LECTURE NOTES

ON

CEMENT

ENGINEERING CHEMISTRY

B.Tech 1st year

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Cement

Concrete is widely used as a non-metallic material in construction of buildings, dams, bridges, high ways etc. In concrete, cement is a building material that possesses cohesive and adhesive properties and capable of bonding with stones, bricks, building blocks etc.

Portland cement

The name Portland cement is used because this powder on mixing with water gives a hard, stone like mass which resembles Portland rock (Leeds city UK). It is widely used as a non-metallic material in construction. It is a composition of calcium silicates, calcium aluminates and small amount of gypsum.

Composition of Portland cement:-

A sample of Portland cement contain following composition:

i) Calcium Oxide or lime (CaO) : 60-70%
ii) Silica (SiO_2) : 20-24%
iii) Alumina (Al_2O_3) : 5-7.5%
iv) Magnesia (MgO) : 2-3%
v) Ferric Oxide (Fe_2O_3) : 1-2.5%
vi) Sulphur trioxide (SO_3) : 1-1.5%
vii) Sulphur Oxide (Na_2O) : 1%
viii) Potassium Oxide (K_2O) : 1%

Manufacture of Portland Cement:

The steps involve in the manufacturing process are as follows:

i) Crushing
ii) Mixing
iii) Burning
iv) Grinding

i) Crushing:

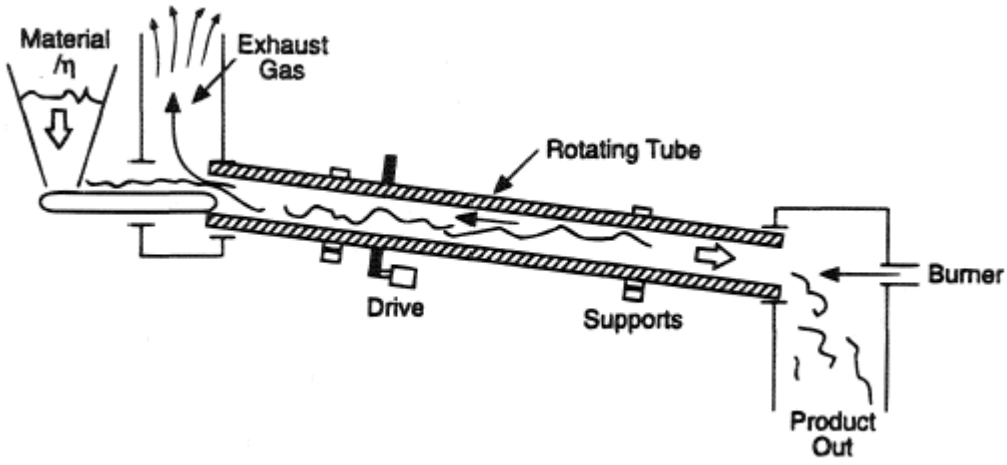
In this step raw material of Portland cement lime, Silica, Alumina, Magnesia, Ferric Oxide, Sulphur trioxide, Sulphur Oxide, Potassium Oxide are crushed and ground to fine powder through ball mill.

ii) Mixing:

In this step raw ingredients or fine powder are mixed in presence (wet process) or absence (dry process) of water to form slurry, then slurry is stored in storage tank.

iii) Burning:

The burning process is done in Rotary Kiln. The Rotary Kiln possesses three different temperature zone like drying zone, calcinations zone and Clinkering zone.



Rotary Kiln

Drying zone:

It is the upper part of Rotary Kiln having temperature around 250^{o}C where the water from the slurry evaporates.

Calcinations zone:

It is middle portion of Rotary Kiln where temperature ranges from 700^{o}-1200^{o}C. in this region limestone undergoes decomposition to form quick lime and carbon dioxide (escape out).

