2.4 Types Of Cement

Cements of unique characteristics for desired performance in a given environment are being manufactured by changing the chemical composition of OPC or by using additives, or by using different raw materials. Some of the cements available in the market are as follows.

1. Rapid Hardening Portland Cement
2. High Alumina Cement
3. Supersulphated Portland Cement
4. Sulphate Resisting Portland Cement
5. Portland slag Cement
6. Low Heat Portland Cement
7. Portland Puzzolana Cement
8. Quick Setting Portland Cement
9. Masonry Cement
10. White and Coloured Portland Cement
11. Air Entraining Cement
12. Calcium Chloride Cement

1)Rapid Hardening Portland Cement (IS: 8041) has high lime content and can be obtained by increasing the C3S content but is normally obtained from OPC clinker by finer grinding (450 m^2/kg). The basis of application of rapid hardening cement (RHC) is hardening properties and heat emission rather than setting rate. This permits addition of a little more gypsum during manufacture to control the rate of setting. RHC attains same strength in one day which an ordinary cement may attain in 3 days. However, it is subjected to large shrinkage and water requirement for workability is more. The cost of rapid hardening cement is about 10 per cent more than the ordinary cement. Concrete made with RHC can be safely exposed to frost, since it matures more quickly.

Properties:

Initial setting time30 minutes (minimum)

Final setting timel0 hours (maximum)

Compressive strength

1 day 16.0 N/mm^2

3 day 27.5 N/mm^2

Uses:

It is suitable for repair of roads and bridges and when load is applied in a short period of time.

2)High Alumina Cement (IS: 6452):

This is not a type of Portland cement and is manufactured by fusing 40 per cent bauxite, 40 per cent lime, 15 per iron oxide with a little of ferric oxide and silica, magnesia, etc. (Table 5.5) at a very high temperature. The alumina content should not be less than 32%. The resultant product is ground finely. The main cement ingredient is monocalcium aluminate CA which interacts with water and forms dicalcium octahydrate hydroaluminate and aluminium oxide hydrate.

$$2(CaO.AL_2O_3.10H_2O) + H_2O = 2CaO.Al_2O_3.8H_2O + 2Al(OH)_2$$

The dicalcium hydroaluminate gel consolidates and the hydration products crystallize. The rate of consolidation and crystallization is high leading to a rapid gain of strength. Since C_3A is not present, the cement has good sulphate resistance.

Table 4 Composition of a Typical High Alumina Cement

Composition	Percentage
Al_2O_3, TiO_2	43.5
Fe_2O_3, FeO, Fe_3O_4	13.1
CaO	37.5
SiO_2	3.8
MgO	0.3
SO_3	0.4
Insoluble material	1.2

Loss on ignition	0.2

Properties:

It is not quick setting: initial setting time (minimum) is 30 minutes, even up to 2 hours. The final setting time should not exceed 600 minutes. It attains strength in 24 hours, high early strength, high heat of hydration and resistance to chemical attack. Compressive strength after one day is 30.0 N/mm^2 and after 3 days it is 35.0 N/mm^2. After setting and hardening, there is no free hydrated lime as in the case of ordinary Portland cement. The fineness of the cement should not be less than 225 m^2/kg. The cement should not have expansion more than 5 mm.

Uses:

It is resistant to the action of fire, sea water, acidic water and sulphates and is used as refractory concrete, in industries and is used widely for precasting. It should not be used in places where temperature exceeds 18°C.

3)Supersulphated Portland Cement (IS: 6909)

It is manufactured by intergrinding or intimately blending a mixture of granulated blast furnace slag not less than 70 per cent, calcium sulphate and small quantity of 33 grade Portland cement. In this cement tricalcium aluminate which is susceptible to sulphates is limited to less than 3.5 per cent. Sulphate resisting cement may also be produced by the addition of extra iron oxide before firing; this combines with alumina which would otherwise form C3A, instead forming C4AF which is not affected by sulphates. It is used only in places with temperature below 40°C.

Water resistance of concretes from supersulphate Portland cements is higher than that of common Portland cements because of the absence of free calcium oxide hydrate. In supersulphate Portland cements the latter is bound by slag into calcium hydroaluminates of low solubility and calcium hydrosilicates of low basicity, whereas concretes from Portland cement carry a large amount of free calcium oxide hydrate which may wash out and thus weaken them. Supersulphate Portland cement has satisfactory frost and air resistances, but it is less resistant than concrete from Portland cement due to the fact that hydrosilicates of low basicity show greater tendency to deformation from humidity fluctuations and resist the combined action of water and

frost less effectively.

