Government Polytechnic, Jhajjar

Cement Technology

Semester 4

Ceramic Branch

By:-

Unit 1

(Cement)

1.1 Introduction: Cement is binder cement used in construction are usually inorganic, often lime or calcium silicate based, and can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to set in the presence of water.

1.1.1 Non- hydraulic cement:

Non- hydraulic will not set in wet condition or under water; rather it set s as it driers as reacts with carbon dioxide in the air. It is resistance to attack by chemical after setting.

1.1.2 Hydraulic [cement: (e.g. Portland cement)

Set and becomes adhesive due to a chemical reaction between the dry ingredients and water. The chemical reaction result in mineral hydrates that are not very water soluble and so are quit durable in water and safe from chemical attack. The chemical processes for hydraulic cement found by "Ancient Romans" used volcanic ash (Pozzolona) with added lime (Calcium oxide).

1.2 Portland cement:

The most commonly use cement now a days is hydraulic cement (i.e. hardens when water is added) known as Portland cement blends. These are usually the basic ingredient in making concrete. Which is a construction material used as a load bearing element.

Portland cement is a suitable for wet climates and can be used under water. Different types of Portland cement include Portland blast furnace slag cement, Portland and flay ash cement, Portland silica fume cement, masonry cement, expensive cement, white cement, Coloured cement, blended cement and very finely ground cement.

1.2.1 Composition of Portland cement:-

85% Portland cement clinker. (37-72% of 3Cao Sio2, 6-47% 2Cao.2Al2o3, 2-19% 4Cuo. Al2o3. Fe2o3), 1.5-3.5% Gypsum by so3 cement up to 15% adds mintures.

1.3 Pozzolonic cement:in this cement type clinker and pozzolanic material. Such as (volcanic ash, flay ash etc.) are mixed in a defined proportion with and in a defined proportion with and Portland cement.

The pozzolanic material does not have any cementing qualities when used alone. But when mixed with Portland cement, they are reacting with cement and the components and from compounds with cementing properties. The Pozzolonic cement has many properties

similar to ordinary Portland cement, but it also offers some addition properties. Which are given below?

i) It produces less heat. Due to this property it can be used in mega projects.
ii) 'It offers greater resistance to sulphates and corrosive actions of sea water.
iii) It more useful for construction near or aloe the cost and also in sulphates soil. It can also be used in sewage works and for under water construction.

1.3.1 Blast furnace slag cement:

Blast furnace slag cement is waste obtained from furnace slag. Blast furnace slag is made by mixing furnace slag more than 60% in the clinker. It is used where economic concentration is of almost importance.

1.3.2 Definition:

It is modifier type of Portland type of Portland cement which contains 25-65% (by weight) of blast furnace slag. It is manufactured by grinding clinker and specific amount of blast furnace slag together. A small percentage of gypsum is also added for controlling it's a setting time.

The slag, as we know, is waste products from the blast furnace, which is used in the manufactured of iron (ferrous metal)

1.3.3 Properties:

i) They possess better work ability and plasticity. These qualities are explained to be due to lesser specific gravity and greater specific surface area of slag cement.
ii) They have better resistance to sulphates of alkali metals, alumina and iron.

1.4 Quick setting cement:

It is very quickly after its application. It is made by adding a small percentage of alumina sulphates and reducing the cement of gypsum in ordinary cement with the fine grinding of the mix at the time of manufacturing. It is used in rainy season and in places where water cannot be prevented from coming in contact with the cement.

It's that is it set into a stone like mass with in a period of fewer than 30minutes.

The property of setting as quickly as possible is achieved by following controls in the manufacturing process.

i) The quantity of retarding agents like gypsum is reduced to bare minimum.
ii) The quantity of alumina- rich compound is reduced.
iii) The clinker is ground to extreme fineness.

The quick cement is used only in very specific situations such as white constructing piers for bridges and other structures in running or standing water.

1.5 Rapid hardening cement:

Rapid hardening cement is very similar to ordinary Portland cement. It contains higher c3s content and finer grinding.

Therefore, it gives greater strength development at an early stage than opc. The strength of this cement at the age of 3 days is almost same as the 7 days strength of opc with the same water content ratio.

1.5.1 Definition of rapid hardening cement:

It is also known as high- early strength cement. It is manufactured with such adjustment in the proportion of raw materials so that the cement produced attains maximum strength within 24-72 hours.

1.5.2 Properties:

i) It contains relatively more tri-calcium silicate. This is done by adding a greater proportion of limestone in the raw materials compared to that required for ordinary cement.

ii) It is more fine grained (air permeability 3250 cm^2/gm.) than the ordinary cement. This factor helps in quicker and complete hydration of cement particles during setting and helps in gaining early strength however, the setting time and ultimate strength of rapid hardening cement are same as of ordinary cement.

1.5.3 Uses:

It special purpose cement. It is used in those types' projects, where quick hardening is required. Where quick hardening is required. In advanced countries, an ultra-high early strength cement is produced by separating the finest fraction (above 700m^2/kg) from the rapid hardening cement at the manufactured stage itself.

1.6 Low Heat cement:

It is that type in which very low amount of heat or hydration is liberated during setting and hardening. Mostly it is setting in massive concrete structures like dams etc.

1.6.1 Properties:

I) The proportion of di calcium silicate (c_2s) is almost double than ordinary cement.

II) The proportion of tetra calcium alumina ferrite (c_4Alfe) is also increased to one and one half time.

III) The proportion of tri calcium silicate (C_2S) and tri-calcium aluminate (C_3AL) are reduced by about 50%.

This is because these compounds are known to liberate a very high amount of heat during hydration.

1.6.2 Fineness:

The residue in the sieve test shall not exceed than 10%.

1.6.3 Setting time:

The initial setting time shall not be less than 60 minutes and the final setting time shall not be less than 10 hours.

1.6.4 Strength:

It should develop a corrosive strength not less than.

a) 70 kg/sq. cm in 3 days
b) 115kg/sq. cm in 7 days
c) 265 kg/sq. cm in 28 days

1.6.5 Uses:

It is mostly used in mega projects construction like DAMS. It we use ordinary Portland cement instead of low heat cement in such structures cracks will develop in such structures due to the great amount of heat liberated during setting and hardening.

A and D a DAM with cracks in use less structure. But when low heat cement is used this danger (development of cracks) can be eliminated.

1.7 High alumina cement:

These type of cement contains alumina in considerably larger proportion by calcining a well Proportion mixture of lime stone and Bauxite ($Al_2O_3.NH_2O$) no other raw material is added, not even gypsum is mixed with the clinker, during grinding. The total alumina cement is generally above 32%.

1.7.1 Properties:

i) It is resistance to the corrosive action of acids and salts of sea water.

ii) The ratio of alumina to lime is kept between 0.85 and 1.30.

iii) It grains compressive strength of 400kg/sq. cm within 24 hours and 500 kg/sq. cm after 72 hours.

iv) It evolves great heat during setting. Due to this, it is not suitable for use in mega projects like Dams. But at the same time it gives an advantage to high alumina cement for use in fast forming areas.

v) They react quickly with lime therefore it must not come in contact with lime.

