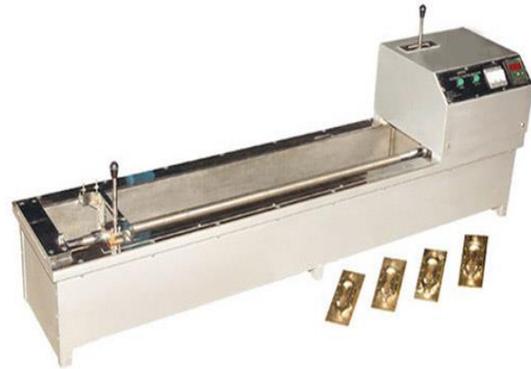




# BRCM COLLEGE OF ENGINEERING & TECHNOLOGY

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**HIGHWAY  
ENGINEERING LAB  
MANUAL**

## **LIST OF EXPERIMENTS**

- **To determine the flash and fire point of bituminous material.**
- **To determine the softening point of paving bitumen.**
- **To determine the specific gravity of bituminous material.**
- **To determine ductility of bitumen.**
- **To determine the hardness of bitumen.**
- **To determine the grade of a given binder.**
- **To determine the viscosity of bituminous material.**
- **To determine the granular mix design.**
- **To determine the bituminous mix design by Marshall's method.**
- **To determine the cement concrete mix design for pavements.**
- **Demonstration of BBD & Bump Integrator.**

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## EXPERIMENT NO - 1

**Aim:** To determine the flash and fire point of a given bituminous material.

### **Apparatus:**

- Pensky-Martens Closed Cup Tester
- Thermometer
- Heating Source
- Flame Exposure

### **Theory:**

Flash and Fire point test is a safety test conducted on a bituminous material so that it gives an indication of the critical temperature at and above where precautions should be taken to eliminate fire hazards during its applications. Bituminous materials leave out volatiles at high temperature depending upon their grade. These volatile vapors catch fire causing a flash. This condition is very hazardous and it is therefore essential to qualify this temperature for each bitumen grade, so that the paving engineers may restrict the mixing or application temperature well within the limits. Flash and Fire point test is conducted as per IS: 1209.

As per IS: 1209 the definitions of flash and fire point are:

**Flash Point:** "The flash point of a material is the lowest temperature at which the vapour of substance momentarily takes fire in the form of a flash under specified conditions of test".

**Fire Point:** "The fire point is the lowest temperature at which the material gets ignited and burns under specified condition of test".

### **\Procedure:**

- All parts of the cup are cleaned and dried thoroughly before the test is started.

- The material is filled in the cup upto a mark. The lid is placed to close the cup in a closed system. All accessories including thermometer of the specified range are suitably fixed.
- The bitumen sample is then heated. The test flame is lit and adjusted in such a way that the size of a bed is of 4mm diameter. The heating of sample is done at a rate of 5° to 6°C per minute. During heating the sample the stirring is done at a rate of approximately 60 revolutions per minute.
- The test flame is applied at intervals depending upon the expected flash and fire points and corresponding temperatures at which the material shows the sign of flash and fire are noted
- **Observation and Calculation:**

Test	Trails			Mean Value
	1	2	3	
Flash Point				
Fire point				

**Result:**

The temp at which the flame application that causes a bright flash ... °C and temperature at which the sample.

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## EXPERIMENT NO - 2

**AIM:** To determine the softening point of bitumen

### **APPARATUS REQUIRED:**

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

### **PROCEDURE**

- Heat the material to a temperature between  $75^{\circ} - 100^{\circ}\text{C}$  above its softening point, stir until, it is completely fluid and free from air bubbles and water. If necessary filter it through IS sieve 30.
- Place the rings, previously heated to a temperature approximating to that of the molten material. On a metal plate which has been coated with a mixture of equal parts of glycerin and dextrin. After cooling for 30 minutes in air, level the material in the ring by removing the excess with a warmed, sharp edged knife.
- Assemble the apparatus with the rings, thermometer and ball guides in position.
- Fill the bath with distilled water to a height of 50mm above the upper surface of the rings. The starting temperature should be  $5^{\circ}\text{C}$ .
- Apply heat to the bath and stir the liquid so that the temperature rises at a uniform rate of
- $5 \pm 0.5^{\circ}\text{C}$  per minute.
- Note down the temperature when any of the steel ball with bituminous coating touches the bottom plate.



