

CONCRETE TECHNOLOGY
TWO MARK QUESTION AND ANSWERS
UNIT-I
CONSTITUENT MATERIALS

1. What is meant by Surkhi?
Surkhi is fine powdered under burnt bricks. It is also known as artificial pozzolona
2. Define hydration of cement?
Cement in dry state has no bonding property. When mixed with water react Chemically and becomes a bonding agent. These reactions are called hydration.
3. Define setting of cement
When water is added to cement, hydration takes place immediately as it continuous, cement paste which is plastic becomes stiff and rigid known as setting of cement.
4. What are pozzolonas?
These are siliceous materials which, while having no cementations values within themselves, will chemically react with calcium hydroxide at ordinary temperature and in the presence of moisture to form compounds possessing cementitious properties.
5. Name any 2 natural pozzolonas.
Clay and shales, opalinc cherts, diatomaceous earth, volcanic tuffs and pumicites.
6. Name any 2 artificial pozzolonas.
Surkhi, fly ash, blast furnace slag, silica fume, rice husk ash, metakaoline.
7. What is natural cement?
Natural cement is manufactured by burning and then crushing the natural cement stones. Natural cement stones are such stones which contain 20 to 40% of argillaceous matter i.e. clay, and remaining content mainly calcareous matter which is either calcium carbonate alone or a mixture of calcium carbonate and magnesium carbonate.
8. What is artificial cement?
Artificial cement is manufactured by burning approximately proportioned mixture of calcareous and argillaceous materials at a very high temperature and then grinding the resulting burnt mixture to a fine powder.
9. What is the function of gypsum in the manufacture of cement?
In order to delay the setting action of cement, when mixed with water, a little percentage of gypsum is added in the clinker before grinding them to fine powder.
10. What is known as clinker?
Artificial cement is manufactured by burning approximately proportioned mixture of calcareous and argillaceous materials at a very high temperature and then grinding the

resulting burnt mixture to a fine powder. The burnt mixture of calcareous and argillaceous matter is known as clinker.

11. What are the constituents of ordinary cement?

Alumina or clay, silica, lime, iron oxide, magnesia, sulphur trioxide, Alkalies, calcium sulphate (gypsum).

12. What are the harmful constituents of cement?

Alkalies which are oxides of potassium and sodium, and magnesium oxide are the harmful constituents of cement.

13. What are ball mills?

Ball mills are used for grinding the clinkers. The ball mills consist of 2 to 2.5m diameter steel cylinder. The clinkers to be ground are fed into the cylinder and the cylinder is rotated about its horizontal axis to carry out the grinding action.

14. What are the types of cement?

Ordinary Portland cement, rapid hardening cement, low heat cement, blast furnace slag cement, sulphate resistant cement, air entraining cement, white and coloured cement, high alumina cement, pozzolanic cement, super sulphate cement, expansive cement, quick setting cement, water repellant cement, water proofing cement.

15. What are the 2 methods of manufacture of cement

Dry process

Wet process

16. Define mortar.

The mortar is a paste like substance prepared by adding required amount of water to a dry mixture of sand or fine aggregate with some binding material like clay, lime or cement.

17. Define lime mortar.

If lime is used as a binding material, the resulting mortar is known as lime mortar.

18. Define mud mortar.

When clay is used as a binding material, the resulting mortar is known as mud mortar

19. What is known as bulking of sand?

Bulking of sand means increase in its volume. Fine aggregates or sands, increase in volume when they possess some moisture. Bulking is due to formation of a thin film of water around the fine aggregate or sand particles. Thickness of water film goes on increasing with more and more moisture and consequently increase in volume continues. But after certain percentage of water, volume of sand starts decreasing with increasing

amount of water. At certain percentage of water, increase in volume completely vanishes and volume occupied by sand becomes equal to the volume of dry sand.

20. What are the types of mortars?

- Mud mortar
- Lime mortar
- Gauged mortar

21. What is meant by grading of aggregates?

Grading of aggregate means particle size distribution of the aggregate. If all the particle of an aggregate were of one size, more voids will be left on the aggregate mass. Properly graded aggregate produces dense concrete and needs smaller quantities of fine aggregate and cement. Grading determines the workability of the mix, which controls segregation, bleeding, water-cement ratio, handling, placing, and other characteristics of the mix.

22. What are the methods of proportioning of concrete mixes?

- Arbitrary standard method
- Minimum voids method
- Fineness Modulus method
- Maximum density method

23. Define Abram's water cement law.

According to Abram's water cement law, the strength of concrete depends on the water cement ratio used.

24. Define bleeding.

The tendency of water to rise to the surface of freshly laid concrete is known as bleeding.

25. Define laitance.

Water rising to the surface during bleeding carries with it, particles of sand and cement, which on hardening form a scum layer known as laitance.

26. What are the steps adopted to control bleeding.

- By adding more cement
- By using more finely ground cement
- By using little air entraining agent
- By increasing finer part of fine aggregate
- By properly designing the mix and using minimum quantity of water.

27. Define Segregation.

The tendency of separation of coarse aggregate grains from the concrete mass is called segregation.

28. What are the methods adopted to avoid segregations of concrete.

Addition of little air entraining agents in the mix.
Restricting the amount of water to the smallest possible amount.
Concrete should not be allowed to fall from larger heights.

29. Define workability.

Workability is that property of concrete which determines the amount of internal work necessary to produce full compaction. It is a measure with which concrete can be handled from the mixer stage to its final fully compacted stage.

30. What are the factors affecting workability.

Quantity of water in the mix
Proper grading of the aggregate mix
Ratio of fine aggregate and coarse aggregate
Maximum size of coarse aggregates
Method of compaction of concrete

31. What are the factors affecting proportioning of concrete mixes?

Water cement ratio
Cement content
Temperature
Age of concrete
Size, shape and grading of aggregate
Curing

32. Define mixing of concrete.

The process of mixing cement, water, fine aggregate and coarse aggregate in suitable proportion is known as mixing of concrete.

33. What are the methods of consolidation or compaction of concrete?

Hand compaction
Machine compaction – i) Internal vibrators
ii) Form vibrators
iii) Surface vibrators

34. Define curing of concrete.

Curing is the operation by which moist conditions are maintained on finished concrete surface, to promote continued hydration of cement.

35. What are admixtures?

Admixtures are ingredients other than cement, fine aggregate and coarse aggregate to improve the quality of concrete. The addition of an admixture may improve the concrete with respect to its strength, hardness, workability, water resisting power etc.

36. Name the types of joints in concrete.

Construction joints 2. Expansion joints
Contraction joints 4. Working joints

37. What are the types of concrete used?

Plum concrete, light weight concrete, air-entrained concrete, no-fines concrete, vacuum concrete, water-proof concrete, reinforced cement concrete, pre-stressed concrete, cellular or aerated concrete, foamed concrete, pre-cast concrete.

