2019

RANK Improvement WORKBOOK

Answer key and Hint of Objective & Conventional *Questions*

Civil Engineering

Construction Materials

MADE EASY Publications

1 Cement, Mortar and Lime

LEVEL 1 Objective Questions

1. (a)
2. (b)
3. (d)
4. (c)
5. (d)
6. (a)
7. (c)
8. (d)
9. (c)
10. (d)
11. (c)
12. (a)
13. (d)
14. (d)
15. (c)

LEVEL 2 Objective Questions

16. (c)
17. (c)
18. (b)
19. (a)
20. (c)
21. (d)
22. (b)
23. (d)
24. (b)
25. (b)
26. (b)
27. (d)
28. (b)
29. (a)
30. (a)
31. (b)
32. (d)
33. (c)
34. (d)
35. (d)

LEVEL 3 Conventional Questions

Solution : 1

Item	Quantity	Rate	Cost
Cement	4 bags	170/-	Rs. 680/-
Sand	0.49 m^3	970/-	Rs. 475.3/-
Ballast	2.027 m^3	1800/-	Rs. 3648.6
			Rs. 4803.9/m^3 of work
Labour	**Number (per m^3)**	**Rate**	**Cost**
S.mason	0.05	320/-	16
Mason	0.6	275/-	165
Men	1.6	150/-	240
			Rs.421

Total cost for cu.m of finished work = Rs. (4803.9 + 421) = Rs. 5224.9/-

Solution : 2

The compressive strength test of cement mortar is carried out as per the guidelines specified by **IS:4031 (Part 6)-1988**. The material for each cube shall be mixed separately and the quantity of cement, standard sand and water shall be as follows:

(i) Cement — 200 gm

(ii) Standard sand — 600 gm

(iii) Water — $\left(\frac{P}{4}+3.0\right)$ per cent of combined mass of cement and sand, where P is the percentage of water required to produce a paste of standard consistency.

The mixture of cement and standard sand is placed on a non-porous plate. This mixture is mixed dry with a trowel for one minute and then with water until the mixture is of uniform colour. The time of mixing shall in any event be not less than 3 minute and should the time taken to obtain a uniform colour exceed 4 min, the mixture shall be rejected and the operation repeated with a fresh quantity of cement, sand and water. Immediately after mixing the mortar, it is filled into a cube mould of size 7.06 cm. The area of the face of the cube should be 50 cm^2. The mortar shall be prodded 20 times in about 8 seconds to ensure elimination of entrained air and honey combing. Place the remaining quantity of mortar in the hopper of cube mould and prod again as specified for the first layer and then compact the mortar by vibration The period of vibration shall be two minutes at the specified speed of 12000 ± 400 vibration per minute. Keep the compacted cube in the mould at a temperature of 27°C ± 2°C and at least 90 per cent 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. Test three cubes for compressive strength for each period of curing. The compressive strength shall be the average of the strengths of the three cubes for each period respectively.

The compressive strength of hardened cement is the most important of all the properties. Therefore, it is not surprising that the cement is always tested for its strength at the laboratory before the cement is used in important works.

Solution : 3

The following tests are usually conducted in laboratory to assess the quality of cement:

(i) **Fineness test:** The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Fineness of cement can be tested in two ways viz. by sieving and by determination of specific surface using air permeability apparatus.

(ii) **Setting time test:** In actual construction dealing with cement paste, mortar or concrete, certain time is required for mixing, transporting, placing, compacting and finishing. During this time cement paste, mortar or concrete should be in plastic condition. This time is known as initial setting time. Once the concrete is placed in the final position, compacted and finished, it should lose its plasticity in the earliest possible time so that it is least vulnerable to damages from external destructive agencies. This time is known as final setting time. Setting time test is carried out with the help of Vicat apparatus.

(iii) **Compressive strength test:** The compressive strength of hardened cement is the most important of all the properties. Therefore, it is not surprising that the cement is always tested for its strength in laboratory before the cement is used in important works.

(iv) **Soundness test:** It is very important that the cement after setting shall not undergo any appreciable change of volume. The testing of soundness of cement, to ensure that the cement does not show any appreciable subsequent expansion is of prime importance. Unsoundness in cement is due to excess of lime, excess of magnesia or excessive proportions of sulphates. Unsoundness due to lime can be tested using Le Chatelier apparatus. Unsoundness due to magnesia can be tested using Autoclave test. Unsoundness due to calcium sulphate can be tested using chemical analysis.

