

UPPSC-AE

2023

Uttar Pradesh Public Service Commission

Combined State Engineering Services Examination
Assistant Engineer

Civil Engineering

Building Materials

Well Illustrated **Theory** with
Solved Examples and **Practice Questions**



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Building Materials

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1.1 Introduction

- Cement is an extremely fine material having adhesive and cohesive properties which provides a binding medium for the discrete ingredients.
- Cement is a product obtained by pulverizing clinker formed by calcinating raw-materials primarily consisting of lime (CaO), silicate (SiO_2), Alumina (Al_2O_3), and Iron oxide (Fe_2O_3).
- When cement is mixed with water it forms a paste which hardens and bind aggregates (fine coarse) together to form a hard durable mass called concrete.
- Cements used in construction industry can be classified as hydraulic and non-hydraulic.
- Hydraulic cement set and harden extremely fast in presence of water (Due to the chemical action between cement and water known as hydration) and results in water resistance product which is stable. This allows setting in wet condition or underwater and further protects the hardened material from chemical attack. e.g.: (Portland cement).
- Non-hydraulic cements are derived from calcination of gypsum or limestone because their products of hydration are not resistant to water. However, the addition of pozzolanic materials can render the gypsum and make cement hydraulic. Thus, it will not set in wet condition or underwater, rather it sets as it dries and reacts with carbon-dioxide in the air. It can be attacked by some aggressive chemicals after setting. e.g.: Plaster of Paris.
- The cement experiences the exothermic chemical reactions when comes in contact with water.
- The cement is assumed to have a specific gravity of 3.15.
- Standard density of cement is 1440 kg/m^3 and 1 bag of cement is of 50 kg, thus volume would be $50/1440 = 0.0347 \text{ m}^3$.
Hence, volume of 1 bag of cement can be approximated as 0.035 m^3 or 35 litres.
- Cement can be manufactured either from natural cement stones or artificially by using calcareous and argillaceous materials.

Argillaceous	Calcareous
<ul style="list-style-type: none"> • Shale and clay • Blast furnace slag • Slate 	<ul style="list-style-type: none"> • Cement rock • Limestone • Chalk • Marine shells • Marl

1.2 Cement and Lime

Following points of differences may be noted between ordinary cement and lime:

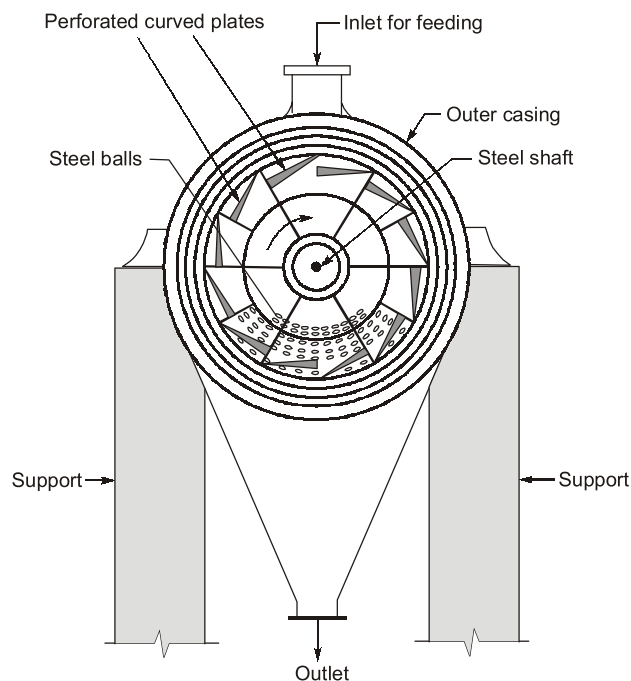
1. The cement is used for the gain of early strength whereas lime gains the strength slowly.
2. The cement and lime color are different.
3. The cement and lime both is a binding material having good ultimate strength but lime experiences less early strength as compare to cement.

1.3 Manufacture of Cement

- The manufacturing of cement was first started in England by the scientist named Joseph Aspdin.
- The first time manufacturing of cement is named as Ordinary Portland Cement (OPC) because when the cement comes in contact with water it becomes a hard mass after a certain period and this hard mass resembles the stone found in portland area of England.
- The India is 2nd largest manufacturing hub after China.
- The cement is manufactured by integrating the calcareous component and argillaceous component in ratio 3 : 1.
- The calcareous components can be limestone chalk, marine shells, marl whereas argillaceous components can be shale clay, blast furnace slag, slate.
- The calcareous component is used to derive the ingredient called lime whereas the argillaceous component composed of silica, alumina, iron oxide, and other impurities.
- Cement can be manufactured either by dry process or wet process.

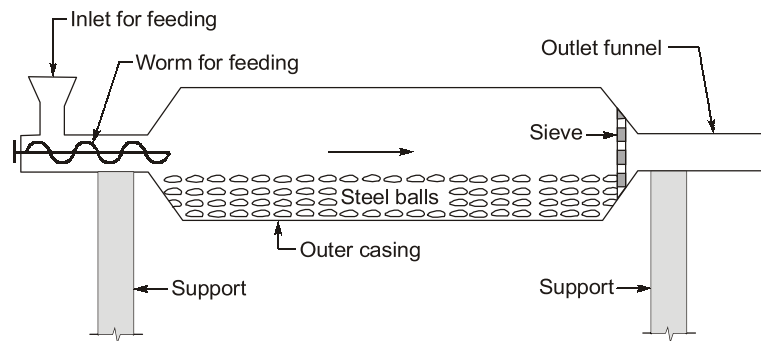
1.3.1 Dry Process

Step (i): The material is gathered from quarry with the help of dumper to manufacturing plant. The material gathered is having content of limestone and clay which is calcareous component and argillaceous component respectively. The material gathered is about more than 80 mm size.



