FACULTY OF ENGINEERIN & TECHNOLOGY

TOPIC: CEMENT (L-8)

Today , it will be discussed :

- **Chemical Properties Of Cement .**
- **Types of Cement**

Chemical Properties of Cement

The raw materials for Cement Production are limestone (calcium), sand or clay (silicon), bauxite (aluminum) and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate. Chemical analysis of cement raw materials provides insight into the chemical properties of cement.

Tricalcium Aluminate (C_3A)

Low content of C3A makes the cement sulfate-resistant. Gypsum reduces the hydration of C_3A, which liberates a lot of heat in the early stages of hydration. C3A does not provide any more than a little amount of strength.

Type I cement: contains up to 3.5% SO_3 (in cement having more than 8% C_3A)

Type II cement: contains up to 3% SO_3 (in cement having less than 8% C_3A)

Tricalcium Silicate (C_3S)

C_3S)causes rapid hydration as well as hardening and is responsible for the cement's early strength gain an initial setting.

Dicalcium Silicate (C_2S)

As opposed to tricalcium silicate, which helps early strength gain, dicalcium silicate in cement helps the strength gain after one week.

Tetracalcium Ferrite (C_4AF)

Ferrite is a fluxing agent. It reduces the melting temperature of the raw materials in the kiln from 3,000°F to 2,600°F. Though it hydrates rapidly, it does not contribute much to the strength of the cement.

Magnesia (MgO)

The manufacturing process of Portland cement uses magnesia as a raw material in dry process plants. An excess amount of magnesia may make the cement unsound and expansive, but a little amount of it can add strength to the cement. Production of MgO-based cement also causes less CO2 emission. All cement is limited to a content of 6% MgO.

Sulphur trioxide

Sulfur trioxide in excess amount can make cement unsound.

Iron oxide/ Ferric oxide

Aside from adding strength and hardness, iron oxide or ferric oxide is mainly responsible for the color of the cement.

Alkalis

The amounts of potassium oxide (K_2O) and sodium oxide (Na_2O) determine the alkali content of the cement. Cement containing large amounts of alkali can cause some difficulty in regulating the setting time of cement. Low alkali cement, when used with calcium chloride in concrete, can cause discoloration. In slag-lime cement, ground granulated blast furnace slag is not hydraulic on its own but is "activated" by addition of alkalis. There is an optional limit in total alkali content of 0.60%, calculated by the equation $Na_2O + 0.658\ K_2O$.

Free lime

Free lime, which is sometimes present in cement, may cause expansion.

Silica fumes

Silica fume is added to cement concrete in order to improve a variety of properties, especially compressive strength, abrasion resistance and bond strength. Though setting time is prolonged by the addition of silica fume, it can grant exceptionally high strength. Hence, Portland cement containing 5-20% silica fume is usually produced for Portland cement projects that require high strength.

Alumina

Cement containing high alumina has the ability to withstand frigid temperatures since alumina is chemical-resistant. It also quickens the setting but weakens the cement.

Types of Cement as per IS Code

- Rapid Hardening Cement
- Quick Setting Cement
- High Alumina Cement
- Portland Slag Cement
- Low Heat Cement
- Air Entraining Portland Cement
- White Portland Cement
- Coloured Cement

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- Portland Pozzolna Cement
- Supersulphated Cement
- Hydrophobic Portland Cement
- High Strength Ordinary Portland Cement

Rapid Hardening or High Early Strength Cement (IS : 8041 E – 1978):

This cement gains strength faster than the ordinary Portland cement. Its initial and final setting times are the same as those of ordinary cement. It contains more of tri-calcium silicate and is more finely ground. It gives out more heat while setting and is as such unsuitable for mass concreting. It is used for such structures as are to be subjected to loads early e.g. repair of bridges and roads etc. It is more costly than the ordinary cement.

It is manufactured by burning at clinkering temperature an intimate mixture of calcareous and agrillaceous material and grinding the resultant clinker without the addition of gypsum and not more than 1 per cent of air entraining agents.

