1.3 TESTS ON CEMENT

Testing of cement can be brought under two categories:

- Field testing
- Laboratory testing.

Field Testing

It is sufficient to subject the cement to field tests when it is used for minor works. The following are the field tests:

- Open the bag and take a good look at the cement. There should not be any visible lumps. The colour of the cement should normally be greenish grey.
- Thrust your hand into the cement bag. It must give you a cool feeling. There should not be lump inside.
- Take a pinch of cement and feel-between the fingers. It should give a smooth and not a gritty feel
- Take a handful of cement and throw it on a bucket full of water, the particles should float for some time before they sink.
- Take about 100 grams of cement and a small quantity of water and make a stiff paste. From the stiff paste, pat a cake with sharp edges. Put it on a glass plate and slowly take it under water in a bucket. See that the shape of the cake is not disturbed while taking it down to the bottom of the bucket. After 24 hours the cake should retain its original shape and at the same time it should also set and attain some strength.

Laboratory testing:

The following tests are usually conducted in the laboratory.

- Fineness test.
- Setting time test.
- Strength test.
- Soundness test.

- Heat of hydration test.
- Chemical composition test.

Fineness Test

The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence faster the development of strength, Fineness of cement is tested in two ways:

- By sieving.
- By determination of specific surface (total surface area of all the particles in one gram of cement) by air-permeability appartus. Expressed as cm2/gm or m2/kg. Generally Blaine Air permeability appartus is used

Sieve Test

- Weigh correctly 100 grams of cement and take it on a standard IS Sieve No. 9 (90 microns).Break down the air-set lumps in the sample with fingers. Continuously sieve the sample giving circular and vertical motion for a period of 15 minutes.
- Mechanical sieving devices may also be used. Weigh the residue left on the sieve. This weight shall not exceed 10% f or ordinary cement. Sieve test is rarely used.

1. Air Permeability Method

- This method of test covers the procedure for determining the fineness of cement as represented by specific surface expressed as total surface area in sq. cm/gm. of cement. It is also expressed in m^2/kg. Lea and Nurse Air Permeability Appartus is shown in Fig. This appartus can be used for measuring the specific surface of cement.
- The principle is based on the relation between the flow of air through the cement bed and the surface area of the particles comprising the cement bed. From this the surface area per unit weight of the body material can be related to the permeability of a bed of a given porosity.

- The cement bed in the permeability cell is 1 cm. high and 2.5 cm. in diameter. Knowing the density of cement the weight required to make a cement bed of porosity of 0.475 can be calculated.
- Slowly pass on air through the cement bed at a constant velocity. Adjust the rate of air flow until the flow meter shows a difference in level of 30-50 cm. Read the difference in level (h1) of the manometer and the difference in level (h2) of the flow meter.
- Repeat these observations to ensure that steady conditions have been obtained as shown by a constant value of h1/h2. Specific surface. Fineness can also be measured by Blain Air Permeability apparatus. This method is more commonly employed in India.