1.7.2 Uses:

Unfortunately it is more costly. Therefore it is used only in that situation. Where resistant against corrosion is required. It is commonly used in construction work near & along sea – shore.

1.8 White cement:

It may be also defined as a special type of Portland cement when used it gives a milky or snow – white appearance.

White cement is manufactured from pure lime stone (chalk) and clay that are totally free from iron oxide and any other pigments like Magnese and chromium. The kiln is fired contamination.

These strength and setting time is similar to ordinary Portland cement.

White cement is the most favoured material for use in making highways, curbs and for a variety of ornamental work. They are also used widely for making cost stones of appealing appearance.

White cement is comparatively costly cement type and is therefore used only selectively.

1.9 Coloured cement:

In this type of cement pigment (colour) is mixed with the Portland cement in a definite proportion. The pigment is mixed in a finest powered state. The amount of pigment used depends upon the shape of the desired colour.

It is, however generally less than 10% (by weight).

The following pigments are used to obtain Coloured cement.

i) Chromium oxide is used for green colour.

ii) Cobalt is used for blue colour.

iii) Iron oxide is used for various shades of red, brown and yellow colour.

iv) Magnese dioxide is used to obtain black and deep brown colour.

v) This type of cement extensively is used for top coat in flooring and for decorative purposes I various places in a building.

1.10 Sulphates resisting cement:

It provides better resistance against the sulphates which are present in water. It is made by limiting the amount of tri-calcium aluminate below the 6% at the time of manufacturing used in the environments where concrete is exposed to high concentrations of sulphates in water.

Hydrophobic cement:

It is made by adding water repelling agents in the cement. These type of cement generally use for retaining structures. It is special type of cement containg added mixtures which reduce the affinity of cement grain for water. Such cements types used specially in cold frost forming conditions add mixtures of naphtha a soap and acidly are generally added to achieve this property.

1.11 Oil well cement:

This cement are used to cementing the steel casting of gas and oil well to the walls of the bore both porous and formation.

1.12 Water proof cement:

This cement is obtained by mixing of calcium special oil or ordinary Portland avoids the leakage of water moisture.

1.13 Irons are Portland cement:

This cement has high iron and low alumina cement.

Unit 2

(Function of Cement's Oxide)

2.1 Ingredient of cement

1. **Lime (CaO):** It is the major ingredient of cement. So its proportion should be carefully maintained. It makes the cement strong and also provides strength to the cement.(Up to 60-67 %.)

2. **Silica (SiO_2):** It is an important ingredient of cement. It produces strength to the cement. In excess causer the cement to set slowly. (Up to 17-25%)
3. **Alumina (Al_2O_3):** It provides crack sitting quality to the cement. It is also lower the clinkering temperature. Alumina in access weak the strength of the cement. (Up to 3-8%)
4. **Calcium sulphate ($CaSO_4$):** It is present in the from of gypsum. It helps in increasing the initial setting time of the cement.
5. **Iron Oxide (Fe_2O_3):** IT provides colour hardness and strength to the cement. It also helps in the fusion of the raw material during in the fusion of raw material during the manufacture of the cement. (Up to 0.5-0.6%)
6. **Magnesium Oxide (MgO):** It provides colour and hardness of cement. Magnesium oxide in excess will remain Free State and cause the cement unsound. (Up to 0.1-4%)
7. **Sulphur Trioxide (SO_3):** It makes the round of the present in very small amount. In the excess it makes the cement unsound. (Up to 1-3%)

2.2 Chemical Compostion of Portland cement:

Raw Material	Approx. percentage of raw material (%)	Common percentage of raw material (%)
Lime (CaO)	60-64	63
Silica (SiO_2)	17-25	22
Alumina (Al_2O_3)	3-8	6
Iron oxide (Fe_2O_3)	0.5-6	3
Magnesium oxide (MgO)	0.1-4	2.5
Sulphur trioxide (SO_3)	1-3	1.75
Sodium residue	1-5	0.25

2.3 Raw material of cement:

2.3.1 Raw material for Portland cement:

These are two types of raw materials which are used for manufacture of cement.

I. Calcareous material
II. Argillaceous material

2.3.2 Calcareous material: The material which contains calcium or lime as the main constituent are called calcareous materials.

Examples: Limestone, marble, chalk or shell etc.

Following types of calcareous material:

a. **Chalk:**It contains calcium carbonate. In chalk sad (SiO_2) and flint are present as impurities. It is very soft can be grind to soft powder.
b. **Sedimentary lime stone:**It is also known as natural cement rocks.
   It occurs in number of forms. It contains some impurities like magnesiaoxide (MnO_2); Phosphate metallic oxide etc. these impurities

if present affect the colour, rate of setting, development and of strength.

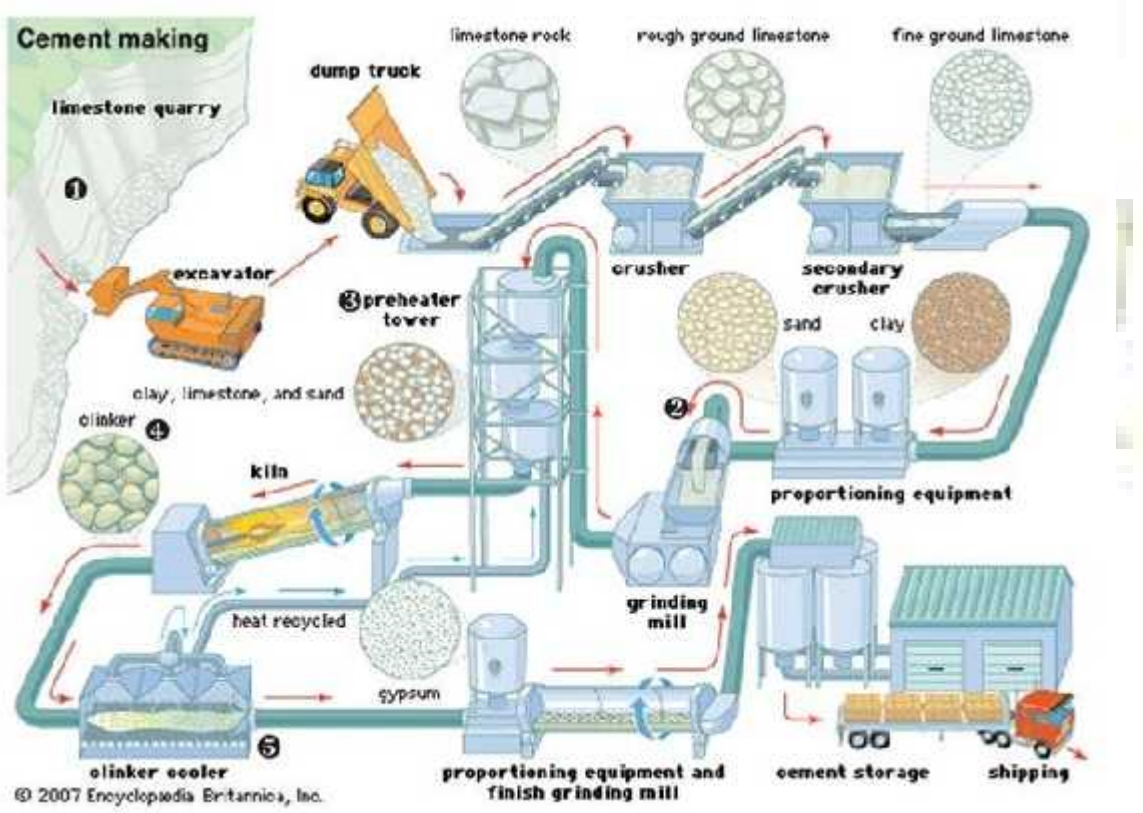
c. **Metamorphic limestone:**it chemical composition same as sedimentary lime stone. These have coarse and grind.
d. **Marl:** it occurs as the sedimentary rocks. It is found at the bottom of the some lakes. Generally if contain number of small shells.
e. **Carbonate:** If occurs as volcanic rocks. It contains impurities such as magnesia etc.
f. **Alkali waste:**It contains calcium carbonates which areobtained during manufacture of caustic soda.

