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Cement

Building Materials

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BUILDING MATERIALS

CEMENT

INTRODUCTION

- Cement is a material which has cohesive and adhesive properties in the presence of water.
- It was invented by Joseph Aspdin of UK in 1824. He named it portland cement because the hardened concrete made out of the cement, aggregate and water in definite proportion resembled the natural stone occurring at Portland in England.
- When cement is mixed with water it forms a paste which hardens and binds aggregates (fine and coarse) together to form a hard durable mass called concrete.
- Standard density of cement is 1440 kg/m^3 and 1 bag of cement is of 50 kg; thus volume would be 50/1440 = 0.0347 m^3 approximately 0.035 m^3 or 35 litres.

Hydraulic and Non Hydraulic cement

Hydraulic Cement

- **Hydraulic cement** set and harden extremely fast in presence of water (Due to chemical action between cement and water known as hydration) and results in water resistant product which is stable. This allows setting in wet condition or under water and further protects the hardened material from chemical attack. Eg: Portland Cement.

Non hydraulic cement

- **Non hydraulic cements** are derived from calcination of gypsum or limestone. Their products of hydration are not resistant to water. Thus it will not set in wet conditions or under water rather it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting. Eg: Plaster of paris, lime.

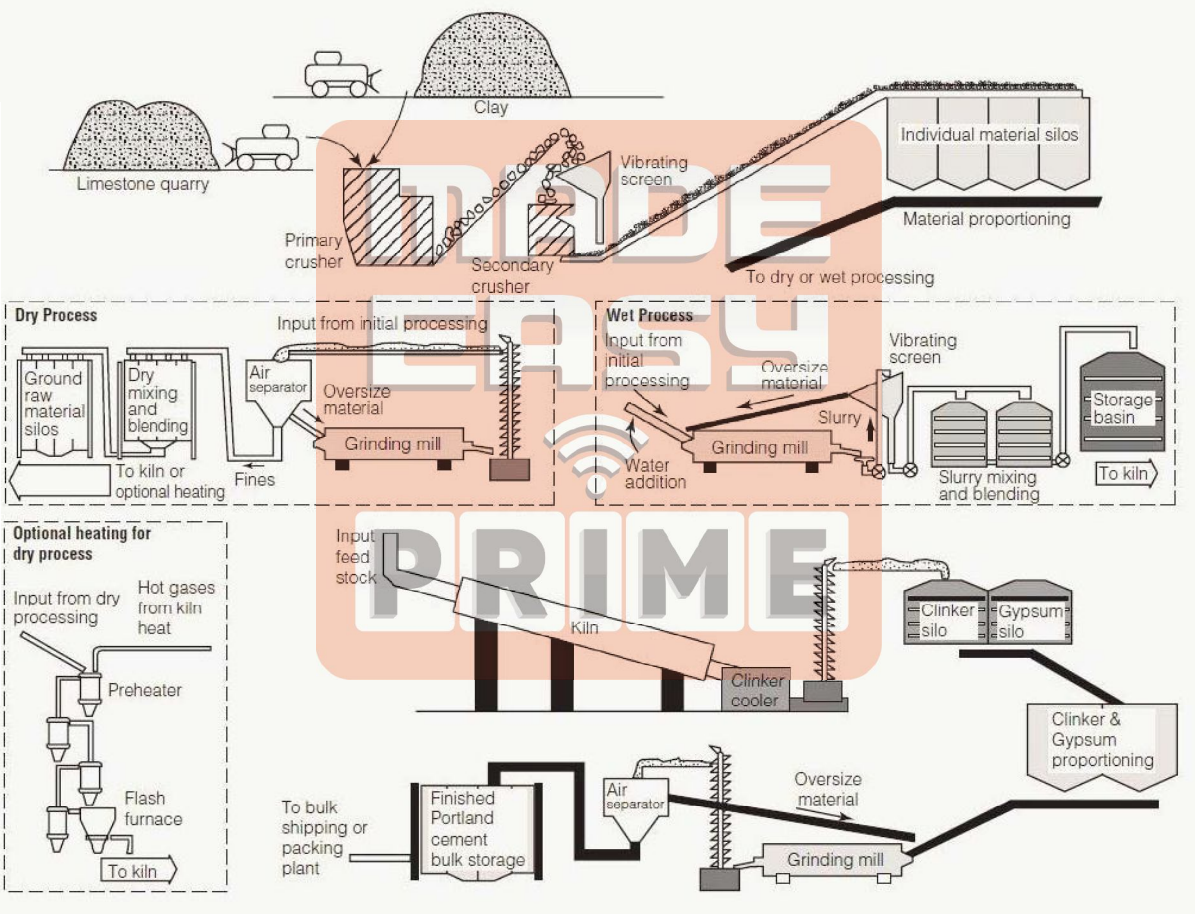
  Note:

  - *The addition of pozzolanic materials can render gypsum and lime cement hydraulic.*
  - *Calcination is the process of heating a substance to a high temperature in the absence or limited supply of oxygen but below the melting point or fusing point, causing loss of moisture, thermal decomposition, oxidation and removal of volatile substances.*

PORTLAND CEMENT PRODUCTION

- Cement can be manufactured either from natural cement stones or artificially by using calcareous and argillaceous materials. Examples of natural cement are Roman Cement, Pozzolana cement and medina cement and of artificial cement are Portland cement and special cements.

