Department of
CIVIL ENGINEERING

Zakura Campus

HIGHWAY MATERIAL LABORATORY MANUAL

NAME: _____

ROLL NO: _____

BRANCH: _____

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Srinagar, Jammu and Kashmir
190006

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Srinagar, Jammu and Kashmir

Certificate

This is to certify that Mr. / Ms. _____

bearing roll no _____ of B. Tech _____ semester _____

_____ Branch has satisfactorily completed _____

_____ laboratory during the academic year ____.

Signature of Coordinator **Signature of Faculty**

Signature of Internal Examiner **Signature of External Examiner**

PREFACE

Learning is a process that requires class instructions and practice labs. If we omit any of the above then the learning process is clearly flawed. This book is an attempt to standardize the lab instructions through development curriculum that is based on the class curriculum. The document is intended to be used by lab instructors, course instructors and students.

The intent of this curriculum is to define a clear lab structure that can be followed by the lab instructor and the students. In the absence of such curriculum the labs are often run without any formal structure. Another problem is that there are no grading criteria defined for each lab which leads to unethical practices. Perhaps one of the greatest problems faced by lab instructors is that they are unable to keep the students occupied for the entire duration of the lab due to which the learning process is hampered.

The labs have been developed in such a way that there is synchronization between the class and the lab. The entire book has been divided into 14 experiments having duration of three hours each. Students of the course are expected to carefully read the scope and objectives before coming to the lab. Each lab has a detailed walkthrough task which provides a problem statement and its programmable solutions to the students. The students can raise the queries about the experiments and the lab instructor will guide the students on how the solution has been designed. Students are graded upon their accomplishments in these experiments. At the end of lab, the lab instructor will assign an unseen task to the students. This unseen task contains all the concepts taught in the lab. These unseen tasks have a higher level of complexity and generally have a greater gain in terms of marks.

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1. SIEVE ANALYSIS

OBJECTIVE AND SCOPE:

The aggregate most of which passes IS 4.75 mm sieve is classified as fine aggregate. The fine aggregate obtained from the natural disintegration of rocks and deposited by streams is known as natural sand. Fine aggregate resulting from the crushing of hard stone and natural gravel is known as crushed stone and crushed gravel is known as crushed stones sand and crushed gravel sand respectively. Aggregate most of which is retained on IS 4.75 mm sieve is known as coarse aggregate. It may be in the form of uncrushed gravel or stone resulting from the natural disintegration of rocks. Crushed gravel or stone aggregate is obtained by crushing gravel or hard stone. The mixture of the above two is classified as partially crushed gravel or stone. Sieve analysis is carried out for the determination of particle size distribution of fine and coarse aggregates by sieving or screening. Sieves of size 80mm, 40mm, 20mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600 micron,s and 150 microns conforming to IS-46 specificationson are used.

APPARATUS:

1) Balance: sensitive to 0.1 percent of the weight of the sample to be weighed.
2) Sieves: 20 cm dia and 5 cm height; provided with screens, top lid, and bottom pan.
3) Rubber Pestle and Mortar
4) Mechanical Rotary Sieve Shaker

Figure 1: Sieves

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PROCEDURE:

Spread the given sample on a container and weigh the given sample. Transfer the weighed sample to the top of the sieves. Cover the top sieve with the lid and sieve on the rotary shaker for 10 minutes. Collect the sample retained on each sieve carefully and weigh each sieve separately by transferring it to a pre-weighed container. Plot the semi-log graph of percent passing versus sieve size. Determine the Nominal Maximum Aggregate Size (NMAS) and maximum size of the aggregates. The aggregate size distributions are classified as gap/skip graded, uniformly graded, well/dense graded, and open-graded.

OBSERVATION AND CALCULATIONS:

Size of sieve	Weight retained	% Weight retained	% Weight passing	Cumulative % Weight retained
4.75mm				
2.36mm				
1.18mm				
600 microns				
300 microns				
150 microns				

2. AGGREGATE ABRASION TEST

OBJECTIVE AND SCOPE:

Due to the movement of traffic, the road stones used in the surfacing course are subjected to wearing action on the top. When fast-moving traffic fitted with pneumatic tires moves on the road, the soil particles present between the wheel and the road surface causes abrasion on the road stone. Thus, road stones should be hard enough to resist abrasion due to the traffic.

APPARATUS:

1) Los Angeles machine which consists of a hollow steel cylinder, closed at both ends, having an inside diameter of 70cm and an inside length of 50cm.
2) Abrasive charge consisting of cast iron spheres app 4.8cm in diameter and 390 to 445g in weight are used.
3) Sieves.

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Figure 2: Los Angeles Abrasion Testing Machine

PROCEDURE:

The test sample consists of clean aggregates dried in an oven at 105 – 110°C. The sample should conform to any of the gradings.

