Interview Guidebook

for

Engineering Services Examination,
State Engineering Services, PSUs and
other competitive examinations

Civil Engineering

Part-I : Theory

Interview oriented concise theory, definitions,
concepts and formulae

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UNIT 1

Building Materials

1. Cement

- 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 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
• Shale and clay • Blast furnace slag • Slate	• Cement rock • Limestone • Chalk • Marine shells • Marl

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.

Chemical Composition of Cement

Oxide	Composition (%)	Average
Lime CaO	60 - 65	63
Silica, SiO_2	17 - 25	20
Alumina, Al_2O_3	3 - 8	6
Iron oxide, Fe_2O_3	0.5 - 6	3
Magnesia, MgP	0.5 - 4	2
Soda/or potash ($Na_2O + K_2O$)	0.5 - 1	1
Sulphur tri-oxide	1 - 2	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_3S	30 - 50%
2. Di-calcium silicate	$2CaOSiO_2$	Belite	C_2S	20 - 45%
3. Tri-calcium alluminate	$3CaOAl_2O_3$	Celite	C_3A	8 - 12%
4. Tetra-calcium alumino ferrite	$4CaOAl_2O_3Fe_2O_3$	Felite	C_4AF	6 - 10%

1. **Tri-calcium Silicate (C_3S):** It produces faster rate of reaction with greater heat evolution, it imparts early strength to the cement and also contribute 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.

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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.

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

Testing of Cement

Field Tests for Cements

- **Colour:** Grey colour with a light greenish shade.
- **Physical Properties:** Cement should feel smooth when rubbed in between the fingers.
- If hand is inserted in a bag or heap of cement, **it should feel cool.**
- If a small quantity of cement is thrown in a bucket of water, **it should sink and should not float on the surface.**
- **Presence of lumps:** Cement should be free from lumps.

Laboratory Tests for Cements

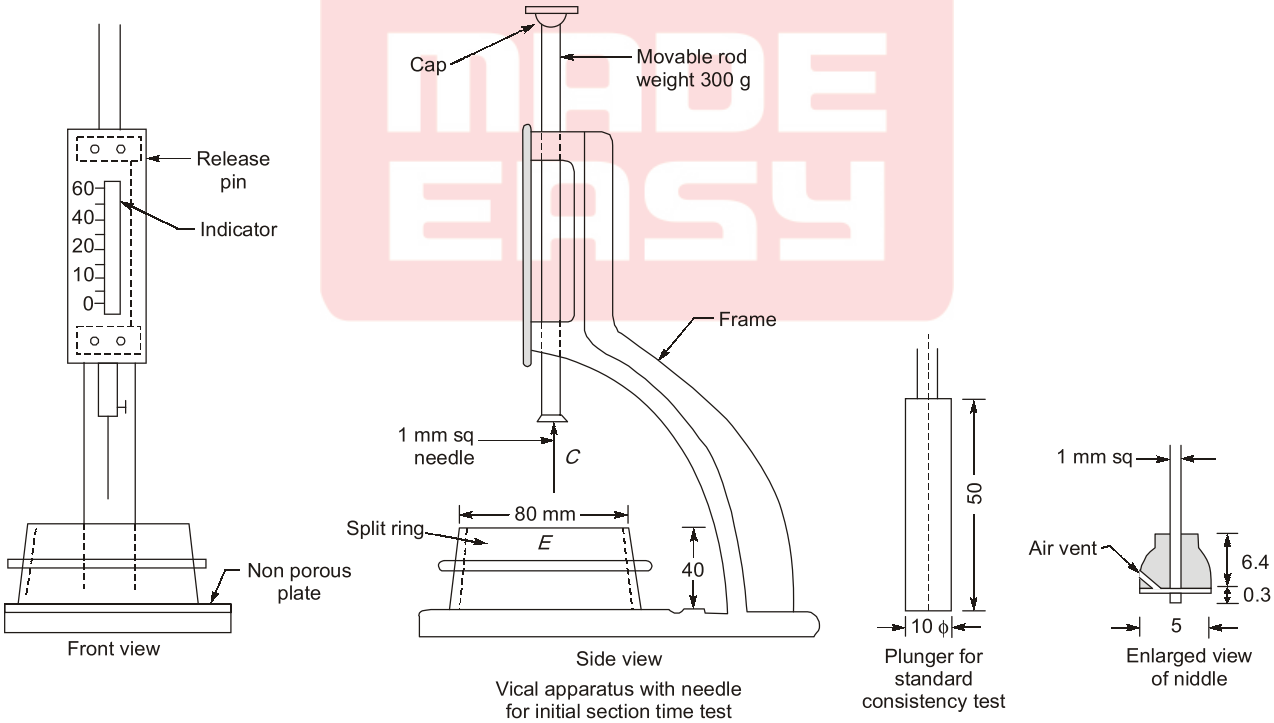
- Tests on cement are performed in accordance with **IS : 4032-1985** and **IS : 4031 (Parts 1 to 15)-1988-99** to assess the following:
  (i) Chemical composition
  (ii) Normal (standard) consistency

(iii) Initial and final setting times
(iv) Soundness
(v) Strength
(vi) Fineness
(vii) Heat of hydration
(viii) Specific gravity

Chemical Composition Test

- Ratio of percentage of lime to percentage of silica, alumina and iron oxide known as Lime Saturation Factor (LSF), when calculated by the formula $\frac{CaO - 0.7SO_3}{(2.8SiO_2 + 1.2Al_2O_3 + 0.65Fe_2O_3)}$ shall not be greater than 1.02 and not less than 0.66.
- Ratio of percentage of alumina (Al_2O_3) to that of iron oxide (Fe_2O_3) shall not be less than 0.66
- Weight of insoluble residue shall not be more than 4 per cent.
- Weight of magnesia shall not be more than 6 per cent.
- Total loss on ignition shall not be more than 5 per cent.
- Total sulphur content calculated as sulphuric anhydride shall not be more than 2.5% when C_3A is 5% or less and shall not be more than 3% when C_3A is more than 5%.