Argillaceous (containing silicates of alumina)	Calcareous (Containing lime)
Shale and clay	Cement rock
Blast furnace slag	Lime stone
Slate	Chalk
	Marine shells
	Marl

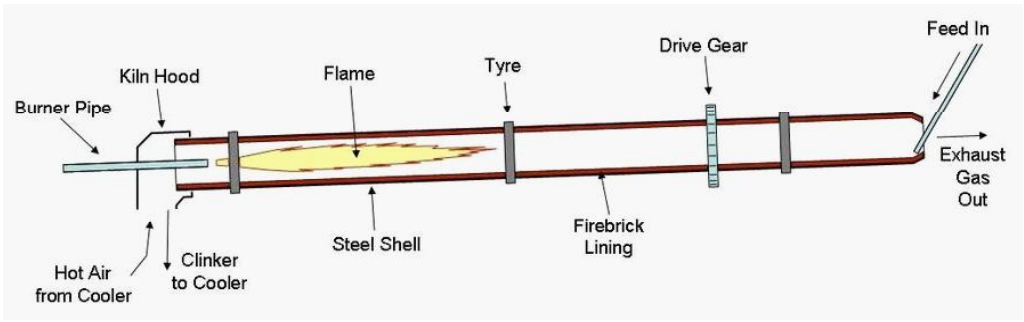


- Process consists of grinding the raw materials, mixing them in certain proportions depending upon their purity and composition and burning them in a kiln at 1300°C to 1500°C.
- At this temperature, material sinters and fuses to form Clinker (a solid solution)
- Clinker is cooled and grounded to fine powder. During grinding gypsum (2-3%) is added in order to prevent the flash setting of the cement.

- There are two processes known as "wet" and "dry" processes depending upon whether the mixing and grinding of raw materials is done in wet or dry conditions.
- Previously wet process was used because control in the mixing of raw materials in powder form was not available.
- Today dry processes is used as technique of dry mixing of powdered materials is available and it is more energy efficient (requires much less fuel).
- In dry process as materials are already in a dry state, where as in wet process material are in slurry form having 35% to 50% of water. Thus to dry the slurry we require more fuel.

Wet Process

- Limestone and clay are crushed and are fed in to grinding mills. Raw materials form a slurry with water in the grinding mill.
- The slurry is passed to silos (storage tanks) where the proportioning of the compounds is adjusted to ensure desired chemical composition.
- Finally the slurry passes into the rotary kiln.
- This is a large refractory lined steel cylinder, 3 m to 8 m in diameter and 30 m to 230 m in length, slowly rotating about its axis ,which is slightly inclined to the horizontal.
- Slurry is fed in at the upper end while pulverized (powdered coal) is blown in by an air blast at the lower end of the kiln, where the temperature reaches about 1450°C.
- Slurry moving down the kiln, encounters a progressively higher temperature.
- At first, the water is driven off and CO_2 is liberated; thereafter, dry material undergoes a series of chemical reactions until finally, in the hottest part of the kiln some 20% to 30% of material get fused and lime, silica and alumina recombine.
- The fused mass turns into 3mm to 20mm nodules known as clinker.
- Clinker drops into rotary coolers where it is cooled in controlled condition
- Cooled clinker is ground in a ball mill with the addition of 2% to 3% of gypsum in order to prevent flash setting of the cement
- The cement is then is stored in silos from where it is supplied in bags or filled into barrels for bulk supply.



Dry Process

- Limestone and clay are ground to fine powder separately and are mixed in correct proportions in a grinding mill, where they are dried and reduced in size to fine dry powder also called Raw Meal.

- The raw meal is then pumped to a blending silo where final adjustment are made for manufacture of cement.
- To obtain a uniform mixture the raw meal is blended, usually by means of compressed air.
- In the dry process the raw meal which has moisture content of about 0.2% is passed through a preheater. Hear the raw meal is heated to about 800°C before it is fed into the kiln.
- Because the raw meal contains no moisture to be driven off the kiln can be shorter than in the wet process.

Comparison of Wet and Dry Process

- Dry process is considered to be economical as compared to wet process because of less consumption of fuel in the kiln.
- Longer kilns are required in wet process which are costly and less responsive to a variable clinker demand then the short kilns which can be used in dry process.
- Advantages of the wet process are the low cost of grinding raw materials, the accurate control of composition and homogeneity of the slurry.

CHEMICAL COMPOSITION OF RAW MATERIALS

- Three basic constituents of hydraulic cements are lime, silica and alumina.
- Relative proportions of these oxide compositions are responsible for influencing the various properties of cement.
- The approximate limits of chemical composition in cement are given below.

Ingredient	Function	Composition (%)	Average (%)
Lime (CaO)	• It controls strength and soundness • Its deficiency reduces strength and setting time and excess of it causes unsoundness.	60 to 65	62
Silica (SiO_2)	• It imparts strength • Excess of it increases the strength but causes slow setting	17 to 25	22
Alumina (Al_2O_3)	• Responsible for quick setting • Excess of it reduces the strength	3 to 8	5
Iron Oxide (Fe_2O_3)	• Gives color and helps in fusion of different ingredients • Excess of it produces a hard clinker which is difficult to grind	0.5 to 6	3
Calcium Sulphate ($CaSO_4$)	• It increases initial setting time of cement	2 to 3	3
Magnesia (MgO)	• It imparts color and hardness (Rigidity of paste) • Excess amount makes the cement unsound	0.5 to 4	2
Sulphur Trioxide (SO_3) Alkalies [Soda (Na_2O) and Potash (K_2O)	• These are residue • Excess of it causes efflorescence and cracking	1 to 3 0.5 to 1.3	1 1