2.3.3 Argillaceous Material: The material which contains alumina (Al_2O_3) as their main constituent are called argillaceous material.

Examples: Clay, shales etc.

These materials provide required proportion of silica, clay, iron oxide etc. in the manufacturing cement.

2.4 Manufacturing of cement:



2.4.1 Manufacturing of cement are completed into following three states:-

1) Mixing
    i) Dry process
    ii) Wet process
2) Burning
3) Grinding

2.5 Two processes are used to manufacturing cement:

I. Dry process
II. Wet process

2.5.1 Dry process:

This process is used when raw material is hard. The dry process consists of following steps:-

i. In first step the different material re first crushed and then ground to powder in ball mill and tube mill separately and then stored in separate storage bins.
ii. These raw materials are then dried. These raw material are then mixed in proper proportion and a raw mixed is prepared.
iii. The chemical compostion of this mixture is checked and if necessary corrected to required chemical compostion in dry state.
iv. The raw mix is then fed in to the rotarykiln in the form of a fine powder.
v. The calcination is carried out in the rotary to the form of clinker.
vi. The clinker so obtained from rotary kiln is grinded to fine powder in ball mill. This state gypsum also added to slow down the setting role of cement.

Site selection for cement factory:-

The following points should be considered while making selection of suitable site for the cement factory:-

i. Climate condition of the locality should be favourable for manufacturing process of the cement.

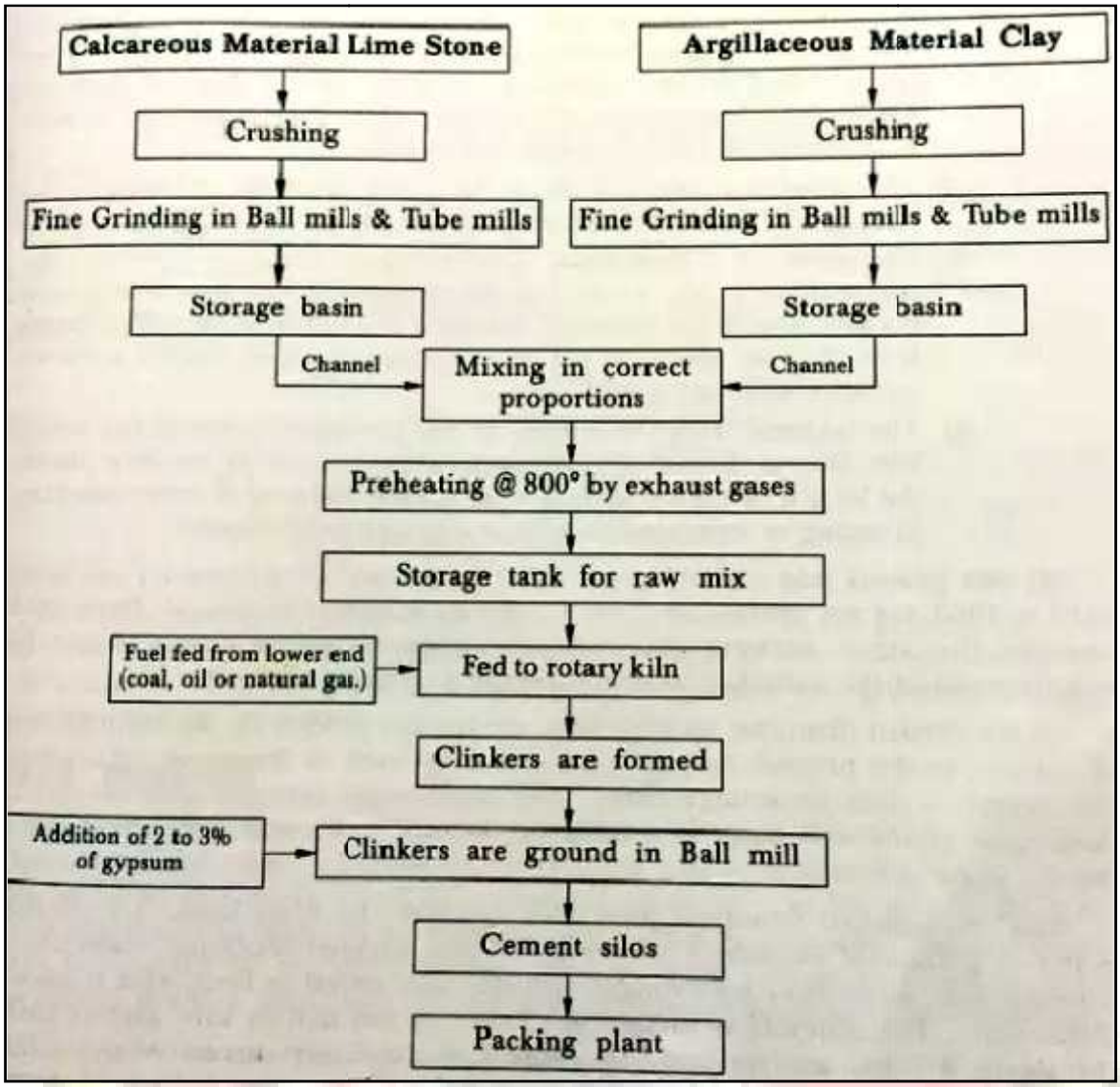
ii. Check load bearing capacity of the soil at the site. It must be sufficient to take the trust of the machine safely.
iii. Labour should be easily and cheaply available near to the site.
iv. Raw material should be easily and continuously available in large amount near the site.
v. The site should be such that those are facility for transport of raw material and to dispatch off the finished product.
vi. A good market should be near to the site.
vii. These should be adequate quantity of water available which should be lift for drinking purpose.
viii. Electric power and full should be available at reasonable rate.
ix. General facilities like medical, market etc available.
x. The site selection should perfectly be connected by roads and railway.

