TESTING OF CEMENT

- Exhaustive tests are carried out in laboratory to decide precisely the quality of cement.
- In order to make a representative sample, it is desirable to collect in nearly equal portions as follows.

  I) When cement is loose: It should be taken from at least 12 points from heap or heaps cement,
  (ii) When cement is in bags: it should be taken from at least 12 different bags or packages.

- Quantity of cement so collected is intimately mixed and the final sample of cement weighing at least 50N is prepared. It's then stored in airtight container till the tests are started.
  - Following are the purposes of testing of cement (BIS:4031/1968)

(i) Determine the physical and chemical properties of cements;

(ii) Regulate the various stages in the manufacturing process as a slight difference in the process of manufacture of cement may cause a great difference in the quality of cement.

(iii) Understand the behavior of cement after its use on the works. Following are standard. Test cement.

Testing of cement		
Field Test	**Lab Test**	
• Colour	**Physical properties**	**Chemical Test**
• Physical Test	▪ Fineness Test	♦ Lois on ignition
• Strength	▪ Consistency Test test	♦ Chemical composition Test
	▪ Initial and Final setting time	
	▪ Soundness Test	
	▪ Determination of strength	
	▪ Heat of Hydration	
	▪ Specific Gravity	

FIELD TESTS FOR CEMENTS

Following four field tests may be carried out to ascertain roughly the quality of cement:

1. **Colour:** Colour of cement should be uniform. i.e. grey colour with a light greenish shade.
2. **Physical Properties:** Cement should feel smooth when touched or rubbed in-between fingers.
    - If felt rough, it indicates adulteration with sand.
    - If hand ia inserted in a bag or heap of cement, it should feel cool and not warm
    - If a small quantity of cement is thrown in a bucket of water, it should sink and should not float on the surface.
    - A thin paste of cement with water should feel sticky between the fingers. . If the cement contains too much of pounded clay and silt as an adulterant, the paste gives an earthy smell.
3. **Presence of lumps**: Cement should be free from any hard lump. Such lumps are formed by the absorption of moisture from the atmosphere.

• Any bag of cement containing such lumps should be rejected.

Strength: Strength of cement can be roughly ascertained in the following ways.

(a)Briquettes with a lean or weak mortar are made. Size of briquette may be about. 75mm x 25mmx 12mm. The proportion of cement and sand may be 1: 6. The briquettes are immersed in water for a period of 3 days. If cement is of sound quality, such briquettes will not be broken easily and it will be difficult to convert them into powder form will not be broken easily and it will be difficult to convert them into powder form.

(b) A block of cement 25mm x25mm and 200 mm long is prepared and it is immersed for 7 days in water. It is then placed on support 150mm apart and it is loaded with a weight of 340 N. The block should not show signa of failure.

(c) A thick faster of cement with water is made on a piece of thick glass and it is kept under water for 24 hours. It should set and not crack.

PHYSICAL LAB TEST

1. Fineness Test

Degree of fineness of cement is the measure of the mean size of the grain in it.

There are three methods of testing of fineness of cement.

(a) Sieve method using 90-micron (9.No.) Sieve

(b) Air permeability method)- Nurse and Blaine's method

(c) Sedimentation method – Wanger turbidimeter method

Sieve method measures grain size whereas air permeability method and sedimentation measures surface area.

Since cement grains are finer than 90 micron, the sieve analysis method does not represent true mean size of cement grains. Also, the tiny cement grains tend to conglomerate into lumps resulting in distortion in the final grain size distribution curves.

Due to these demerits, fineness is generally expressed in terms of specific area, which is the total surface area of the particles in unit weight of material.

