Engineering Material
Cement and Lime

By

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CHAPTER 1

INTRODUCTION

Definition: “Cement is a crystalline compound of calcium silicates and other calcium compounds having hydraulic properties” (Macfadyen, 2006). Lime and clay have been used as cementing material on constructions through many centuries.

Romans are commonly given the credit for the development of hydraulic cement, the most significant incorporation of the Roman’s was the use of pozzolan-lime cement by mixing volcanic ash from the Mt. Vesuvius with lime. Best know surviving example is the Pantheon in Rome ,In 1824 Joseph Aspdin from England invented the Portland cement

The early days:

– Setting stone blocks without cementing them

– Mud mixed with straw is the oldest cementing material used to bind dried bricks

Non-hydraulic cements Gypsum and lime

Cements based on compounds of lime (calcareous cements)

Gypsum(Calcining impure gypsum at 130°C)

Add water calcined gypsum and water recombine

Cannot harden under water because gypsum is quite soluble.

CHAPTER TWO

Types of Cement

Cement is a binding material which makes a bond between aggregates and reinforcing materials together. With the development of technology, quality and types of cement have also developed. So there are different types of cement for different construction works.

Cement is mainly classified into two categories depending on the hardening and setting mechanism. These are-

١. Hydraulic Cement
٢. Non-hydraulic Cement

Along with these main types, depending on the composition and characteristics there are many types of cement.

Hydraulic Cement

As the name indicates, hydraulic cement is those which harden by hydration in the presence of water. Limestone, clay, and gypsum are the main raw material to produce non-hydraulic cement. This raw material is burned at a very high temperature to manufacture Hydraulic Cement.

Hydraulic cement (cement that not only hardens by reacting with water but also forms a water-resistant product) produced by pulverizing clinkers which consist essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulfate as an inter ground addition.

Non-Hydraulic Cement

The non-hydraulic cement doesn't require water to get harden. It gets with the help of carbon dioxide (CO_2) from the air. This type of cement needs dry conditions to harden. Lime, gypsum plasters, and oxychloride are the required raw material to produce non-hydraulic cement. Example: slaked lime is a non-hydraulic cement.

Ordinary Portland Cement (OPC)

In usual construction work, Ordinary Portland Cement is widely used.

Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates, (3 $CaO \cdot SiO_2$, and 2 $CaO \cdot SiO_2$), the remainder consisting of aluminium- and iron-containing clinker phases and other compounds. The ratio of CaO to SiO_2 shall not be less than 2.0. The magnesium oxide content (MgO) shall not exceed 5.0% by mass.

European Standard EN 197-1

The composition of Ordinary Portland Cement:

- Argillaceous or silicates of alumina (clay and shale)
- Calcareous or calcium carbonate (limestone, chalk, and marl)

Uses of Ordinary Portland Cement

- It is used for general construction purposes.
- It is also used in most of the masonry works.

Portland Pozzolana Cement (PPC)

Pozzolans are natural or synthetic materials that contain silica in reactive forms. It reacts with calcium hydroxide generated by hydrating cement to form additional cementations materials when it is finely divided. The composition of Portland Pozzolana Cement:

- OPC clinker
- Gypsum

- Pozzolanic Materials (Fly ash, volcanic ash, and Calcined clay or silica fumes.)

Uses of Portland Pozzolana Cement

- PPC is usually used in hydraulic structures, marine structures, construction near the seashore, dam construction, etc.
- It is also used in pre-stressed and post-tensioned concrete members.
- As it gives a better surface finish, it is used in decorative and art structures.
- It is also used in the manufacture of precast sewage pipes.

Rapid Hardening Cement

When finely grounded Tri-calcium silicate (C3S) is present in OPC with higher content, it gains strength more quickly than OPC. This type of OPC is called Rapid Hardening Cement. It's initial Setting Time 30 minutes and Final Setting Time 600 minutes.

Uses of Rapid Hardening Cement

- Rapid hardening cement is mostly used where rapid construction is needed like the construction of pavement.
- It also gives high strength.

- Rapid Hardening Cement - All You Need to Know
- Uses of Rapid Hardening Cement
- Advantages & Disadvantages of Rapid Hardening Cement

Quick Setting Cement

Quick setting cement is the cement which sets in a very short time. The initial setting time is 5 minutes and the final setting time is 30 minutes. The composition of Quick Setting Cement:

- Clinker
- Aluminum sulfate (1% to 3% by weight of clinker)
- The aluminum sulfate increases the hydration rate of silicate.

Uses of Quick Setting Cement

- It is used in underwater construction.
- It is also used in rainy & cold weather conditions.
- It is used a higher temperature where water evaporates easily.
- Used for anchoring or rock bolt mining and tunneling

Low Heat Cement

It is a spatial type of cement which produces low heat of hydration during the setting. Some chemical composition of Ordinary Portland Cement is modified to reduce the heat of hydration. The chemical composition of low heat cement:

- A low percentage (5%) of tricalcium aluminate (C3A)
- A higher percentage (46%) of declaiming silicate (C2S).

Uses of Low Heat Cement

- It is used for the construction of dam's large footing, large raft slabs, and wind turbine plinths.
- It is also used for the construction of chemical plants.

Sulphate Resisting Cement

Sulfate resisting cement is used to resist sulfate attacks in concrete. Due to the lower percentage of Tricalcium aluminate, the production of calcium sulpho-aluminates gets reduced.

Uses of Sulphates resisting Cement

- Construction in contact with soils or groundwater having more than 0.2% or 0.3 % g/l sulfate salts respectively.
- Concrete surfaces subjected to alternate wetting and drying such as bridge piers, concrete surface in the tidal zone, apron, Building near the seacoast.
- Effluent treatment plans, Chimney, Chemical industries, water storage, sumps, drainage works, Cooling towers, Coastal protective works such as sea walls, breakwaters, tetrapods, etc.

Blast Furnace Cement

Portland cement clinker and granulated blast furnace slag are intergraded to make blast furnace cement. A maximum of 65 percent of the mixture could be comprised of blast furnace slag.

Uses of Blast Furnace Cement

- It is highly sulfate resistant
- Frequently used in seawater construction.

High Alumina Cement

High Alumina cement is obtained by mixing calcining bauxite (it’s an aluminum ore) and ordinary lime with clinker during the manufacture of OPC. In which the total amount of alumina content should not be lesser than 32% and it should maintain the ratio by weight of alumina to the lime between 0.85 to 1.30.

Uses of High Alumina Cement

- It is used where concrete structures are subjected to high temperatures like workshops, refractory, foundries, etc.
- It also used where the concrete is subjected to frost and acidic action.

White Cement

White cement is quite similar to Ordinary Portland Cement except for color. Amounts of iron oxide and manganese oxide are low in White Cement. It is expensive then OPC so not economical for ordinary work.

Uses of White Cement

- It is usually used in decorative work.
- It can also use for traffic barriers, tile grouts, swimming pools, roof tiles patching materials, and terrazzo surfaces.

