A Laboratory Manual for

Transportation Engineering (3150611)

B.E. Semester 5 (Civil)

Government Engineering College, Valsad

Directorate of Technical Education
Gandhinagar, Gujarat

Government Engineering College, Valsad

Certificate

This is to certify that Mr./Ms. _____ _____ Enrollment No. _____ of B.E. Semester _____Civil Engineering of this Institute (GTU Code: _____) has satisfactorily completed the Practical / Tutorial work for the subject **Transportation Engineering** (3150611) for the academic year 2023-24 within the four walls of _____(Institute)

Place: _____
Date: _____

Name and Sign of Faculty member

Head of the Department

Preface

The basic aim of laboratory/practical/field work is to enhance the required skills as well as creating ability amongst students to solve real time problem by developing relevant competencies in psychomotor domain. By keeping this in view, GTU has designed competency focused outcome-based curriculum for engineering degree programs where sufficient focus is given to the practical work. It shows importance of enhancement of skills amongst the students and pays attention to utilize every second of time allotted for practical amongst students, instructors and faculty members to achieve relevant outcomes by performing the experiments rather than having merely study type experiments. It is must for effective implementation of competency focused outcome-based curriculum that every practical is keenly designed to serve as a tool to develop and enhance relevant competency required by the various industry among every student. These psychomotor skills are very difficult to develop through traditional chalk and board content delivery method in the classroom. Accordingly, this lab manual is designed to focus on the industry defined relevant outcomes, rather than old practice of conducting practical to prove concept and theory.

By using this lab manual students can go through the relevant theory and procedure in advance before the actual performance which creates interest and students can have basic idea prior to performance. This in turn enhances pre-determined outcomes amongst students. Each experiment in this manual begins with competency, industry relevant skills, course outcomes as well as practical outcomes (objectives). The students will also achieve safety and necessary precautions to be taken while performing practical.

This manual also provides guidelines to faculty members to facilitate student centric lab activities through each experiment by arranging and managing necessary resources in order that the students follow the procedures with required safety and necessary precautions to achieve the outcomes. It also gives an idea that how students will be assessed by providing rubrics.

Fluid Mechanics & Hydraulics is the fundamental course which deals with the behavior of the fluids at rest as well as in motion. It provides a platform for students to apply the basic principles of Fluid Mechanics to solve real life problems.

Utmost care has been taken while preparing this lab manual however always there are chances of improvement. Therefore, we welcome constructive suggestions for improvement and removal of errors if any.

Practical – Course Outcome matrix

Course Outcomes (COs):

1. Illustrate and demonstrate parameters of highway planning, geometric and pavement design.
2. Analyze pavement distresses, failures and suggest prevention measures.
3. Describe basics of traffic flow parameters, parking, marking, signal, and signs.
4. Solve problems of railway track geometrics and to understand various railway track materials, their properties and use.
5. Identify various component parts of dock, harbour and airports and apply ship and aircraft characteristics in planning of harbour and airports.
6. Design of pavement for the given for traffic.

Sr. No.	Objective(s) of Experiment	CO 1	CO 2	CO 3	CO 4	CO 5
1.	Determination of aggregate crushing Value					
2.	Determination of aggregate impact value					
3.	Determination of Los Angeles Abrasion value					
4.	Determination of shape tests on aggregate					
5.	Determination of California Bearing Ratio (CBR) values					
6.	Determination of viscosity of Bitumen					
7.	Determination of softening point of bitumen					
8.	Determination of ductility of the bitumen					
9.	Determination of flash point and fire point of bitumen					
10.	Determination of Bitumen content					
11.	Determination of stripping value of road aggregate					
12.	Determination of Marshall Stability value for Bituminous mix					

Industry Relevant Skills

The following industry relevant competencies are expected to be developed in the student by undertaking the practical work of this laboratory.

1. To comprehend basic requirements of Highway, Rail, Water and Air Transportation.
2. To enable the students to apply the basic principles of geometric design, design of highway and traffic engineering in the field.
3. To know the functions and design of water transportation structures.
4. To know basic elements in Airport Engineering

Guidelines for the Faculty members

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain basic concepts/theory related to the experiment to the students before starting of each practical.
3. Involve all the students in performance of each experiment.
4. Teacher is expected to share the skills and competencies to be developed in the students and ensure that the respective skills and competencies are developed in the students after the completion of the experimentation.
5. Teachers should give opportunity to students for hands-on experience after the demonstration.
6. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected from the students by concerned industry.
7. Give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions or not.
8. Teacher is expected to refer complete curriculum of the course and follow the guidelines for implementation.

Instructions for Students

1. Students are expected to carefully listen to all the theory classes delivered by the faculty members and understand the COs, content of the course, teaching and examination scheme, skill set to be developed etc.
2. Students shall organize the work in the group and make record of all observations.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and build confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. apart from those included in scope of manual.
6. Student shall refer technical magazines and data books.
7. Student should develop a habit of submitting the experimentation work as per the schedule and s/he should be well prepared for the same.

Common Safety Instructions

Students must be careful while performing above practicals with all safety precautions. The institute shall have to make suitable safety related requirement.

Index
(Progressive Assessment Sheet)

Sr. No.	Objective(s) of Experiment	Page No.	Date of performance	Date of submission	Assessment Marks	Sign. of Teacher with date	Remarks
1.	Determination of aggregate crushing Value						
2.	Determination of aggregate impact value						
3.	Determination of Los Angeles Abrasion value						
4.	Determination of shape tests on aggregate						
5.	Determination of California Bearing Ratio (CBR) values						
6.	Determination of viscosity of Bitumen						
7.	Determination of softening point of bitumen						
8.	Determination of ductility of the bitumen						
9.	Determination of flash point and fire point of bitumen						
10.	Determination of Bitumen content						
11.	Determination of stripping value of road aggregate						
12.	Determination of Marshall Stability value for Bituminous mix						
Total							

Experiment No. - 1

AGGREGATE CRUSHING VALUE TEST (IS: 2386 PART - 4)

Date:

Competency and Practical Skills: Observation skills

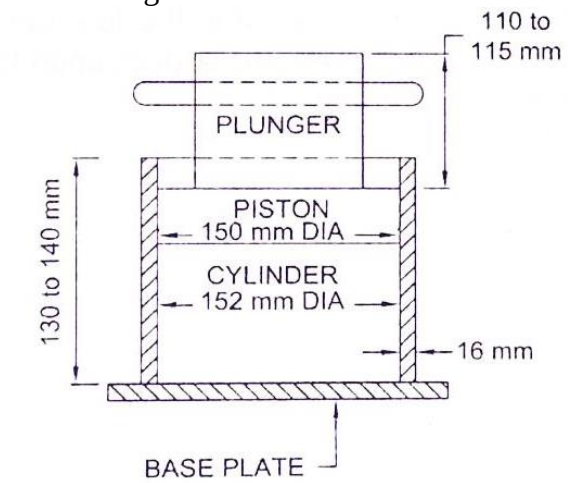
Relevant CO:

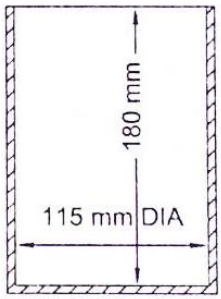
OBJECTIVES :

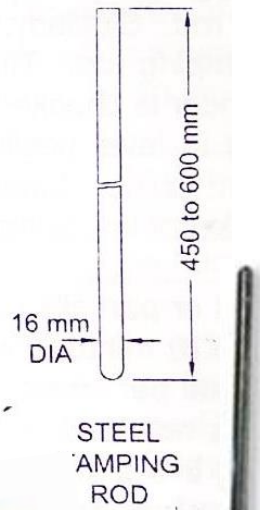
- To determine the aggregate crushing value of coarse aggregate
- The aggregate impact value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load.

APPARATUS :

- A 15 cm diameter open-ended cylinder, with plunger and base plate, of the general form and dimensions shown in figure.
- A straight metal tamping rod of circular cross-section 16 mm in diameter and 45 to 60 cm long, rounded at one end.
- A balance of capacity 3 kg, readable and accurate to one gram.
- IS sieves of sizes 12.5 mm, 10 mm and 2.36 mm.
- A compression testing machine capable of applying load of 40 tonnes and which can be operated to give a uniform rate of loading so that the maximum load is reached in 10 minutes.
- For measuring the sample, cylindrical metal measure of internal dimension diameter 11.5 cm and height 18 cm.







TEST SAMPLE:

- The material for the standard test shall consist of aggregate passing 12.5 mm IS sieve and retained on a 10 mm IS sieve.
- The aggregate shall be tested in a surface-dry condition. If dried by heating, the period of drying shall not exceed four hours, the temperature shall be 100 to 110^{o}C and the aggregate shall be cooled to room temperature before testing.
- The quantity of aggregate shall be such that the depth of material in the cylinder, after tamping as mentioned below shall be 10 cm.
- The appropriate quantity may be found conveniently by filling the cylindrical measure in three layers of approximately equal depth, each layer being tamped 25 times with rounded end of tamping rod and levelled off, using the tamping as a straight edge.
- The weight of material comprising the test sample shall be determined *(Weight A)* and the same weight of sample shall be taken for the repeat test.

TEST PROCEDURE:

- The cylinder of test apparatus is positioned on base plate and the test sample is added in thirds; each third being subjected to 25 strokes from the tamping rod.
- The surface of the aggregate shall be carefully levelled, and the plunger inserted so that it rests horizontally on this surface, care being taken to ensure that the plunger does not jam in the cylinder.
- The apparatus, with the test sample and plunger in position, shall then be placed between the platens of the testing machine and loaded at as uniform a rate as possible so that the total load is reached in 10 minutes. The total load shall be 40 tonnes i.e, 400 kN. (4 tonnes per minute)
- The load shall be released and the whole of the material removed from the cylinder and sieved on 2.36 mm IS sieve. The fraction passing the sieve shall be weighed *(Weight B)*.
- In all operations, care shall be taken to avoid loss of the fines. Two tests shall be made.

CALCULATION:

- The ratio of the weight of fines formed to the total sample weight in each test shall he expressed as a percentage; the result being recorded to the first decimal place:

$$\text{Aggregate crushing value} = \frac{B}{A}\ X\ 100$$

Where, B = Weight of fraction passing 2.36-mm IS Sieve,
A = Weight of surface-dry sample.

REPORTING OF RESULTS:

- The mean of the two results shall be reported to the nearest whole number as the aggregate crushing value of the tested material.

OBSERVATION TABLE:

Table 1: Observation Table for Aggregate Crushing Value Test

Sr. No.	Description	Test -1	Test-2
1.	Original weight of the aggregate passing through 12.5 mm IS sieve and retained on 10 mm IS sieve, **A g**		
2.	Weight of sample passing through 2.36 mm IS sieve after test, **B g**		
3.	Weight of sample retained on 2.36 mm IS sieve after test, **C g**		
4.	Aggregate Crushing Value (%) = $\frac{B}{A}$ x 100	%	
5.	Avg. Aggregate Crushing Value in %	%	

RESULT:

Calculation:

Conclusion:

Quiz:

1) What is the size of aggregate on which crushing test is performed?

2) What is the total load that is to be applied on aggregate during crushing test and at what rate the load must be applied?

