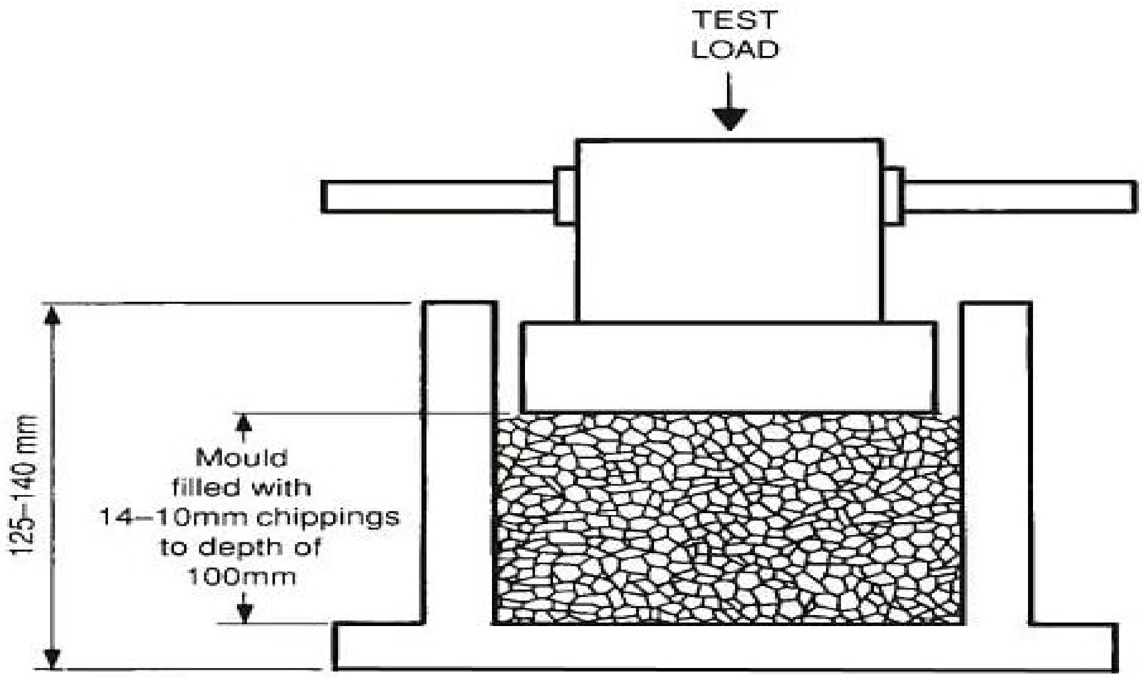
AIM: To determine the aggregates crushing value of the given sample of aggregates..

APPARATUS: Crushing machine, Tamping Rod, Trowel, Weighing Balance, Cylindrical mould, plunger etc.

THEORY:

INTRODUCTION

Different rock samples give different compressive strength varying from minimum of about 45Mpa to maximum of 545Mpa. The compressive strength of parent rock does not exactly indicate the strength of aggregates in concrete. For this reason assessment of strength of the aggregates are made by using a sample bulk aggregates in standardized manner. The test conducted to know the compressive strength of aggregate is known as aggregates crushing value test. The crushing value of aggregates is rather insensitive to variation in strength of weaker aggregates. For this reason, a simple test known as 10 percent fine value is introduced. When the aggregates crushing value become 30% or higher, the results are likely to be inaccurate.



Aggregate Crushing Load(Source: IS 2386(Part 4):1963)

The aggregates crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load. The principal mechanical property of aggregate required in any construction is (i) satisfactory resistance to crushing under the roller during construction (ii) adequate resistance to surface abrasion under traffic. Aggregates used in road construction should be strong enough to resist crushing under traffic wheel load. If aggregates are weak the stability of pavement structure is adversely affected. The strong aggregates will have low crushing value and weak aggregates have high crushing value. The aggregate crushing strength for various types of surface course of pavements should be high enough to withstand the high wheel load, including the steel tires of loaded bullock-carts. However, low strength aggregates having lesser crushing strength are used in base and sub-base courses of pavements. IRC have specified aggregates crushing values of the coarse aggregates used for cement concrete surface should not exceed 30%. For aggregates used for concrete other than surfaces, the aggregates crushing values should not exceed 45%.

Aggregate Crushing Value for different types of Roads / Pavements

Types of Roads / Pavements	Aggregate Crushing Value Limit
Flexible Pavements	
Soling	50
Water bound macadam	40
Bituminous macadam	40
Bituminous surface dressing or thin premix carpet	30
Dense mix carpet	30
Rigid Pavements	
Other than wearing course	45
Surface or Wearing course	30

PROCEDURE:

1. Take the Empty weight of cylindrical measure as W1.
2. Fill aggregate sample passing through 12.5 mm and retained on 10 mm IS sieve in measuring cylinder in 3 equal layers such that each layer is subjected to 25 strokes using the tamping rod. Take the weight of aggregate with measuring cylinder as W2.
3. Find out the weight of aggregate sample W = W2 – W1
4. Now, fill the aggregate sample in 15 cm dia. and 13 cm height steel cylinder and level the surface of aggregate carefully and insert the plunger so that it rests horizontally on the surface.
5. Place a steel cylinder with a plunger on the loading plate of the compression testing machine.
6. Operate Compression machine such that 40 tonnes of the load is applied on aggregate in approximately 10 min.
7. Release load and remove the steel cylinder from the machine.
8. Take out the crushed aggregate sample and sieve on with 2.36mm IS sieve, care being taken to avoid loss of fines.
9. Take off the weight of fraction passing through 2.36 mm IS sieve as (W3).

CALCULATIONS:

The crushing strength of aggregate can be found by the following formula,

"Aggregate crushing value is determined by taking a percentage of weight crushed aggregate sample passing through 2.36 mm IS Sieve divided by weight of aggregate sample taken for test"
The aggregate crushing value formula is given below,

Aggregate crushing value % = (W3 / W)*100 or W3 / (W2 – W1)*100

W1 = Empty weight of cylindrical Measure.(in grams)
W2 = Weight of Aggregate with Cylindrical Measure (in grams)
W = W2 –W1 = Weight of Aggregate Sample
W3 = Weight of crushed aggregate sample passed through 2.36 mm IS Sieve.(in grams)

RESULTS:

For accurate test results conduct the test at least 3 times and take an average of 3 values.

Experiment No: 2

AIM: To determine the aggregates impact value of the given sample of aggregates.

THEORY:

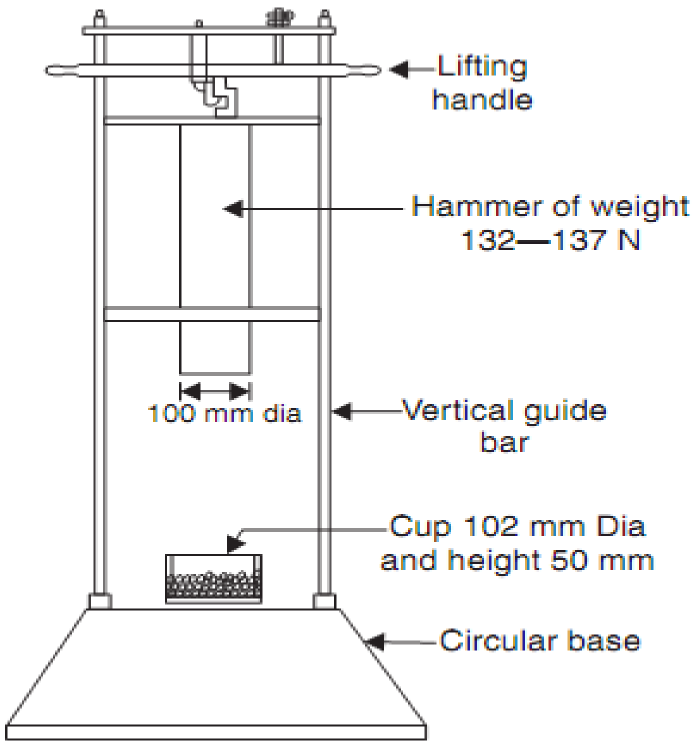
INTRODUCTION

Aggregates undergo significant wear and tear throughout their life. Aggregates must be hard and tough enough to resist crushing, degradation and disintegration and be able to transmit loads from the pavement surface to the underlying layers and eventually the subgrade. Testing the strength of parent rock alone does not exactly indicate the strength of aggregates in concrete. For this reason assessment of strength of the aggregates are made by using a sample bulk aggregates in standardized manner.Several tests are thus performed to assess the stability and quality of roads. The Aggregate Impact Value Test is one such test. The impact test is a type of quality control test for highway pavements that is used to determine the suitability of aggregates for use in highway pavement construction.