Selection of the raw material:

The following point must be considered for the selection of raw material.

i. The raw material should be near to the factory.
ii. Raw material free forms any impurities.
iii. The required raw material percentage in the material should be high.
iv. The size of the raw material is in required range.
v. The raw material should be available in abundant.

Flow chart of manufacturing cement by dry process:-



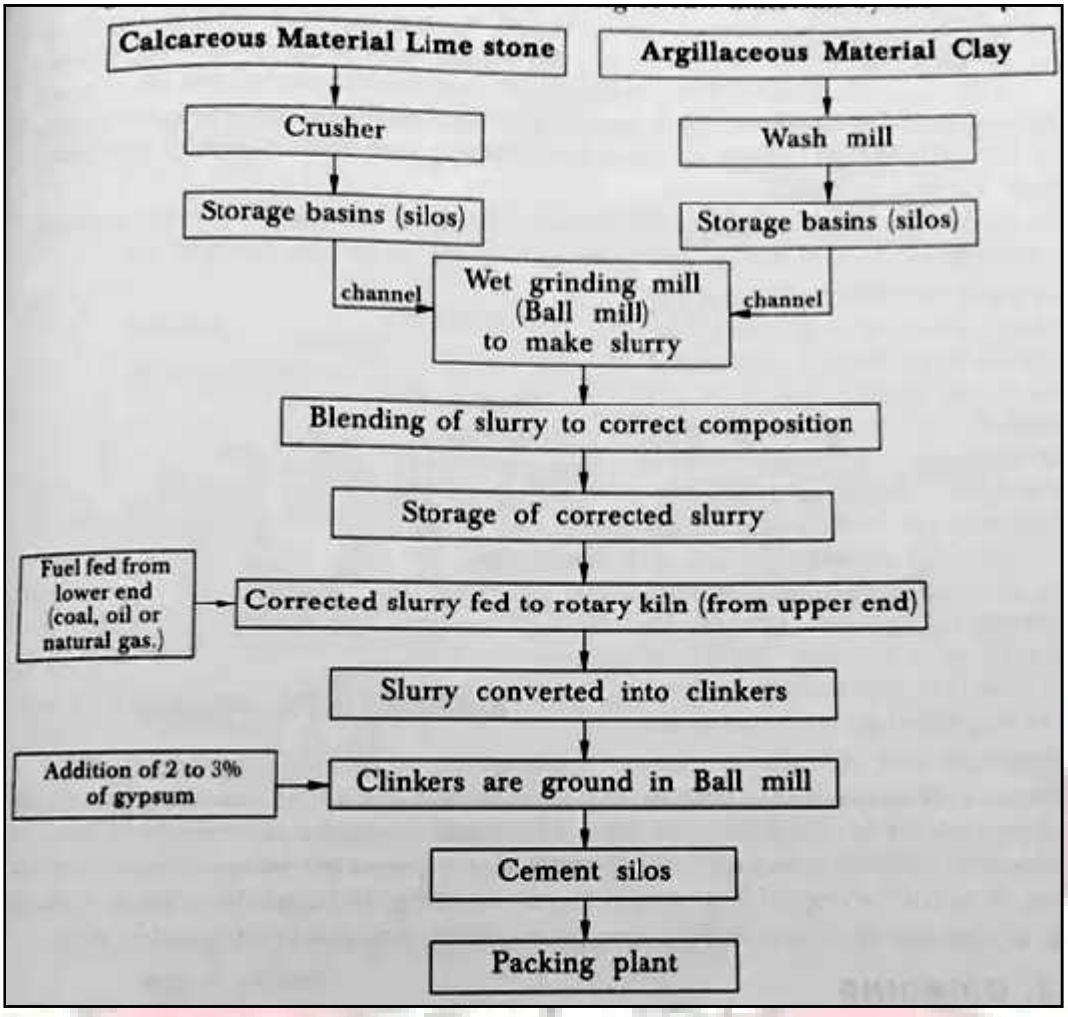
2.5.2 Wet process:

This method of manufacturing cement is adopted. When a raw material are soft. This process mostly used now-a-days as the quality of the cement prepared.

Wet process iscompleted following ways:

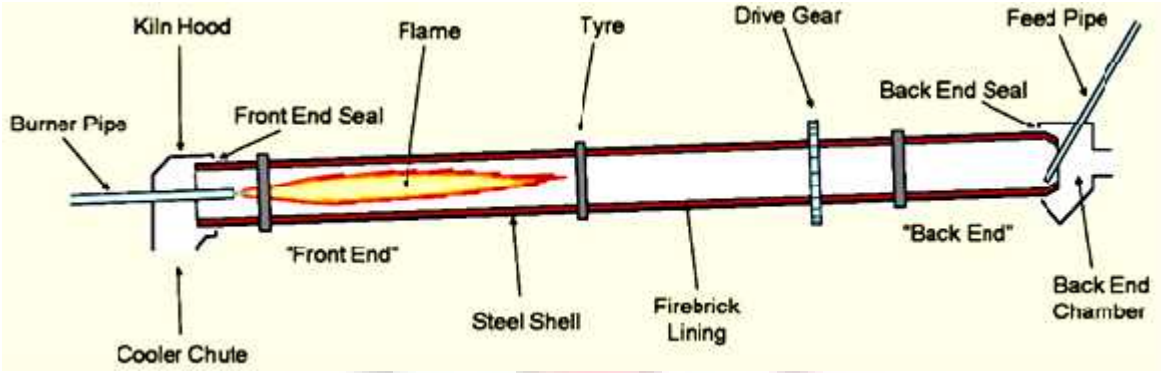
i. Collection of raw material
ii. Crushing, grinding and mixing
iii. Burning
iv. Grinding of clinker

Flow chart of wet process of manufacturing cement:



a. **Collection of the raw material: -** The raw materials calcareous as well as agrilleous material arecarried from nearest carry. Thesematerials are then transported and collected at the plant.
b. **Mixing:-** The carried calcareous material (lime stone) is first crushed up to 1cm size pebbles and these are than grind and then store in large tank than add water prepare slurry. Take raw material slurry put top of the rotary kiln.
c. **Burning: -** The burning process is carried in a rotary kiln, the slurry so obtained is corrected.

Rotary kiln:-



It consist of a cylindrical shell made by steel plate 2.5 to 4 cm thick having length 90-120m and diameter 3-4m. The inside of the kiln is provided with refractory lining.

d. **Grinding: -** finally the clinker isgrinded to a very fine powder in a ball mill and tube mill.

2.6 Admixture or additives:-

Cement aggregates and water are the common material required for the preparation of concrete. To improve some particular of the concrete material other than those mention above are added sometimes during the preparation of the concrete.

2.6.1 Purpose: -The admixture may be used for one or more of the following purpose:-

1. To improve disability of concrete by entering air in it.
2. To improve work ability.
3. To accelerate setting and hardening time.
4. To retard setting.
5. To impart water proofing properties to concrete.
6. To improve wear resistance.
7. To reduce shrinkage during setting.
8. To reduce the evolution of heat.