Specification	1	2	Average softening point of bitumen
Temperature when the ball touches bottom °C			

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### EXPERIMENT NO - 3

#### AIM:

To determine the specific gravity of given Bituminous material.

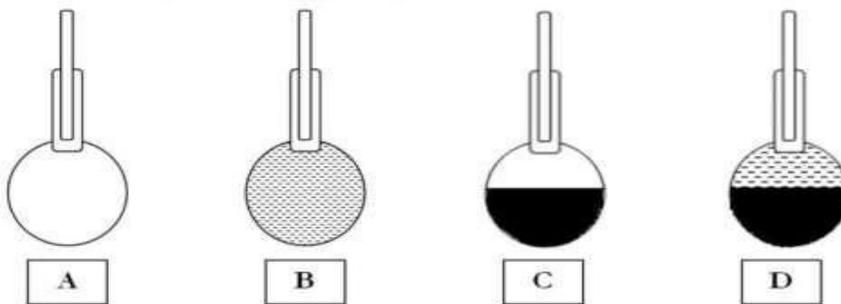
#### APPARATUS REQUIRED:

- Specific gravity bottle
- Balance
- Distilled water.

#### PROCEDURE:

- The clean, dried specific gravity bottle is weighed let that be  $W_1$  gm
- Than it is filled with fresh distilled water and then kept in water bath for at least half an hour at temperature  $27^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ .
- 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.
- 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.
- The remaining space in specific gravity bottle is filled with distilled water at  $27^{\circ}\text{C}$  and is weighed. Let this be  $W_4$  gm.

Specific Gravity Computation of Bituminous Material



		TRIAL 1	TRIAL 2
Mass of Pycnometer plus Stopper	<b>W<sub>1</sub></b>		
Mass of Pycnometer filled with water	<b>W<sub>2</sub></b>		
Mass of Pycnometer partially filled with Bitumen	<b>W<sub>3</sub></b>		
Mass of Pycnometer plus Bitumen plus Water	<b>W<sub>4</sub></b>		
Specific gravity of bituminous material =	$\frac{(W_3 - W_1)}{(W_2 - W_1) - (W_4 - W_3)}$		
Mean Specific Gravity			



## EXPERIMENT NO – 4

### **AIM:**

1. To measure the ductility of a given sample of bitumen
2. 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 and pulling device at a pre calibrated rate
- A putty knife
- Thermometer

### **PROCEDURE**

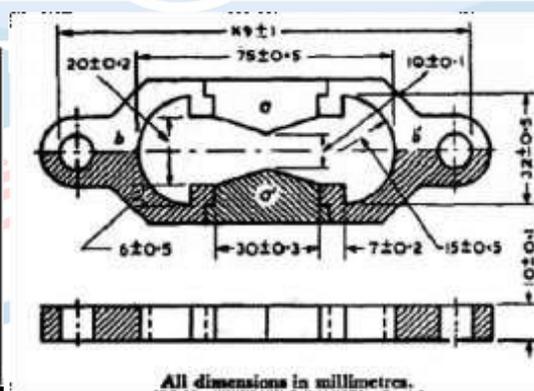
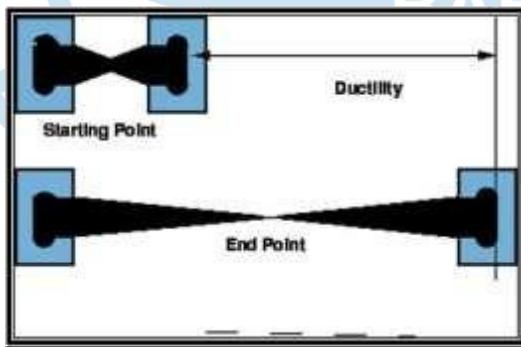
- Melt the bituminous test material completely at a temperature of 75°C to 100°C above the approximate softening point until it becomes thoroughly fluid.
- Strain the fluid through IS sieve 30.
- After stirring the fluid pour it in the mould assembly and lace it on the brass plate.
- In order to prevent 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.
- After about 30 – 40 minutes, keep the plate assembly along with the sample in a water bath. Maintain the temperature of the water bath at 27°C for half an hour.
- Remove the sample and mould assembly from the water bath and trim the specimen by leveling the surface using a hot knife.
- Remove the sides of the moulds.
- Hook the clips carefully on the machine without causing any initial strain.

