Al-Mansour University College

قسم الهندسة المدنية
المرحلة الثانية

Civil Eng. Dept
2nd. Stage

Concrete Technology

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تكنولوجيا الخرسانة

1

Manufacture of Portland Cement

The raw materials required for manufacture of Portland cement are:

1- calcareous materials, such as limestone or chalk

2- argillaceous material such as shale or clay

1- Grinding the raw materials
2- Mixing them intimately in certain proportions depending upon their purity and composition
3- Burning them in a kiln at a temperature of about 1300 to 1500°C,
at which temperature, the material sinters and partially fuses to form nodular shaped clinker

4- The clinker is cooled and ground to fine powder with addition of about 3 to 5% of gypsum. The product formed by using this procedure is Portland cement.

There are two processes depending upon whether the mixing and grinding of raw materials is done in wet or dry conditions. These processes are :

1- Wet process
2- Dry rocess
3-

For many years the wet process remained popular because of the possibility of more accurate control in the mixing of raw materials. The technique of intimate mixing of raw materials in powder form was not available then. Later, the dry process gained momentum with the modern development of the technique of dry mixing of powdered materials using compressed air.

The dry process requires much less fuel as the materials are already in a dry state, whereas in the wet process the slurry contains about 35 to 50 per cent water. To dry the slurry we thus require more fuel. Recently a number of factories have been commissioned to employ the dry process method.

The wet process:

1- The limestone brought from the quarries is first crushed to smaller fragments
2- Then taken to a ball or tube mill it is mixed with clay or shale as the case may be and ground to a fine consistency of slurry with the addition of water

3- The slurry is pumped to slurry tanks or basins where it is kept in an agitated condition by means of rotating arms with chains or blowing compressed air from the bottom to prevent settling of limestone and clay particles.

4- The composition of the slurry is tested to give the required chemical composition and
corrected periodically in the tube mill and also in the slurry tank by blending slurry from different storage tanks.

5- The corrected slurry is stored in the final storage tanks and kept in a homogeneous condition by the agitation of slurry.

6- The corrected slurry is sprayed on to the upper end of a rotary kiln against hot heavy hanging chains.

Rotary kiln : is an important component of a factory. It is a thick steel cylinder of diameter from 3 m to 8 m, lined with refractory materials, mounted on roller bearings and capable of rotating about its own axis at a specified speed. The length of the rotary kiln may vary from 30 m to 200 m. The kiln is fired from the lower end. The fuel is powered coal, oil or natural gas.

7- The slurry on being sprayed against a hot surface of flexible chain los .

8- By the time the material rolls down to the lower end of the rotary kiln, the dry material undergoes a series of chemical reactions until finally, in the hottest part of the kiln, where the temperature is in the order of 1500°C, about 20 to 30 per cent of the materials get fused. Lime, silica and alumina get recombined.

9- The fused mass turns into nodular form of size 3 mm to 20 mm known as clinker.

10- The clinker drops into a rotary cooler where it is cooled under controlled conditions.

11- The clinker is stored in silos or bins. The clinker weighs about 1100 to 1300 gms per litre. The liter weight of clinker indicates the quality of clinker.

12- The cooled clinker is then ground in a ball mill with the addition of 3 to 5 per cent of gypsum in order to prevent flash-setting of the cement.

Ball mill: A ball mill consists of several compartments charged with progressively smaller hardened steel balls. The particles crushed to the required fineness ar rge work sites.

**The good grading pattern of the cement particles is important for making good concrete.

The dry and semi-dry process:

1- The raw materials are crushed dry and fed in correct proportions into a grinding mill.

2- in grinding mill, they are dried and reduced to a very fine powder. The dry powder called the raw meal.

3- the raw meal is then further blended and corrected for its rig owder tends to behave almost like liquid and in about one hour of aeration a uniform mixture is obtained.

4- The blended meal is further sieved and fed into a rotating disc called granulator.

5- A quantity of water about 12 per cent by wright is added to make the blended meal into pellets.

7- pellets are done to permit air flow for exchange of heat for further chemical reaction in the rotary kiln.

Advantages of Dry process:

1- The equipment used in the dry process kiln is comparatively smaller.

2- The process is quite economical.

3- The total consumption of coal in this method is only about 100 kg when compared to the requirement of about 350 kg for producing a ton of cement in the wet process.

**** note**

The strength properties of cement are con linker.

A moderate rate of cooling of clinker in the rotary cooler will result in higher strength.

The moderate cooling it is implied:

The clinker is brought from 1200°C to 500°C in about (15 minutes)-

-Then from the 500°C the temperature to normal atmospheric temperature in about (10 minutes)

The rate of cooling influences

*The degree of crystallization

*The size of the crystal

*The amount of amorphous materials present in the clinker

*** T al for similar chemical composition will be different from the one which is crystallined.

Chemical Composition:

**The raw materials used for the manufacture of cement consist mainly of:

1-Lime- CaO

2-Silica- $Si0_2$

3-Alumina- Al_20_3

4-

1- influencing the various properties of cement
2- the rate of cooling
3- fineness of grinding

Specifies the following chemical requirements:

(a) Ratio of percentage of lime to percentage of silica, alumina and iron oxide; known as Lime Saturation Factor, when calculated by the formula

$$LSF=CaO/(\quad + 1.2Al2O3 + 0.65Fe2O3)$$

Not greater than 1.02 and not less than 0.66

(b) Ratio of percentage of   to that of iron oxide
(c) Weight of insoluble residue
(d) Weight of magnesia
(e) Total sulphur content
(f) Total loss on ignition

The oxide shown within the brackets represents the percentage of the same in the raw materials.