Read More about White Cement:

- What is White Portland Cement?
- Uses of White Portland Cement

Colored Cement

To make 5 to 10 percent of suitable pigments are ground with OPC. Types of pigments are selected according to the desired color.

Uses of Colored Cement

- Colored cement is used for different decorative work.

Air Entraining Cement

It is seen that entrainment of air or formation of gas bubbles while applying cement increases resistance to frost action, fire, scaling, and other similar defects. Air-entraining cement is a special type of cement which entrains tinny air bubbles in concrete.

. It is produced by grinding minute air entertaining materials with clinker by adding some resinous materials e.g. vinsol resin to ordinary portland cement.

When the water in concrete gets frizzed due to low temperature, it expands. When air-entraining cement, the air voids in concrete provides space for water to expand without cracking concrete. But this type of cement does not provide high strength in concrete.

Uses of Air-Entraining Cement

- Especially it is used in areas where the temperature is very low.
- It also resists the Sulphet attack.
- It is used where the de-icing chemical is used

Expansive Cement

In the hydration process, the expansive cement expands its volume. It can be possible to overcome shrinkage loss by using expansive cement.

There are three types of expansive cement:

١. K Type expansive cement
٢. M Type expansive cement
٣. S Type expansive cement

K Type expansive cement

Raw materials of these types of cement

- Portland cement
- Anhydrous tetracalcium trialuminate sulfate (C_4A_3S)
- Calcium sulfate ($CaSO_4$)
-
- Lime (CaO).

M Type Expansive Cement

Raw materials of these types of cement

١. Portland cement clinkers
٢. Calcium sulfate.

S Type Expansive Cement

Raw materials of these types of cement

١. Portland cement clinkers
٢. Calcium sulfate (High amount)

- Tricalcium aluminate (C3A) (High amount)

Uses of Expansive cement

- It is used in the construction of the pre-stressed concrete component.
- It is also used for sealing joints and grouting anchor bolt.
- In the construction of different hydraulic structures, this type of cement is used.

Hydrophobic Cement

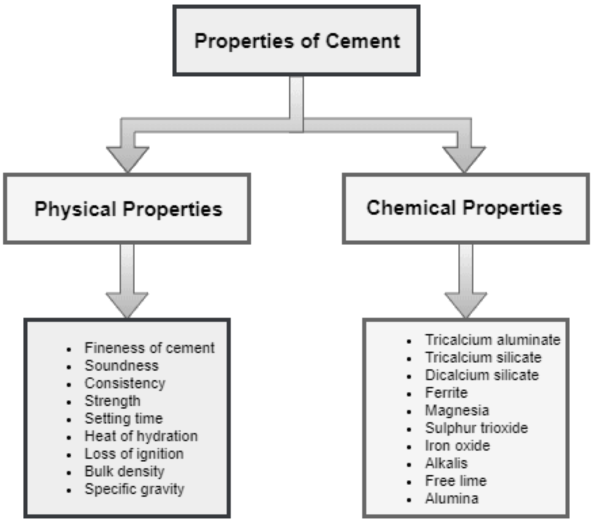
To resist the hydration process in the transportation or storage stage, clinkers are ground with water repellent film substance such as Oleic Acid or Stearic Acid. These chemicals form a layer on the cement particle and do not allow water to mix and start the hydration process. When cement and aggregate are thoroughly mixed in the mixer, protective layers break and start normal hydration with some air-entrainment which increases workability.

Uses of Hydrophobic Cement

- Usually, it is used in the construction of water structures such as dams, spillways, or other submerged structures.
- It is also used in the construction of underground structures like tunnel etc.

CHAPTER 3

Cement, a popular binding material, is a very important civil engineering material. This article concerns the physical and chemical properties of cement, as well as the methods to test cement properties.



What is the chemistry of cement?

The most important compounds present in cement are: **3CaO·Al2O3, tricalcium aluminate; 3CaO·SiO3, tricalcium silicate; 2CaO·SiO3, dicalcium silicate; and CaO, calcium oxide**. The 2CaO·SiO3 reacts slowly with water to yield Ca(OH)2 and H2SiO3.

Chemical Properties of Cement

The raw materials for cement production are limestone (calcium), sand or clay (silicon), bauxite (aluminum) and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate. Chemical analysis of cement raw materials provides insight into the chemical properties of cement.

١. **Tricalcium aluminate (C3A)**
Low content of C3A makes the cement sulfate-resistant. Gypsum reduces the hydration of C_3A, which liberates a lot of heat in the early stages of hydration. C3A does not provide any more than a little amount of strength.
Type I cement: contains up to 3.5% SO_3 (in cement having more than 8% C_3A)
Type II cement: contains up to 3% SO_3 (in cement having less than 8% C_3A)

٢. **Tricalcium silicate (C_3S)**
C3S causes rapid hydration as well as hardening and is responsible for the cement’s early strength gain an initial setting.

٣. **Dicalcium silicate (C_2S)**
As opposed to tricalcium silicate, which helps early strength gain, dicalcium silicate in cement helps the strength gain after one week.

٤. **Ferrite (C_4AF)**
Ferrite is a fluxing agent. It reduces the melting temperature of the raw materials in the kiln from 3,000°F to 2,600°F. Though it hydrates rapidly, it does not contribute much to the strength of the cement.

٥. **Magnesia (MgO)**
The manufacturing process of Portland cement uses magnesia as a raw material in dry process plants. An excess amount of magnesia may make the cement unsound and expansive, but a little amount of it can add strength to the cement. Production of MgO-based cement also causes less CO2 emission. All cement is limited to a content of 6% MgO.

٦. **Sulphur trioxide**
Sulfur trioxide in excess amount can make cement unsound.

٧. **Iron oxide/ Ferric oxide**
Aside from adding strength and hardness, iron oxide or ferric oxide is mainly responsible for the color of the cement.

٨. **Alkalis**

The amounts of potassium oxide (K_2O) and sodium oxide (Na_2O) determine the alkali content of the cement. Cement containing large amounts of alkali can cause some difficulty in regulating the setting time of cement. Low alkali cement, when used with calcium chloride in concrete, can cause discoloration. In slag-lime cement, ground granulated blast furnace slag is not hydraulic on its own but is "activated" by addition of alkalis. There is an optional limit in total alkali content of 0.60%, calculated by the equation $Na_2O + 0.658\ K_2O$.

٩. **Free lime**

Free lime, which is sometimes present in cement, may cause expansion.

١٠. **Silica fumes**

Silica fume is added to cement concrete in order to improve a variety of properties, especially compressive strength, abrasion resistance and bond strength. Though setting time is prolonged by the addition of silica fume, it can grant exceptionally high strength. Hence, Portland cement containing 5-20% silica fume is usually produced for Portland cement projects that require high strength.

١١. **Alumina**

Cement containing high alumina has the ability to withstand frigid temperatures since alumina is chemical-resistant. It also quickens the setting but weakens the cement.