(v) **Heat of hydration test:** The reaction of cement with water is exothermic. It is estimated that about 120 calories of heat is generated in the hydration of 1 gm of cement. The total quantum of heat produced in a conservative system such as the interior of a mass concrete dam, a temperature rise of about 50°C has been observed. This unduly high temperature developed at the interior of a concrete dam causes serious expansion of the body of dam and with the subsequent cooling considerable shrinkage takes place resulting in serious cracking of concrete. Heat of hydration test can be easily carried out over a few days by vacuum flask methods, or over a longer period in an adiabatic calorimeter.

(vi) **Chemical composition test:** The raw materials used for the manufacture of cement consist mainly of lime, silica, alumina and iron oxide. The relative proportions of these oxide compositions are responsible for influencing the various properties of cement, in addition to rate of cooling and fineness of grinding. Thus the chemical composition test is carried out in laboratory.

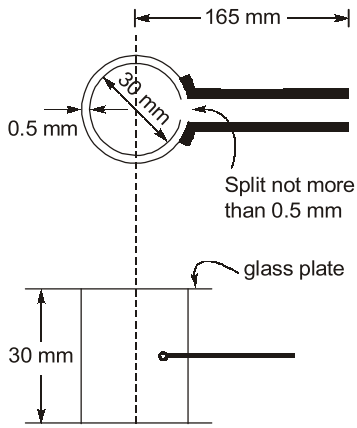
Solution : 4

It is very important that the cement after setting shall not undergo any appreciable change of volume. Certain cements have been found to undergo a large expansion after setting causing disruption of the set and hardened mass. This will cause serious difficulties for the durability of the structures when such cement is used. The testing of soundness of cement to ensure that the cement does not show any appreciable subsequent expansion is of prime importance. Unsoundness in cement is due to excess of lime, excess of magnesia or excessive proportion of sulphates.

Soundness test can be carried out with the help of **Le Chatelier apparatus**. It consists of a small split cylinder of spring brass or other suitable metal. 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.

Cement is gauged with 0.78 times the water required for standard consistency in a standard manner and filled into the mould kept on a glass plate. The mould is covered on the top with another glass plate. The whole assembly is immersed in water at a temperature of 27°C-32°C and kept there for 24 hours. The distance between the indicator points is measured and the mould is again submerged in water.

The water is heated and brought to boiling point in about 25-30 minutes and kept in the same condition for 3 hours. Now, the mould is removed from water and allowed to cool. The distance between the indicator points is measured again. The difference between these two measurements represents the expansion of cement. This must not exceed 10 mm for ordinary, rapid hardening and low heat portland cement. If in case the expansion is more than 10 mm as tested above, the cement is said to be unsound.



The most important limitation of the Le Chatelier test is that it detects unsoundness due to free lime only. This method of testing does not indicate the presence and after effect of the excess of magnesia. The sketches of Le Chatelier apparatus are shown:

Solution : 5

Use of lime:

(i) It is used as a chemical raw material in the purification of water and for sewage treatment.
(ii) It is used as a flux in the metallurgical industry.
(iii) It is used as a matrix for concrete and mortar.
(iv) It is used as a refractory material for lining open-hearth furnaces.
(v) It is used in the production of glass.
(vi) It is used for making mortar for masonry work.
(vii) It is used for plastering of walls and ceilings.
(viii) It is used for soil stabilisation.
(ix) It is used for whitewashing.
(x) Lime mortar can be used in place of the costly cement mortar.

Test for lime :

(i) Physical properties :

- The pure limestone is indicated by white colour.
- The hydraulic limestones are indicated by bluish grey, brown or some dark colour.
- The presence of lumps give an indication of quick lime or unburnt limestone.

(ii) Heat test :

- A piece of dry limestone is weighted and it is heated in an open fire for few hours. The sample is weighted again and loss of weight indicates the amount of carbon dioxide.

(iii) Acid test :

- A teaspoon of powdered lime is taken in a test tube and dilute hydrochloric acid is poured in it. The contents are now stirred and the test tube with its contents is then kept standing in its stand for 24 hours
- If content of calcium carbonate is high, there will be vigorous effervescence and less formation of residue.
- If a thick jet is formed, it indicates lime of class A.