3) What type of load is applied on aggregate during crushing test?
(a) Sudden Load (b) Gradual Load

4) Allowable maximum crushing value for
Granular Sub-Base (GSB) = ……%
Water Bound Macadam (WBM) = ……...%
Dense Bituminous Macadam (DBM) = ……...% and
Bituminous Concrete (BC) = …… %

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						

Experiment No. - 2

AGGREGATE IMPACT VALUE TEST

Date:

Competency and Practical Skills: Observation skills

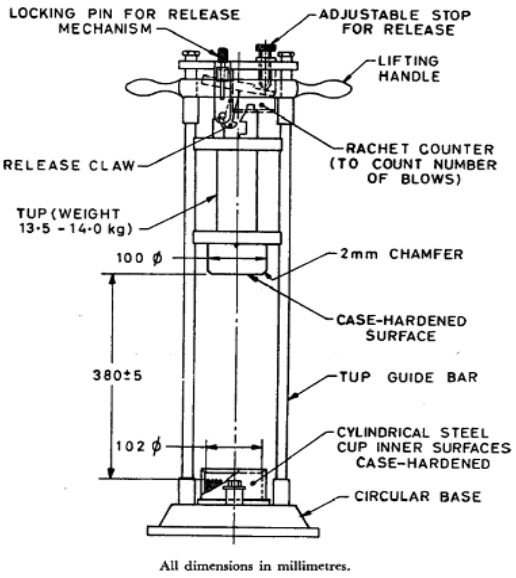
Relevant CO:

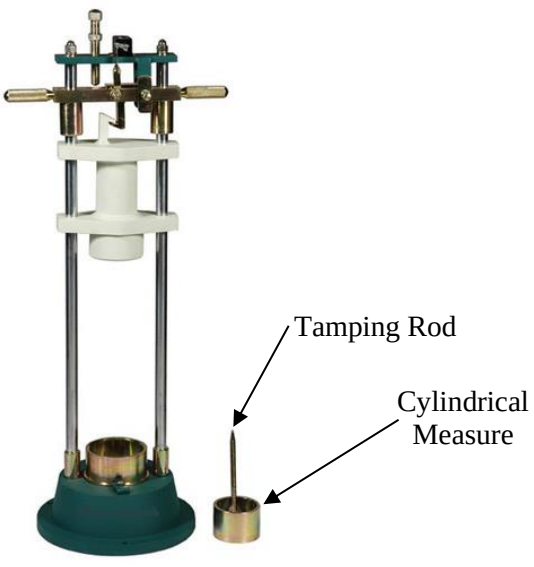
OBJECTIVE:

- To determine the aggregate impact value of coarse aggregate
- The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregates differs from its resistance to a slow compressive load.

APPARATUS:

- An impact testing machine as shown in figure and complying with the following:
  - Total *weight of machine not more than 60 kg nor less than 45 kg*
  - Machine shall have *metal base* weighing *22 to 30 kg* with plane lower surface of minimum *30 cm diameter*.
  - A *cylindrical steel cup* of internal dimensions *102 mm diameter, 50 mm depth and 6.3 mm minimum thickness*
  - *A metal tup or hammer* weighing *13.5 to 14 kg*, the lower end shall be cylindrical in shape, *100 mm diameter* and *5 cm long*, with a *2 mm chamfered lower edge*.
  - Means for raising and adjusting the height of hammer to *380 ± 5 mm* to allow it to fall freely on to the test sample in cup.
  - Means for supporting the hammer whilst fastening or removing the cup.
- Sieves of sizes *12.5 mm, 10.0 mm and 2.36 mm.*
- A cylindrical measure of internal dimensions *75 mm diameter and 50 mm depth.*
- Tamping rod of circular cross section *10 mm in diameter and 230 mm long*, rounded at one end.
- Balance of capacity not less than 500 g, and accurate to 0.1 g
- A ventilated oven thermostatically controlled to maintain a temperature of *100 to 110^{o}C.*





TEST SAMPLE:

- The test sample shall consist of aggregate the whole of which passes a 12.5 mm IS Sieve and is retained on a 10 mm IS Sieve.
- The aggregate comprising the test sample shall be dried in an oven for a period of four hours at a temperature of 100 to 110°C and cooled.
- The measure shall be filled about one-third full with the aggregate and tamped with 25 strokes of the rounded end of the tamping rod further similar quantity of aggregate shall be added and a further tamping of 25 strokes given. The measure shall finally be filled to overflowing, tamped 25 times and the surplus aggregate struck off, using the tamping rod as a straight-edge.
- The net weight of aggregate in the measure shall be determined to the nearest gram ***(Weight A)*** and this weight of aggregate shall be used for the duplicate test on the same material.

TEST PROCEDURE:

- The impact machine shall rest without wedging or packing upon the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.
- The cup shall be fixed firmly in position on the base of the machine and the whole of the test sample is placed in it and compacted by a single tamping of 25 strokes of the tamping rod
- The hammer shall be raised until its lower face is 380 mm above the upper surface of the aggregate in the cup, and allowed to fall freely on to the aggregate. The test sample shall be subjected to a total of 15 such blows each being delivered at an interval of not less than one second.
- The crushed aggregate shall then be removed from the cup and the whole of it sieved on the 2.36-mm IS Sieve until no further significant amount passes in one minute. The fraction passing the sieve shall be weighed to an accuracy of 0.1 g ***(Weight B)***
- The fraction retained on the sieve shall also be weighed ***(Weight C)*** and, if the total ***Weight (B+C)*** is less than the initial weight ***(Weight A)*** by more than one gram, the result shall be discarded, and a fresh test made. Two tests shall be made.

CALCULATION:

- The ratio of the weight of fines formed to the total sample weight in each test shall he expressed as a percentage; the result being recorded to the first decimal place:

$$\text{Aggregate impact value} = \frac{B}{A}\ X\ 100$$

Where, B = Weight of fraction passing 2.36-mm IS Sieve,
A = Weight of oven-dried sample.

REPORTING OF RESULTS:

- The mean of the two results shall be reported to the nearest whole number as the aggregate impact value of the tested material.

OBSERVATION TABLE:

Table 1: Observation Table for Aggregate Impact Value Test

Sr. No.	Description	Test -1	Test-2
1.	Original weight of the aggregate passing through 12.5 mm IS sieve and retained on 10 mm IS sieve, **A g**		
2.	Weight of sample passes 2.36 mm IS sieve after test **B g**		
3.	Weight sample retain 2.36 mm IS sieve after test **C g**		
4.	D = B + C ***(If A – D > 1 g, then sample must be discarded)***		
5.	Aggregate Impact Value (%) = $\frac{B}{A}$ x 100	%	
6.	Avg. Aggregate Impact Value in %	%	

Calculation:

Result: Aggregate Impact value = ……..%

Conclusion:

Quiz:

1) The test sample shall be subjected to…..…..blows each being delivered at an interval of not less than one second.

2) Aggregate passing from 12.5.mm and retained on……..mm sieve is used as test sample.

3) The hammer weighing…..kg is allowed to fall freely from a height of …….mm on the test sample.

4) Allowable maximum Impact value for

Granular Sub-Base (GSB) =. . …... . . . . .%
Water Bound Macadam (WBM) = . ……. . . . .%
Dense Bituminous Macadam (DBM) = ……. . . . and
Bituminous Concrete (BC) = . …… . . . . . %

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						

Experiment No. - 3

Determination of Los Angeles Abrasion value

Date:

Competency and Practical Skills: Observation skills

Relevant CO:

OBJECTIVE:

- To determine the aggregate abrasion value.

APPARATUS:

- The Los Angeles abrasion testing machine having following specifications:
  - The machine shall consist of a hollow steel cylinder, closed at both ends, having an inside diameter of 700 mm and an inside length of 500 mm.
  - An opening in the cylinder shall be provided for the introduction of the test sample.
  - The opening shall be closed dust-tight with a removable cover bolted in place.
  - A removable steel shelf, projecting radially 88 mm into the cylinder and extending its full length, shall be mounted along one element of the interior surface of the cylinder.
- IS sieve of 1.7 mm size.
- The abrasive charge shall consist of cast iron spheres or steel spheres approximately 48 mm in diameter and each weighing between 390 and 445 g.

SAMPLE:

- The test sample shall consist of clean aggregate which has been dried in an oven at 105 to 110^{o}C and shall conform to one of the gradings as shown in table below.

Grading	Weight in grams of test sample for different gradings (Sieve size in mm)										No. of sphere	Total Weight of Charge in grams
	80-63	63-50	50-40	40-25	25-20	20-12.5	12.5-10	10-6.3	6.3-4.75	4.75-2.36		
A	---	---	---	1250	1250	1250	1250	---	---	---	**12**	5000±25
B	---	---	---	---	---	2500	2500	---	---	---	**11**	4584±25
C	---	---	---	---	---	---	---	2500	2500	---	**8**	3330±20
D	---	---	---	---	---	---	---	---	---	5000	**6**	2500+15
E	2500*	2500*	5000*	---	---	---	---	---	---	---	**12**	5000+25
F	---	---	5000*	5000*	---	---	---	---	---	---	**12**	5000±25
G	---	---	---	5000*	5000*	---	---	---	---	---	**12**	5000+25

**** Tolerance of ±2 percent is permitted***

TEST PROCEDURE:

- The test sample and the abrasive charge shall be placed in the Los Angeles abrasion testing machine and the machine rotated at a speed of 20 to 33 rev/min.
- For Grading **A, B, C** and **D**, the machine shall be rotated for **500 revolutions**
- For Grading **E, F** and **G**, it shall be rotated for **1000 revolutions**.

- The machine shall be so driven and so counter-balanced as to maintain a substantially uniform peripheral speed. If an angle is used as the shelf, the machine shall be rotated in such a direction that the charge is caught on the outside surface of the angle.
- At the completion of the test, the material shall be discharged from the machine and a preliminary separation of the sample made on a sieve coarser than the l.70-mm IS Sieve. The finer portion shall then be **sieved on a 1.70-mm IS Sieve**.
- The material coarser than the 1.70-mm IS Sieve shall be washed dried in an oven at 105 to 110°C to a substantially constant weight, and accurately weighed to the nearest gram, ***Weight W_B***

CALCULATION:

- Aggregate abrasion value shall be calculated as follows:
  - Aggregate abrasion value $= \frac{W_A - W_B}{W_A} \; X \; 100$

Where, W_A = Original weight of the test sample

W_B = Final weight of the test sample (Material coarser than 1.7 mm)

REPORTING OF RESULTS:

- The Difference between the original weight and the final weight of the test sample shall be expressed as a percentage of the original weight of the test sample. This value shall be reported as the percentage of wear.

OBSERVATION TABLE:

Sr. No.	Description	Test-1	Test-2
1	Original weight of the test sample, $\boldsymbol{W_A\ g}$		
2	Final weight of the test sample (Material coarser than 1.7 mm), $\boldsymbol{W_B\ g}$		
3	Abrasion Value in % = [(W_A - W_B) / W_A] x 100		
4	Average Abrasion Value		

Calculation:

Result:

Conclusion:

Quiz:

1) Allowable maximum crushing value for

Granular Sub-Base (GSB) =. . . . . .%
Water Bound Macadam (WBM) = ...%
Dense Bituminous Macadam (DBM) = ...%
Bituminous Concrete (BC) = ... %
Cement Concrete Pavement (Wearing Pavement) = ... %

2) The …….. property of aggregate is checked by Abrasion test.

3) For grading A, B, C & D the machine shall be rotated for …… revolutions and for E, F & G the machine shall be rotated for ……revolutions.

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

Experiment No. - 4

Determination of shape tests on aggregate

Date:

Competency and Practical Skills: Observation skills

Relevant CO:

OBJECTIVE:

- To determine the value of Flakiness and Elongation Index of Coarse aggregates and Combined Index (CI) = FI+EI
- The flakiness index of an aggregate is the percentage by weight of particles in it whose least dimension (thickness) is less than three-fifths times of their mean dimension. The test is not applicable to sizes smaller than 6.3 mm.
- The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than nine-fifths times of their mean dimension. The test is not applicable to sizes smaller than 6.3 mm.