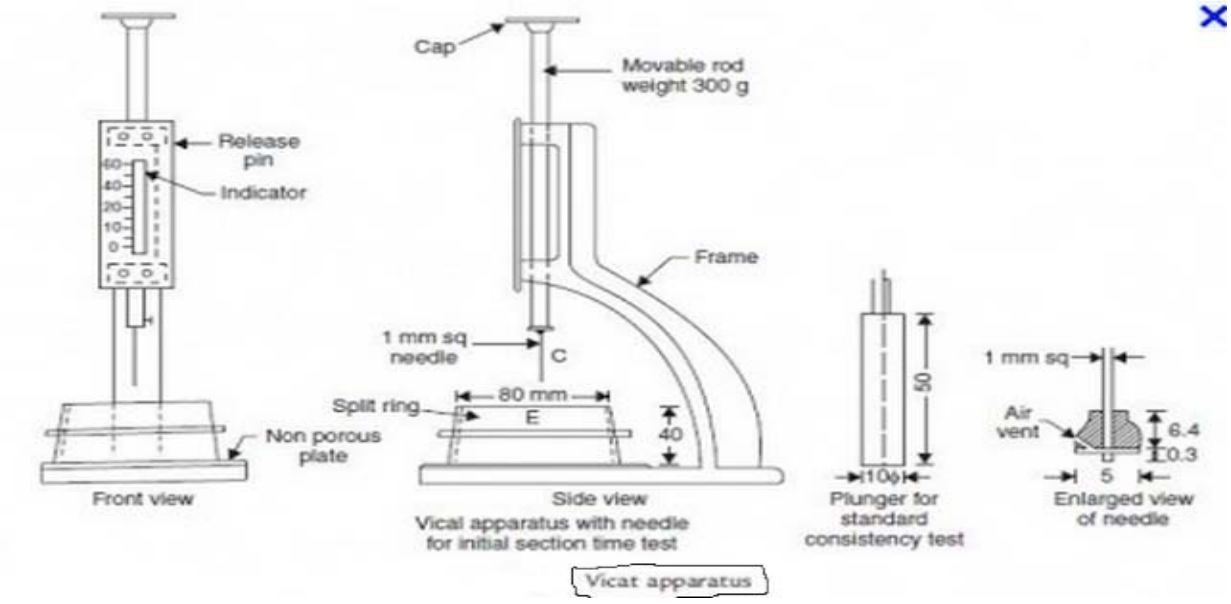
Chemical composition

2.Consistency Test

- This test is to estimate the quantity of mixing water to form a paste of normal consistency.
- Normal consistency is defined as that percentage water requirement of the cement paste, the viscosity of which will be such that the Vicat's plunger penetrates up to a point 5 to 7mm" from the bottom of the Vicat's Mould.

Why it is done?

- The water requirement for various tests for various tests of cement depends on the normal consistency of the cement, which itself depends upon the compound composition and fineness of the cement.



Vicats Apparatus

- It consists of a frame to which is attached a movable rod weighing 300 gm and having diameter and length as 10 mm and 50 mm respectively
- An indicator is attached to the movable rod, which indicator moves on a vertical scale and it gives the penetration.

- Vicat mould is in the form of a cylinder and it can be split into two halves. Vicat mould is placed on a non porous plate.
- There are three attachments, square needle, plunger, and needle with annular collar.

Attachment	Use
10 mm Dia Plunger	Consistency test
1 mm square needle	Initial setting time
5 mm Dia annular collar	final setting time

Procedure

- A square needle 10 mm x 10 mm attached to the plunger is then lowered gently over the cement paste surface and is released quickly. Plunger pierces the cement paste and reading on the attached scale is recorded.
- When the reading is 5-7 mm from the bottom of the mould, the amount of water added considered to be correct percentage of water for normal consistency.

3. Setting Time

- When water is added to cement and mixed properly, the chemical Reaction soon starts and the cement paste remains plastic for a short period. During this period it is possible to remix the paste and this period is called initial setting time.

- It is assumed that no hardening will start in this period. As the time passes, the reaction is continued and cement begins to Harding and time elapse at the times of mixing water to hardened is known as final setting time.

(a) Initial setting time test

Procedure

- The cement weighing 300 gm is taken and make a cement paste of consistency 0.85 P.
- The cement paste is. Filled in the vicat mould.
- Square needle 1x1 mm is attached to the moving rod of the vicat apparatus.
- The needle is quickly released and it is allowed to penetrate the cement paste.
- When the needle penetrates only 5 to 7mm from the bottom, it show that test is completed.
- Initial setting time should not be less than 30 minutes for OPC and 1 hr. For low heat cement.

