Manufacturing of Portland Cement

- **Calcium silicates are the primary constituents of portland cement.**

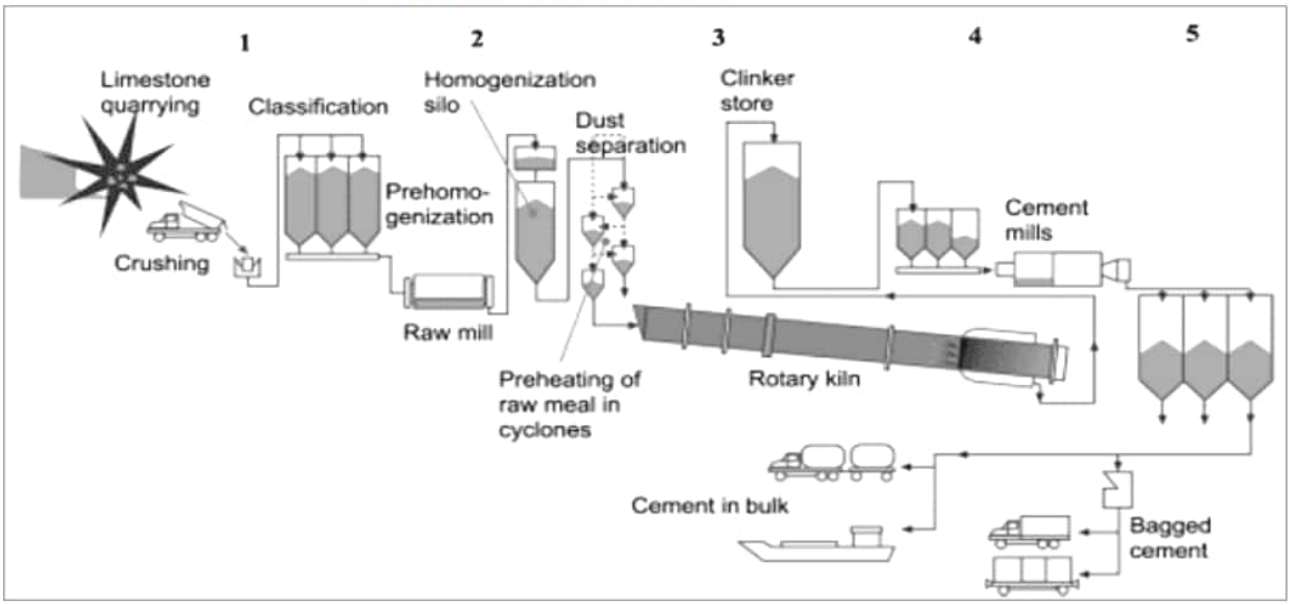
- **Raw material for P.C. is Calcium & Silica**

  Calcium: Limestone, chalk, etc ($CaO + CO_2$)

  Silica: Clays and shales ($SiO_2 + Al_2O_3 + Fe_2O_3 + H_2O$)

2/3 Calcium
1/3 Clay
→ Raw mix should be well homogenized before the heat treatment

Process Flow Chart



Cement Making Process

Raw Mill Feed

Manufacturing Process

Kiln Line Overview

Manufacturing Process

1. Crushing and Proportioning

Limestone rock is the principal raw material, the first step after quarrying in the processes is the primary crushing. Mountains of rock are fed through crushers capable of handling pieces as large as an oil drum. The first crushing reduces the rock to a maximum size of about 15 cm (6 po). The rock then goes to secondary crushers or hammer mills for reduction to about 7.5 cm or smaller.

2. Raw milling & Blending

The next step in the process is to grind the above particles to a size of 90 microns or less which is done in a raw mill, a closed circuit ball mill equipped with high efficiency separator. After achieving the 90 microns size the fine grinded material also known as raw meal is sent to the continuous blending silos (CFC) for homogenization & extracted by means of load cell hopper for the next step which is feeding to the kiln pre heaters.

3. Pyro processing

The raw material is heated to exceeding 1,450 °C (2,700 degrees F) in huge cylindrical steel rotary kilns lined with special firebrick. Kilns are frequently as much as 3.7 M (12 pi) in diameter, large enough to accommodate an automobile and longer in many instances than the height of a 40-story building. Kilns are mounted with the axis inclined slightly from the horizontal. The finely ground raw material or the slurry is fed into the higher end. At the lower end is a roaring blast of flame, produced by precisely controlled burning of powdered coal, oil or gas under forced draft.

4. Burning and cooling

As the material moves through the kiln, certain elements are driven off in the form of gases. The remaining elements unite to form a new substance with new physical and chemical characteristics. The new substance, called clinker, is formed in pieces about the size of marbles.

Clinker is discharged red-hot from the lower end of the kiln and generally is brought down to handling temperature in various types of coolers. The heated air from the coolers is returned to the kilns, a process that saves fuel and increases burning efficiency.

5. Cement milling, Storage & Packing

Portland cement, the basic ingredient of concrete, is a closely controlled chemical combination of calcium, silicon, aluminum, iron and small amounts of other ingredients to which gypsum is added in the final grinding process to regulate the setting time of the concrete. Lime and silica make up about 85% of the mass. Common among the materials used in its manufacture are limestone, shells, and chalk or marl combined with shale, clay, slate or blast furnace slag, silica sand, and iron ore. The above mixture

Cement Chemistry

In cement chemistry, the individual oxides and clincker compounds are expressed by their abbreviations

Short Hand Notation

- C (CaO, calcium oxide)
- A (Al2O3, alumina)
- S (SiO2, silica)
- S (SO3, sulfate)
- H (H20, water)

Reactive Compounds

- C3S (tricalcium silicate)
- C2S (dicalcium silicate)
- C3A (tricalcium aluminate)
- CSH2 (gypsm)
- C4AF (tetra-calcium alumino ferrite)

Compounds of Portland Cement

- C_3S $3CaO \cdot SiO_2$
- C_2S $2CaO \cdot SiO_2$
- C_3A $3CaO \cdot Al_2O_3$
- C_4AF $4CaO.Al_2O_3.Fe_2O_3$
- $C_4A_3\overline{S}$ $4CaO.3Al_2O_3.SO_3$

$$\begin{cases} C_3S = \text{Tricalcium Silicate} \\ C_2S = \text{Dicalcium Silicate} \\ C_3A = \text{Tricalcium aluminate} \\ C_4AF = \text{Tetracacium aluminate ferrite} \end{cases}$$

Cement Chemistry

- **Hydration Reactions**
  - $2C_3S + 6H \rightarrow C\text{-}S\text{-}H + 3CH$ (120 cal/g)
  - $2C_2S + 4H \rightarrow C\text{-}S\text{-}H + CH$ (62 cal/g)
  - $C_3A + 3C\overline{S}H_2 + 26H \rightarrow C_6A\overline{S}_3H_{32}$ (300 cal/g)
  - $2C_3A + C_6AS_3H_{32} + 4H \rightarrow 3C_4A\overline{S}H_{12}$
  - $C_4AF + 10H + 2CH \rightarrow C_6AFH_{12}$
- **$C_3S_2H_3$** (C-S-H gel)
- **CH** (calcium hydroxide)
- **$C_6A\overline{S}_3H_{32}$** (ettringite)
- **$C_4A\overline{S}H_{12}$** (monosulfate)

Other Compounds

- *Magnesium Oxide, MgO*
- *Calcium Oxide, Lime, CaO*

- *Alkali, Na2O, K2O*

  equivalent Na2O=(Na2O+0.46 K2O) limited to about 1-2%