Cement : Physical Properties and Types of Cement

Lecture No. 3

Field Testing

a) 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.

b) Thrust your hand into the cement bag. It must give you a cool feeling. There should not be any lump inside.

c) Take a pinch of cement and feel-between the fingers. It should give a smooth and not a gritty feeling.

d) Take a handful of cement and throw it on a bucket full of water, the particles should float for some time before they sink.

Physical Properties of Cement

1. Setting Time
2. Soundness
3. Fineness
4. Strength

Setting Time

- Cement paste setting time is affected by a number of items including: cement fineness, water-cement ratio, chemical content (especially gypsum content) and admixtures.
- For construction purposes, the initial set must not be too soon and the final set must not be too late. Normally, two setting times are defined:
- Initial set. Occurs when the paste begins to stiffen considerably.
- Final set. Occurs when the cement has hardened to the point at which it can sustain some load.
- Setting is mainly caused by C3A and C3S and results in temperature rise in the cement paste.

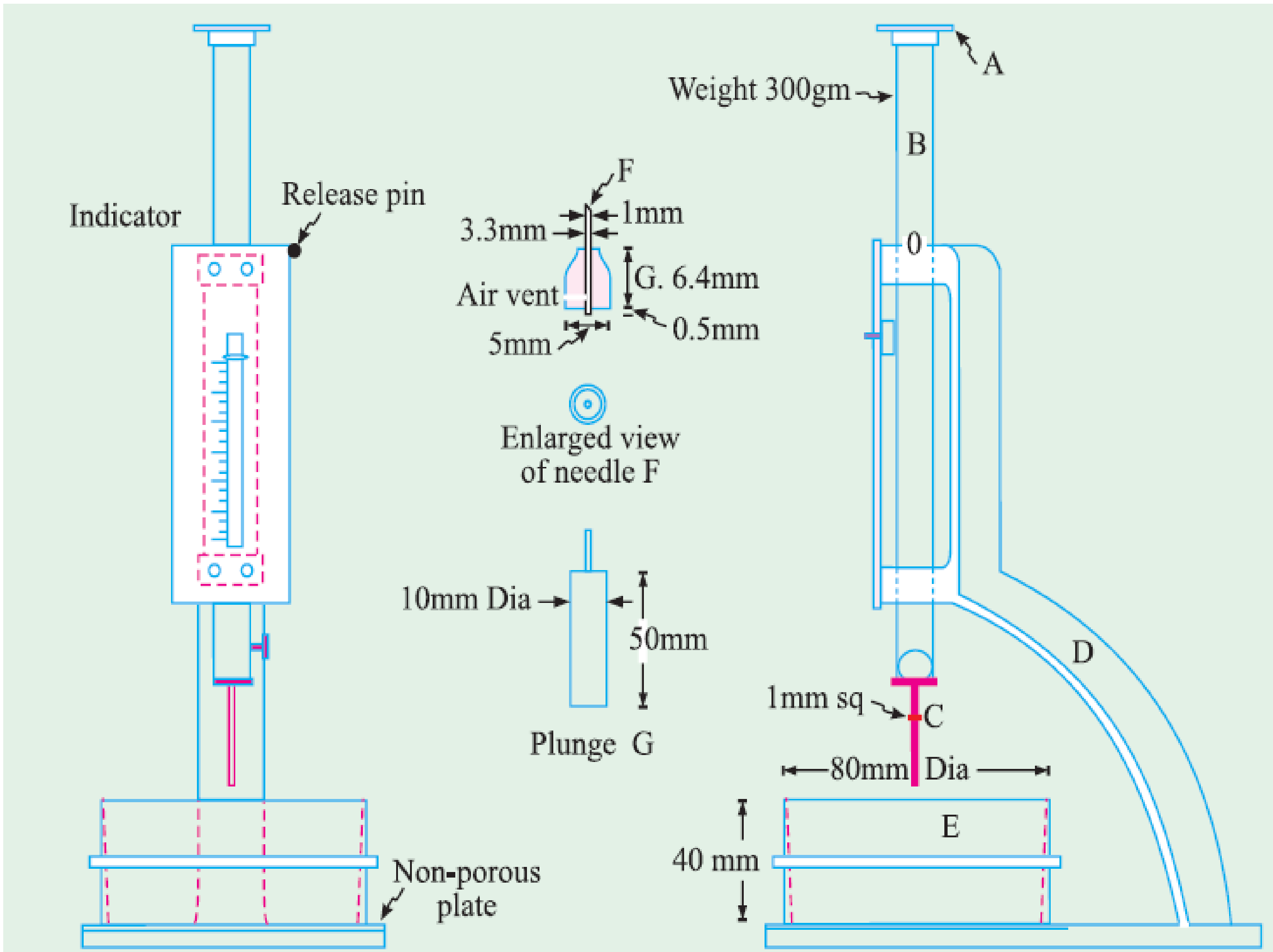
Setting Time : Consistency

- The consistency is measured by the Vicat apparatus using a 10mm diameter plunger.
- A trial paste of cement and water is mixed and placed in the mould having an inside diameter of 70mm at the base and 60mm at the top, and a height of 40mm.