Physical Properties of Cement

Different blends of cement used in construction are characterized by their physical properties. Some key parameters control the quality of cement. The physical properties of good cement are based on:

- Fineness of cement
- Soundness
- Consistency
- Strength
- Setting time
- Heat of hydration
- Loss of ignition
- Bulk density
- Specific gravity (Relative density)

These physical properties are discussed in details in the following segment. Also, you will find the test names associated with these physical properties.

Fineness of Cement

The size of the particles of the cement is its fineness. The required fineness of good cement is achieved through grinding the clinker in the last step of cement production process. As hydration rate of cement is directly related to the cement particle size, fineness of cement is very important.

Soundness of Cement

Soundness refers to the ability of cement to not shrink upon hardening. Good quality cement retains its volume after setting without delayed expansion, which is caused by excessive free lime and magnesia.

CHAPTER 4

Uses

Main use is in the fabrication of concrete and mortars

Modern uses

Building (floors, beams, columns, roofing, piles, bricks, mortar, panels, plaster)

Transport (roads, pathways, crossings, bridges, viaducts, tunnels, parking, etc.)

Water (pipes, drains, canals, dams, tanks, pools, etc.)

Civil (piers, docks, retaining walls, silos, warehousing, poles, pylons, fencing)

Agriculture (buildings, processing, housing, irrigation)

How is cement manufacture?

Cement manufacturing is a complex process that begins with mining and then grinding raw materials that include limestone and clay, to a fine powder, called raw meal, which is then heated to a sintering temperature as high as 1450 °C in a cement kiln

Manufacturing Of Cement. by any one of the two methods : (i) Dry process, and (ii) Wet process. In both these processes the three distinct operations of (a) Mixing, Ball mill (b) Burning, Rotary kiln and (c) Grinding are carried out.

١. **Dry process.** In this process lime stone and clay are ground separately to tine powders and are then mixed together in the desired proportions. Water is then added to it so as to get a thick paste of which cakes are then made, dried and burnt in kilns. To the clinker obtained after burning, is added three to four per cent of gypsum and ground to very fine powder. This powder is cement ready for use.

This process is slow and costly. Also it is difficult to have the correct proportion of constituents and to do so is a cumbersome operation. The quality of cement is not so good as that of the one manufactured by the Wet process. this method has, therefore, become obsolete and the Wet process of manufacturing cement, described in details below, is widely used. Or we can describe the prosses by : from the quarry we bring the material (limestone +clay) to the crusher after that for transporting the material we have these machines {shovels , bulldozers, dump track , excavators } then the crusher double shaft the hummers ,the material put in to the hoopers of line and clay ,the capacity of crusher is ١٢٠٠ to ١٦٠٠ tones/hour ,in the crusher we have ٩٠ hummers each ٧٠kg weight ,they are divided on two rooters each ٤٥ hummers which are rotating by (motors +fly wheels +V-belts) after that we have (anvil + great bars) under this we have two scrappers of clay and lime which working by motors and gear box . under the crusher we have belt conveyor to transport the material to the mixing bed, to storage the material using the stacker by chevron method . the stacker is operating by motor and gear box , for every belt conveyor there is rollers plus drums ,motor and gear box .after the stacker we have rake and scrapper to put the material on the flaps under the mixing bed ,then transported by belt conveyor to hoppers of lime and raw mixture ,before the mixing bed we have sampling station to take a sample for checking .

Raw mill : the mill is vertical type it contain two rollers each ٥٧ tones weight , the tray of the mill is rotating by motor and gear box to grind the material under the pressure of weight of the rollers , then the material transport by air pole and then to the preheater before entering the kiln . we have the mill fan sectioning the hot gas from the kiln also dipole fan pushing the hot gas and the dust of the kiln the burner of the kiln is heated by pilard system .and its heating the boiler by the fuel coming from fuel station by the pump . its diameter (kiln) ٤,٢ m , the length is ١٠٠ m , and lastly the temp is ١٢٠٠ Celsius .

Gypsum storage:

From this storge the gypsum is transport to cement mills and mixing by ٪٥ with klinker .

Cement mill capacity is ٨٠ tone per hour diameter ٤,٢ m ,the mill has two chamber : in the first chamber there is large steel balls in the second there is smaller once , and it has two neck bearing rotating by high tension motors , gear box and coupling connected to the mill .

The bearing are lubricated by { high and low } presser pump that's cooled by water and finally the cement is transported to the silos and then to the packing plant . its important to mention that we have

١- Water station
٢- Fuel station
٣- Compressor and blower station

The departments

١- Mechanical department
٢- Electrical department
٣- Instrument department
٤- Maintenance planning department
٥- Store department
٦- Garage department
٧- CCR {central control room}
٨- Control room for operating the crusher
٩- Control room for packing plant
١٠- Firefighting department

١١- Administration department

٢. Wet process.

(i) Mixing. The crushed raw materials in desired proportions are fed into ball mills (Fig. ٥,١). A little water to is added to it. Ball mill is a rotating steel cylinder in which there are hardened steel balls. When the mill rotates, the steel balls pulverise the raw materials which forms into a solution with water. This liquid mixture is known as slurry. This slurry is then passed into storage tanks known as silos where their proportioning is finally adjusted to ensure the correct chemical composition. Composition of raw mix can be controlled better by the wet process than in dry process. Corrected slurry is then fed into the rotary kiln for burning.

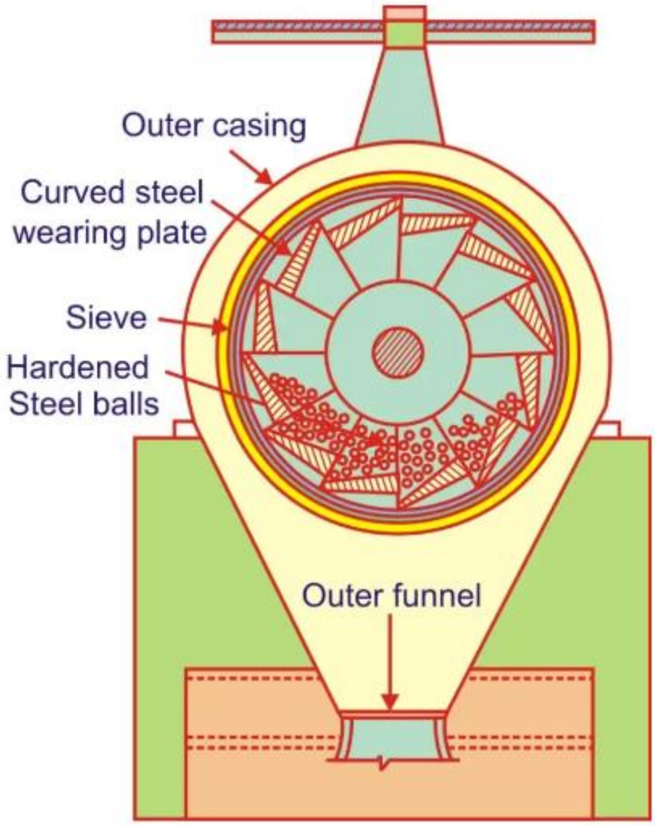


FIG. 5.1. Cross-section of a Ball Mill.

cross section of a ball mill

(ii) *Burning.* Corrected slurry is fed at the higher end of the inclined rotary kiln (Fig. ٥,٢) whereas from the lower end of the kiln flame is produced by injecting pulverized coal with a blast of air. Rotary kiln is a steel tube lined inside with free bricks. It is ٩٠ to ١٢٠ metres long and from ٢,٥ to ٣,٥ meters in diameter. The kiln is mounted on rollers at a gradient of ١ in ٢٥ to ١ in ٣٠ and rotating once in every minute.

