

INTRODUCTION

Inorganic cements are those materials that exhibit properties of setting and hardening when mixed with water to make paste. The paste is capable for joining the rigid substances like stones, bricks, tiles etc. to get coherent structure. Inorganic cement is of two types. (i) Hydraulic cementing materials like Portland cement which are capable of setting and hardening with water and (ii) Non-hydraulic cement like ordinary lime.

PORTLAND CEMENT

Portland cement is defined as finely ground mixture of calcium aluminates, calcium silicates and a small amount of greenish grey coloured gypsum, which is capable of setting and hardening with water giving a hard stone like substance.

RAW MATERIALS FOR THE MANUFACTURE OF CEMENT

Raw materials for the manufacture of cement are :

1. **Calcareous materials** : It is rich in lime such as lime stone, chalk, blast furnace slag etc.
2. **Argillaceous material** : It is rich in silica and alumina such as clay, slate, shale, furnace slag etc.
3. Powdered coal.
4. Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)

MANUFACTURE OF PORTLAND CEMENT BY WET PROCESS

Process : The raw materials-calcareous rich in CaO and Argillaceous rich in SiO_2 are mixed in 3 : 1 by weight and ground in a grinding mill. Then the ground material is mixed with water in a tank to form a paste which is known as slurry. The slurry is fed into a rotary furnace where powdered coal is passed with hot air which maintains the temperature of the furnace between $1400^\circ\text{C} - 1500^\circ\text{C}$. The furnace is called rotary kiln. At this high temperature lime stone, silica, alumina undergo chemical reaction producing a crystalline like solid substance. This is known as cement clinker. The clinker is collected from the end of the furnace and passed to rotary cooler for cooling. With the cooled clinker, gypsum is added and ground in a tube mill. A grey coloured ground powder is known as commercial cement.



Composition of Portland Cement :

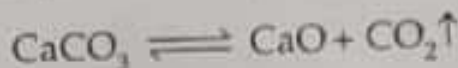
Component	Percentage
Lime (CaO)	60 - 69
Silica (SiO ₂)	17 - 25
Alumina (Al ₂ O ₃)	3 - 8
Iron oxide (Fe ₂ O ₃)	2 - 4
Magnesium oxide (MgO)	1 - 5
Sulphur trioxide (SO ₃)	1 - 3
Alkali oxides (Na ₂ O + K ₂ O)	0.3 - 1.5

Functions of ingredients of cement :

- Lime** : It is the main constituent of cement. Strength of cement depends upon the amount of lime. Its proportion must be regulated properly otherwise excess of lime reduces the strength of cement. On the other hand if amount of lime is lower than requirement; it also reduces the strength of cement and makes quick setting.
- Silica** : It increases the strength of cement.
- Alumina** : Alumina makes the cement quick setting. Excess of alumina weakens cement.
- Iron oxide** : It provides colour, strength and hardness of cement.
- Gypsum** : Gypsum retards the setting property of cement. Quick setting is good finishing. Therefore gypsum takes time for setting initially, it increases setting time.
- Sulphur trioxide** : A small amount of it is required. It imparts soundness to cement.
- Alkalis** : Presence of excess alkali causes the cement efflorescent.

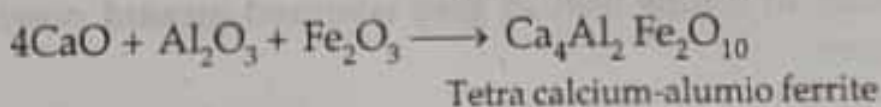
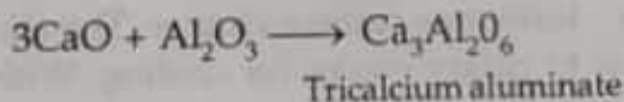
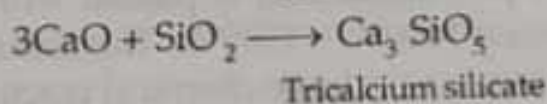
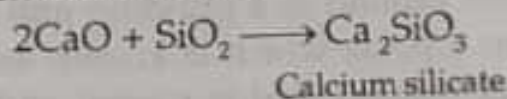
8.4. CHEMISTRY OF MANUFACTURE OF CEMENT

- (i) In the control position of kiln where the temperature is about 1,000°C limestone slurry undergoes decomposition to form quick lime and carbon-dioxide.



