Construction Materials For Food Science and Engineering

Construction Material: Lime and Cement

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Lime

Lime: Lime is a more or less impure calcium oxide (CaO) and obtained by calcination (Heating of limestone($CaCo_3$) to redness (1500^oC) in air). Lime acts as a binding or cementing material in engineering constructions.

Uses of Limes

Lime is used for the following purposes:

- White washing
- Lime punning
- Making mortar (lime mortar and surki mortar)
- Making concrete (lime concrete)
- Manufacturing cement

Classification of Lime

There are mainly three types of lime:

1. ***Fat Lime:*** This also known as High Calcium Lime (calcium oxide 96%). This is a purer type of lime and is so alleged because it swells two to three times of its volume when slakes. Fat lime is obtained by calcinations of nearly pure limestone, chalk and sea shells. It is nearly white and free from other substance to produce any major effect upon either the slaking or setting action. It does not set under water but dissolves. Fat lime is generally used for finishing coat in plastering, white washing and lime punning.
2. ***Hydraulic Lime:*** It possesses the property of setting and hardening under water (calcium oxide 45-65%). This is obtained from kankar or clayer limestone. It is not white because it contains impurities of clay and magnesium carbonate. This is used for masonry in foundations and for thick walls. It is also used for mortar for masonry work in superstructure of buildings and plastering.
3. ***Natural Cement:*** These are hydraulic binding materials, almost similar to hydraulic limestone **(calcium oxide 30-35%)** but containing a higher percentage of clayey matter **(40%).** Can be used as mortar where Hydraulic line is used. In addition it can be used for thin wall.

Cement

Cement: Cement is a binding or cementing material used in engineering construction. It is manufactured from calcareous substance (Compound of calcium and magnesium) and is similar in many aspects to the strongly hydraulic lime but possessing far greater hydraulic properties.

Superiority of Cement over Lime

Cement is superior to lime under the following conditions and requirements:

1. For construction of structures in wet places and under water.
2. Where greater strength and durability of structures are required.
3. Where mortar or plaster has to set quick and attain its strength.
4. Where hard surface is required for the protection of exposed surfaces of structures against the destructive agents of the weathering and certain organic or inorganic chemicals.
5. For water tightness of structures.
6. For decorative, ornamental and pointing works.

Classification of Cement

1. **Natural Cement:** This is manufactured by burning and crushing to powder natural stones containing 25 to 40 percent of clay and remainder being the carbonate of lime. Sometimes mixed with carbonate of magnesia. It is brown in color and sets very quickly when mixed with water. However, natural cement is not so strong as the artificial cement. The best variety of natural cement is known as "Roman cement" in England. Romans first used powdered calcined limestone as binding materials in construction works. It is not used in Bangladesh.

2. **Artificial Cement:** The best variety of artificial cement is known as **Ordinary Portland Cement** due to its resemblance in color and quality to Portland stone which was first found and quarried in Dorset in Europe. This is also known as '**Normal Setting cement**'. In most of the engineering works Portland cement is used.

Composition of Portland Cement

Row materials used for manufacturing of Portland Cement are:

- **Calcareous materials** (compound of calcium and magnesium)
- **Argillaceous materials** (compound of silica, alumina and oxide of iron)

Constituents of Portland cement are mainly two types:

- **Mineral constituents:**

constituents	Percentage
1. Tricalcium silicate	45-55
2. Dicalcium siliate	20-30
3. Tricalcium Aluminate	9-13
4. Tetracalcium Aluminoferrite	8-20
5. Calcium Sulphate	2-6
6. Other compounds	2-8

Composition of Portland Cement

- **Acid and Alkaline constituents:**

Constituents	Composition	Range of percentages
1. Calcium Oxide	CaO	60 - 67
2. Silica	SiO_2	17 - 25
3. Alumina	Al_2O_3	3 - 8
4. Iron Oxide	Fe_2O_3	0.5 - 6
5. Magnisium Oxide	MgO	0.1 - 4.0
6. Sulphur Trioxide	SO_3	1 - 3
7. Potassium Oxide	K_2O	0.3 - 1
8. Sodium Oxide	Na_2O	0.4 - 1.3
9. Loss of ignition		1.8 - 2
10. Insoluble residue		0.3 - 0.5

