

## INTRODUCTION

- Cement is an extremely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients.
- The processes used for the manufacture of cement can be classified as dry and wet.
- In the wet process, the limestone brought from the quarries is first crushed to smaller fragments. Then, it is taken to a ball or tube mill where it is mixed with clay or shale as the case may be and ground to a fine consistency of slurry with addition of water. The slurry is stored in tanks under constant agitation and fed into huge firebrick lined rotary kilns.
- In the dry process the raw materials are ground, mixed and fed to the rotary kiln in the dry state.

## CHEMICAL COMPOSITION

- The identification of the major complex compounds is largely based on R.H. Bogue's work and hence these are called Bogue's compounds.

Constituents	Percentage	Average
Lime (CaO)	60 to 67%	63
Silica (SiO <sub>2</sub> )	17 to 25%	20
Alumina (Al <sub>2</sub> O <sub>3</sub> )	3 to 8%	6
Iron oxide (Fe <sub>2</sub> O <sub>3</sub> )	0.5 to 6%	3
Magnesia (MgO)	0.1 to 4%	2
Sulphur Trioxide (SO <sub>3</sub> )	1 to 3%	1.5
Soda and Potash (Na <sub>2</sub> O + K <sub>2</sub> O)	0.5 to 1.3%	1

### Bogue's Compounds

Name	Chemical formula	Percentage
Tricalcium Silicate (C <sub>3</sub> S)	3CaO.SiO <sub>2</sub>	30-50
Dicalcium Silicate (C <sub>2</sub> S)	2 CaO.SiO <sub>2</sub>	20-45
Tricalcium Aluminate (C <sub>3</sub> A)	3CaO.Al <sub>2</sub> O <sub>3</sub>	8-12
Tetracalcium Alumino Ferrite (C <sub>4</sub> AF)	4 CaO.Al <sub>2</sub> O <sub>3</sub> .Fe <sub>2</sub> O <sub>3</sub>	6-10

## TYPE OF CEMENTS

- Ordinary Portland Cement
- Rapid Hardening Cement – IS : 8041-1990

- Extra Rapid Hardening Cement
- Low Heat Portland Cement – IS : 12600-1989
- Portland Slag Cement – IS : 455-1989
- Portland Pozzolana Cement – IS : 1489-1991(Part 1 and 2)
- Sulphate Resisting Portland Cement – IS : 12330-1988
- White Portland Cement – IS : 8042-1989
- Coloured Portland Cement – IS : 8042-1989
- Hydrophobic Cement – IS : 8043-1991
- High Alumina Cement – IS : 6452-1989
- Super Sulphated Cement – IS : 6909-1990
- Special Cements
  - Masonry Cement
  - Air Entraining Cement
  - Expansive Cement
  - Oil Well Cement

## FIELD TESTS FOR CEMENTS

- Colour:** Grey colour with a light greenish shade.
- Physical Properties:** Cement should feel smooth when touched between fingers.
- If hand is inserted in a bag or heap of cement, it should feel cool.
- If a small quantity of cement is thrown in a bucket of water, it should sink and should not float on the surface.
- Presence of lumps:** Cement should be free from lumps.
- Permissible Limits for Impurities in Water**

Impurity	Permissible Limits
Organic	200 mg/L
Inorganic	3000 mg/L
Sulphates (SO <sub>3</sub> )	400 mg/L
Chlorides (Cl)	2000 mg/L for plain concrete work, 500 mg/L for reinforced concrete work
Suspended matter	2000 mg/L

## LABORATORY TESTS FOR CEMENTS

### 1. Chemical Composition Test

- Ratio of percentage of lime to percentage of silica, alumina and iron oxide known as Lime Saturation Factor (LSF), when calculated

by the formula  $\frac{\text{CaO} - 0.7\text{SO}_3}{(28\text{SiO}_2 + 12\text{Al}_2\text{O}_3 + 0.65\text{Fe}_2\text{O}_3)}$  shall not be greater than 1.02 and not less than 0.66.



- Ratio of percentage of alumina ( $\text{Al}_2\text{O}_3$ ) to that of iron oxide ( $\text{Fe}_2\text{O}_3$ ) shall not be less than 0.66
- Weight of insoluble residue shall not be more than 4 per cent.
- Weight of Magnesia shall not be more than 6 per cent.
- Total loss on ignition shall not be more than 5 per cent.
- Total sulphur content calculated as sulphuric anhydride shall not be more than 2.5% when  $\text{C}_3\text{A}$  is 5% or less and shall not be more than 3% when  $\text{C}_3\text{A}$  is more than 5%

## 2. Normal Consistency Test

- The normal (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 a depth of 33 to 35 mm from the top (or 5 to 7 mm from the bottom) of the mould.
- **Vicat Apparatus:** Vicat apparatus assembly consists of a plunger 300 gm in weight with a length of 50 mm and diameter of 10 mm and a mould which is 40 mm deep and 80 mm in diameter.

## 3. Initial Setting Time Test

- Initial setting time should not be less than 30 minutes for OPC and 60 minutes for low heat cement.

## 4. Final Setting Time Test

- The final setting time should not be more than 10 hours.

## 5. Soundness Test

- The soundness of cement is determined either by 'Le Chatelier's method' or by means of a 'Autoclave' test.
- No satisfactory test is available for deduction of soundness due to excess of calcium sulphate. But its content can be easily determined by chemical analysis.
  - Le Chatelier's Method
  - Autoclave Test

## 6. Strength Test

### (a) Compressive Strength Test

- Three cubes are tested for compressive strength at 1 day, 3 day, 7 day and 28 day where the period of testing 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.
- The compressive strength of 33 grade OPC at 3 day, 7 day and 28 day is 16 MPa, 22 MPa and 33 MPa respectively.

### (b) Tensile Strength Test

- Six briquettes are tested and average tensile strength is calculated.
- Load is applied steadily and uniformly, starting from zero and increasing at the rate of  $0.7 \text{ N/mm}^2$  in 12 seconds.
- OPC should have a tensile strength of not less than 2 MPa and 2.5 MPa after 3 and 7 days respectively.
- Generally tensile strength is 10-15% of compressive strength.

## 7. Fineness Test: There are three methods for testing fineness viz.

### (a) Sieve Method

- 100 gm of cement sample is taken and air set lumps, if any, in the sample are broken with fingers.
- The sample is placed on a 90 micron sieve and continuously sieved for 15 minutes.
- The residue should not exceed the limits specified below:

	Type of cement	%Residue by weight
(i)	Ordinary Portland cement	10
(ii)	Rapid hardening cement	5
(iii)	Portland pozzolana cement	5

### (b) Air Permeability Method

- Fineness of cement is represented by specific surface i.e. total surface area in  $\text{cm}^2$  per gram of cement.

### (c) Wagner Turbidimeter Test

- The cement is dispersed uniformly in a rectangular glass tank filled with kerosene.
- Parallel light rays are passed through the solution which strike the sensitivity plate of a photoelectric cell.

## 8. Heat of Hydration Test

- The apparatus used to determine the heat of hydration of cement is known as calorimeter.
- The heat of hydration for low heat Portland cement should not be more than 66 and 75 cal/gm for 7 and 28 days respectively.

## 9. Specific Gravity Test

- The specific gravity of cement is obtained by using Le Chatelier's flask.