Select the grading to be used in the test such that it conforms to the grading being used in the construction, to the maximum extent possible. Take 5 kg of sample for grading A, B, C & D, and 10 kg for grading E, F & G. Choose the suitable abrasive charge depending on the grading of aggregates. Place the aggregates and abrasive charge in the cylinder and fix the cover.

Rotate the machine at a speed of 30 – 33 revolutions per minute. The number of revolutions is 500 for grades A, B, C & D and 1000 for grading E, F & G. The machine should be balanced and driven such that there is uniform peripheral speed. Stop the machine after the desired number of revolutions and discharge material to a tray. Sieve the entire material on a tray through 1.70 mm IS sieve. Weigh the material retained on a 1.70 mm IS sieve correct to one gram.

OBSERVATION AND CALCULATIONS:

The difference between the original and final weights of the sample is expressed as a percentage of the original weight of the sample is reported as the percentage wear.

Let the original weight of aggregates =W_1 g

Weight of aggregates retained on 1.70mm IS sieve after the test =W_2 g

Loss in weight due to wear = (W_1-W_2) g

Los Angeles Abrasion value, % = percentage wear =

$$\frac{(W_1 - W_2)}{W_1} * 100$$

Test values and calculation	Test Number		Average
	1	2	
1) Weight of specimen = W_1 g. 2) Weight of specimen after Abrasion test, coarser than 1.70mm IS sieve = W_2 g 3) Percentage wear = $\frac{(W_1 - W_2)}{W_1} * 100$			

RESULT:

The result of the Los Angeles Abrasion test is expressed as percentage wear and the average value of the two tests.

Los Angeles Abrasion value =

3. SOUNDNESS TEST

OBJECTIVE & SCOPE:

This test is intended to study the resistance of aggregates to weathering action. In order to quicken the effect of weathering due to alternate wet-dry and or freeze-thaw cycles in the laboratory, the resistance to disintegration of aggregate is determined by soaking the specimen in saturated solution of sodium sulphate or magnesium sulphate.

APPARATUS:

1) Containers for aggregate.
2) Sieves.
3) Balance.
4) Device for temperature regulation and a drying oven.
5) A balance of capacity 5kg.

PROCEDURE:

Saturated solution of Sodium sulphate (the anhydrous Na_2SO_4 or the crystalline $Na_2SO_410H_20$) is prepared in water at a temperature of 25°C to 30°C. The solution is maintained at a temperature of 27 °C and stirred at frequent intervals, until it is used. At the time of using the solution should have a specific gravity of not less than 1.151 and not more than 1.171 and discolored solution should not be used. It may be necessary to use not less than 420 gm of anhydrous salt or 1300 gm of the crystalline decahydrate salt per liter of water.

Alternatively, saturated solution of Magnesium sulphate may be prepared by dissolving either anhydrous ($MgSO_4$ or crystalline ($MgSO_47H_20$) magnesium sulphate. At the time of using, the solution should have a specific gravity of not less than 1.295 and not more than 1.308. Not less than 400g of the anhydrous salt or 1600 gm of the crystalline heptahydrate may be used per liter of water.

The specimen of coarse aggregate for the test may be prepared after removing the fraction finer than 4.75 IS sieve. The sample should be of such a size that it would yield not less than the following amounts of the different sizes which should be available in amount of 5 percent or more.

After the immersion period, the aggregates are removed from the solution drained for about 15 minutes and placed in the drying oven maintained at a temperature of 105°C to 110°C. The

samples are dried to a constant weight at this temperature by checking the weights after 4 hours up to 18 hours. When the successive weights differ by less than 12 mg, it may be considered that constant weight has been attained and then it may be allowed to cool to room temperature. Then the aggregates are again immersed in the prepared solution, for the next cycle of immersion and drying. The number of cycles of alternate immersion and drying are minimum 5 for road aggregates

The sample of coarse aggregate should be thoroughly washed and dried to a constant weight at 105°C to 110°C and is separated to different size ranges, as given above, by sieving. The proper weight of the sample for each fraction is weighed and placed in separate containers for the test. In the case of fraction coarser than 20 mm. the particles are also counted. The samples are immersed in the prepared solution of sodium sulphate or magnesium sulphate for 16 to 18 hours in such a manner that the solution covers them to a depth of at least 15 mm. The containers are kept covered to reduce evaporation and during the period of immersion, the temperature of the solution is maintained at 27°C$\pm$1°C.

After completion of the final cycle, the sample is cooled washed free from the sulphate. This may be determined when there is no more reaction of the wash water with barium chloride (i.e. when there is no white precipitation when barium chloride is added to wash water, it can be said that there is no sulphate with wash water). Each fraction of the sample is then dried to constant temperature of 105°C to110°C and weighed.