The average compressive strength of at least three mortar cubes (area of face 50cm^2) composed of one part of cement and three parts of standard sand by mass and P/4+3 per cent (of combined mass of cement and sand) water shall be as under :

(a) After 24 hours +30 minutes Not less than 15.69 N/mm^2 (160 kg/cm^2)

(b) After 72 hours + 1 hour Not less than 26.97. N/mm^2 (275 kg/cm^2)

Quick Setting Cement:

It sets faster than the ordinary Portland cement. Its initial setting time is 5 minutes and the final setting time is 30 minutes. It is used for making concrete that is required to set early, as for laying under water or in running water. Initial setting time being very little there is always the danger of concrete having undergone initial setting during mixing and placing. As such this cement is used only in exceptional circumstances.

High Alumina Cement (IS : 6452-1972):

It is manufactured by fusing together a mixture of bauxite and lime stone in correct proportions and at high temperatures. The resulting product is ground finely. It develops strength rapidly. It is of black colour and resists well the attack of chemicals especially of sulphates and of sea water. Its ultimate strength is much higher than that of ordinary Portland cement. Its initial setting time is not less than 30 minutes and final setting time not more than 10 hours. Most of the heat is given out by it in the first 10 hours as a result of which it can be conveniently used in freezing temperatures but is used in thin layers in normal temperatures. Compressive strength of 1:3 Mix cubes made with this cement and standard sand shall be :

After 24 hours+30 minutes Not less than 300 kg/cm^2

After 72+1 hour Not less than 350 kg/cm^2

It not be used in locations where temperature exceeds 18^{o}C. It should NOT be mixed with other types of cements.

Portland Slag Cement (IS : 455-1976):

It is obtained by mixing Portland cement clinker, gypsum and granulated slag in proper proportions and grinding it finely. This cement has properties very much similar to those of ordinary Portland cement with the following improvements :

a) It has lesser heat of hydration.

b) It has better resistance to soils, sulphates of alkali metals, alumina and iron.

c) It has better resistance to acidic waters.

This cement can advantageously be used in marine works.

Compressive strength of 1:3 Mix cubes made with this cement and standards sand shall be :

After 72+1hour Not less than 160 kg/cm^2

After 168+2 hours Not less than 220 kg/cm^2

Manufacture of Portland slag cement is aimed primarily at profitably utilizing blast furnace slag a waste product from blast furnaces.

Low Heat Cement:

Heat generated by cement while setting y cause the structure to crack in case of concrete. Heat generation is controlled by keeping the percentage of Tri-Calcium aluminate and of Tri-Calcium silicate low. Its initial setting time shall not be less than 60 minutes and final setting time shall not be more than 10 hours. The rate of its developing strength is very slow. It is not very suitable for use in ordinary structures, when not only the use of structure shall be delayed but also the shuttering shall have to be kept for long and curing shall be prolonged.

Air Entraining Portland Cement:

It is ordinary Portland cement mixed with small quantities of air entraining materials at the time of grinding. Usual air entraining materials used are resin, vinsol resin, oils, fats and fatty acids, Vinsol resin and darex are most commonly used. These materials have the property of entraining air in the form of fine air bubbles in concrete. these bubbles render the concrete more plastic, more workable and more resistant to freezing. However, because of air entraining the strength of concrete reduces and as such the quantity of air so entrained should not exceed five per cent.

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White Portland Cement (IS : 8042-1978):

It is cement with pure white colour and having same properties as those of ordinary Portland cement. Greyish colour of ordinary cement is due to iron oxide as such white cement is manufactured from white chalk and clay free from iron oxide. Oil fuel and not the coal is used for the burning of this cement. It is much more costly than ordinary cement.

White cement is generally used for architectural and decorative purposes and is generally meant for non-structural use.

Coloured Cement:

By mixing suitable pigments ordinary Portland cement could be given red or brown colour. For other colours 5 to 10 per cent of desired pigments are ground with white cement.

Pigments used in cement should be chemically inert and also durable so as not to fade due to the effect of light, sun or weather.

