MAHA BARATHI ENGINEERING COLLEGE

NH-79, SALEM-CHENNAI HIGHWAY, A.VASUDEVANUR, CHINNASALEM TK, KALLAKURICHI DT – 606 201.
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www.mbec.ac.in | 04151-256333, 257333 | mbec123@gmail.com

DEPARTMENT OF CIVIL ENGINEERING

CE3511 – HIGHWAY ENGINEERING LABORATORY

(Regulation 2021)

PREPARED BY

Mr.S.SELVAKUMAR
ASST.PROFESSOR / CIVIL

VERIFIED BY

Mr.P. ASHOK M.E.,
HOD / CIVIL

ANNA UNIVERSITY, CHENNAI SYLLABUS
(R-2021)

CE3511 – HIGHWAY ENGINEERING LABORATORY

OBJECTIVE

- To learn the principles and procedures of testing of materials used in the construction of highways.

LIST OF EXPERIMENTS

I TEST ON AGGREGATES

1) Specific gravity determination of the coarse aggregate sample
2) Determination of abrasion value of the coarse aggregate sample.
3) Determination of water absorption capacity of the coarse aggregate sample.

II TEST ON BITUMEN

4) Specific gravity determination of the bitumen/asphalt sample.
5) Determination of consistency of the bituminous material.
6) Viscosity determination of bituminous binder.
7) Determination of softening point of the asphalt/bitumen sample
8) Determination of ductility value of the bitumen sample
9) Estimation of loss of bitumen on heating
10) Determination of optimum binder content by Marshall method

III BITUMINOUS MIXES

11) Determination of stripping value of the bituminous mix Demonstration
12) Determination of bitumen content in the bituminous mix by cold solvent extraction method

COURSE OUTCOME:

CO1 Characterize Pavement Aggregate through relevant test.
CO2 Ascertain the Quality of Bitumen.
CO3 Determine the Optimum Binder Content Using Marshall Method.
CO4 Evaluate the Consistency and Properties of Bitumen.
CO5 Determine the Bitumen Content in the Bituminous Mixes

TOTAL: 60 PERIODS

ANNA UNIVERSITY, CHENNAI

LAB MANNERS

- Students should bring their own calculators, drawing instruments, charts, data book, etc. whenever needed.
- Students should wear their own lab coats and bring observation note books to the laboratory classes regularly.
- Record of experiments done in a particular class should be submitted in the next lab class.
- Students who do not submit the record note book in time will not be allowed to do the next experiment and will not be given attendance for that laboratory class.
- Students will not be allowed to leave the laboratory until they complete the experiment

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SIGNATURE OF THE FACULTY **AVERAGE MARKS**

DETERMINATION OF LOS-ANGELES ABRASION VALUE

Exp No:

DATE:

AIM:

- To determine Los Angeles abrasion value
- To find out the suitability of aggregates for its use in road construction.

THEORY:

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

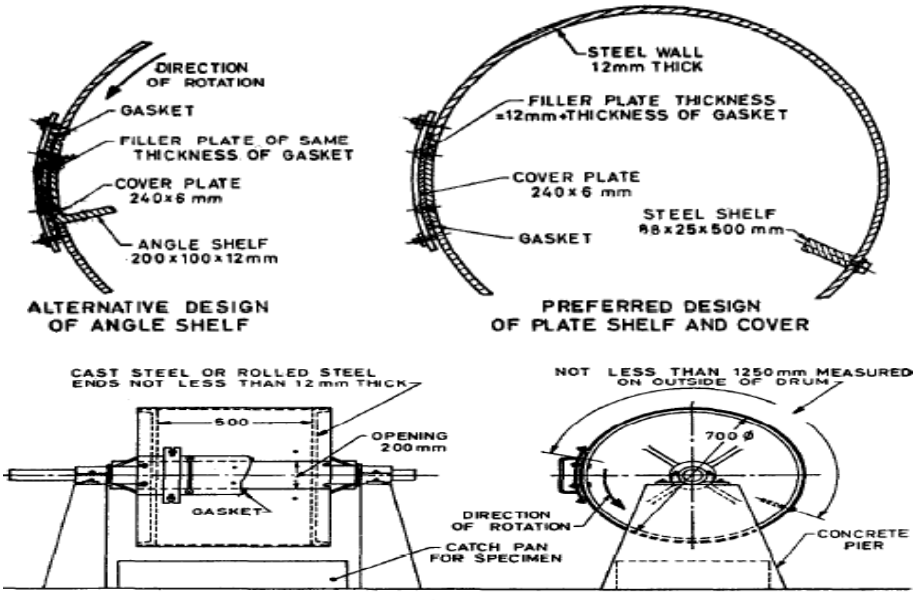
The principle of Los Angeles abrasion test is to produce the abrasive action by use of standard steel balls which when mixed with the aggregates and rotated in a drum for specific number of revolutions also causes impact on aggregates. The percentage wear of the aggregates due to rubbing with steel balls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