OBSERVATION AND CALCULATIONS:

Sieve size, mm		Grading of Original Sample Percent	Weight of Test Fraction Before Test (grams)	Percentage Passing Finer Sieve After Test (actual percent loss)	Average Weight (corrected percent loss)
Passing	Retained				
63					
40					
20					
10					

4. AGGREGATE IMPACT VALUE

OBJECTIVE AND SCOPE:

Due to traffic loads, the road stones are subjected to the impact and there is possibility of stones breaking into the smaller pieces. The road stones should be tough enough to resist fracture under impact. The aggregate impact value indicates a relative measure of the resistance of aggregate to a sudden shock or an impact. The aggregate Impact value indicates a relative measure of the resistance of aggregate to a sudden shock or an Impact, which in some aggregates differs from its resistance to a slope compressive load in crushing test. A modified Impact test is also often carried out in the case of soft aggregates to find the wet Impact value after soaking the test sample.

APPARATUS:

1) Impact testing machine
2) Measure of 7.5cm and depth 5cm.
3) Tamping rod of diameter 1cm and 23cm long.
4) Sieve of size 12.5mm, 10 mm and 2.36mm.
5) Balance of capacity not less than 500g.

PROCEDURE:

The aggregates are filled in a cylindrical measure in three layers and each layer is tamped 25 times with the help of tamping rod. The test sample is then weighed. The cup is fixed firmly in position on the base of the machine and the whole of the test sample from the cylindrical measure is transferred to the cup and compacted by tamping with 25 strokes. The hammer is raised until its lower face is 38cm above the upper surface of the 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 1 sec. The crushed aggregate is then removed from the cup and the whole of it is sieved on the 2.36mm sieve. The fraction retained on the sieve is then weighed.

OBSERVATION AND CALCULATIONS:

Let the original weight of the oven dry sample be W_1g and the weight of the fraction passing 2.36mm IS sieve be W_2 g.

Aggregate Impact value, % = 100 x (W_3/ W_1)

OBSERVATION:

Serial No.	Details	Trial number		Average
		1	2	
1	Total weight of aggregate sample filling the cylindrical measure = W_1g			
2	Weight of aggregate passing 2.36mm sieve after the test = W_2 g			
3	Weight of aggregate retained on 2.36mm sieve after the test = W_2 g			
4	Difference in weight = W_1- (W_2+W_3) g			
5	Aggregate Impact value = percent fines = $\frac{100 * W_2}{W_1}$ %			

RESULT:

The mean of the two results is reported as the aggregate Impact value of the specimen to the nearest whole number.

The Aggregate impact Value of the given aggregate is_____%

5. AGGREGATE CRUSHING TEST

OBJECTIVE AND SCOPE:

Aggregates should be strong enough to resist crushing under traffic wheel loads. The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load. Aggregates possessing a low crushing value should be preferred. This is one of the major mechanical properties required in a road stone. With this the aggregates should also provide sufficient resistance to crushing under the roller during construction and under rigid tyre rims of heavily loaded animal drawn vehicles. The crushing strength or aggregate crushing value of a given road aggregate is found out as per IS-2386 Part- 4

APPARATUS:

1) Steel cylinder with open ends and internal diameter 25.2cm, square base plate plunger having a piston of diameter 15cm.
2) Cylindrical measure having internal diameter of 11.5cm and height 18cm.
3) Steel temping rod with one rounded end, having a diameter of 1.6cm and length 45 to 60cm.
4) Compressions testing machine capable of applying load of 40 tons, at a uniform rate of loading of 4 tons per minute.

PROCEDURE:

The aggregate passing 12.5mm sieve and retained on 10 mm IS sieve is selected for standard test. The cylindrical measure is filled by the test sample of aggregate in three layers of approximately equal depth, each layer being tamped 25 times by tamping rod. The test sample is then weighed. The cylinder of test sample is placed on base plate; one third of the test sample is placed in the cylinder and tamped 25 times by tamping rod. Similarly, the other two parts of the test specimen are added, each layer being subjected to 25 blows. The surface of aggregates is leveled and the cylinder with the test sample and the plunger is placed on the compression testing machine. Load is then applied through the plunger at the uniform rate of 4 tons per min until the total load is 40 tons, and then the load is released. Aggregates including

the crushed portion are removed from the cylinder and sieved on a 2.36mm IS sieve. The material which passes this sieve is collected.

OBSERVATION AND CALCULATIONS:

Total weight of dry sample taken = W_1 g. Weight of the portion of crushed material passing 2.36mm IS sieve =W_2 g.

The aggregate crushing value = 100 W_2/ W_1

Sample No	Total weight of dry sample, W_1g	Weight of fines passing 2.36mm IS sieve, W_2 g	Aggregate crushing value = $\frac{100 * W_2}{W_1}$ %
(1)	(2)	(3)	(4)
1.			
2.			

RESULT:

The mean of the crushing value obtained in the two tests is reported as the aggregate crushing value.

The mean (average) of the crushing value aggregate is _____%

6. SPECIFIC GRAVITY AND WATER ABSORPTION TEST

OBJECTIVE AND SCOPE:

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 considered as weaker than those with higher Specific Gravity values. Stones having more water absorption are more pours in nature and are generally considered unsuitable.

