

centenary celebrated Sharanabasveshwar Vidya Vardhak Sangha's

# SHARANBASVESHWAR

College of Science, Kalaburgi 585103

## one day webinar by student on,

# MANUFACTURE OF CEMENT

CONDUCTED BY:DEPARTMENT OF CHEMISTRY

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Through:ZOOM APP

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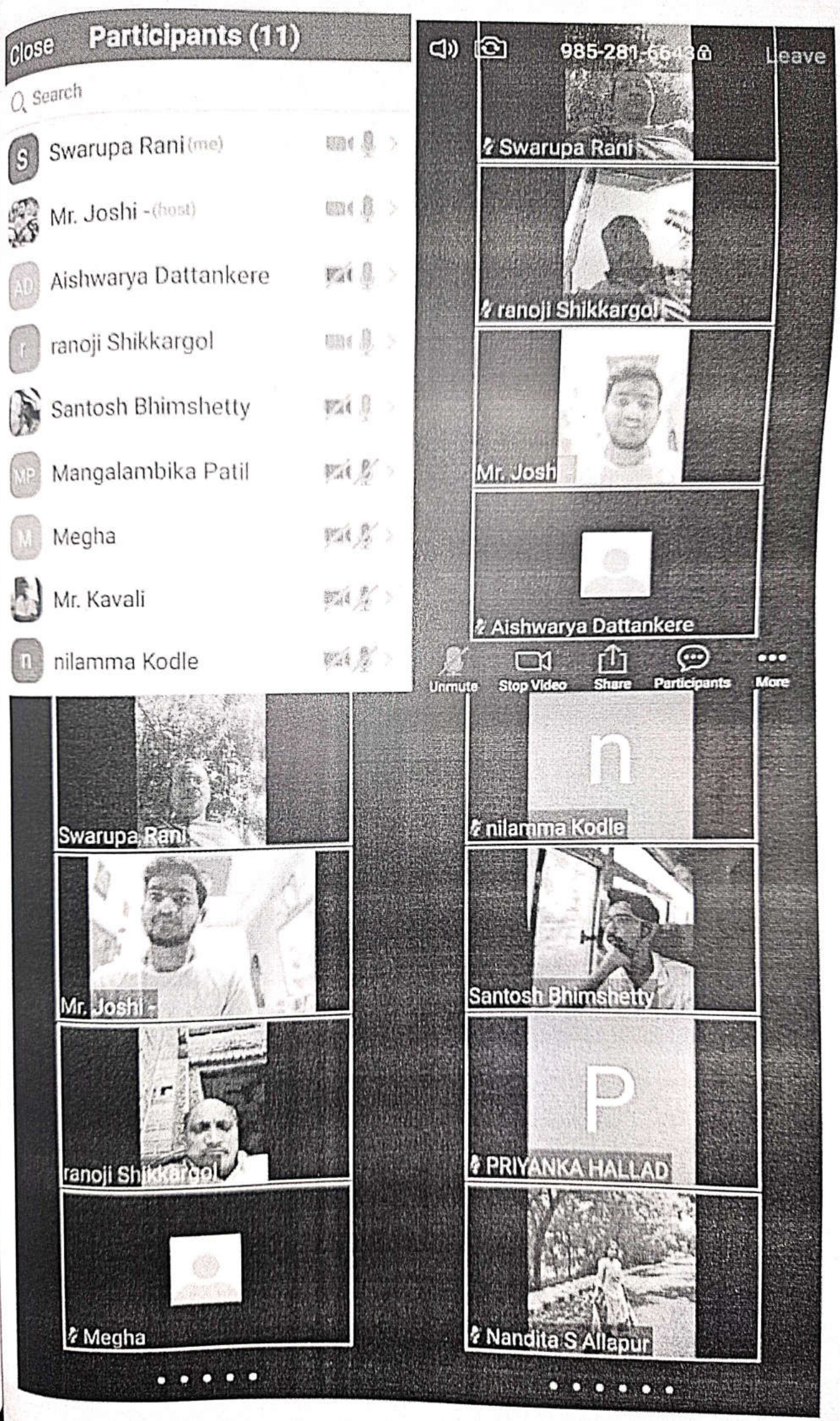
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# Cement