REFERENCE CODES:

IS: 2386 (Part IV) - 1963.

APPARATUS USED:

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



NOTE 1 — Shaft bearing will be mounted on concrete piers or other rigid supports.
NOTE 2 — Suggested horse power for motor is not less than one.

All dimensions in millimetres.

- Sieve: The 1.70 mm IS sieve
- Balance of capacity 5 kg or 10 kg
- Drying oven

PROCEDURE:

a) Clean and dry aggregate sample confirming to one of the grading A to G is used for the test. (Refer table 1)
b) Aggregates weighing 5 Kg for grading A, B, C or D and 10 Kg for gradings E, F or G may be taken as test specimen and placed in the cylinder.
c) The abrasive charge is also chosen in accordance with the above table and placed in the cylinder of the machine, and cover is fixed to make dust tight.
d) The machine is rotated at a speed of 30 to 33 revolutions per minute.
e) The machine is rotated for 500 revolutions for gradings A, B, C and D, for gradings E, F and G, it shall be rotated for 1000 revolutions.
f) After the desired number of revolutions, the machine is stopped and the material is discharged from the machine taking care to take out entire stone dust.
g) Using a sieve of size larger than 1.70 mm I.S sieve, the material is first separated into two parts and the finer position is taken out and sieved further on a 1.70 mm I.S sieve.
h) Let the original weight of aggregate be gm, weight of aggregate retained on 1.70 mm I.S sieve after the test be gm.

Los Angeles abrasion value (%) = × 100

OBSERVATION:

Sl. No.	Details of sample	Trial 1	Trial 2	Trial 3	Average
1.	Weight of Specimen, W_1 gm				
2.	Weight of specimen after abrasion test, coarser than 1.70 mm IS sieve, W_2 gm				
3.	Percentage wear = × 100				

RESULT:

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

SPECIFIC GRAVITY AND WATER ABSORPTION

Exp No:

DATE:

AIM: To determine water absorption of the given aggregate sample.

THEORY:

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

REFERENCE CODES:

IS: 2386 (Part III) - 1963.

APPARATUS USED:

- A wire basket of not more than 6.3mm mesh or a perforated container of convenient size with thin wire hangers for suspending it from the balance.
- A thermostatically controlled oven to maintain temperature of 100° to 110°C.
- A container for filling water and suspending the basket.
- An airtight container of capacity similar to that of the basket.
- A balance of capacity about 5 kg to weigh accurate to 0.5 g and of such a type and shape as to permit weighing of the sample container when suspended in water.
- A shallow tray and two dry absorbent clothes, each not less than 750 × 450 mm.

PROCEDURE:

a) About 2 kg of the aggregate sample is washed thoroughly to remove fines, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22° to 32°C with a cover of at least 50mm of water above the top of the basket.

b) Immediately after immersion the entrapped air is removed from the sample by lifting the basket containing it 25mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per second.