APPARATUS:

- Thickness gauge for Flakiness Index as shown in Figure-1
- Length gauge for Elongation Index as shown in Figure-2
- Balance of capacity not less than 500 g with an accuracy of 0.1 % of the weight of the test sample
- IS Sieve as shown in Table 1

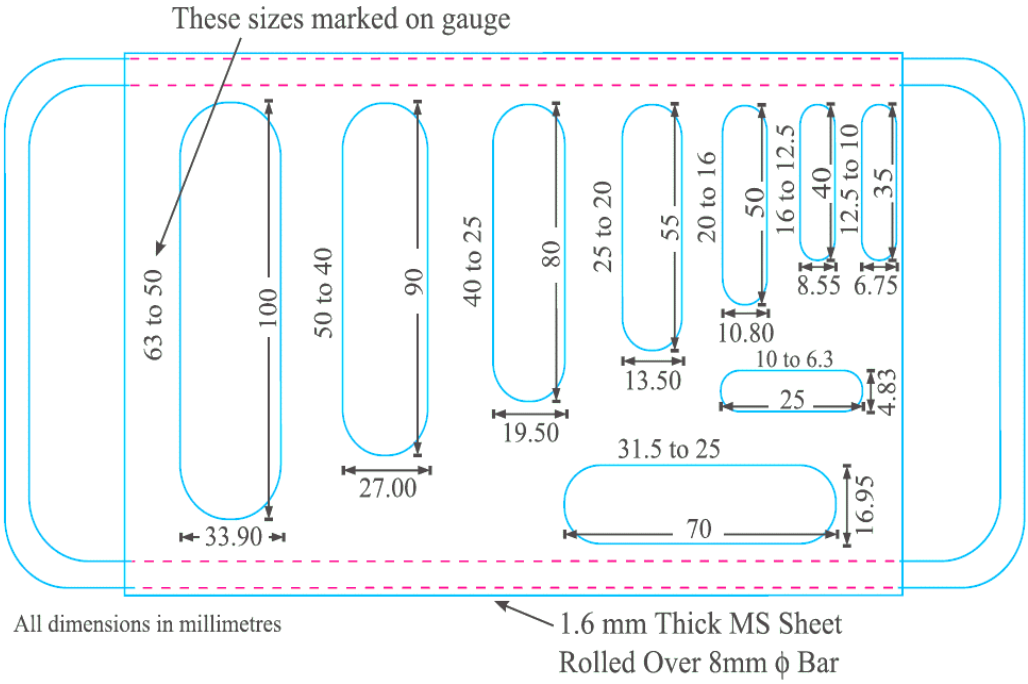


Figure 1 Thickness Gauge

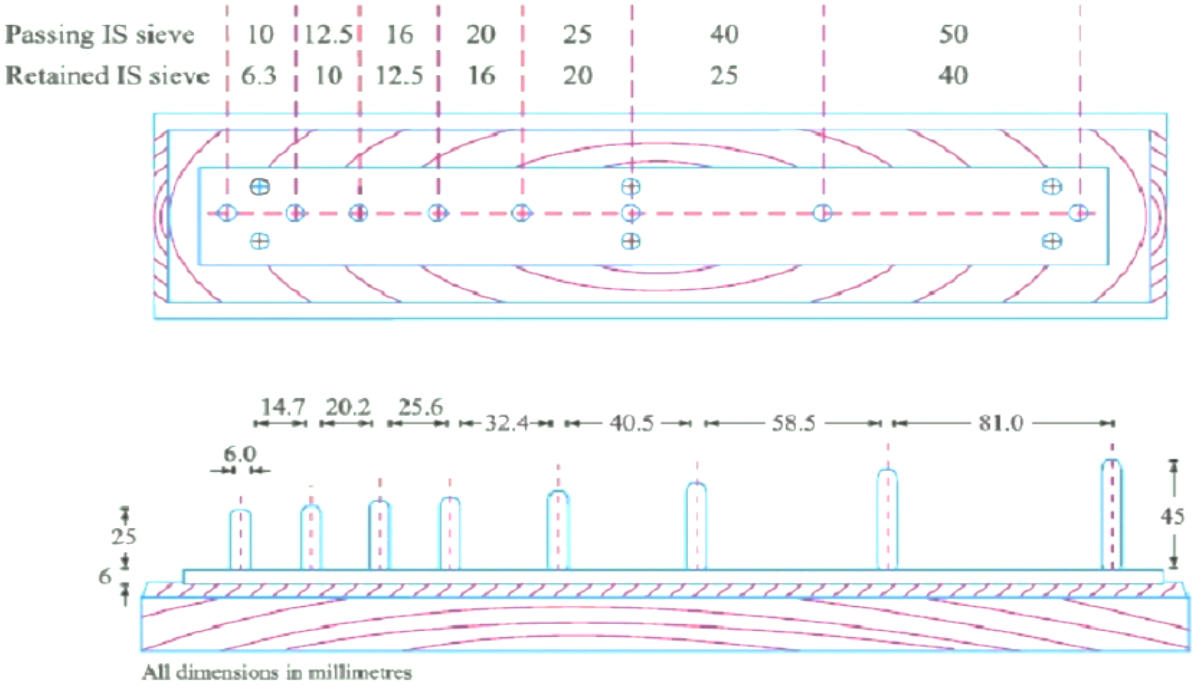


Figure 2 Length Gauge

TEST SAMPLE:

- A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.

TEST PROCEDURE:

- The sample shall be sieved with the sieves specified the Table-1
- Each fraction shall be gauged in turn for thickness on ***thickness gauge*** as shown in Figure 1.
- The thickness of slot for a specific sample size is worked out as follows:
  - For sample passing through 40 mm sieve and getting retained on 25 mm sieve the average size is (40+25) / 2 = 32.5 mm
  - Thickness of slot = 0.6 x 32.5 = 19.5 mm
  - Same calculation applies to all sample sizes
- The total amount passing the gauge shall be weighed to an accuracy of at least 0.1% of the weight of the test.
- The flakiness index is the total weight of the material passing the various thickness gauges, expressed as a percentage of the total weight of the sample gauged.
- ***After carrying out the flakiness index test, the flaky material shall be removed from the sample and the remaining portion (Non-Flaky Material) will be used as a sample for carrying out elongation index.***
- Each fraction shall be gauged individually for length on a length gauge as shown in Figure 2.
- The length of slot for a specific sample size is worked out as follows:
  - For sample passing through 40 mm sieve and getting retained on 25 mm sieve the average size is (40+25) / 2 = 32.5 mm
  - Thickness of slot = 1.8 x 32.5 = 58.5 mm
  - Same calculation applies to all sample sizes
- The total amount retained on the gauge shall be weighed to an accuracy of at least 0.1% of the weight of the test.
- The elongation index is the total weight of the material retained on the various length gauges, expressed as a percentage of the total weight of the ***non-flaky*** sample gauged.

- Indices so worked out shall be numerically added to give ***combined flakiness and elongation index.***
- Flakiness index and elongation index can also be determined and reported separately without numerically adding them, in this case the sample is quantity of aggregate, sufficient to provide a minimum number of 200 pieces to be gauged for thickness as well as length on thickness gauge and length gauge respectively. Rest of the procedure remains same as mentioned in previous points.

OBSERVATION TABLE:

Table 1: Observation Table for Flakiness and Elongation Index

Sr. No.	FLAKINESS INDEX				ELONGATION INDEX	
	Passing through IS sieve (mm)	Retained on IS sieve (mm)	Weight of 200 Nos. Aggregate (gms)	Weight of aggregate (Flaky) passing the thickness Gauge (gms)	Weight of Non- Flaky Aggregate taken as sample (gms)	Weight of the aggregate (Elongated) retained on the length Gauge (gms)
	A	B	C	D	E = C – D	F
1.	63	50				
2.	50	40				
3.	40	31.5				
4.	31.5	25				
5.	25	20				
6.	20	16				
7.	16	12.5				
8.	12.5	10				
9.	10	6.3				
			W =	w =	W_1 =	w_1 =
			FI = (w / W) x 100 = %		EI = (w_1 / W_1) x 100 = %	
Combined index (CI) = Flakiness Index (FI) + Elongation Index (EI) = % + % = %						

Calculation:

Result:

Conclusion:

Quiz:

1. Slot dimension for flakiness index and elongation index for aggregates passing through 25mm and retained on 20 mm sieves would be respectively……

(a) 13.5 and 40.5 mm(b) 40.5 and 13.5 mm (c)10.8 and 32.4 mm (d) 27.0 and 81.0 mm

2. Allowable maximum **C**ombined **I**ndex (FI+EI) value for
   Water bound macadam (**WBM**) = . …….. .%
   Dense Bituminous macadam (**DBM**) = …….. .% and
   Bituminous concrete (**BC**) = . . . ……. . . . .%

4) The flakiness and elongation index tests are not applicable for aggregate sizes smaller than……

(a) 6.3 mm (b) 4.75 mm (c) 2.36 mm (d) 10 mm

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						

Experiment No. - 5

Determination of California Bearing Ratio (IS: 2720 PART 16 - 1987) values

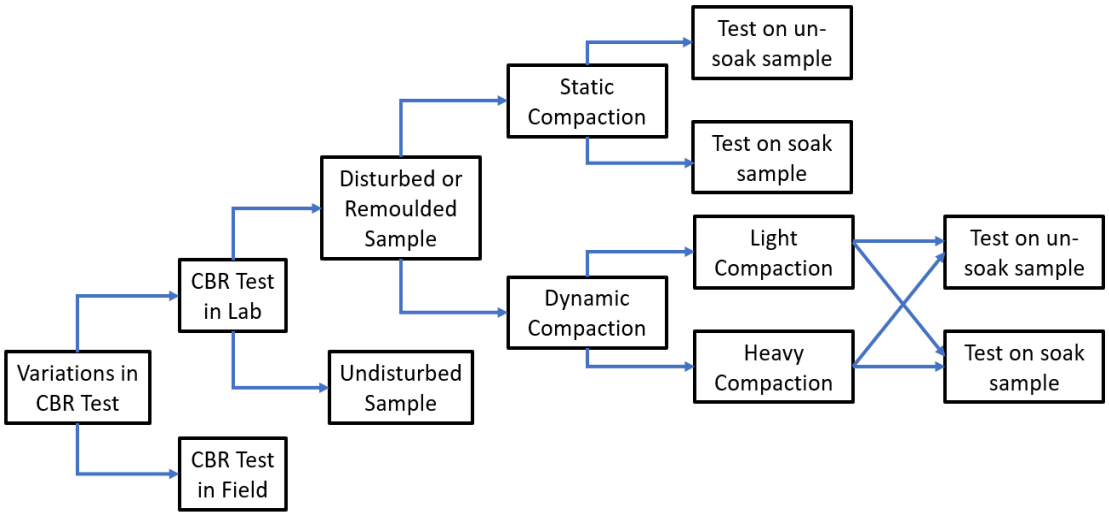
Date:

Competency and Practical Skills: Observation skills and result interpretation skills

Relevant CO:

OBJECTIVE:

- To determine the ratio which is expressed in percentage of force per unit area required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in standard material.
- The ratio is determined for penetration of 2.5 and 5.0 mm.
- The CBR value of a soil is an index which up to some extent is related to its strength.



APPARATUS:

- CBR mould of height 175±0.1 mm and internal diameter 150±0.1 mm
- Extension collar of height 60 mm and internal diameter 150±0.1 mm
- A base plate of diameter 235±0.5 mm and having a suitable seating about 2 mm deep on the top face for proper seating of the mould and the diameter of seating shall be 156 mm.
- Spacer disc of height 47.7 mm and diameter 148 mm and T-shaped handle for spacer disc of 75 mm web and 115 mm flange.
- Penetration plunger of 50±0.1 mm diameter and height maximum 100 mm
- Expansion measuring equipment: Adjustable stem and perforated plates
- Annular weight and slotted weight of thickness to give 2.5 kg
- Loading machine equipped with a movable head or base which enables the plunger to penetrate the specimen at a deformation rate of 1.25 mm/min.
- Dial gauge capable of measuring up to 0.01 mm
- IS sieve of size 19 mm and 4.75 mm sieve.

- Metal rammers of 2.6 kg or 4.89 kg
- Miscellaneous equipment's such as a mixing bowl, straight edge, scales soaking tank or pan, drying oven, filter paper and containers.

SAMPLE:

- The test may be performed on undisturbed specimens and
- Remoulded specimens which may be compacted either statically or dynamically.