(h) Final setting time test

Procedure

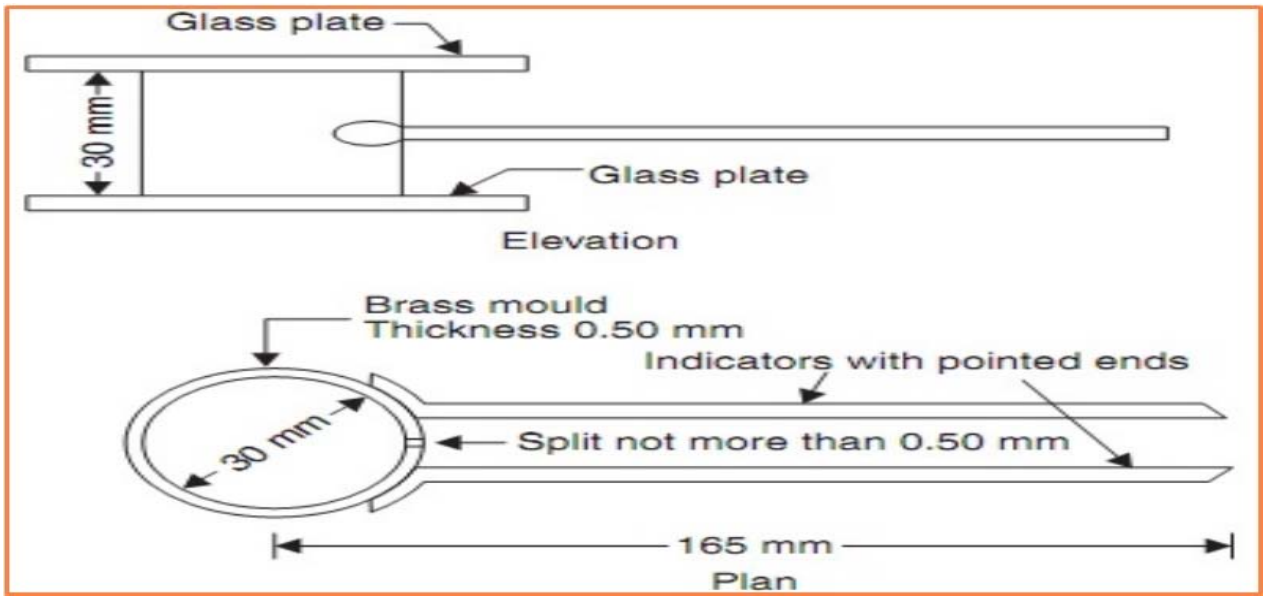
- The cement paste is prepared as above in (a) and it is filled in the vicat mould.
- The needle with annular collar is attached in place of square needle.
- The needle is gently released. The time at which the needle makes an impression on test block and the collar fails to do so is noted.
- The final setting time is the difference w. the time at which water was added to cement and the time as recorded (noted) ".
- The final setting time not greater than 10 hours.

Why Initial and Final Setting Test is done?

- Initial setting time test in done because:
- Concrete once placed should not be disturbed till the initial setting has taken place.
- There must be sufficient time for placing of second batch otherwise this may disturb the first batch of concreting.
- The transportation of concrete from the place where concrete is prepared to the placing of concrete required some finite time for that also initial setting time test is required.
- Final setting time test is done because the concrete should achieve the desired strength as early as possible so that the shuttering can be removed and reused.

4. Soundness Test

Purpose of this test is to detect the change in volume of cement after setting. Soundness of cement is tested by Le-Chatelier method or by autoclave method. Soundness of cement can be ensured by limiting the quantities of free lime and magnesia which shake slowly causing change in volume of cement (known as unsound). It is a very important test to assure the quality of cement since an unsound cement produces cracks, distortion and disintegration, ultimately leading to failure.



Procedure

1. Cement paste is prepared with 100 gm of cement sample + 0.78P, (P = water required to give a paste of standard consistency)

2. A Mould of 30 mm dia and height 30mm is placed on glass plate and it is filled by cement paste.

3. Now mould is covered with a glass sheet and a small weight is placed on the covering glass sheet.

4. Mould is then submerged in the waler at temperature of 27 to 32◦ C. After 24 hours, the Mould is taken out and the distance separating the indicator points ie measured.

5. Mould is again submerged in water in such a way that boiling point of water ia reached in 25 to 30 minutes and water is now boiled for 3 hours.

6. Mould is removed from water and is cooled down, The distance between the indicator points is measured again.

7. Difference between the two measurements represents the unsoundness of cement.

8. For OPC. RHC, LHC and PPC it is limited to 10mm, whereas for High Alumina Cement and Super Sulphate Cement it should not exceed 5mm.