Vertical Section of a Ball Mill

Step (ii): The collected material is fed into heavy crusher where the size of the material get reduced to 60 mm from 80 mm and later this size material is fed into light crusher (Tubemill/Ballmill) where the size reduced to 40-60 mm finally it is stored in the tank.



Longitudinal Section of a Tube Mill

Step (iii): Now, the grinding material called raw mix is fed into preheater (heater before rotary kiln), the temperature is gradually increased upto 500°C due to this increase in temperature the raw mix get fraction into smaller size nearly (25 mm).

Benefits of Preheaters:

- (a) It makes the process fast.
- (b) Fuel consumption is reduced because the burning time of rotary kiln is get reduced.

Now, this raw mix is fed into rotary kiln where the temperature is $800-1000^{\circ}\text{C}$, $1000-1200^{\circ}\text{C}$, $1200^{\circ}-1500^{\circ}\text{C}$. In three separate zones respectively. The product obtained is of size 8 to 10 mm from rotary kiln is called clinker.

Rotary Kiln

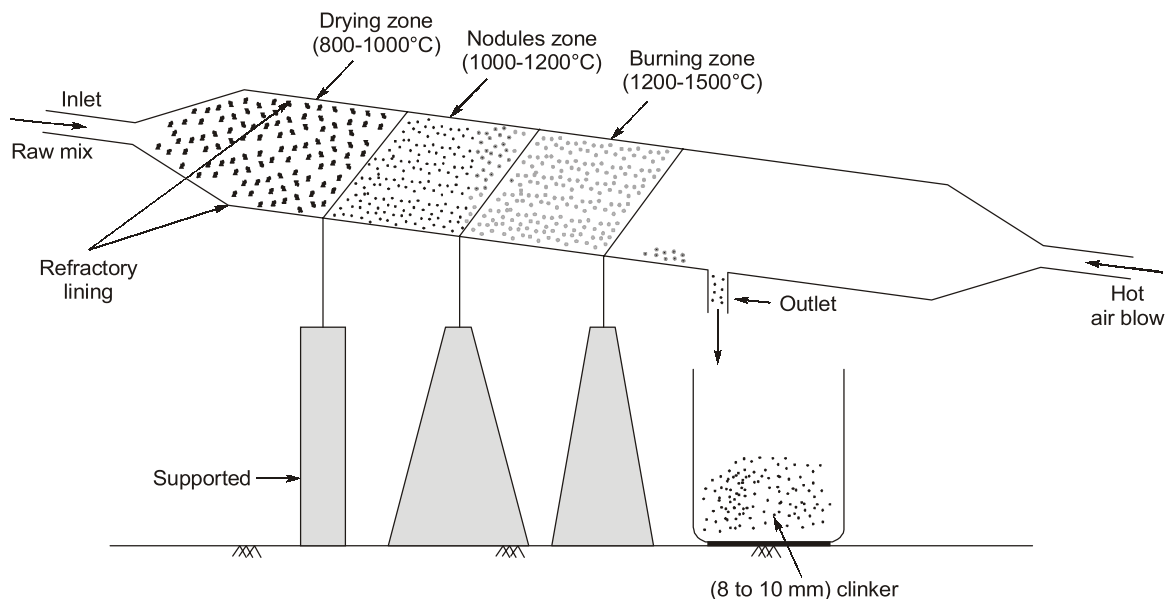
Dimensions:

Diameter = 3 m

Length = 100 m

Revolutions = 3 rounds in 1 minute

Gradient 1 in 25 to 1 in 30.

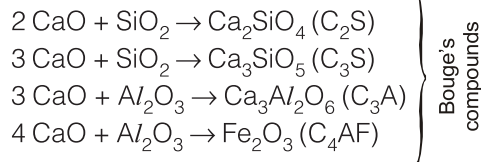


Zone-1 (Drying zone): In this zone the raw mix, is fractioned into more smaller size. In this zone if there is some water or moisture exist in raw mix then it is also evaporated.

Zone-2 (Nodule zone): In this zone, the major breakdown of raw mix occur. In this zone the calcination

of limestone takes place $\text{CaCO}_3 \xrightarrow{\text{Superheat}} \text{CaO} + \text{CO}_2 \uparrow$.
(Limestone) (Lime)

Zone-3 (Burning zone): Now, the raw mix which is also called nodules, is sloped down and the major chemical reaction between ingredient of clinker occurs i.e. lime, silica, alumina, iron oxides.