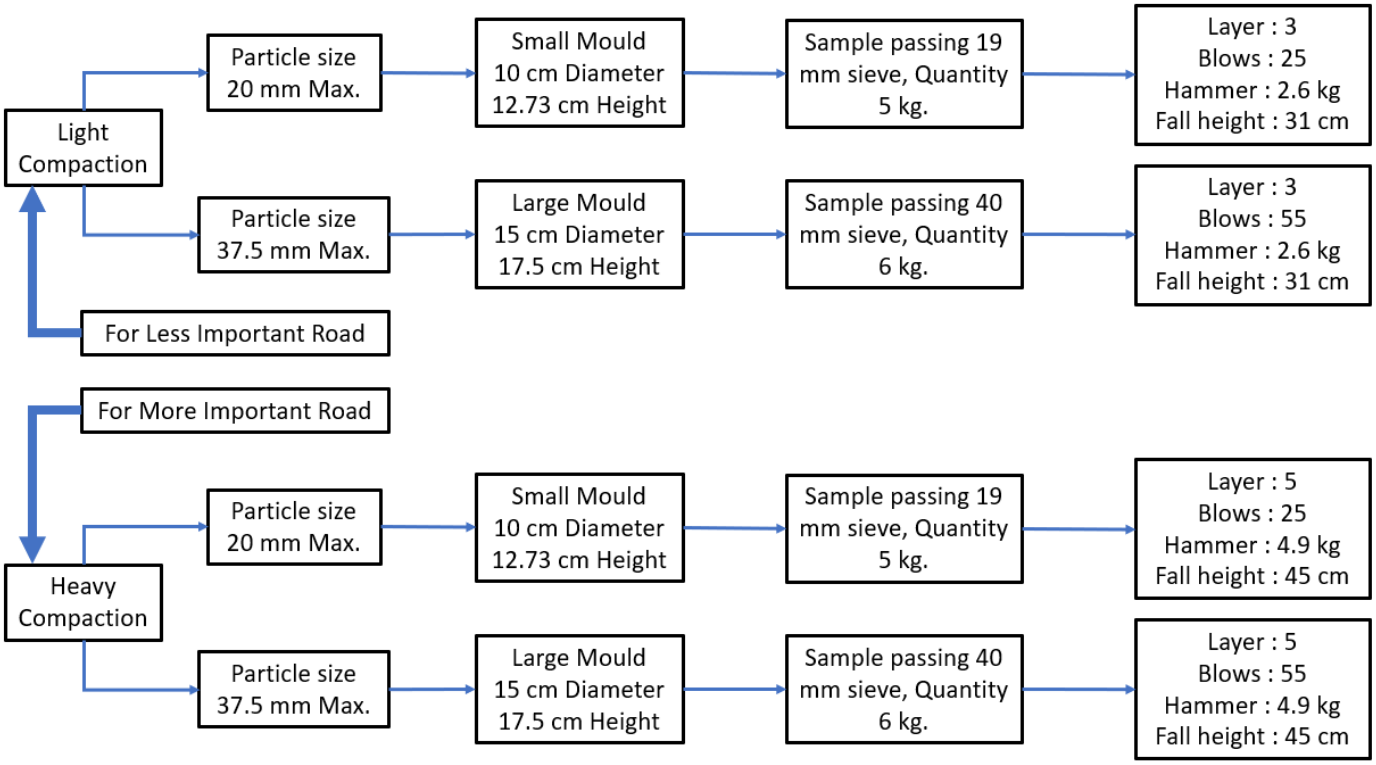
UNDISTURBED SPECIMEN

- Undisturbed specimens shall be obtained by fitting to the mould, the steel cutting edge of 150 mm internal diameter and pushing the mould as gently as possible into the ground.
- This process may be facilitated by digging away soil from the outside as the mould is pushed in.
- When the mould is sufficiently full of soil, it shall be removed by under digging, the top and bottom surfaces are then trimmed flat so as to give the required length of specimen ready for testing.
- If the mould cannot be pressed in, the sample may be collected by digging at a circumference greater than that of the mould and thus bringing out a whole undisturbed lump of soil.
- The required size of the sample to fit into the test mould shall then be carefully trimmed from this lump.
- If the specimen is loose in the mud, the annular cavity shall be filled with paraffin wax thus ensuring that the soil receives proper support from the sides of the mould during the test.
- The density of the soil shall be determined either by weighing the soil with mould when the mould is full with the soil, or by measuring the dimensions of the soil sample accurately and weighing or by measuring the density in field in the vicinity of the spot at which the sample is collected.

REMOULDED SPECIMEN

- The dry density for a remoulding shall be either the field density or the value of the maximum dry density estimated by compaction tests. The water content used for the compaction should be the OMC or the field moisture as the case may be.
- The material used in the remoulded specimen shall pass 19.0 mm IS sieve. Allowance for larger material shall be made by replacing it bay an equal amount of material which passes a 19.0 mm sieve and retained on 4.75 mm sieve.

- For Static Compaction the mass of wet soil at the required moisture content to give the desired density when occupying the standard specimen volume in the mould shall be calculated.
- A batch of soil shall be thoroughly mixed with water to give the required water content.
- The correct mass of moist soil shall be placed in the mould and compaction obtained by pressing in the spacer disc, a filter paper being placed between the disc and the soil.
- For Dynamic Compaction, a representative sample of the soil weighing approximately 4.5 kg or more for fine grained soils and 5.5 kg or more for granular soils shall be taken and mixed thoroughly with water.
- If the soil is to be compacted to the maximum dry density at the optimum moisture content, then the exact mass of soil required shall be taken and necessary quantity of water added so that the water content of the soil sample is equal to the determined optimum water content.



COMPACTION PROCEDURE FOR REMOULDED SPECIMEN

Remoulded Specimen can be compacted by		
Static Method	**Dynamic Method**	
	Light Compaction	**Heavy Compaction**
• Determine OMC and MDD of sample • Determine dry weight of sample required to fill the mould up to height of 12.5 mm. • Mix water with soil sample as per OMC. • A disc of coarse filter paper shall be placed on the perforated base plate. • Fill the mould with wet soil sample and place spacer disc on top of the soil with the extension collar attached. • Apply compression force on spacer disc until the top edge of the mould and top of spacer disc gets levelled.	• Determine OMC and MDD of sample • Determine dry weight of sample required to fill the mould up to height of 12.5 mm. • Mix water with soil sample as per OMC • Place spacer disc at bottom of the mould. • Attach the extension collar at the top of mould. • Fill the mould with wet soil sample in ***3 layers.*** • Each layer is compacted by giving ***55 blows of rammer.*** • Weight of rammer shall be ***2.6 kg*** and free fall height of ***31 cm.***	• Determine OMC and MDD of sample • Determine dry weight of sample required to fill the mould up to height of 12.5 mm. • Mix water with soil sample as per OMC • Place spacer disc at bottom of the mould. • Attach the extension collar at the top of mould. • Fill the mould with wet soil sample in ***5 layers.*** • Each layer is compacted by giving ***55 blows of rammer.*** • Weight of rammer shall be ***4.89 kg*** and free fall height of ***45 cm.***

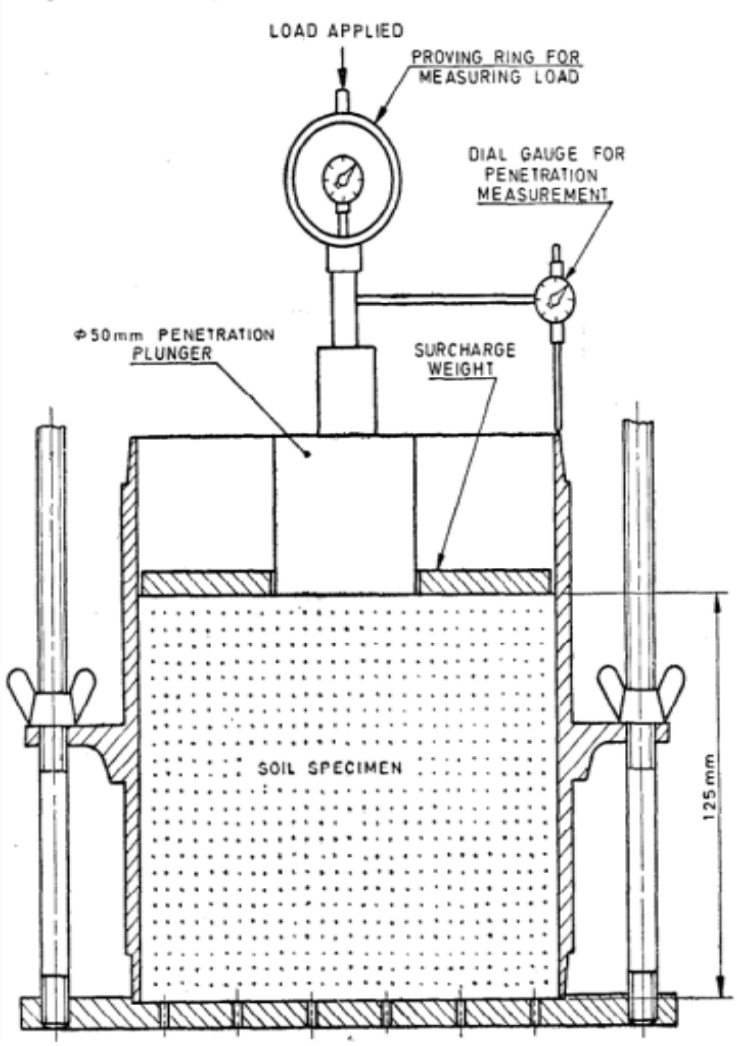
- After compaction the extension collar shall be removed, and the compacted soil carefully trimmed even with the top of the mould by means of a straightedge.
- Any hole that may then develop on the surface of the compacted soil by the removal of coarse material, shall be patched with smaller size material; the perforated base plate and the spacer disc shall be removed, and the mass of the mould and the compacted soil specimen recorded.
- A disc of coarse filter paper shall be placed on the perforated base plate and in the case of dynamic compaction, the mould and the compacted soil shall be inverted and the perforated base plate clamped to the mould with the compacted soil in contact with the filter paper.
- In both cases of compaction, if the sample is to be soaked, representative samples of the material at the beginning of compaction and another sample of the remaining material after compaction shall be taken for determination of water content. Each water content sample shall weigh not less than about 50 g.
- If the sample is not to be soaked, a representative sample of material from one of the cut-pieces of the material after penetration shall be taken to determine the water content. In all cases, the water content shall be determined.

TEST PROCEDURE FOR SWELLING TEST:

- A filter paper shall be placed over the specimen and the adjustable stem and perforated plate shall be placed on the compacted soil specimen in the mould.
- Weights to produce a surcharge equal to the weight of base material and pavement to the nearest 2.5 kg shall be placed on the compact soil specimen.
- The whole mould and weights shall be immersed in a tank of water allowing free access of water to the top and bottom of the specimen. The tripod for the expansion measuring device shall be mounted on the edge of the mould and the initial dial gauge reading recorded.
- This set-up shall be kept undisturbed for 96 hours noting down the readings every day against the time of reading. A constant water level shall be maintained in the tank through-out the period.
- At the end of the soaking period, the change in dial gauge shall be noted, the tripod removed, and the mould taken out of the water tank.
- The free water collected in the mould shall be removed and the specimen allowed to drain downwards for 15 minutes. Care shall be taken not to disturb the surface of the specimen during the removal of the water.
- The weights, the perforated plate and the top filter paper shall be removed and the mould with the soaked soil sample shall be weighed and the mass recorded.

TEST PROCEDURE FOR PENETRATION TEST:

- The mould containing the specimen, with the base plate in position but the top face exposed, shall be placed on the lower plate of the testing machine.
- Surcharge weights, enough to produce an intensity of loading equal to the weight of the base material and pavement shall be placed on the specimen.
- If the specimen has been soaked previously, the surcharge shall be equal to that used during the soaking period.
- To prevent upheaval of soil into the hole of the surcharge weights, 2.5 kg annular weight shall be placed on the soil surface prior to seating the penetration plunger after which the remainder of the surcharge weights shall be placed.
- The plunger shall be seated under a load of 4 kg so that full contact is established between the surface of the specimen and the plunger. The load and deformation gauges shall then be set to zero (In other words, the initial load applied to the plunger shall be considered as zero when determining the load penetration relation).



- Load shall be applied to the plunger into the soil at the rate of 1.25 mm per minute. Reading of the load shall be taken at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 4.0, 5.0, 7.5, 10.0 and 12.5 mm (The maximum load and penetration shall be recorded if it occurs for a penetration of less than 12.5 mm).
- The plunger shall be raised, and the mould detached from the loading equipment. About 20 to 50 g of soil shall be collected from the top 30 mm layer of the specimen and the water content is determined.
- If the average water content of the whole specimen is desired, water content sample shall be taken from the entire depth of the specimen.
- The undisturbed specimen for the test should be carefully examined after the test is completed for the presence of any oversize soil particles which are likely to affect the results if they happen to be located directly below the penetration plunger.

OBSERVATIONS:

SPECIMEN DATA

- The specimen data includes the condition of specimen at the time of testing, type of compaction adopted, the amount of soil fraction above 20 mm that has been replaced and the water content and density determinations before and after the mould has been subjected to soaking.