Lime stone Quick lime

- (ii) In the lower part of the kiln where the temperature is 14000°C — 15000°C limestone and clay undergo chemical reaction.



After these reactions, aluminates and silicates of calcium fuse together to form hard, grey coloured stones like materials which are called clinker. Hot clinker is then allowed to cool to get cement.

The diagram of rotary cement kiln is shown in Fig. 8.1.

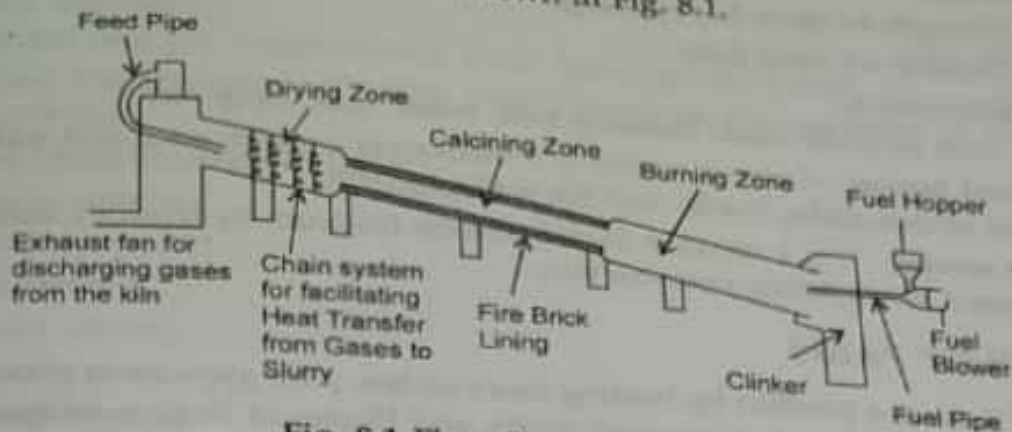


Fig. 8.1 Flow Sheet of Rotary Kiln

8.5. SETTING AND HARDENING OF PORTLAND CEMENT

When cement is mixed with water a gel like mass is formed by hydration and undergoes hydrolysis resulting in the formation of crystalline product.

Interlocking of the small crystals finally bind them into a compact rock like material. The process is completed by setting and then hardening.

Gel formation by hydration is setting; crystal formation by hydrolysis and solidification by interlocking is hardening, so, "setting" is stiffening of the original mass due to initial formation and "hardening" is development of strength due to crystallization.

During setting and hardening the following compounds are formed :

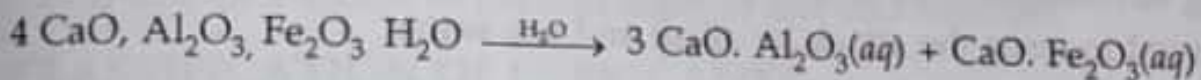
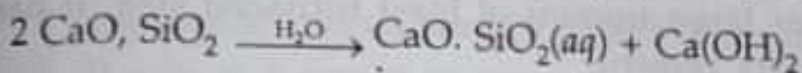
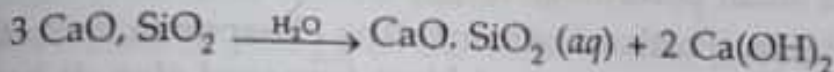
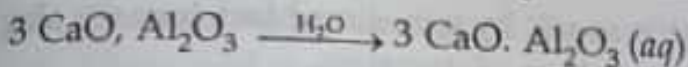
2 CaO, SiO₂ — di calcium silicate