The principal mechanical property of aggregate required in any construction is

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

   Aggregates used in road construction should be strong enough to resist abrasion and crushing and also the impact load. If aggregates are weak, then the stability of pavement structure will be adversely affected. The toughness of aggregate is its ability to resist sudden load acting on it. The movement of vehicles on the road sometimes gives rise to impact loading which results in breaking of aggregates into smaller pieces. Therefore the aggregates should have sufficient toughness to resist their disintegration due to impact. This characteristic of aggregate is measured by impact value test.



Aggregate Impact Testing Machine

In this test sample of standard aggregates kept in a mould which is subjected to fifteen blows of metal hammer of weight 14 kgs falling from the height of 38cms. The quantity of finer materials resulting from pounding will indicate the toughness of the sample of aggregates. As per IS 283-1970 Aggregates Impact Value is defined as the ratio of weight of fines formed to weight of total sample taken and is expressed in percentage

Aggregates Impact Value gives relative measure of resistance of aggregates to sudden shock or impact, which in some aggregates differs from its resistance to slow compression load. Impact Value should not be less than 45% for aggregates used for concrete other than wearing surface and 30% for concrete used in wearing surface. Table below shows the classification of aggregate with respect to aggregate impact value and limits of aggregate impact value for different types of road construction suggested by Indian Road Congress.

Classification of aggregates based on Aggregate Impact Value

Aggregate Impact Value	Classification
<20%	Exceptionally Strong
10 – 20%	Strong
20-30%	Satisfactory for road surfacing
<35%	Weak for road surfacing

Impact Value of Aggregate for different types of pavement

Type of pavement	Impact Value of Aggregate not more than
Wearing Course	30
Bituminous surface dressing	
Penetration macadam	
Bituminous carpet concrete	
Cement concrete	
Bitumen bound macadam base course	35
WBM base course with bitumen surfacing	40
Cement concrete base course	45

PROCEDURE:

- The aggregate uses for the sample are passed through the 12.5mm IS sieve and retained on the 10mm IS sieve.
- The aggregate which is retained on the 10mm sieve is dried in an oven for a time period of 4 hours at the oven temperature of 100 to 110º C.
- The cylindrical measure used for the collection sample filled about 1/3 full with the aggregates and it tamped 25 stokes with help of the rounded end of the tamping rod. Further similar 1/3 quantity of aggregates are filled in it and again 25 stokes are given. Then measure is finally filled to overflowing then apply 25 stokes again and the extra aggregates are removed from the measure with the help of the straight portion of the tamping rod.
- The impact machine is rest on a horizontal flat surface like the level plate, block, or floor without any packing. So, the application of a hammer is straight and vertical.
- The cup is fixed in a proper position on the base of the impact machine.
- Transfer aggregate sample from cylindrical measure to cut fitted in an impact test machine and apply 25 strokes of the rod to compact it.
- Then the hamm er is lifted 380mm and falls on the upper surface of the aggregate which fills in the cup.
- A total of 15 blows are applied to the cup each delivered at an interval of not less than 1 second.
- The crushed aggregates are removed from the cup and the crushed sample is sieved from the 2.36mm IS sieve.
- Weight the fraction of sample passing through 2.36mm IS sieve accuracy up to 0.1 gm. (W1)
- Weight the fraction of sample retains on the 2.36mm IS sieve. (weight W2)
- The total weight of the sample (W1 + W2) is less than the initial weight (weight W) by more than one gram than the result discarded.

CALCULATIONS

- The aggregate impact value is the ratio of the weight of the fraction passing through 2.36 mm (weight W2) by the total weight of the sample (weight W1 + W2).

Aggregate Impact Value = (W2/ (W1+W2)) * 100

Where, W1= Weight of the fraction passing through a 2.36 mm IS sieve. (gm)
W2= Weight of sample retained on 2.36 mm IS sieves. (gm)
W1+W2 = Total Weight of Sample (gm)

RESULT:

The Aggregate Impact Value is ________.

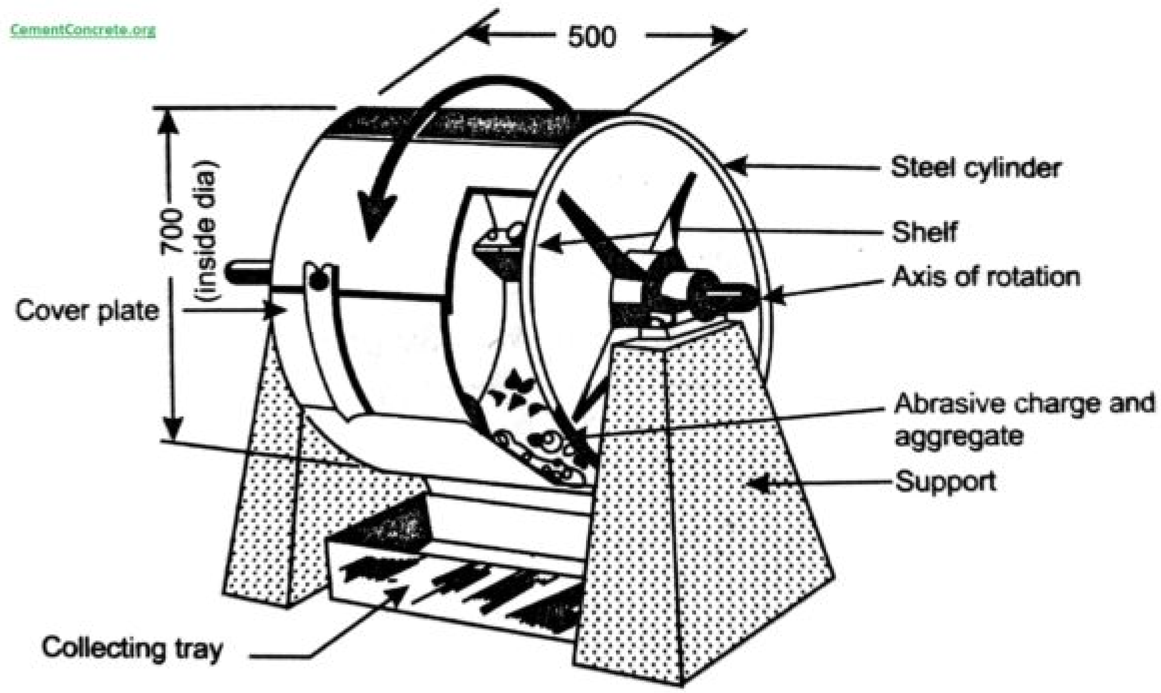
EXPERIMENT NO. 3

AIM: To determine the abrasion value of coarse aggregate by using Los - Angeles testing machine with an abrasive charge.

APPARATUS:
Los Angeles Abrasion Machine, Abrasive Charges, Sieve Shaker, Trowel , Weighing Machine.