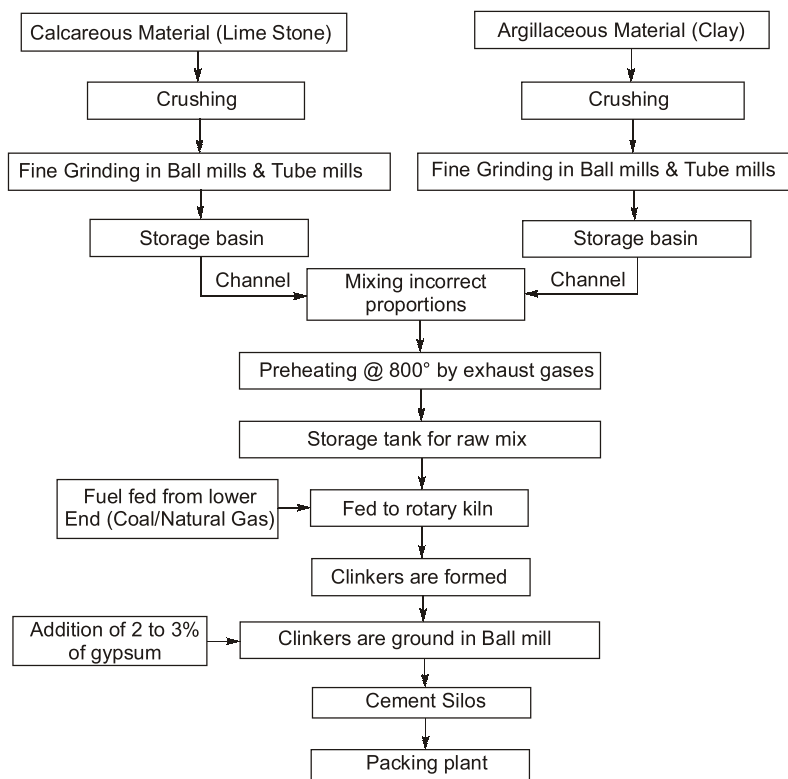
Now, from this rotary kiln the product obtained is called clinker which is composed of major and minor compounds.

NOTE: The clinker obtained has high efficiency to react with water and set immediately (flash set) to prevent this immediately setting of clinker in presence of water is done by adding gypsum in a tubemill.

(v) Now, the clinker is cooled upto temperature of 100°C , after colling it is fed into tubemill where the gypsum is also added to it, the fine grinded powder having gray colour is obtained which is called cement.

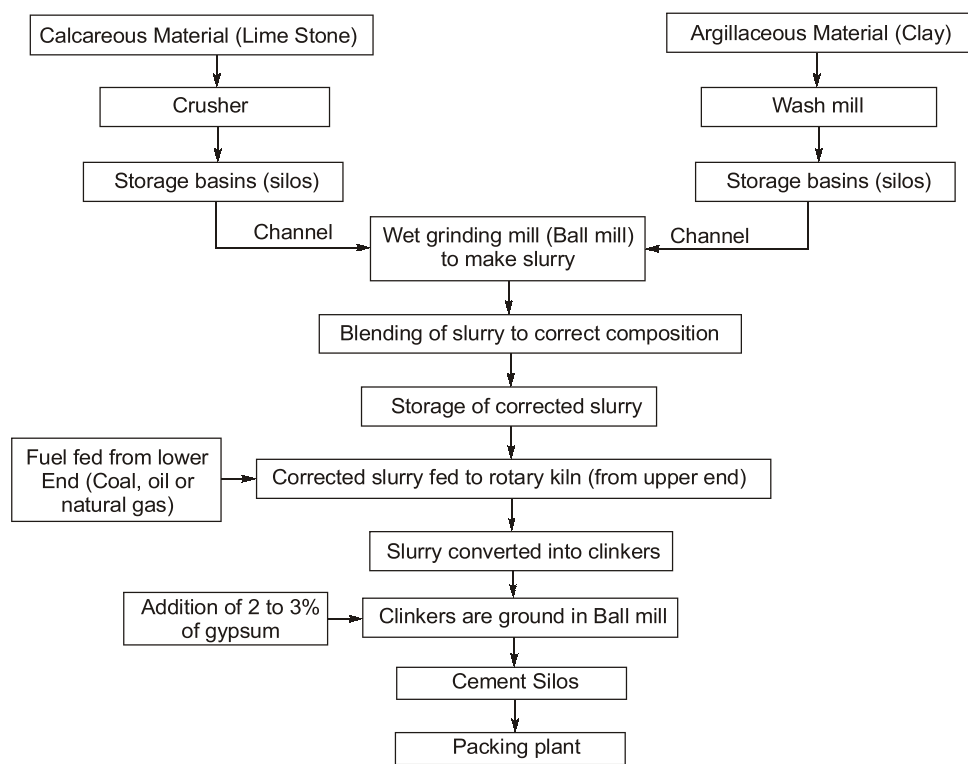
(vi) It is packed in 50 kg bag having $\pm 5\%$ volume capacity of 0.035 m^3 .

(vii) Now, after packing it is transported to dealers.



1.3.2 Wet Process

In a wet process the heavier crushed material is made wet in storage tank before feeding into tubemill. In wet process, the preheater is not used, the mix obtained from tubemill is directly fed into rotary kiln.



Flow diagram of wet process

Disadvantages

- (i) The process time is long.
- (ii) The fuel consumption is more.

1.4 Chemical Composition of Cement

Oxide	Composition (%)	Average
Lime CaO	60 - 65	63
Silica, SiO ₂	17 - 25	20
Alumina, Al ₂ O ₃	3 - 8	6
Iron oxide, Fe ₂ O ₃	0.5 - 6	3
Magnesia, MgP	0.5 - 4	2
Soda/or potash (Na ₂ O + K ₂ O)	0.5 - 1	1
Sulphur tri-oxide	1 - 2	1.5

- The relative proportional of three oxide compositions are responsible for influencing the various properties of cement, like lime, silica and alumina.
- An increase in lime content beyond a certain value makes it difficult to combine completely with other compounds.
- Consequently, free time will exist in the clinker and will result in an unsound cement. An increase in silica content at the expense of alumina and ferric oxide makes the cement difficult to fuse and form clinker.