APPARATUS:

4) A balance of capacity about 3kg, to weigh accurate to 0.5 g.
5) Perforated container of convenient size with convenient size with thin wire hangers for suspending it from the balance.
6) A container for filling water and suspending the basket.
7) An air tight container of capacity similar to that of the basket.
8) A shallow tray and two dry absorbent clothes, each not less than 75 x 45cm.

PROCEDURE:

About 2 kg of the aggregate sample is washed 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 a cover of at least 5cm of water above the top of the basket. Immediately after the immersion the entrapped air is removed from the sample by lifting the basket containing it 25mm above the base of the tank and allowing it to drop 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$\pm$ ½ hour afterwards.

The basket and the sample are then weighed. The weight is noted while suspended in water = W_1g. 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 g.

The aggregates placed on the dry absorbent clothes are surface dried and then the aggregates are transferred to the second dry cloth spread in single layer, covered and allowed to

dry at least for 10 minutes until the aggregates are completely surface dry, 10 to 60 minutes drying may be needed. The surface dried aggregate is then weighed =W_3 g. The aggregates are placed in a shallow tray and kept in an oven maintained at a temp of 110°C for 24 hours. It is then removed from the oven, cooled in an air tight container and weighed = W_4 g.

OBSERVATION AND CALCULATIONS:

1) Specific Gravity = $\frac{W_4}{W_3-(W_1-W_2)}$
2) Apparent Specific Gravity = $\frac{W_4}{W_4-(W_1-W_2)}$
3) Water Absorption = $\frac{(W_3-W_4)*100}{W_4}$ percent

Details	Test Number		Mean Value
	1	2	
Weight of saturated aggregate and basket in water = W_1 g			
Weight of basket in water =W_2g			
Weight of saturated surface dry aggregates in water =W_3 g			
Weight of oven dried aggregates in air =W_4g			
Specific Gravity = $\frac{W_4}{W_3-(W_1-W_2)}$			
Apparent Specific Gravity = $\frac{W_4}{W_4-(W_1-W_2)}$			
Water Absorption = $\frac{(W_3-W_4)*100}{W_4}$ percent			

7. SHAPE TESTS

7 (a). ELONGATION INDEX TEST

OBJECTIVE AND SCOPE:

The particle shape of the aggregate mass is determined by the percentage of flaky and elongated particles in it. Aggregates which are flaky or elongated are detrimental to higher workability and stability of mixes.

APPARATUS:

1) Length Gauge
2) Sieves
3) Balance to weigh the samples.

Figure 3: Length gauge

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PROCEDURE:

The sample is sieved and a minimum of 200 pieces of each fraction is taken and weighed. The pieces of aggregates from each fraction tested which could not pass through the specified gauge length with its long side are elongated particles and are collected separately to find the total weight of aggregate retained on the length gauge from each fraction. The total amount of elongated material retained by the length gauge is weighed to an accuracy of at least 0.1% of the weight of the test sample.

OBSERVATIONS AND CALCULATIONS:

Elongation Index: The amount of elongated material is weighed to an accuracy of 0.1 percent of the test sample If W_1, W_2, …, Wi are the total weights of each size of aggregates taken. If X_1, X_2, …, Xi are the weights of material retained on different length gauges then

Passing through I.S. Sieve, (mm)	Retained on I.S. Sieve, (mm)	Weight. Of the fraction consisting of at least 200 pieces (gm)	Weight of aggregate in each fraction retained on length gauge grams	Length gauge size, (1.8 times the mean sieve) (mm)
25	20	W_1	X_1	40.5
20	16	W_2	X_2	32.4
16	12.5	W_3	X_3	25.6
12.5	10	W_4	X_4	20.2
10	6.3	W_5	X_5	14.7

$$\text{Elongation index} = \frac{X}{W} * 100$$

7 (b). FLAKINESS INDEX TEST

OBJECTIVE AND SCOPE:

To determine the percentage of elongated material in the aggregate material. Flakiness Index is the percentage by weight of particles in it, whose least dimension (Thickness) is less than three-fifths of its mean dimension. The test is not applicable to particles Smaller than 6.3 mm in size.

APPARATUS:

1) Thickness Gauge
2) Sieves
3) Balance to weigh the samples.

Figure 4: Thickness gauge

PROCEDURE:

The portion of coarse aggregate sample passing through 6.3 mm sieve is not subjected to flakiness index and therefore the sample is first sieved and the portion passing 6.3 mm sieve is removed. The flakiness index of a sample of coarse aggregate is carried out in two stages. In the first stage sieve analysis is carried out and the aggregates are separated into specified size ranges and in the second stage, the flaky particles are separated from each size range.