38. Mention the test adopted to test the properties of cement in laboratories?

- a. Fineness
- b. Consistency test
- c. Setting time
- d. Soundness
- e. Compressive strength

39. Mention the test adopted to test the properties of cement in field?

- a. Open the bag and take a good look at the cement, there should not be any visible lumps
- b. Thrust your hand into the cement bag should feel cool feeling
- c. Take a pinch of cement and feel between the fingers. It should give a smooth feeling not a gritty feeling
- d. Take a hand full of cement and throw it on a bucket full of water, the particle should float for sometime before they sink.

40. Mention the test adopted to test the quality of water?

- a. Determination of acids and alkalis
- b. Determination of total solids.

16 MARKS WITH ANSWERS

1. Describe the process of manufacture of cement by Dry process.

MANUFACTURING PROCESS OF CEMENT

The following raw materials are basically required for manufacturing of cement:

Calcareous Materials

The materials which contain calcium or lime as their major constituent are known as calcareous materials. The various calcareous materials used in the manufacture of cement are lime stone, marl, chalk, shells, etc. These materials provide the required proportion of lime to the cement.

Argillaceous Materials

The argillaceous materials contain alumina as their major constituent. The various argillaceous materials used in the manufacture of cement are shale, clay, laterite, etc. These materials provide the required proportion of silica, alumina, oxide of iron, etc. to the cement.

The process of manufacture of cement consists of grinding the raw materials (calcareous and

argillaceous materials) mixing them intimately in certain proportions and burning them in a kiln at a temperature of about 1500°C at which the material sinters and fuses to form nodular shaped clinker. The clinker is cooled and ground to a fine powder with addition of about 2 to 3 % of gypsum. The product obtained by this procedure is called as Portland cement. There are two processes known as Wet and Dry processes depending upon whether the mixing and grinding of raw materials is done in wet or dry condition. The wet process requires more fuel as slurry contains about 35-50 % water. The dry process requires less fuel as materials are already in dry state.

Wet Process

In this process, the limestone is crushed to smaller fragments and then it is taken to a ball or tube mill where clay or shale is mixed with it and ground to a fine consistency of slurry with the addition of water. The slurry is pumped to slurry tanks where it is kept in an agitated condition by means of rotating arms with chains to prevent setting of limestone and clay particles. At this stage, the chemical composition of slurry is adjusted as necessary. The corrected slurry is stored in storage tanks and kept in homogeneous condition by the agitation of slurry.

The corrected slurry is injected at the upper end of a rotary kiln. Rotary kiln is formed of steel tubes. The diameter of rotary kiln varies from 3 m to 8 m and length varies from 30 m to 200 m. The kiln is supported at intervals by columns of masonry or concrete. It is laid at a gradient of about 1 in 25 to 1 in 30. The refractory lining is provided on the inside surface of rotary kiln. It is so arranged that the kiln rotates at about one to three revolutions per minute about its longitudinal axis. The burning is carried out in this rotary kiln.

The hot gases or flames are forced through the lower end of the kiln. The portion of the kiln near its upper end is known as dry zone and in this zone, the water of slurry is evaporated. As the slurry gradually descends, there is rise in temperature and in the next section of kiln, the carbon dioxide from slurry is evaporated. The small lumps, called as nodules, are formed at this stage. These nodules then gradually roll down passing through zones of rising temperature and ultimately reach to the burning zone, where temperature is about 1500°C . In burning zone, the calcined product is formed and nodules are converted into small hard dark greenish blue balls, which are known as clinkers. The size of clinkers varies from 3 mm to 20 mm and they are very hot when they come out of burning zone of kiln. The temperature of clinker at the outlet of kiln is nearly 1000°C . The clinker drops into a rotary cooler where it is cooled under controlled conditions.

The clinkers as obtained from the rotary kiln are finely grounded in ball mills and tube mills. During grinding a small quantity, about 2 to 3% of gypsum is added. If gypsum is not added, the cement would set as soon as water is added. The gypsum controls the initial setting time of cement. The gypsum acts as a retarder and delays the setting action of cement. Thus, gypsum permits cement to be mixed with the aggregates and to be placed in position.

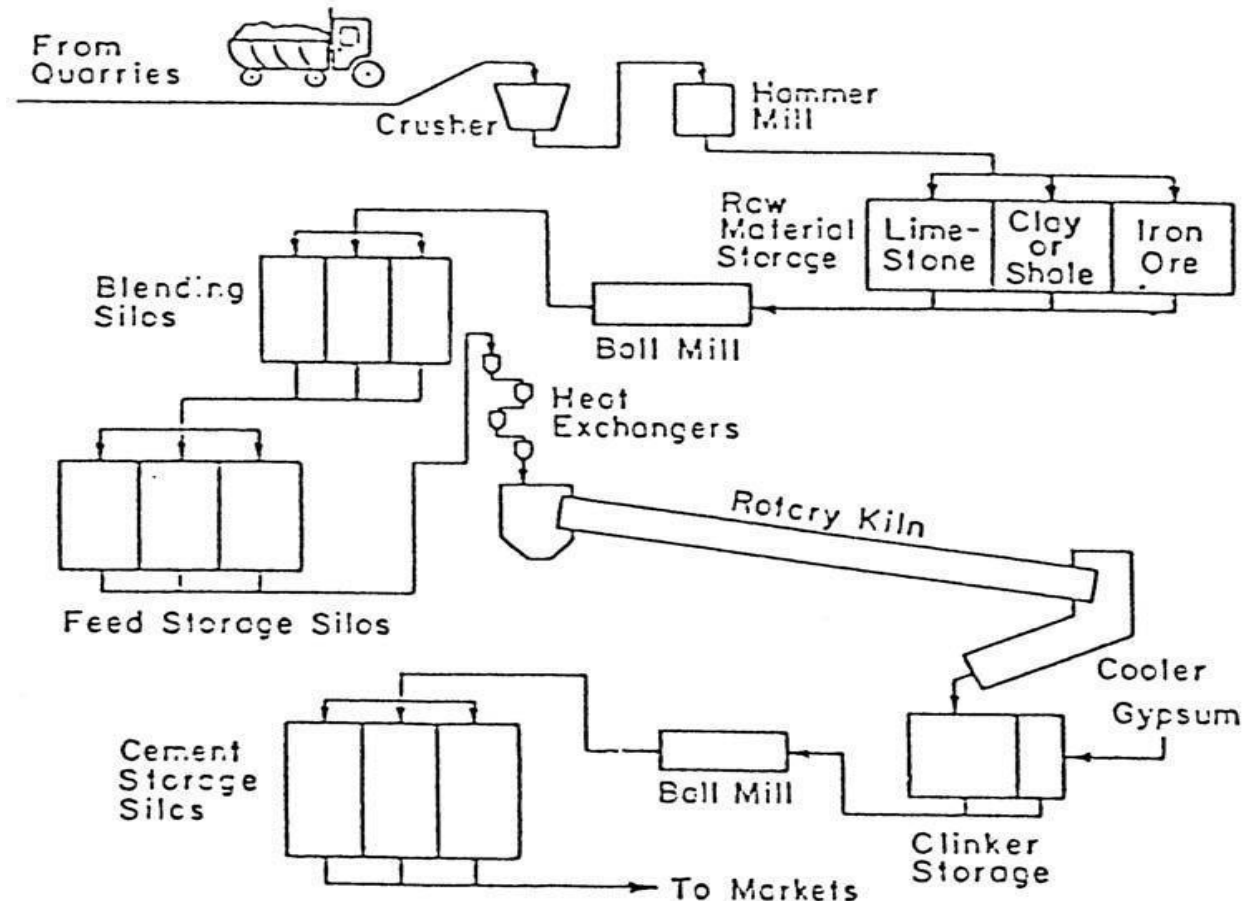
A ball mill consists of several compartments charged with progressively smaller hardened steel balls. The particles crushed to the required fineness are separated by currents of air and taken to storage silos from where the cement is bagged or filled into barrels for bulk supply to dams, bridges or other large work sites.