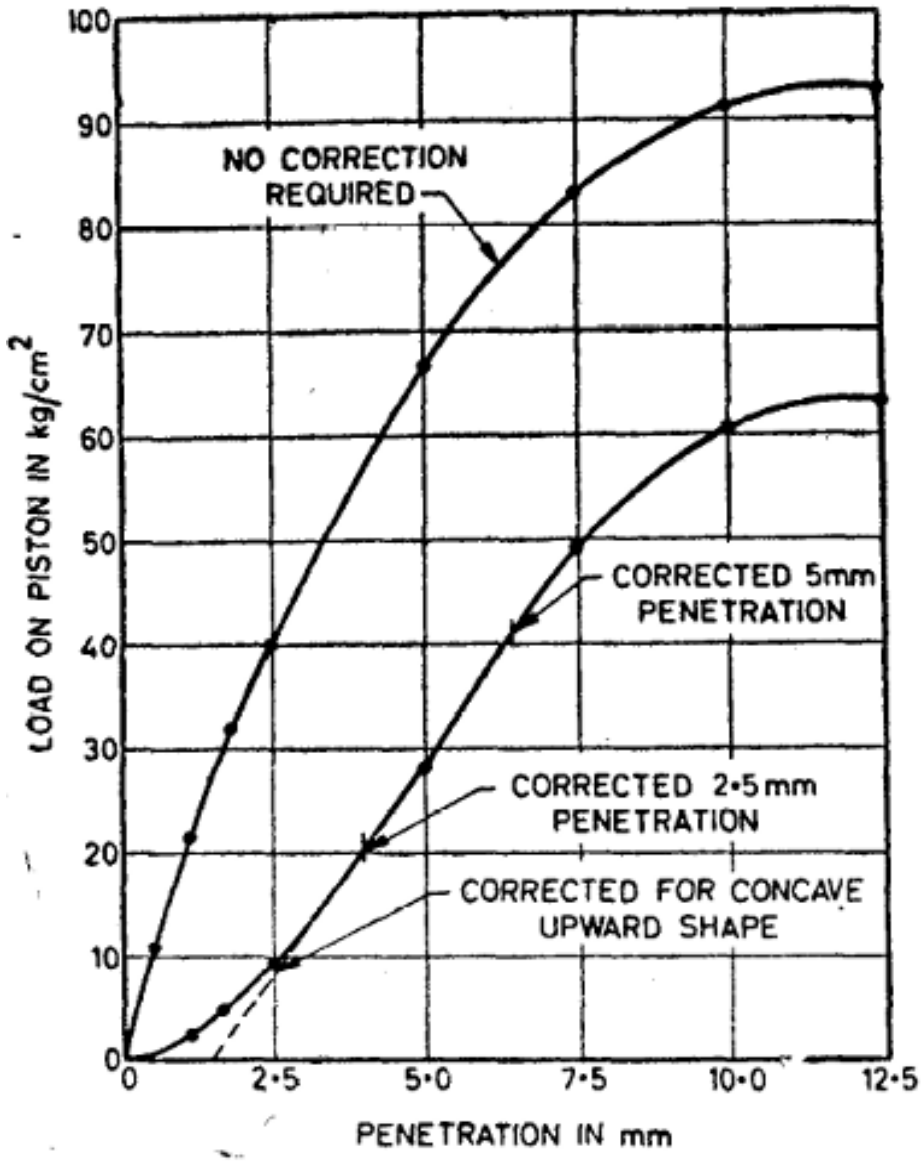
PENETRATION DATA

- The readings for the determination of expansion ratio and the load penetration data shall be recorded.

LOAD PENETRATION CURVE

- The load penetration curve shall be plotted. This curve is usually convex upwards although the initial portion of the curve may be convex downwards due to surface irregularities.

- A correction shall then be applied by drawing a tangent to the point of greatest slope and then transposing the axis of the load so that zero penetration is taken as the point where the tangent cuts the axis of penetration.
- The corrected load-penetration curve would then consist of the tangent from the new origin to the point of tangency on the re-sited curve and then the curve itself, as illustrated in figure below.



SOIL SAMPLE DETAILS

Sr. No.	Details	For Dynamic Compaction	For Static Compaction
1	Optimum water content, *w (%)*		
2	Weight of empty mould, *A (g)*		
3	Weight of mould + compacted specimen, *B (g)*		
4	Weight of compacted Specimen, *C = B – A (g)*		
5	Volume of specimen, *V* (cm^3)		
6	Bulk density, γ_b *(g/cc) = V/C*		
7	Dry density, γ_d *(g/cc)* = γ_b / [1 + (w/100)]		
8	Period of soaking (If soaked sample)		

LOAD PENETRATION READINGS

Proving Ring Capacity: ……. kN
Calibration Factor of Proving Ring: ……. kg / Ring Division
Surcharge Weight: …… kg
Least Count of Dial Gauge for measuring penetration: ……. mm / Ring Division

Penetration in mm	Proving Ring's Dial Gauge Ring Division	Load in kg	Corrected Load in kg
0.0			
0.5			
1.0			
1.5			
2.0			
2.5			
4.0			
5.0			
7.5			
10.0			
12.5			

CALCULATIONS:

Expansion Ratio = [(d_t - d_s)/h] X 100 =

Where, d_t = final dial gauge reading in mm,
d_s = initial dial gauge reading in mm, and
h = initial height of the specimen in mm
The expansion ratio is used to qualitatively identify the potential expansiveness of the soil.

California Bearing Ratio

The CBR values are usually calculated for penetrations of 2.5 and 5.0 mm. Corresponding to the penetration value at which the CBR values is desired, corrected load value shall be taken from the load penetration curve and the CBR calculated as follows:
California Bearing Ratio (%) = (P_T/P_S) x 100
Where, P_T = corrected unit (or total) test load corresponding to the chosen penetration from the load penetration curve, and
P_S = unit (or total) standard load for the same depth of penetration as for P_T taken from the below table
CBR at 2.5 mm Penetration =
CBR at 5.0 mm Penetration =

Generally, the C.B.R. value at 2.5 mm will be greater that at 5 mm and in such a case/the former shall be taken as C.B.R. for design purpose. If C.B.R. for 5 mm exceeds that for 2.5 mm, the test should be repeated. If identical results follow, the C.B.R. corresponding to 5 mm penetration should be taken for design.

STANDARD LOAD

Penetration of plunger (mm)	**Standard load (kg)**
2.5	1370
5.0	2055
7.5	2630
10.0	3180
12.5	3600

Calculation:

Result:

Conclusion:

Quiz:

A sub grade soil sample was tested using standard CBR test apparatus and observations are given below. Assume that the load penetration curve in convex throughout. What will be the CBR value in % for the given sample?

Load in Kg	Penetration in mm
60.5	2.5
80.5	5.0

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						

Experiment No. - 6

Measurement of Viscosity of Bitumen

Date:

Competency and Practical Skills: Observation skills and result interpretation skills

- **Objectives:**

  To determine viscosity of paving grade and cut-back bitumen.

Relevant CO:

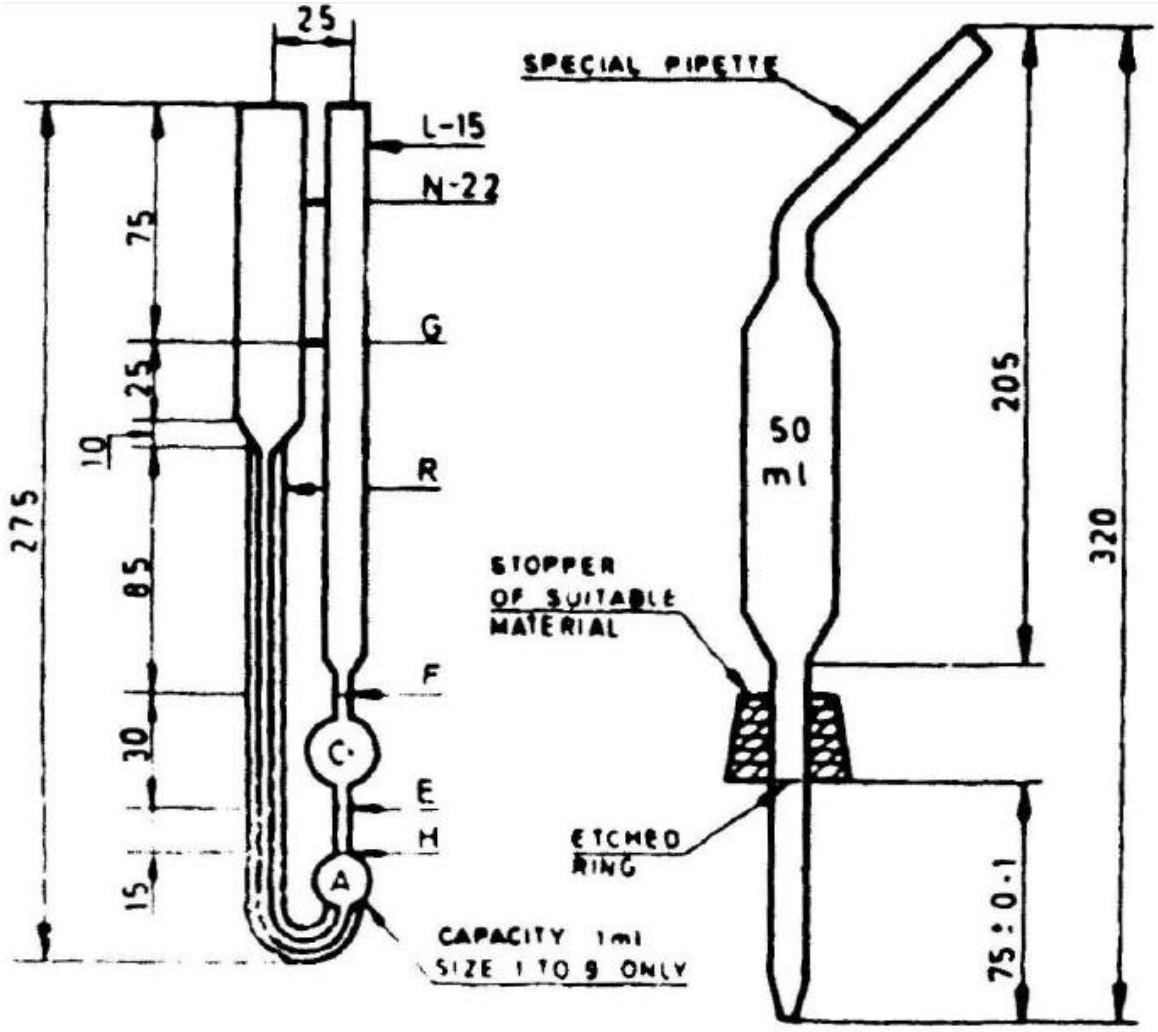
Kinematic Viscosity of Bitumen is defined as the quotient of the absolute or dynamic viscosity divided by the density of the liquid under test; both at the same temperature. The CGS unit of kinematic viscosity is the stoke which has the dimensions square centimetre per second. For petroleum products the kinematic viscosity is generally expressed in centistokes (sSt) which is 1/100 th of a stoke.

APPARATUS:

- **Viscometer** – Capillary type made of borosilicate glass.
  - Cannon-Fenske Viscometer for Opaque Liquids.
  - BS U-Tube Modified Reverse Flow Viscometer
- **Thermometer** of range $0^{o}C$ to $150^{o}C$
- **Bath:** A suitable bath for immersion of the viscometer so that the liquid reservoir or top of the capillary, whichever is uppermost is at least 20 mm below the upper bath level, and with the provision for the visibility of the viscometer and the thermometer.
- **Timing Device:** A stopwatch or stop clock capable of being read up to half a second.
- **Viscometer Holder**

SAMPLE:

- Heat the sample to a temperature not more than 60°C for tars and pitches and not more than 90% for bitumen above the corresponding approximate softening point temperature respectively until it attains pouring consistency.
- Stir it thoroughly and transfer approximately 20 ml in a 30 ml container**.**
- Local over-heating and entrapped air should be avoided.