OBSERVATIONS AND CALCULATION:

The amount of flaky material is weighed to an accuracy of 0.1 percent of the test sample If W_1, W_2… W_i are the total weights of each size of aggregates taken If X_1 X_2…. X_i are the weights of material passing the different thickness gauges then:

Passing through I.S. Sieve, (mm)	Retained on I.S. Sieve, (mm)	Weight. Of the fraction consisting of at least 200 pieces (gm)	Weight of aggregate in each fraction retained on length gauge grams	Length gauge size, (1.8 times the mean sieve) (mm)
25	20	W_1	13.50	X_1
20	16	W_2	10.80	X_2
16	12.5	W_3	8.55	X_3
12.5	10	W_4	6.75	X_4
10	6.3	W_5	4.89	X_5

$$\text{Flakiness index} = \frac{X}{W} * 100$$

8. PENETRATION TEST

OBJECTIVE AND SCOPE:

Penetration measures the hardness or the softness of the bitumen. The consistency of bitumen is determined by penetration test, the consistency measured is then used for grading of the bitumen. The penetration of a bituminous material is the distance in tenths of a mm, that a standard needle would penetrate vertically, into a sample of the material maintained at 25°C during a time duration of 5 sec, the total weight of the needle assembly being 100g. The softer the bitumen, the greater will be the penetration. Softer grade bitumen is preferred in cold regions whereas bitumen with lower penetration value is used in hot climatic conditions.

APPARATUS:

1) Container
2) Water Bath
3) Standard Penetrometer
4) Transfer Tray

Figure 5: Standard Penetrometer

PROCEDURE:

The bitumen sample is heated to a temperature of 75 to 100°C above the softening point. The sample material is thoroughly stirred to make it homogeneous and free from air bubbles and water. The sample is then poured into containers of 35 mm depth; the sample containers are placed in trays and cooled at temperatures between 15 to 30°C for 60 to 90 minutes. The tray with sample container is placed in thermostatically controlled bath at a temperature of 25°C for a period of 60 to 90 minutes.

Transfer tray with the samples from the water bath and place under the needle of the Penetrometer. The needle of the assembly is lowered and the tip of the needle is made to touch the top surface of the bitumen sample and the needle assembly is clamped in this position. The total weight of the assembly should be 100g. The initial reading of the Penetrometer dial is either adjusted to zero or the initial reading is taken before releasing the needle. The needle is released exactly for the period of 5 seconds by pressing the knob and the final reading is taken on the dial. The test is repeated on the sample by conducting the repeat test at a distance not less than 10 mm apart.

OBSERVATION AND CALCULATIONS:

The average of the three penetration readings is taken as the penetration value.

Grade of bitumen		
No.	Dial Gauge Reading	Penetration Value (0.1 mm)

9. SOFTENING POINT TEST

OBJECTIVE & SCOPE:

As the temperature increases, bitumen gradually became softer until it flows readily. The softening point is the temp at which the substance attains particular degree of softening under specified conditions of test. Unlike some substances, bituminous materials do not have a definite melting point. Instead, as the temperature rises, these materials slowly change from brittle or very thick and slow-flowing materials to softer and less viscous liquids. For this reason, the determination of 'softening point' must be made by a fixed, arbitrary and closely defined method if results are to be comparable

APPARATUS:

1. Ring and ball apparatus
2. Steel balls
3. Brass rings
4. Thermometer
5. Bath & Stirrer

Figure 6: Softening Point Apparatus

PROCEDURE:

Sample material is heated to a temperature between 75°C and 100°C above the appropriate softening point until it is completely fluid and is poured in heated rings placed on metal plate. After cooling the rings in air for 15 minutes, the excess bitumen is trimmed. At this time the temperature of distilled water is kept at 5°C .This temperature is maintained for 15 min after which the balls are placed in position .The temp of water is raised at uniform rate of 5°C per min with a controlled heating unit until the bitumen softens and touches the bottom plate by sinking of balls.

OBSERVATION AND CALCULATIONS:

The temperature at the instant when each of the balls and sample touches the bottom plate of support is recorded as softening value.

Softening point (◦C) =

10. DUCTILITY TEST

OBJECTIVE & SCOPE:

In the flexible pavement construction where bitumen binders are used, it is of significant importance that the binders form ductile thin films around the aggregates. This serves as a satisfactory binder in improving the physical interlocking of the aggregates. The ductility of a bituminous material is measured by the distance in cm to which it will elongate before breaking when a standard briquette specimen of the material is pulled apart at a specified speed and a specified temperature.