Normal Consistency Test



- The normal (standard) consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having 10 mm diameter and 50 mm length to penetrate a depth of 33 to 35 mm from the top (or 5 to 7 mm from the bottom) of the mould.

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Vicat Apparatus:

- Vicat apparatus assembly consists of a plunger 300 gm in weight with a length of 50 mm and diameter of 10 mm and a mould which is 40 mm deep and 80 mm in diameter.
- There are two attachments for the plunger viz.:
  (i) A square needle with 1 mm^2 cross-section which is attached to the plunger for initial setting time test.
  (ii) A needle with an annular collar of 5 mm diameter which is used for final setting time.

Test Procedure:

- To prepare the paste, take weighed quantity (300 g) of cement and place it in a crucible.
- Mix a weighed quantity of water (approximately 24% by weight of cement) for the first trial.
- The time of mixing or gauging should not be less than 3 minutes nor more than 5 minutes and gauging time should be counted from the time of adding water to the dry cement until commencing to fill the mould.
- The Vicat mould is filled with the paste, which is levelled off at its top.
- The mould is placed under the Vicat plunger.
- The vicat plunger is brought down to touch the surface of paste in the mould and quickly released allowing it to sink into the paste by its own weight.
- Take the reading by noting the depth of penetration of the plunger.
- Similarly conduct the trials with increasingly water/cement ratios till such time the plunger penetrates for a depth of 33 to 35 mm from the top (or 5 to 7 mm from the bottom).
- That particular percentage of water which allows the plunger to penetrate only to a depth of 33 to 35 from the top (or 5 to 7 mm from the bottom) is known as the percentage of water required to produce a cement paste of normal (standard) consistency.
- This percentage is generally denoted by *P*.
- This test should be conducted at a constant temperature of 27° ± 2°C and a constant humidity of 90%.

Initial Setting Time Test

- It is the time elapsed between the moment that the water is added to the cement, to the time that the paste starts losing its plasticity.
- The test procedure is as follows:
  (i) Take 300 gm of cement and make a cement paste of consistency 0.85 *P*
  (ii) Attach the square needle to the Vicat plunger and lower it gently to make contact with the surface of test block and quickly release it.
  (iii) When the needle penetrates only to a depth of 33 to 35 mm from the top (or 5 to 7 mm from the bottom), the test is completed.
- Initial setting time should not be less than 30 minutes for OPC and 60 minutes for low heat cement.

Final Setting Time Test

- The final setting time is the time elapsed between the moment the water is added to the cement and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure.
- The test procedure is as follows:
  (i) Take 300 gm of cement and make a cement paste of consistency of 0.85 *P*.

(ii) Replace the square needle by a needle with annular collar.

(iii) Lower the attachment to gently cover the surface of test block.

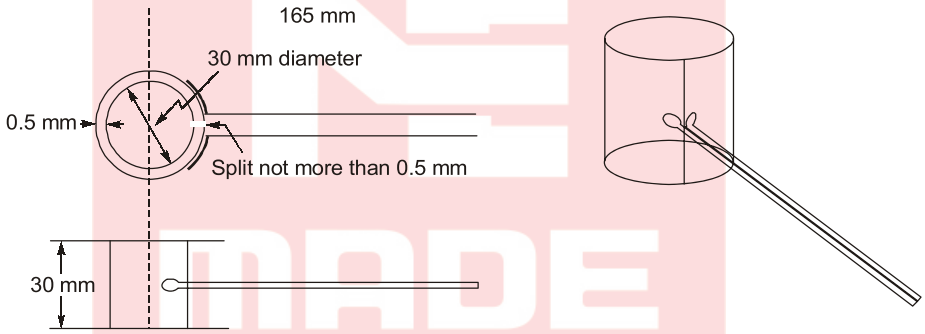
(iv) If the needle makes an impression, while the annular collar of the attachment fails to do so, the cement is considered to be finally set. Thus, the paste has attained such hardness that the needle does not pierce through the paste more than 0.5 mm.

- The final setting time should not be more than 10 hours.

Soundness Test

- Soundness of cement indicates that the cement paste, once it has set, does not undergo appreciable change in volume causing concrete to crack.
- The cement having some quantity of free lime, magnesia and excess sulphates undergoes large changes in volume as the time elapses tending to cause cracks.
- The soundness of cement is determined either by 'Le Chatelier's method' or by means of 'Autoclave' test.
- No satisfactory test is available for assessment of soundness due to excess of calcium sulphate, but its content can be easily determined by chemical analysis.