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

d) The basket and the sample are then weighed while suspended in water at a temperature of 22° to 32°C. In case it is necessary to transfer the basket and the sample to a different tank for weighing, they should be jolted 25 times as described above in the new tank to remove air before weighing.

e) This weight is noted while suspended in water W_1 g. The basket and the aggregate are then removed from water and allowed to drain for a few minutes, after which the aggregates are transferred to one of the dry absorbent clothes.

f) The empty basket is then returned to the tank of water, jolted 25 times and weight in water W_2 g.

g) The aggregates placed on the absorbent clothes are surface dried till no further moisture could be removed by this cloth. Then the aggregates are transferred to the second dry cloth spread in a single layer, covered and allowed to dry for at least 10 minutes until the aggregates are completely surface dry. 10 to 50 minutes drying may be needed.

h) The aggregates should not be exposed to the atmosphere, direct sunlight or any other source of heat while surface drying.
i) A gentle current of unheated air may be used during the first ten minutes to accelerate the drying of aggregate surface.
j) The surface dried aggregate is then weighed W3 g. The aggregate is placed in a shallow tray and kept in an oven maintained at a temperature of 110°C for 24 hours.
k) It is then removed from the oven, cooled in an airtight container and weighed W4 g. At least two tests should be carried out, but not concurrently.

OBSERVATIONS:

Sl. No.	Description	Trial 1	Trial 2	Average
1.	Weight of saturated aggregate suspended in water with the basket , W_1 gm			
2.	Weight of basket suspended in water, W_2 gm			
3.	Weight of saturated aggregate in water , $W_S = (W_1 - W_2)$ gm			
4.	Weight of saturated surface dry aggregate in air , W_4 gm			
5.	Weight of water equal to the volume of the aggregate= (W_3-W_S) gm			
6.	Specific Gravity =			
7.	Water absorption = × 100			

RESULT:

a) The Specific Gravity of given aggregate sample is found to be _____.
b) The water absorption of given aggregate sample is found to be_____%.

SPECIFIC GRAVITY OF BITUMEN

Exp No:

DATE:

AIM: To determine the Specific gravity of given Bituminous material.

THEORY:

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

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 at 27ºC±0.1ºC.

REFERENCE CODES:

IS: 1202- 1978

APPARATUS USED:

- Specific gravity Bottle
- Distilled water.

PROCEDURE:

a) The clean, dried specific gravity bottle is weighed let that be W_1 gm.

b) Then it is filled with fresh distilled water and then kept in water bath for at least half an hour at temperature 27°C ± 0.1°C.

c) The bottle is then removed and cleaned from outside. The specific gravity bottle containing distilled water is now weighed. Let this be W_2 gm.

d) Then the specific gravity bottle is emptied and cleaned. The bituminous material is heated to a pouring temperature and the material is poured half the bottle, by taking care to prevent entry of air bubbles. Then it is weighed. Let this be W_3 gm.

e) The remaining space in specific gravity bottle is filled with distilled water at 27°C and is weighed. Let this be W_4 gm. Then specific gravity of bituminous material is given by formula,

$$\text{Specific Gravity} = \frac{\quad}{\quad}$$

OBSERVATION AND CALCULATION:

Description		**Trial 1**	**Trial 2**	**Trial 3**
Weight of specific gravity bottle	W_1 gm			
Weight of bottle + distilled water	W_2 gm			
Weight of bottle + bitumen	W_3 gm			
Weight of bottle + bitumen + water	W_4 gm			

RESULT:

The specific gravity of given bituminous binder is_____.

PENETRATION VALUE

Exp No:

DATE:

AIM: To determine the grade of a given binder.

THEORY:

The consistencies of bituminous materials vary depending upon several factors such as constituents, temperature, etc. As temperature ranges between 25°C and 50°C most of the paving bitumen grades remain in semi-solid or in plastic states and their viscosity is so high that they do not flow as liquid.