Properties:

It has low heat of hydration and is resistant to chemical attacks and in particular to sulphates. Compressive strength should be as follows:

72 ± 1 hour	15 N/mm^2
168 ± 2 hours	22 N/mm^2
672 ± 4 hours	30 N/mm^2

It should have a fineness of 400 m^2/kg. The expansion of cement is limited to 5 mm. The initial setting time of the cement should not be less than 30 minutes, and the final setting time should not be more than 600 minutes.

Uses:

Supersulphated Portland cement is used for similar purpose as common Portland cement. But owing to its higher water-resisting property, it should be preferred in hydraulic engineering installations and also in constructions intended for service in moist media. RCC pipes in ground water, concrete structures in sulphate bearing soils, sewers carrying industrial effluents, concrete exposed to concentrated sulphates of weak mineral acids are some of the examples of this cement. This cement should not be used in constructions exposed to frequent freezing-and-thawing or moistening-and-drying conditions.

4)Sulphate Resisting Portland Cement (IS: 12330):

In this cement the amount of tricalcium aluminate is restricted to on acceptably low value(< 5). It should not be mistaken for super-sulphated cement. It is manufactured by grinding and intimately mixing together calcareous and argillaceous and/ or other silica, alumina and iron oxide bearing materials. The Materials are burnt to clinkering temperature. The resultant clinker is ground to produce the cement. No material is added after burning except gypsum and not more than one per cent of air-entraining agents are added.

Properties:

The specific surface of the cement should not be less than 225 m^2/kg. The expansion of cement is limited to 10 mm and 0.8 per cent, when tested by Le-chatelier method and autoclave test, respectively. The setting times are same as that for ordinary Portland

cement. The compressive strength of the cubes should be as follows.

72 ± 1 hour	10 N/mm^2
168 ± 2 hours	16 N/mm^2
672 ± 4 hours	33 N/mm^2

It should have a fineness of 400 m^2/kg. The expansion of cement is limited to 5 mm. The initial setting line of the cement should not be less than 30 mm and the final setting time should not be more than 600 mm.

This cement can be used as an alternative to order Portland cement or Portland pozzolana cement or Portland slag cement under normal conditions. Its use however is restricted where the prevailing temperature is below 40°C. Use of sulphate resisting cement is particularly beneficial in conditions where the concrete is exposed to the risk of deterioration due to sulphate attack; concrete in contact with soils or ground waters containing excessive sulphate as well as concrete in sea water or exposed directly to sea coast.

5)Portland slag Cement (IS: 455):

It is manufactured either by intimately intergrinding a mixture of Portland cement clinker and granulated slag with addition of gypsum or calcium sulphate, or by an intimate and uniform blending of Portland cement and finely ground granulated slag. Slag is a non- metallic product consisting essentially of glass containing silicates and alumino-silicates of lime and other bases, as in the case of blast-furnace slag, which is developed simultaneously with iron in blast furnace or electric pig iron furnace. Granulated slag is obtained by further processing the molten slag by rapid chilling or quenching it with water or steam and air. The slag constituent in the cement varies between 25 to 65 per cent.

Properties:

The chemical requirements of Portland slag cement are same as that of 33 grade Portland cement. The specific surface of slag cement should not be less than 225 m^2/kg. The expansion of the cement should not be more than 10 mm and 0.8 per cent when tested be Le Chatelier method and autoclave test, respectively. The initial and final setting times and compressive strength requirements are same as that for 33 grade ordinary Portland cement.

Uses:

This cement can be used in all places where OPC is used. However, because of its low heat of hydration it can also be used for mass concreting, e.g., dams, foundations, etc.

6)Low Heat Portland Cement (IS:12600)

To limit the heat of hydration of low heat Portland cement (LHC), the tricalcium aluminate component in cement is minimised and a high percentage of dicalcium silicate and tetracalcium alumino ferrite is added. The heat of hydration should not be more than 272 and 314 J/g at the end of 7 and 28 days respectively. The rate of development of strength is slow but the ultimate strength is same as that of OPC. To meet this requirement, specific surface of cement is increased to about 3200 cm^2/g.

Properties:

Less heat is evolved during setting low heat Portland cement. When tested by Le Chatelier method and autoclave test the expansion should not be more than 10 mm and 0.8%, respectively. The minimum initial setting time should not be less than 60 minutes, and the final setting should not be more than 600 minutes.

The compressive strength should be as follows.

72 ± 1 hour	10 N/mm^2
168 ± 2 hours	16 N/mm^2
672 ± 4 hours	35 N/mm^2

Uses:

It is most suitable for large mass concrete works such as dams, large raft foundations, etc.