(a) Le Chatelier's Method:



Le-Chatelier apparatus for finding soundness of cement

- The Le Chatelier's apparatus consists of a small split cylinder of spring brass. It is 30 mm in diameter and 30 mm high. On either side of the split are attached two indicator arms 165 mm long with pointed ends.
- Take 100 gm of cement and make a cement paste of consistency 0.78 *P*.
- Fill the cement paste in the mould and keep it on a glass plate.
- Cover the mould on the top by another glass plate.
- The whole assembly is immersed in water at a temperature of 27°-32°C and kept there for 24 hours.
- The assembly is taken out after 24 hours and the distance between the indicator points is measured.
- The mould is then immersed in a water bath.
- The water of the bath is brought to boiling point with the mould submerged in 25 to 30 minutes and kept boiling for 3 hour.
- The mould is taken out from water and allowed to cool.
- Distance between the points is then measured.
- The difference between the two measurement represents the expansion of cement.
- The Le Chatelier's method detects unsoundness due to free lime only.
- This method of testing does not indicate the presence and after effect of the excess of magnesia and calcium sulphate.

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- The expansion of cement must not exceed 10 mm for OPC, rapid hardening and low heat Portland cements by this method.
- OPC, Rapid Hardening Cement, Low Heat Cement, PPC can have maximum expansion less than 10 mm whereas high alumina cement and super sulphated cement can have maximum expansion less than 5 mm.

(b) Autoclave Test:

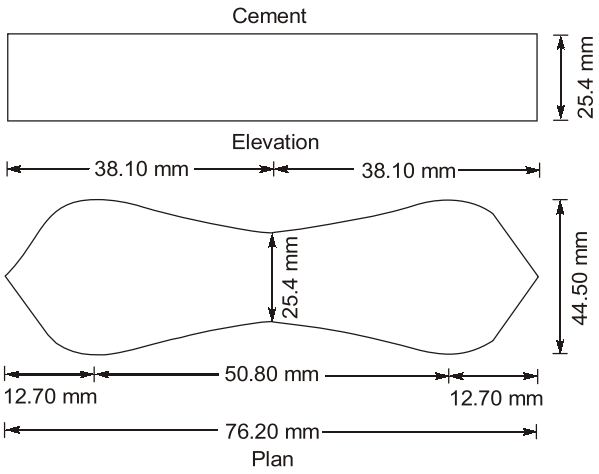
- Indian Standard specification recommends that a cement having a magnesia content of more than 3 per cent shall be tested for soundness by autoclave test which is sensitive to both free magnesia and free lime.
- In this test, a cement paste of 25 mm × 25 mm × 250 mm is placed in a standard autoclave.
- Now, the steam pressure inside the autoclave is raised at such a rate so as to bring the gauge pressure of the steam to 21 kg/cm^2 in 1 hour to 1 hour 15 minutes from the time the heat is turned on.
- This pressure is maintained for three hours.
- The autoclave is cooled and length of the specimen is measured again.
- The expansion should not exceed 0.8%.
  - For OPC (33, 43, 53); SRC; PPC, RHC, LHC, Slag cement
  - 1% for masonry cement.

Strength Test

(a) Compressive Strength Test:

- The compressive strength of the hardened cement is the most important of all the properties.
- Take 185 gm of standard sand (Ennore sand), 55 gm of cement (i.e. ratio of cement to sand is 1: 3) and mix them with a trowel for one minute.
- Add water of quantity $\left(\frac{P}{4}+3.0\right)$% of combined weight of cement and sand where P is the percentage of water required to produce a cement paste of normal consistency.
- This time of mixing should not be less than 3 minutes and not more than 4 minutes.
- Immediately, after mixing, the mortar is filled in a cube mould of size 7.06 cm. The area of the face of cube should be 50 cm^2.
- Compact the mortar either by hand compaction in a standard specified manner or on the vibrating equipment for 2 minutes. (vibrations = 1200 ± 400 vibrations/minute)
- Keep the compacted cube in the mould at a temperature of 27° ± 2°C and at least 90% relative humidity for 24 hours.
- After 24 hours, the cubes are removed from the mould and immersed in clean fresh water until taken out for testing.
- Three cubes are tested for compressive strength at 1 day, 3 days, 7 days and 28 days where the period of testing being reckoned from the completion of vibration.
- The compressive strength shall be the average of the strengths of the three cubes for each period respectively.
- The compressive strength of 33 grade OPC at 3 days, 7 days and 28 days is 16 MPa, 22 MPa and 33 MPa respectively.
- Load applied gradually as 0 to 35 N/mm^2/min on cubes by using compressive testing machine (UTM machine).

(b) Tensile Strength Test:



Standard briquette

- The tensile strength of cement may be obtained by Briquette test.
- A mixture of cement and sand is gauged in the proportion of 1:3 by weight.
- The percentage of water to be used is calculated by the formula $\left(\frac{P}{5}+2.5\right)$ % where P is percentage of water required to produce a paste of standard consistency.
- The mix is filled in the briquette moulds and the surface of the mould is finished with the blade of a trowel.
- Briquette mould is then kept for 24 hours at a temperature of 27° ± 2°C and in an atmosphere having 90% humidity.
- The briquettes (6.45 cm^2) are then kept in clean water and are taken out before testing.
- Six briquettes are tested and average tensile strength is calculated.
- Load is applied steadily and uniformly, starting from zero and increasing at the rate of 0.7 N/mm^2 in 12 seconds.
- OPC should have a tensile strength of not less than 2 MPa and 2.5 MPa after 3 and 7 days respectively.
- Generally tensile strength is 10-15% of compressive strength.
- Load applied steadily or uniformly from 0 to 0.7 N/mm^2 in 12 second.