3 CaO, SiO₂ — tri calcium silicate

3 CaO, Al₂O₃ — tri calcium aluminate

4 CaO, Al₂O₃, Fe₂O₃ — tetra calcium aluminoferrite

The following reactions take place during setting and hardening. The reactions are



8.6. CEMENT CONCRETE AND CEMENT MORTAR

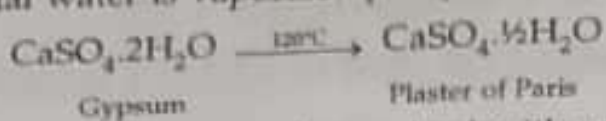
For the constructional work cement alone cannot be used because of very sensitive to moisture, many internal stresses. These matters cause cracking and reduce strength. To avoid these problems some construction materials are used with cement such as concrete, cement mortar, lime mortar.



- Cement Concrete** : It is a mixture of cement, sand, coarse aggregates (crushed stone, gravels, broken bricks etc) and water.
Concrete must have three fundamental qualities :
 - Strength to carry heavy weight
 - Durable for long time
 - Economical.
 It is used to make road, building roof, water tank, floor etc.
- Cement mortar** : Cement mortar is a mixture of cement, sand and water. It is used to join stones, slabs, bricks and for wall plastering.
- Lime mortar** : It is a mixture of slaked lime (calcium hydroxide), sand and water. It is used for building construction.

8.7. PLASTER OF PARIS

Plaster of Paris is a product by heating more or less pure gypsum at about 120°C - 160°C . During heating crystal water is vaporized partly and Plaster of Paris is formed.



It forms a plastic like substance when mixed with water.

It is used to join broken bone, to make model and for wall plastering.

Special Cements

- Aluminous cement** : The cement is made by fusing a mixture of boauxite and limestone at 1500°C - 1600°C in rotary kiln and then grinding the resulting mass like Portland cement.
The rate of hardening of aluminous cement is very rapid and full strength is attained in 24 hrs. It is used for making refractory concrete.
- White cement** : The cement is white in colour due to the absence of iron compounds. It is made from raw materials which are free from iron oxide.
White cement is used to make cement paints. It has architectural value. It is mostly used for finishing touch for concrete work.
- Blast Furnace slag cement** : The cement is made by grinding blast furnace slag and Portland cement clinker with a small percentage of gypsum.
It is very much similar to ordinary Portland cement. It is cheaper than Portland cement since the cement contains large amount of blast furnaced slag. It has the following advantages over ordinary cement.
 - It is used to resist the attack by alkali and sea water.
 - It gives higher strength.
 - It has better plasticity and workability.
 - Cracking is reduced when it is used in concrete.
- Low-heat cement** : It contains higher percentage of lime than ordinary cement. Consequently, no shrinkage cracks occur due to liberation of low heat. The cement is very much useful for construction of dams.



5. **Water-proof cement** : The cement is obtained by adding water proofing substances like (calcium stearate, aluminum stearate and gypsum with tannic acid) to ordinary Portland cement during grinding. The quality of this type of cement depends upon the quantity of admixture added.

It has two functions :

- (i) It makes concrete impervious to water under pressure and
- (ii) to resist the absorption of water. Also it increases the resistance in the penetration of moisture.

Cements Manufacturers in India :

1. Ambuja cement
2. India cement Ltd
3. Birla cement
4. Dalmia cement
5. Orissa cement
6. Lafarge cement
7. Mysore cement
8. A.C.C (Associated Cement Company)

8.8. LUBRICANTS

Lubricant is a substance which is introduced between two moving or sliding surfaces with a view to reduce the frictional resistance between them.

The process of reducing frictional resistance between two moving or sliding surface by the introduction of lubricants in between them, is called lubrication.

