CEMENT INDUSTRY

Introduction:

Cement is a material with adhesive and cohesive properties which make it capable of bonding minerals fragments into a compact whole. It is a substance used in construction that sets and hardens and can bind other materials together .like stones, sand, bricks, building stones, etc. The cements of interest in the making of concrete have the property of setting and hardening under water by virtue of a chemical reaction with it and are, therefore, called hydraulic cement. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete, which is a combination of cement and an aggregate to form a strong building material.

Portland cement is the most common type of cement in general use around the world. The name "Portland cement" given originally due to the resemblance of the color and quality of the hardened cement to Portland stone – Portland island in England, used as a basic ingredient of concrete, mortar, stucco, and most non-speciality grout. Portland cement gets its strength from chemical reactions between the cement and water. The process is known as hydration. This is a complex process that is best understood by first understanding the chemical composition of cement.

History of Cement:

The cementitious properties of lime in mortars and concrete have been known since early historic times. The Romans used lime concretes and developed pozzolanic cements of lime and certain volcanic earths. Lime mortars and concretes continued to be used in the middle Ages. In 1824, Joseph Aspdin from Leeds (England) produced a powder made from limestone and clay. He called it "Portland Cement", because when it hardened it produced a material similar to stones from the quarries near Portland Island in UK. Although the method of making cement has been improved, the basic process has remained same.

Types of Cement, their Composition and Uses

The following are the types of cement that are in practice:

Acid-resistant cement: Acid-resistant cement is composed of the following:

- Acid-resistance aggregates such as quartz, quartzites, etc.
- Additive such as sodium fluosilicate Na_2SiF_6
- Aqueous solution of sodium silicate or soluble glass.

The addition of additive sodium flousilicate accelerates the hardening process of soluble glass and it also increases the resistance of cement to acid and water. The binding material of acid-resitance cement is soluble glass which is a water solution of sodium silicate, $Na_2O.nSiO^{-2}$ or potassium silicate, $K_2O.nSiO_2$, where n is the glass modulus. The acid-resistance cement is used for acid-resistance and heat resistance coatings of installations of chemical industry. It is not water-resistant and it fails when attacked by water or weak acids. By adding 0.5 percent of linseed oil or 2 percent of ceresit, its resistance to the water is increased and it is then known as the acid and water resistant cement.

Rapid Hardening Cement: Increased Lime content. Attains high strength in early days it is used in concrete where form work is removed at an early stage.

Quick Setting Cement: This cement is produced by adding a small percentage of aluminium sulphate and by finely grinding the cement. The percentage of gypsum or retarder for setting action is also greatly reduced. The addition of aluminium sulphate and fineness of grinding are responsible for accelerating the setting action of cement. The setting action of cement starts within five minutes after addition of water and it becomes hard like stone in less than 30 minutes or so. The extreme care is to be taken when this cement is used as mixing and placing of concrete are to be completed in a very short period. This type of cement is used to lay concrete under static water or running water.

Low Heat Cement: Manufactured by reducing tricalcium aluminate. It is used in massive concrete construction like gravity dams.

Sulphates resisting cement: It is prepared by maintaining the percentage of tricalcium aluminate below 6% which increases power against sulphates. It is used in construction exposed to severe sulphate action by water and soil in places like canals linings, culverts, retaining walls, siphons etc.

Blast Furnace Slag Cement: It is obtained by grinding the clinkers with about 60% slag and resembles more or less in properties of Portland cement. It can be used for works economic considerations are predominant.

High Alumina Cement: It is obtained by melting mixture of bauxite and lime and grinding with the clinker, it is rapid hardening cement with initial and final setting time of about 3.5 and 5 hours respectively. It is used in works where concrete is subjected to high temperatures, frost, and acidic action.