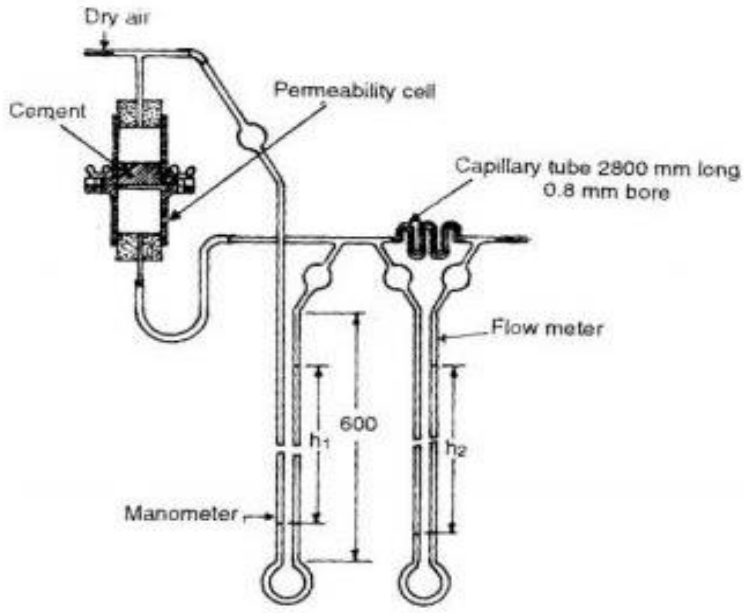
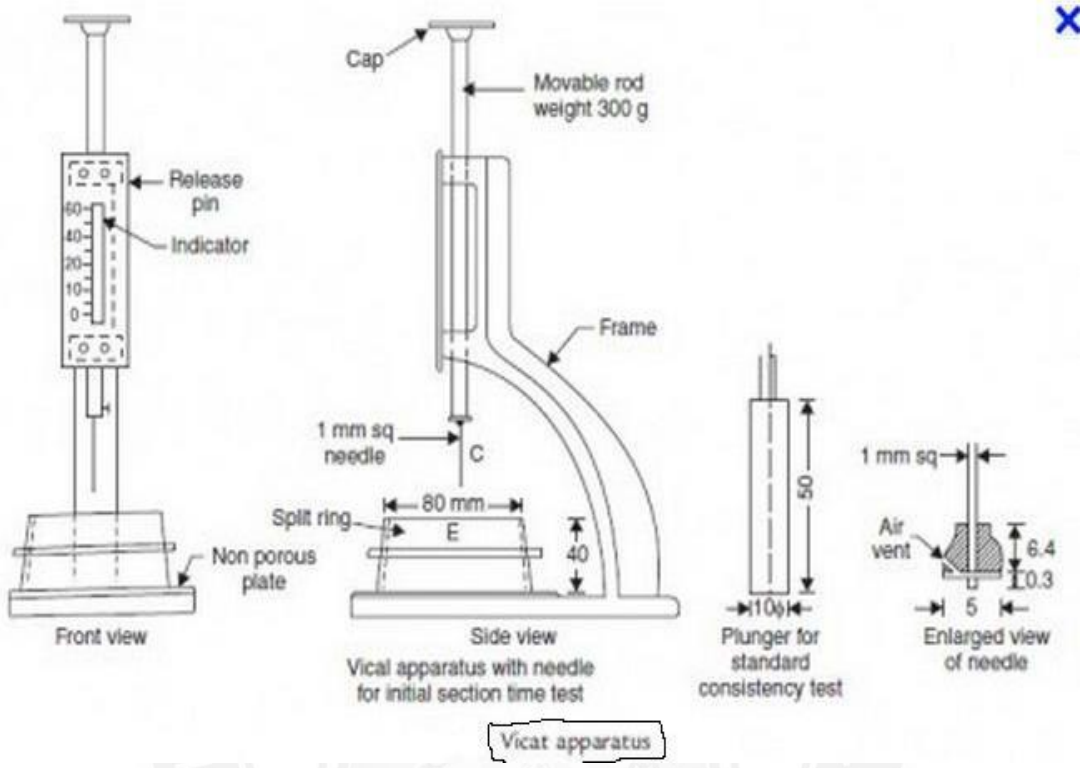


Fig. 28 Permeability Apparatus

Standard Consistency Test

- For finding out initial setting time, final setting time and soundness of cement, and strength a parameter known as standard consistency has to be used.
- The standard consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having 10 mm diameter and 50 mm length to penetrate to a depth of 33-35 mm from the top of the mould .The apparatus is called Vicat

Appartus. This appartus is used to find out the percentage of water required to produce a cement paste of standard consistency or normal consistency.



Procedure:

- ✓ Take about 500 gm of cement and prepare a paste with a weighed quantity of water (say 24 per cent by weight of cement) for the first trial.
- ✓ The paste must be filled into the Vicat mould within 3-5 minutes. After completely filling the mould, shake the mould to expel air. A standard plunger, 10 mm diameter, 50 mm long is attached and brought down to touch the surface of the paste in the test block and quickly released allowing it to sink into the paste by its own weight.
- ✓ Take the reading by noting the depth of penetration of the plunger. Conduct a 2nd trial (say with 25 per cent of water) and find out the depth of penetration of plunger.
- ✓ Similarly, conduct trials with higher and higher water/cement ratios till such time the plunger penetrates for a depth of 33-35 mm from the top. That particular percentage of water which allows the plunger to penetrate only to a depth of 33-35 mm from the top is known as the percentage of water required to produce a cement paste of standard consistency. This percentage is usually denoted as _P‘.

- ✓ The test is required to be conducted in a constant temperature (27° + 2°C) and constant humidity (90%).