Dry Process:

In the dry process, the raw materials are crushed dry and fed in correct proportions into a grinding mill. The raw materials are dried and crushed into a very fine powder. The dry powder is called raw meal. The dry powder is further blended and corrected for its right composition and mixed by using compressed air. The aerated powder tends to behave almost like liquid and

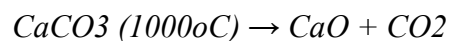
in about one hour of aeration a uniform mixture is obtained. The sieved blended meal fed into a rotating disc called as granulator. The pellets of blended meal are formed by adding water approximately 12% to permit air flow for exchange of heat for chemical reactions and conversion of the same into clinker.

The dry process is economical. In this method, equipment used is comparatively smaller. The consumption of coal in this method is very low as compared to wet process. In case of mixing of raw materials by dry process, the raw mix is formed and in case of mixing of raw materials by wet process, the slurry is formed. The remaining operations, e.g. burning and grinding are same as that of the wet process.

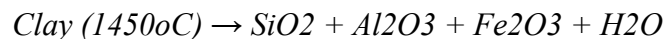


The raw materials used for manufacturing Portland cement are limestone, clay and Iron ore.

a) Limestone (CaCO_3) is mainly providing calcium in the form of calcium oxide (CaO)



b) Clay is mainly providing silicates (SiO_2) together with small amounts of $\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$



c) Iron ore and Bauxite are providing additional aluminium and iron oxide (Fe_2O_3) which help the formation of calcium silicates at low temperature. They are incorporated into the raw mix.

Limestone		3	$\text{CaO} \cdot \text{SiO}_2$
High temperature	2		$\text{CaO} \cdot \text{SiO}_2$
Clay		3	$\text{CaO} \cdot \text{Al}_2\text{O}_3$
(1,450 °C)			
Iron Ore, Bauxite	4		$\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$

2. Describe the hydration reaction of important Bogue compounds indicating the products of hydration.

The setting and hardening of concrete are the result of chemical and physical processes that take place between Portland cement and water, i.e. hydration. To understand the properties and behaviour of cement and concrete some knowledge of the chemistry of hydration is necessary.

A) Hydration reactions of pure cement compounds

The chemical reactions describing the hydration of the cement are complex. One approach is to study the hydration of the individual compounds separately. This assumes that the hydration of each compound takes place independently of the others.

I. Calcium silicates

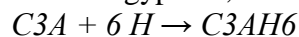
Hydration of the two calcium silicates gives similar chemical products, differing only in the amount of calcium hydroxide formed, the heat released, and reaction rate.



The principal hydration product is $C_3S_2H_4$, calcium silicate hydrate, or C-S-H (non-stoichiometric). This product is not a well-defined compound. The formula $C_3S_2H_4$ is only an approximate description. It has amorphous structure making up of poorly organized layers and is called glue gel binder. C-S-H is believed to be the material governing concrete strength. Another product is CH - $Ca(OH)_2$, calcium hydroxide. This product is a hexagonal crystal often forming stacks of plates. CH can bring the pH value to over 12 and it is good for corrosion protection of steel.

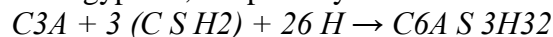
II. Tricalcium aluminate

Without gypsum, C_3A reacts very rapidly with water:



The reaction is so fast that it results in flash set, which is the immediate stiffening after mixing, making proper placing, compacting and finishing impossible.