THEORY:
INTRODUCTION
Aggregates undergo significant wear and tear throughout their life. Aggregates must be hard and tough enough to resist crushing, degradation and disintegration and be able to transmit loads from the pavement surface to the underlying layers and eventually the subgrade. Testing the strength of parent rock alone does not exactly indicate the strength of aggregates in concrete. For this reason assessment of strength of the aggregates are made by using a sample bulk aggregates in standardized manner. The principal mechanical property of aggregate required in any construction is

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



Los Angeles Abrasion Testing Machine

Aggregates used in road construction should be strong enough to resist abrasion and crushing under traffic wheel load. If aggregates are weak the stability of pavement structure is adversely affected. If the aggregates used are not resistant to abrasion it may cause premature failure or a loss of skid resistance of pavements, also poor resistance to abrasion can produce excessive dust. Abrasion test is carried out on the aggregate sample to test the hardness property of aggregates and to decide whether they are suitable for different pavement construction works. Los Angeles test is widely used to test abrasion of aggregate and the method has been standardized in India (IS:2386 part-IV). The Los Angeles abrasion test finds the percentage wear due to relative rubbing action between the aggregate and steel balls.

Los Angeles machine has a circular rotating drum of length 520 mm and internal diameter 700 mm mounted on horizontal axis. An abrasive charge consisting of cast iron spherical balls of 48 mm diameters and weight 340-445 g is placed in the cylinder along with the aggregates based on the selected grading. The number of the abrasive spheres varies according to the grading of the sample. The quantity of aggregates to be used depends upon the grading and usually ranges from 5-10 kg. The cylinder is then locked and rotated at the speed of 30-33 rpm for a total of 500 -1000 revolutions depending upon the gradation of aggregates. After specified revolutions, the material passing 1.7 mm IS sieve is measured and expressed as percentage total weight of the sample. This value is called Los Angeles abrasion value.

The table below shows limits of Los Angeles abrasion value for different types of road construction:

Type of Pavement	Max. permissible abrasion value in %
Water bound macadam sub base course	60
WBM base course with bituminous surfacing	50
Bituminous bound macadam	50
WBM surfacing course	40
Bituminous penetration macadam	40
Bituminous surface dressing, cement concrete surface course	35
Bituminous concrete surface course	30

PROCEDURE:

The aggregates sample consists of clean aggregates dried in an oven at 105° – 110°C. The aggregates sample should conform to any of the grading shown in the below table.

1. Select the size of aggregate to be used in the test such that it conforms to the grading to be used in construction, to the maximum extent possible.
2. Take exactly 5 kg of the sample for grades A, B, C & D, and 10 kg for grading E, F & G.
3. Choose the abrasive charge balls as per Table 2 depending on the grading of aggregates.
4. Place the aggregates and abrasive charge balls on the cylinder and fix the cover.
5. After that Rotate the machine at a speed of 30 to 33 revolutions per minute. The number of revolutions should be 500 for grades A, B, C & D and 1000 for grading E, F & G.
6. The machine is stopped after the specified number of revolutions and the aggregate sample is discharged to a tray.
7. The entire stone dust made from a machine is sieved on 1.70 mm IS sieve.
8. The material size more than 1.7 mm size is weighed correct to one gram.

CALCULATION:

The original weight of aggregate sample = W1 g
The weight of the aggregate sample retained = W2 g
Weight sample passing 1.7mm IS sieve = W1 – W2 g

Abrasion Value = (W1 – W2) / W1 X 100

EXPERIMENT NO.4

AIM: To determine California Bearing Ratio value of soil by conducting load penetration test.

APPARATUS: CBR setup, CBR mould, Filter paper ,Rammer, plunger, Spacer Disc, Surcharge weight, Slotted Weight.

THEORY:

INTRODUCTION

The California Bearing Ratio (CBR) test is a penetration test meant for the estimation of subgrade strength of roads and pavements. The results found by these tests are used with the empirical curves to find the thickness of pavement and its component layers. This is the most commonly used method for the design of flexible pavement. California Division of Highway developed CBR test as a method of classifying and evaluating soil-sub grade and base course materials for flexible pavements. An empirical test, the CBR test has been used to find the material properties for pavement design.

It is a penetration test in which a standard piston, with a diameter of 3 in or 76 mm, is used to penetrate the soil at a standard rate of 1.25 mm/minute. The pressure up to a penetration of 12.5 mm and its ratio to the bearing value of a standard crushed rock is defined as CBR. In most of the cases, CBR value decreases as the penetration value increases. The ratio is usually determined for the penetration of 2.5mm and 5.0mm.

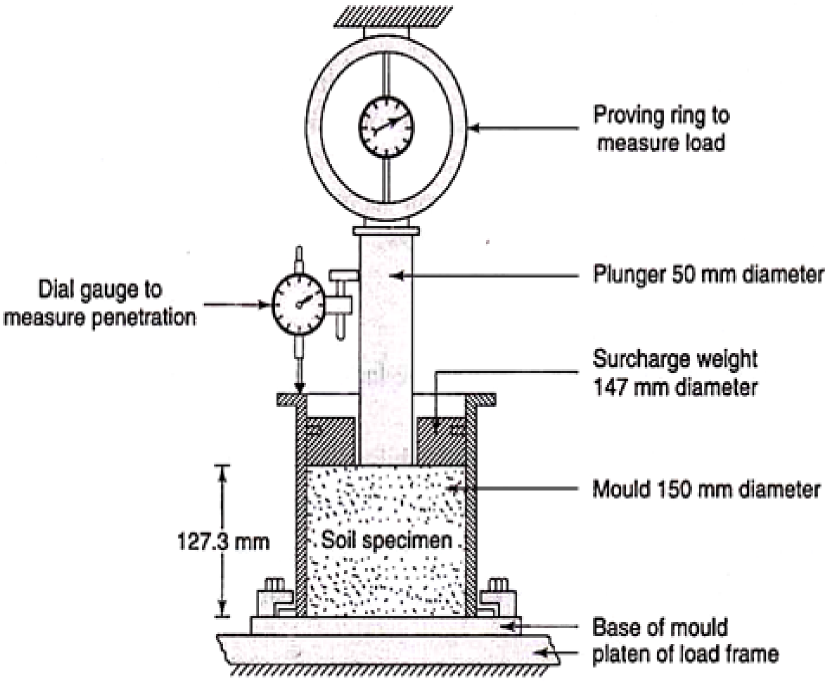
In some cases, the ratio at 5 mm may be greater than that at 2.5 mm. If this occurs, the ratio at 5 mm must be used. The CBR is a measure of resistance of a material to penetration of a standard plunger under controlled density and moisture conditions. The test procedure should be strictly adhered, if a high degree of reproducibility is desired.

The CBR test is conducted on a remolded or undisturbed specimen in the laboratory. The test is simple and has been widely investigated for field correlations of flexible pavement thickness condition.

CBR apparatus consists a mould of 150 mm diameter with a base plate and a collar, a loading frame and dial gauges for measuring the penetration values and the expansion on soaking. The specimen in the mould is soaked in water for four days and the swelling and water absorption values are noted. The surcharge weight is placed on the top of the specimen in the mould and the assembly is placed under the plunger of the loading frame.

Load is applied on the sample by a standard plunger with diameter of 50 mm at the rate of 1.25 mm/min. A load penetration curve is drawn. The load values on standard crushed stones are 1370 kg, 2055 kg, 2630 kg, 3180 kg and 3600 kg at 2.5 mm, 5.0 mm, 7.5 mm, 10.0 mm and 12.5 mm penetrations respectively. CBR value is defined as the percentage of the actual load causing the penetrations of 2.5 mm or 5.0 mm to the standard loads mentioned above. The test is carried out on the undisturbed specimens and on remoulded specimens which may be compacted either statically or dynamically. For light compaction, compact the soil in 3 equal layers, each layer being given 55 blows with 2.6 kg rammer. For heavy compaction compact the soil in 5 layers, 56 blows to each layer with 4.89 kg rammer.

Generally, the CBR value at 2.5 mm will be greater that at 5 mm and in such a casethe former shall be taken as CBR for design purpose. If CBR for 5 mm exceeds that for 2.5 mm, the test should be repeated. The CBR can therefore be mathematically expressed as below:



Schematic Diagram of CBR Experimental Setup

$$CBR = \frac{p}{p_s} \times 100$$

Where,

p = measured pressure for site soils [N/mm^2]

p_s = pressure to achieve equal penetration on standard soil [N/mm^2]

The California Bearing Ratio (CBR) test is a strength test that compares the bearing capacity of a material with that of a well-graded crushed stone. The harder the surface, the higher the CBR value. Typically, a value of 2% equates to clay, while some sands may have a CBR value of 10%. High quality sub-base will have a value of between 80-100% (maximum).