Setting Time Test

- Initial Setting Time is the time elapsed between the moments that the water is added to the cement, to the time that the paste starts losing its plasticity.
- The final setting time is the time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure.
- In actual construction dealing with cement paste, mortar or concrete certain time is required for mixing, transporting, placing, compacting and finishing. During this time cement paste, mortar, or concrete should be in plastic condition. The time interval for which the cement products remain in plastic condition is known as the initial setting time. Normally a minimum of 30 minutes is given for mixing and handling operations.
- Once the concrete is placed in the final position, compacted and finished, it should lose its plasticity in the earliest possible time so that it is least vulnerable to damages from external destructive agencies. This time should not be more than 10 hours which is often referred to as final setting time.

Preparation of specimen

- o Take 500 gm. of cement sample and guage it with 0.8 5 times the water required to produce cement paste of standard consistency (0.85 P). The paste shall be gauged and filled into the Vicat mould in specified manner within 3-5 minutes. Start the stop watch the moment water is added to the cement. The temperature of water at the time of gauging shall be within 27°C ± 2°C.

Procedure

INITIAL SETTING TIME.

Lower the needle (C) gently and bring it in contact with the surface of the test block and quickly release. Allow it to penetrate into the test block and the needle will completely pierce through the test block. But after some time when the paste starts losing its

plasticity, the needle may penetrate only to a depth of 33-35 mm from the top. The period elapsing between the times when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35 mm from the top is taken as initial setting time.

FINAL SETTING TIME

Replace the needle (C) of the Vicat appartus by a circular attachment (F) The cement shall be considered as finally set when, upon, lowering the attachment gently over the surface of the test block, the centre needle makes an impression, while the circular cutting edge of the attachment fails to do so. In other words the paste has attained the hardness and the centre needle does not pierce through the paste more than 0.5 mm.

Strength Test

The compressive strength of hardened cement is the most important of all the properties. Strength tests are not made on neat cement paste because of difficulties of excessive shrinkage and subsequent cracking of neat cement. Strength of cement is indirectly found on cement sand mortar in specific proportions.

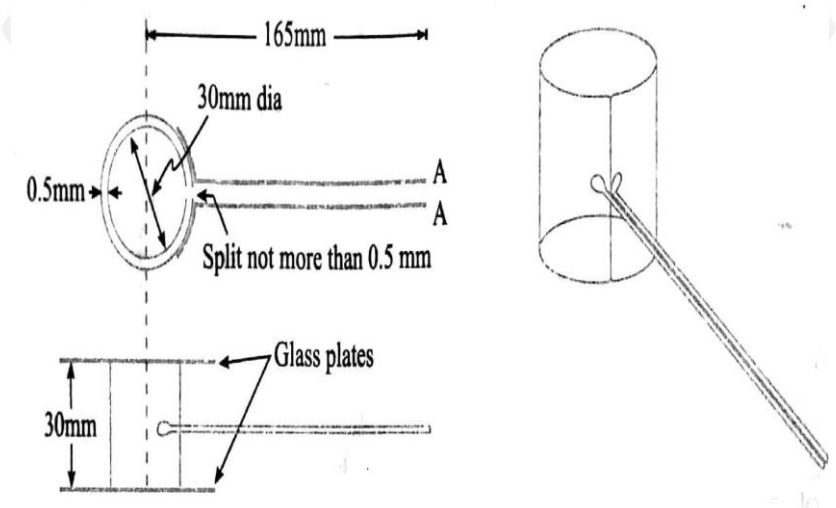
- The standard sand is used for finding the strength of cement. It shall conform to IS 650-1991. Take 555 gm of standard sand (Ennore sand), 185 gm of cement (i.e., ratio of cement to sand is 1:3) in a non-porous enamel tray and mix them with a trowel for one minute, then add water of quantity + 3.0 per cent of combined weight of cement and sand and mix the three ingredients thoroughly until the mixture is of uniform colour.
- The time of mixing should not be less than 3 minutes nor more than 4 minutes. Immediately after mixing t, he mortar is filled into a cube mould of size 7.06 cm. The area of the face of the cube will be equal to 50 sq cm.
- Compact the mortar either by hand compaction in a standard specified manner on the vibrating equipment (12000 RPM) for 2 minutes. Keep the compacted cube in the mould at a temperature of 27°C ± 2°C and at least 90 per cent relative humidity for 24 hours. Where the facility of standard temperature and humidity room is not

available, the cube may be kept under wet gunny bag to simulate 90 per cent relative humidity.