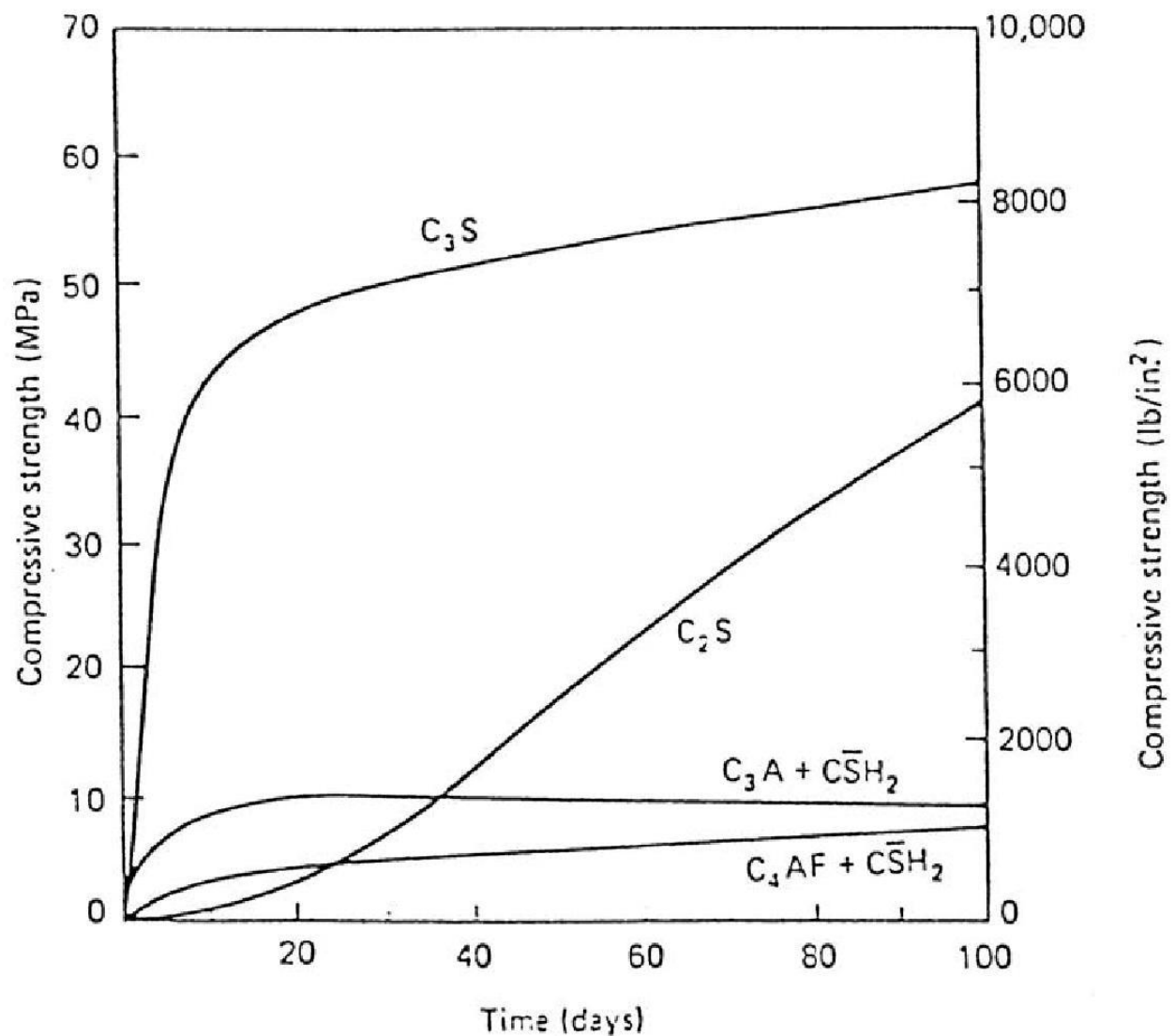
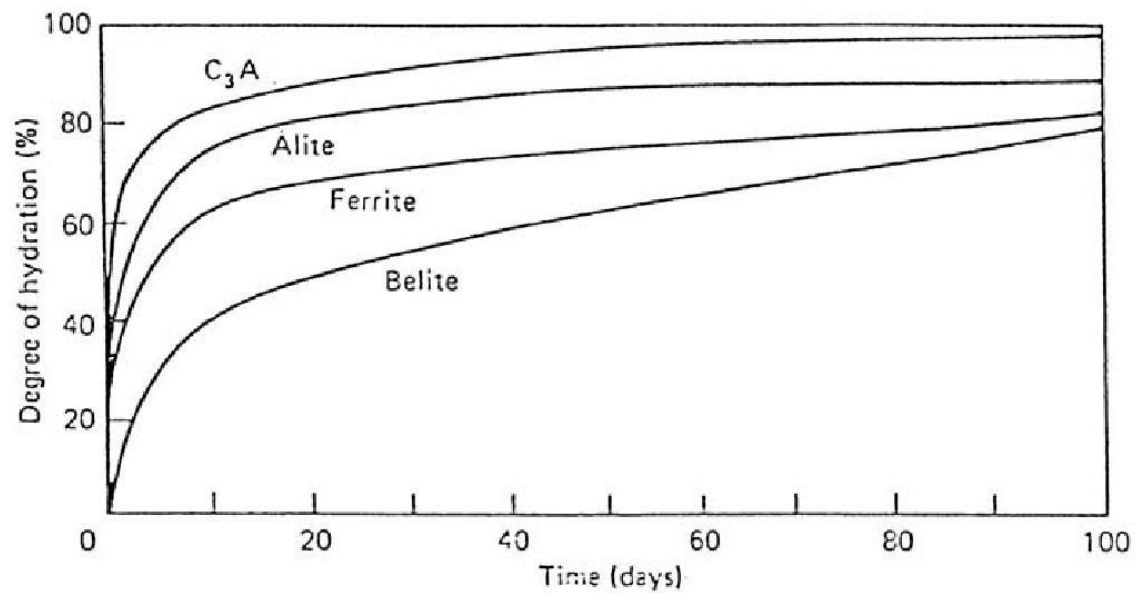
With gypsum, the primary initial reaction of C_3A with water is :



The 6-calcium aluminate trisulfate-32-hydrate is usually called ettringite. The formation of ettringite slows down the hydration of C_3A by creating a diffusion barrier around C_3A . Flash set is thus avoided. Even with gypsum, the formation of ettringite occurs faster than the hydration of the calcium silicates. It therefore contributes to the initial stiffening, setting and early strength development. In normal cement mixes, the ettringite is not stable and will further react to form monosulphate ($C_4A S H_{18}$).

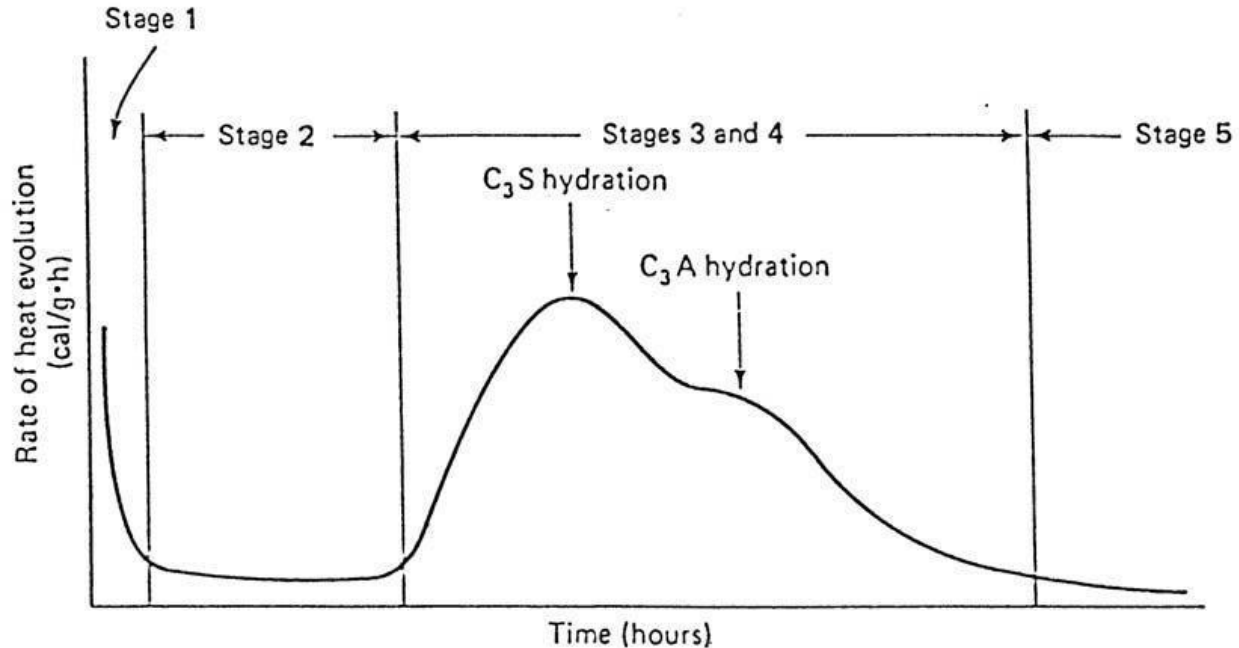
B) Kinetics and Reactivities

The rate of hydration during the first few days is in the order of $C_3A > C_3S > C_4AF > C_2S$.
Their reactivities can be observed in the following figures.