As per IRC: 37-2001, if the maximum variation in CBR values among the three specimens tested in the laboratory exceed the permissible variation in CBR values for different ranges (as given in the table below), the CBR test should be repeated on additional three specimens and the average value of six specimens is to be accepted as the CBR value.

CBR value (%)	Maximum permissible variation in CBR values between 3 individual test value (±, %)
< 5	1
5 – 10	2
11 – 30	3
31 or above	5

PROCEDURE:

- Take the soil sample which passes through 20 mm IS sieve, but it should retain on 4.75 mm IS sieve.
- Take about 4.5 to 5.5 kg of the material and mix it with water content. Taken water content should be equal to the optimum water content which is found by light compaction or heavy compaction test.
- Sample is to be compacted at optimum water content and corresponding dry density.
- Further, fixing of the extension collar to the top of the mould is done. Also fixing the base plate to the bottom is necessary.
- Spacer disc should be inserted over the base along with the central hole of the disc at the lower face. Place coarse filter paper disc on the top of the displacer disc.
- Take the soil sample in the mould. Further compact it either with the light compaction rammer or the heavy compaction rammer as favourable.
- For light compaction of the soil, it must be compacted in 3 equal layers, each layer is to be given 56 blows by 2.6 kg rammer with drop of 310 mm height.
- For heavy compaction, the soil must be compacted in 5 equal layers and each layer is should be given 56 blows by 4.89 kg rammer with drop of 450 mm height.
- Remove the extension collar. Trim excess compacted soil carefully with a straight edge with the top of the mould. Loosen the base plate and then remove the spacer disc and the base plate.
- Weight the mould with the compacted soil. After weighing the compacted soil, cover the filter paper disc on the base plate.
- Invert the mould with the compacted soil and clamp the base plate.
- Place a perforated disc fitted with an extension stem on the specimen top after placing a filter disc.
- Place 2.5 kg annular masses to produce a surcharge equal to the mass of the base material and wearing coat of the pavement expected. Minimum of two annular masses should be placed.
- Further the mould assembly should be immersed in a tank full of water and allow free access of water on the top and bottom of the specimen.
- Mount the tripod of the expansion measuring device on the edge of the mould and take the initial reading of the mould and dial gauge.
- Keep the mould in the tank undisturbed for 96 hrs. Take the readings of the dial gauge every 24 hrs and note the time of reading.

- Maintain water level constant in the tank. Take the final reading at the end of 96 hrs.
- Remove the tripod and take out the mould from the tank. Allow the water from the specimen to drain off for atleast 15 minutes.
- Free water from the mould should be completely removed without disturbing the specimen surface. Weight the mould with the soaked specimen.
- The mould containing the specimen along with the base plate should be placed in position where the top face is exposed on the lower plate of the loading machine.
- Place the required surcharge masses on the top of the soaked specimen. To prevent upheaval of soil into the hole of the surcharge mass, one 2.5 kg annular mass shall be placed on the soil surface prior to seating the penetration plunger.
- Further adding to it, the remaining masses are also placed.
- Seal the penetration plunger at the center of the specimen to establish full contact between the plunger and the specimen. The seating load should be about 40 N.
- The displacement dial gauge and the load dial guage should be set to zero.
- Already applied initial load to the plunger should be considered as zero.
- Apply the load on the plunger and keep the rate of penetration as 1.25 mm/min.
- At the end of the test, the plunger and the mould are raised and removed from the loading machine.
- Take about 20 to 50 gm soil specimen from the top 30 mm layer for the water content determination. If the water content of the whole specimen is required, take soil specimens from the entire depth.

Data Sheet for CBR Test

optimum water content = ……………………..
Empty Mould Mass = ……………………..
Mass of mould + compacted soil = ……………………..
Mass of compacted soil = ……………………..
Bulk density = ……………………..
Dry density = ……………………..

Soaking and Swelling :

Dry density before soaking = ……………………..
Bulk density before soaking = ……………………..
Bulk density after soaking = ……………………..
Surcharge mass after soaking = ……………………..

Date & Time			
Dial Guage Reading			
Total Expansion			

Final expansion : $\frac{Final\,Reading - Initial\,Reading}{Initial\,Height}$

Surcharge Test :

Surcharge mass used = ……………………..
Water content after penetration test = ……………………..

Plotting of load- penetration curve should be done along with the readings. Find the corrected loads, after zero correction, corresponding to penetration of 2.5 mm and 5.0 mm

CBR Test Result :

CBR (2.5 mm) = $\dfrac{corrected..load@2.5mm}{13.44} \times 100$

CBR (5.0 mm) = $\dfrac{corrected..load@5.0mm}{20.16} \times 100$

EXPERIMENT NO. 5

AIM: To determine the ductility value of asphaltic bitumen.

APPARATUS: Briquette Mould, Ductility Setup, Water Bath,Bunsen Burner.

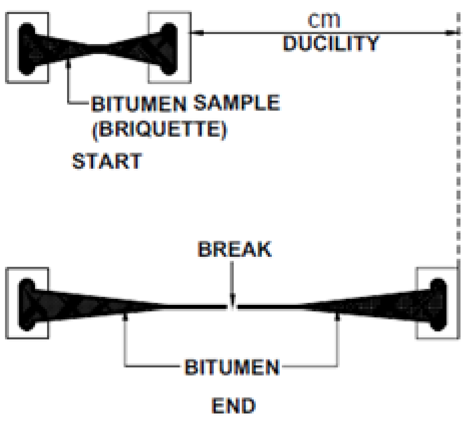
THEORY:

INTRODUCTION

Bitumen is the residue or by-product obtained by the refining of crude petroleum. A wide variety of refining techniques like straight distillation technique, solvent extraction technique etc are used to produce bitumen of different consistency and other desirable properties. Depending on the origin and other characteristics of the crude oil and property of bitumen required, more than one processing method may be employed. The type of construction decides the type of bitumen needs to be used. But in general good bitumen should have following properties.

1. **Temperature susceptibility of bitumen**: the bitumen mix should not become too soft or unstable during hot weather, and not become too brittle during cold weather.
2. **Viscosity of the bitumen**: at the time of mixing and compaction should be adequate. This can be managed by the use of cutbacks or emulsions of suitable grades or heating the bitumen and aggregates prior to mixing.
3. **Affinity and adhesion of bitumen**: There should be adequate affinity and adhesion between the bitumen and aggregates used in the mix.

Ductility is one such property of bitumen which is dependent on the purpose of construction. Ductility is the property that permits the material to undergo great deformation or elongation. Indirectly, ductility measures the adhesive property of bitumen and its ability to stretch. It is necessary that binder should form a thin ductile film around aggregates to improve the interlocking of the aggregates in flexible pavements. It is important in pavement to resist crack due to temperature or traffic stresses to avoid damage the pavement structure. Specifically, the ductility of a bituminous material is defined as the distance in centimeters, to which it will elongate before breaking when two ends of a briquette specimen of the material are pulled apart at a specified speed and a specified temperature. A temperature of 25 ± 0.5 °C and pulling speed of 5 cm/min ± 5.0 % is to be maintained while carrying out the experiment. The ductility of a bitumen specimen mainly gives information about the tensile strength and ductility grade of bitumen.



Ductility Test on Bitumen

Due to temperature stress's roads expand at daytime and contract at night. So, if the bitumen is not adequately ductile cracking will occur. The ductility value of bitumen usually varies from 5 to over 100 cm's and several standards have specified minimum ductility values for various pavement types. However a ductility value of 100 cm's is specified generally for bituminous construction. Ductility value of bitumen varies based on source of it, the minimum values of ductility specified by ISI for various grades are as follows.

