CIVIL ENGINEERING MATERIALS
COURSE CODE: CE-116
LECTURE # 3

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Cement

- Introduction to Ordinary cement
- Constituents of cement
- Manufacturing of Ordinary cement
- Types of cement
- Cement hydration
- Properties and field tests of cement
- Special cements

Lime

- Introduction and manufacturing of lime
- Applications of lime
- Comparison of lime and cement

Introduction to Cement

- **Joseph Aspedin** of Yorkshire (U.K.) was the first to introduce Portland cement in 1824. It was a mixture of **limestone** and **clay** heated in furnace at high temperature.
- In 1845, Johnson made the cement clinker by increasing the temperature of limestone & clay mixture.
- From then onwards, a gradual improvement in the properties and qualities of cement has been made possible by researchers around the world.

Manufacturing of Ordinary Cement

Manufacturing of ordinary cement is done by two processes. They are

- Dry Process
- Wet Process

Dry Process

- The dry process is adopted when the raw materials are quite hard.
- The process is slow and costly.
- Limestone and clay are ground to fine powder separately and are mixed. Water is added to make a thick paste.
- The paste, which contains about 14 percent of moisture, are dried and are shifted into a rotary kiln for **calcination** at a temperature of about 1400° to 1500°C.

Dry Process

- The product obtained after calcination in rotary kiln is called ***clinker***.
- Clinker is then cooled and ground in tube mills for grinding where **2-3%** of **gypsum** is also added.
- The purpose of adding gypsum is to slow down the setting time of cement.
- Generally, cement is stored in bags of 50 kg.

Wet Process

- In Wet Process the crushed raw materials are feed into ball mill and water is added. On operating the ball mill, the steel balls in it **pulverize** the raw materials which form a slurry.
- This slurry is passed to **silos** (storage tanks), where the proportioning of the compounds is adjusted to ensure desired chemical composition.
- The slurry possess about 40 percent moisture content, is then feed into rotary kiln where it loses moisture and form clinker at **1500-1600°C**.

Wet Process

- The Clinker is cooled and then ground in tube mills for grinding where about 3 percent gypsum is added.
- The cement is then stored in silos from where it is supplied.

Manufacturing of Ordinary Cement

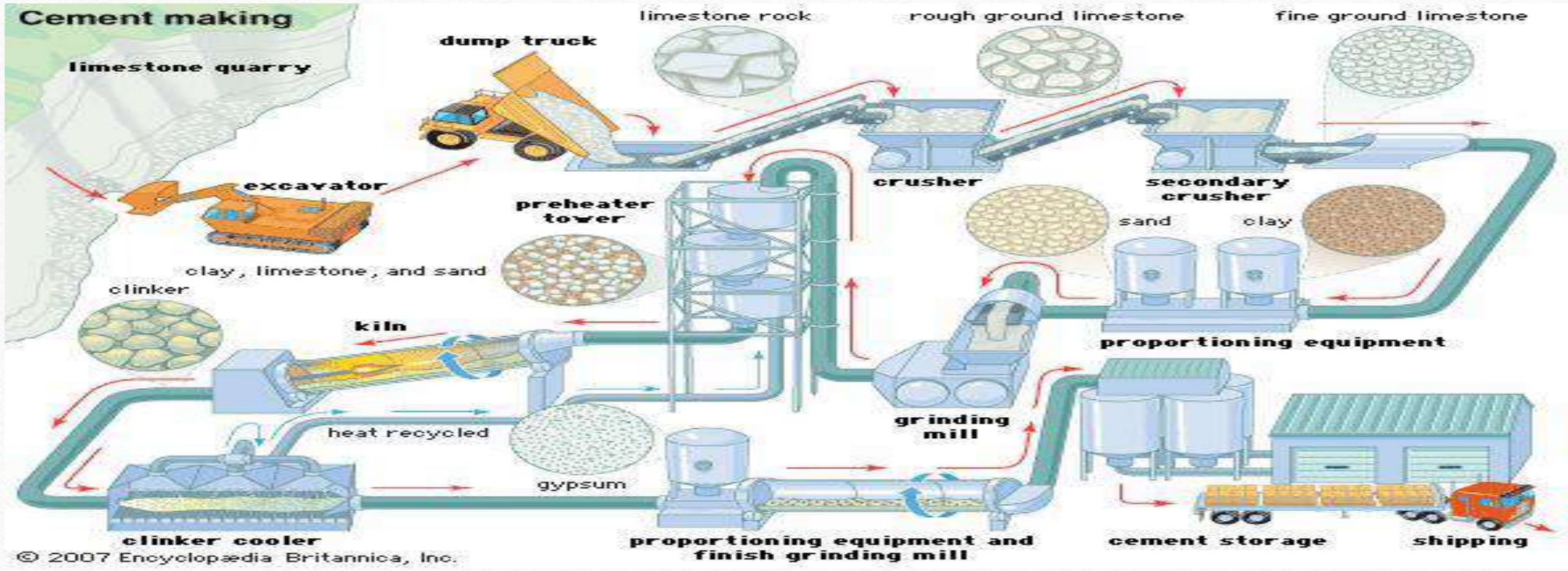
Limestone

Clay

Rotary Kiln

Clinker

Manufacturing of Ordinary Cement



Hydration of Cement

- The chemical reaction between cement and water is known as hydration of cement. *The* reaction takes place between the active components of cement and water.
- When the cement comes in contact with water, the hydration reaction starts. This reaction proceeds slowly for 2-5 hours and is called induction or dormant period.

Types of Cement

- Ordinary Portland Cement
- Sulphate Resisting Cement
- Rapid Hardening Cement
- Quick Setting Cement
- Low Heat Cement
- High Alumina Cement
- White Cement

Ordinary Portland Cement

- It is called Portland cement because on hardening (setting) its colour resembles to rocks near Portland in England.
- It was first of all introduced in 1824 by Joseph, a bricklayer of Leeds, England.