2.6.2 Types of work additives and admixture:-

1. **Workability admixture: -** The use of this admixture to improve workability. This becomes essential when the aggregate is not properly grinded.
2. **Air entering agents: -** The resistance of the concrete to posing considerably increased with the entering of air in fame of mixture.

3. **Accelerators: -** Accelerators are used to accelerate, setting and hardening time of cement. Examples: Calcium Chloride, Calcium carbonate, and silicate.
4. **Retarders: -** these are used to reduce accelerating effect of the hot weather on the setting time of the concrete and to eliminate false setting of setting cement.
5. **Pozzolonic material: -** This material combines with lime in percentage of water cement like compound. Example: Clay, shale and fly ash are pozzolonic material. Those materials require continuous pressure of water. Thesematerials lower the heat of hydration.
6. **Water proofing: -** These materials are added to cement during concrete mixing these material make cement water proofing. Water proffer reacts with the cement chemically or fill the pore area physically.

Unit 3

(Effect of raw material and constituent on the properties)

3.1 Effect of raw material and constituent on the properties

Lime (Cao):- It is major ingredient of cement, so it proportion should be carefully maintained. It makes the cement sound and also provides strength of the cement (60-70%).

Silica: - It is an important ingredient of cement cess, causes the cement to set slowly silica (17-25%)

3.1.1 Thermo chemistry of cement or clinker:-

During clinker formation is absorbed or evolved

1. Evaporation of free water takes place shoot ion absorbed.
2. At 500^0C and above evolution of chemically combined water takes place and heat is absorbed.
3. At 900^0C crystallisation of amorphous products taken place and heat is evolved.
4. At 900^0C and above evolution of co_2 takes place and heat is absorbed.

$$Ca\,CO_3 \xrightarrow{900^0C} Cao + CO_2$$

5. At 900-1200^0C reaction between lime and clay takes place and heat is evolved.
6. At 1250-1280^0C liquid formation starts and heat is evolved.
7. At temperature above 1280^0C more formation of liquid takes place and formation of cement compound complete and heat is absorbed.

3.1.2 Sequence of reaction in cement burning:-

The raw material fid to rotary kiln to make cement contains calcium carbonate ($CaCO_3$), magnesium carbonate ($MgCO_3$) clay water. The reaction which occurs during burning is as follows:-

1. Evaporation of free water: - below (100-110^{0}C)
2. Release of chemically combined water:-

At 500^{0}C,

$$Al_2O_3.2SiO_2+2H_2O \xrightarrow{500\text{-}600^0C} Al_2O_3.SiO_2 + H_2O \uparrow$$

At 1000^{0}C

$$Al_2O_3.2SiO_2 \xrightarrow{1000^0C} Al_2O_3.2SiO_2 \uparrow$$

3. Disassociation of magnesium carbonate:

$$MgCO_3 \xrightarrow{1000^0C} MgO + CO_2 \uparrow$$

4. Disassociation of calcium carbonate:

$$CaCO_3 \xrightarrow{894^0C} CaO + CO_2 \uparrow$$

5. Combination of the lime and clay:-
    a. Relation between calcium carbonate and silica.
    b. Starts at 600^{0}C.
    c. Proceed slowly up to 800^{0}C.
    d. Speed high at 1100^{0}C.
    e. Rapid at 1400^{0}C.

First di-calcium silicate is formed

$2CaO.SiO_2$

Starts at 800^0C, complete at 1200^0C

$$Al_2O_3.2SiO_2+2H_2O \xrightarrow{500\text{-}600^0C} Al_2O_3.2SiO_2+2H_2O\uparrow$$

Formation of $CaO.SiO_2 \rightarrow 1300\text{-}1400^0C$

A. **Evaporation of free water**: - When the raw materials are fed into rotary kiln for burning first of all evaporation free water takes place at 100^0C.
B. **Release of chemically combined water from the clays: -** When temperature of material reactant about 500^0C when the water is chemically with clay gets release. Kaolin clay – $Al_2O_3.2SiO_2.2H_2O$ At temperature below $500\text{-}600^0C$ the kaolin clay rebase water form and anhydrous alumina silicates ($Al_2O_3.2SiO_2$)

   Amorphous (700^0C) melts: - When the temperature is reached at about 1000^0C. alumina silicates gets split into silica and alumina.

C. **Disassociation of MgO: -** It present in raw material decomposed at about $600\text{-}700^0C$ from magnesia and carbon dioxide.

$$MgCO_3 MgO + CO_2 \xrightarrow{600\text{-}700^0C}$$

D. **Disassociation of calcium carbonate**: - When the temperature of the material reaches 894^0C the calcium carbonate decomposed into lime and carbon dioxide.

$$CaCO_3 CaO + CO_2 \xrightarrow{894^0C}$$

E. **Combustion of clay: -** The section of $CaCO_3.SiO_2$ starts at 600^0C. It proceeds very slowly up to 800^0C. The section speed becomes high at 1100^0C and becomes solid at 1400^0C during the section di-calcium silicates are formed first. The formation starts at about 800^0C gets completed at 1200^0C ($2CaO.SiO_2$) 3CaO.SiO2→1300-1400^{0}C. The formation of tri-calcium aluminate ($3CaO.Al_2O_3$) and tetra-calcium aluminate ($4CaO.Al_2O_3$) first states at temperature of 1100-1200^0C.

3.2 Hydration of the Portland cement or cement hydration:-

Tri calcium silicate hydrolyses to di calcium silicates and releases the excess lime as calcium hydroxide. This calcium hydroxide precipitation out as crystal forms the solution. The calcium silicates from hydrolysis and that present originally in cement combined with water and from hydrated calcium silicates. This following reaction takes place during hydration.

$3Cao.Al_2O_3 + H_2O \rightarrow$ Hydrated calcium (deposition) + $Ca(OH)_2$

$3CaO.SiO_2 + H_2O \rightarrow$ hydrated calcium silicates + $Ca(OH)_2$

Due to high solubility of aluminates with water immediate reaction takes place rapid deposition of calcium.

Aluminates crystals take place tri calcium silicates and di calcium hydrated slower than tri calcium aluminates. Rapid deposition of aluminates crystals are responsible for initial setting of cement and contribute to setting between 24 hours to 72 hours tri calcium silicates reacts slowly with water then tri calcium silicates. Di calcium silicates react continues for 2 to 3 years and contributed to later strength development.

3.2.1 Setting and hardening of cement:-

When cement is mixed with water stiff paste is formed. This cement paste remains plastic for short time. The phenomenon by virtue of which the plastic cement change into a solid mass is known as setting of cement. For an

ordinary cement the initial setting time should not be less than 30 min. and the final setting tie should not be more than 10 hours similarly for quick setting the initial setting time should not be less than 5 min. and the final setting time should not be more than 30 minutes.