Source of Paving Bitumen and Penetration Grade	Min ductility value (cm)
Assam Petroleum A25	5
A35	10
A45	12
A65, A90 and A200	15
Bitumen from sources other than Assam Petroleum S35	50
S45, S65 and S90	75

(Source: Minimum ductility value for different source of Paving Bitumen and Penetration Grade)

PROCEDURE:

1. Melt the bituminous test material completely at a temperature of 75oC to 100oC above the approximate softening point until it becomes thoroughly fluid

2. Strain the fluid through IS sieve 30.

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

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

5. 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 27oC for half an hour.

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

7. Replace the mould assembly in water bath maintained at 27oC for 80 to 90 minutes

8. Remove the sides of the moulds

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

10. Adjust the pointer to read zero

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

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

13. Record the observations in the proforma and compute the ductility value report the mean of two observations, rounded to nearest whole number as the "Ductility Value"

RECORD AND OBSERVATIONS:

I. Bitumen grade = _
II. II. Pouring temperature oC =
III. III. Test temperature oC =
IV. IV. Periods of cooling, minutes =
V. a) In air =
VI. b) In water bath before trimming =
VII. c) In water bath after trimming =

RESULT: The Ductility value of given bitumen is _______________

EXPERIMENT NO.6

AIM: To Determine penetration test on Bitumen/ Tar.

APPARATUS: Penetration setup, mould, Needle, Bunsen Burner, Water Bath.

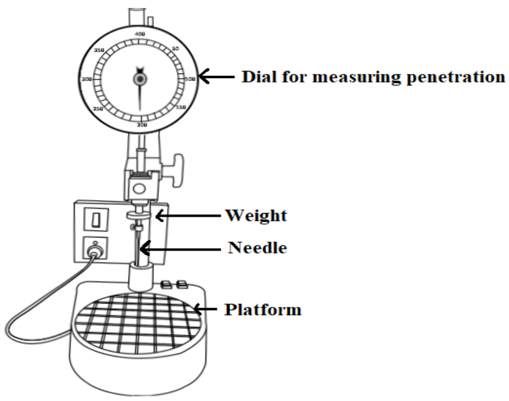
THEORY:

INTRODUCTION

Bitumen is the residue or by-product obtained by the refining of crude petroleum. A wide variety of refining techniques like straight distillation technique, solvent extraction technique etc are used to produce bitumen of different consistency and other desirable properties. Depending on the origin and other characteristics of the crude oils and property of bitumen required, more than one processing method may be employed. The type of construction decides the type of bitumen needs to be used. But in general good bitumen should have following properties.

1. **Temperature susceptibility of bitumen**: the bitumen mix should not become too soft or unstable during hot weather, and not become too brittle during cold weather.
2. **Viscosity of the bitumen**: at the time of mixing and compaction should be adequate. This can be managed by the use of cutbacks or emulsions of suitable grades or heating the bitumen and aggregates prior to mixing.
3. **Affinity and adhesion of bitumen**: There should be adequate affinity and adhesion between the bitumen and aggregates used in the mix.

Penetration is a measure of consistency. It quantifies the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds under specified temperature, load and duration of loading. BIS had standardized the equipment and test procedure. The penetrometer consists of a needle assembly with weight of 100g and a device for releasing and locking in any position. The bitumen is softened to a pouring consistency, stirred thoroughly and poured into containers at a depth at least 15 mm in excess of the expected penetration. The test should be conducted at a specified temperature of 25°C. It may be noted that penetration value is largely influenced by any inaccuracy with regards to pouring temperature, size of the needle, weight placed on the needle and the test temperature. A grade of 40/50 bitumen represents the penetration value is in the range 40 to 50 at standard test conditions. Higher is the penetration of bitumen softer is the consistency. This is one of the most widely used test for classifying bituminous materials into different grades.



Penetration Test on Bitumen

The use of different grade of bitumen depends on climatic conditions and type of construction. Commonly used grades are 30/40, 60/70 and 80/100. For bituminous macadam and penetration macadam, IRC suggests bitumen grades 30/40, 60/70, 80/100. Generally, in warmer regions, lower penetration grades are preferred to avoid softening and in colder regions bitumen with higher penetration grades like 180/200 are used to prevent the occurrence of excessive brittleness. The test is not intended to estimate consistency of softer materials like cut back which are usually graded by viscosity test. High penetration grade is used in spray application works.

PROCEDURE:

1.The bitumen is softened to a pouring consistency, stirred well and poured into the test containers. The depth of bitumen in container is kept at least 15mm more than the expected penetration. (I.S. 1203-1978).

2. Now the sample containers are placed in a temperature controlled water bath at a temperature of 25 c for one hour.

3. Then at the end of one hour, the sample is taken out of water bath and the needle is brought in contact with the surface of bitumen sample at that time reading of dial is set at zero or the reading of dial noted, when the needle is in contact with the surface of the sample.

4. After that the needle is released and the needle is allowed to penetrate for 5 seconds and the final reading is recorded. On that sample at least three penetration observations should be taken at distances at least 10 mm apart. After each test, the needle should be disengaged, wiped with benzene and dried. The amount of penetration is recorded.

5. The main value of three measurements is reported is the penetration test.

6. The accuracy of the test depends upon pouring temperature, size of needle, weight placed on the needle, and test temperature.

7. Te grade of bitumen is specified in terms of penetration value. For example, 30/40 grade bitumen indicates the penetration value of the bitumen in the range of 30 to 40 at standard test conditions.

8. Readings are taken as units of penetration Where, 1 unit = (1/10) mm

EXPERIMENT NO.7

AIM: To determine the softening point of the given sample of bitumen.

APPARATUS: Ring And Ball Apparatus, Water Bath with Stirrer, Steel Ball, Bunsen Burner.

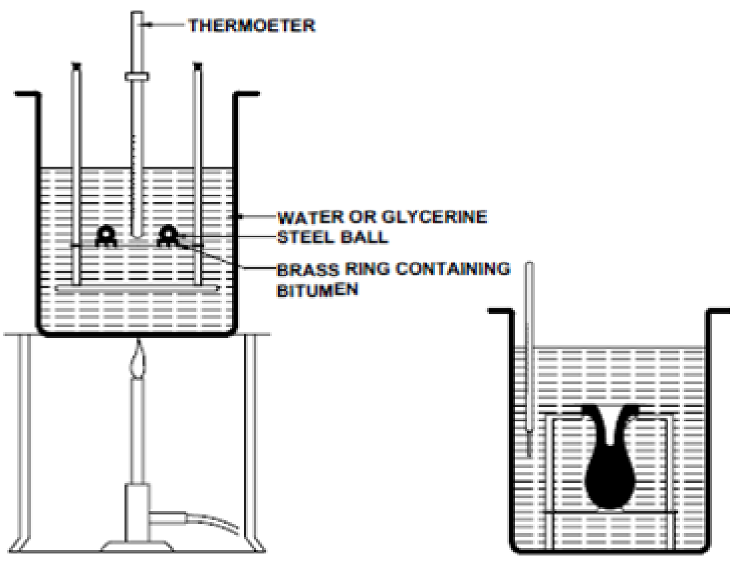
THEORY:

INTRODUCTION

Bitumen is the residue or by-product obtained by the refining of crude petroleum. A wide variety of refining techniques like straight distillation technique, solvent extraction technique etc are used to produce bitumen of different consistency and other desirable properties. Depending on the origin and other characteristics of the crude oils and property of bitumen required, more than one processing method may be employed. The type of construction decides the type of bitumen needs to be used. But in general good bitumen should have following properties.

1. **Temperature susceptibility of bitumen**: the bitumen mix should not become too soft or unstable during hot weather, and not become too brittle during cold weather.
2. **Viscosity of the bitumen**: at the time of mixing and compaction should be adequate. This can be managed by the use of cutbacks or emulsions of suitable grades or heating the bitumen and aggregates prior to mixing.
3. **Affinity and adhesion of bitumen**: There should be adequate affinity and adhesion between the bitumen and aggregates used in the mix.