Adjust the pointer to read zero.

1. Start the machine and pull two clips horizontally at a speed of 50mm per minute.
2. Note the distance at which the bitumen thread of specimen breaks.
3. Record the observations in the Performa and compute the ductility value report the mean of two observations, rounded to nearest whole number as the "Ductility Value".

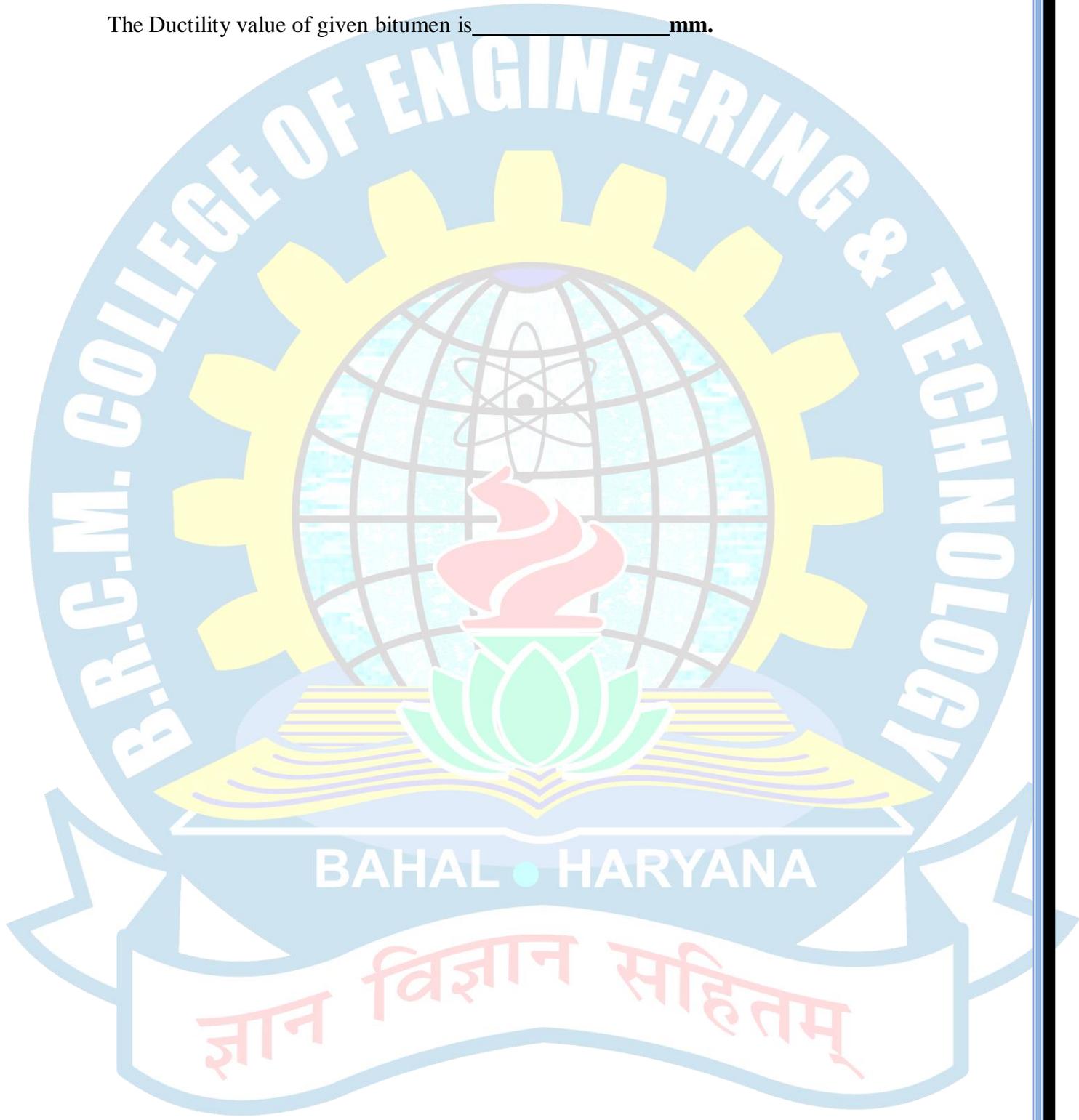
### RECORD AND OBSERVATION

I	Bitumen grade	=	
II	Pouring temperature °C	=	