- Lime (CaO):** If lime is provided in excess then the cement becomes unsound and if it is in deficiency then the strength is reduced therefore chances of quick setting will be enhanced.
- Silica (SiO₂):** It imparts strength to the cement due to the formation of di-calcium and tri-calcium silicates. If it is in excess then the strength of the cement would be enhanced therefore setting time gets prolonged, hence it prevents quick setting.
- Alumina (Al₂O₃):** It imparts quick setting property of cement. If it is in excess then the strength of cement is reduced and the chances of rapid hardening would be increased. It acts as a flux and it lowers the clinker temperature.
- Calcium Sulphate (CaSO₄):** It is a retarder (admixture). If it is in excess then it slows down the quick setting which dominates to increase the strength. It is a gypsum form.
- Iron Oxide (Fe₂O₃):** It imparts colour, hardness, and strength to the cement. If it is in excess, then it imparts more colour to the cement (grey).
- Magnesia (MgO):** It imparts hardness and colour (yellow) to the cement, if it is in small quantity, and if it is in excess then it imparts unsoundness to the cement.
- Sulphur (S):** If it is in reference quantity then it imparts strength to the cement and if it is in excess then the unsoundness is increased.
- Alkalies (Soda and Potash) (Na₂O + K₂O):** The most of the alkalies present in raw materials are carried away by the flue gases heating and the cement contains only a small amount of alkalies. If they are in excess in cement then they cause a number of troubles such as alkali-aggregate reaction, efflorescence and staining when used in concrete, brick work or masonry mortar.



Example - 1.1 Four main oxides present in ordinary portland cement are: CaO, Al₂O₃, SiO₂ and Fe₂O₃. Identify the correct ascending order of their proportions in a typical composition of OPC.

- (a) Al₂O₃, Fe₂O₃, CaO, SiO₂ (b) Al₂O₃, CaO, Fe₂O₃, SiO₂
 (c) Fe₂O₃, Al₂O₃, SiO₂, CaO (d) Fe₂O₃, SiO₂, Al₂O₃, CaO

Solution: (c)

1.5 Basic Properties of Bouge Compounds

The principle mineral compounds in portland cement	Formula	Name	Symbol	Percentage
1. Tri-calcium silicate	3CaOSiO ₂	Alite	C ₃ S	30 - 50%
2. Di-calcium silicate	2CaOSiO ₂	Belite	C ₂ S	20 - 45%
3. Tri-calcium aluminate	3CaOAl ₂ O ₃	Celite	C ₃ A	8 - 12%
4. Tetra-calcium aluminoferrite	4CaOAl ₂ O ₃ Fe ₂ O ₃	Felite	C ₄ AF	6 - 10%

- Tri-calcium Silicate (C₃S):** It produces faster rate of reaction with greater heat evolution, it imparts early strength to the cement and also contributes good for ultimate strength. If it is in excess then rapid hardening enhances.

2. **Di-calcium Silicate (C_2S)** : It hydrates slowly and imparts ultimate strength much. The C_2S has less heat of hydration therefore it is resistant against chemical attack.
3. **Tri-calcium Aluminate (C_3A)** : It imparts fast reaction with water and it produces very high heat therefor it imparts more towards rapid hardening.
If C_3A would be more then immediate setting (flash set) would be enhanced to prevent this flash setting gypsum is added to it during manufacturing.
4. **Tetracalcium Alumino Ferite (C_4AF)** : It also reacts with water at faster rate and evolves heat by greater extent but it is more stable then C_3A because if produces less heat compared to C_3A .


Example - 1.2 The initial setting time of cement depends most on

- (a) tri-calcium aluminate
- (b) tri-calcium silicate
- (c) tri-calcium alumino-ferrite
- (d) di-calcium silicate

Solution: (a)

The compound C_3A is characteristically fast reacting with water and may lead to an immediate stiffening of paste, and this process is termed flash set. Hence, initial setting time of cement depends most on C_3A .


NOTE

- Decreasing order of ultimate: ($C_2S > C_3S > C_3A > C_4AF$)
Decreasing order of quickest reaction with water: ($C_3A > C_4AF > C_3S > C_2S$)
- The rate of hydration is increased by an increase in fineness of cement. However, total heat evolved is the same. The rate of hydration of the principal compounds is shown in figure and will be in the following descending order. $C_4AF > C_3A > C_3S > C_2S$

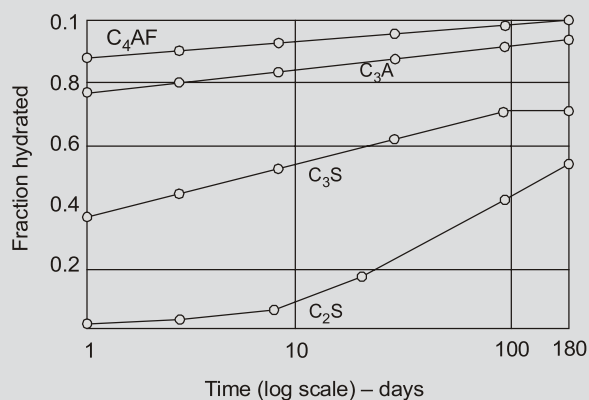


Fig. Rate of Hydration of Pure Compounds

- Rate of heat evolution of Bougue compound, if equal amount of each is considered will be in following descending order
 C_3A (865 J/gm) > C_3S (865 J/gm) > C_3AF (420 J/gm) > C_2S (260 J/gm).