Slurry on entering the furnace losses moisture and forms into small lumps or “nodules”. The nodules gradually roll down passing through zones of rising temperature until they reach burning zone where they are finally burnt at ١٥٠٠ to ١٦٥٠ºC. At this temperature “nodules” change to clinkers. Clinkers are air-cooled in another inclined tube similar to the kiln but of lesser length.

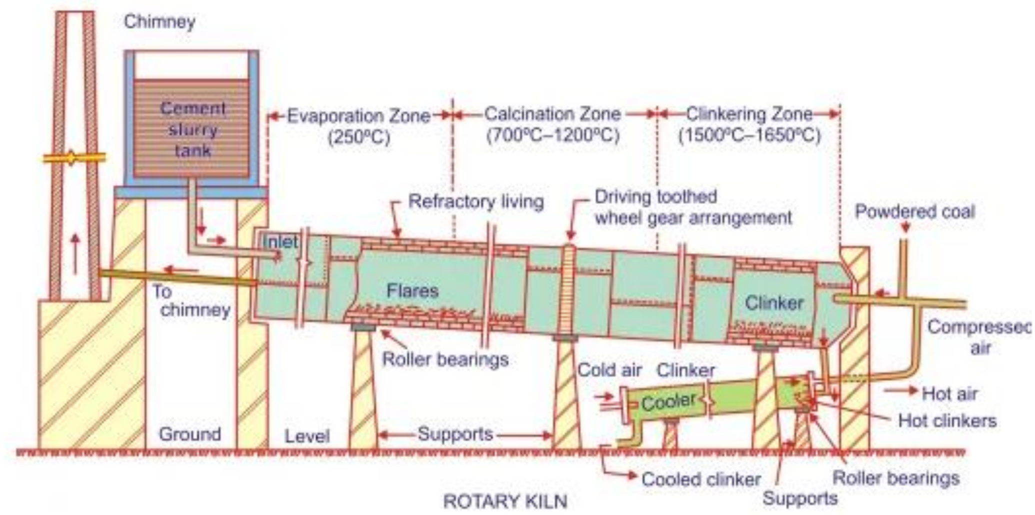


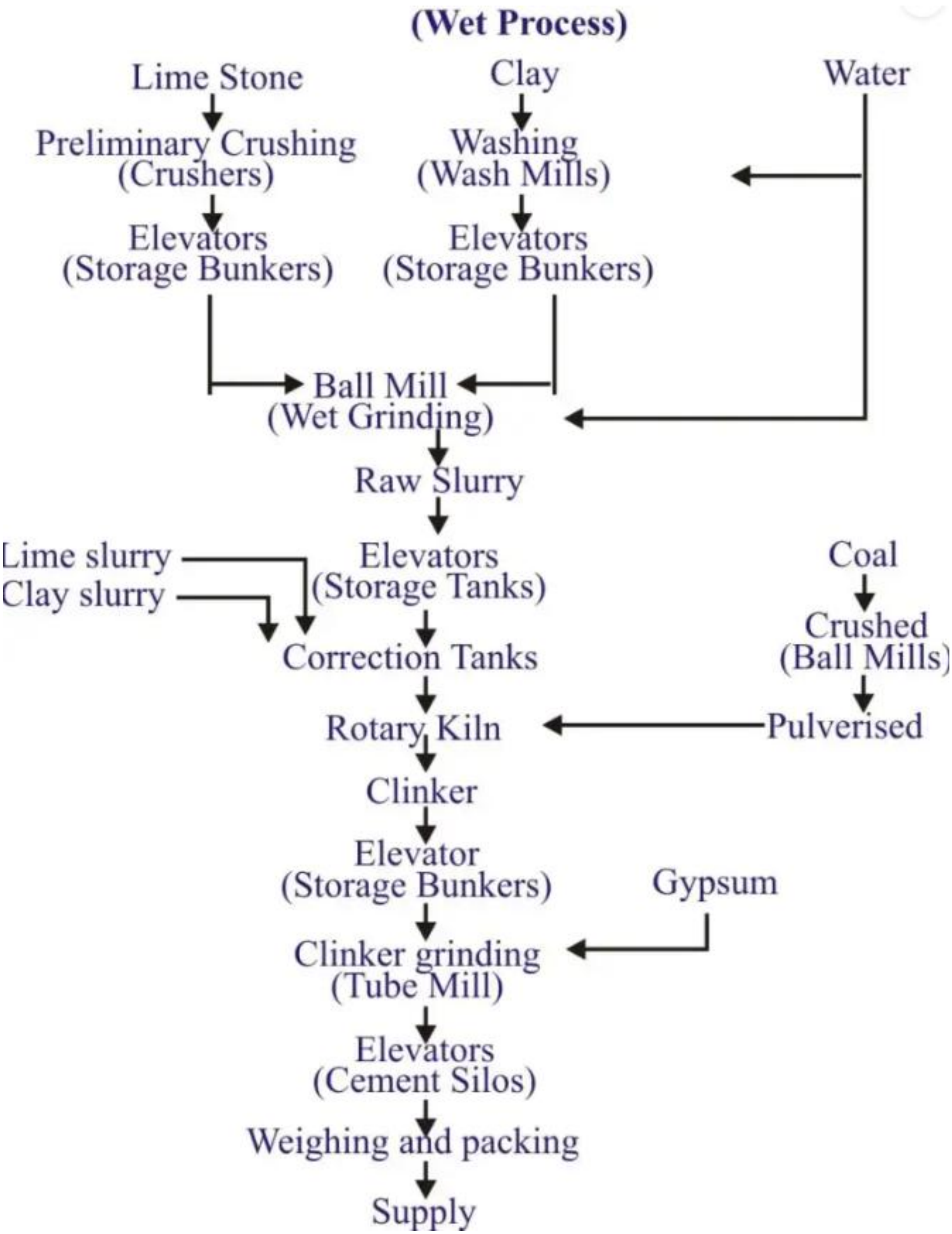
FIG. 5.2. Rotary Kiln.