- The plunger is then brought into contact with the top surface of the paste and released. Under the action of its weight the plunger will penetrate the paste. The depth depending on the consistency.

Setting Time : Consistency

- When the plunger penetrates the paste to a point 5 to 7mm from the bottom of the mould. The paste is considered to be at "normal consistency".
- The water content of the paste is expressed as a percentage by weight of dry cement. The usual range of values being between 26% and 33%.

Setting Time : Consistency



Setting Time : Setting time

- Initial setting time is regarded as the time elapsed between the moment 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.

Setting Time : Setting time

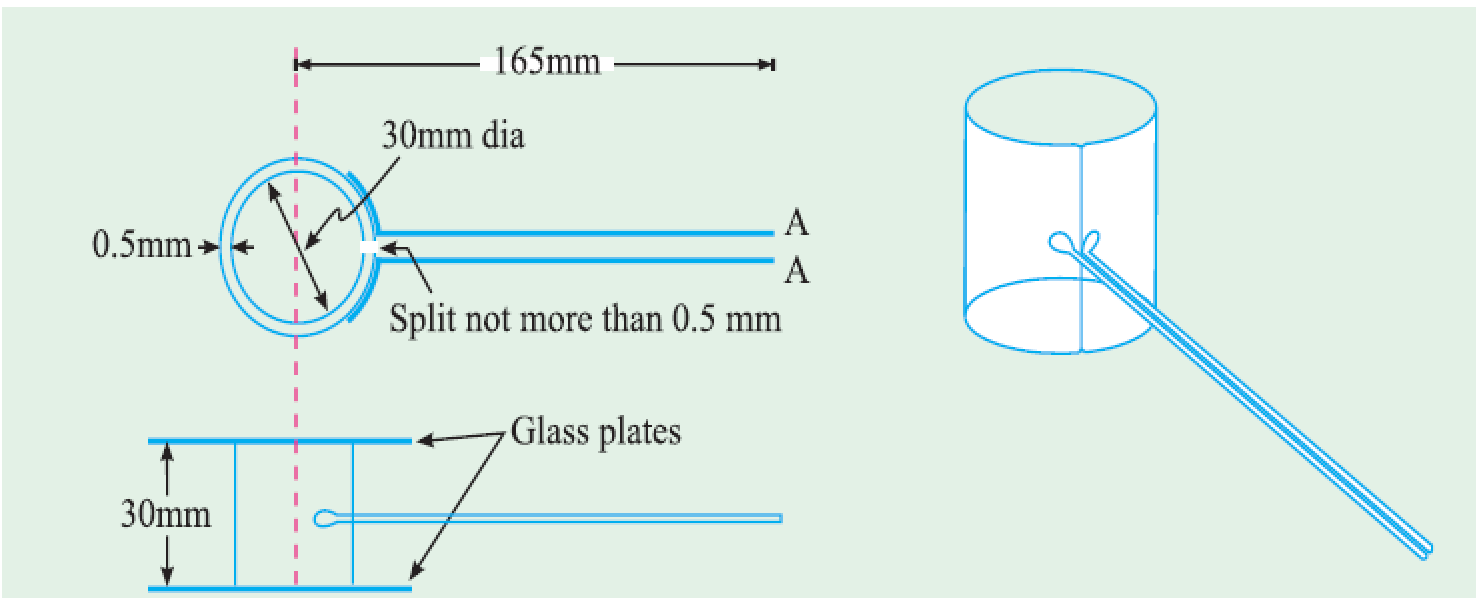
- The setting time test is conducted by using the same Vicat apparatus, except that a 1mm diameter needle is used for penetration.
- The test is started about 15 minutes after placing the cement paste (which has normal consistency) into the mould. Trials for penetration of the needle are made.
- The final setting time is defined as the length of time between the penetration of the paste and the time when the needle(with annular ring) no longer sinks visibly into the paste.
- The initial setting time is defined as the length of time between the penetration of the paste and the time when the needle penetrates 25mm into the cement paste.