2. Aggregates

- Aggregates are the materials basically used as filler with binding material in the production of mortar and concrete.
- They are derived from igneous, sedimentary and metamorphic rocks or manufactured from blast furnace slag etc.
- They occupy 70-80 percent of the volume and have considerable influence on the properties of the concrete.
- They should be clean, hard, strong, durable and graded in size to achieve almost economy from the paste.

Classification of Aggregates

(i) On the basis of geological origin
  (a) Natural Aggregates
  (b) Artificial Aggregates

(ii) On the basis of size
  (a) Coarse Aggregates
  (b) Fine Aggregates

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Civil Engineering

Part-II

Topicwise Bifurcated
Previous Interview Questions
and Practice Questions

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UNIT 1

Building Materials

1. Cement

1.1 For road repair works, which type of cement is recommended?

Ans. Rapid Hardening Cement

1.2 Which is the initial setting time of extra rapid hardening cement?

Ans. The initial setting time of the extra rapid hardening cement should not be less than 20 minutes.

1.3 What is the maximum percentage of C_3A in sulphate resisting cement?

Ans. 5%

1.4 What is the meant by the standard consistency of a cement?

Ans. The standard consistency of a cement paste may be defined as the consistency which will permit the Vicat Plunger (10 mm diameter, 50 mm length) to penetrate to a depth of 33-35 mm from the top of the mould.

1.5 What is the aim of standard consistency test of cement.

Ans. Standard consistency test of cement is carried out to ascertain the initial setting time, final setting time and soundness cement.

1.6 What are aggregates?

Ans. The generally inert materials such as sand, gravel, crushed rock, etc. used for manufacture of mortars, and concrete, are known as aggregates.

1.7 How much water is required to hydrate 50 kg cement in sealed container?

Ans. About 19 liters (38 percent)

1.8 What is grade 53 cement?

Ans. The ordinary Portland cement when tested for its compressive strength at 28 days according to the method described by the standard specification, yields a minimum compressive strength of 53 N/mm^2 is called 53 grade cement.

1.9 What are the benefits of blast furnace slag cement?

Ans. It has a low heat of hydration, more durability and is better resistant to soil and water containing excessive amount of sulphates, alkalies, metals as well as acidic waters. It is helpful for marine works.

1.10 What is flash setting of cement?

Ans. As soon as the water is added to cement, the reaction between cement and water immediately starts, if gypsum is not added while grinding of clinker. This is called flash setting. However, this is not acceptable since mixing the ingredients and placing the concrete to the required location requires some time. Cement does not gain prominent strength during flash setting.

1.11 What is the volume of one 50 kg bag of cement?

Ans. The density of OPC lies between 1000-1300 kg/m^3. (say 1300 kg/m^3). Mass of 1 bag of cement = 50 kg

$\therefore$ Volume of 1 bag of cement

$$= \frac{50}{1300}\ m^3 = \frac{50}{1300} \times 1000l$$

$$= 38.46\ l$$

1.12 Explain the difference between setting and hardening of cement.

Ans. The change from fluid to rigid state of a cement paste is termed as setting of cement. The hardening refers to the gain of strength of set cement paste. During setting, cement acquires some strength, however for practical purpose, the terms setting and hardening are separately defined.

1.13 Is setting time of cement related with setting time of concrete?

Ans. The setting time of cement is purely independent one. It is not related to the setting and hardening of actual concrete.

1.14 How is the rapid hardening property of rapid hardening cement obtained?

Ans. The rapid hardening property of this cement is obtained by a higher C_3S content, lower C_2S content and by finer grinding of the cement clinker.

1.15 Why is rapid hardening cement not used for mass concrete or for large structural sections?

Ans. In early stage, this cement gives out a large quantity of heat of hydration. Due to this, the temperature inside the concrete increases leading to the formation of undesirable cracks on cooling. Therefore, it is not used for mass concrete or for large concrete sections.

1.16 What are the benefits of blast furnace slag cement?

Ans. It has a low heat of hydration, requires low w/c ratio for same slump more durability and is better resistant to soil and water containing excessive amount of sulphates, alkalies, metals as well as acidic waters. It is helpful for marine works.

1.17 How is the high strength of cement achieved in cement factories?

Ans.
(a) Selecting good quality of lime stone as a raw material
(b) Using low ash coal firing as the coal ash is detrimental to the quality of clinker. Many plants in India import good quality coal to ensure consistent quality product.
(c) Ratio of CaO with SiO_2, Al_2O_3 and Fe_2O_3 is always maintained during manufacturing.
(d) At all stages of manufacturing, required quality controls are carefully exercised.

1.18 What are the advantages of using higher grade of cements?

Ans. The following are the noteworthy advantages of using higher grade cements:
(a) Saving of cement consumption for required specification of concrete.
(b) Development of high early strength which may facilitate the early stripping of form work.
(c) The reduced quantity of cement reduces the shrinkage cracks and heat of hydration.
(d) Due to low percentage of alkalies, chlorides, magnesia and free lime, they offer more durable structures.