C) Calorimetric curve of Portland cement

A typical calorimetric curve of Portland cement is shown in the following figure. The second heat peaks of both C₃S and C₃A can generally be distinguished, although their order of occurrence can be reversed.



From the figure, five stages can be easily identified. Since C₃S is a dominating component in cement, the five stages above can be explained using the reaction process of C₃S by the following table.

Reaction Stage	Kinetics of Reaction	Chemical Processes	Relevance to Concrete
1. Initial hydrolysis	Chemical control; rapid	Initial hydrolysis; dissolution of ions	-
2. Induction period	Nucleation control; slow	Continued dissolution of ions	Determines initial set
3. Acceleration	Chemical control; rapid	Initial formation of hydration products	Determines final set and rate of initial hardening
4. Deceleration	Chemical and diffusion control; slow	Continued formation of hydration products	Determines rate of early strength gain
5. Steady State	Diffusion control; slow	Slow formation of hydration products	Determines rate of later strength gain

On first contact with water, calcium ions and hydroxide ions are rapidly released from the surface of each C3S grain; the pH values rises to over 12 within a few minutes. This hydrolysis slows down quickly but continues throughout the induction period. The induction (dormant) period is caused by the need to achieve a certain concentration of ions in solution before crystal nuclei are formed for the hydration products to grow from. At the end of dormant period, CH starts to crystallize from solution with the concomitant formation of C-S-H and the reaction of C3S again proceeds rapidly (the third stage begin). CH crystallizes from solution, while C-S-H develops from the surface of C3S and forms a coating covering the grain. As hydration continues, the thickness of the hydrate layer increases and forms a barrier through which water must flow to reach the unhydrated C3S and through which ions must diffuse to reach the growing crystals. Eventually, movement through the C-S-H layer determines the rate of reaction. The process becomes diffusion controlled.

D) Setting and Hydration

Initial set of cement corresponds closely to the end of the induction period, 2-4 hours after mixing. Initial set indicates the beginning of forming of gel or beginning of solidification. It represents approximately the time at which fresh concrete can no longer be properly mixed, placed or compacted. The final set occurs 5-10 hours after mixing, within the acceleration period. It represents approximately the time after which strength develops at a significant rate. In practice, initial and final set are determined in a rather arbitrary manner with the penetration test. While the determination of initial and the final set has engineering significance, there is no fundamental change in hydration process for these two different set conditions.

3. Discuss About Cement and Its Types

Types of Cement

- (a) Ordinary Portland Cement
 - (i) Ordinary Portland Cement 33 Grade– IS 269: 1989
 - (ii) Ordinary Portland Cement 43 Grade– IS 8112: 1989
 - (iii) Ordinary Portland Cement 53 Grade– IS 12269: 1987
- (b) Rapid Hardening Cement – IS 8041: 1990
- (c) Extra Rapid Hardening Cement – –
- (d) Sulphate Resisting Cement – IS 12330: 1988
- (e) Portland Slag Cement – IS 455: 1989
- (f) Quick Setting Cement – –
- (g) Super Sulphated Cement – IS 6909: 1990
- (h) Low Heat Cement – IS 12600: 1989
- (j) Portland Pozzolana Cement – IS 1489 (Part I) 1991 (fly ash based)
- (k) Air Entraining Cement
- (l) Coloured Cement: White Cement – IS 8042: 1989
- (m) Hydrophobic Cement – IS 8043: 1991
- (n) Masonry Cement – IS 3466: 1988
- (o) Expansive Cement – –
- (p) Oil Well Cement – IS 8229: 1986
- (q) Rediset Cement – –
- (r) Concrete Sleeper grade Cement – IRS-T 40: 1985
- (s) High Alumina Cement – IS 6452: 1989
- (t) Very High Strength Cement

Ordinary Portland cement

These are available in many grades, namely 33 grade, 43 grade, 53 grade etc. If 28 day strength is not less than 33N/mm^2 then it is called 33 grade cement. If 28 day strength is not less than 43N/mm^2 then it is called 43 grade cement. Use of higher grade cement offers many advantages for making stronger concrete. Although they are little costlier than the low grade cement, they offer 10 to 20% saving in the cement consumption and also they offer many other hidden benefits. One of the most important benefits is the faster rate of development of the strength. Used for the ordinary works.

Rapid hardening cement

As the name indicates it develops the strength rapidly. This cement develops at the age of three days, the same strength as that expected of Ordinary Portland cement at seven days. The rapid rate of development of the strength is due to the higher fineness and higher C_3S and lower C_2S . Used for the Road repair work, Early removal of the formwork, Cold weather concrete.

Sulphate resisting cement

Ordinary Portland cement is susceptible to the sulphate attack. Sulphate reacts with the free calcium hydroxide to form calcium sulphate and the hydrate of calcium aluminate to form calciumsulphoaluminates, the volume of which is approximately 227% of the volume of the original aluminates. Their expansion results in cracks. To remedy this the use of the cement with the low C_3A is recommended. Such cement with the low C_3A content is known as the Sulphate resisting cement. Used for Marine condition, Foundation in soil infested with sulphates, Concrete used for the fabrication of pipes etc.

Quick setting cement

As the name indicates this type cement sets quickly. This property is brought out by reducing the gypsum content at the time of the clinker grinding. This cement is required to mix, place and compacted very easily. Used for the underwater construction.

Super sulphated cement

Super sulphated cement is manufactured by grinding together a mixture of 80 to 85 % of the granulated slag, 10 to 15 % of the hard burnt gypsum, and 5% Portland cement clinker. This cement is high sulphate resistant. Because of this property it is used for the Foundation where chemically aggressive condition exists.