3.2.2 Various reactions during setting of cement:-

Cement has the property of the setting to hard mass after mixed with water. This is known as setting cement. It revolves various complicated reaction which are given below:

i. Hydration of aluminate to give colloidal

$$3CaO.Al_2O_3 + 6\,H_2O \rightarrow 3CaO.Al_2O_3.6\,H_2O$$

Tri **calcium** **Aluminates**

ii. Hydration of tri calcium silicate to colloidal get

$$3CaO.SiO_2 + 6\,H_2O \rightarrow 3CaO.SiO_2.6\,H_2O$$

Tri calcium colloidal

Water

iii. Hydration of di calcium silicate to give colloidal

$$2CaO.SiO_2 + H_2O \rightarrow 2CaO.SiO_2.H_2O$$

Di calcium silicates

iv. Hydration of tetra calcium alumina ferrite to give tri calcium aluminates colloidal get

$$4CaO.\ Al_2O_3.Fe_2O_3 + 6\ H_2O \rightarrow 3CaO.Al_2O_3.6\ H_2O + CaO + H_2O_3$$

Tetra calcium alumina ferrite **Tri calcium alumina hydroxide**

v. Hydrolysis of tri calcium silicate to liberate free get

$$3CaO.SiO_2 + H_2O \rightarrow Ca\ (OH)_2 + 2Cao.SiO_2$$

Tri calcium silicates **(free lime gel)** **di calcium silicate**

vi. Hydrolysis of tri calcium aluminate to liberate free alumina hydroxide

$$2Cao.Al_2O_3 + 6H_2O \rightarrow 3Ca\ (OH)_2.Al(OH)_2$$

3.3 Physical and mechanical properties:-

1) **Density: -** Density is defined as mass per unit volume. It is measured for its required volume. It is measured for its required in the measurement surface area. It is determined using displacement of liquid in a density of Portland cement ranges from 3 to 3.29 g/cm^3.
    a. Apparent density: - the density off the cement not a property of much important. So its value of apparent density is measured by filling a granulated clinker and some degree of soaking is done. The apparent density of Portland cement is 1280-1440 Kg/m^3.
2) **Fineness:-**

i. By sieve test the residue by weight on IS test No. 9 should not be more than 5% in the case of rapid hardening cement and Portland pozzolana cement.

ii. The specific surface by the air permeability method should not less than 3250 cm^2/gm.

3) Soundness:-

a. When tested by the boiling test, the expansion should not be more than 10mm in all types of cement.

b. When tested by the autoclave test, the expansion should not be more than 0.8% in all types of the cement. Cement containing more than 3 % MgO must pass the autoclave.

4) Setting time :-

a. When tested by the standard method (vicat) the initial setting tie of low heat cement should not be less than 60 min. and for all other types of cement it should not be less than 30 min.

b. The final setting time should not be more than 10 hours for all types Portland and blended cements.

5) Compressive strength:-

a. The compressive strength of 50mm cubes made of 1:3 cement: sand mix (using standards graded sand) expressed as Kg/cm^2 should not be less than as given below:

	OPC	RHC	LHC	PBFSC	PPC	MC	SRC
At 1 day	_	160	_	_	_	_	_
At 3 days	160	275	100	160	_	_	150
At 7 days	220	_	160	220	220	25	220
At 28 days	_	_	350	_	310	50	300

6) Heat of hydration:-

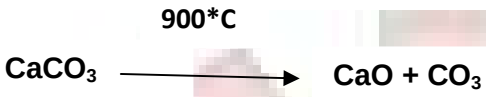
For low heat cement, the heat of hydration test is compulsory and the heat of hydration at 7 days should not be more than 65 calories per gram and at 28 days not more than 75 calories per gram.

Unit 4

(Lime)

4.1 Lime:

The product obtained by calcining limestone above the 900*C is called lime.



It is not naturally aviable in Free State and it is obtained by burning limestone when the lime stones (calcium carbonate is calcined (burn) the moisture and CO_2 are removed and lime is left behind.

4.1.1 Source of Limestone: -Various sources from limestone are obtained are:

a. Limestone from rock is block from.
b. Kankar form
c. Corals and shells o0f sea animals

4.1.2 Forms of limestone:-

I. **Block from: -**It is a solid mass of lime stone in the form of rocks. These are to be quarried mined and used as a building stone for manufacturing of lime stone this is almost pour form.

II. **Modular form: -**modular form of lime stone is taken from water stream. It is found on the surface of rough ground a few meters below ground near river. It can be easily calculated and has more cementing value.

III. **Kankar lime: -** kankar lime is impure limestone containg about 30% impurities. It is available in both modular form and block form.

IV. **Shells of sea animals: -** some sae animals have calcium skeletons have calcium carbonate. This is the purest form but the manufacture of lime is not economical.

4.1.3 Various terms used in lime manufacture:-

I. **Calcination: -** It means heating of material (lime stones, calcium carbonates) to used ness in absence of air to form lime.

II. **Quick lime: -** It is calcined material major party of which is lime (Cao). In nature it is found in association with small amount of magnesium oxide. Itslackeswith water.

III. **Fat lime: -** lime having high calcium oxide content which can set and become hard only in presence of carbon dioxide from atmosphere.

IV. **Hydraulic lime: -** lime containing small quantity of silica alumina and iron oxide which are in chemical combination with calcium oxide. It can set and become hard even in the absence of carbon dioxide. It can also set under water.

V. **Hydrated lime: -** It is the dry power obtained by adding just sufficient water to quick lime converts into hydrated power. In this way calcium hydroxide is formed.

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

Quick lime water hydrated lime

VI. **Lump lime: -** lime obtained after burning or calcination of calcium carbonates in Kilns in the form of lumps is known as lump lime.

VII. **Slaking:-** the process of adding water to convert it into hydrated lime is know as slaking during the process heat is given out.

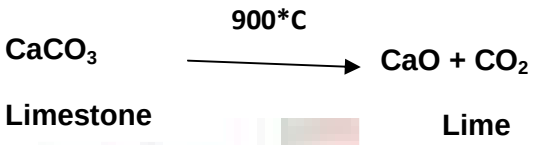
VIII. **Slaked lime: -** slaked lime is obtained by adding slightly more water then required to convert hydrated lime.

IX. **Lime putty: -** A plastic mass of lime which result from the slaked lime on adding just sufficient quantity of water.

X. **Milk of lime: -** It is the thin pour able suspension of slaked lime in water.

4.2 Calcination or conversion of lime stone to lime

1. Lime or other several of calcium carbonate is heated to high temperature. It dissociate to the equation.



During this process heat is absorb is lime stone is burnt or heated in a closed vessel. CO and can be escape and there will be no conversion of lime. This is because reaction is reversible.

So to make lime, lime stone must be heated over 500*C in open vessel for dissociation to take place. The burning of limestone is burned at 900*C – 1200*C.

Pure lime stone ($CaCO_3$) looses 94% of it's weight when it is burnt to calcium acid and shrinks in volume by 12- 20% similarly if it is heated in vessel having small opening and it's temperature during burning is small (500*C) it may not dissociate.

4.3 Classification of lime:-

1. **Rich, fat, common, pore or high calcium lime characteristics:-**
    i. Impurities are not more than 5%.
    ii. It's stages very slowly.
    iii. It makes good paste with water.
    iv. It sets in air.
    v. It does not have hydraulic properties.