1.19 What happens if the cement is too fine?

Ans. Too fine cement is susceptible to air set deteriorates earlier, generates more heat of hydration, hardens rapidly and provide lesser durable concrete.

1.20 What happens if the cement is not uniformly fine?

Ans. If the cement is not uniformly fine, the concrete made out of it will have poor workability and will require a large quantity of water for mixing. Also bleeding (flowing of water above surface) of concrete can occur.

1.21 How is the setting time of cement controlled?

Ans. The setting time of cement can be controlled by varying the quantity of gypsum in cement.

1.22 What is false set?

Ans. Sometimes with the addition of water to cement, a premature set occurs within 5 minutes. This is called false set and is due to the presence of anhydrous gypsum which is formed due to grinding of gypsum with too hot clinker. This is not to be worried. Continuous mixing of aggregates, cement and water will break the false set without harming any property of the concrete (molecular water evaporates and during hydration gypsum across H_2O and form crystal).

1.23 Why are the excess quantities of magnesium oxide, free lime or sodium oxide in cement considered undesirable?

Ans. These are considered undesirable as they undergo a large change in volume, which produce cracks in concrete.

1.24 What is soundness of cement?

Ans. The ability of cement to maintain a constant volume is known as soundness of cement.

1.25 What are the causes of unsoundness of cement?

Ans. **Causes of unsoundness of cement:** Many a times in cement, certain constituents undergo undesirable expansion. This volume change owing to expansion of cement constituents leads to disintegration and cracking. Unsoundness in cement occur due to the presence of magnesia and free lime in cement. Free lime is covered by a thin film of cement and thus it hydrates very slowly. After setting of cement, moisture penetrates into the free lime resulting in hydration. The hydrated/slacked lime being larger in volume, results in expansion of cement causing thereby cracking and disintegration.

1.26 What is meant by the water of hydration?

Ans. **Water of hydration:** Water is one of the prime constituent of concrete. A part of water which is added to concrete gets used up in the hydration of cement to form a binding matrix which acts as a suspension for inert aggregates until the suspension has hardened. Remaining water acts as a lubricant between coarse and fine aggregates thereby making the concrete workable. The water required in the former case above is called as water of hydration.

1.27 What is the difference between false set and flash set?

Ans. **False set:** For OPC, the initial setting time is 30 min and final setting time $\not<$ 30 min and $\not>$ 600 min (10 hours). Within the first few minutes of mixing the water to cement, abnormal premature hardening of cement takes place. This is called as false set. Not much heat is evolved in this and remixing of cement paste without further addition of water restores the original plasticity and then cement paste sets in a normal way.

Flash set: The compound tricalcium aluminate (C_3A) is generally present in cement in a proportion of about 8 to 12% by mass. C_3A reacts very fast with water leading to an immediate hardening of paste and this is called as flash set. Gypsum is added in cement to prevent such a fast reaction.

1.28 What is the difference between initial set and final set?

Ans. **Initial Set:** Time at which cement paste loses its plasticity from the time of addition of water to cement is called as initial setting time.

Final Set: The time at which cement parts becomes a hard mass and starts to gain strength is called as final set.

1.29 What is the difference between ordinary portland cement and rapid-hardening portland cement? Which of these cements would you use for mass concrete?

Ans. **Rapid hardening portland cement v/s ordinary portland cement:** Rapid hardening portland cement is similar to ordinary portland cement but with higher content of tricalcium silicate (C_3S) and much finer grinding. It gains strength more quickly than OPC but the final strength of both the cements differ only slightly. At same w/c ratio, one day strength of rapid hardening portland cement is equal to three days strength of OPC.

Rapid hardening is accompanied by higher rate of heat evolution and this thing in mass concreting may lead to cracking due to thermal effects.

Thus for mass concreting, OPC should be preferred over rapid hardening cement.

1.30 What is meant by the total heat of hydration of cement?

Ans. **Heat of hydration of cement:** Silicates (C_3S, C_2S) and aluminates (C_3A, C_4AF) present in cement react with water to form a binding medium which later on solidifies into a hardened mass. This chemical reaction of cement and water is called as hydration. Hydration is usually exothermic which results in increase of temperature in the interior of cement mass. The amount of heat (cal/g or Joules/g) evolved upon complete hydration of cement is called as heat of hydration of cement. This heat of hydration increases with temperature at which the hydration takes place.

1.31 Under what conditions would you recommend the use of HAC?

(ESE 2020)

Ans. **Use of HAC:** HAC or High Alumina Cement is highly reactive. About 80% of strength of concrete is developed within 24 hours. Its final setting time is about 4 to 5 hours. HAC contains about 40% alumina. It is used where very early

strength development of concrete is required. Also HAC is highly resistant to chemical attack and is suitable for under sea concreting.

1.32 Describe the consequences of mixing portland cement and HAC.

Ans. **Mixing portland cement with high alumina cement (HAC):** Addition of HAC to portland cement accelerates the setting time to a degree that depends upon the proportions of the two cement. Because of uncertainty in the reactions, HAC as an accelerator is generally not recommended. Instead the use of commercial accelerator from a reliable supplier is preferred.

1.33 Why is C_3A undesirable in cement?

Ans. **C_3A in cement:** Tricalcium aluminate (C_3A) reacts very vigorously with water leading to immediate setting of cement called flash set and High heat of hydration.