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Portland Pozzolana Cement (IS : 1489-1976):

Portland Pozzolana Cement is produced either by grinding together Portland cement clinker and pozzolana, or by intimately and uniformly blending Portland cement and fine Pozzolana.

This cement has properties similar to those of ordinary Portland cement, and can therefore be used for all general purposes where the latter is employed, with no change in the proportion of coarse or fine aggregates and cement. Gypsum is added in both cases. Portland Pozzolana Cement produces less heat of hydration and offers greater resistance to the attack of aggressive waters or sulphate bearing soils than ordinary Portland cement. It also reduces leaching of calcium hydroxide liberated during the setting and hydration of cement. Concequently Portland Pozzolana cement is particularly useful in marine works and also in mass concrete structures..Pozzolana Cement takes a little longer than ordinary Portland cement to gain strength. It is recommended that when Pozzolana Cement is used in reinforced concrete, the centering be left in position a little longer than would be the case with ordinary Portland Cement.

Ultimate strength of this cement is more than that of ordinary Portland cement but initial and final setting times are the same.

Compressive strength of 1:3 Mix cubes made with this cement, and standard sand is :

After 168+2 hours Not less than 220 kg/cm^2

After 672+4 hours Not less than 310 kg/cm^2

Masonry Cement (IS : 3466-1967):

It is a product obtained by intergrinding a mixture of Portland cement clinker with inert materials (non-pozzolanic) such as lime stone, conglomerates and dolomite; and gypsum and an air entraining plasticizer.

It is primarily used in mortars for general purposes masonry. It is NOT for use in structural concrete, for flooring and foundation work or for reinforced and presetressed concrete works.

Masonry cement is a product obtained by intergrinding a mixture of Portland cement clinker with inert materials (non-pozzolanic) such as lime stone, conglomerates and dolomite; and gypsum and an air entraining plasticizer. Its initial setting time is not less than 90 minutes and the final setting time is not more than 24 hours.

Compressive strength of 1:3 Mix cubes made with cement and standard sand shall be :

After 7 days Not less than 25 kg/cm^2

After 28 days Not less than 50 kg/cm^2

Supersulphated Cement (IS : 6909-1973):

It compares favourably with ordinary Portland cement in strength and other physical properties but gives lesser heat of hydration. It is chemically resistant to attack of sulphates. It is useful for marine works, mass concrete works to resist attack of agressive waters, for reinforced pipes in ground water; concrete constructions in sulphate bearing soils, in chemical works exposed to high concentration of sulphates or weal solutions of mineral acids, underside of bridges over railways and concrete sewers carrying industrial wastes. It is best used for use in tropical conditions where temperature is below 40ºC.

Its initial setting time is not less than 30 minutes and the final setting time not more than 10 hours.

For details refer to IS : 6909-1973.Compressive strength of 1:3 Mix cubes made with this cement and standard cement shall be

After 72+1 hour Not less than 150 kg/cm^2 ,

After 161+2 hours Not less than 220 kg/cm^2

Hydrophobic Portland Cement (IS : 8043-1978):

It does not deteriorate very little during prolonged storage under unfavourable conditions. It is obtained by intergrinding ordinary Portland cement clinker with certain hydrophobic agents which impart water repelling properties to cement by forming a water repellant film around each particle of cement. The film is broken by striking of particles with each other during mixing of concrete. The cement floats on water for a period of not less than 24 hours. Compressive strength of this cement is the same as of ordinary Portland Cement.

High Strength Ordinary Portland Cement (IS : 8112-1976):

It specifically meets the needs of certain specialized works, such as prestressed concrete and certain items of precast concrete, where cement having compressive strength much higher than that of ordinary Portland cement specified in IS : 269-1976 are needed. This cement is used by Indian Railways for the manufacture of prestressed concrete sleepers etc.

Its initial setting time is not less than 30 minutes and final setting time is not more than 10 hours.

Compressive strength of 1:3 Mix cubes made with this cement and standard sand shall be :

After 72+1 hour	Not less than 230 kg/cm^2
After 168+2 hours	Not less than 330 kg/cm^2

Thank You