The softening point of materials like asphalt, bitumen have no definite melting point, but when heated it gradually changes from brittle or very thick and slow-flowing materials to more mobile liquid material. The softening point of bitumen or tar is the temperature at which the substance attains particular degree of softening under specified conditions of test. The test is conducted by using Ring and Ball apparatus. A brass ring containing test sample of bitumen is suspended in liquid like water or glycerine at a given temperature. A steel ball is placed upon the bitumen sample and the liquid medium is heated at a rate of 5 degree per minute.



Softening Point Test Setup

As per IS: 334-1982 it is the temperature in °C at which a standard ball passes through a sample of bitumen in a mould and falls through a height of 2.5 cm. The binder material used in pavement construction should have sufficient fluidity before its applications. The softening point of the binder helps to know the temperature up to which a bituminous binder should be heated for various pavement applications. Generally, higher softening point represents lower temperature susceptibility of bitumen and is preferred in warmer regions.

PROCEDURE:

Sample Preparation

1. Take the bitumen sample in a vessel and heat it to a temperature of 75-100°C- above its approximate softening point. Allow the bitumen to melt until it is converted completely into a liquid state. Stir the bitumen if necessary so that it is melted completely and is free from air bubbles and water. If the need arises, filter it through IS sieve 30.
2. Prepare a mixture of glycerine and dextrine in equal proportions. Mix it well. Then coat the surface of the metal or glass plate. This prevents the bitumen from sticking to the plate.
3. Heat the rings to approximately same temperature as that of the molten bitumen and place them on the glass or metal plate coated with the mixture of glycerine and dextrine.
4. Pour the molten bitumen in the rings carefully till the rings are slightly filled above the top level.
5. Allow the rings to cool at room temperature in air for 30 minutes.
6. Cut the excess bitumen on the surface with the help of hot, straight-edged putty knife or spatula and level the top surface.

Testing of the Specimen

1. Fill the water bath with freshly boiled distilled water to such a height that the water level remains 50 mm above the upper surface of the rings. Maintain this water bath at 5 °C temperature.
2. Fix the rings filled with bitumen to the ball guide. Assemble the rings in the support frame.
3. Place the rings fixed in the support frame in the water bath at 5 °C for 15 minutes.
4. Cool the steel balls to a temperature of 5 °C.
5. Place a steel ball on the top of the ring guide of the rings attached to the support with the help of forceps.
6. Place this assembly in a glass beaker filled with distilled water to such a height that the water level is at least 50 mm above the top surface of the ball.
7. Put the beaker on the hotplate and adjust the stirrer. Insert the thermometer too.
8. Allow the beaker to be heated at a uniform rate of 5 ± 0.5 °C/min. The rate can be adjusted with the help of the energy regulator.
9. Stir the water continuously to ensure that the water is heated uniformly.
10. Continue the heating till the bitumen filled in the ring softens and the ball placed on it starts to move down owing to its own weight.
11. Note the temperature when each of the balls touches the bottom plate while sinking from the thermometer.

OBSERVATION:

Following observation taken during ring and ball test of bitumen,

- As the water is heated continuously, the bitumen in the rings starts to melt.

- As a result, the steel balls placed over it starts to descend in the water due to its own weight.

The temperature at which the steel ball touches the bottom plate is observed and its value is recorded. This is done for both the balls.

OBSERVATION TABLE:

A sample observation table for softening point test is drawn below

Description	Ball No. – 1	Ball No. – 1
The temperature when the ball touches the bottom plate °C		

The softening point of Bitumen = Average value of softening point of 1 and 2 (to the nearest 0.5 °C).

RESULT:

The average of the **softening point values to the nearest 0.5 °C** obtained for the two steel balls is the softening point of the given bitumen specimen.

The softening point value of the two readings should not exceed 1.0 °C for the softening point of bitumen range 40-60 °C and 1.5 °C for the softening point between 61-80 °C. Else the test is considered invalid and it is repeated**.**

Minimum softening point values standardized by Bureau of Indian Standard for Bitumen to be used for pavement for different grades are tabulated below:

Also softening point of various bitumen grades,

Paving Grades	Softening Point
VG 10	40 °C
VG 20	45 °C
VG 30	47 °C
VG 40	50 °C

EXPERIMENT NO.8

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

APPARATUS : Pensky Martens Tester, Closed Cup Tester, Open Cup Tester, stirring device, Shutter, Flame Exposure Device,Heating Device With Temperature Regulator , Thermometer.

MATERIAL:

- Bituminious material
- Solvent for Cleaning

THEORY:

Flash point: It is the lowest temperature whose application causes the vapour of the bituminous material to catch an instant fire in a flash form in specified conditions.

Fire point: It is the lowest temperature whose application causes the binder material to ignite for at least 5 seconds in specified conditions.

Flash and fire point test of bitumen sample is one of the important tests of bitumen to be conducted before road construction.

Flash and fire point measures the temperature at which the material is at risk of catching fire.

The temperature at which the vapour of the bituminous material catches an instant fire or the material burns for some seconds is different for different types and grades of bitumen binders.

Bituminous materials are primarily hydrocarbons and hence at high temperatures, they release various volatile materials. These liberated volatile compounds catch fire with a flash. And this can prove hazardous.

Bitumen is heated for its application as bitumen binder for road pavements.

While dealing with hot bitumen during the processes like heating, mixing, or application, the temperature should be kept well below the critical temperatures determined by flash and fire point.

PROCEDURE:

There are two types of tester for determining the flash point of bitumen- closed cup tester and open cup tester. However, fire point of bitumen is determined by an open cup tester only.

Determination of Flash Point by Closed Cup Tester:

The procedure for finding out the flash point in closed cup tester varies for cutback bitumen. Both the procedure are described below-

For Bituminous material EXCEPT for Cutback Bitumen:

1. Clean all the parts of the cup and its accessories thoroughly and allow them to dry.
2. Take the bitumen sample in a beaker and heat it to a temperature of 75-100°C- above its approximate softening point. Allow the bitumen to melt until it is converted completely into a liquid state.
3. Fill the melted bitumen in the cup up to the filling mark indicated on the cup.
4. Close the cup with the help of the lid. Ensure that the locating devices of the cup and lid are properly engaged.
5. Place the cup on the stove.
6. Insert a thermometer and adjust the test flame to a size of a bead of about 4 mm diameter. Control the rate of the application of heat such that the temperature increases by 5-6 °C per minute as recorded from the thermometer.
7. Turn the stirrer at the rate of 60 rev/min.
8. Apply the first test flame when the temperature reaches approximately 17 °C before the actual flash point. When test flame is applied, discontinue the stirring.
9. Apply test flame at every reading of the temperature up to 104 °C in the multiples of 1 °C. When the temperature exceeds 104 °C, carry out the test at an interval of 2 °C.
10. Operate the device to apply the test flame by controlling shutter and test flame burner in such a way that the flame is lowered in 0.5 seconds for. It remains in the lowered position for a second and is raised quickly to the higher position.
11. Note down the temperature at which a distinct flash is observed in the interior of the cup.

Determination of Flash Point and Fire Point by Open Cup Tester in Flash and Fire Point Test:

1. Clean all the parts of the cup and its accessories thoroughly and allow them to dry. Ensure all the traces of solvent used for cleaning are removed.
2. Take the bitumen sample in a beaker and heat it to a temperature of 75-100°C- above its approximate softening point. Allow the bitumen to melt until it is converted completely into a liquid state.
3. Fill the melted bitumen in the cup up to the filling mark indicated on the cup.
4. Fix the clip in position on the cup. Ensure that the locating devices of the cup and lid are properly engaged.
5. Insert a thermometer and adjust the test flame to a size of a bead of about 4 mm diameter. Control the rate of the application of heat such that the temperature increases by 5-6 °C per minute as recorded from the thermometer.
6. Observe the surface of the material carefully during heating.
7. Then after the same steps are followed as mentioned in closed cup tester except that the stirrer is rotated **manually** instead of mechanically.
8. Note down the temperature when the first distinct flash appears at any point on the surface of the material. Record this temperature as the flash point.
9. Continue the heating beyond the flash point and applying the test flame at intervals of 1 °C.
10. Note down the temperature when the material ignites and continues to burn for at least 5 seconds. Record this temperature as fire point.