Determination of absolute viscosity of bituminous material is not so simple. Therefore the consistency of these materials is determined by indirect methods. The consistency of bitumen is determined by penetration test which is a very simple test. Various types and grades of bituminous materials are available depending on their origin and refining process. The penetration test determines the consistency of these materials for the purpose of grading them, by measuring the depth (in units of one tenth of a millimeter or one hundredth of a centimeter) to which a standard needle will penetrate vertically under specified conditions of standard load, duration and temperature. Thus the basic principle of the penetration test is the measurement of the penetration (in units of one tenth of an mm) of a standard needle in a bitumen sample maintained at 25°C during five seconds, the total weight of the needle assembly being 100gm.

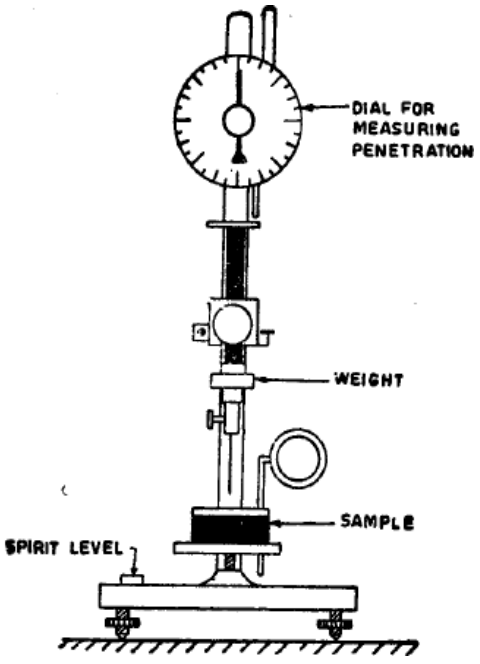
The softer the bitumen, the greater will be the penetration.

REFERENCE CODES:

IS: 1203- 1978

APPARATUS USED:

- container: 55mm in diameter and 35mm to 57mm height
- needle: provided with a shank approximately 3.0mm in diameter into which it is immovably fixed.
- water bath
- penetrometer
- Stop watch etc.



PROCEDURE:

a) The bitumen is softened to a paving consistency between 75° and 100°C above the approximate temperature at which bitumen softens.

b) The sample material is thoroughly stirred to make it homogeneous and free from air bubbles and water.

c) The sample containers are cooled in atmosphere of temperature not lower than 13°C for one hour. Then they are placed in temperature controlled water bath at a temperature of 25°C for a period of one hour.

d) The weight of needle, shaft and additional weight are checked. The total weight of this assembly should be 100gm.

e) Using the adjusting screw, the needle assembly is lowered and the tip of the needle is made to just touch the top surface of the sample.

f) The needle assembly is clamped in this position. The contact of the tip of the needle is checked using the mirror placed on the rear of the needle.

g) The initial reading of the penetrometer dial is either adjusted to zero or the initial reading is noted.

h) Then the needle is released by pressing a button and a stop watch is started. The needle is released exactly for a period of 5.0 secs.

i) At least 3 measurements are made on this sample by testing at distance of not less than 100mm apart.

j) The difference between the initial and final penetration readings are taken as the penetration value.

OBSERVATION AND CALCULATION:

Readings	**Trials**			**Mean Value**
	1	**2**	**3**	
Penetrometer Dial Initial Reading				
Penetrometer Dial Final Reading				
Penetration Value				

RESULT:

The average penetration value of a given bitumen sample is_____and the grade of bitumen is _____.

SOFTENING POINT TEST

Exp No:

DATE:

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

THEORY:

Bitumen does not suddenly change from solid to liquid state, but as the temperature increase, it gradually becomes soften until it flows readily. The softening point is the temperature at which the substance attains particular degree of softening under specified condition of test. For bitumen it is usually determined by Ring and Ball apparatus.

REFERENCE CODES:

IS: 1205- 1978

APPARATUS USED:

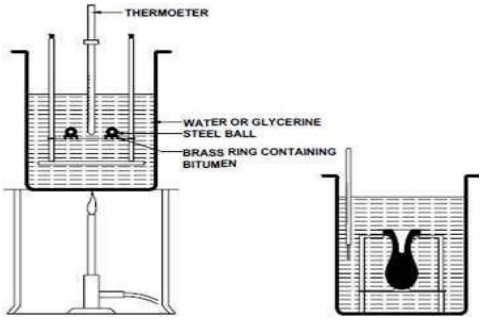
- Ring and Ball apparatus
- Water bath with stirrer
- Thermometer
- Glycerin
- Steel balls each of 9.5mm and weight of 2.5 ± 0.08gm.