Rotary kiln

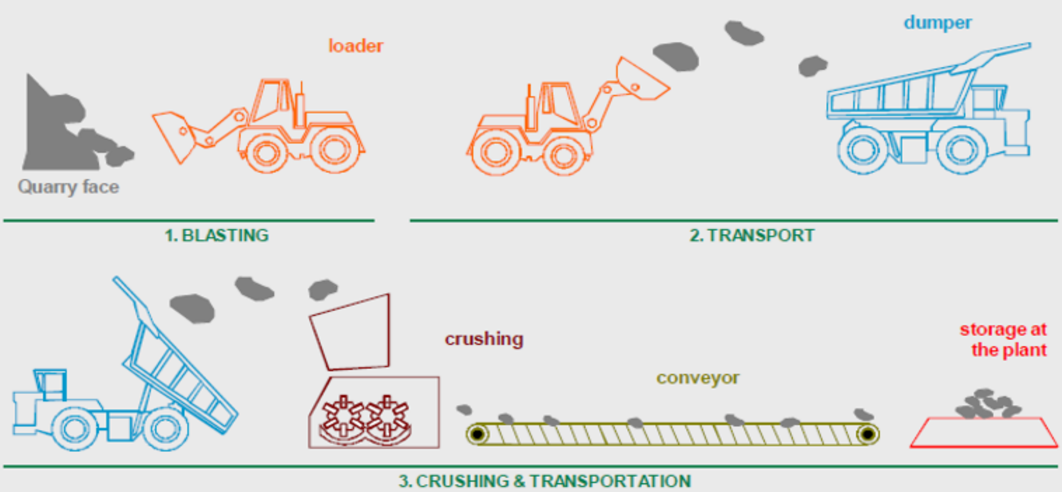
(iii) Grinding. Grinding of the clinker is done in large tube mills which are kept cool by spraying water on them from outside. While grinding the clinker three to four per cent gypsum (Calcium sulphate) is added so as to control the setting time of cement. Finely ground cement is stored in silos from where it is drawn for packing.

So we can say that the material will brought to the crusher by tracks from the quarry , then putting the material by feeders which is working by motor and gear box to the jaw crusher which is working by [motor + fly wheel by v-belts].

Then to material storage then to the mill mixing with water after that it is brought to the mixer then to the kiln then to the cooler.


(Wet Process)
Lime Stone
Clay
Water
Preliminary Crushing
(Crushers)
Washing
(Wash Mills)
Elevators
(Storage Bunkers)
Elevators
(Storage Bunkers)
Ball Mill
(Wet Grinding)
Raw Slurry
Lime slurry
Clay slurry
Elevators
(Storage Tanks)
Coal
Crushed
(Ball Mills)
Correction Tanks
Rotary Kiln
Pulverised
Clinker
Elevator
(Storage Bunkers)
Gypsum
Clinker grinding
(Tube Mill)
Elevators
(Cement Silos)
Weighing and packing
Supply

quarry

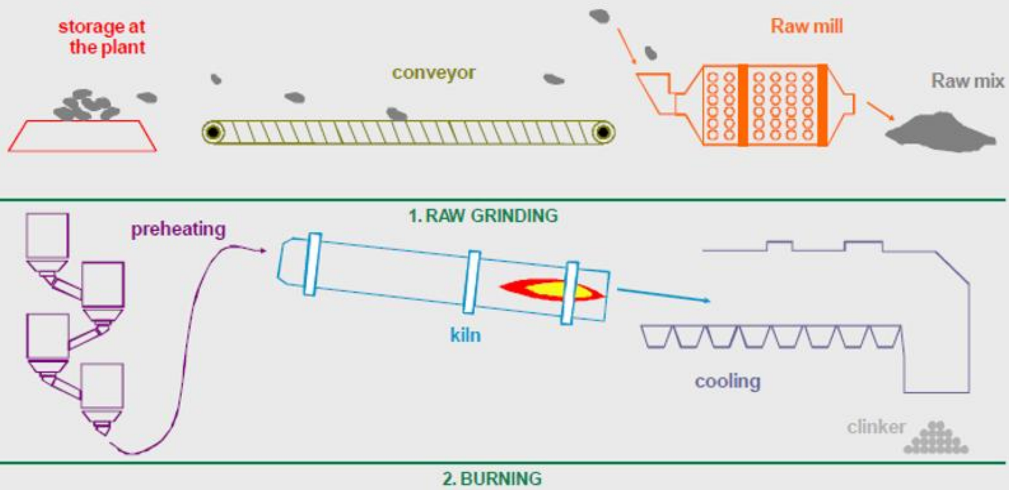


1. BLASTING : The raw materials that are used to manufacture cement (mainly limestone and clay) are blasted from the quarry.

2. TRANSPORT : The raw materials are loaded into a dumper.

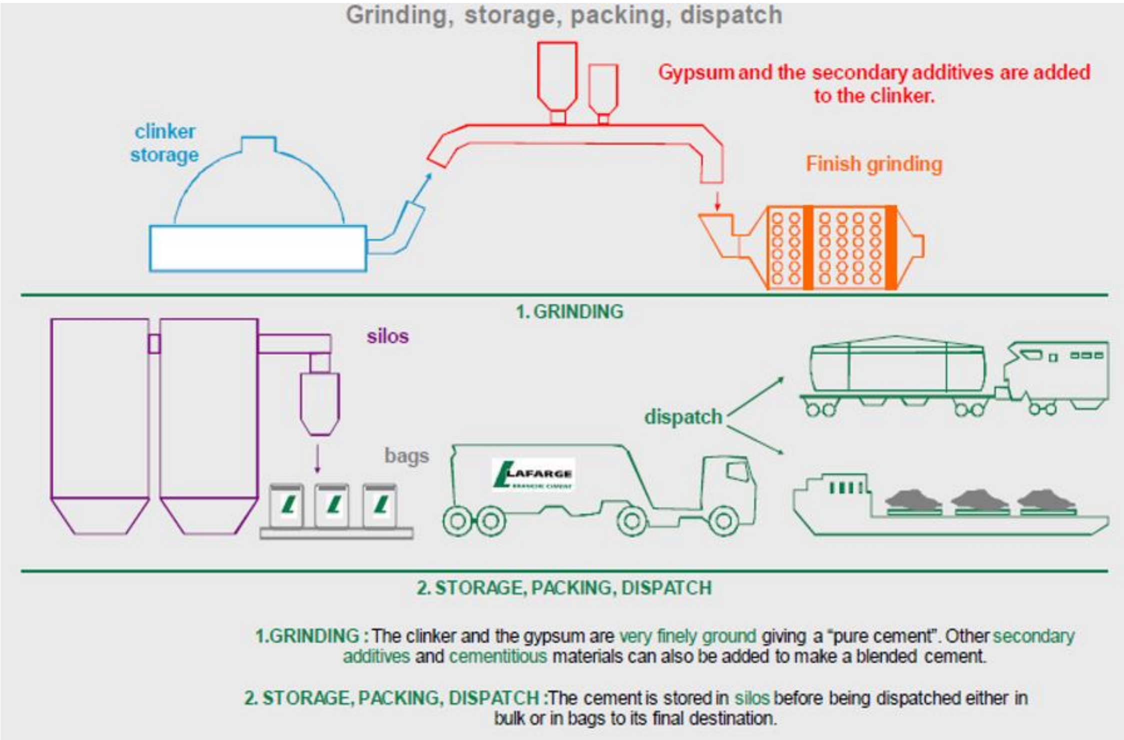
3. CRUSHING AND TRANSPORTATION : The raw materials, after crushing, are transported to the plant by conveyor. The plant stores the materials before they are homogenized.