All dimensions in millimetres

TEST PROCEDURE:

- Mount the BS U-tube viscometer in the constant temperature bath keeping tube *L* vertical.
- Pour sample through tube *N* to a point just above filling mark G, allow the sample to flow freely through capillary *R*, taking care that the liquid column remains unbroken until the lower mark *H* and then arrest its flow by closing the timing tube with a cork or rubber stopper in tube *L*.
- Add more liquid, if necessary, to bring the upper meniscus slightly above mark G.
- After allowing the sample to attain bath temperature and any air bubble to rise to the surface (usually about 20-30 min is required), gently loosen the stopper allowing the sample to flow until it is approximately at the lower filling mark *H* and press back the stopper to arrest flow.
- Remove the excess sample above filling mark G by inserting the special pipette until its cork rests on top of the tube *N* and apply gentle suction until air is drawn through.
- The upper meniscus shall coincide with mark G. Allow the viscometer to remain in the constant temperature bath for an enough time to ensure that the sample reaches temperature equilibrium.
- It takes about 20 min at 38°C, 25 min at 100°C and 30 min at 135°C. Remove the stopper in the tube N and *L* respectively and allow the sample to flow by gravity.
- Measure to the nearest 0.1 s the time required for the leading edge of the meniscus to pass from timing mark *E* to timing mark *F*.
- If this efflux time is less than 60 s select a viscometer of smaller capillary diameter and repeat the operation.
- Upon of the test, clean the viscometer thoroughly by several mixing with an appropriate solvent completely miscible with the sample followed by a completely volatile solvent.

- Dry the tube by passing slow stream of filtered dry air through the capillary until the last trace of solvent is removed.

CALCULATION:

- Calculate and report the kinematic viscosity to three significant figures, by the following equation:
  - Kinematic viscosity cSt = Ct

  Where, C = calibration constant of the viscometer in centistokes per second; and
  t = flow or efflux time, in seconds
- Report always the test temperature along with the results

OBSERVATION:

Grade of Bitumen:

Test Temperature:

Parameter	For Bulb C
Flow Time, Seconds (FT)	
Calibration Factor (CF)	
Viscosity in cSt (FT x CF)	

Calculation:

Result:

Conclusion:

Quiz:

1) Suggest the minimum kinematic viscosity for VG-30 Grade Bitumen. ……
2) For viscosity graded bitumen the kinematic viscosity is determined at temperature…….
3) Is there any need to apply vacuum for determination of kinematic viscosity? Yes / No

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

Experiment No. - 7

Determination of softening point of bitumen (IRC: 1203 - 1978)

Date:

Competency and Practical Skills: Observation skills and result interpretation skills

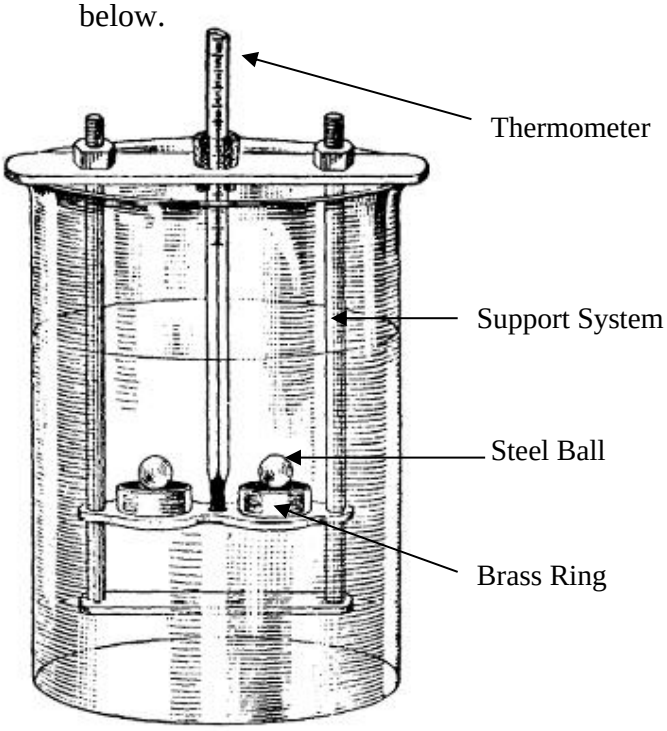
- **Objectives:**

  To determine softening point of asphaltic bitumen.

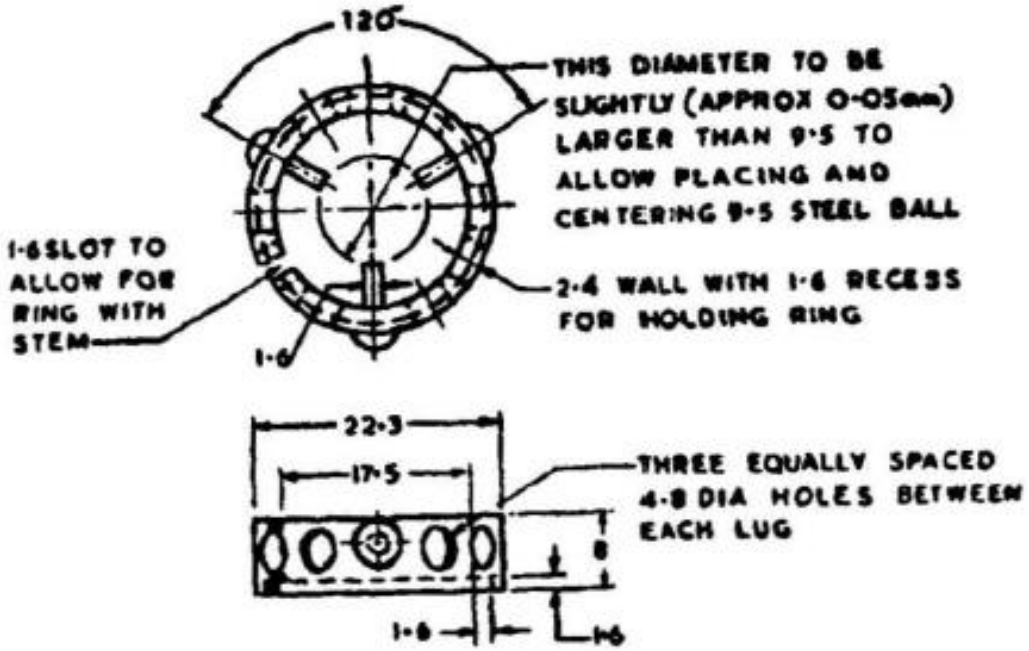
Relevant CO:

APPARATUS:

- **Ring and Ball Apparatus:** A convenient form of apparatus as shown in the figure below.



- **Steel Balls:** 2 Numbers; each 9.5 mm in diameter and weighing 3.5 ± 0.05 g.
- **Brass Rings:** 2 Numbers; the rings shall be tapered and shall conform to the following dimensions:
  - Depth: 6.4 ± 0.1 mm
  - Inside Diameter at Bottom: 15.9 ± 0.1 mm
  - Inside Diameter at Top: 17.5 ± 0.1 mm
  - Outside Diameter: 20.6 ± 0.1 mm
- **Ball Guide:** A convenient form of ball centering guide as shown in figure below:



- **Support:** Any means of supporting the rings may be used provided the following conditions are observed:
    - The rings shall be supported in a horizontal position with the upper surface of the rings 50 mm below the surface of the bath liquid.
    - There shall be exactly 25 mm between bottom of the rings and the top surface of the bottom plate of the support, if any, or the bottom of the bath.
    - The thermometer shall be suspended so that the bottom of the bulb is level with the bottom of the rings, and within 10 mm of the rings, but not touching them.
- **Thermometer:** It shall be of the range -2°C to 80°C
- **Bath:** A heat resistance glass vessel not less than 85 mm in diameter and 120 mm in depth. The bath liquid shall be boiled with distilled water when testing materials having softening points below 80°C, and pure glycerin for materials having softening points above 80°C.
- **Stirrer:** Manual or mechanical, which always operates smoothly to ensure uniform heat distribution throughout the bath.

SAMPLE:

- Heat the material to a temperature between 75°C and 100°C above its softening point, stir until it is completely fluid and free from air bubbles and water, and filter, if necessary, 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, and fill with sufficient melt to give an excess above the level of the ring when cooled.
- After cooling for 30 minutes in air, level the material in the ring by removing the excess with a warmed, sharp knife.

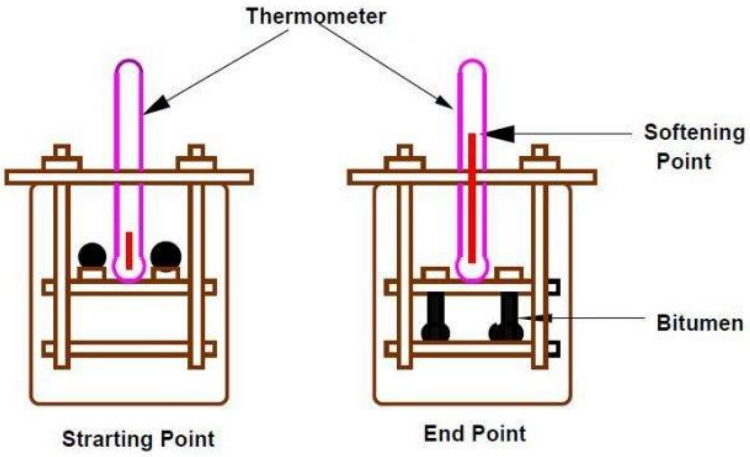
TEST PROCEDURE:

- **For Materials of Softening Point Below 80°,** Assemble the apparatus with the rings, thermometer, and ball guides in position, and fill the bath to a height of 50 mm above the upper surface of the rings with freshly boiled distilled water at a temperature of 5°C.
- Maintain the bath at a temperature of 5°C for 15 minutes after which place a ball, previously cooled to a temperature of 5°C, by means of forceps in each ball guide.

- Apply heat to the bath and stir the liquid so that the temperature rises at a uniform rate of 5.0 ± 5ºC per minute until the material softens and allows the ball to pass through the ring.
- The rate of temperature rise shall not be averaged over the period of test, and any test in which the rate of temperature rise does not fall within the specified limits after three minutes shall be rejected.
- Make determination in duplicate.
- **For Materials of Softening Point Above 80º,** the procedure is like that described above with the difference that glycerin is used in place of water in the bath and the starting temperature of the test is 35ºC.
- Make the determination in duplicate.

REPORTING OF RESULT:

- Record for each ring and ball, the temperature shown by the thermometer at the instant the sample surrounding the ball touches the bottom plate of the support, if any, or the bottom of the bath.
- Report to the nearest 0.5ºC the mean of the temperature recorded in duplicate determinations, without correction for the emergent stem of the thermometer, as the softening point.



OBSERVATION:

Bitumen grade: …….

Period of air cooling: ……..minute

Medium of liquid bath: water

Test starting temperature: 5 °c

Period up to which starting temperature of test is maintained: 15 minutes

Rate of heating: 5 °c per minute

Bitumen pouring temp °c: 75 °c to 100 °c

Description	For Ball 1	For Ball 2	Mean Value
Temperature at which the bitumen around the ball touches the bottom as the ball falls	……°c	……..°c	……..°c

Calculation:

Result:

Conclusion:

Quiz:

1) Suggest the softening point for following grades of bitumen:
   VG 10: …… ^{o}C
   VG 20: …… ^{o}C
   VG 30: …… ^{o}C
   VG 40: …… ^{o}C
2) Which liquid medium shall be used as liquid bath for determination of softening point of materials whose approximate softening point is above 80^{o}C? ……..
3) The rate at which bitumen sample is heated during softening point test is ……..…….