APPARATUS:

1) Ductility Testing machine
2) Standard briquette mould
3) Water bath
4) Thermometer – Range 0 to 44°C, Graduation 0.2°C

Figure 7: Ductility Testing Machine

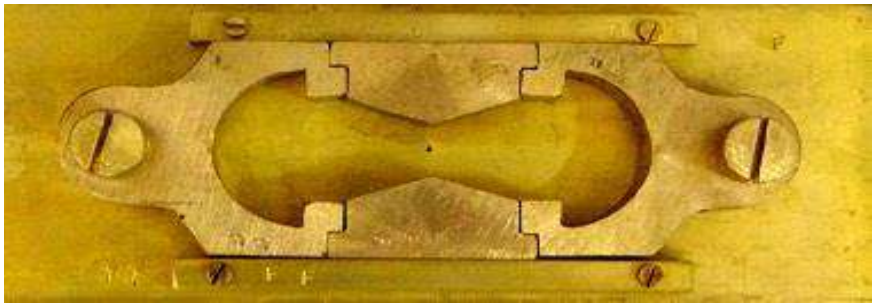

Figure 8: Standard Briquette Mould

PROCEDURE:

The bitumen sample is melted and is strained through IS sieve 30, poured in the mould assembly and placed on a brass plate, after a solution of glycerin and dextrine is applied at all surfaces of the mould, the plate assembly along with the sample is placed in water bath maintained at 20°C for 30 minutes. The sample and mould assembly are removed from water bath and excess bitumen material is cut off, the mould assembly containing sample is replaced in water bath. The sides of the mould are now removed and the clips are carefully booked on the machine without causing any initial strain.

OBSERVATION AND CALCULATIONS:

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

Ductility value of the sample:

Grade of Bitumen	
No.	Ductility (cm)
1	
2	
3	

11. FLASH AND FIRE POINT TEST

OBJECTIVE & SCOPE:

The flash point of the material is the lowest temp at which the vapor of substance momentarily takes a fire in the form of a flash under specified condition of test.

The fire point is the lowest temp at which the material gets ignited and burns under specified conditions of test.

APPARATUS:

1) Pensky-Martens apparatus
2) Thermometer- Low Range: -7 to 110°C, Graduation 0.5°C
   High Range: 90 to 370°C, Graduation 2°C

Figure 9: Pensky-Martens Apparatus

PROCEDURE:

The material is filled in a cup up to a filling mark. The bitumen sample is then heated. The heating is done at the rate of 5 to 6 degree per min. The stirring is done at the rate of approximately 60 revolutions per min. The flame is applied at interval depending upon the expected flash and fire points. First application is made at least 17°C below the actual flash point and then at every 1 to 3°C. The stirring is discontinued during the application of the test flame.

OBSERVATION AND CALCULATIONS:

The flash point is taken as the temp read on the thermometer at the time of the flame application that causes a bright flash in the interior of the test system.

Flash point temperature (°C) =

Fire point temperature (°C) =

12. SPECIFIC GRAVITY TEST FOR BITUMEN

OBJECTIVE & SCOPE:

The specific gravity is greatly influenced by the chemical composition of binder. The 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 being specified as 27^{o}C ± 0.1^{o}C.

APPARATUS USED:

1) Analytical balance.
2) Pan straddle.

PROCEDURE:

In balance method the bitumen test specimen is cube shaped, about 12 mm on each edge. It is prepared by pouring the liquefied bitumen sample in grass mould to provide the sample of required dimensions and is cooled. The sample is weighed in air and is then weighed in distilled water maintained at 27°C±0.1°C.

OBSERVATION AND CALCULATIONS:

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

Where e = weight of the dry specimen

f = weight of the specimen, when immersed in distilled water.

Sample No	Weight of Dry Sample	Weight of Sample in Distilled Water, G	Specific Gravity
1			
2			
3			
4			

13. VISCOSITY TEST OF BITUMEN BY USING CAPILLARY VISCOMETER

OBJECTIVE & SCOPE:

This test method covers procedures for the determination of viscosity of asphalt binder (bitumen) by vacuum capillary viscometers at 60°C.

APPARATUS:

1) Viscometers- Cannon-Manning Vacuum Viscometer.
2) Thermometers
3) Bath
4) Vacuum System
5) Timer

Figure 10: Cannon Manning viscometer

PROCEDURE:

Maintain the bath at the test temperature within ±0.03°C. Apply the necessary corrections, if any, to all thermometer readings. Select a clean, dry viscometer that will give a flow time greater than 60 s, and preheat to 135±5.5°C.

Charge the viscometer by pouring the prepared sample to within 62 mm of fill line *E*. Place the charged viscometer in an oven or bath maintained at 135±5.5°C for a period of 10± 2 min, to allow large air bubbles to escape. Remove the viscometer from the oven or bath and, within 5 min, insert the viscometer in a holder, and position the viscometer vertically in the bath so that the upper most timing mark is at least 20 mm below the surface of the bath liquid. Establish a 40.0±0.07 kPa [300 ±0.5 mm Hg] vacuum below atmospheric pressure in the vacuum system and connect the vacuum system to the viscometer with the toggle Valve or stopcock closed in the line leading to the viscometer.

After the viscometer has been in the bath for 30 ± 5 min, start the flow of asphalt in the viscometer by opening the toggle valve or stopcock in the line leading to the vacuum system. Measure to within 0.1 s the time required for the leading edge of the meniscus to pass between successive pairs of timing marks.