Raw grinding and burning



1. RAW GRINDING : The raw materials are very finely ground in order to produce the raw mix.

2. BURNING : The raw mix is preheated before it goes into the kiln, which is heated by a flame that can be as hot as 2000 ° C. The raw mix burns at 1500 ° C producing clinker which, when it leaves the kiln, is rapidly cooled with air fans. So, the raw mix is burnt to produce clinker : the basic material needed to make cement.


Grinding, storage, packing, dispatch
Gypsum and the secondary additives are added to the clinker.
clinker storage
Finish grinding
1. GRINDING
silos
dispatch
bags
LAFARGE
2. STORAGE, PACKING, DISPATCH
1.GRINDING : The clinker and the gypsum are very finely ground giving a "pure cement". Other secondary additives and cementitious materials can also be added to make a blended cement.
2. STORAGE, PACKING, DISPATCH :The cement is stored in silos before being dispatched either in bulk or in bags to its final destination.

CHAPTER 5

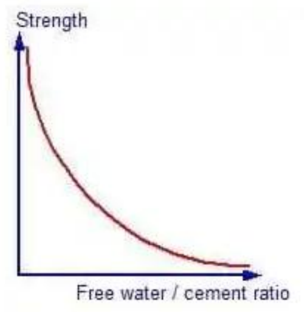
Leaching of metals from cement under various environmental conditions was measured to evaluate their environmental safety. A cement product containing clinker, which was produced from cement kiln co-processing of hazardous wastes, was solidified and leaching of metals was characterized using the 8-period test. Concentrations and speciation of metals in cements were determined. Effects of ambient environment and particle size on leachability of metals and mineralogical phases of cement mortars were evaluated by use of XRD and SEM. Results indicated that metals in cements were leachable in various media in descending order of: sea water, groundwater and acid rain. Cr, Ni, As, Co and V were leached by simulated sea water, while Cu, Cd, Pb, Zn, Mn, Sb and Tl were not leached in simulated sea water, groundwater or acid rain. When exposed to simulated acid rain or groundwater, amounts of Cr, Ni, As and V leached was inversely proportional to particle size of cement mortar. According to the one-dimensional diffusion equation, Cr was most leachable and the cumulative leached mass was predicted to be 9.6 mg kg^{-1} after 20 years. Results of this study are useful in predicting releases of metals from cement products containing ash and clinkers cement kiln co-processing of hazardous wastes, so that they can be safely applied in the environment.

CHAPTER 6

Concrete strength is affected by many factors, such as quality of raw materials, water/cement ratio, coarse/fine aggregate ratio, age of concrete, compaction of concrete, temperature, relative humidity and curing of concrete.

Quality of Raw Materials
Cement: Provided the cement conforms with the appropriate standard and it has been stored correctly (i.e. in dry conditions), it should be suitable for use in concrete. Aggregates: Quality of aggregates, its size, shape, texture, strength etc determines the strength of concrete. The presence of salts (chlorides and sulphates), silt and clay also reduces the strength of
concrete. Water: frequently the quality of the water is covered by a clause stating "..the water should be fit for drinking..". This criterion though is not absolute and reference should be made to respective codes for testing of water construction purpose.

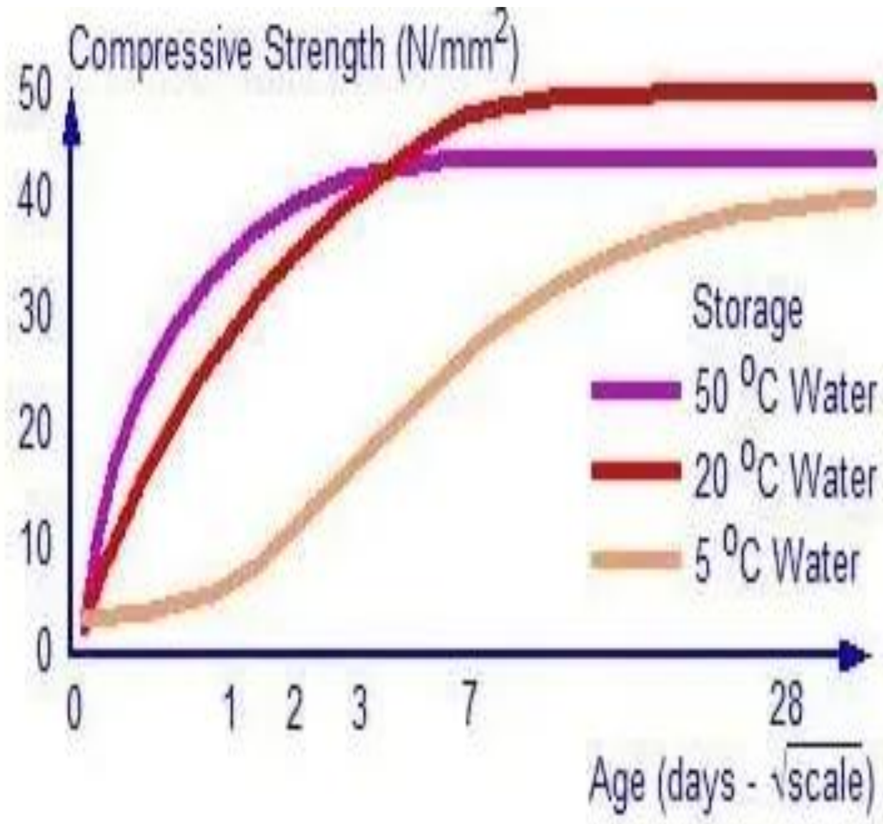
Water / Cement Ratio
The relation between water cement ratio and strength of concrete is shown in the plot as shown below



The higher the water/cement ratio, the greater the initial spacing between the cement grains and the greater the volume of residual voids not filled by hydration products. There is one thing missing on the graph. For a given cement content, the workability of the concrete is reduced if the water/cement ratio is reduced. A lower water cement ratio means less water, or more cement and lower workability. However if the workability becomes too low the concrete becomes difficult to compact and the strength reduces. For a given set of materials and environment conditions, the strength at any age depends only on the water-cement ratio, providing full compaction can be achieved.

Age of concrete
The degree of hydration is synonymous with the age of concrete provided the concrete has not been allowed to dry out or the temperature is too low. In theory, provided the concrete is not allowed to dry out, then it wil always be increasing albeit at an ever reducing rate. For convenience and for most practical applications, it is generally accepted that the majority of the strength has been achieved by 28 days.