The Le-chatterer's method detect. Unsoundness due to free line only.

The excess of magnesia and calcium sulphate is not detected.

(b) Autoclave test

- In India, the occurrence of low magnesia lime stone is limited so Indian standard. Specification recommended that cement having a magnesia content > 3% be tested for soundness by autoclave test. This test is sensitive to both free magnesia and free lime.

Procedure

- A specimen in mould of 25x25mm x 282mm internal length is placed.
- The specimen is removed from the mould and placed in autoclave at room temperature.
- Now the steam pressure inside the autoclave is raised at such a state as to bring the gauge.
- Pressure of the steam to 2.1 + 0.1 N/nm is 60 to 75 minutes from the time heat is switched on.
- This pressure is allowed to maintained for 3 hrs.
- The autoclave is cooled and length of the specimen is measured again.
- The difference in-length of test specimen before and after autoclaving is calculated to the nearest 0.01% of the effective length and reported as autoclave expansion of the cement.
- For sound cement the expansion should-not exceed 0.8%.

5. Strength Test

- Cement hydrates when water is added to it and cohesion and solidity is experienced. It binds together the aggregates by adhesion.
- The strength of mortar and concrete depends upon the type and nature of cement.
- Therefore, it should develop at least a minimum-opacified strength if it is to be used in structures.
- Cement is tested for compressive and tensile strengths.

Compressive Strength

It is fundamental and basic information required for the concrete mix design.

By this test, the quality and the quantity of concrete can be controlled and the degree of adulteration can be checked

Procedure

1. A mixture of cement (185 gm) is mixed with standard sand 55 gm (Ennore sand) proportion of 1:3 by weight is mixed for one minute and then water % is added until the mixture is of uniform colour, where P= percentage of water required to produce a past of standard consistency.
2. 2.Temperature of water and test room should be 27°C + 2◦ C.
3. Material for each specimen cube is mixed separately.
4. Mould is filled completely with the cement paste and is placed on the vibration table. Vibrations are imparted for about 2 minutes at a speed off 12000+400 per minute.
5. Three specimen cubes are prepared of size 70.6 mm (having face area of about 5000 m square).
6. Cubes are then removed from the Moulds and submerged in clean fresh water and are taken out just prior to testing in a compression testing machine.
7. Load is applied starting from zero at a rate of 35 N/sq mm/minute.
8. Compressive strength is calculated from the crushing load divided by the average over which the load is applied. The result is expressed in N/mm.
9. Compressive strength is taken to be the average of the results of the three cubes.

Minimum Specified Strength in N/mm square

Type/Day	**1 Day**	**3 Days**	**7 Days**	**28 Days**
Ordinary Portland Cement (33 grade)		**16.00**	**22.00**	**33.00**
Portland Pozzolana cement		**16.00**	**22.00**	**33.00**
Low heat Portland cement		**10.00**	**16.00**	**35.00**
Rapid hardening cement	**16.00**	**27.5**		
High alumina cement	**30.00**	**35.00**		