## What is cement ?

- They are finely ground powders that when mixed with water set (solidify) to a hard mass
- They are generally adhesives and used mainly in building and construction

## Types of cement :

- **Hydraulic cement** set in the presence of water by a means of chemical reaction (Ex : Portland cement)
- **Non hydraulic cement** don't set in the presence of water and wet conditions but they set by reacting with CO2 in dry air
- There are other types of cement like slag cement and high alumina cement but they are not commonly used

## Portland cement :

- This is the most common type of cement in general use around the world
- It is made by heating limestone (calcium carbonate) with other materials to1450 Celsius in a kiln in a process called calcination
- The resulted hard substance (clinker) is then ground with small amount of gypsum into a powder to make ordinary Portland cement (OPC)

## some uses of cement

- the most important use of cement is production of mortar and concrete which is important for stronger buildings
- Portland cement is used in manufacture of some products like

1.Bricks
2.Shingles
3.Beams
4.Tiles
5.Pipes
6.Railroad ties

# CEMENT

Cement is one of the main building materials used in the modern society. It was first prepared English builder Joseph Aspidin in the year 1824. In earlier days mortar which is an intimate re of lime, sand and water was used as cementing material for the construction of buildings, s, dams etc. This has been replaced by cement as it has quicker setting property and greater gth.

Cement is a finely ground mixture of calcium aluminates and silicates, which when d with water forms a hard rigid mass of high durability. The intimate mixture of aluminates icates of calcium is also called Portland cement because, after setting, the mass resembles nd rock, a famous building stone of England.

## Raw materials used in the manufacture of cement

The average composition of cement is as shown in the Table 3E. Accordingly, relative proportions materials are used in the manufacture of cement.

*Table 3E - Composition of cement*

| Constituent | Average percentage |
|---|---|
| Lime (CaO) | 62 |
| Silica ($SiO_2$) | 22 |
| Alumina ($Al_2O_3$) | 7.5 |
| Iron oxide ($Fe_2O_3$) | 2.5 |
| Magnesia (MgO) | 2.5 |
| Sulphur trioxide ($SO_3$) | 1.0 |
| Alkali ($Na_2O$/$K_2O$) | 1.5 |

Thus, the essential raw materials required for the manufacture of cement are limestone, clay gypsum ($CaSO_4.2H_2O$). The limestone provides CaO and $Fe_2O_3$, while clay provides $SiO_2$ and The calcareous materials are limestone, chalk, shells of marine animals etc. The silicious ls are clay, shale, slate, blast furnace slag etc. The role of main constituents of cement are:

major constituent of cement. It should be present in proper proportion (58 - 65%). Excess of lime reduces strength of cement by causing cracks while lesser amount makes it quick setting.

Silica imparts strength to cement by forming silicates but excessive silica renders it slow setting. Alumina increases the rate of setting of cement, while gypsum retards the rate of setting.

The greyish black colour of cement is due to the presence of iron oxide. In the absence of iron oxide, cement is white but becomes hard to burn.

## 15.8 Manufacture of Portland cement

There are two processes of manufacture of cement; wet process and dry process. These methods differ only in mixing raw materials prior to heating in the rotary kiln.

1) **Wet process.** If limestone and clay are soft and fuel is cheap this method is practised. Most of the cement companies in India follow this method. In the wet process, limestone is crushed into particles of suitable size and clay is washed with water to remove flint and other impurities. Both the raw materials are mixed and a homogeneous slurry containing about 40% water is prepared.

2) **Dry process:** Dry process of mixing of raw materials is used when the limestone and clay are hard. This method is economical as the calcination in kiln requires less fuel. However, the quality of cement obtained by this method is less superior compared to wet process.

In this method, the calcareous and argillaceous (materials containing silica and alumina) materials are mixed in the ratio 3 : 1, dried, powdered so as to get a homogeneous mixture. The mixture is called raw meal.

**Calcination of raw material mixture**

The mixture of raw materials obtained by the wet or the dry process is subjected to calcination in the rotary kiln. The kiln is a steel cylinder lined inside with refractory bricks. The length of the cylinder is about 50-120 m and the diameter is about 2 m. It is fixed in an inclined position and rotated at the rate of 30 60 rpm per hour.