Low heat cement

Hydration of the cement is an exothermic process which liberates high quantity of the heat. This will cause the formation of the cracks. A low heat evolution is brought about by Reducing the C_3A and C_3S which are the compounds evolving the greater heat of hydration and increasing C_2S . Rate of evolution of heat of hydration will therefore be less and evolution of heat will extend over a large period. Therefore Low heat cement rate of the development of the strength is very low. Used for the mass construction works.

Portland Pozzolona cement

Portland Pozzolona cement is manufactured by intergrinding OPC clinker with 10 to 25% of the Pozzolona material. Portland Pozzolona cement produces low heat of hydration and offers greater resistance to the attack of the aggressive water than OPC. Used for the mass construction works, marine and hydraulic works.

Air entraining cement

This cement is manufactured by mixing small amount of the air entraining agent with the OPC clinker at the time of grinding. At the time of mixing this cement will produce air bubbles in the body of the concrete which will modify the properties of the plastic concrete with respect to the workability, segregation and bleeding.

Coloured cement

Coloured cement consists of the Portland cement with the 5 to 10 % of the pigment. The cement and the pigment is grinded together.

Hydrophobic cement

This cement is manufactured by grinding the OPC clinker with the water repellent film forming substance. The water repellent film formed around each grain of the cement reduces the deterioration of the cement during the long storage, transportation and unfavorable conditions. Water repellent film formed will also improve the workability

Expansive cement

Concrete formed using the OPC shrinks during the setting due to the loss of the water. In grouting works if concrete shrinks the purpose for which the grout is used will be to some extent defeated. A slight expansion with time is advantageous for the grouting works. This type of the cement which does not suffer an overall change in the volume on drying is known as the Expansive cement. This cement is manufactured by using an expansive agent and a stabilizer.

Cement is a mixture of various chemical compounds. All ingredients have their own specific roles to play and impart different properties to cement. Ratio of all ingredients is required to be maintained to get the desired quality.

4.Describe in detail about the test on cement.**Density**

The density is the fundamental physical characteristic of the material. Density is defined by mass of a unit volume of a material substance, expressed as kilograms per cubic metre.

The mass can be determinate by scale (usually analytic balance), to determine volume of loose material is more difficult. For determination of cement density the pycnometric method is used.

Determination of Density by Pycnometric Method.

Pycnometric method is indirect method; the measuring of volume is substituted by several weighing of

material in pycnometer. Pycnometer is glass (or metal) bottle with a tight fitting stopper having a small hole in its centre. The hole in the stopper allows excess liquid to escape and the volume of the liquid in the pycnometer is always the same. Density by pycnometry is calculate from basic formula:

Testing procedure

_weight mass of the empty pycnometer with stopper - m fill the pycnometer with measuring liquid. Replace stopper carefully, allowing excess liquid to escape through the hole in the stopper. Make sure there are no bubbles. Dry outside and weight fill the dry, empty pycnometer about 1/3 full of the sample. Closed it and weight again add measuring liquid to the sample. Fill pycnometer about 2/3 full. Mix up with caution and boil the pycnometer for 2 hours. After cooling refill with the liquid, closed the pycnometer and weight calculate the mass of the sample from formula: the density from the basic formula.

Fineness

Standard EN 196-6 describes two methods of determining the fineness of cement:

sieving method**air permeability method (Blaine)**

Sieving Method

This method serves only to demonstrate the presence of coarse cement particles. This method is primarily suited to checking and controlling production process. The fineness of cement is measured by sieving it on standard sieves. The proportion of cement of which the grain sizes are larger than the specified mesh size is thus determined.

Air Permeability Method (Blaine Method)

The fineness of cement is measured as specific surface. Specific surface is expressed as the total surface area in square metres of all the cement particles in one kilogram of cement. The higher the specific surface is, the finer cement will be. Principle of air permeability method is in observing the time taken for a fixed quantity of air to flow through compacted cement bed of specified dimension and porosity. Under standardised conditions the specific surface of cement is proportional to the flow of air through the compacted cement bed. The number and size range of individual pores in the specified bed are determined by the cement particle size distribution which also determines the time for the specified air flow. The method is comparative rather than absolute and therefore a reference sample of known specific surface is required for calibration of the apparatus. A bed of cement is prepared in special permeability cell and has exact porosity $e = 0.500$ weight quantity of cement. The weight of the cement is calculated from

Testing procedure

Place the perforated disc on the ledge at the bottom of the cell and place on it a new filter paper disc. Place the weighed quantity of cement, m in the cell. Place a second new filter paper disc on the levelled cement. Insert the plunger and press it gently but firmly until the lower face of the cap is in contact with the cell. Slowly withdraw the plunger, rotate it through 90° and press once again. The bed is now compacted and ready for the permeability test. Test is performed on the Blaine apparatus. It is practically a manometer in the U-tube form. One arm of the manometer is provided at the top with conical socket to form an airtight fit with the conical surface of the cell. The same arm has four etched lines M to Mand T-joint, which lead to an airtight stopcock beyond which is attached aspiration rubber bulb. Manometer is filled to the level of the lowest etched line with non-volatile, non-hygroscopic liquid of low viscosity and density (such as dibutylphthalate or light mineral oil). Insert the conical surface of the cell into the socket at the top of the manometer. Open the stopcock and with gentle aspiration raise the level of the manometer liquid to that of the highest etched line. Close the stopcock and the manometer liquid will begin to flow. Start the timer as the liquid reaches the second etched line and stop it when the liquid reaches the third etched line. Record the time, t , and the temperature, T . The procedure repeats three times. Calculate three values of the specific surface and the mean of them.

Determination of Setting Time

The setting time is determined by observing the penetration of needle into cement paste of standard

consistence until it reaches a specified value. The laboratory shall be maintained at a temperature of $20 \pm 2^\circ\text{C}$ and a relative humidity of not less than 65 %.

Standard Consistence Test

Cement paste of standard consistence has a specified resistance to penetration by a standard plunger.

The water required for such a paste is determined by trial penetrations of pastes with different water

contents. Content of water is expressed as percentage by mass of the cement. Vicat apparatus (see Fig.:31) with the plunger is used for the test. The plunger shall be of noncorrodible metal in the form of a right cylinder of 50 ± 1 mm effective length and of $10,00 \pm 0,05$ mm diameter. The total mass of moving parts shall be 300 ± 1 g. Part of the Vicat apparatus is the mould from hard rubber (of truncated conical form) on the glass base-plate.