4.3.1 Uses:-

i. It is used as that or mortar.
ii. It is used as base for distemper in white washing and other sanitary purpose.
iii. It is used to manufacture artificial hydraulic lime and cement.
iv. It is not used to thick wall having wet foundation or under water.

4.4 Poor lime or meagre lime:

4.4.1 Properties and characteristics:

vi. It has impurities greater than 7%.
vii. It makes thin paste with water.
viii. It slakes slowly.
ix. It sets or hardens very poorly.
x. It has not hydraulic properties.

4.4.2 Uses:

It makes poor mortar, so it is used in interior structure or in places which good lime is not aviable.

4.5 Hydraulic lime:-

4.5.1 Properties:

xi. It has impurities 5-30%.
xii. It takes more time for slaking. The time of slaking depends upon percentage of impurities.
xiii. It makes thin paste with water.
xiv. Its setting time is depending upon percentage of impurities.
xv. Its show greater hydraulic properties.

4.5.2 Uses:

i. It is used in damp place there is no free air.
ii. It is used as a binding material for stone ware and also to bind bricks.
iii. It is also used for plastering interior surface of wall.
iv. It is used for stabilization the solid.
v. It is used as there in the manufacture of the steel.
vi. It is used for preparing concrete for foundation and flooring works.

Unit 5

(Gypsum and Plaster of Paris)

5.1 Introduction: The chemical formula of gypsum ($CaSO_4.2H_2O$). Those are number of connecting material made of calcium sulphate are produced by heating gypsum naturally aviable gypsum out artificially produced gypsum (which is a by product of the manufacture of phosphate fertilizer) are used as raw material for manufacture of plaster of paris ($CaSO_4.1/2H_2O$). the plaster of paris is obtained by heating gypsum at about 150*C. gypsum is added 3-9% during at grinding of the clinker of Portland cement. This delay the initial setting time of cement. This help to give time proportion transportation and placing or mortal or concrete before initial setting of cement takes places.

5.1.1 Uses of gypsum:-

i. To manufacture of $CaSO_4.1/2H_2O$ (plaster of paris).
ii. It is used in cement industry as retarder.

5.2 Plaster Of Paris:-

Plaster of paris is calcined gypsum. It is prepared by heating naturally occurring gypsum ($CaSO_4.2H_2O$) an artificial gypsum (by product) obtained during phosphate fertilizers. The plaster of paris so, obtained is semi-hydrated. If plasterof paris is mixed with water thus it will hydrates to form rigid mass. It is used in making moulds for slip casting. It is cheap.

Setting and hardening Plaster of Paris:-

The plaster of paris set and harder when the water added to it on addition of water it will hydrate to from rigid mass. In this reaction the evolution of

heat takes place. The setting and hardening time of plaster of paris can be decreased and increased by adding various chemical. It can also be increased or decreased by changing the percentage of water. The ratio of water added to P.O.P. setting time, hardness and porosity. In general lower the moisture content the setting time will be less, hardness will be more and porosity will n=be low.

5.2.1 Uses:

i. It is used in manufacture of cement as retarder to during grinding clinker to provide.
ii. It is used for moulds making in slip casting process.
iii. It is used in medical science for joining of broken bones.
iv. For models making.

5.3 Bleeding of cement:-

It is sometimes observed that when concrete is placed in position while it is still plastic before initial setting water appears at the surface. This known as bleeding of cement.

This is due to sedimentation process in which solid settles in plastic mass and liquid starts flowing in capillary system. This can be reduced by adding plasticity agents and air entrainment agents.

5.4 Roles of Gypsum:-

Portland cement obtained from grinding clinker sets and hard immediately after addition of water. In order then the setting and hardeningMay not takes place. Immediately 30-32% for calcium sulphate($CaSO_4$) such that gypsum is added during the process of clinker grinding added to slow down the setting time so that the operation of preparation transportation in placing by mortar or cement can be can be completed before the initial set takes place.

The quality of gypsum to be added should be as to adjust the initial setting time of cement occurring to India standard specification.

Unit 6

(Testing of Cement)

6.1 Testing of Cement:-

In standardised the quality of Portland cement. It should satisfy the following test before its volume recommended any important engineering work. This test are based on Indian standard specification as per IS 269; 1967; 1975. The following test may be perfumed.

6.1.1 Fineness test:

This test is performing that check grinding of cement. The cement must be well ground during manufacture to a uniform fine powder. If grinder is not uniform and finer large quality of water will be needed for mixing chemical reaction set up during setting will be delayed more even bleeding will be occur even before concrete begin to as water will come to the solids.Atfinalsetting moresurface area on the aggregate will recovered by it two types of test performed.

I. Sieve test:-

100 grams of cement continuouslysieved for period of 15 minutes. In this test sieve 90 micron and residue by weight released on sieve is obtained which shall not be grater than 10% of ordinary portland cement residue not more than 5% much difficulty standard sieve of fineness is maintaining the uniformly of sieve hence other method are more reliable for determining the fines.

II. Surface Area test:-

This test is better in comparison to sieve test it generally is tested. This is also known as specific surface area test. It is defined as the total surface area of all the particles in one gram of the cement. It can determine by air permeability method or by Wagner cup diameter specific surface number at cement should not be

more than 2250cm^3/g of cement or 160cm^3/g of cement. It found by air permeability and turbidiamter method respectively.

6.1.2 Water consistency test:-

For preparing the test for setting time soundness compressive strength of cement. The test quantity of water required to produced a cement paste of standard or normal consistency which will permit the vicat plunger 10mm diameter and 10-50mm in length to penetrate to a point 5-7cm from the bottom of the vicat mould when the cement the cement paste is tested with 2-5 minute after it is through mixed with the help of vicat apparatus describe.

6.2 Vicat apparatus:-

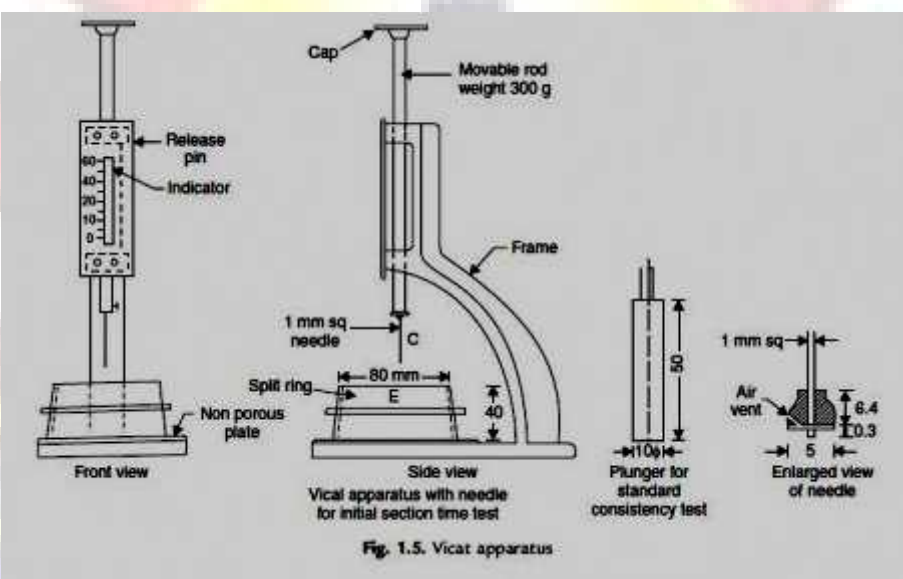


Fig. 1.5. Vicat apparatus

It consist of metal frame having a moveable rod with a cap at the top and a plunger is total weight of movable rod along with cap and attached cement is limited that is up to 300gms. It is provided with a free vertical scale when is granulated from 0-40mm in direction. It is also provided with hollow conical type mould of depth and having top mould it held in position on glass plate. The whole apparatus is made either steel or alumina.