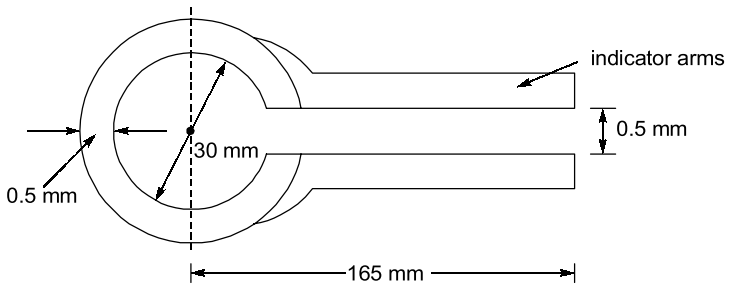
(iv) Ball test :

- The balls of about 40 mm size of stiff lime formed by adding enough water are made and they are left undisturbed for six hours. The balls are then placed in a basin of water. If there are signs of slow expansion and slow disintegration within minutes after placing in water, it indicates class C lime.

Solution : 6

A quality which indicates that the cement paste, once it has set, does not undergo appreciable change in the volume (causing crack) is called **soundness**. Unsoundness of the cement is due to the presence of lime, magnesia and sulphur in it.

1. Le-chatelier's Test :
   - It measures unsoundness due to lime.
   - It consists of split cylinder of diameter and height of 30 mm and indicator arms of length 165 mm provided on either side of the split.
   - 100 gm of cement is taken and paste of consistency 0.78 P is formed. The paste is filled in the split cylinder, which is covered from top and bottom with the help of glass plates.
   - The entire assembly is immersed in the water having the temperature in range of 27 to 32°C for 24 hours.
   - The cylinder is removed from the water and the distance between the indicator arm is noted (x).
   - The entire assembly is again immersed in the water, temperature of which is increased upto its boiling point in 25 to 30 minutes and is maintained for next 3 hours.
   - The assembly is removed from the water and distance between the indicator arms is again noted (y).
   - For OPC, difference between the two readings must not exceed 10 mm.



2. Autoclave Test :
   - This test is sensitive to both unsoundness due to lime and magnesia.
   - Mould of size 25 mm × 25 mm is placed in 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 min from the time the heat is turned on.
- This pressure is maintained for three hours. The autoclave is cooled and length of the specimen measured again.
- The expansion should not exceed 0.8%.
- IS specification recommends that a cement having a magnesia content of more than 3% shall be tested for soundness by autoclave test.

Solution : 7

Physical properties :

1. Colour test : A sample of cement to be tested should be of uniform grey in colour.
2. The cement should feel smooth when touched or rubbed in between the fingers. If it is felt rough, it indicates adulteration with sand. If hand is inserted in a bag or heap of cement, it should feel cool and not warm.
3. If a small quantity of cement is thrown in a bucket of water, it should sink and should not float on the surface. A thin paste of cement with water should feel sticky between the fingers. If the cement contains too much of pounded clay and silt as an adulterant, the paste will give an earthy smell.
4. Presence of lumps : The cement should be free from any hard lumps. Such lumps are formed by the absorption of moisture from the atmosphere. Any bag of cement containing such lumps should be rejected.
5. Strength : It can be roughly ascertained in following ways :
   (i) The briquettes with a lean or weak mortar are made. The size may be about 75 mm × 25 mm × 12 mm. The proportion of cement and sand may be 1 : 6. The briquettes are immersed in water for a period of 3 days. If cement is of sound quality, such briquettes will not be broken easily and it will be difficult to convert them into powder form.
   (ii) A block of cement 25 mm × 25 mm and 200 mm long is prepared and it is immersed for 7 days in water. It is then placed on supports 150 mm apart and it is loaded with a weight of 340 N. The block should not show signs of failure.
   (iii) A thick paste of cement with water is made on a piece of thick glass and it is kept under water for 24 hours. It should set and not crack.

Solution : 8

(i) Guniting: The gunite may be defined as mortar comprising. Cement and sand conveyed through an equipment known as gun. It is pneumatically forced on backing surface, through a nozzle where water is added at a high velocity. The mix leaving the nozzle at high velocity strikes the surface to be repaired or prepared or protected. In the process, the coarser particles rebound from the surface and leave an excellent bond coat of fine grout in intimate gr contact with backing surface. In the process a thin layer of grout builds up and acts like a cushion reducing the percentage rebound in the successive layers.

The application of mortar or concrete under pneumatic pressure through a cement gun is known as guniting; concrete becomes extremely strong and high bond is achieved.