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						

Experiment No. - 8

Determination of ductility of bitumen (IRC: 1208 - 1978)

Date:

Competency and Practical Skills: Observation skills and result interpretation skills

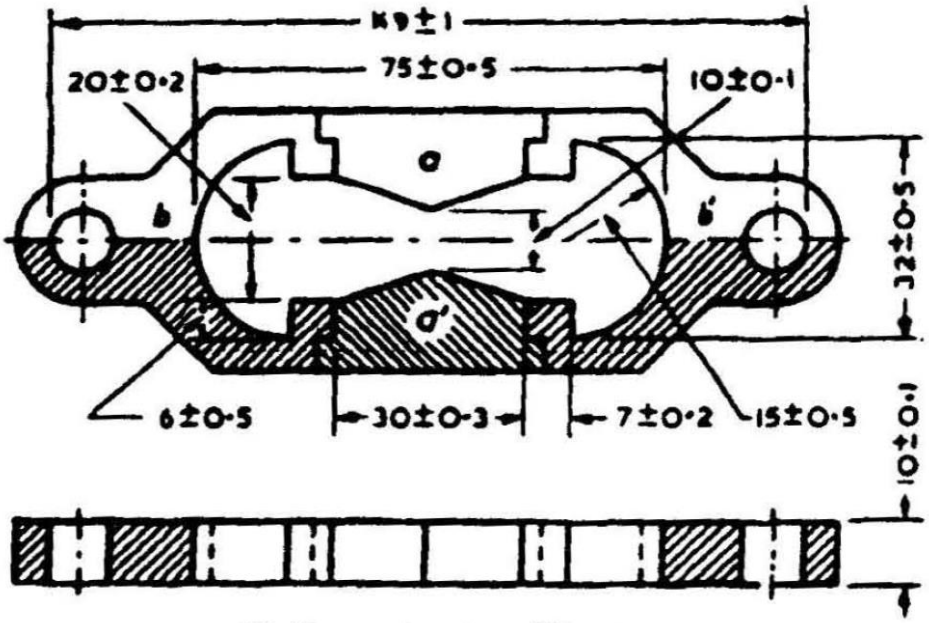
- **Objectives:**

  To determine ductility of bitumen.

Relevant CO:

APPARATUS:

- Mould having dimensions as shown in figure. The ends a and a' are sides of mould and b and b' are clips of mould.
- The dimensions of mould are such that when properly assembled, it will form a briquette specimen having following dimensions:
  - Total length: 75 ± 0.5 mm
  - Distance between clips: 30 ± 0.3 mm
  - Width at mouth of clip: 20 ± 0.2 mm
  - Width at minimum cross section: 10 ± 0.1 mm
  - Thickness throughout: 10 ± 0.1 mm



All dimension in millimetres.

- Water Bath preferably with a thermostat maintained within ± 0.1°C of the specified test temperature.
- Testing Machine for pulling the briquette of bituminous material apart horizontally with minimum vibrations at a speed of 50 mm per minute and it shall have suitable arrangement for stirring the water for attaining uniformity in temperature.

SAMPLE:

- Completely melt the bituminous material to be tested to a temperature of 75 to 100°C above the approximately softening point until it becomes thoroughly fluid.
- Assemble the mould on a brass plate and in order to prevent the material under test from sticking, thoroughly coat the surface of the plate and interior surfaces of the sides of the mould with a mixture of equal parts of glycerine and dextrine.
- In filling, pour the material in a thin stream back and forth from end to end of the mould until it is more than level full.
- Leave it to cool at the room temperature for 30 to 40 min, and then place in a water bath maintained at the specified temperature for 30 min after which cut off the excess bitumen by means of a hot, straight-edged putty knife or spatula so that the mould shall be just level full.

TEST PROCEDURE:

- Unless otherwise specified, the test shall be conducted at a temperature of 25.0 ± 0.5°C and at a rate of pull of 50.0 ± 2.5 mm/mm.
- Place the brass plate and mould with briquette specimen, in the water bath and keep at the specified temperature for about 85 to 95 minutes.
- Then remove the briquette from the plate, detach the side pieces, and test the briquette immediately.
- Attach the rings at each end of the clips to the pins or hooks in the resting machine and pull the two clips apart horizontally at a uniform speed as specified until the briquette ruptures.
- Measure the distance in centimetres through which the clips have been pulled to produce rupture. While the test is being made, make sure that the water in the tank of the testing machine covers the specimen both above and below it by at least 25 mm and is maintained continuously within ± 0.5°C of the specified temperature.
- A normal test is one in which the material between the two clips pulls out to a point or to a thread and rupture occurs where the cross-sectional area is a minimum.
- Report the average of three normal tests as the ductility of the sample.
- If the bituminous material meets the surface of the water or the bottom of the bath, the test shall not be considered normal.
- Adjust the specific gravity of the water in the bath by the addition of either methyl alcohol or sodium chloride so that the bituminous material does not either come to the surface of the water or touch the bottom of the bath at any time during the test.

OBSERVATION:
Grade of Bitumen:
Pouring Temperature:
Period of Air Cooling:
Period up to which Sample placed in water bath:
Rate of Pulling:

Briquette No.	Distance in cm. at which Bitumen thread breaks	Mean Value
1		
2		
3		

Calculation:

Result:

Conclusion:

Quiz:
1) The temperature at which ductility test is carried out is …… ^{o}C.
2) The rate of pulling briquettes during ductility test is …… mm/min.
3) What is the minimum ductility value for VG 30 Grade Bitumen?.....

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						

Experiment No. - 9

Determination of flash point and fire point of bitumen (IS:1209-1978)

Date:

Competency and Practical Skills: Observation skills and result interpretation skills

FLASH POINT – The flash point of a material is the lowest temperature at which the application of test flame causes the vapours from the material to momentarily catch fire in the form of a flash under specified conditions of the test.

FIRE POINT – The fire point is the lowest temperature at which the application of test flame causes the material to ignite and burn at least for 5 seconds under specified conditions of the test.

- **Objectives:**

  To determine the temperatures at which bitumen causes flash and fire respectively.

Relevant CO:

APPARATUS:

- ***Pensky-Martens Tester consisting of following major parts:***
  - ***Cup***
  - ***Lid including*** *stirring device, cover proper, shutter and flame exposure device*
  - ***Stove consisting of air bath and top plate***
  - ***Thermometer of range – 7°C to 400 °C***

TEST PROCEDURE:

- Clean and dry all parts of the cup and its accessories thoroughly before the test is started. Take particular care to avoid the presence of any solvent used to clean the apparatus after a previous test.
- Fill the cup with the material to be tested up to the level indicated by the filling mark. Place the lid on the cup and set the latter in the stove.
- Take care that the locating devices are properly engaged. Insert the thermometer.
- Light and adjust the test-flame so that it is of the size of a bead of 4 mm in diameter. Apply heat at such a rate that the temperature recorded by the thermometer increases between 5 to 6^{o}C per minute.
- Turn the stirrer at a rate of approximately 60 revolutions per minute. Apply the test-flame at each temperature reading which is a multiple of 1°C up to 104°C.
- For the temperature range above 104°C, apply the test-flame at each temperature reading which is a multiple of 2°C, the first application of the test-flame being made at a temperature at least 17°C below the actual flash point.
- Apply the test-flame by operating the device controlling the shutter and test-flame burner so that the flam e is lowered in 0.5 seconds, left in its lowered position for one second, and quickly raised to its high position.
- The test-flame will neither be larger than stipulated nor will it be applied more frequently than specified as the surface layer is liable to be superheated.
- The bluish halo that sometimes surrounds the test-flame shall not be confused with the true flash.
- Discontinue the stirring during the application of the test-flame.

TEST PROCEDURE:

- Clean and dry all parts of the cup and its accessories thoroughly before the test is started. Take particular.

OBSERVATION:

Property	Test I	Test II	Mean Value
Flash point, ^{o}C			
Fire point, ^{o}C			

Calculation:

Result:

Conclusion:

Transportation Engineering

Quiz:

1) Define Flash Point
2) Define Fire Point

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						

Experiment No. - 10

Determination of bitumen content (IRC – SP 11 - 1988)

Date:

Competency and Practical Skills: Observation skills and result interpretation skills

- **Objectives:**

To determine the percentage amount of bitumen in the paving mixture.

Relevant CO:

APPARATUS:

- **Extraction Apparatus:** consisting of a rotating machine in which the bowl may be revolved at controlled variable speeds up to 3600 rpm The apparatus shall be provided with a shell for catching the solvent thrown from the bowl and a drain for removing the solvent. The apparatus preferably shall be provided with explosion proof features and installed under a hood to provide ventilation.
- **Benzene**
- **Filter Rings**
- **Oven:** capable of being maintained at 150^{o}C
- **Balance:** of 5000 g capacity, sensitivity to 0.1 g
- **Graduate**: 2000 ml capacity

SAMPLE:

- A representative sample about 500 gm is exactly weighed and placed in the bowl of the extraction apparatus and covered with commercial grade of benzene.
- Enough time (not more than 1 hour) is allowed for the solvent to disintegrate the sample before running the centrifuge.

TEST PROCEDURE:

- The filter ring of the extractor is dried, weighed and then fitted around the edge of the bowl. The cover of the bowl is clamped tightly. A beaker is placed under to collect the extract.
- The machine is revolved slowly and then gradually, the speed is increased to a maximum of 3600 RPM. The speed is maintained till the solvent ceases to flow from the drain.
- The machine is allowed to stop and 200ml of the benzene is added and above procedure is repeated.
- Several 200 ml solvent additions (not less than three) are used till the extract is clear and not darker than a light straw colour.
- The filter ring from the bowl is removed, dried in air and then in oven to a constant temperature at 115^{o}C, and weighed.
- The fine materials that have passed through the filter paper are collected back from the extract preferable by centrifuging.
- The material is washed and dried to constant weight as before.

OBSERVATIONS:
Weight of Sample, $\mathbf{W_1}$ =
Weight of Sample after extraction, $\mathbf{W_2}$ =
Weight of fine material recovered from the extract, $\mathbf{W_3}$ =
Increase in weight of filter ring, $\mathbf{W_4}$ =
Percentage Binder in Mix = $\frac{W_1-(W_2+W_3)+W_4}{W_1}$

Calculation:

Result:

Conclusion:

Quiz:
1) Name the chemical used in the test for stripping bitumen from aggregate ……

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

Experiment No. - 11

Determination of stripping value of road aggregate (IS: 6241-1971)

Date:

Competency and Practical Skills: Observation skills and result interpretation skills

- **Objectives:**

To determine the adhesion property of aggregate with different types of bituminous binders so that suitability of aggregates could be ascertained.

Relevant CO:

APPARATUS:

- IS Sieve of sizes 20.0 mm and 12.0 mm
- Water Bath
- Stove
- 500 ml Beaker

TEST PROCEDURE:

- Take 200 grams of dry and clean aggregates passing 20 mm and retained on 12.5 mm sieves and heat up to 150° C.
- Take five percent by weight of bitumen binder and heat up to 160° C.
- Mix the aggregates and the binder till they are completely coated and transfer the mixture in to a 500 ml beaker and allow to cool at room temperature for about 2 hours.
- Add distilled water to immerse the coated aggregates.
- Cover the beaker and keep in a water bath maintained at 40° C taking care that the level of water in the water bath is at least half the height of the beaker.
- After 24 hours take the beaker out, cool at room temperature and estimate the extent of stripping visually while the specimen is still under the water.