Compound	Heat of hydration at the given age (J/g)		
	3 days	90 days	13 years
C_3S	242.44	434.72	509.96
C_2S	50.16	175.56	246.62
C_3A	886.16	1299.98	1354.32
C_4AF	288.42	409.64	426.36

Heat of Hydration

- Development of strength of four Bougue compounds of cement with age.

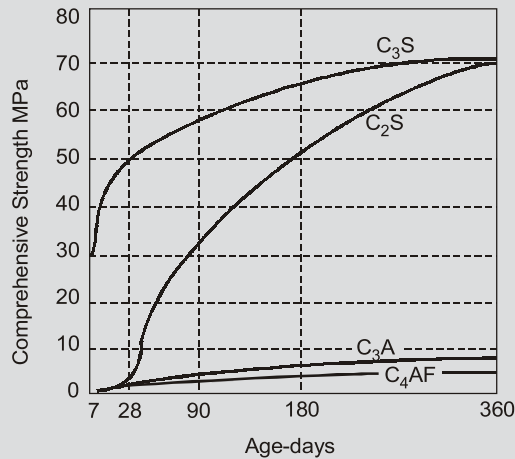


Fig. Development of Strength of Pure Compounds



Example - 1.3 Which of the following shows the CORRECT decreasing order of rate of hydration of Portland cement compounds?

- (a) $C_3A > C_4AF > C_3S > C_2S$ (b) $C_3A > C_4AF > C_2S > C_3S$
 (c) $C_3A > C_3S > C_2S > C_4AF$ (d) $C_4AF > C_3A > C_2S > C_2S$

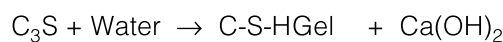
Solution: (d)

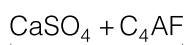
The rate of hydration is increased by an increase in fineness of cement. However, total heat evolved is the same. The rate of hydration of the principal compounds is shown in figure and will be in the following descending order.

$$C_4AF > C_3A > C_3S > C_2S$$

1.6 Hydration of Cement

- The chemical reaction of cement with water is referred as hydration of cement.
- The reaction of cement and water is exothermic reaction i.e. heat is liberated in a considerable quantity and this liberated heat is called heat of hydration.
- The water added to the cement will leads to evolution of heat, the C_3S and C_2S reacts with water during hydration to form a calcium silicate hydrate along with $Ca(OH)_2$.
- The calcium silicate hydrate is responsible for good properties of cement concrete. The calcium silicate hydrate is having binding property whereas the $Ca(OH)_2$ is not a desirable product in a cement concrete because it is responsible for lack of durability of concrete.
- The $Ca(OH)_2$ also reacts with sulphur present in water or soil to form $CaSO_4$. Which further reacts with C_3A and C_4AF to cause a deterioration of concrete this effect is called sulphate attack.





↓
Product
(Salty nature)
↓
Deterioration
of concrete
↓
Durability
decreases

- To reduce sulphate attack:
 1. Sulphur content in water (↓es)
 2. C_3A and C_4AF (↓es)

**NOTE**

The total amount of water required for complete chemical reaction between cement and water is 38%. If the gel pores/voids in cement exist where 15% of water is required to fill the voids and gel pores and this percentage is taken by weight.

1.7 Types of Cement

There are different types of cement as classified by the Bureau of Indian Standards (BIS):

- (i) Ordinary Portland Cement
 - (a) 33 grade – **IS : 269-1989**
 - (b) 43 grade – **IS : 8112-1989**
 - (c) 53 grade – **IS : 12269-1987**
- (ii) Rapid Hardening Cement – **IS : 8041-1990**
- (iii) Extra Rapid Hardening Cement
- (iv) Low Heat Portland Cement – **IS : 12600-1989**
- (v) Portland Slag Cement – **IS : 455-1989**
- (vi) Portland Pozzolana Cement – **IS : 1489-1991(Part 1 and 2)**
- (vii) Sulphate Resisting Portland Cement – **IS : 12330-1988**
- (viii) White Portland Cement – **IS : 8042-1989**
- (ix) Coloured Portland Cement – **IS : 8042-1989**
- (x) Hydrophobic Cement – **IS : 8043-1991**
- (xi) High Alumina Cement – **IS : 6452-1989**
- (xii) Super Sulphated Cement – **IS : 6909-1990**
- (xiii) Special Cements
 - (a) Masonry Cement
 - (b) Air Entraining Cement
 - (c) Expansive Cement
 - (d) Oil Well Cement

1.7.1 Ordinary Portland Cement (OPC)

- It is obtained by Pulverizing argillaceous and calcareous material in correct proportion.
- Portland cement is most common variety of artificial cement and most commonly known as O.P.C. (Ordinary Portland Cement).

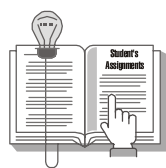
- It is available in 3 grades:
 - (a) OPC-33 grade (IS: 269–989)
 - (b) OPC-43 grade (IS : 8112–1989)
 - (c) OPC-53 grade (IS: 12269–1987)
- The number 33, 43, 53 corresponds to 28 days characteristic compressive strength of cement as obtained from standard test on cement sand mortar (1 : 3) specimens.
- The OPC 33 is recommended for concrete mix having strength upto 20 N/mm² i.e. M20.
- These are most commonly used in general concrete construction, where there is no exposure to sulphates.
- Due to high fineness, the workability of concrete increases for a given water-cement ratio. IS10262 has classified the OPC gradewise from “A to F” based on 28 days compressive strength as follows:
- It is presently available in three different grades viz. OPC 33, OPC 43 and OPC 53. The numbers 33, 43 and 53 correspond to the 28 days (characteristic) compressive strength of cement as obtained from standard tests on cement-sand mortar specimens.
- It is used in general concrete construction where there is no exposure to sulphates in the soil or in ground water.