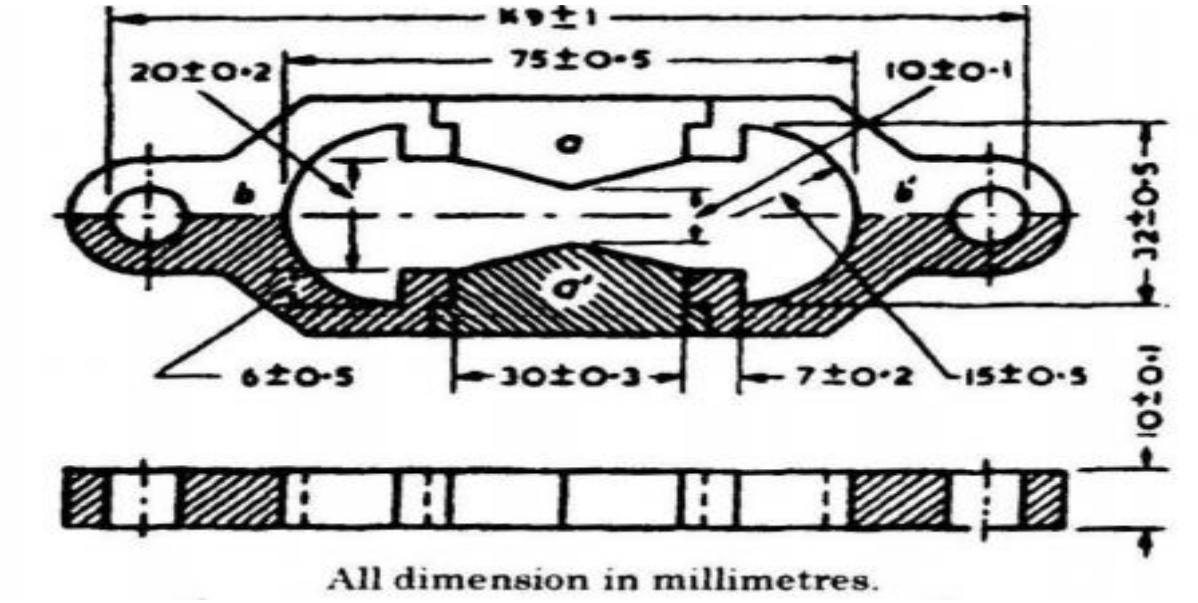
Tensile Strength

- Tensile strength is determined by Briquette test method.
- This test was formerly used to have an indirect indication of compressive strength of cement.
- It is approximately 10-15% of compressive strength.
- This method at present is generally used for RHC.
- Tensile strength test can be performed more conveniently and provide quicker indications of defects in cement in comparison to compressive strength test.

Briquette Method

Procedure

- Mixture ofcement and sand in gauged in the proportion of 1:3 by weight.
- Percentage of water to be used is [P/5 + 2.5]%, where P= parentage of water required to produce a paste of standard consistency Mix is filled in the briquette moulds and surface of would be finished with the blade of a trowel.
- Now they are leaved for 24 hrs. temperature of 27+/- 2◦ C having 90% atmospheric humidity.



- Briquettes are then kept in clean fresh water and are taken out before tenting. 6 briquettes are tested and the average tensile strength in calculated.
- Load is applied steadily and uniformly, starting from zero and increasing at the rate of 0.7 Nimm' 12 second.
- Ordinary Portland cement should have a tensile strength of not less than 2.0 N/mm after 3 days and not less than 2.5 N/mm after 7days.

6. Heat of Hydration

During hydration of cement heat is evolved and it is dependent on the relative quantities of clinker on the relative quantities of clinker compounds. Heat of hydration is important in two cases.

(a) Mass, concrete: As the thermal Conductivity of concrete is low, the heat liberated in the interior of large mass does not come to the surface, while exterior surface loses the heat to atmosphere quickly This causes a temperature difference with in the concrete mass causing differential movement in the concrete which is restrained and resulting unnecessary stress and cracks.

(b) Concreting during winter: During winter heat of hydration prevents the capillary moisture in the concrete from freezing which is advantageous.

Procedure

Apparatus used to determine the heat of hydration of cement is known as calorimeter

60 g of cement and 24 ml of distilled water are mixed for 4 minutes at temperature 15-25°C.

Three specimen glass vials 100 x 20 mm are filled with this mixture, corked and sealed with wax.

Vials are then stored with the mixture in s vertical position at 27 +/-2° C

Heat of hydration is obtained by subtracting the respective heat of solution of unhyrated cement calculated nearest to 0.1 calorie.

For determining the heat of solution of unhydrated cement, weigh a sample of about 3 g. At the same time, weigh out 7.0 g of cement for the loss on ignition.

Heat of solution (Cal/g) of unhydrated cement = [(Heat capacity x corrected temperature rise) / Weight of sample for ignition loss] -0.2(room temp – final temp of the calorimeter)