Uses: Gunite can be employed for construction of thin section, e.g., folded plates, shells, and thin walls; lining for tunnels and suiting pools; repairing of deteriorated concrete damaged by fire, earthquake

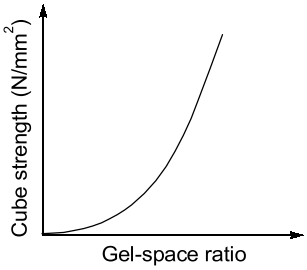
chemicals and in hydraulic structures, strengthening building, bridge and jetties, stabilizing rocks and earth slopes; protective coating over prestressing wires and steel pipes and to furnish rough surface texture form architectural point of view. Pneumatic guniting is also used for refractory castables.

(ii) Gel-space ratio-gel-space ratio is defined as the ratio of volume of hydrated cement paste to the sum of the volumes of the hydrated cement and that of the capillary pores. A typical curve relating gel-space ratio to compressive strength is shown below:

$$S = 240\,x^3$$

where S = Strength of concrete

x = gel-space ratio



(iii) **Duff Abraham's Law:** It states that "for plastic mixtures using neat and clean aggregates, the strength of concrete under specified conditions is governed by the net quantity of water mixed per bag of cement". He gave the following equation to estimate the strength of concrete.

$$S = \frac{A}{B^x}$$

Where, S = Strength of concrete at 28 days

A = 14000 lbs/sq in and $B = 7$

According to Abraham's law it is evident that strength of concrete depends only upon w/c ratio provided the mix is workable.

■■■■

2 Admixture and Aggregates

LEVEL 1 Objective Questions

1. (a)
2. (b)
3. (a)
4. (d)
5. (d)
6. (b)
7. (d)
8. (d)
9. (d)
10. (b)

LEVEL 2 Objective Questions

11. (b)
12. (b)
13. (a)
14. (c)
15. (a)
16. (b)
17. (a)
18. (b)

LEVEL 3 Conventional Questions

Solution : 1

The water absorption of an aggregate is the percentage by weight of water absorbed in terms of oven dry weight of specimen and it is an accepted measure of porosity. For aggregates normally used in construction, the water absorption value varies from 0.1 to 2%.

Procedure :

(i) The sample of not less than 2000 g should be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22 and 32°C.

(ii) After immersion, the entrapped air should be removed by lifting the basket and allowing it to drop 25 times in 25 seconds. The basket and sample should remain immersed for a period of 24 + 1/2 hrs afterwards.

(iii) The basket and aggregates should then be removed from the water, after which the aggregates should be gently emptied from the basket. The aggregates should be surface dried and weighed (A).

(iv) The aggregates should then be placed in an oven at a temperature of 100 to 110°C for 24 hours. It should then be removed from oven, cooled and weighted (B).

$$\text{water absorption} = \left(\frac{A-B}{B}\right)\times 100$$

Solution : 2

Plasticizers are usually based on lignosulphates, which is a natural polymer, derived from wood processing in the paper industry. These admixtures are used for following purposes :

(i) To achieve a higher strength by decreasing the water cement ratio at the same workability as in admixture free mix.

(ii) To achieve the same workability by decreasing the cement content so as to reduce the heat of hydration in mass concrete.

(iii) To increase the workability so as to ease placing in accessible locations

(iv) Water reduction more than 5% but less then 12%

Action involved :

(i) **Dispersion :** Surface active agents alter the physical chemical forces at the interface. They are adsorbed on the cement particles, giving them a negative charge which leads to repulsion between the particles. Electrostatic forces are developed causing disintegration and free water become available for workability.

(ii) **Lubrication :** As these agents are organic by natures, thus they lubricate the mix reducing the friction and increasing the workability.

(iii) **Retardation :** A thin layer is formed over the cement particles protecting them from hydration and increasing the setting time. Most normal plasticizers give some retardation of 30-90 minutes.

Solution : 3

(i) Tests to measure workability of fresh concrete: (IS : 1199)

1. Slump test
2. Compacting Factor Test
3. Vee-Bee consistometer method

4. Flow test
5. Kelly Ball test

(ii) **Super plasticizing admixture:** Superplasticizers are hydrodynamic lubricators which impart high workability by reducing friction between the grains or by reducing the amount of water to be added. They are improved versions of plasticizers interact both physically and chemically with cement particles. The mechanism of action of superplasticizers is same as that of plasticizer. Superplasticizers are anionic in nature and impart a negative charge to the cement particles, causing them to repel each other.