1.7.2 Rapid Hardening Cement (RHC)

- It is finer than ordinary Portland cement.
- It contains more C₃S and less C₂S than the OPC.
- The 1 day strength of this cement is equal to the 3 days strength of OPC with the same water cement ratio.
- The main advantage of rapid hardening cement is that shuttering may be removed much earlier, thus saving considerable time and expenses.
- Rapid hardening cement is also used for road work where it is imperative to open the road traffic with the minimum delay.
- Cost of Rapid hardening cement is nearly 10–15% more than OPC.
- It can be **safely exposed to frost** as it matures more quickly.

1.7.3 Extra Rapid Hardening Cement (ERHC)

- It is obtained by mixing calcium chloride (not exceeding 2% by weight of the rapid hardening cement) with rapid hardening cement.
- Addition of CaCl₂ imparts quick setting properties in extra rapid hardening cement.
- The acceleration of setting, hardening and evolution of heat in the early period of hydration makes this cement **very suitable for concreting in cold weathers**.
- The 1 or 2 day strength of extra rapid hardening cement is 25% more than that of rapid hardening cement.
- The gain of strength disappears with age and 90 days strength of extra rapid hardening cement and rapid hardening cement are nearly the same.
- Use of extra rapid hardening cement is prohibited in prestressed concrete construction.
- Maximum time of using this cement is 20 minute for mixing, transporting, placing and compaction.



Student's Assignment

- Q.1** The main constituent of cement which is responsible for initial setting of cement is
(a) Dicalcium silicate
(b) Tricalcium silicate
(c) Tricalcium aluminate
(d) None of above
[APPSC-2016]
- Q.2** Cement used for railway sleeper is designated as:
(a) 40 - s (b) 53 - s
(c) 46 - s (d) 48 - s
[APPSC-2016]
- Q.3** The apparatus used for determining the soundness of cement is
(a) Slump cone
(b) Le-Chatelier apparatus
(c) Vicat's needle
(d) UTM
[APPSC-2016]
- Q.4** Rotary kiln used in manufacturing cement rotates at a speed of
(a) 1 rpm - 3 rpm (b) 10 rpm - 12 rpm
(c) 18 rpm - 22 rpm (d) > 25 rpm
[BPSC-2018]
- Q.5** Which of the following is responsible for the initial set and high heat of hydration?
(a) Tricalcium silicate
(b) Dicalcium silicate
(c) Tricalcium aluminate
(d) Tetracalcium alumino ferrite
[RPSC-2013]
- Q.6** The addition of pozzolona to portland cement may cause
(a) decrease in early strength
(b) increase in early strength
(c) decrease in curing time
(d) increase in permeability
[OPSC-2016]
- Q.7** The two main compounds imparting strength for ordinary portland cement are
(a) tricalcium silicate and dicalcium silicate
(b) dicalcium silicates and aluminates
(c) tricalcium aluminates
(d) tricalcium silicate and tricalcium aluminates
[OPSC-2016]
- Q.8** Gypsum is added to portland cement during its manufacturing so that it may
(a) accelerate the setting time
(b) retard the setting time
(c) decrease the burning temperature
(d) facilitate grinding
[MPSC-2017]
- Q.9** Which is the major constituent of ordinary portland cement?
(a) CaO (b) MgO
(c) SO₃ (d) Fe₂O₃
[MPSC-2017]
- Q.10** As per IS specification the heat of hydration of low heat portland cement for 28 days is
(a) not more than 100 calories/gm
(b) not more than 50 calories/gm
(c) not more than 75 calories/gm
(d) not more than 150 calories/gm
[MPSC-2015]
- Q.11** The following cement is used in the construction of dam
(a) low heat (b) rapid hardening
(c) quick setting (d) sulphate resisting
[MPSC-2015]
- Q.12** The consistency test on cement is to obtain
(a) tensile strength of cement
(b) fineness of cement
(c) percentage of water for consistent paste
(d) compressive strength

Q.13 Match **List-I (Type of cement)** with **List-II (Property/characteristics)** and select the correct answer using the code given below the lists:

List-I

- A. High strength portland cement
- B. Super sulphated cement
- C. High alumina cement
- D. Rapid hardening portland cement

List-II

- 1. should not be used with any admixture
- 2. is extremely resistant to chemical attack
- 3. gives a higher rate of heat development
- 4. has a higher content of tricalcium

Codes:

	A	B	C	D
(a)	3	2	1	4
(b)	3	1	2	4
(c)	4	1	2	3
(d)	4	2	1	3

[HPSC-2016]

Q.14 Consider the following statements:

- (a) Tests on cement paste to determine initial setting and final setting times are done at normal consistency.
- (b) Low heat cement has a high percentage of tri-calcium aluminate.
- (c) High early strength portland cement contains a large percentage of tricalcium silicate and lower percentage of dicalcium silicate.

Which of these statements are correct?

- (a) 1 and 2
- (b) 1 and 3
- (c) 2 and 3
- (d) 1, 2 and 3

[HPSC-2016]

Q.15 Which one of the following statements regarding the fineness of cement is not correct?