The charge is introduced into the kiln and at the same time a blast of burning coal dust and air is blown from the other end. As the charge flows down slowly it loses all the water. When it reaches the middle portion of the kiln at which temperature is about 1250K, limestone decomposes to calcium oxide and carbon dioxide.

At the lowest portion, at which the temperature is about 1870 K, calcium oxide and clay undergo fusion forming calcium silicate and calcium aluminate. This grey-coloured mass of hard balls containing silicate and aluminates of calcium is called clinker. Various chemical reactions which lead to the formation of cement clinker during the 2-3 hour journey of the charge from one end to the other end are as follows:

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$2CaO + SiO_2 \longrightarrow 2CaO \cdot SiO_2 \quad \text{(Dicalcium silicate } C_2S\text{)}$$

$$3CaO + SiO_2 \longrightarrow 3CaO \cdot Si_2O_3 \quad \text{(Tricalcium silicate } C_3S\text{)}$$

$$3CaO + Al_2O_3 \longrightarrow 3CaO \cdot Al_2O_3 \quad \text{(Tricalcium aluminate } (C_3A)\text{)}$$

$$4CaO \cdot Fe_2O_3 + Al_2O_3 \longrightarrow 4CaO \cdot Al_2O_3 \cdot Fe_2O_3 \quad \text{(Tetracalcium alumino ferrate } C_4AF\text{)}$$