Examples of lubricants : Graphite, olive oil, molybdenum disulphide, grease, petroleum oil etc.

Lubricant Reduces :

1. The surface deformation of the moving surface.
2. Expansion of metals by local frictional heat.
3. Wastage of energy, so that efficiency of machine is enhanced.
4. Unsmooth relative motion of the moving or sliding parts.
5. The maintenance cost of the machine.
6. Wear and tear of parts.
7. Loss of energy in the form of heat developed.
8. It protects metals surface against corrosion.
9. It acts as a screen to prevent entry of dirt and moisture.

9. CLASSIFICATION OF LUBRICANTS

Lubricants are classified on the basis of their physical state as follows :

1. Liquid lubricants
2. Semi-solid lubricants
3. Solid lubricants



1. **Liquid lubricants or lubricating oil** : Liquid lubricants i.e., lubricating oils reduce friction and wear between two moving metallic surfaces by providing a continuous fluid film in between them. They also act as coolant, corrosion preventer and sealing agent.

Good lubricating oil must have the following characteristics :

1. Low pressure or high boiling point
2. Sufficient viscosity
3. Low freezing point
4. High oxidation resistance
5. Heat stability
6. Non-corrosive properties
7. Stability to decomposition

Lubricating oils are classified as :

1. **Vegetable oil** : Olive oil, rape-seed oil, castor oil, nut oil, palm oil etc.
2. **Animal oil** : Whale oil, talon oil, lard oil etc.
3. **Minerals oil or petroleum oil** : Petroleum and by-products of petroleum (petrol, kerosene, diesel etc.)
4. **Blended oil** : It is a mixture of mineral oil with vegetables or animals oil. The blended oil is more economical than mineral oil.

For such blending volatility of the mineral oil is decreased, oiliness is increased which increases the thickness of the oil.

Various organic compounds are added with lubricating oil to increase its oiliness, are known as additives e.g., fatty acid, fatty ester, organic phosphors compound, organic chlorine compound etc.

Semi-Solid lubricants or grease : grease is a semi-solid consisting of calcium, lithium, sodium soap, dispersed petroleum oil or synthetic oil.

The main functions of soap are thickness agent so that grease sticks firmly to the metal surfaces.

Solid Lubricants : Most useful solid lubricants employed are graphite and molybdenum disulphide.

Solid lubricants are used either in the dry powder form or mixed with water or oil. The solids fill up the low spots in the surface of moving parts and form solid films which have low frictional resistance.

Uses of some important lubricants :

1. **Palm oil** : It is used in clock, scientific instruments, gun etc.
2. **Castor oil** : It is used in bearing and low pressure machinery.
3. **Graphite** : graphite is used in very great pressure machine (led machine), joints rail line, bearing of cast iron and in internal combustion engine.
4. **Grease** : Grease is used to lubricate machine parts.



Important properties of lubricating oil :

1. **Flash point** : Flash point is the lowest temperature at which the oil lubricant gives off enough vapours that ignite for a moment, when a tiny flame is brought near it.
2. **Fire point** : Fire point is the lowest temperature at which the vapors of the oil burn continuously for at least five seconds, when a tiny flame is brought near it.
3. **Cloud point** : When oil is cooled slowly the temperature at which it becomes cloudy or hazy in appearance, is called its cloud point.
4. **Pour point** : The temperature at which the oil ceases to flow or pour is called its pour point.
5. **Viscosity** : It is the property of a liquid by virtue of which it offers resistance to its own flow.
6. **Oiliness** : Oiliness of lubricants is a measure of its capacity to slick on to the surface of machine parts under conditions of heavy pressure or load.
7. **Volatility** : When lubricating oil is used in heavy machinery working at high temperature, a portion of oil may vapourise leaving behind residual oil, which have different lubricating properties.
Good lubricants should have low volatility.

8. **Aniline point** : Aniline point of an oil is defined as the minimum equilibrium solution temperature for equal volumes of aniline and oil sample.