Procedure

calibrate the Vicat apparatus by lowering the plunger to rest on the base-plate to be used and adjusting the pointer to read zero on the scale. Raise the plunger to the stand-by position. weight 500 g of cement (to the nearest 1g). Weight a quantity of water (distilled or deionized), e.g.125 g, in the mixer bowl or measure the water from the graduated cylinder into the mixer bowl. add the cement carefully to the water in order to avoid loss of water or cement. The time of addition shall be not less than 5 s nor more than 10 s. Note the time of completion of the addition as zero time, from which later measurements of time shall be made. start the mixer immediately and run at low speed. stop the machine after 90 s for 15 s during which remove with a suitable scraper any paste adhering to the bowl outside the mixing zone and return it to the mix. Restart the machine and run at low speed for further 90 s. The total mixer running time shall be 3 min. transfer the paste immediately to the mould and fill it to excess. Remove the excess gently and make a smooth upper surface immediately after levelling the paste, transfer the mould and base-plate to the Vicat apparatus and position it centrally under the plunger. Lower the plunger gently until it is in contact with the paste. Pause in that position for between 1s and 2s. Than release the moving part quickly and allow the plunger to penetrate vertically into the centre of the paste. The release of the plunger shall occur 4 min after zero time. Read the scale when penetration has ceased or 30 s after the release of theplunger, whichever is the earlier. record the scale reading, which indicates the distance between the bottom face of the plunger and the base plate. Clean the plunger immediately after each penetration. repeat the test with pastes containing different water contents until one is found to produce a distance between plunger and base-plate of 6 ± 1 mm. Record the water content of that paste to the nearest 0,5% as the water for standard consistence.

Setting Time Test

Cement paste of standard consistence is used for this test. Vicat apparatus is used, but the plunger is replaced by the steel needle in the form of a right cylinder of effective length 50 ± 1 mm and diameter $1,13 \pm 0,05$ mm. The total mass of moving part is 300 ± 1 g.

Procedure

calibration of Vicat apparatus with the needle is the same as for the apparatus with the plunger.mould, filled by paste of standard consistence and base plate transfer to the Vicat apparatus.procedure of penetration is the same as by using plunger. repeat the penetration test on the same specimen at conveniently spaced position, not less than 10 mm from the rim of the mould or from each other, at conveniently spaced intervals of time, e.g. at 10 min intervals. clean the Vicat needle after each penetration initial setting time is time measured from zero at which distance between the needle and the base-plate is 4 ± 1 mm . Record it to the nearest 5 min.final setting time is time measured from zero at which the needle first penetrates only 0,5 mm into the specimen.Automatic setting time machines are commercially available and may be used provided that they can be shown to give the same test results as the specified apparatus and procedure.

5.Describe in detail about the testing of aggregates.

Test for Determination of Flakiness Index

The flakiness index of aggregate is the percentage by weight of particles in it whose least dimension (thickness) is less than three-fifths of their mean dimension. The test is not applicable to sizes smaller than 6.3 mm. Cone Crushers. This test is conducted by using a metal thickness gauge, of the description

. A sufficient quantity of aggregate is taken such that a minimum number of 200 pieces of any fraction can be tested. Each fraction is gauged in turn for thickness on the metal gauge. The total amount passing in the gauge is weighed to an accuracy of 0.1 per cent of the weight of the samples taken. The flakiness index is taken as the total weight of the material passing the various thickness gauges expressed as percentage of the total weight of the sample taken.

Test for Determination of Elongation Index

The elongation index on an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than 1.8 times their mean dimension. The elongation index is not applicable to sizes smaller than 6.3 mm. This test is conducted by using metal length gauge of the description. A sufficient quantity of aggregate is taken to provide a minimum number of 200 pieces of any fraction to be tested. Each fraction shall be gauged individually for length on the metal gauge. The gauge length used shall be that specified in column of 4 of Table 3.18 for the appropriate size of material. The total amount retained by the gauge length shall be weighed to an accuracy of at least 0.1 per cent of the weight of the test samples taken. The elongation index is the total weight of the material retained on the various length gauges expressed as a percentage of the total weight of the sample gauged. The presence of elongated particles in excess of 10 to 15 per cent is generally considered undesirable, but no recognised limits are laid down.

Test for determination of aggregate crushing value

The “aggregate crushing value” gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. With aggregates of ‘aggregate crushing value’ 30 or higher, the result may be anomalous and in such cases the “ten per cent fines value” should be determined and used instead. The standard aggregate crushing test is made on aggregate passing a 12.5 mm I.S. Sieve

and retained on 10 mm I.S. Sieve. If required, or if the standard size is not available, other sizes upto 25 mm may be tested. But owing to the nonhomogeneity of aggregates the results will not be comparable with those obtained in the standard test. About 6.5 kg material consisting of aggregates passing 12.5 mm and retained on 10 mm sieve is taken. The aggregate in a surface dry condition is filled into the standard cylindrical measure in three layers approximately of equal depth. Each layer is tamped 25 times with the tamping rod and finally levelled off using the tamping rod as straight edge. The weight of the sample contained in the cylinder measure is taken (A). The same weight of the sample is taken for the subsequent repeat test. The cylinder of the test apparatus with aggregate filled in a standard manner is put in position on the base-plate and the aggregate is carefully levelled and the plunger inserted horizontally on this surface. The plunger should not jam in the cylinder. The apparatus, with the test sample and plunger in position, is placed on the compression testing machine and is loaded uniformly upto a total load of 40 tons in 10 minutes time. The load is then released and the whole of the material removed from the cylinder and sieved on a 2.36 mm I.S. Sieve. The fraction passing the sieve is weighed (B),

The aggregate crushing value = $BA \times 100$

where, B = weight of fraction passing 2.36 mm sieve,

A = weight of surface-dry sample taken in mould.

The aggregate crushing value should not be more than 45 per cent for aggregate used for concrete other than for wearing surfaces, and 30 per cent for concrete used for wearing surfaces such as runways, roads and air field pavements.

Test for determination of ‘ten per cent fines value’

The sample of aggregate for this test is the same as that of the sample used for aggregate crushing value test. The test sample is prepared in the same way as described earlier. The cylinder of the test apparatus is placed in position on the base plate and the test sample added in thirds, each third being subjected to 25 strokes by tamping rod. The surface of the aggregate is carefully levelled and the plunger inserted so that it rests horizontally on this surface. The apparatus, with the test sample and plunger in position is placed in the compression testing machine. The load is applied at a uniform rate so as to cause a total penetration of the plunger in 10 minutes of about: 15.00 mm for rounded or partially rounded aggregates (for example uncrushed gravels) 20.0 mm for normal crushed aggregates, and 24.0 mm for honeycombed aggregates (for example, expanded shales and slags). These figures may be varied according to the extent of the rounding or honeycombing. After reaching the required maximum penetration, the load is released and the whole of the material removed from the cylinder and sieved on a 2.36 mm I.S. Sieve. The fines passing the sieve is weighed and the weight is expressed as a percentage of the weight of the test sample. This percentage would fall within the range 7.5 to 12.6, but if it does not, a further test shall be made at a load adjusted as seems appropriate to bring the percentage fines within the range of 7.5 to 12.5 per cent. Repeat test is made and the load is found out which gives a percentage of fines within the range of 7.5 to 12.5

Load required for 10 per cent fines = $144 \times X/Y + 4$

where,

X = load in tons, causing 7.5 to 12.5 percent fines.