Temperature
The rate of hydration reaction is temperature dependent. If the temperature increases the reaction also increases. This means that the concrete kept at higher temperature will gain strength more quickly than a similar concrete kept at a lower temperature. However, the final strength of the concrete kept at the higher temperature will be lower. This is because the physical form of the hardened cement paste is less well structured and more porous when hydration proceeds at faster rate. This is an important point to remember because temperature has a similar but more pronounced detrimental effect on permeability of the concrete.


Compressive Strength (N/mm²)
50
40
30
20
10
0
Storage
50 °C Water
20 °C Water
5 °C Water
0
1
2
3
7
28
Age (days - √scale)

CHAPTER 7

How should cement be stored?

Storing cement

- Refrain from storing it in damp, moist environments. Instead, store them in a dry, enclosed area which is protected from rain.
- Stacking cement bags should be covered with tarpaulin or waterproof sheets.
- Do not store them on concrete or wooden floors. Put them on a raised surface which has been protected with an impermeable plastic sheet.
- Store cement bags separately. It’s important they aren’t placed with other products, such as fertilizers, as the quality and performance of your concrete could be affected due to contamination.
- Provide adequate ventilation – this could be done by placing the bags on pallets, if you have any.
- Rotate stock, especially if you have more than two bags of cement. The strength of the cement deteriorates over time, so always use the product according to the manufacturer’s date and use the oldest stock first.
- Any cement which has been leftover in half-empty bags (from a previous project) should be used first (if you’re starting a new project). If you have leftover cement following your project, ensure the cement is re-bagged in heavy-duty plastic bags (thick, layered bin liners should do the trick here). Ensure the mouths are securely sealed with string or duct tape and ensure no holes are present.

Handling cement

- Ensure cement bags are never dropped. They should be carefully placed on a flat, raised surface.
- Roll the cement bags over before lifting them. This can help to loosen the cement, therefore reducing the chances of the bag splitting.
- Do not carry cement bags at the ends. The bag should be supported on the underside, preventing the bag from sagging in the middle and subsequently splitting.
- Ensure cement bags are never stored upright or on their side. They must be laid flat with broad sides down.

Transporting cement

- To prevent the bags from being punctured or damaged, ensure all sharp objects are removed from the car before loading the bags into the boot.
- When loading, ensure the bags are stacked in alternate directions.
- Cover the bags with tarpaulin or waterproof sheets.

- Ensure the bags are secured properly to prevent movement during transportation.

Can you store mixed concrete?

In short, no. As soon as your concrete is ready to pour, it won't be possible to store it. If the concrete isn't 'agitated' by either a portable concrete mixer, a concrete truck or by hand, then it will begin to cure. 'Curing' can also be referred to as the 'setting' of the concrete, meaning it will eventually harden. Once concrete has begun the curing process, it's impractical and often dangerous to attempt to lay it again. Once hardened, it will be much weaker than concrete poured from a fresh batch.

Instead, you can order ready mixed concrete from us here at EasyMix. In order for you to receive an accurate amount, and to reduce waste and costs, use our concrete calculator. This way, we'll be able to deliver an appropriate amount of concrete in accordance with the size and scale of your project.

By ordering ready mixed concrete from us, you won't have to worry about storing, handling or transporting cement bags. For your ultimate convenience, order concrete from us today!

Chapter 8

Blended Hydraulic Cement
ASTM C 595

a hydraulic cement consisting of two or more inorganic constituents, which contribute to the strength gaining properties of cement.

{Clinker, Gypsum, Portland cement, Fly ash, Slag, Silica Fume ,Calcined Clay}

Fineness

95% of cement particles are smaller than 45 micrometer with the average particle around 15 micrometer.

-Fineness of cement affects heat released and the rate of hydration.

-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.

-Fineness tests indirectly measures the surface area of the cement particles per unit mass :

Wagner turbidi meter test: (ASTM C 115)

Blaine air-permeability test (ASTM C 204)

Sieving using No. 325 (45 μ m) sieve (ASTM C 430)

Soundness

-Soundness is the ability of a hardened paste to retain its volume after setting.

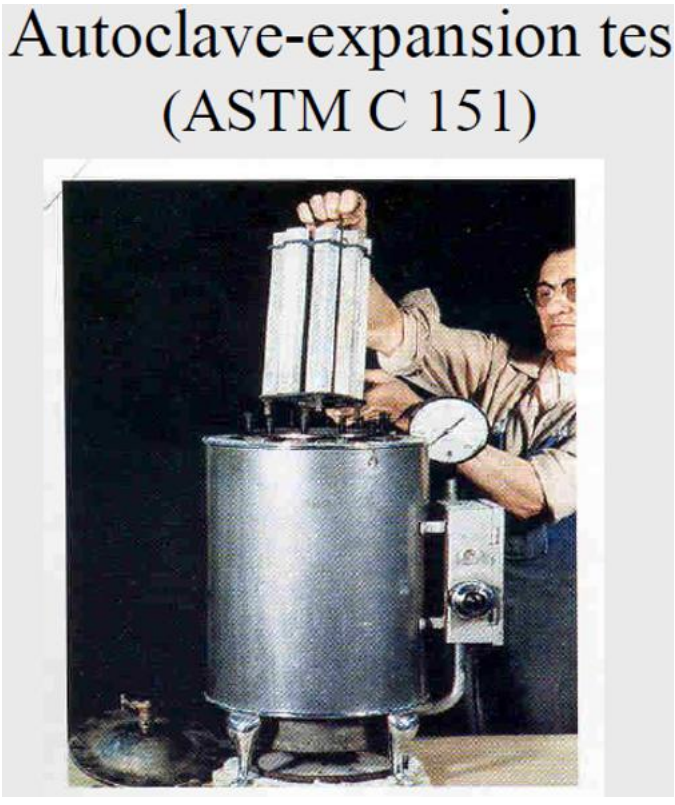
-A cement is said to be unsound (i.e. having lack of soundness) if it is subjected to delayed destructive expansion.