1.34 What are the alkalies in cement?

Ans. **Alkalies** generally present in cement are sodium and potassium ions along with their sulphates and/or hydroxides i.e. Na_2SO_4, NaOH, K_2SO_4, KOH. It is believed that alkalies generally accelerate the hydration of cement.

1.35 What is insoluble residue in cement?

Ans. **Insoluble residue in cement:** The non-reactive part of cement is referred to as insoluble residue. It is determined by adding 1 g of cement in about 40 ml of water and adding 10 ml of concentrated HCl. Mixture is boiled for 10 minutes and solution is filtered. The filter residue is washed with sodium carbonate followed by water followed by HCl and finally again with water. Filter paper is dried and weighed to give amount of insoluble residue. Minimum is the residue, better is the cement and maximum permissible insoluble residue is 0.85%.

1.36 What is a blended cement?

Ans. **Blended Cement:** It is defined as hydraulic cement consisting essentially of an intimate and uniform mixture of different constituents. It is produced by intergrinding portland cement clinker with other materials. By varying the proportions of constituents, attributes like sulphate resistance, resistance to alkali-silica reaction can be obtained with blended cement.

1.37 What are the various types of water in hydrated cement paste?

Ans. **Water in hydrated cement paste:** Water in hydrated cement paste is classified as evaporable water and non-evaporable water. Evaporable water can be determined by the loss of water upon drying at 105°C. The remaining water is called as non-evaporable water. Amount of non-evaporable water increases as hydration proceeds. In well hydrated cement, the non-evaporable water is about 18% by mass of anhydrous material.

The water held by the surface portion of gel particles is called as adsorbed water and the water held between the surfaces of certain planes in a crystal is called as interlayer or zeolitic water. Lattice water is that part of water of crystallization which is not chemically associated with the principal constituents of the lattice.

diagram

1.38 What is the minimum water/cement ratio for full hydration of cement?

Ans. Minimum w/c ratio for full hydration of cement is about 23%. (23% for full hydration and 15% to fill the gel pores)

1.39 Define the gel/space ratio.

Ans. **Gel space ratio** is the ratio of solid products of hydration to the space available for these hydration products. It is a measure of capillary pore space. Before hydration, this space is occupied by mixing water, after hydration, the space is sum of the hydrated cement and the remaining capillary pore space.

1.40 Discuss the uses of glass fibre reinforced cement.

Ans. **Uses of glass-fibre reinforced cement:** Glass-fibres are made up of about 200-400 individual filaments lightly bonded together to form a strand. Glass fibres are mainly used in reinforcing the cement or mortar matrices used in production of thin-sheets. Glass fibre reinforced cement is used in formwork systems, ducting, roofing material, lining of sewers, swimming pools, drainage elements, etc.

1.41 **Explain what is meant by ferrocement.**
(ESE 2020, 2024)

Ans. **Ferro-cement:** It is a type of reinforced concrete where cement mortar matrix is reinforced with many layers of thin wire mesh. Ferro-cement possesses very high strength to weight ratio and provides very high resistance against cracking.

1.42 **How extra rapid hardening cement is obtained? For how much time it can be stored?**

Ans. It is obtained by intergrinding $CaCl_2$ with rapid hardening portland cement. The amount of $CaCl_2$ added should not exceed 2% by weight of rapid hardening cement, this cement should not be stored more than 1 month.

1.43 **What is the advantage of GGBS (Ground granulated blast furnace slag) when added to cement?**
(ESE 2020)

Ans.
(a) Reduced heat of hydration.
(b) Refinement of pore structure
(c) Reduced permeability
(d) Increased resistance to chemical attack.

1.44 **In low heat cement, how the low heat evolution is achieved?**

Ans. By reducing the content of C_3S and C_3A which are the compounds evolving maximum heat of hydration and increasing C_2S.

1.45 **As per the IS guidelines, what is the value of heat of hydration for low heat cement.**

Ans. 7 days-not more than 65 calories per gm. 28 days-not more than 75 calories per gm.

1.46 **What are the advantages of portland pozzolana cement?**

Ans.
(a) Costly clinker is replaced by cheaper pozzolanic material.
(b) Soluble calcium hydroxide is converted into insoluble cementitious products resulting in improvement of permeability.
(c) It generates reduced heat of hydration and that too at a low rate.

1.47 **What is bound water and gel water? What is the consequence of adding excess water in cement?**

Ans. An average 23% of water by weight of cement is needed for chemical reaction with portland cement compound. This water which chemically combines with cement is called bound water. A certain quantity of water is imbibed within gel-pores. This water is called gel-water. It is about 15% of weight of cement. When this total (23+15)=38% water is added to cement, the cement undergoes full hydration and any excess water leads to the formation of undesirable capillary cavities.

1.48 **What is sulphate resisting cement?**

Ans. Ordinary portland cement is susceptible to the attack of sulphates. To remedy the sulphate attack, the use of cement with low C_3A content is found to be effective. Such cement with low C_3A and comparatively low C_4AF content is known as sulphate resisting cement. The specification generally limits the C_3A content to 5 percent.

1.49 **What is the consequence of adding excess gypsum in the cement? Why the soundness test is necessary for cement?**

Ans. The quantity of gypsum added varies from 3 to 5% depending upon C_3A content. If the addition of gypsum is more than that may combine with C_3A, excess quantity of gypsum will remain in free state leading to the expansion and consequent disruption of the set cement paste. The soundness test is done to ensure that the cement does not show any appreciable subsequent expansion.