Y = mean percentage fines from two tests at X tons load.

Test for determination of aggregate impact value

The aggregate impact value gives relative measure of the resistance of an aggregate to sudden shock or

impact. Which in some aggregates differs from its resistance to a slow compressive load. The test sample consists of aggregate passing through 12.5 mm and retained on 10 mm I.S. Sieve. The aggregate shall be dried in an oven for a period of four hours at a temperature of 100°C to 110°C and cooled. The aggregate is filled about one-third full and tamped with 25 strokes by the tamping rod. A further similar quantity of aggregate is added and tamped in the standard manner. The measure is filled to overflowing and then struck off level. The net weight of the aggregate in the measure is determined (weight A) and this weight of aggregate shall be used for the duplicate test on the same material. The whole sample is filled into a cylindrical steel cup firmly fixed on the base of the machine. A hammer weighing about 14 kgs. is raised to a height of 380 mm above the upper surface of the aggregate in the cup and allowed to fall freely on the aggregate. The test sample shall be subjected to a total 15 such blows each being delivered at an interval of not less than one second. The crushed aggregate is removed from the cup and the whole of it is sieved on 2.36 mm I.S. Sieve. The fraction passing the sieve is weighed to an accuracy of 0.1 gm. (weight B). The fraction retained on the sieve is also weighed (weight C). If the total weight (B + C) is less than the initial weight A by more than one gm the result shall be

discarded and a fresh test made. Two tests are made. The ratio of the weight of fines formed to the total sample weight in each test is expressed as percentage.

Therefore, Aggregate Impact Value = $BA \times 100$

where, B = weight of fraction passing 2.36 mm I.S. Sieve.

A = weight of oven-dried sample.

The aggregate impact value should not be more than 45 per cent by weight for aggregates used for concrete other than wearing surfaces and 30 per cent by weight for concrete to be used as wearing surfaces, such as runways, roads and pavements.

6. Write short notes on chemical composition of cement.

The chief chemical ingredients and their proportions in ordinary cement are given below

Table : Chief Chemical Ingredients of Cement

Sl. No.	Chemical Ingredients	Formula	Commonly Used (%)	Range (%)
1..	Lime	CaO	63	60 to 67
2..	Silica	SiO ₂	22	17 to 25
3..	Alumina	Al ₂ O ₃	6	3 to 8
4..	Iron Oxide	Fe ₂ O ₃	3	0.5 to 6
5..	Magnesium	MgO	2.5	0.1 to 4
6..	Sulphur Oxide	SO ₃	1.25	1 to 3
7..	Alkalies such as Soda and Potash	Na ₂ O, K ₂ O	0.25	0.2 to 1

The functions and effects of various chemical ingredients of cement are as follows:

Lime:

Lime is the major ingredient of cement. It makes the cement sound and also provides strength to the cement. Lime in excess makes the cement unsound and causes the cement to expand and disintegrate. The deficiency of lime will decrease the strength and cause the cement to set quickly.

Silica:

Silica provides strength to the cement. Silica in excess causes the cement to set slowly.

Alumina:

Alumina lowers the clinkering temperature. It provides quick setting property to the cement. Alumina in excess weakens the strength of the cement.

Iron oxide:

Iron oxide provides colour, hardness and strength to the cement. It helps the fusion of material at lower temperature during the manufacturing of cement.

Magnesium oxide:

Magnesium oxide provides colour and hardness to the cement. Excess magnesium oxide remains in Free State and makes the cement unsound.

Sulphur trioxide:

Sulphur trioxide makes the cement sound if present in very small quantity. Excess sulphur trioxide makes the cement unsound.

Alkalies;

Alkalies may be present in a very small quantity. Alkalies in excess cause efflorescence.

CHEMICAL COMPOUNDS OF CEMENT

Chief Chemical Compounds of Cement

Sl. No	Compounds	Chemical Formula	Accepted	Range	Common
1.	Tricalcium	3CaO	C ₃	25 to 50	40
2.	Dicalcium	2CaO	C ₂	21 to 45	30
3.	Tricalcium Aluminate	3CaO Al ₂ O ₃	C ₃ A	5 to 11	11
4.	Tetra Calcium Alumino ferrite	4CaO Al ₂ O ₃ Fe	C ₄ AF	9 to 14	11
5.	Other constituents	-----	----- -	8	8

7. Write short notes on qualities of water used for manufacture of concrete

Qualities of Water

A popular yard-stick to the suitability of water for mixing concrete is that, if water is fit for drinking it is

fit for making concrete. This does not appear to be a true statement for all conditions. Some waters containing a small amount of sugar would be suitable for drinking but not for mixing concrete and conversely water suitable for making concrete may not necessarily be fit for drinking. Some specifications require that if the water is not obtained from source that has proved satisfactory, the strength of concrete or mortar made with questionable water should be compared with similar concrete or mortar made with pure water. Some specification also accept water for making concrete if the pH value of water lies between 6 and 8 and the water is free from organic matter. Instead of depending upon pH value and other chemical composition, the best course to find out whether a particular source of water is suitable for concrete making or not, is to make concrete with this water and compare its 7 days' and 28 days' strength with companion cubes made with distilled water. If the compressive strength is upto 90 per cent, the source of water may be accepted. This criteria may be safely adopted in places like coastal area of marshy area or in other places where the available water is brackish in nature and of doubtful quality. However, it is logical to know what harm the impurities in water do to the concrete and what degree of impurity is permissible in mixing concrete and curing concrete. Carbonates and bi-carbonates of sodium and potassium effect the setting time of cement. While sodium carbonate may cause quick setting, the bi-carbonates may either accelerate or retard the setting. The other higher concentrations of these salts will materially reduce the concrete strength. If some of these salts exceeds 1,000 ppm, tests for setting time and 28 days strength should be carried out. In

lower concentrations they may be accepted. Brackish water contains chlorides and sulphates. When chloride does not exceed 10,000ppm and sulphate does not exceed 3,000 ppm the water is harmless, but water with even higher salt content has been used satisfactorily. Salts of Manganese, Tin, Zinc, Copper and Lead cause a marked reduction in strength of concrete. Sodium iodate, sodium phosphate, and sodium borate reduce the initial strength of concrete to an extra-ordinarily high degree. Another salt that is detrimental to concrete is sodium sulphide and even a sulphide content of 100 ppm warrants testing. Silts and suspended particles are undesirable as they interfere with setting, hardening and bond characteristics. A turbidity limit of 2,000 ppm has been suggested.