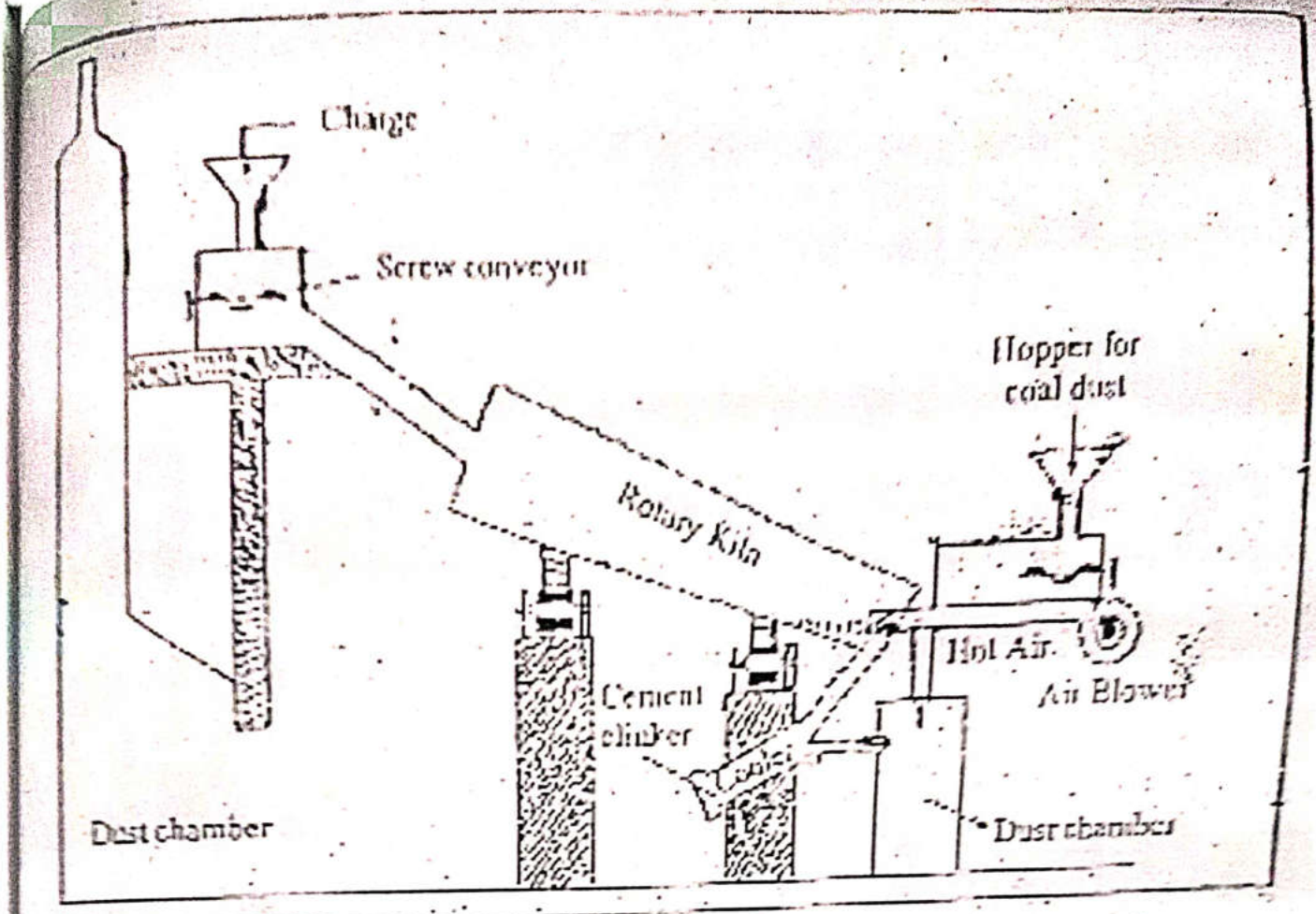


*Fig. 3.8 - Manufacture of Portland cement*

It may be noted that the spent gases contain lot of cement dust and cause particulate pollution. vent this, the exhaust gases are passed through a dust chamber or electrostatic precipitator allowing them into the atmosphere].

Finally, the hot cement clinker is cooled, mixed with 3-5% of gypsum and ground to fine r in grinding machines and packed in air tight bags.

Depending upon the particle size, cements are graded as 33, 43 and 53. Smaller the size of e, higher is the grade. Finer cement increases the strength of concrete made from it.

## Composition of Portland cement

The main components of Portland cement are indicated below:

**Dicalcium silicate - ($C_2S$):** It is present to an extent of 25%. It undergoes hydration slowly. Though it has low early-strength it contributes to the ultimate-strength. Its setting time is about 7 days.

**Tricalcium silicate - ($C_3S$):** It is present to an extent of 45%. It develops the ultimate strength quickly and has medium rate of hydration. Its setting time is about 7 days.

**Tricalcium aluminate - ($C_3A$):** It is present to an extent of 10%. It develops good early-strength but contributes less towards the ultimate-strength. It has a setting time of about 1 day.

**Tetracalcium aluminoferrite - ($C_4AF$):** It is also present to an extent of 10% but contributes less towards developing early-strength or ultimate-strength.

## 3.5D Setting of cement

When cement is mixed with water, made into a paste and allowed to stand it becomes a hard rigid mass. This phenomenon is called **setting of cement**. The process of setting of cement is partly due to chemical changes involving hydrolysis of constituents accompanying heat changes and partly due to physical changes involving **gel formation** followed by **crystallisation**. When the paste of cement and water is allowed stand, the following reactions take place with the passing of time.

(a) **During first 24 hours**, tricalcium aluminate undergoes hydration forming a colloidal gel.

$$3CaO\ Al_2O_3 + 6H_2O \longrightarrow \underset{\text{hydrated gel}}{3CaO\ Al_2O_3\ 6H_2O}$$

The gel acquires cubic, hexagonal or orthorhombic structures depending upon the extent of hydration.

(b) In between 1-7 days, dicalcium silicate undergoes hydrolysis forming $Ca(OH)_2$, which changes into needle-shaped crystals:

$$3CaO\ SiO_2 + H_2O \longrightarrow \underset{\text{(amorphous)}}{2CaO\ SiO_2} + Ca(OH)_2$$

Simultaneously, some amount of tricalcium aluminate also undergoes hydrolysis forming calcium and aluminium hydroxides. These hydroxides plug the interstices and harden the mass.