To prefer this test about 400gms of sieved cement through 9o micron sieve is taken. To this 25% (100gms) of water by with is added in non pours vessel mixed

thoroughly about 3-5 minutes the paste is than filled into vicat mould place on non porous vessel moving it level to the top mould by level scale care should be taken that the time of gauging shall less than 3 min. and not more than 5 min. for filling. The mould is either taken slightly or a base of the cement paste is made and test in hand to expel in air , the filled up mould is placed on the base plate of the apparatus centrally flow the module rode to which plunger is attached. The bottom surface of the plunger is thought in contact with the surface of cement paste and the reading on the scale is taken. The rod is than quickly released without any jerk and the penetration of noted. If the rod penetrate into the paste by 33mm to 35 mm or 5-7 mm from the bottom of the mould the paste is said to be form consistency otherwise trial paste should bee made with varying quantities of water and test is repeated as above till the desired penetration is obtained 5-7 mm from the bottom.

Thus the percentage of water necessary or making a paste of normal consistency is found.

Let, Weight of cement taken= w

Weight of water taken= W

Penetration 5-7 mm from the bottom then penetration of water for normal consistency =

$$P\ (\%) = \frac{W}{w} X100$$

It varies from 25-34%.

6.2.1 Initial and final setting time:-

This test is done to check the initial and final setting time of cement. The initial setting time is read for various operations like mixing, transportation, placing and compaction of cement mortar or concrete.

The final setting time is determined to final that after laying the mortar or concrete hardening should be rapid so that the structure may be made in use as early as possible.

6.2.2 Determination of initial setting time:-

The time elapsed when the water the water is added to the cement and the time at which the standard initial setting time needle fails to pass the test block by arith 5-7mm from the bottom is called initial setting time.

Methods: -On this test 400g of sieved cement is taken and water is added to it at the rate of 0.85xP% the weight of the cement at time of adding water the stop watch also started. The prepared test block is placed under the rod, now fettled with a needle. It is brought in contact with the top surface of the paste in the mould and reading on the scale is noted after 15 minutes needles released. In the begins the needle will completely pierce the test block an it will be observed from the final reading on the scale. The procedure is repeated the care should be taken that each time the needle should be cleaned and released at a new place.

Find time from the stop watch and find reading from the needle is allowed to peace in paste scale should be recorded continuously. The time thus recorded shall be thaw initial setting time.

This test is preformed at the same temperature and relative humidity as in the case of consistency.

6.2.3 Determine of final setting time:-

Thetime elapsed when the water is add in to the cement till the slandered final setting time needle makes only on impression on the test block and fail to do so is called final setting time.

Method: - In this case the initial setting time needle replaced by the final setting time needle. It is replaced on the top surface of the mould at regular interval and the time is recorder .when the cement is finally set the needle will only make impression and the collar will foul to do so care must be taken to cleaned the needle each time and needle should be released shall be the final setting time

The same temperature precaution should be taken as in case of consistency test.

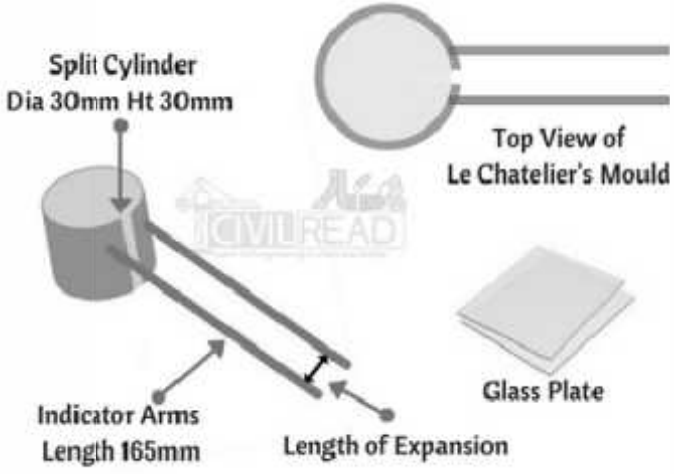
National	Ordinary	Rapid hardening	Low heat
Initial setting time less than	30 min	30 min	60 min
Final setting time less than	10 hrs.	10 hrs.	10 hrs.

6.3 Soundness test or constancy of volume test:-

This test is performed to determine the present of uncombined lime in cement in the cement if uncombined lime is present in the cement them, during the setting action it might shake causing increase in volumeand will cause the development of cracks in structure these cracks are objectionable as they deteriorate the structure

Cement is under go large change in volume is said to be unsound .Soundness of cement it judged.

6.3.1 Le- chateliers Apparatus:-



It consists of a small split cylinder of brass 0.5 mm thick 30 mm internal diameterand 30 mm in height. On other side of two split are attached two indicator with pointed and length of there indicator up to the centre of the cylinder is 165mm. A cement paste made by adding 0.78% of water is prepared with 100g of cement

Le-chateliers apparatus is placed on a glass plate and the cement paste is filled up to the top .It is covered with another glass plate placed at top and the hole combination is immediately immersed in water for 24hour to avoids shrinkage during setting .It is then taken out and the distanced between the tips is measured . The cylinder is immersed in water is through to boiling point is 30minute and kept boiling fort one hour cylinder is removed and allowed to cool. Again the distance between the tips is measured the difference between two reading which should not exceed 10m for cement in which the slaking of free lime take place by aerating cement for 7 day bat a humidity of 50.80% .The expansion should not be greater then 5mm .

6.4 Compressive strength test:-

This test is done to know the solubility of cement for developing required compressive strength of the concrete and mortar to perform this test cement and standard sand is mixed in 1:3 to x gram of cement 3x g standard sand is mixed. To this mixture 4x g add 0.4v g of water or P/4 +3 of combined weight of cement and sand. (where P = percentage of the water required to make cement paste standard consistency) from a mixture of cement, sand and water make 6 cube of the side 70.6mm to perform this test each cube must be made separately and mixed the material separately. Nearly 185g of the cement, 555g of sand and 74g of water to make cube. The cubes are made in wooden mould. The moulds having cement mortar are placed than cubes are taken out from the mould and then immerse in water. 3 cubes are then tested in compression testing machine after three days. 3 cubes are tested after 7 days note of loading during should be apply 350kg/cm^2 as per the highest specification, compressive strength should not be less than 150kg/cm^2 175 kg/cm^3 after 7 days to of bottom and top of cube.