White Cement: This just a variety of ordinary cements and is prepared from such raw materials which are practically free from colouring oxides of iron, manganese or chromium. For burning of this cement, the oil fuel is used instead of coal. It is white in colour. It is more costly and is used for architectural purposes such as precast curtain wall, facing panels and for floor finish, plaster work, ornaments work, etc.

Coloured cement: The cement of desired colour may be obtained by intimately mixing mineral pigments with ordinary cement. The amount of colouring material may vary from 5 to 10 percent. If this percentage exceeds 10 percent, the strength of cement is affected. The chromium oxide gives green colour. The cobalt imparts blue colour. The iron oxide in different proportions gives brown, red or yellow colour. The manganese dioxide is used to produce black or brown coloured cement. These types of coloured cement are widely used for finishing of floors, external surfaces, artificial marble, window sill slabs, textured panel faces, stair treads, etc.

Pozzolanic Cement: Pozzolana is a volcanic powder. It is found in Italy. It is prepared by grinding pozzolanic clinker with Portland cement. It is used in marine structures, sewage works, sewage works and for laying concrete under water such as bridges, piers, dams etc.

Air Entraining Cement: It is produced by adding indigenous air entraining agents such as resins, glues, sodium salts of Sulphates etc during the grinding of clinker. This type of cement is specially suited to improve the workability with smaller water cement ratio and to improve frost resistance of concrete.

Hydrographic cement: It is prepared by mixing water repelling chemicals. This cement has high workability and strength

Raw Materials:

Portland cement is manufactured by crushing, milling and proportioning the following materials:

- Calcareous material; Lime or calcium oxide (CaO) from limestone, chalk, shells, shale or calcareous rock
- Clayey material; Clay or shale (soft clayey stones), as a source of silica and alumina.
  - Silica (SiO_2); from sand, old bottles, clay or argillaceous rock
  - Alumina (Al_2O_3); from bauxite, recycled aluminum, clay
  - Iron, (Fe_2O_3); from clay, iron ore, scrap iron and fly ash
  - Gypsum ($CaSO_4.2H_20$); found together with limestone

A typical chemical analysis of ordinary Portland cement is as follows:

Item	*Percentage (%)*	*Item*	*Percentage (%)*
CaO	**63.6**	**SiO_2**	**20.7**
Al_2O_3	**6.0**	**Fe_2O_3**	**2.4**
SO_3	**1.4**	**MgO**	**2.4**

Na_2O	**0.1**	**K_2O**	**0.7**
Losson ignition	**1.2**	**Insoluble residue**	**0.3**
Free CaO	**1.1**		
		Total	**100**

Manufacture of Portland cement

Methods of cement manufacturing

1- Wet process; Grinding and mixing of the raw materials in the existence of water. The percentage of the moisture in the raw materials is high.

2- Dry process; Grinding and mixing of the raw materials in their dry state.

The process to be chosen, depend on the nature of the used raw materials.

• The raw materials is so hard (solid) that they do not disintegrate by water

• Cold countries, because the water might freeze in the mixture

• Shortage of the water needed for mixing process.

Wet process

When chalk is used, it is finely broken up and dispersed in water in a wash mill. The clay is also broken up and mixed with water, usually in a similar wash mill. The two mixtures are now pumped so as to mix in predetermined proportions and pass through a series of screens. The resulting – cement slurry – flows into storage tanks. When limestone is used, it has to be blasted, then crushed, usually in two progressively smaller crushers (initial and secondary crushers), and then fed into a ball mill with the clay dispersed in water. The resultant slurry is pumped into storage tanks. From here onwards, the process is the same regardless of the original nature of the raw materials. The slurry is a liquid of creamy consistency, with water content of between 35 and 50%, and only a small fraction of material – about 2% - larger than a 90 µm (sieve No. 170). The slurry mix mechanically in the storage tanks, and the sedimentation of the suspended solids being prevented by bubbling by compressed air pumped from bottom of the tanks. The slurry analyze chemically to check the achievement of the required chemical composition, and if necessary changing the mix constituents to attain the required chemical composition.