Soundness

- When referring to Portland cement, "soundness" refers to the ability of a hardened cement paste to retain its volume after setting without delayed expansion. This expansion is caused by excessive amounts of free lime (CaO) or magnesia (MgO). Most Portland cement specifications limit magnesia content and expansion.
- The cement paste should not undergo large changes in volume after it has set. However, when excessive amounts of free CaO or MgO are present in the cement, these oxides can slowly hydrate and cause expansion of the hardened cement paste.
- Soundness is defined as the volume stability of the cement paste.

Soundness: Le Chatelier Test

- IS prescribe a Soundness Test conducted by using the Le Chatelier apparatus. The apparatus consists of a small brass cylinder split along its generatrix. Two indicators with pointed ends are attached to the cylinder on either side of the split.



Soundness: Le Chatelier Test

- The cylinder (which is open on both ends) is placed on a glass plate filled with cement paste of normal consistency, and covered with another glass plate.
- The whole assembly is then immersed in water at 20 ± 1°C for 24 hours. At the end of that period the distance between the indicator points is measured. The mould is then immersed in water again and brought to a boil. After boiling for one hour the mould is removed from the water, after cooling, the distance between the indicator points is measured again.
- This increase represents the expansion of the cement paste for Portland cements, expansion is limited to 10mm.

Fineness

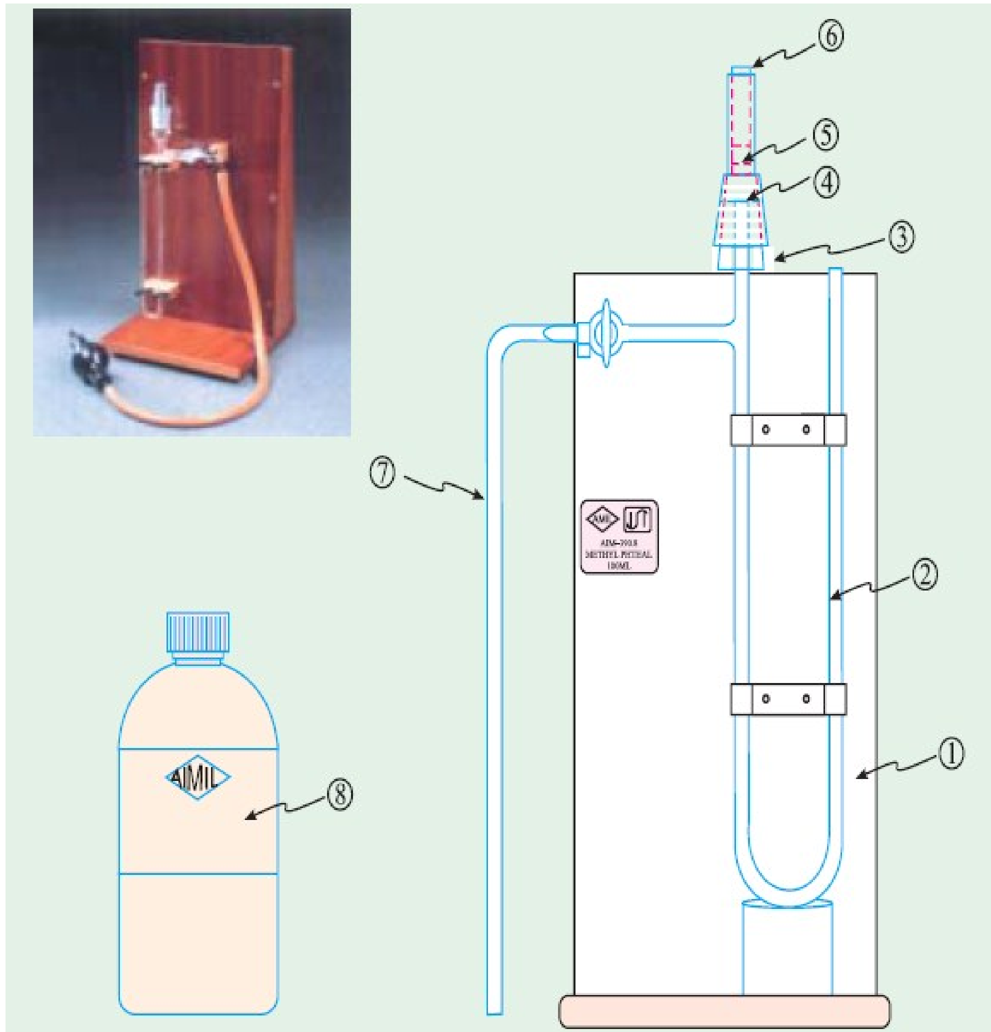
- Fineness, or particle size of Portland cement affects Hydration rate and thus the rate of strength gain. The smaller the particle size, the greater the surface area-to-volume ratio, and thus, the more area available for water-cement interaction per unit volume. The effects of greater fineness on strength are generally seen during the first seven days.
- When the cement particles are coarser, hydration starts on the surface of the particles. So the coarser particles may not be completely hydrated. This causeslow strength and low durability.
- For a rapid development of strength a high fineness is necessary.