Clinkering zone:

It is the lower part of Rotary Kiln where quick lime with clay to form calcium silicate, aluminates and ferrite.

$$2CaO + SiO_2 \longrightarrow Ca_2SiO_4\ (Ca_2S)$$
Dicalcium silicate

$$3CaO + SiO_2 \longrightarrow Ca_3SiO_5\ (Ca_3S)$$
Tricalcium silicate

$$3CaO + Al_2O_3 \longrightarrow Ca_3Al_2O_6\ (Ca_3A)$$
Tricalcium aluminate

$$4CaO + Al_2O_3 + Fe_2O_3 \longrightarrow 4CaO.Al_2O_3.Fe_2O_3\ (Ca_4AF)$$
Tetracalcium alumino ferrite

The aluminates and silicates are mixed with CaO to form stone like structure, known as clinkers.

iv) Grinding:

The cooled clinkers are ground to a fine powder in ball mill. At this time 2-3% of gypsum is added to prevent the early setting of cement.

Setting and hardening of cement

When water mixed with Cement, form a plastic paste. The past is subjected to hydration and gel and finally crystalline products are formed.

$$3CaO.Al_2O_3 + 6H_2O \rightarrow 3CaO.Al_2O_3.6H_2O + Heat$$

$$2(2CaO.SiO_2) + 4H_2O \rightarrow 3CaO.2SiO_2.6H_2O + Ca(OH)_2 + Heat$$

$$4CaO.Al_2O_3.Fe_2O_3 + 7H_2O \rightarrow Ca_3Al_2O_6.6H_2O + CaO.Fe_2O_3.H_2O + Heat$$

Tobermonite gel, calcium hydroxide crystallization and hydrated tricalcium aluminate are responsible for final setting and hardening of cement.

$$2(2\ CaO.SiO_2) + 6H_2O \longrightarrow 3CaO.2SiO_2.3H_2O + 3Ca(OH)_2 + Heat$$
$$3CaO.Al_2O_3 + 6H_2O \rightarrow 3CaO.Al_2O_3.6H_2O + Heat$$

Role of gypsum:

2-3% of gypsum is added to prevent the early setting of cement.

$$3CaO.Al_2O_3 + xCaSO_4.2H_2O \longrightarrow 3CaO.Al_2O_3.\ xCaSO_4.2H_2O$$

Tricalcium aluminate gypsum Tricalciumsulphoaluminate

Plaster of Paris (POP)

Plaster of Paris is Calcium sulphate hemihydrates having molecular formula $2CaSO_4.H_2O$ or $CaSO_4.1/2H_2O$.

Preparation:

When gypsum is heated about at 150°C then plaster of Paris is formed.

$$\underset{\text{Gypsum}}{CaSO_4.2H_2O} \xrightarrow{150^o\text{-}160^o} \underset{\text{plaster of Paris}}{2CaSO_4.H_2O + 3H_2O}$$

Properties:

i) When plaster of Paris reacts with water, large amount of heat is release. It absorbed water and convert into gypsum. This process is known as setting of plaster of Paris.

$$\underset{\text{Plaster of Paris}}{2CaSO_4.H_2O + 3H_2O} \longrightarrow \underset{\text{Gypsum}}{CaSO_4.2H_2O}$$

ii) Plaster of Paris is a fine white powder. When heated at 200°C it first convert into *gamma*- $CaSO_4$ and on further heating at 600°C it changes into *beta*-$CaSO_4$.

$$2CaSO_4.H_2O \xrightarrow{200^oC} \textit{gamma}\text{-}CaSO_4 \xrightarrow{600^oC} \textit{beta}\text{-}CaSO_4 \xrightarrow{1100^oC} CaO + SO_3$$

When *beta*-$CaSO_4$ is heated about 1100°C, then it converted into quick lime (CaO) and SO_3. The quick lime is used in formation of cement.

Uses of Plaster of Paris:

i) It is used in making casting and in surgical bandage.
ii) Used in making plaster wall and for making plaster boards
iii) Used in making statue, toy, models etc.
iv) Used in formation of gypsum and cement.
v) Used in the formation of calcium sulphate.