1.50 **What is plasterer's is laths?**

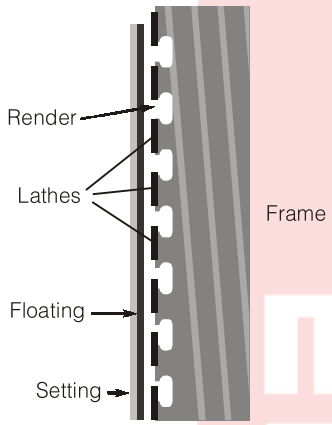
Ans. **Plasterer Laths:** It consists of wood laths. These wood laths are narrow strips of wood which are nailed horizontally across the wall. Each wall frame is covered with lath. The size of the lath is about two inches wide by four feet long by 1/4 inch thick. Each horizontal course of lath is spaced about 3/8 inch away from its neighboring courses.
Temporary lath guides are then placed vertically to the wall. Plaster is then applied, typically using a wooden board as the application tool. The supplier drags the board upward over the wall, forcing the plaster into the gaps between the laths and leaving a layer on the front. A helper feeds new plaster onto the board, as the plaster is applied in quantity. When the wall

is fully covered, the vertical lath "guides" are removed, and their "slots" are filled in, leaving a fairly uniform undercoat.

It is a standard to apply a second layer in the same fashion, leaving about a half inch of rough, sandy plaster (called a *brown coat*). A smooth, white finish coat goes on last. After the plaster is completely dry, the walls are ready to be painted.

Eventually the wood laths have become less common.

Lath and plaster has been mostly replaced with solid drywall or plasterboard (also a type of gypsum wall board, although a bit thicker), since it is faster and less expensive to install.



1.51 What is the composition of fly ash?

(ESE 2020)

Ans. The principal constituents of fly ash are more silica, alumina, iron oxide and calcium with varying amounts of carbon as measured by loss on ignition.

1.52 Tell me about utilisation of fly ash.

(ESE 2020)

Ans. Fly ash can be used in

(a) Road embankment construction & filling works
(b) Concrete works (in RMC Plants)
(c) Building construction works (as Fly Ash Bricks)
(d) Mine filling (Fill Materials)

1.53 Why a rounded aggregate is economical?

Ans. It gives good workability for the given amount of water and hence it needs less cement for given w/c ratio. It is very economical in cement consumption.

1.54 What is form work?

Ans. It is temporary ancillary construction used as a mould for the structure, in which concrete is placed and in which it hardens and matures.

1.55 What compounds are formed during the setting of high alumina cement?

Ans. During the setting of the high alumina cement mono calcium aluminate decahydrate(CAH_{10}), dicalcium aluminate octahydrate(C_2AH_8) and alumina gel(AH_n) are formed. This gives the high strength but they are unstable and at normal temperature convert gradually to tricalcium alumina hexahydrate (C_3AH_6) and gibbsite which is more stable.

1.56 How high early strength cement is obtained. Where it is used and what is the value of the strength for this?

Ans. It is obtained by using lithium salts as accelerators in high alumina cement. It is used in repair and emergency work. Using this a strength of as high as 4 MPa has been obtained within one hour and 27 MPa has been obtained within 3 hours time and 49 MPa in one day.

1.57 Where the fly ash was used for the first time in India?

Ans. In India, fly ash was used for the first time in the construction of Rihand Irrigation Project, Uttar Pradesh in 1962, replacing cement upto about 15 percent.

1.58 What is surkhi?

Ans. Surkhi is an artificial pozzolana made by powdering bricks or burnt clay balls.

1.59 What are the principal raw materials used in the manufacture of cement?

Ans.
(a) Argillaceous or silicates of alumina in the form of clays and shales.
(b) Calcareous or $CaCO_3$, in the form of limestone, chalk and marble which is a mixture of clay and $CaCO_3$.

1.60 What type of cement is used for under water concreting?

(ESE 2005)

Ans. Quick setting and hydrophobic cement is generally used for under water concreting.

1.61 What is epoxy based cement?

(ESE 2005)

Ans. **Epoxy** is a polymer that is added to cement so as to increase the strength and anti-stain properties of cement.

1.62 Which type of cement is preferred in construction near sea coast regions?

(ESE 2006)

Ans. For coastal regions, sulphate resistant cement (SRC) is preferred. SRC is a type of Portland cement in which tricalcium aluminate is restricted to 5% and di-calcium aluminate, tetra-calcium alumino ferrite is lower than 25%. It is used where risk of deterioration due to sulpahte attack is predominant like in coastal areas.

1.63 Differentiate between silica fume and fly ash?

(ESE 2007)

Ans. **Silica Fume:** It is a byproduct of reduction of high purity quartz with coal in an electric arc furnace for production of ferro-silicon metal. It is extremely fine (nearly 2 crore sq.mm/gram) and high glass content, it is a very good pozzolanic material. About 1 kg of silica fume can replace 3-4kg of cement in concrete without affecting the compressive strength of the concrete.

Fly Ash: It a byproduct of thermal power plants which is carried upwards by combustion gases and collected in ESP. It has a grayish colour which becomes darker in colour with increasing content of unburnt carbon. Fly ash when added to concrete increases the effective volume of paste in the mix and has been attributed for pozzolanic reaction and water reduction. However it reduces the rate of strength development and increases the dying shrinkage and creep strain.