Where, 0.2 = Specific heat of Un hydrated cement

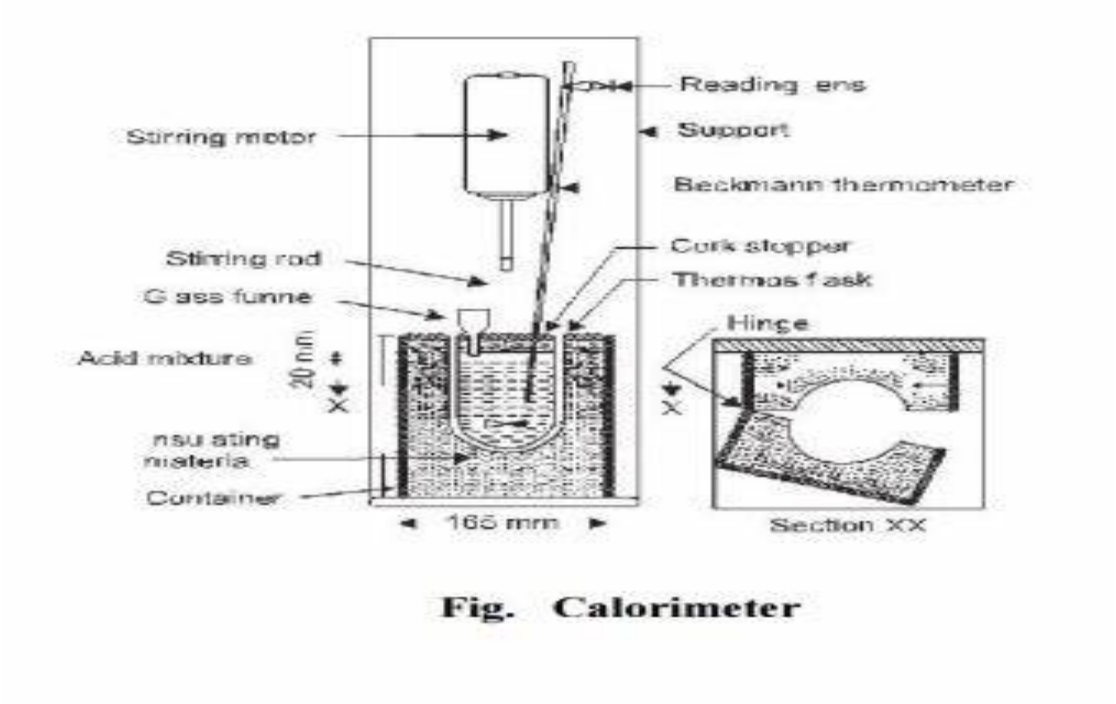


Fig. Calorimeter

Sub-Topic:

Quality Control for Bitumen

- **Laboratory tests on bitumen to check quality: -**

Various tests are conducted on bitumen to assess its consistency, gradation, viscosity, temperature, susceptibility, and safety.

There are a number of tests to assess the properties of bituminous materials.

Following tests are usually conducted to evaluate different properties of bituminous materials.

1. Penetration Test
2. Ductility Test
3. Softening Point Test
4. Specific Gravity Test
5. Viscosity Test
6. Flash and Fire Point Test
7. Float Test
8. Water Content Test
9. Loss on heating test

1. Penetration Test

It measures the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds. BIS had standardized the equipment and test procedure. The penetrometer consists of a needle assembly with a total weight of 100g and a device for releasing and locking in any position. The bitumen is softened to a pouring consistency, stirred thoroughly and poured into containers at a depth at least 15 mm in excess of the expected penetration. The test should be conducted at a specified temperature of 25-degree Celsius. It may be noted that penetration value is largely influenced by any inaccuracy with regards to pouring temperature, size of the needle, weight placed on the needle and the test temperature. A grade of 40/50 bitumen means the penetration value is in the range 40 to 50 at standard test conditions. In hot climates, a lower penetration grade is preferred.

2. Ductility Test

Ductility is the property of bitumen that permits it to undergo great deformation or elongation. Ductility is defined as the distance in cm, to which a standard sample or briquette of the material will be elongated without breaking. Dimension of the briquette thus formed is exactly 1 cm square. The bitumen sample is heated and poured in the mould assembly placed on a plate. These

samples with moulds are cooled in the air and then in water bath at 27-degree Celsius temperature. The excess bitumen is cut and the surface is leveled using a hot knife. Then the mould with assembly containing sample is kept in water bath of the ductility machine for about 90 minutes. The sides of the moulds are removed, the clips are hooked on the machine and the machine is operated. The distance up to the point of breaking of thread is the ductility value which is reported in cm. The ductility value gets affected by factors such as pouring temperature, test temperature, rate of pulling etc. A minimum ductility value of 75 cm has been specified by the BIS.