The entire practical is repeated for 2 more times. The corresponding average value of the three tests is the flash point and fire point of the given bitumen specimen.

Observation:

As the test flame is applied, at a certain temperature, a flash can be observed. This temperature is noted down as flash point.

Again, the test flame is continued to be applied. At a certain temperature, the fire occurs for at least 5 seconds. This temperature is noted down as fire point.

Observation Table:

(A sample observation table for flash and fire point test is drawn below)

	Readings		
	Trial 1	**Trial 2**	**Trial 3**
Flash Point in °C			
Fire point (b) in °C			

Flash point of the sample = Average value of flash point of 1, 2, 3.

Fire point of the sample = Average value of fire point of 1, 2, 3.

RESULT:

The average of the flash point and fire point values to the obtained from the three tests are the flash point and fire point values of the given bitumen specimen respectively.

For close cup tester, the value of flash point carried out for three times should not differ by more than ± 2 °C for temperature below or equal to 104 °C. And for temperature beyond 104 °C, the tolerance value is increased to ± 5.5°C.

For open cup tester, the values of both the flash and fire point carried out for three times should not differ by more than ± 8 °C.

Flash and fire point of the bitumen specimen is dependent on the grade of the bitumen.

EXPERIMENT NO.9

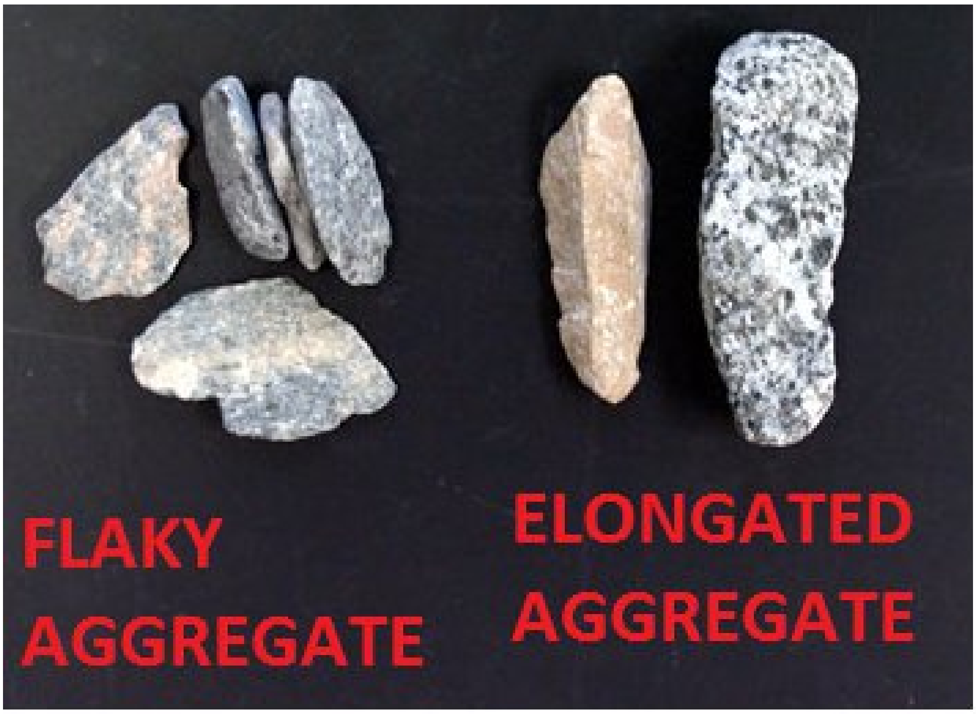
AIM: To determine Flakiness index of given aggregate.

THEORY:

The particle shape of aggregates (road metals) is determined by the percentages of flaky and elongated particles contained in it. In 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 road construction as the workability of concrete improves. Flaky and elongated particles may have adverse effects on concrete and bituminous mix. For instance, flaky and elongated particles tend to lower the workability of concrete mix which may impair the long-term durability. For bituminous mix, flaky particles are liable to break up and disintegrate during the pavement rolling process. Angular shapes of particles are desirable for granular base course due to increased stability derived from the better interlocking. Thus evaluation of shape of the particles, particularly with reference to flakiness, elongation of angularity is necessary.

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

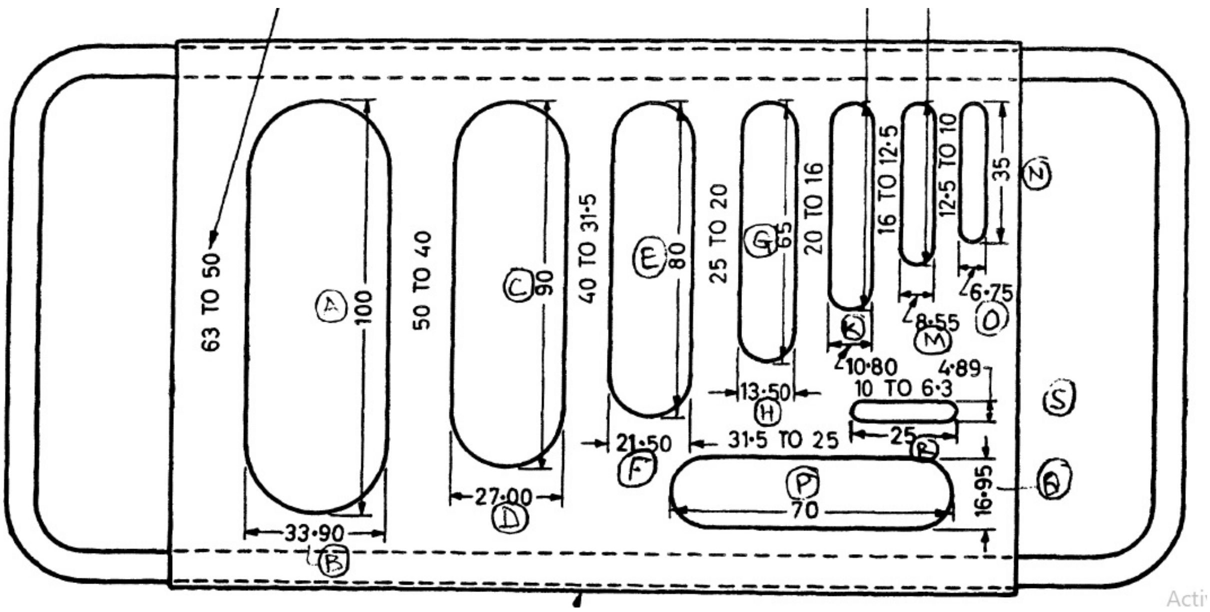
In pavement construction flaky and elongated particles are to be avoided, particularly in surface course. In flaky and elongated aggregate are present in appreciable proportions, the strength of pavement layer would be adversely affected due to possibility of breaking down under loads. In cement concrete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



IRC Recommendation:

Sr. No.	Types of construction	Maximum limit of Flakiness Index
1	Bituminous and Non-bituminous Roads	15%
2	Combined Flakiness and Elongation Index for Both Bituminous and Non-bituminous Roads	30%
3	Concrete roads	35%

PRACTICAL SETUP:



RESOURSES REQUIRED

S.NO	Particular	Specification	Quantity	Remark
1	Thickness Gauge	As Per IS:2386(part-I)-1963	2nos.	
2	IS sieves of sizes	63,50,40,31.5,25,20,16,12.5,10 and 6.3mm	1 no. each	
3	Electronic Balance	0.001gm accuracy	1no.	
4	Aggregate sample	-	-	

PROCEDURE:

1. Sieve the given aggregate sample through the sieves specified in observation table given below,

2. Take minimum 200 pieces of sieved sample and measure its weight "W" in grams.

3. Now, pass the each individual aggregate particle thickness wise through various opening of thickness gauge.

4. Note down the weight of aggregate fraction passed through opening of various sizes in

the observation table given below as 'W in grams. The weight of aggregate fraction should be measured to an accuracy of at least 0.1 percent of the test sample.