1.64 Give practical examples of some pozolonic material?

(ESE 2007)

Ans. Silica fume, fly ash are used as pozzolanic material.

1.65 What is pozzolanic reaction?

(ESE 2007)

Ans. **Pozzolanic Reaction:** This reaction occurs in cement containing pozzolanas. These pozzolanic materials react with calcium hydroxide to form calcium silicate hydrate. Many pozzolannas contain aluminum in the form of aluminate $Al(OH)_4^-$ that reacts with calcium hydroxide and water to form calcium aluminate hydrate.

1.66 How do you test the strength of cement?

[ESE 2007, 2024]

Ans.

(a) The briquettes with a lean or weak mortar are made. The size of briquette is 75 mm × 25 mm × 12 mm. The proportion of cement and sand may be 1:6. The briquette is immersed in water for a period of 3 days. If cement is of sound quality the briquette will not break easily and it will be difficult to convert them into powder form.

(b) A block of cement 25 mm × 25 mm and 20 cm long is prepared and immersed in water for 7 days. It is then placed on support 15cm apart and loaded with a weight of 340 N. The block should not show signs of failure.

(c) A thick paste of cement with water is made on a piece of thick glass and it is kept under water for 24hrs. It should set and not crack.

1.67 What is setting time of cement?

(ESE 2009, 2016, 2018, 2020)

Ans. **Setting time of cement:** When water is added to cement, then a water-cement paste is formed which loses its plasticity gradually and gets converted into a hard mass of cement. The time from the instant water is added to the cement to the stage where it becomes sufficiently hard is referred to as setting time. It is divided in two stages viz. **initial setting time** and **final setting time**. The time taken by cement paste to loose its plasticity is called as **initial setting time** and the time taken to reach a stage at which cement paste becomes a hardened mass is called as **final setting time.**

1.68 What is slag?

(ESE 2009)

Ans. **Slag:** It is a by-product of iron production from iron formed by intrusion of water or steam in mortar material.

1.69 What is slag cement? What are its characteristics?

(ESE 2009)

Ans. **Slag cement and its characteristics:** Slag cement is obtained by mixing OPC (preferably more than 35%) clinker with granulated blast furnace slag. Slag is a by-product obtained during the manufacture of pig-iron and it contains lime, silica and alumina. This cement is less reactive than OPC and gains strength slowly during the first 28 days. It generates heat at a slower rate than OPC and is suitable for mass concreting but not suitable for cold weather concreting. Due to its high resistance against sulphur, it is widely used in sea-water constructions.

1.70 What is form work? What are its uses?

(ESE 2009, 2020)

Ans. **Formwork:** Formwork also known as shuttering is defined as mould of timber or steel or any other material into which freshly mixed concrete is poured and which holds this concrete till it sets. A good formwork must be simple, strong, stiff, smooth and leak proof

1.71 Which type of cement is used in railway sleepers and why?

[ESE 2009, 2020]

Ans. IRS-T40 special grade cement is used in sleepers which is manufactured as per specification laid down by the Ministry of Railways under IRS-T40 : 1985. It is very fine cement with high C_3S content to develop high early strength required.

1.72 What is OPC, PPC, PAC?

(ESE 2009, 2014, 2020)

Ans. **OPC:** Ordinary Portland Cement

PPC: PPC is produced by grinding together the Portland cement clinker and pozzolana with addition of gypsum or $CaSO_4$, PPC produces low heat of hydration and is more resistant against the attack of impurities in water than OPC. PPC is particularly useful for marine and hydraulic construction.

PAC: Preplaced aggregate concrete, made by forcing grout into the voids of a mass of clean, graded coarse aggregate density prepacked in formwork.

1.73 How many grades are there for cement? What do you understand by 43 grade cement?

(ESE 2012)

Ans. Ordinary portland cement, is classified into three grades:

(a) 33 grade (b) 43 grade (c) 53 grade

(i) Various grades of cement with different grade names available in the market. Some of them are (IS 8112), (S 12269)

(ii) Portland Pozzolana cement (Fly ash based IS 1489).

If the 28 days strength of cube of face area 50 cm^2 made up of the cement sand mortar (1 : 3) is not less than 43 N/mm^2, it is called the 43 grade cement.

1.74 What is sulphur? (ESE 2013)

Ans. Sulphur is an element with atomic number 16 which lies in the 16^{th} group of modern periodic table. It is an abundant multivalent non-metal element. It occurs naturally as pure sulphur or sulphites or sulphates. It is an essential element for all forms of life.

1.75 What is white cement? (ESE 2013)

Ans. White cement is the ordinary cement but contains less amount of iron oxide which is responsible for greyish colour in cement. The percentage of iron oxide is usually less than one percent. The raw materials for this cement are chalks and limestone with low iron content and white clays.

1.76 What are the tests required to be done on cement?

(ESE 2013, 2016, 2020)

Ans. The following are some of the **cement tests** that are required to be done on cement:

(a) Soundness test

(b) Compressive strength test

(c) Test for setting time, consistency

(d) Fineness test

1.77 What is fiber reinforced concrete?

(ESE 2013, 2016, 2020)

Ans. Fiber reinforced concrete (FRC) refers to