Finally, the slurry with the desired lime content passes into the rotary kiln. This is a large, refractory-lined steel cylinder, up to 8 m in diameter, sometimes as long as 230 m, which is slightly inclined to the horizontal. The slurry is fed in at the upper end while pulverized coal (oil or natural gas also might be used as a fuel) is blown in by an air blast at the lower end of the kiln, where the temperature reaches about 1450^{o}C. The slurry, in its movement down the kiln, encounters a progressively higher temperature. At first, the water is driven off and CO_2 is liberated; further on, the dry material undergoes a series of chemical reactions until finally, in the hottest part of the kiln, some 20 to 30% of the material becomes liquid, and lime, silica and alumina recombine. The mass then fuses into balls, 3 to 25 mm in diameter, known as clinker. The clinker drops into coolers.

Dry process

The raw materials are crushed and fed in the correct proportions into a grinding mill, where they are dried and reduced in size to a fine powder. The dry powder, called raw meal, is then pumped to a blending silo, and final adjustment is now made in the proportions of the materials required for the manufacture of cement. To obtain a uniform mixture, the raw meal is blended in the silo, usually by means of compressed air. The blended meal is sieved and fed into a rotating dish called a granulator, water weighing about 12% of the meal being added at the same time. In this manner, hard pellets about 15 mm in diameter are formed. The pellets are baked hard in a pre-heating grate by means of hot gases from the kiln. The pellets then enter the kiln, and subsequence operations are the same as in the wet process of manufacture.

Grinding of the clinker

The cool clinker (produced by wet or dry process), which is black and hard, is inter ground with gypsum $CaSO_4.2H_2O$ in order to prevent flash setting of the cement, and to facilitate the grinding process. The grinding is done in a ball mill. The cement discharged by the mill is passed through a separator, fine particles being removed to the storage silo by an air current, while the coarser particles are passed through the mill once again.

Properties of cement compounds

These compounds contribute to the properties of cement in different ways

- Tricalcium aluminate, C_3A:-

  It liberates a lot of heat during the early stages of hydration, but has little strength contribution. Gypsum slows down the hydration rate of C_3A. Cement low in C_3A is sulfate resistant.
- **Tricalcium silicate, C_3S:-**

  This compound hydrates and hardens rapidly. It is largely responsible for portland cement's initial set and early strength gain.
- **Dicalcium silicate, C_2S:**

  C_2S hydrates and hardens slowly. It is largely responsible for strength gain after one week.
- **Ferrite, C_4AF:**

  This is a fluxing agent which reduces the melting temperature of the raw materials in the kiln (from 3,000^o F to 2,600^o F). It hydrates rapidly, but does not contribute much to strength of the cement paste.

  By mixing these compounds appropriately, manufacturers can produce different types of cement to suit several construction environments.

Chemical shorthand

Because of the complex chemical nature of cement, a shorthand form is used to denote the chemical compounds. The shorthand for the basic compounds is:

Compound	Formula	Shorthand form
Calcium oxide (lime)	Ca0	C
Silicon dioxide (silica)	SiO_2	S
Aluminum oxide (alumina)	Al_2O_3	A
Iron oxide	Fe_2O_3	F
Water	H_2O	H
Sulfate	SO_3	$\underline{S}$

Chemical composition of clinker

The cement clinker formed has the following typical composition:

Compound	Formula	Shorthand form	% by weight
Tricalcium aluminate	$Ca_3Al_2O_6$	C_3A	10
Tetracalcium aluminoferrite	$Ca_4Al_2Fe_2O_{10}$	C_4AF	8
Belite or dicalcium silicate	Ca_2SiO_5	C_2S	20
Alite or tricalcium silicate	Ca_3SiO_4	C_3S	55
Sodium oxide	Na_2O	N	≤ 1
Potassium oxide	K_2O	K	Up to 2
Gypsum	$CaSO_4.2H_2O$	$C\underline{S}H_2O$	5

Uses

• Cement mortar for Masonry work, plaster and pointing etc.