- After 24 hours the cubes are removed from the mould and immersed in clean fresh water until taken out for testing. The periods being reckoned from the completion of vibration. The compressive strength shall be the average of the strengths of the three cubes for each period respectively.

Soundness Test

- It is very important that the cement after setting shall not undergo any appreciable change of volume. Certain cements have been found to undergo a large expansion after setting causing disruption of the set and hardened mass.
- This will cause serious difficulties for the durability of structures when such cement is used. The testing of soundness of cement, to ensure that the cement does not show any appreciable subsequent expansion is of prime importance.
- The unsoundness in cement is due to the presence of excess of lime than that could be combined with acidic oxide at the kiln. This is also due to inadequate burning or insufficiency in fineness of grinding or thorough mixing of raw materials. It is also likely that too high a proportion of magnesium content or calcium sulphate content may cause unsoundness in cement. For this reason the magnesia content allowed in cement is limited to 6 per cent. It can be recalled that, to prevent flash set, calcium sulphate is added to the clinker while grinding.



- The quantity of gypsum added will vary from 3 to 5 per cent depending upon C_3A content. If the addition of gypsum is more than that could be combined with C_3A, excess of gypsum will remain in the cement in Free State. This excess of gypsum leads to an expansion and consequent disruption of the set cement paste.
- Unsoundness in cement is due to excess of lime, excess of magnesia or excessive proportion of sulphates. Unsoundness in cement does not come to surface for a considerable period of time. Therefore, accelerated tests are required to detect it.
- There are number of such tests in common use. It consists of a small split cylinder of spring brass or other suitable metal. It is 30 mm in diameter and 30 mm high. On either side of the split are attached two indicator arms 165 mm long with pointed ends.
- Cement is gauged with 0.78 times the water required for standard consistency (0.78P), in a standard manner and filled into the mould kept on a glass plate. The mould is covered on the top with another glass plate. The whole assembly is immersed in water at a temperature of 27°C – 32°C and kept there for 24 hours.
- Measure the distance between the indicator points. Submerge the mould again in water. Heat the water and bring to boiling point in about 25-30 minutes and keep it boiling for 3 hours. Remove the mould from the water, allow it to cool and measure the distance between the indicator points.
- The difference between these two measurements represents the expansion of cement. This must not exceed 10 mm for ordinary, rapid hardening and low heat Portland cements. If in case the expansion is more than 10 mm as tested above, the cement is said to be unsound. The Le Chatelier test detects unsoundness due to free lime only.
- This method of testing does not indicate the presence and after effect of the excess of magnesia. Indian Standard Specification stipulates that a cement having a magnesia content of more than 3 per cent shall be tested for soundness by Autoclave test which is sensitive to both free magnesia and free lime.
- In this test a neat cement specimen 25 × 25 mm is placed in a standard autoclave and the steam pressure inside the autoclave is raised in such a rate as to bring the

gauge pressure of the steam to 21 kg/ sq cm in 1 – 11/4 hour from the time the heat is turned on. This pressure is maintained for 3 hours.

- The autoclave is cooled and the length measured again. The high steam pressure accelerates the hydration of both magnesia and lime. No satisfactory test is available for deduction of unsoundness due to an excess of calcium sulphate.

1.3.1 IS SPECIFICATIONS

CEMENT

Specifications	Minimum Requirements for OPC as per IS:8112-1989
Specific Gravity	3.15
Fineness (m^2/kg) specific surface	225
Setting Time (Initial)	30 min
Setting Time (Final)	600 min
Compressive strength (N/mm^2)	
3 Days	23
7 Days	33
28 Days	43

Physical properties	**Grade of cement**		
	33	43	53
Minimum compressive strength at 28 days (N/mm^2)	33	43	53
Fineness-minimum specific surface area (m^2/kg)	225	225	225
Initial setting time (minimum)	30 min.	30 min.	30 min.
Final setting time (maximum)	600 min.	600 min.	600 min.
Soundness (expansion) in mm	10	10	10
Autoclave test for MgO, percent, maximum	0.8	0.8	0.8

Chemical Properties			
Loss on ignition (%)	5	5	4
Insoluble residue (%), maximum	4	2	2
Magnesia MgO (%), maximum	6	6	6
SO_3 (%) , maximum for C_3A > 5 percent	2.5	2.5	2.5
Lime saturation factor (LSF)	0.66-1.02	0.66-1.02	0.8-1.02
Ratio A F minimum	0.66	0.66	0.66