3. Softening point test

Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of test. The test is conducted by using Ring and Ball apparatus. A brass ring containing test sample of bitumen is suspended in liquid like water or glycerin at a given temperature. A steel ball is placed upon the bitumen sample and the liquid medium is heated at a rate of 5 C per minute. Temperature is noted when the softened bitumen touches the metal plate which is at a specified distance below. Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates.

3. Specific Gravity Test

In paving jobs, to classify a binder, density property is of great use. In most cases bitumen is weighed, but when used with aggregates, the bitumen is converted to volume using density values. The density of bitumen is greatly influenced by its chemical composition. Increase in aromatic type mineral impurities cause an increase in specific gravity.

The specific gravity of bitumen is defined as the ratio of mass of given volume of bitumen of known content to the mass of equal volume of water at 27 C. The specific gravity can be measured using either pycnometer or preparing a cube specimen of bitumen in semi solid or solid state. The specific gravity of bitumen varies from 0.97 to 1.02.

4. Viscosity Test

Viscosity denotes the fluid property of bituminous material and it is a measure of resistance to flow. At the application temperature, this characteristic greatly influences the strength of resulting paving mixes. Low or high viscosity during compaction or mixing has been observed to result in lower stability values. At high viscosity, it resists the compactive effort and thereby resulting mix is heterogeneous, hence low stability values. And at low viscosity instead of providing a uniform

film over aggregates, it will lubricate the aggregate particles. Orifice type viscometers are used to indirectly find the viscosity of liquid binders like cutbacks and emulsions. The viscosity expressed in seconds is the time taken by the 50 ml bitumen material to pass through the orifice of a cup, under standard test conditions and specified temperature. Viscosity of a cutback can be measured with either 4.0 mm orifice at 25 C or 10 mm orifice at 25 or 40 C.

5. Flash and Fire Point Test

At high temperatures depending upon the grades of bitumen materials leave out volatiles and these volatiles catches fire which is very hazardous and therefore it is essential to qualify this temperature for each bitumen grade. BIS defined the flash point as the temperature at which the vapor of bitumen momentarily catches fire in the form of flash under specified test conditions. The fire point is defined as the lowest temperature under specified test conditions at which the bituminous material gets ignited and burns.

6. Float Test

Normally the consistency of bituminous material can be measured either by penetration test or viscosity test. But for certain range of consistencies, these tests are not applicable and Float test is used. The apparatus consists of an aluminum float and a brass collar filled with bitumen to be tested. The specimen in the mould is cooled to a temperature of 5C and screwed in to float. The total test assembly is floated in the water bath at 50C and the time required for water to pass its way through the specimen plug is noted in seconds and is expressed as the float value.

7. Water Content Test

It is desirable that the bitumen contains minimum water content to prevent foaming of the bitumen when it is heated above the boiling point of water. The water in a bitumen is determined by mixing known weight of specimen in a pure petroleum distillate free from water, heating and distilling of the water. The weight of the water condensed and collected is expressed as percentage by weight of the original sample. The allowable maximum water content should not be more than 0.2% by weight.

8. Loss on Heating Test

When the bitumen is heated it loses the volatility and gets hardened.

About 50gm of the sample is weighed and heated to a temperature of 163C for 5hours in a specified oven designed for this test. The sample specimen is weighed again after the heating period and loss in weight is expressed as percentage by weight of the original sample.

Bitumen used in pavement mixes should not indicate more than 1% loss in weight, but for bitumen having penetration values 150-200 up to 2% loss in weight is allowed.

- **List of IS Codes related to Bitumen Testing**

Name of Test	**IS Code**
Penetration Test	IS: 1203- 1978
Ductility Test	IS: 1208- 1978
Softening Point Test	IS: 1205- 1978
Specific Gravity Test	IS: 1202- 1978
Viscosity Test	IS: 1206- 1978
Flash & Fire Point Test	IS: 1209- 1978
Float Test	IS; 1210- 1978
Determination of Water Content	IS: 1211- 1978
Loss on Heating Test	IS: 1212- 1978

- **Field Tests of Bitumen**

Check Bitumen Odour or Smell:

- Odour of bitumen is similar to lubricating oil. It is generally smell like lubricating oil which is used in machines to reduce and increase the speed or working process of machines like diesel, grease etc.

Check Bitumen color:

- Mix the bitumen with either petrol, kerosene or diesel, if it gives uniform dark color liquid then it means it is suitable for our road construction.