III	Test temperature °C	=	
IV	Periods of cooling, minutes	=	



**RESULT:**

The Ductility value of given bitumen is \_\_\_\_\_ mm.



## EXPERIMENT NO – 5

### **AIM:**

To determine the grade of bituminous material

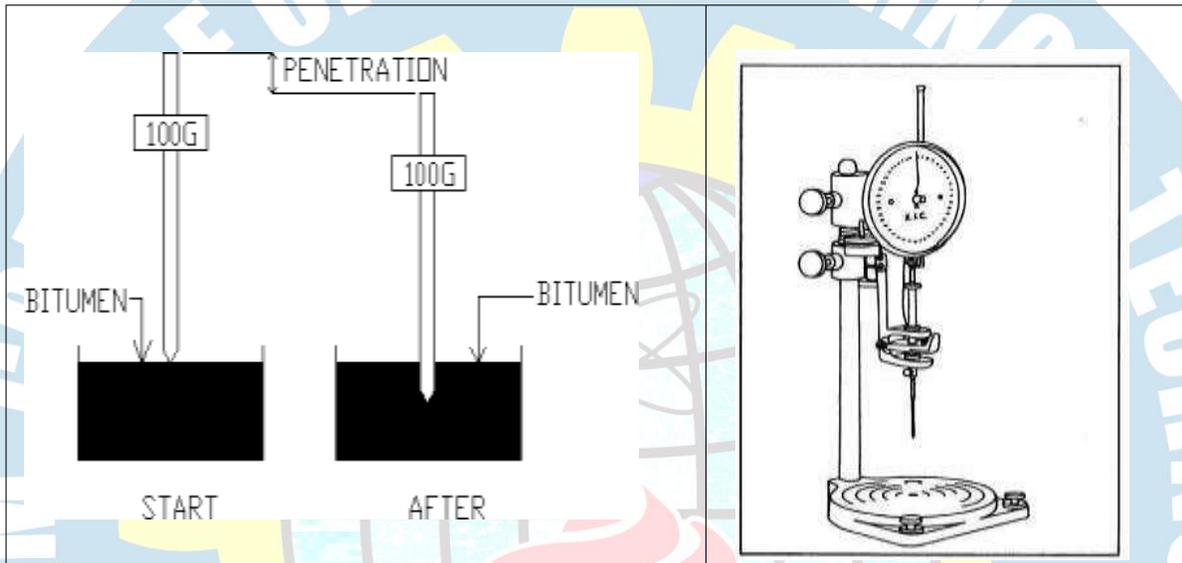
### **APPARATUS REQUIRED:**

Penetrometer, Thermometer, Time measuring device, Transfer dish, Water bath, Needle, Container with a flat bottomed cylindrical metallic dish of diameter 55mm and depth 35mm is required.