PROCEDURE:

a) Sample material is heated to a temperature between 75° and 100°C above the approximate softening point until it is completely fluid and is poured in heated rings placed on the metal plate.

b) To avoid sticking of the bitumen to metal plate, coating is done to this with a solution of glycerin and dextrin.

c) After cooling the rings in air for 30 minutes, the excess bitumen is trimmed and rings are placed in the support.



d) At this time the temperature of distilled water is kept at 5°C. This temperature is maintained for 15 minutes after which the balls are placed in position.

e) Then the temperature of water is raised at uniform rate of 5°C per minute with a controlled heating unit, until the bitumen softens and touches the bottom plate by sinking of balls. At least two observations are made. For material whose softening point is above 80°C, glycerin is used for heating medium and the starting temperature is 35°C instead of 5°C.

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

OBSERVATION AND CALCULATION:

Test Property	Trials			Mean Value
	1	2	3	
Temperature (°C) at which I ball touches the bottom plate				
Temperature (°C) at which II ball touches the bottom plate				
Final Softening Point Temperature				

RESULT:

The softening point value of given bitumen sample is_____0°C and grade of bitumen is_____.

DETERMINATION OF DUCTILITY OF THE BITUMEN

Exp No:

DATE:

AIM:

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

APPARATUS REQUIRED:

Briquette mould, (length – 75mm, distance between clips – 30mm, width at mouth of clips – 20mm, cross section at minimum width – 10mm x 10mm), Ductility machine with water bath a pulling device at a precaliberated rate, a putty knife, thermometer.

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. Pouring temperature oC =
III. Test temperature oC =
IV. Periods of cooling, minutes =

a) In air =
b) In water bath before trimming=
c) In water bath after trimming =

RESULT:

The Ductility value of given bitumen is_____mm.

DETERMINATION OF VISCOSITY OF BITUMINOUS MATERIAL

Exp No:

DATE:

AIM:

To determine the viscosity of bituminous binder.

APPARATUS REQUIRED:

A orifice viscometer **(one of 4.0mm diameter used to test cut back grades 0 and 1 and 10mm** orifice to test all other grades), water bath, stirrer and thermometer.

PROCEDURE:

1. Adjust the tar viscometer so that the top of the tar cup is leveled. Select the test temperature. Heat the water in water bath to the temperature specified for the test and maintains it within $0 \pm \mathbf{0.1}_{\mathbf{C}}$ of the specified temperature throughout the duration of test.
2. Rotate the stirrer gently at frequent intervals or perfectly continuously Clean the tar cup orifice of the viscometer with a suitable solvent and dry thoroughly
3. Warm and stir the material under examination to **20 ^{o}C** above the temperature specified for test and cool, while continuing the stirring.
4. When the temperature falls slightly above the specified temperature, pour the tar into the cup until the leveling peg on the valve rod is just immersed when the latter is vertical.
5. Pour into the graduated receiver **20ml** of mineral oil, or one percent by weight solution of soft soap, and place it under the orifice of the tar cup.

6. Place the other thermometer in the tar and stir until the temperature is **within ±0.1 °C** Of the specified temperature. When this temperature has been reached, suspend the thermometer coaxially with the cup and with its bulb approximately at the geometric center of the tar.

7. Minutes during which period the thermometer reading should remain within **0.05 C** of the specified temperature. Remove the thermometer and quickly remove any excess of tar so that the final level is on the central line of the leveling peg when the valve is in vertical position.