(c) **During 7-28 days**, amorphous dicalcium silicate is formed as indicated in (b) and gets hydrated forming colloidal gel. The needle-shaped $Ca(OH)_2$ now penetrates into the gel resulting in the increase of binding strength. Meanwhile, hydrated tetracalcium aluminoferrite slowly loses water by evaporation as well as by hydrating anhydrated components forming a rigid hard mass.

$$2CaO\ SiO_2 + x\ H_2O \longrightarrow \underset{\text{gel}}{2CaO\ SiO_2\ xH_2O}$$

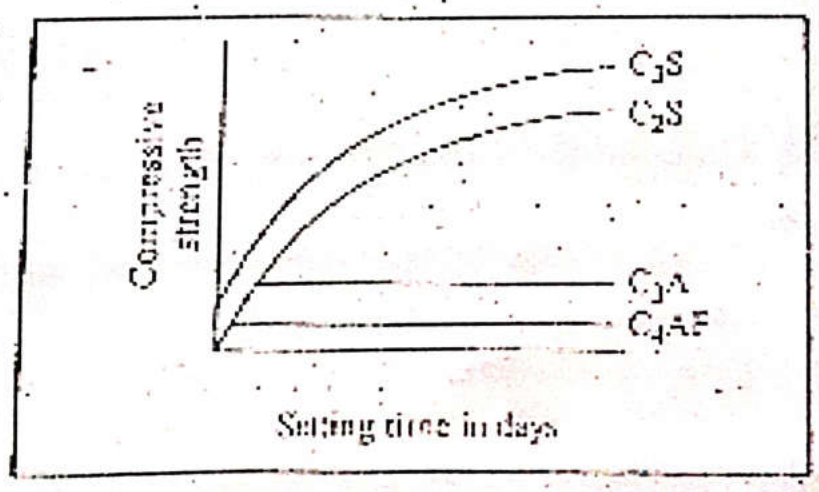


*Fig 3.9 Setting of cement*

Thus, the process of setting of cement involves hydration, hydrolysis and crystallisation reactions. The presence of crystals has been verified using an electron microscope. The following figures depict visualisation of the concept of setting of cement.