### **PROCEDURE:**

- Soften the material to a pouring consistency at a temperature not more than 60°C for tars and 90°C for bitumen above the approximate softening point and stir it thoroughly until it is homogenous and is free from air bubbles and water. Pour the melt into the container to a depth at least 10mm in excess of the expected penetration. Protect the sample from dust and allow it to cool in an atmosphere at a temperature between 15° to 30°C for one hour. Then place it along with the transfer dish in the water bath at 25.0° ±0.1°C and allow it to remain for 1 to 1 1/2 hour. The test is carried out at 25.0° ±0.1°C, unless otherwise stated.
- Fill the transfer dish water from the water bath to depth sufficient to cover the container completely. Place the sample in it and put it upon the stand of the penetration apparatus.
- Clean the needle with benzene, dry it and load with weight. The total moving load required is 100±0.25gms, including the weight of the needle, carrier and super-imposed weights
- Adjust the needle to make contact with the surface of the sample. This may be done by placing the needle point with its image reflected by the surface of the bituminous material.
- Make the pointer of the dial to read zero or note the initial dial reading
- Release the needle for exactly five seconds
- Adjust the penetration machine to measure the distance penetrated.
- Make at least 3 reading at points on the surface of the sample not less than 10mm apart and not less than 10mm from the side of the dish. After each test return the sample and transfer dish to the water bath and wash the needle clean with benzene and dry it. In case of material of penetration greater than 225 three determinations on each of the two

identical tests specimens using a separate needle for each determination should be made, leaving the needle in the sample on completion of each determinations to avoid disturbance of the specimen.