Fineness : Blaine air-permeability Test

- There are various methods for determining the fineness of cement particles. The Blaine air-permeability method is the most commonly used method.

- In the Blaine air-permeability method, given volume of air is passed through a prepared sample of definite density. The number and size of the pores in a sample of given density is a function of the particles and their size distribution and determines the rate of air flow through the sample. Calculations are made and the fineness is expressed in terms of cm2/g or m2/kg

Fineness : Blaine air-permeability Test



Strength

- Cement paste strength is typically defined in three ways: compressive, tensile and flexural. These strengths can be affected by a number of items including: water cement ratio, cement-fine aggregate ratio, type and grading of fine aggregate, curing conditions, size and shape of specimen, loading conditions and age.

Strength : Compressive Strength

- The cement paste (consisting of 1 part cement+3 parts standard sand+ water, by weight) is placed in 7cm moulds. And the specimens are water cured for various ages for testing.
- The mortar specimens taken out of the mould are subjected to compression to determine the strength.
- The compressive strength test is conducted on mortar cubes. After finding the breaking load in compression, Pmax , Compressive Strength is calculated by the = Pmax /A, where $A=50cm^2$.
- The average of the results found by testing six specimen is the compressive strength of the mortar cubes.

Strength : Compressive Strength

Sl.No.	Type of Cement	Fineness (m^2/kg) Min.	Soundness By Le chatelier (mm) Max.	Soundness By Autoclave (%) Max.	Setting Time Initial (mts) min.	Setting Time Final (mts) max.	Compressive Strength 1 Day min. MPa	Compressive Strength 3 Days min. MPa	Compressive Strength 7 Days min. MPa	Compressive Strength 28 Days min. MPa
1.	33 Grade OPC (IS 269-1989)	225	10	0.8	30	600	N S	16	22	33
2.	43 Grade OPC (IS 8112-1989)	225	10	0.8	30	600	N S	23	33	43
3.	53 Grade OPC (IS 12269-1987)	225	10	0.8	30	600	N S	27	37	53
4.	SRC (IS 12330-1988)	225	10	0.8	30	600	N S	10	16	33
5.	PPC (IS 1489-1991) Part I	300	10	0.8	30	600	N S	16	22	33
6.	Rapid Hardening (IS 8041-1990)	325	10	0.8	30	600	16	27	N S	N S
7.	Slag Cement (IS 445-1989)	225	10	0.8	30	600	N S	16	22	33
8.	High Alumina Cement (IS 6452-1989)	225	5	N S	30	600	30	35	N S	N S
9.	Super Sulphated Cement (IS 6909-1990)	400	5	N S	30	600	N S	15	22	30
10.	Low Heat Cement (IS 12600-1989)	320	10	0.8	60	600	N S	10	16	35
11.	Masonry Cement (IS 3466-1988)	*	10	1	90	1440	N S	N S	2.5	5
12.	IRS-T-40	370	5	0.8	60	600	N S	N S	37.5	N S