Lime	**(CaO)**	**60- 63%**
Silica	**SiO_2**	**17- 25%**
Alumina	**Al_2O_3**	**03- 08%**

Rapid Hardening Cement

- **Rapid Hardening Cement** is obtained by adding 2% of **Calcium chloride** ($CaCl_2$) to the O.P.C
- The strength obtained by this cement in **04** days is same as obtained by O.P.C in **14** days.
- This cement is used in highway slabs which are to be opened for traffic quickly.
- This is also suitable for use in cold weather areas.

Quick Setting Cement

- This cement is manufactured by adding small %age of **aluminium sulphate** (Al_2O_3) which accelerates the setting action.
- When concrete is to be laid under water, quick setting cement is to used.
- The setting action of such cement starts with in 05 minutes after addition of water and it becomes stone hard in less than half an hour.

White Cement

- This cement is called Snow Crete.
- **Iron oxide** gives the grey colour to cement, it is therefore necessary for white cement to keep the content of iron oxide as low as possible.
- Lime stone and china clay free from iron oxide are suitable for its manufacturing.
- This cement is costly than O.P.C.
- It is mainly used for architectural finishing work in buildings, like Marble Grouting

Special Cement

Special cements are cements that serve some specific function such as:

- Altering the setting or hardening behaviour of a concrete
- Producing different colours for architectural effects
- Resisting the penetration of water in walls or other parts of structures.

For Example:

- Quick Setting Cement
- Whit Cement
- Rapid Hardening Cement etc.

Quality Check of Cement in Field

- Open the cement bag and take a good look at the cement, it should not contain any visible **lumps**.
- Color of cement should be **greenish grey**.
- One feels **cool** by thrusting one's hand in the cement bag.
- When we touch the cement, it should give a **smooth** feeling.
- When we throw the cement in a bucket full of water before it sinks the particles should **flow**.

Field Tests of Cement

- Fineness Test of Cement
- Soundness Test of Cement
- Consistency Test of Cement
- Setting Time Test
- Compressive Strength Test

Fineness Test of Cement

- **95%** of cement particles are smaller than **45 micrometer**, with the average particle around 15 micrometer.
- More is the fineness of cement more will be the rate of hydration.
- Thus the fineness accelerates strength development principally during the first seven days.

Soundness Test of Cement

- "**Soundness**" refers to the ability of a hardened **cement** paste to retain its volume after setting without delayed destructive expansion. This destructive expansion is caused by excessive amounts of free lime (CaO) or magnesia (MgO).
- This test is to ensure that the cement does not show any subsequent expansions.
- Unsoundness is due to magnesia content in cement and it should be limited to 6%.
- Unsoundness of a cement is determined by Le-Chatelier Apparatus

Introduction to Lime

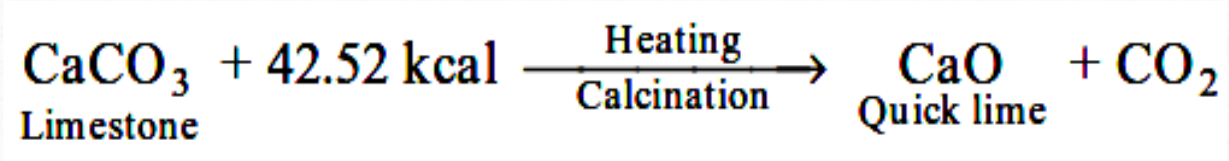
- Until the invention of Portland cement, lime was used as the chief cementing material in building construction **(mortar & plasters).**
- Most of the ancient palaces, forts, temples, monuments, etc., have been built with lime.
- Usually, lime in free state is not found in nature.
- The raw material for the manufacture of lime **(CaO)** is calcium carbonate which is obtained by the calcination of lime stone.
- Lime is obtained by burning **limestone** at a temperature of about **800°C**.

Manufacturing of Lime

- Lime is obtained by burning limestone. Hydraulic lime is obtained by burning kankar. It is usually burned in some form of vertical kiln which is a tunnel shaped working on continuous or intermittent systems.
- The kiln is either mixed-feed or separate-feed on the basis of arrangement of fuel and limestone.
- In mixed-feed type, bituminous coal and limestone are fed into top of the kiln and in alternate layers.
- In separate-feed type, limestone is not brought into contact with fuel during burning process. Fuel is burned in a grate which is attached to the sides of the kiln and is so arranged that the heat produced will ascend into the stack.

Manufacturing of Lime

- The mixed-feed kiln uses less fuel, but does not produce as high grade product as the separate-feed kiln.
- Modern furnace fired lime kilns yield about 25-35 cu m of good hydraulic lime per day.



Application of Lime

As a construction material:

- Lime was used as main binding material in all types of construction till 19th century.
- Used as a mortar (lime-mortar) mixed with sand or surkhi.
- Used for plastering
- Used for whitewash which gives sparking white finish at a very low cost
- Used for lime-concrete similar to cement concrete made by mixing lime, sand and coarse aggregate in proper proportions
- Used in sand-lime bricks which are quite popular in many countries

Comparison of Cement and Lime

Property	*Lime*	*Cement*
Colour	White or greyish white	Dark grey or greyish brown
Slaking	Slaking takes place on adding Water	Hardening takes place on adding water
Setting	It sets slowly by taking CO_2 from air or by reacting with water	It sets rapidly by reacting water
Hardening	Slow	Rapid
Compressive Strength	Less	High
Cost	Cheap	Costly
Use	Suitable for ordinary construction works	Suitable for all construction works

THANK YOU