Hydration of Cement

The chemical reactions that take place between cement and water is referred as hydration of cement

1- Anhydrous cement does not bind fine and coarse aggregate. It acqu1res adhesive property only when mixed with water.
2- The chemistry of concrete is essentially the chemistry of the reaction between cement and water
3- The products of hydration are important because they have cementing or adhesive value.
4- The quality, quantity, continuity, stability and the rate of formation of the hydration products are important

*** Anhydrous cement compounds when mixed with water react with each other to form hydrated compounds of very low solubility.

The hydration of cement can be visualised in two ways:-

1- Through solution: in this way, the cement compounds dissolve to produce a supersaturated solution from which different hydrated products get precipitated
2- Solid state: - is that water attacks cement compounds in the solid state converting the compounds into hydrated products starting from the surface and proceeding to the interior of the compounds with time.

**** It is probable that both "through solution" and "solid state" types of mechanism may occur during the course of reactions between cement and water

**** The former mechanism may predominate in the early stages of hydration in view of large quantities of water being available, and the latter mechanism may operate during the later stages of hydration.

Heat of Hydration:

The reaction of cement with water is exothermic. The reaction liberates a considerable quantity of heat. This liberation of heat is called heat of hydration.

** This is clearly seen if freshly mixed cement is put in a vaccum flask and the temperature of the mass is read at intervals.

The study and control of the heat of hydration becomes important in:

1- The construction of concrete dams
2- The mass concrete constructions.

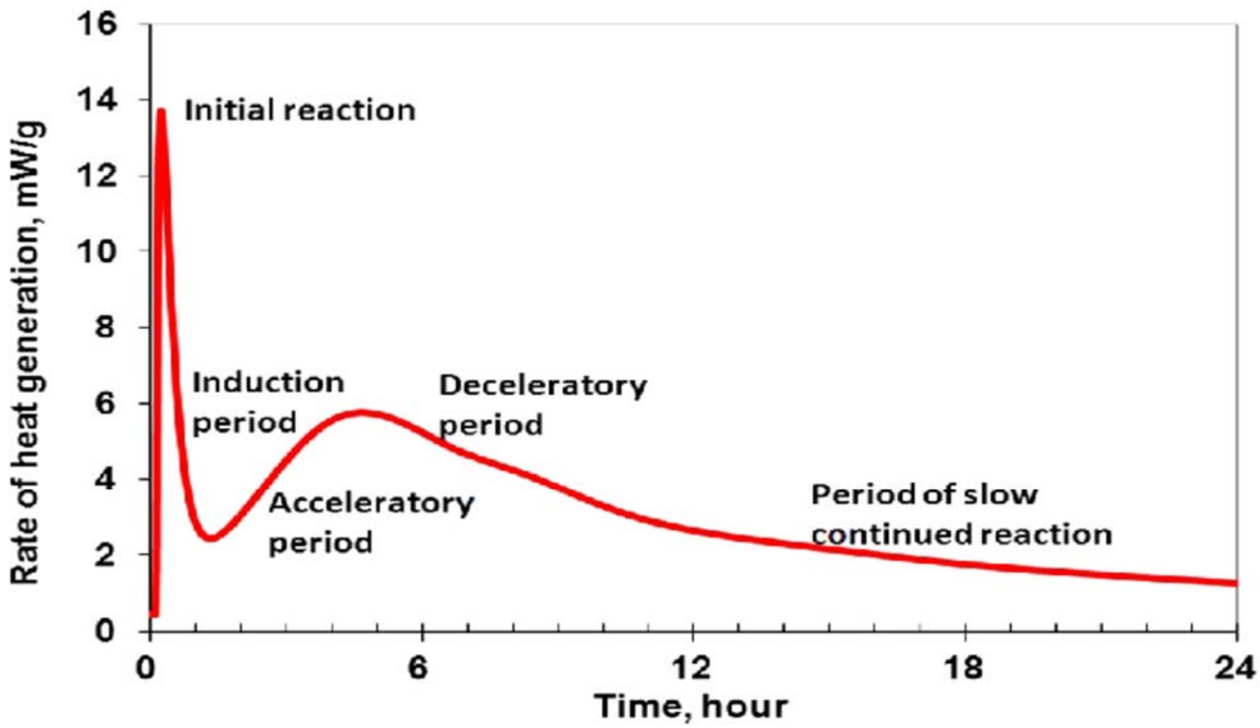
** It has been observed that the temperature in the interior of large mass concrete is SOOC above the original temperature of the concrete mass at the time of placing and this high temperature is found to persist for a prolonged period.

** The Figure shows the pattern of liberation of heat from setting cement and during early hardening period. On mixing cement with water, a rapid heat evolution, lasting a few minutes, occurs.

--This heat evolution is probably due to the reaction of solution of aluminates and sulphates (ascending peak A).

--This initial heat evolution ceases quickly when the solubility of aluminate is depressed by gypsum. (descending peak A).

-- Next heat evolution is on account of formation of ettringite and also may be due to the reaction of C_3S (ascending peak B).



- Since retarders are added to control the flash setting properties of C_3A,
- Actually the early heat of hydration is mainly contributed from the hydration of c3s.
- Fineness of cement also influences the rate of development of heat but not the total heat.
- The total quantity of heat generated in the complete hydration will depend upon the relative quantities of the major compounds present in cement.

Verbec and Foster analysis of heat of hydration data of large number of cements and computed heat evolution of four major compounds of cement, Table below shows the heats of hydration of four compounds.

Table: Heat of Hydration

Heat of Hydration at the given age (cal/g)			Compound
13 years	90days	3 days	
122	104	58	c3s
59	42	12	c2s
324	311	212	C3A
102	98	69	C_4AF