OBSERVATION:

Test No.	Uncovered area observed visually/Total area of the aggregates	Mean
1		
2		
3		

Calculation:

Result:

Conclusion:

Quiz:

1)

2)

3)

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						

Experiment No. - 12

Determination of Marshall Stability value for Bituminous mix

Date:

Competency and Practical Skills: Observation skills and result interpretation skills

Relevant CO:

OBJECTIVE:

- To determine the optimum binder content for a paving mixture

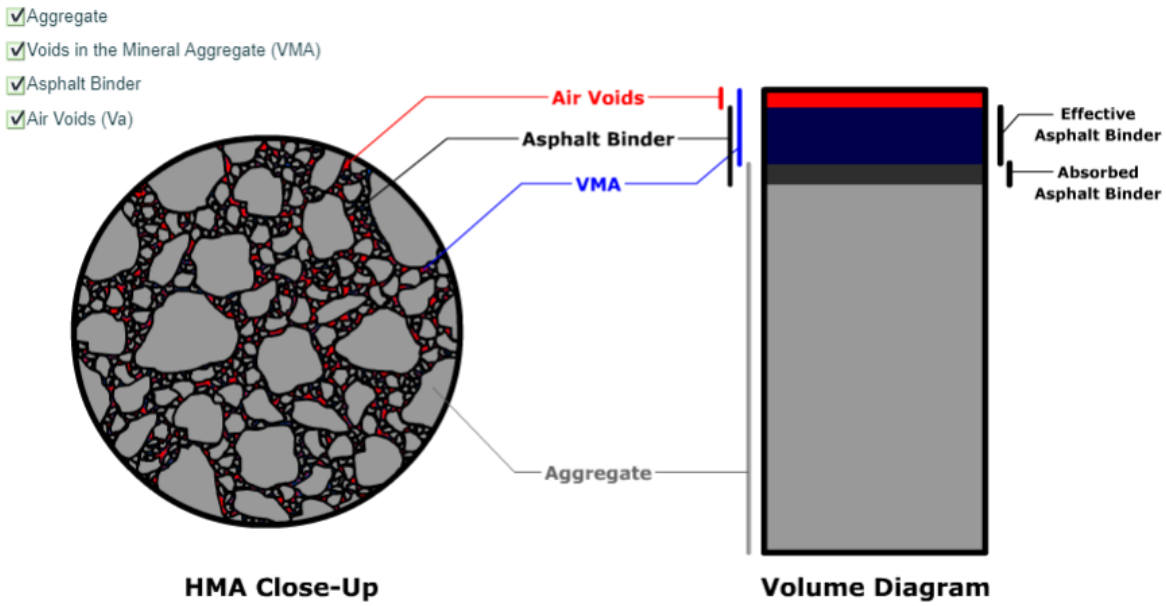
APPARATUS:

- Marshall Stability testing machine
- Cylindrical Mould internal diameter 100 mm and height 75 mm
- Compaction Hammer of 4500 g and free fall of 4570 mm
- Compaction Pedestal
- IS Sieves

SAMPLE:

- Before developing the Marshall mix design, representative samples of paving bitumen and aggregates proposed to be used on the project should be collected.

- These samples must be tested and must meet all specification criteria as laid down in MoRT&H specifications.



TEST PROCEDURE:

Preparation of Compacted Specimens

- Decide the type of mix to be prepared viz., Bituminous Macadam, Dense Bituminous Macadam, Bituminous Concrete, Semi-Dense Bituminous Concrete etc….
- Collect different sizes of aggregate and mix them well in adequate proportion to achieve desired gradation of the above stated types of mixes. (For this refer Experiment No. 6)
- Prepare a sample of 1200 g mixed aggregates as discussed in previous point.
- Heat the prepared aggregate mixture.
- Also heat the sufficient amount of bitumen. Three compacted specimens each should be prepared at 5 different bitumen contents. Bitumen contents are usually selected in 0.5% increments with at least two bitumen contents above estimated "optimum" and at least two below "optimum". Refer to MoRT&H guidelines for approximate "optimum" bitumen content or the estimate of optimum bitumen content can be based on experience.
- The temperature for various operations is given in table below for different bitumen grades:

Bitumen Viscosity Grade	Bitumen Temperature	Aggregate Temperature	Mixed Material Temperature	Laying Temperature	Rolling Temperature
VG 40	160-170	160-175	160-170	150 Min.	100 Min.
VG 30	150-165	150-170	150-165	140 Min.	90 Min.
VG 20	145-165	145-170	145-165	135 Min.	85 Min.
VG 10	140-160	140-165	140-160	130 Min.	80 Min.

- As the aggregates and the bitumen reaches sufficient temperature as mentioned in the table above thoroughly mix them keeping in view the Mixed Material Temperature until all the aggregate is coated.
- Mixing can be by hand, but a mechanical mixer is preferred. When mixing is done by hand, place the mixing bowl on a hot plate to ensure mix does not cool while mixing.
- Check temperature of freshly mixed material; if it is above the compaction temperature, allow it to cool to compaction temperature; if it is below compaction temperature, discard the material and make a new mix.
- Place a paper disc into an assembled, preheated Marshall mould and pour in loose bitumen mix. Check the temperature again. Spade the mixture with a heated spatula.
- Remove the collar and mound material inside mould so that middle is slightly higher than edges.
- Attach mould and base plate to pedestal.
- Place preheated hammer in the mould and apply appropriate number of blows (usually 75 blows in India) to top side of specimen.
- Remove the mould from base plate. Place a paper disc on top of specimen and invert the mould upside down. Replace the mould collar and attach mould and base plate to the pedestal. Place hammer on the mould and apply same number of blows to bottom as were applied to the top.
- Remove filter papers from top and bottom of specimens. Cool specimens at room temperature for 24 Hours and then extrude from mould.

- Place identification marks on each specimen.
- Allow specimens to sit at room temperature overnight for further testing.
- Determine the bulk specific gravity (G_{mb}) of each specimen by weighing in air. Submerge samples in water and allow saturating prior to getting submerged weight in saturate surface dry (SSD) condition.
- Remove sample and weigh in air in SSD condition.
- Measure the maximum specific gravity (G_{mm}) of the loose asphalt mix samples in accordance with ASTM D 2041.

Determination of Marshall Stability and Flow

- Heat the water bath to 60^{o}C and place specimens to be tested in the bath for at least 30 min but not more than 40 min. Place specimens in the bath in staggered manner to ensure that all specimens have been heated for the same length of time before testing.
- After heating for the required amount of time, remove a specimen from the water bath, pat with towel to remove excess water, and quickly place in the Marshall testing head.
- Bring loading ram into contact with testing head. Zero the flow gauge and loading gauge.
- Apply load at 50 mm/min until maximum load is reached.
- When load just begins to decrease, remove the flow meter, stop ram movement, and record stability (maximum load) in kN and flow in 0.25 mm.
- Testing should be completed within 1 min from the time the specimen is remove from the hot water bath.
- It is possible while making the specimen that the thickness slightly varies from the standard specification of 63.5 mm. Therefore, measured stability values need to be corrected to those which would have been obtained if the specimens had been exactly 63.5 mm. This is done by multiplying each measured stability value by an appropriated correlation factors as given in Table below:

Volume of specimen (cm^3)	**Thickness of specimen(mm)**	**Correction factor**
457 - 470	57.1	1.19
471 - 482	68.7	1.14
483 - 495	60.3	1.09
496 - 508	61.9	1.04
509 - 522	63.5	1.00
523 - 535	65.1	0.96
536 - 546	66.7	0.93
547 - 559	68.3	0.89
560 - 573	69.9	0.86

Calculation of mix volumetrics

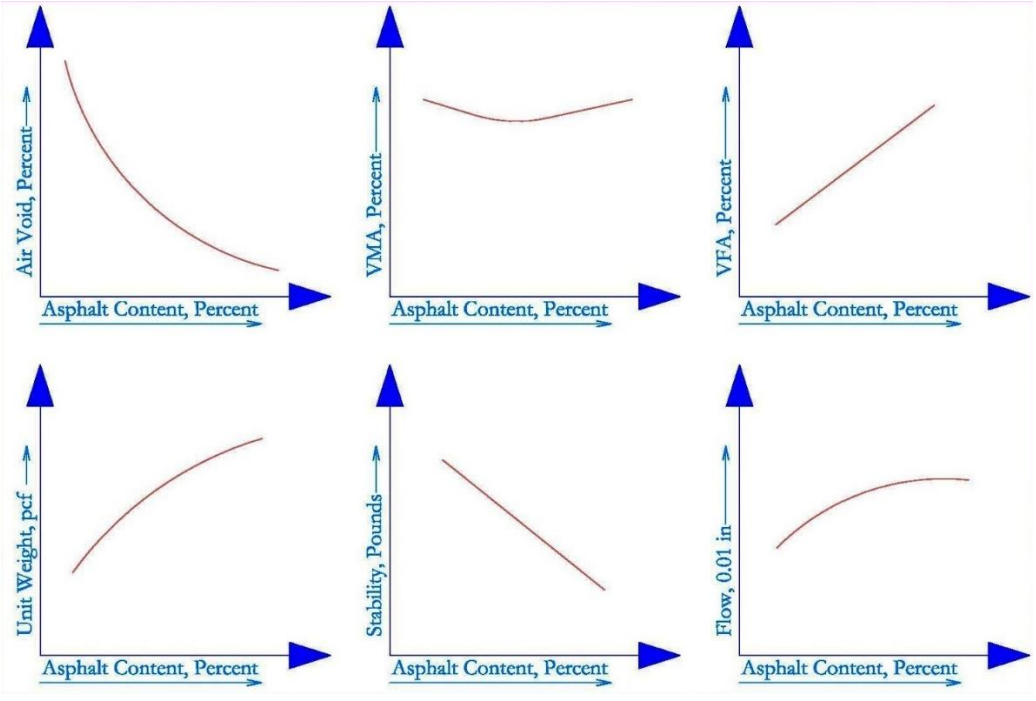
- For each specimen, use bulk specific gravity (G_{mb}) and the maximum specific gravity (G_{mm}) to calculate percentage air voids (V_a) as follows:
  - $V_a = 100\ X\ \frac{G_{mm} - G_{mb}}{G_{mm}}$
- Calculate the voids in mineral aggregate for each specimen using bulk specific gravity of aggregate (G_{sb}) and the bulk specific gravity of compacted mix (G_{mb}), and the percentage of aggregate by weight of total mix (P_s) as follows:
  - $G_{sb} = \frac{P_1 + P_2 + P_3 + \ldots . P_N}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_3}{G_3} + \ldots . \frac{P_N}{G_N}}$

    Where P_1, P_2, P_3…..P_N = Proportion of different sizes of aggregates

    G_1, G_2, G_3…..G_N = Specific Gravity of different sizes of aggregates
  - $VMA = 100 - \frac{G_{mb}\ P_s}{G_{sb}}$
- Calculate the voids filled with bitumen (VFB) for each marshall specimen using the air voids and VMA as follows:
  - $VFB = \frac{100(VMA - V_a)}{VMA}$

Preparation of Graphical Plots with Bitumen Content on X-Axis

- All the volumetric properties, stability and flow values of each specimen (3 Nos.) having same binder content is averaged and graphs are plotted for 5 different binder content samples (2 binder contents below optimum, 2 binder contents above optimum and 1 optimum binder content).
- Plot the graphs
  - Bitumen content vs bulk specific gravity (or density or unit weight)
  - Bitumen content vs Marshall stability
  - Bitumen content vs flow
  - Bitumen content vs air voids
  - Bitumen content vs VMA
  - Bitumen content vs VFB or VFA



Determination of Optimum Binder Content

- Optimum binder content is amount of bitumen corresponding to air voids of 4%.

OBSERVATION:

- Gradation and Blending of Aggregates

IS Sieve Size in mm	**% Weight Passing of ……mm Aggregates**	**% Weight Passing of ……mm Aggregates**	**% Weight Passing of ……mm Aggregates**	**% Weight Passing of ……mm Aggregates**	**Obtained Gradation**	**Desired Gradation**
	Proportion (%) …….	**Proportion (%) …….**	**Proportion (%) ……..**	**Proportion (%) ……..**		

- Specific Gravity of Aggregate Type-1 =
- Specific Gravity of Aggregate Type-2 =
- Specific Gravity of Aggregate Type-3 =
- Specific Gravity of Aggregate Type-4 =
- Bulk Specific Gravity of Total Aggregate = $G_{sb} = \frac{P_1 + P_2 + P_3 + \ldots P_N}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_3}{G_3} + \ldots \frac{P_N}{G_N}}$
- Bitumen percentage by weight of aggregate =
- Compacted Mix Density

Sample No.	Weight in Air (g)	Weight in Water (g)	SSD Weight (g)	Volume, III - II (cc)	Density, I/IV (g/cc)
	I	II	III	IV	V

- Theoretical Maximum Specific Gravity, $\mathbf{G_{mm}}$ =

- Voids in Mineral Aggregates, VMA = $100 - \frac{G_{mb}\, P_s}{G_{sb}}$ =

  1)

  2)

  3)

- Air Voids, $\mathbf{V_a}$ = $100\ X\ \frac{G_{mm} - G_{mb}}{G_{mm}}$

  1)

  2)

  3)

- Voids filled by Bitumen or Asphalt, VFB or VFA = $\frac{100(VMA - V_a)}{VMA}$ =

  1)

  2)

  3)

- Marshall Stability & Flow

Sample No.	Sample Dimensions (mm)		Correction Factor	Marshall Stability Value (kN)	Corrected Marshall Stability (kN)	Flow (mm)
	Diameter	Thickness				

RESULT:

Calculation:

Conclusion:

Suggested Reference:

References used by the students:

Rubric wise marks obtained:

Rubrics	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						