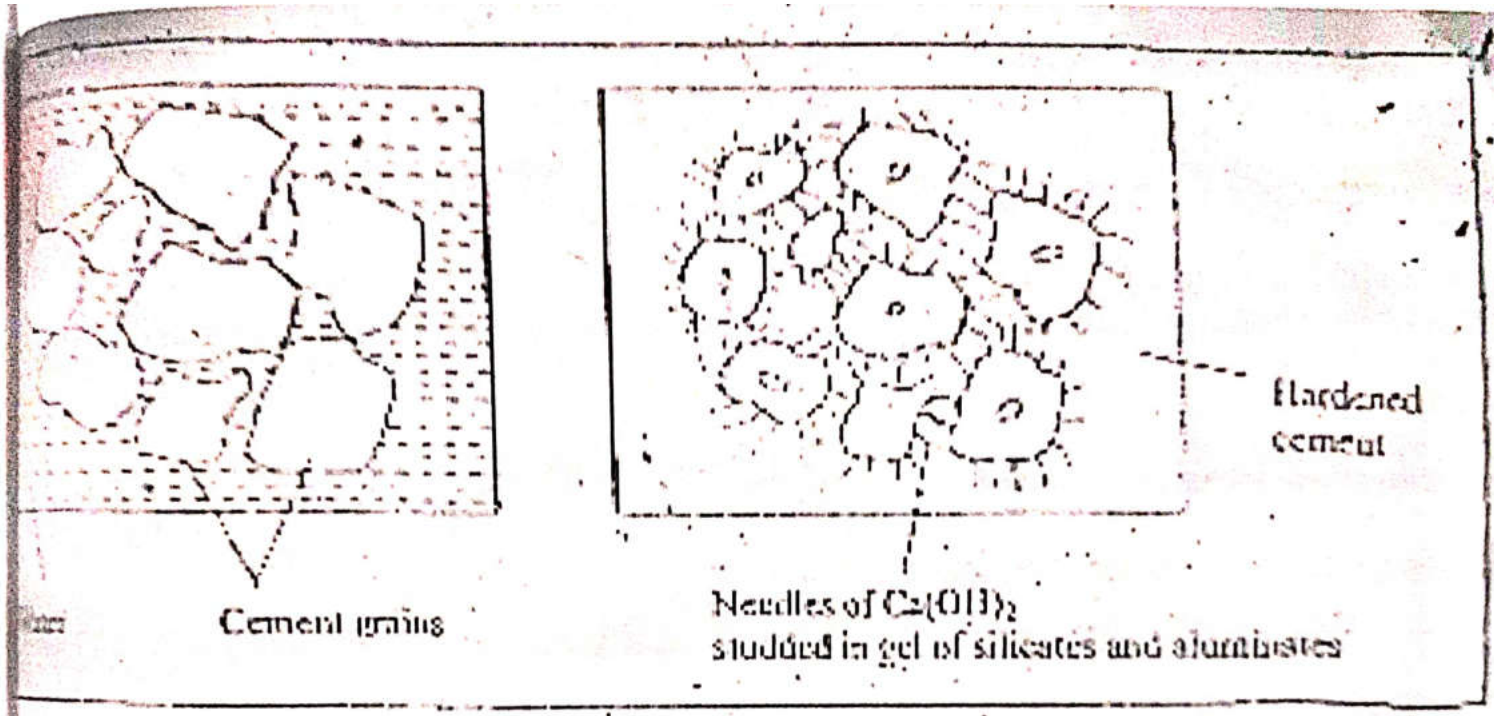


*Fig 3.9A - Physical changes occuring during setting*

## Role of water and gypsum in setting of cement

As stated in the earlier section, setting of cement involves hydration and hydrolysis reactions. This is an exothermic reaction and substantial water may undergo vaporation. So the cement should be cooled by spraying water at regular intervals. The process of maintaining necessary moisture content during the setting of cement is called curing.

Addition of about 3-5% gypsum during grinding of clinker cement helps retarding the process of cement. It is found that slower the setting process, greater is the strength of hardened Gypsum retards the setting process by removing fast setting tricalcium aluminate content of cement by forming calcium sulphoaluminate.

$$3CaO \cdot Al_2O_3 + 3CaSO_4 \cdot 2H_2O \longrightarrow 3CaO \cdot Al_2O_3 \cdot 3CaSO_4\,2H_2O$$

**ng and crushing of raw materials:** Actually the purpose of both processes is to ge the raw materials to fine powder.

| Dry process | Wet process |
|---|---|
| his process is usually used when raw aterials are very strong and hard. | ❑ This process is generally used when raw materials are soft because complete mixing is not possible unless water is added. |
| n this process, the raw materials are anged to powdered form in the absence f water. | ❑ In this process, the raw materials are changed to powdered form in the presence of water |
| ehydration zone requires a somewhat orter distance than wet process. | ❑ Dehydration zone would require up to half the length of the kiln easiest to control chemistry & better for moist raw materials |
| 4% of cement produced. | ❑ 26% of cement produced |
| ins less fuel requirements | ❑ High fuel requirements - fuel needed to evaporate 30+% slurry water- The kiln is a continuous stream process vessel in which feed and fuel are held in dynamic balance |
| n this process calcareous material such s lime stone (calcium carbonate) and yllaceous material such as clay are ound separately to fine powder in the sence of water and then are mixed gether in the desired proportions. ater is then added to it for getting thick rry and then its cakes are formed, dried d burnt in kilns. | ❑ In this process, raw materials are pulverized by using a Ball mill, which is a rotary steel cylinder with hardened steel balls. When the mill rotates, steel balls pulverize the raw materials which form slurry (liquid mixture). The slurry is then passed into storage tanks, where correct proportioning is done. Proper composition of raw materials can be ensured by using wet process than dry process. Corrected slurry is then fed into rotary kiln for burning. |

Report:-

The webinar on the topic of Manufacture of cement was conducted through zoom application was an immense pleasure to me to be a host of it.

With all the guidance and support of Dr. Ranoji shikargol and Dr. Swarupsrani Mam. I successfully completed webinar on 8th april.

The support from the participants was really good they attended the webinar with patience and we had some question answer session, It was a new experience to gain and share the knowledge through online.

Feedback on webinar:-

This new way of learning through webinar was initiated by the dept. of chemistry. I thank everyone for their support and I thank dept. of chemistry for their guidance and support which lead to increase my knowledge and confidence even in this pandemic situation.

Thank you