7)**Portland Puzzolana Cement (IS: 1489 (Part I):**

It is manufactured by grinding Portland cement clinker and puzzolana (usually fly ash 10-25% by mass of PPC) or by intimately and uniformly blending Portland cement and fine puzzolana. Puzzolana (burnt clay, shale, or fly ash) has no cementing value itself but has the property of combining with lime to produce a stable lime-puzzolana compound which has definite cementitious properties. Free lime present in the cement is thus removed. Consequently, the resistance to chemical attack increases making it suitable for marine works. The hardening of Portland puzzolana cement consists in

hydration of Portland cement clinker compounds and then in interaction of the puzzolana with calcium hydroxide released during the hardening of clinker. At the same time, calcium hydroxide is bound into a water-soluble calcium hydrosilicate according to the reaction with the effect that puzzolana Portland cement acquires greater water-resisting property than ordinary Portland cement.

$$Ca(OH)2 + SiO2 + (n - 1)\ H2O = CaO.SiO2.nH2O$$

Properties:

These have lower rate of development of strength but ultimate strength is comparable withordinary Portland cement.

Compressive Strength

72 ± 1 hour	16 N/mm^2
168 ± 2 hours	22 N/mm^2
672 ± 4 hours	33 N/mm^2

The initial and the final setting times are 30 minutes (minimum) and 600 minutes (maximum), respectively. The drying shrinkage should not be more than 0.15% and the fineness should not be less than 300 m^2/kg.

Uses:

It has low heat evolution and is used in the places of mass concrete such as dams and in places of high temperature.

8)Quick Setting Portland Cement:

The quantity of gypsum is reduced and small percentage of aluminium sulphate is added. It is ground much finer than ordinary Portland cement.

Properties:

Initial setting time = 5 minutes

Final setting time = 30 minutes

Uses:

It is used when concrete is to be laid under water or in running water.

9) Masonry Cement (IS 3466):

The Portland cement clinker is ground and mixed intimately with pozzolanic

material (flyash or calcined clay), or non-pozzolanic (inert) materials (lime-stone, conglomrates, dolomite, granulated slag) and waste materials (carbonated sludge, mine tailings) and gypsum and air entraining plasticizer in suitable proportions.

The physical requirements of masonry cement are as follows.

1.Fineness: Residue on 45-micron IS Sieve, Max, Percent (by wet sieving) 15

2.Setting Time (by Vicat Apparatus):

(a) Initial, Min 90 min

(b) Final, Max 24 h

3.Soundness:

(a)Le-Chatelier expansion, Max10 mm

(b)Autoclave expansion, Max1 %

4.Compressive Strength: Average strength of not less than 3 mortar cubes of 50 mm size, composed of 1 part masonry cement and 3 parts standard sand by volume, Min

7 days 2.5 MPa

28 days 5 MPa

5.Air Content: Air content of mortar composed of 1 part masonry cement6 per cent and 3 parts standard sand by volume, Min

6.Water Retention: Flow after suction of mortar composed of 1 part60 % of masonry cement and 3 parts standard sand by volume, Minoriginal flow

10) White and Coloured Portland Cement (IS: 8042):

It is manufactured from pure white chalk and clay free from iron oxide. Greyish colour of cement is due to iron oxide. So, the iron oxide is reduced and limited below 1 per cent. Coloured cements are made by adding 5 to 10 per cent colouring pigments before grinding. These cements have same properties as that of ordinary Portland cement and are non- staining because of low amount of soluble alkalis. Sodium alumino fluoride is added during burning which acts as a catalyst in place of iron.

Properties:

Loss on ignition of white cement is nil. The compressive and transverse strength of this cement is 90 per cent of that of 33 grade ordinary Portland cement.

Uses:

These cements are used for making terrazzo flooring, face plaster of walls (stucco), ornamental works, and casting stones.

11) Air Entraining Cement:

Vinsol resin or vegetable fats and oils and fatty acids are ground with ordinary cement. These materials have the property to entrain air in the form of fine tiny air bubbles in concrete.

Properties:

Minute voids are formed while setting of cement which increases resistance against freezing and scaling action of salts. Air entrainment improves workability and water/cement ratio can be reducedwhich in turn reduces shrinkage, etc.

Uses:

Air entraining cements are used for the same purposes as that of OPC.

12) Calcium Chloride Cement: It is also known as extra rapid hardening cement and is made by adding 2 per cent of calcium chloride. Since it is deliquescent, it is stored under dry conditions and should be consumed within a month of its dispatch from the factory.