• Concrete for laying floors, roofs and constructing lintels, beams, weathershed, stairs, pillars etc.

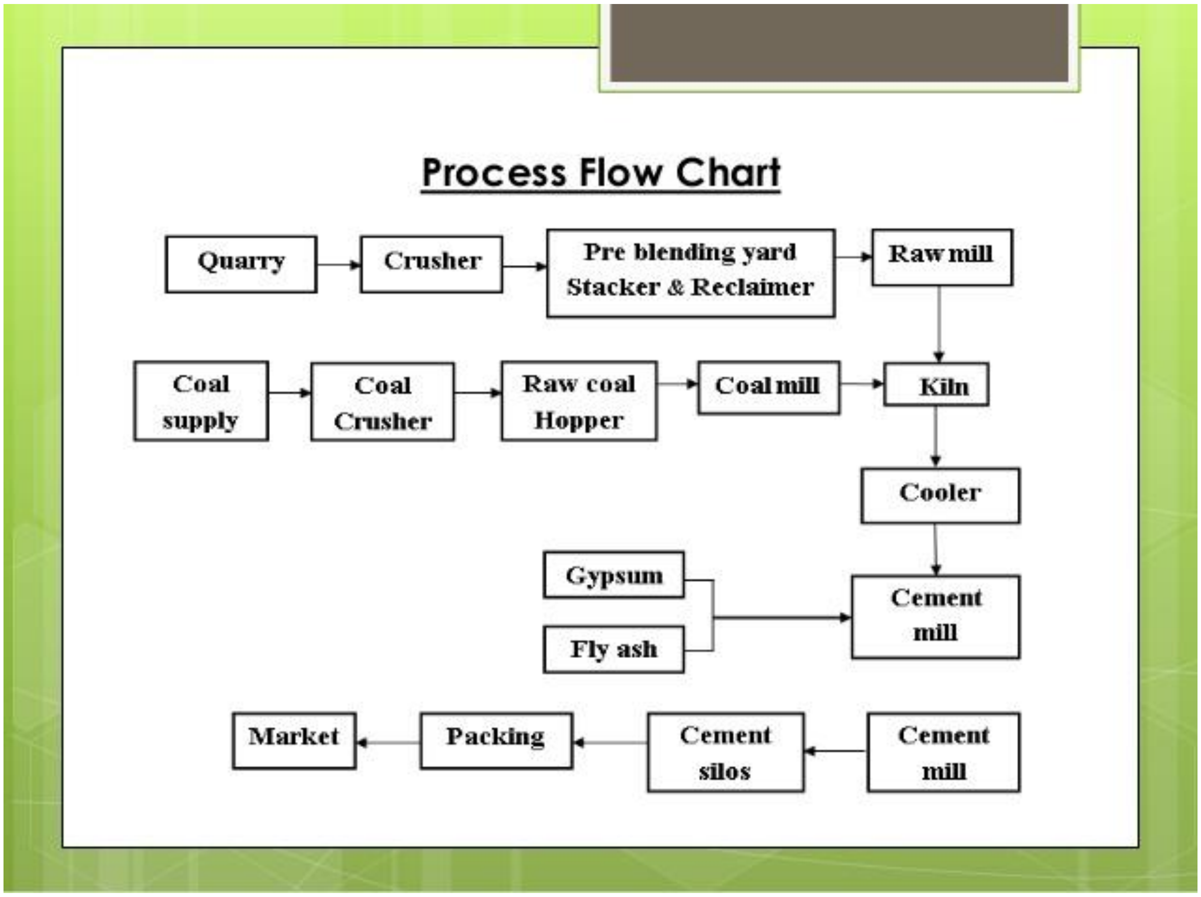
• Construction for important engineering structures such as bridge, culverts, dams, tunnels, light house, clocks, etc.