- (a) Fine cement is more liable to suffer from shrinkage cracking than a coarse cement.
- (b) Fine cement will show faster rate of hardening than coarse cement.
- (c) Fine cement shows faster rate of heat evolution and total quantity of heat evolved is much larger than coarse cement.
- (d) Fine cement shows the same setting time as coarse cement.

[HPSC-2016]

Q.16 As compared to ordinary portland cement high alumina cement has

- (a) higher initial setting time, but lower final setting time.
- (b) lower initial setting time but higher final setting time.
- (c) higher initial and final setting time.
- (d) lower initial and final setting time.

[UKPSC-2013]

Q.17 Air permeability test is done to measure

- (a) setting time of cement
- (b) soundness of cement
- (c) chemical composition of cement
- (d) fineness of cement

[KPSC-2015]

Q.18 I and P is the standard consistency of cement the amount of water used in conducting the initial setting time test on cement is

- (a) 0.65 P
- (b) 0.85 P
- (c) 0.6 P
- (d) 0.8 P

Q.19 Which of the following pairs in respect of Ordinary Portland Cement (OPC) are correctly method?

- 1. Initial setting time - 30 minutes
- 2. Final setting time - 10 hours
- 3. Normal consistency - 10%

Select the correct answers using the codes given below:

- (a) 1, 2 and 3
- (b) 2 and 3
- (c) 1 and 2
- (d) 1 and 3

Q.20 The temperature range in a cement kiln is

- (a) 500°C to 1000°C
- (b) 1000°C to 1200°C
- (c) 1300°C to 1500°C
- (d) 1600°C to 2000°C

Q.21 The fineness of cement is tested by

- (a) air-content method
- (b) air-permeability method
- (c) Le-chatelier apparatus
- (d) Vicat's apparatus

Q.22 For marine works the best suited cement is ____.

- (a) low heat portland cement
- (b) rapid hardening cement
- (c) ordinary portland cement
- (d) blast furnace slag cement

- Q.23** Ultimate strength of cement is influenced which one of the following?
(a) Tricalcium silicate
(b) Dicalcium silicate
(c) Tricalcium aluminate
(d) Tetracalcium alumina ferrite
- Q.24** One bag of portland cement, 50 kg in weight, would normally have a bulk volume of
(a) 30 l (b) 35 l
(c) 40 l (d) 45 l
- Q.25** Before testing setting time of cement one should test for
(a) soundness (b) strength
(c) fineness (d) consistency
- Q.26** Soundness test of cement is done/carried to determine its
(a) alumina content
(b) iron oxide content
(c) free lime content
(d) durability under sea water
- Q.27** Fineness of cement is measured in the units of
(a) volume/mass (b) mass/volume
(c) area/mass (d) mass/area
- Q.28** The test on cement designed to accelerate the slaking process of the ingredient of cement and to determine the resulting expansion in a short time is
(a) setting time test
(b) soundness time
(c) normal consistency test
(d) accelerated test
- Q.29** Increase in fineness of cement
(a) reduces the rate of strength development and leads to higher shrinkage.
(b) increase the rate of strength development and reduces the rate of deterioration.
(c) decreases the rate of strength development and increases the bleeding of cement.
(d) increases the rate of strength development and leads to higher shrinkage.
- Q.30** High alumina cement is produced by fusing together a mixture of
(a) limestone and bauxite
(b) limestone, bauxite and gypsum
(c) limestone, gypsum and clay
(d) limestone, gypsum, bauxite, clay and chalk
- Q.31** The density of cement is taken as
(a) 1000 kg/m³ (b) 1250 kg/m³
(c) 1440 kg/m³ (d) 1800 kg/m³
- Q.32** The high early strength of rapid hardening cement is due to its
(a) increased content of gypsum
(b) burning at high temperature
(c) increased content of cement
(d) higher content of tricalcium silicate
- Q.33** The fineness of cement can be found out by sieve analysis using IS sieve number
(a) 20 (b) 10
(c) 9 (d) 6
- Q.34** Di-calcium silicate (C₂S)
(a) hydrates rapidly
(b) generates less heat of hydration
(c) hardness rapidly
(d) has less resistance to sulphate attack
- Q.35** Out of the constituents of cement namely: Tricalcium silicate (C₃S), Dicalcium silicate (C₂S), Tricalcium aluminate (C₃A) and tetracalcium alumino ferrite (C₄AF), the first one to set and harden is _____.
(a) C₃A (b) C₄AF
(c) C₃S (d) C₂S
- Q.36** The standard consistency test is done in a
(a) Blaine's apparatus
(b) Le-chatalier apparatus
(c) Vane apparatus
(d) Vicat's apparatus
- Q.37** The volume of one bag of cement is
(a) 0.0214 m³ (b) 0.0347 m³
(c) 0.0434 m³ (d) 0.0609 m³