-Unsoundness of cement is due to presence of excessive amount of hard-burned free lime or magnesia

-Unsoundness of a cement is determined by the following tests:

Le-Chatelier accelerated test (BS 4550: Part 3)

Autoclave-expansion test (ASTM C 151)

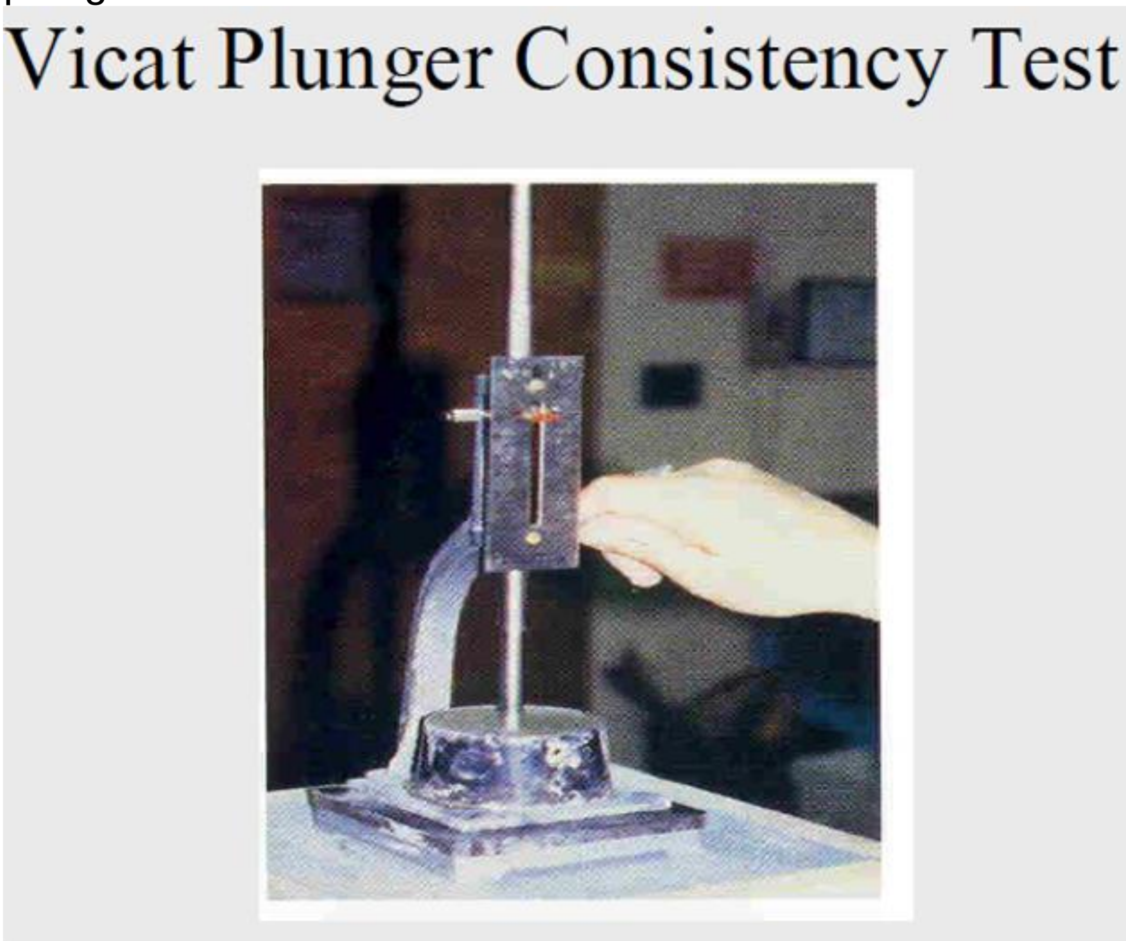


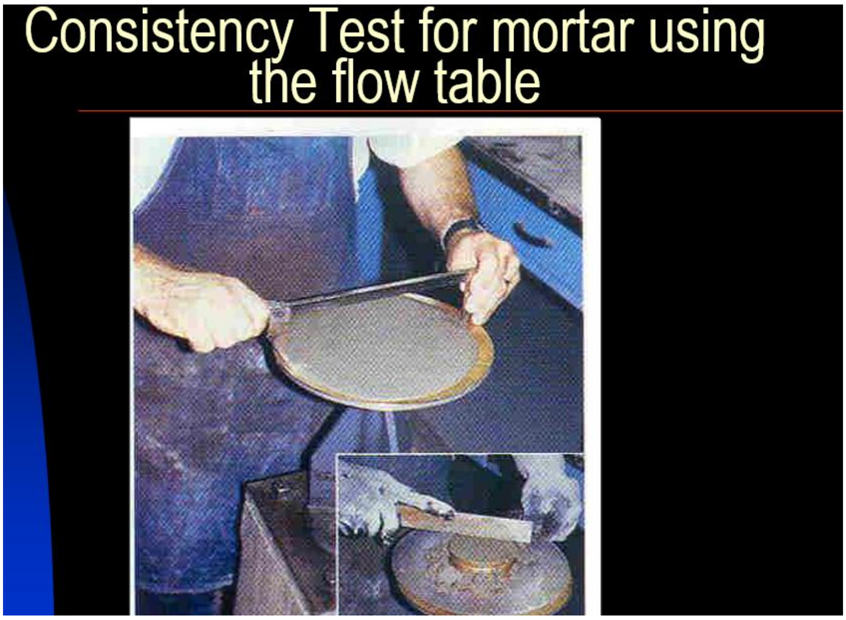
Consistency

-Consistency refers to the relative mobility of a freshly mixed cement paste or mortar or its abilityto flow.

-Normal or Standard consistency of cement is determined using the Vicat's Apparatus.

-It is defined as that percentage of water added to form the paste which allows a penetration of 10 ± 1 mm of the Vicat plunger.





Setting Time

-This is the term used to describe the stiffening of the cement paste.

-Setting time is to determine if a cement sets according to the time limits specified in ASTM C 150.

-Setting time is determined using either the Vicat apparatus(ASTM C 191) or a Gillmore needle (ASTM C 266).

-“Initial setting time” is the time from the instant at which water is added to the cement until the paste ceases to be fluid and plastic which corresponds to the time at which the Vicat’s initial set needle penetrate to a point 5 mm from the bottom of a special mould.

Compressive strength

Compressive strength of cement is the most important property.

It is determined by ducting compression tests on standard 50 mm mortar cubes in accordance with ASTM C 109.

In general, cement strength (based on mortar-cube tests) can not be used to predict concrete compressive strength with great degree of accuracy because of many variables in aggregate characteristics, concrete mixtures, construction procedures, and environmental conditions in the field.

Rates of compressive strength development for concrete, made with various types of cement

Heat of Hydration

It is the quantity of heat (in joules) per gram of un hydrated cement evolved upon complete hydration at a given temperature.

The heat of hydration can be determined by ASTM C

186 or by a conduction calorimeter.

The temperature at which hydration occurs greatly affects the rate of heat development.

Fineness of cement also affects the rate of heat development but not the total amount of heat liberated.

CHAPTER 9

CONCLUSION

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement is mainly used as a binder in concrete, which is a basic material for all types of construction, including housing, roads, schools, hospitals, dams and ports, as well as for decorative applications (for patios, floors, staircases, driveways, pool decks) and items like tables, sculptures or bookcases.

From the limestone quarry to the delivery of the end product, follow every step in the cement manufacturing process.

١. Step 1: Mining.
٢. Step 2: Crushing, stacking, and reclaiming of raw materials.
٣. Step 3: Raw meal drying, grinding, and homogenization.
٤. Step 4: Clinkerization.
٥. Step 5: Cement grinding and storage.
٦. Step 6: Packing.

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