Report the first flow time which exceeds 60s between a pair of timing marks, noting the identification of the pair of timing marks. Upon completion of the test, clean the viscometer thoroughly by several rinsings with an appropriate solvent completely miscible with the sample, followed by a completely volatile solvent. Dry the tube by passing a slow stream of filtered dry air through the capillary for 2 minutes, or until the last trace of solvent is removed.

OBSERVATION AND CALCULATIONS:

Select the calibration factor that corresponds to the pair of timing marks used for the determination. Calculate and report the viscosity to three significant figures using the following equation:

Viscosity, Pa.s = (Kt)

where:

K = selected calibration factor, Pa · s/s, and

t = flow time, s.

14. MARSHALL STABILITY TEST

OBJECTIVE AND SCOPE:

To determine the optimum binder content of given bituminous mix by Marshall Method of Mix Design.

APPARATUS:

1) Mould Assembly: Cylindrical moulds of 10 cm diameter and 7.5 cm height consisting of a base plate and collar extension.

2) Sample Extractor

3) Compaction Pedestal and Hammer: Used to compact a specimen by 4.54 kg weight with 45.7 cm height of fall.

4) Breaking Head: Used to test the specimen by applying a load on its periphery perpendicular to its axis in a loading machine of 5 tones capacity at a rate of 5 cm/min.

5) Loading Machine: Measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/min at 60°C.

6) Flow Meter: An attached dial gauge measuring the flow value as a result of the loading in 0.25 mm increments.

7) Thermometers

8) Water Bath

9) Oven

Figure 11: Marshall Testing Machine

PROCEDURE:

In the Marshall test method of mix design three compacted samples are prepared for each binder content. At least four binder contents are to be tested to get the optimum binder content.

Prepare a mix of coarse aggregates, fine aggregates and mineral filler material in such a proportion that final mix after blending has the graduation within the specified range. Take approximately 1200 grams of aggregates and filler, and heat them to a temperature of 175 to 195°C. Clean the compaction mould assembly and rammer, and heat to a temperature of 100 to 145°C. Heat the bitumen to a temperature of 121 to 138°C and add the required quantity of first trial percentage of bitumen to the heated aggregate and thoroughly mix using a mechanical mixer or by hand mixing with trowel. Then heat the mix at a temperature of 150to 160°C. Transfer the mix into the pre-heated mould and compact it by giving seventy-five blows on each side. Soon after the compacted bituminous mix specimens have cooled to room temperature, take the sample out of the mould using the sample extractor and measure the weight, average thickness and diameter of the specimen. Weigh the specimens in air and then in water. Determine the theoretical specific

gravity of the mix using the known specific gravity values of different aggregates, filler and bitumen. Calculate the bulk density value of the specimen from weight and volume. Then immerse the specimen to be tested under water in a thermostatically controlled water bath maintained at 60 ± 10C for 30 to 40 minutes. Take out the specimens from the water bath and place them in the Marshall loading machine to measure the marshal stability and flow values. If the average height of the specimen is not exactly 63.5mm, then correct the Marshall Stability value of each specimen by applying the appropriate correction factor. Plot five graphs with values of bitumen content against the values of density, Marshall Stability, voids in mineral aggregates (VMA), flow value and voids filled by bitumen (VFB). Let the bitumen contents corresponding to maximum density be B_1, corresponding to maximum stability be B_2 and that corresponding to the specified voids content (at 4.0%) be B_3. Then the optimum bitumen content for mix design is given by B_o= (B1+B2+B3)/3.

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OBSERVATION AND CALCULATIONS:

Specification for Aggregate Selection					
No.	Sieve size (Passing)	Specification Range (%) Pass	Our Selection	% Retained	Sample Wt. (g)
0	25.0 mm to 19.0 mm	100			
1	19.0 mm to 12.5 mm	66 – 95			
2	12.5 mm to 9.5 mm	54 – 88			
3	9.5 mm to 4.75 mm	37 – 70			
4	4.75 mm to 2.36 mm	26 – 52			
5	2.36 mm to 1.18 mm	18 – 40			
6	1.18 mm to 600 µm	13 – 30			
7	600 µm to 300 µm	8 ¯ 23			
8	300 µm to 150 µm	6 ¯ 16			
9	150 µm to 75 µm	4 ¯ 10			
10	< 75 µm (filler) Pan	0			
				Total weight = 1200 grams	