- Q.38** Good quality cement contains higher percentage
(a) tricalcium silicate
(b) tricalcium aluminate
(c) dicalcium silicate
(d) none of the above
- Q.39** During the manufacture of cement, gypsum or plaster of Paris is added to
(a) increase the strength of cement
(b) modify the colour of cement
(c) reduce heat of hydration of cement
(d) adjust setting time of cement
- Q.40** Which of the following type of lime is used for underwater constructions?
(a) Fat lime (b) Quick lime
(c) Slaked lime (d) Hydraulic lime
- Q.41** The percentage of water for normal consistency is _____.
(a) 5% to 15% (b) 10% to 25%
(c) 15% to 25% (d) 20% to 30%
- Q.42** Flash set of ordinary portland cement paste is _____.
(a) premature hardening
(b) surface hardening only
(c) hardening without development of heat of hydration
(d) all the options are correct
- Q.43** Efflorescence in cement is caused due to an excess of _____.
(a) alumina (b) iron oxide
(c) silica (d) alkalis
- Q.44** The commercial name of white and colored cement in India is
(a) colocrete (b) rainbow cement
(c) silicrete (d) all options are correct
- Q.45** The minimum percentage of chemical ingredient of cement is that of
(a) magnesium oxide
(b) iron oxide
(c) alumina
(d) lime
- Q.46** A sample of cement is said to be sound when it does not contain free
(a) lime (b) silica
(c) iron oxide (d) alumina
- Q.47** The main purpose of the soundness test of the cement is to determine the _____.
(a) change in volume of cement after setting
(b) strength
(c) fineness
(d) time taken to harden
- Q.48** Which of the following shows the correct decreasing order of rate of hydration of portland cement compounds?
(a) $C_3A > C_4AF > C_3S > C_2S$
(b) $C_3A > C_4AF > C_2S > C_3S$
(c) $C_3A > C_3S > C_4AF > C_2S$
(d) $C_4AF > C_3S > C_3A > C_2S$
- Q.49** In fineness test rapid hardening portland cement the residue on IS sieve number 9 should not be more than
(a) 0.01 (b) 0.05
(c) 0.1 (d) 0.15
- Q.50** For construction of structures in sea water, the cement generally preferred to is
(a) portland pozzolona cement
(b) quick setting cement
(c) low heat portland cement
(d) none of these

ANSWER KEY

**STUDENT'S
ASSIGNMENTS**

- | | | | | |
|---------|---------|---------|---------|---------|
| 1. (c) | 2. (b) | 3. (b) | 4. (a) | 5. (c) |
| 6. (a) | 7. (a) | 8. (b) | 9. (a) | 10. (c) |
| 11. (a) | 12. (c) | 13. (a) | 14. (b) | 15. (c) |
| 16. (a) | 17. (d) | 18. (b) | 19. (c) | 20. (c) |
| 21. (b) | 22. (d) | 23. (b) | 24. (b) | 25. (d) |
| 26. (c) | 27. (c) | 28. (b) | 29. (d) | 30. (a) |
| 31. (c) | 32. (d) | 33. (d) | 34. (b) | 35. (a) |
| 36. (d) | 37. (b) | 38. (c) | 39. (d) | 40. (d) |
| 41. (d) | 42. (a) | 43. (d) | 44. (d) | 45. (a) |
| 46. (a) | 47. (a) | 48. (c) | 49. (b) | 50. (a) |

HINTS & SOLUTIONS

STUDENT'S
ASSIGNMENT

1. (c)

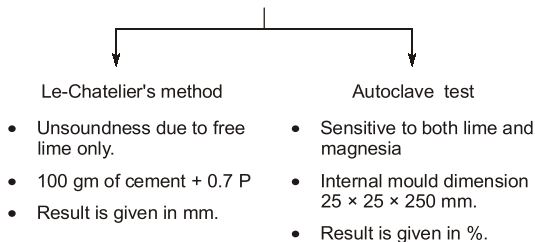
Tricalcium aluminate (C_3A) hydrates and hardens the quickest. It liberates a large amount of heat almost instantaneously and contributes somewhat to early strength.

2. (b)

Cement used for railways sleeper is designated as 53-S. It is because the cement used is OPC grade 53 i.e. ordinary portland cement with strength 53 MPa.

3. (b)

Soundness test: The purpose of this test is to detect the presence of uncombined lime in cement 'or' to detect the change in volume of cement after setting. It is performed with the help of:



4. (a)

The rotary kiln rotates at about 1-3 revolutions per minute about its longitudinal axis.

5. (c)

C_3A (tricalcium aluminate) reacts with water in the start of hydration and generates heat of hydration at fast rate. So lower C_3A will generate less heat. The ultimate strength depends upon C_3S and C_2S . Lower C_3A means higher C_3S and C_2S and higher ultimate strength.

The product of hydration are calcium hydroxide $Ca(OH)_2$ and calcium silicate hydrate ($C_3S_2H_3$), a gel structure.

6. (a)

Addition of pozzolana reduces the initial rate of increase in strength.

7. (a)

C_3S and C_2S together constitute about 70% of cement and are responsible for providing most of the strength to it C_3A is responsible for flash set and C_4AF generates very less strength.

8. (b)

During the manufacturing of Portland cement, admixtures are added which influence the properties according to our desired values. Gypsum acts as retarder and is added to slow down the reaction. Whereas calcium chloride is an accelerator and is used to speed up the reaction.

9. (a)

Constituents of OPC:

Lime CaO (60-65%)

Silica SiO_2 (11-25%)

Alumina (3-8%) and so on

10. (c)

As per IS code specifications, the heat of hydration of low heat portland cement for 28 days is not more than 75 calories/gm.

11. (c)

Since, low heat cement has very low heat of hydration which is suitable for mass concreting such as dams.

13. (d)

- C_3S gives high strength portland cement.
- Super sulphated cement is resistant to sulphate attack and also to chemical attack.
- High alumina cement cannot be used with admixtures.
- RHC gives higher rate of heat development due to increased rate of reaction.

14. (b)

Low heat cement: The considerable heat is produced during the setting action of cement. In order to reduce the amount of heat, this type of cement is used. It contains lower percentage of tricalcium aluminate (C_3A) of about 5% and higher percentage of dicalcium silicate (C_2S) of about 46%.