5. Calculate the flakiness index of given aggregate sample as (W/W) x 100 in percentage.

OBSERVATION & CALCULATION

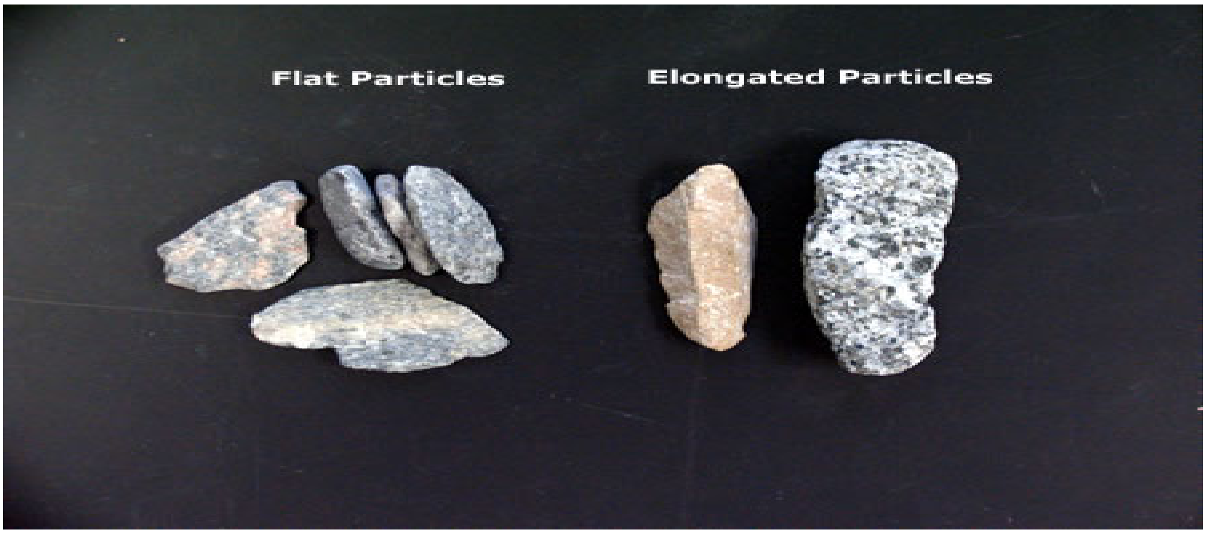
S.NO	Aggregate sample passing through IS sieve (mm)	Aggregate sample retained through IS sieve (mm)	Thickness guage size (mm)	Weight of aggregate sample taken W (gm)	Weight of aggregate in each fraction passing thickness guage W1 (gm)
1	63	50	33.90		
2	50	40	27.00		
3	40	25	19.50		
4	25	20	13.50		
5	20	16	10.80		
6	16	12.5	8.55		
7	12.5	10	6.75		
8	10	6.3	4.89		
				W=	W1=
FLAKINESS INDEX				W1/W)×100=	

EXPERIMENT NO.10

AIM: To determine Elongation index of given aggregate.

THEORY:
The particle shape of aggregates (road metals) 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 road construction as the workability of concrete improves. Angular shape of particles is desirable for granular base course due to increased stability derived from the better interlocking. Thus evaluation of shape of the particles, particularly with reference to flakiness, elongation of angularity is necessary.

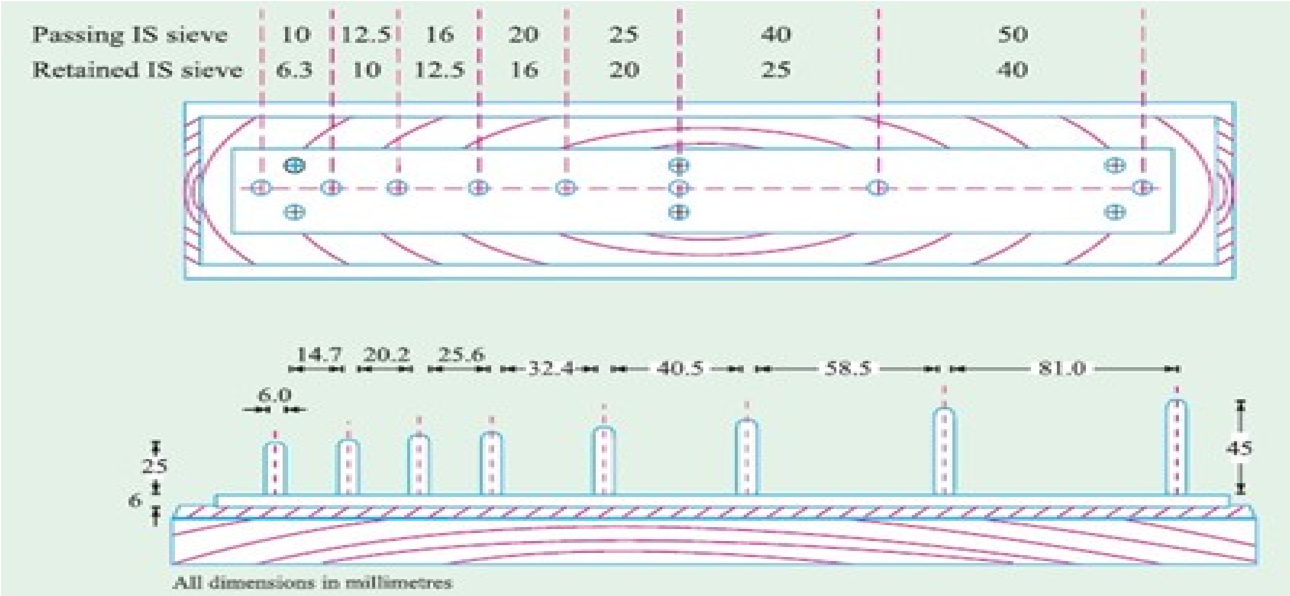
The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and fifth times (1.8 times) their mean dimension. The test is not applicable to sizes smaller than 6.3 mm. In pavement construction flaky and elongated particles are to be avoided, particularly in surface course. In flaky and elongated aggregate are present in appreciable proportions, the strength of 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 is strength in cement concrete depends on the cement content.



IRC RECOMMENDATION

Sr. No.	Types of construction	Maximum limit of Elongation Index
1	Bituminous and Non-bituminous Roads	15%
2	Combined Flakiness and Elongation Index for Both Bituminous and Non-bituminous Roads	30%
3	Concrete roads	35%

PRACTICAL SETUP:



RESOURSES REQUIRED

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S.NO	Particular	Specification	Quantity	Remark
1	Thickness Gauge	As Per IS:2386(part-I)-1963	2nos.	
2	IS sieves of sizes	63,50,40,31.5,25,20,16,12.5,10 and 6.3mm	1 no. each	
3	Electronic Balance	0.001gm accuracy	1no.	
4	Aggregate sample	-	-	

PROCEDURE:

1. Sieve the given aggregate sample through the sieves specified in observation table given below,

2. Take minimum 200 pieces of sieved sample and measure its weight "W" in grams.

3. Now, pass the each individual aggregate particle thickness wise through various opening of thickness gauge.

4. Note down the weight of aggregate fraction passed through opening of various sizes in the observation table given below as 'W in grams. The weight of aggregate fraction should be measured to an accuracy of at least 0.1 percent of the test sample.

5. Calculate the Elongation index of given aggregate sample as (W/W) x 100 in percentage.

OBSERVATION & CALCULATION:

S.NO	Aggregate sample passing through IS sieve (mm)	Aggregate sample retained through IS sieve (mm)	Thickness guage size (mm)	Weight of aggregate sample taken W (gm)	Weight of aggregate in each fraction passing thickness guage W1 (gm)
1	50	40			
2	40	25	58.5		
3	25	20	40.5		
4	20	16	32.4		
5	16	12.5	25.6		
6	12.5	10	20.2		
7	10	6.3	14.7		
				W=	W1=
ELONGATION INDEX				(W1/W)×100=	