Types of Cement

1) Ordinary Portland Cement :

   (i) Ordinary Portland Cement 33 Grade– IS 269: 1989

   (ii) Ordinary Portland Cement 43 Grade– IS 8112: 1989

   (iii) Ordinary Portland Cement 53 Grade– IS 12269: 1987

2) Rapid Hardening Cement – IS 8041: 1990
3) Sulphate Resisting Cement – IS 12330: 1988
4) Portland Slag Cement – IS 455: 1989
5) Quick Setting Cement –
6) Low Heat Cement – IS 12600: 1989

Types of Cement

7) Portland Pozzolana Cement – IS 1489 (Part I) 1991 (fly ash based)
8) Air Entraining Cement –
9) Coloured Cement: White Cement – IS 8042: 1989
10) Hydrophobic Cement – IS 8043: 1991
11) Oil Well Cement – IS 8229: 1986
12) High Alumina Cement – IS 6452: 1989

Types of Cement

1. Ordinary Portland Cement

   The manufacture of OPC is decreasing all over the world in view of the popularity of blended cement on account of lower energy consumption, environmental pollution, economic and other technical reasons.

2. Rapid Hardening Cement (IS 8041–1990)

   As the name indicates it develops strength rapidly and as such it may be more appropriate to call it as high early strength cement. (Where formwork is required to be removed early for re-use elsewhere, Road repair works, In cold weather concrete).

Types of Cement

3. Sulphate Resisting Cement (IS 12330–1988)

   To remedy the sulphate attack, the use of cement with low C_3A content is found to be effective. (Concrete to be used in marine condition, in foundation and basement, where soil is infested with sulphates; construction of sewage treatment works).

4. Portland Slag Cement (PSC) (IS 455–1989)

   Portland slag cement is obtained by mixing Portland cement clinker, gypsum and granulated blast furnace slag. (Reduced heat of hydration, Refinement of pore structure, Reduced permeability)

Types of Cement

5. Quick Setting Cement

   The early setting property is brought out by reducing the gypsum content at the time of clinker grinding. It is used mostly in under water construction where pumping is involved.

6. Low Heat Cement – IS 12600: 1989

   Formation of cracks in large body of concrete due to heat of hydration has focussed the attention of the concrete which produces less heat, at a low rate during the hydration process. A low-heat evolution is achieved by reducing the contents of C_3S and C_3A which are the compounds evolving the maximum heat of hydration and increasing C_2S.

Types of Cement

7. Portland Pozzolana Cement – IS 1489 (Part I)

   The history of pozzolanic material goes back to Roman's time. Portland Pozzolana cement (PPC) is manufactured by the inter grinding of OPC clinker with 10 to 25 per cent of pozzolanic material. A pozzolanic material is essentially a silicious or aluminous material which while in itself possessing no cementitious properties, which will, in finely divided form and in the presence of water, react with calcium hydroxide. The pozzolanic materials generally used for manufacture of PPC are calcined clay (IS 1489 part 2 of 1991) or fly ash (IS 1489 part I of 1991).

Types of Cement

7. Portland Pozzolana Cement – IS 1489 (Part I)
   - In PPC, costly clinker is replaced by cheaper pozzolanic material - Hence economical.
   - Soluble calcium hydroxide is converted into insoluble cementitious products resulting in improvement of permeability. Hence it offers, alround durability characteristics, particularly in hydraulic structures and marine construction.
   - It generates reduced heat of hydration and that too at a low rate.
   - Reduction in permeability of PPC offers many other alround advantages.

Types of Cement

8. Coloured Cement: White Cement – IS 8042: 1989

   For manufacturing various coloured cements either white cement or grey Portland cement is used as a base. The use of white cement as a base is costly. With the use of grey cement only red or brown cement can be produced.

9. Oil Well Cement – IS 8229: 1986

   It is likely that if oil is struck, oil or gas may escape through the space between the steel casing and rock formation. Cement slurry is used to seal off the annular space between steel casing and rock strata and also to seal off any other fissures or cavities in the sedimentary rock layer.