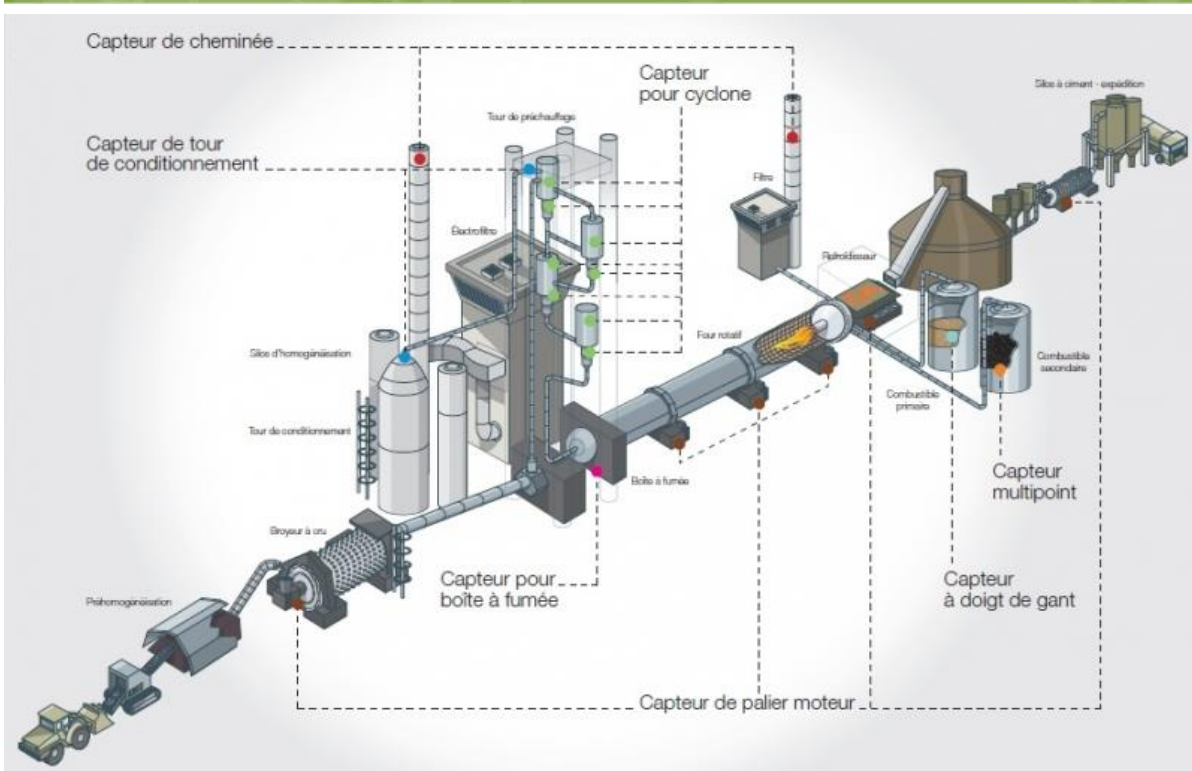
• Construction of water, wells, tennis courts, septic tanks, lamp posts, telephone cabins etc.

• Making joint for joints, pipes, etc.

• Manufacturing of precast pipes, garden seats, artistically designed wens, flower posts, etc.

• Preparation of foundation, water tight floors, footpaths, etc.


Process Flow Chart
Quarry
Crusher
Pre blending yard Stacker & Reclaimer
Raw mill
Coal supply
Coal Crusher
Raw coal Hopper
Coal mill
Kiln
Cooler
Gypsum
Fly ash
Cement mill
Market
Packing
Cement silos
Cement mill


Capteur de cheminée
Capteur pour cyclone
Capteur de tour de conditionnement
Capteur multipoint
Capteur pour boîte à fumée
Capteur à doigt de gant
Capteur de palier moteur