**Observations for Penetration Test**

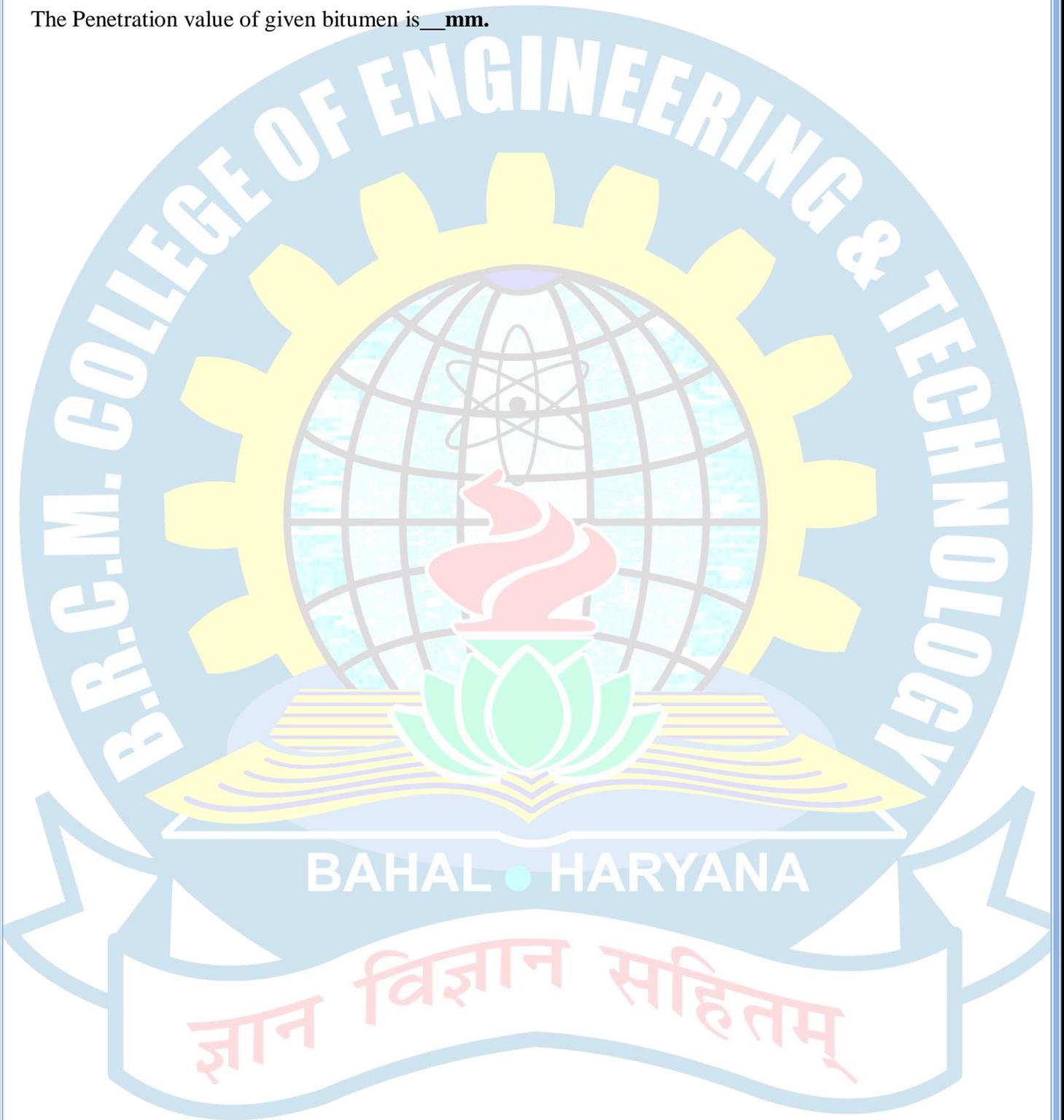
Actual test temperature = °C

**Penetration Test of bitumen**

Penetration Dial Reading	Trial 1	Trial 2	Trial 3
(a) Initial			
(b) Final			
Penetration value			
Mean Value			

**RESULT:**

The Penetration value of given bitumen is      mm.



## EXPERIMENT NO – 6

### 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:

- The tar cup is properly levelled and water in the bath is heated to the test temperature.
- Material is heated to 20°C above the test temperature and material is allowed to cool. During this material is continuously stirred.
- When the temperature reaches 40°C, it is poured into cup of the Tar Viscometer until leveling peg on valve rod is immersed.
- Receiver is placed under the orifice.
- Valve is opened after applying kerosene in the receiver.
- Stop watch is started when cylinder records 50ml time is recorded for flow upto a mark of 100ml.
- The time in seconds for 50ml of the test sample to flow through the orifice is the viscosity of the sample at the given test temperature.

### RECORD AND OBSERVATION:

Specification	Test 1	Test 2
Test temperature		
Time taken to flow 50ml of binder		
Viscosity	<i>Seconds</i>	<i>Seconds</i>

**RESULT:**

The Viscosity value of given bitumen is \_\_\_\_\_ Seconds.



## EXPERIMENT NO – 7

**Aim:** To determine optimum binder content of given bituminous mix by Marshall method of Mix Design.

### **Apparatus:**

- Mould Assemble
- Sample Extractor
- Compaction Pedestal
- Hammer Breaking Head
- Loading machine
- Flow Meter
- Thermometers
- Water Bath And Oven.

### **Theory:**

- Bituminous mixes are used in the surface course of road and airfield pavements. The desirable bituminous mix properties include stability, density, durability, flexibility, resistance to skidding and workability during construction. Stability is defined as resistance of the paving mix to deformation under load and is thus a stress level which causes strain depending upon anticipated field conditions. Stability is function of friction and cohesion. Durability is defined as the resistance of the mix against weathering which causes hardening and this depends upon loss of volatiles and oxidation.
- In this method the resistance to plastic deformation of cylindrical specimen of bituminous mixture is measured when the same is loaded at the periphery at 5 cm per minute. This test procedure is used in designing and evaluating bituminous paving mixes. ASTM vide designation D 1559-62 T has standardized the test procedure.