Functions of Different Ingredients of Cement

Ingredients	Functions	If excess or less
1. Lime (Calcium Oxide, CaO): (about 63%)	It increases the strength of cement and optimize setting time	A deficiency in lime reduces the strength of cement and causes it to set quickly. Excess will make cement unsound and causes it to expand and disintegrate
2. Silica (SiO_2): (about 30%)	It imparts strength to cement	A deficiency in silica reduces the strength of cement
3. Alumina (Aluminum Oxide, Al_2O_3): (about 5%)	It imparts quick setting property to cement.	An excess of alumina weakens the cement
4. Magnesia (Magnesium Oxide, MgO):(should be < 2%)	It imparts strength to cement	An excess will reduce the strength of the cement

Functions of Different Ingredients of Cement (Contd.)

Ingredients	Functions	If excess or less
5. Iron Oxide (Fe_2O_3): (about 3%)	It imparts colour, But at high temperature it react with Ca and Al to form Tricalcium aluminoferrite, which imparts hardness and strength to cement.	An excess will make cement red and brittle.
6. Calium Sulphate ($CaSO_4$) (about 4%)	It presents in the form of gypsum and slows down or retards the setting action of cement.	A deficiency will cause quick setting of cement
7. Sulphur Trioxite (SO_3): (should be < 2%)	It impart strength to cement	An excess causes cement become unsound
8. Alkalies: (should be<1%)	It imparts quick setting property to cement.	An excess alkaline matter causes efflorescence

Manufacturing of Cement

- Wet Process
- Dry Process

Wet Process:

The process is divided into three stages:

- To prepare cement slurry,
- To obtain cement clinkers, and
- To prepare cement,