8. Lift the valve and suspend it on valve support

9. Start the stop watch when the reading in the cylinder is **25ml** and stop it when it is **75ml.**note the time in seconds

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

Specification	Test 1	Test 2
Test temperature		
Time taken to flow 50cc of binder		
Viscosity	***Seconds***	***Seconds***

RESULT :

The Viscosity value of given bitumen is_____**Seconds.**

DETERMINATION OF BITUMEN CONTENT BY CENTRIFUGE EXTRACTOR

Exp No:

DATE:

AIM:

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

PROCEDURE:

1. Weight a 1000 grams sample of asphalt mix.
2. With the fork break the sample down to small pieces and heat the sample to about 115^{o} C.
3. Place the sample in the bowl and weight it.
4. Cover the sample in the bowl with benzene or trichloroethane and allow it to soak for one hour.
5. Weight filter ring. Place it around the edge of the bowl and clamp a lid on the bowl.
6. Place a beaker under the outlet.
7. Place the bowl in a centrifuge and rotate it gradually to increase the speed upto 3600rpm.
8. Rotate until the solvent ceases to flow from the outlet.
9. Stop the centrifuge, add 200ml of trichoroethane or benzene and rotate it again.
10. Repeat the procedure until the extract is no longer cloudy and if fairly light in color.
11. Remove the filter from the bowl and dry in air.
12. Brush the loose particles from the filter into the bowl.
13. Dry the filter to constant weight in a oven at 98^{o}C to 105^{o}C
14. Dry the contents of the bowl on a steam bath and then to constant in an oven at 98^{o} C to 105^{o} C
15. Obtain the weight of the filter and bowl with dry aggregate

RECORD AND OBSERVATION:

BEFORE TEST:

Weight of bowl + sample (W1)____ grams

Weight of bowl(W2)_____grams

Weight of filter(W3)_____grams

AFTER TEST:

Weight of bowl + sample (W4)___grams

Weight of filter(W5)_____grams

Weight of sample(W1-W2)_____grams

Weight of aggregate in bowl (W4-W2)_____grams

RESULT:

The percentage of the bitumen in the given sample is_____%

BITUMINOUS MIX DESIGN BY MARSHALL METHOD

EX.NO:

DATE:

AIM:

To determine optimum binder content of given bituminous mix by marshall method of mix design.

APPARATUS REQUIRED:

Mould assembly, sample extractor, compaction pedestal and hammer, breaking head, loading machine flow meter, thermometers water bath and oven

PROCEDURE:

1. The coarse aggregates, fine aggregates and mineral filler material should be proportioned and mixed in such a way that final mix after blending has the graduation within the specified range.
2. Approximately **1200** grams of aggregates and filler are taken and heated to a temperature of **175^{o}C to 195^{O} C.**
3. The compaction mould assembly and rammer are cleaned and kept pre- heated to a temperature of **100^{o}C to 145^{o}C.** The bitumen is heated to temperature of **121^{o}C to 138^{o}C** and the required quantity of first trial percentage o f bitumen is added to the heated aggregate and thoroughly mixed using a mechanical mixer or by hand mixing with trowel.
4. Then the mix is heated and a temperature of **150^{o} to 160^{o}C** is maintained and then the mix is transferred into the pre-heated mould and compacted by giving seventy five blows on each side.
5. The specific gravity values of different aggregates, filler and bitumen used are determined first. The theoretical specific gravity of the mix is determined.

6. Soon after the compacted bituminous mix specimens have cooled to room temperature, the weight, average thickness and diameter of the specimen are noted. The specimens are weighted in air and then in water.

7. The bulk density value of the specimen if calculated from weight and volume.

8. Then the specimen to be tested is kept immersed under water in a thermostatically controlled water bath maintained at **60 ±1 °C for 30 to 40** minutes.

9. The specimens are taken out one, placed in the marshal test and the marshal stability value and flow are noted.

10. The corrected Marshall Stability value of each specimen is determined by applying the appropriate correction factor, if the average height of the specimen is not exactly **63.5mm**.

11. Five graphs are plotted with values of bitumen content against the values of density, Marshall Stability, voids in total mix, flow value, voids filled by bitumen.

12. 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: **$B_o = (B_1+B_2+B_3)/3$**

RESULT:

The optimum binder content of the given mix is _____