### **Procedure:**

- 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 gradation within the specified range.
- Approximately 1200 gyms of aggregates and filler are taken and heated to a temperature of 175° to 190° C.
- 
- The compaction mould assembly and rammer are cleaned and kept pre -heated to a temperature of 100°C to 145°C. The bitumen is heated to temperature of 121° to 138° C and the required quantity of first trial percentage of bitumen is added to the heated aggregate and thoroughly mixed using a mechanical mixer or by hand mixing with trowel.
- Then the mix is heated and a temperature of 150° to 160°C is maintained and then the mix is transferred into the pre-heated mould and compacted by giving seventy five blows on each side the specific gravity values of different aggregates, filler and bitumen used are determined first. The theoretical specific gravity of the mix is determined. 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 weighed in air and then in water.
- The bulk density value of the specimen is calculated from weight and volume.
- 
- Then the specimens to be tested are kept immersed under water in a thermostatically controlled water bath maintained at 60° + 1° C for 30 to 40 minutes.
- The specimens are taken out one by one, placed in the Marshall test head and the Marshall Stability value and flow value are noted.
- 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 63.5 mm.
- 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.
- Let the bitumen contents corresponding to maximum density be B1, corresponding to maximum stability be B2 and that corresponding to the specified voids content (at 4.0%) be B3. Then the optimum bitumen content for mix design is given by:  $B_0 = (B_1 + B_2 + B_3) / 3$

**Observation and calculation -**

## EXPERIMENT NO – 8

**Aim:** Demonstration of BBD & Bump Integrator

### **Introduction:**

Bucket Brigade Device (BBD) and Bump Integrator are electronic devices used for signal processing. BBDs are analog delay lines that can store and delay an input signal for a short period of time. Bump Integrators are electronic circuits that integrate a signal by adding up small segments of the signal over time. In this lab, you will learn about the principles of operation of BBDs and Bump Integrators and demonstrate their functionality.

### **Objective:**

To demonstrate the principles of operation of BBDs and Bump Integrators and their applications in signal processing.

### **Equipment:**

- BBD module
- Bump Integrator module
- Function generator
- Oscilloscope
- Breadboard
- Jumper wires

### **Procedure:**

#### **Part 1: BBD**

- Connect the function generator to the input of the BBD module using jumper wires.
- Connect the output of the BBD module to the input of the oscilloscope using jumper wires.
- Set the function generator to generate a square wave with a frequency of 1kHz and a peak-to-peak voltage of 5V.
- Observe the output waveform on the oscilloscope. You should see a delayed version of the input waveform.
- Increase the frequency of the input waveform and observe the effect on the output waveform. You should see that the amount of delay decreases as the frequency increases.
- Repeat steps 3-5 for a sine wave input waveform.

## Part 2: Bump Integrator

- Connect the function generator to the input of the Bump Integrator module using jumper wires.
- Connect the output of the Bump Integrator module to the input of the oscilloscope using jumper wires.
- Set the function generator to generate a square wave with a frequency of 1kHz and a peak-to-peak voltage of 5V.
- Observe the output waveform on the oscilloscope. You should see that the output waveform is a ramp waveform that increases in voltage over time.
- Increase the frequency of the input waveform and observe the effect on the output waveform. You should see that the slope of the ramp waveform increases as the frequency increases.
- Repeat steps 3-5 for a sine wave input waveform.

## Part 3: BBD and Bump Integrator Applications

- Connect the output of the BBD module to the input of the Bump Integrator module using jumper wires.
- Connect the output of the Bump Integrator module to the input of the oscilloscope using jumper wires.
- Set the function generator to generate a square wave with a frequency of 1kHz and a peak-to-peak voltage of 5V.
- Observe the output waveform on the oscilloscope. You should see that the output waveform is a sawtooth waveform that increases in voltage and then drops suddenly before increasing again.
- Increase the frequency of the input waveform and observe the effect on the output waveform. You should see that the frequency of the sawtooth waveform increases.
- Repeat steps 3-5 for a sine wave input waveform.

## Conclusion:

In this lab, you have demonstrated the principles of operation of BBDs and Bump Integrators and their applications in signal processing. BBDs can be used to delay an input signal, while Bump Integrators can be used to integrate a signal. The combination of a BBD and a Bump Integrator can be used to generate a sawtooth waveform.

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