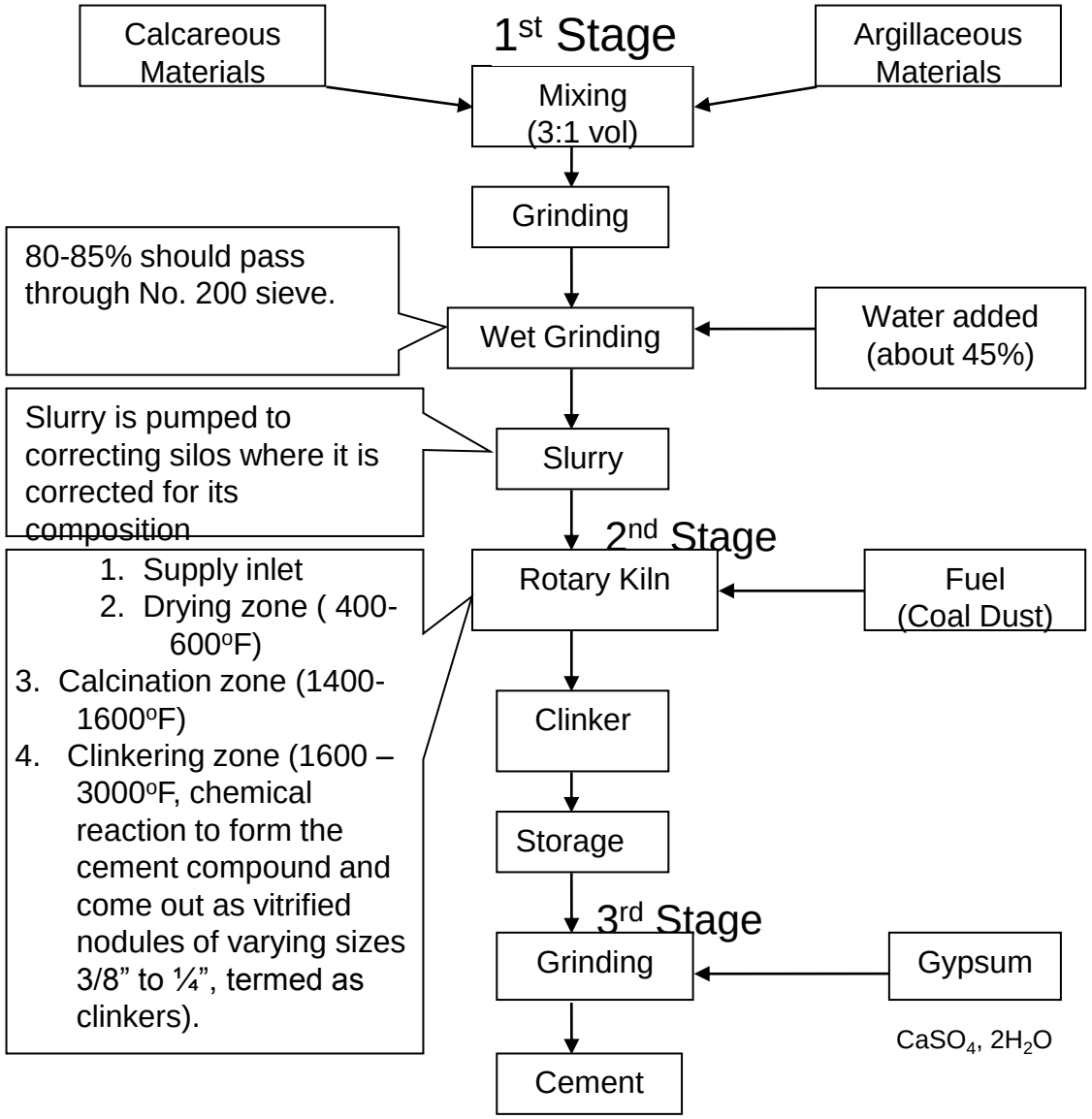
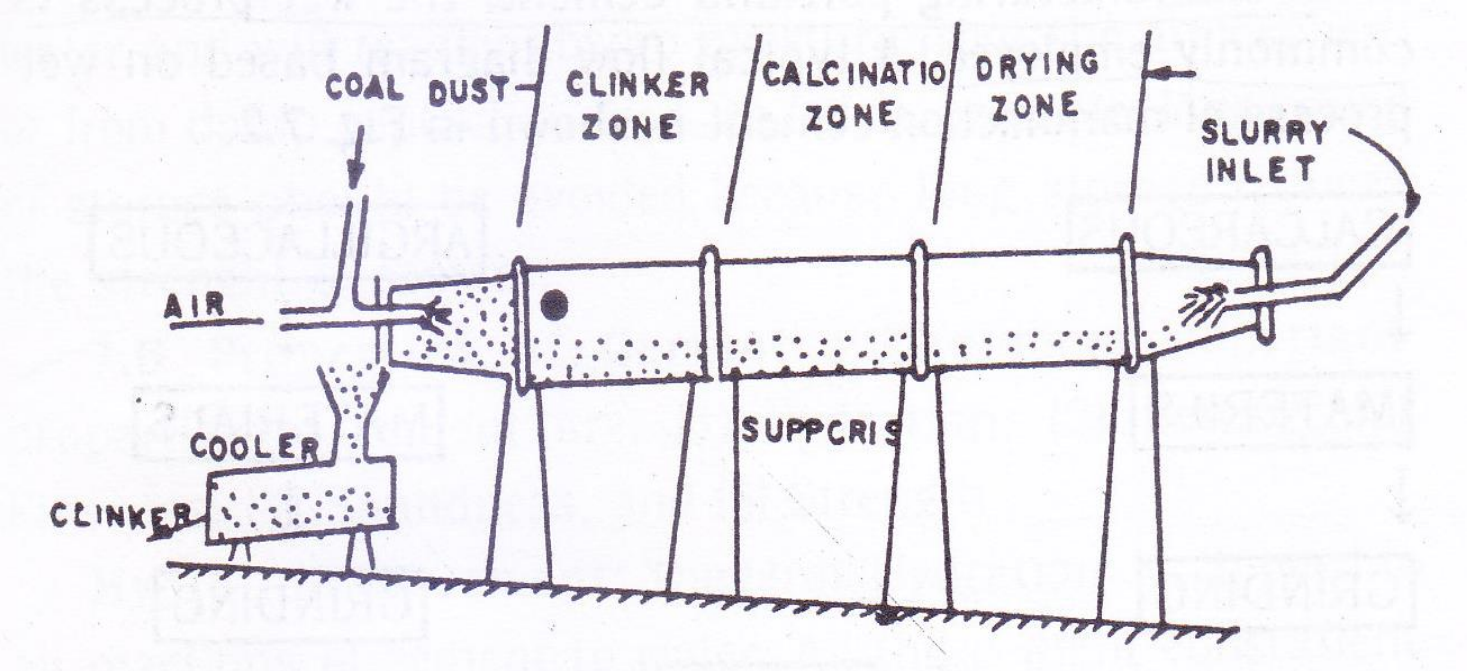