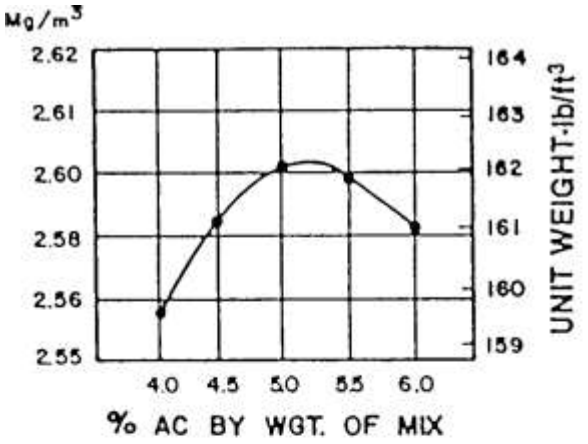
% Bitumen	Wt. of bitumen

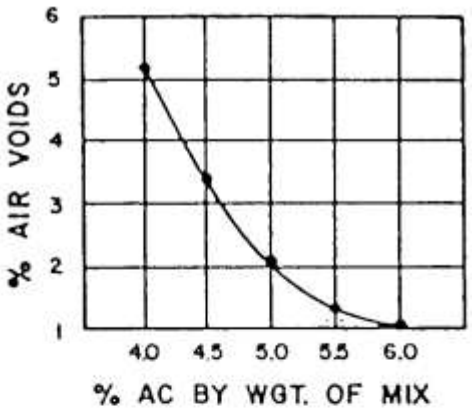
	Specific Gravity
Coarse Aggregate	
Fine Aggregate	
Filler	
Bitumen	

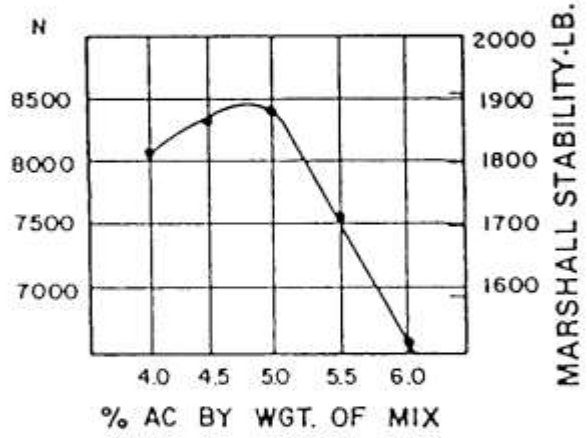
	% of Total Aggregate
Coarse Aggregate =	
Fine Aggregate =	
Filler (Agg. dust) =	

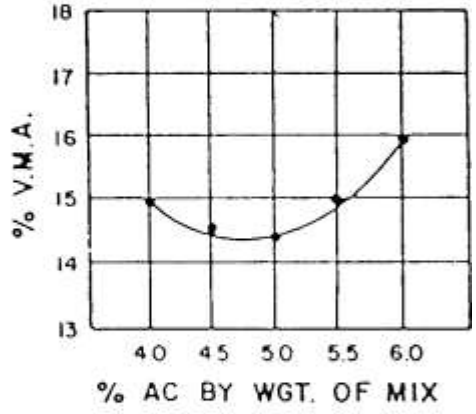
Aggregate grading type															
Mixing temp												Grade of Bitumen			
No. of blows												Compaction temperature			
% Asphalt by Weight of Total Aggregate Mix	Weight of specimen (g)						G_{BCM}			Stability			Flow		
	In Air			In Water											
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3

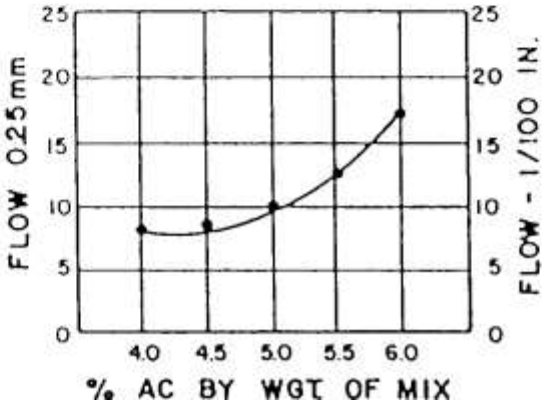
Asphalt % by weight of Total Aggregate Mix	G_{BCM}	Volume	G_{BAM}	Gmp	VMA	P_{AV}	Stability		Flow
							Obs.	Corr.	


Mg/m3
2.62
2.61
2.60
2.58
2.56
2.55
164
163
162
161
160
159
UNIT WEIGHT-lb/ft3
4.0 4.5 5.0 5.5 6.0
% AC BY WGT. OF MIX


6
5
4
3
2
1
% AIR VOIDS
4.0 4.5 5.0 5.5 6.0
% AC BY WGT. OF MIX


N
8500
8000
7500
7000
2000
1900
1800
1700
1600
MARSHALL STABILITY-LB.
4.0 4.5 5.0 5.5 6.0
% AC BY WGT. OF MIX


18
17
16
15
14
13
% V.M.A.
4.0 4.5 5.0 5.5 6.0
% AC BY WGT. OF MIX


25
20
15
10
5
0
FLOW 0.25 mm
FLOW - 1/100 IN.
4.0 4.5 5.0 5.5 6.0
% AC BY WGT OF MIX