Aniline point indicates the possible deterioration of oil in contact with rubber sealing's, packing etc.

Lubricants for various purposes :

1. For very high pressure : Graphite, soap stones.
2. For high pressure with low speed : Palm oil, grease, lard oil
3. For very high pressure and high speed : Palm oil, rape-seed oil, castor oil, mineral oil.
4. For light pressure and high speed : Olive oil, whale oil, light mineral oil,
5. For ordinary machinery : rape-seed oil, medium mineral oil.
6. For clock and watches : olive oil, light mineral oil, nut oil, palm oil.

8.10. SYNTHETIC LUBRICANTS

In some specific fields natural lubricants are not applicable then synthetic lubricants can be used. Synthetic lubricants can meet the most drastic and sever condition such as those existing in aircraft engines, in which the synthetic lubricants may have to use in the temperature range of -50°C and 250°C such a lubricant should possess low freezing point, high viscosity and should be non-inflammable.

Important synthetic lubricants are :

1. Polymerized hydrocarbons – polyethylene, polypropylene, polybutylenc.
2. Polyglycol and related compounds – polyethylene glycol, polypropylene glyco
poly alxene glycol
3. Silicones



4. Organic amines
5. Fluorocarbons
6. Organo phosphate
7. Lithium, sodium soap suspended in synthetic oil.

Additives which develop lubricants, are calcium sulphonate (detergent), polyalkyl styrene etc.

8.11. SELECTION OF LUBRICANTS

For a particular job lubricants are selected in which service condition requirements are to be related to the properties of the lubricants.

- (a) **Lubricants for internal combustion engine (I.C. Engine)** : In the I.C. Engine case lubricants used should possess low variation of viscosity with temperature and high thermal stability. Hence graphite is used as lubricants.
- (b) **Lubricants for Grease** : Lubricants having good oiliness' property, high resistance to oxidation and high load bearing capacity should be used because gears are subjected to extreme pressure. Mineral oil is effective for this purpose.
- (c) **Lubricants for Delicate Machinery** : Delicate machinery is to be said clock, scientific instruments, sewing machine etc. which are not exposed to high temperature, water etc. Vegetable oil, animal oil are used for this purpose.
- (d) **For very High Pressure and low Speed Machinery**. Solid lubricants like grease, soap stone, mica etc are used for concrete mixers, railway truck joints etc.
- (e) **Lubricants for Electric Transformer** : Highly refined mineral oil of high insulating property; optimum oxidation resistance, chemical stability and low viscosity are used.

Lubricants Manufacturers in India :

1. Hindustan petroleum
2. Bharat petroleum
3. Indian Oil Corporation.

OBJECTIVE TYPE QUESTIONS

1. Choose correct answer :

(i) The common solid lubricant is :

Ans. Graphite

(ii) Addition of gypsum during fine grinding of cement clinker accelerates the rate of setting - True or False ?

Ans. False

(iii) Gypsum is used in the manufacture of cement - True or False ?

Ans. True

(iv) Setting and hardening of cement is due to hydration and hydrolysis reaction - True or False.

Ans. True.



Cement

(e) MoS_2 is used as a lubricant – True or False ?

Ans. True.

(vi) The liquid lubricants are mainly of _____ origin.

Ans. petroleum.

(vii) A lubricant is used to _____ frictional resistance.

Ans. resist

Subjective Questions

1. Cement hardens on addition of water. Why ?
2. What is (i) Cement mortar (ii) Cement concrete ?
3. Mention three common lubricants and their uses.
4. What is portland cement ? Why it hardens on addition of water ?
5. (a) Why portland cement hardness on addition of water ?
(b) Write down the chemical compositions of Portland cement.
(c) What are the disadvantage of using excess of lime during manufacture of cement ?
6. (a) Classify lubricant with example.
(b) With the help of the structure of graphite, why this can be used as a solid lubricant ?