Fig 1. Flow diagram of cement manufacturing (Wet Process)

Fig. Rotary Kiln



Rotary Kiln

A rotary kiln is a long inclined steel cylinder lined with refractories . It is about 8 to 12 ft in diameter and 200 to 400 ft in length, and inclined about ½ to a foot and speed is 2-3 RPM. It has following zones:

- Slurry inlet
- Drying zone (400 to 600^{o}F)
- Calcination zone (1200 to 1600^{o}F)
- Clinkering zone (1600 to 3000^{o}F).
- Clinker cooling zone

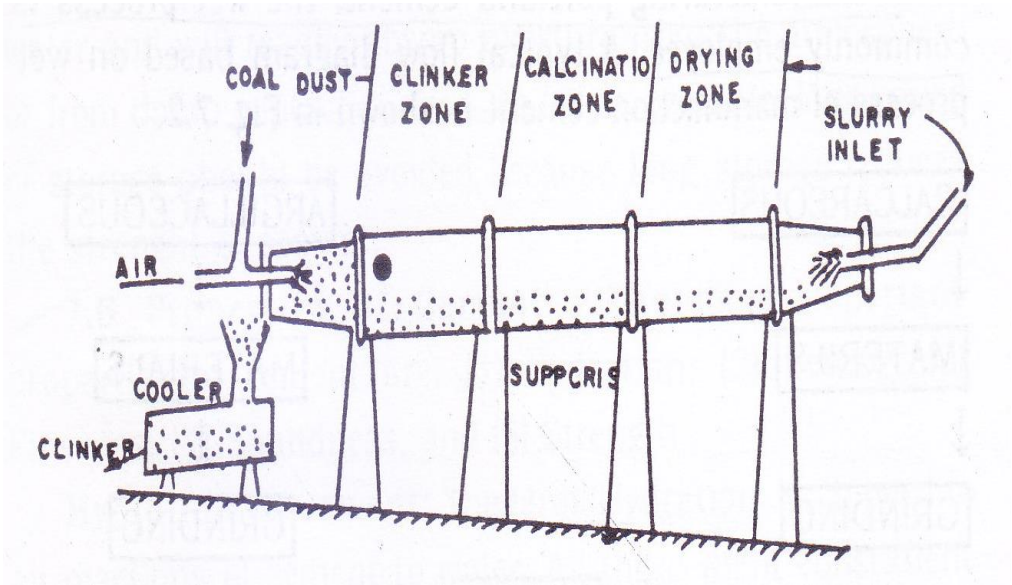


Fig. Rotary Kiln

Properties and Test of Cement

Properties of Cement

The most important properties of cement are:

- Hydration;
- Setting;
- Fineness;
- Soundness; and
- Strength;

Test of Cement

The following tests are performed in the laboratory to ensure that the cement is of the desire quality and that it conforms to the requirement of the relevant standards:

- Test for fineness;
- Test for setting time: Initial and final;
- Test for soundness;
- Test for chemical Composition;
- Test for Strength: Compressive and Tensile;

Type of Cement

Type of Portland Cement

- Ordinary Portland Cement
- Modified Portland Cement
  - Air Entraining Portland Cement
  - Expanding Portland Cement
- Rapid Hardening Portland Cement
- Quick setting Portland Cement
- Low Heat Portland Cement
- Sulphate Resisting Portland Cement
- Blast Furnace Portland Cement
- Pozzolana Portland Cement
- White Portland Cement

Thanks