Effects of superplasticizers:

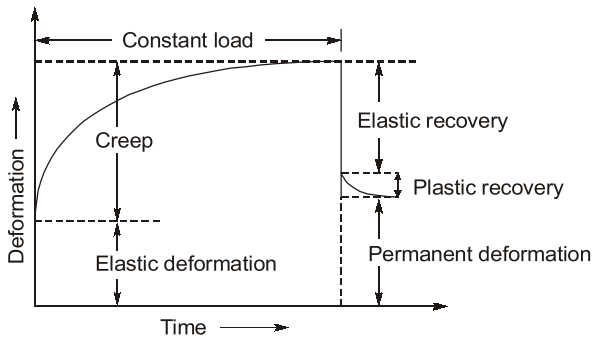
1. The workability of the superplasticised concrete decreases more with time than that of ordinary concrete.
2. The strength, water cement ratio and creep of concrete with the additive are the same as that of concrete before the addition of plasticizer while shrinkage and surface absorption are reduced slightly and then resistance to thawing and freezing is improved.
3. By addition of superplasticizers it is possible to obtain same strength with a reduced cement content.
4. The water-cement ratio of the superplasticised concrete may be reduced upto 30 percent to obtain the initial equality of workability.

Examples: Sulphonated melamine formaldehyde condensates, napthalene sulphonate formaldehyde condensates, modified lignosulphonate etc.

(iii) **Basic qualities of high performance concrete:**

1. **Workability :** In early stages of its development, the HSC has a tendency to be sticky and stiff due to large amount of fines (high cement content and pozzolana, a low water cement ratio and a normal water reducing admixture.
2. **Strength :** The most important point about HSC is their capacity to develop strength at a rapid rate without steam curing. Concrete can develop 20 to 27 MPa on normal curing within 24 hours and the ultra HSC can develop 42 MPa in 12 hours and 64 MPa in 24 hours.
3. **Microstructure, stress-strain relation, creep and fracture:** As a result of reduction in the size and number of micro-cracks in HSCs, its stress-strain relation, creep and fracture behaviour is different from the normal concrete.
4. **Durability :** It has been found that primarily due to low permeability, HSCs exhibit excellent durability to various physical and chemical agents that are normally responsible for concrete deterioration. Due to high cement content, thermal cracking can lead to durability problem in structures using HSC.

(iv) **Creep of concrete:** The continued deformation under applied loads is called creep. It increases strain in concrete with time under sustained stress. This is also known as plastic flow or time yield. The rate of creep decreases with time and the creep strains at five years are taken as ultimate values.



Creep increases rapidly with stress.

The deformation of hardened concrete is shown.

Solution : 4

Admixture: A material other than water, aggregates, or cement that is used as an ingredient of concrete or mortar; to control setting and early hardening, workability, or to provide additional cementing properties is called an *Admixture*. Over decades, attempts have been made to obtain concrete with certain desired characteristics such as high compressive strength, high workability, and high performance and durability parameters to meet the requirement of complexity of modern structures. The properties commonly modified are the heat of hydration, accelerate or retard setting time, workability, water reduction, dispersion and air-entrainment, impermeability and durability factors.

Chemical admixtures: Accelerators, retarders, water-reducing agents and super plasticizers.

Mineral admixtures: Fly-ash, blast-furnace slag, silica fume and rice husk ash.

Solution : 5

Admixtures are the chemical compounds in concrete other than hydraulic cement (OPC), water and aggregates and mineral additives that are added to the concrete mix immediately before or during mixing to modify one of more of the specific properties of concrete in the fresh or hardened state.

The commonly used admixtures are as follows:

(i) **Accelerating admixtures or accelerators:** An admixture used to speed up the initial setting of concrete is called an accelerator. These are added to concrete either (a) to increase the rate of hydration of hydraulic cement and hence to increase the rate of development of strength, or (b) to shorten the setting time. Accelerators are also used when the concrete is to be placed at low temperatures. The most widely used accelerator is calcium chloride ($CaCl_2$). The other less commonly used accelerators consist of NaCl, Na_2SO_4, NaOH, Na_2CO_3, K_2SO_4 and KOH.

(ii) **Retarding admixtures or Retarders:** The retarding admixtures slow down the initial rate of hydration of cement or prolong the setting of the cement paste in concrete. They are used primarily to offset the accelerating and damaging effect of high temperature and to keep concrete workable during the entire placing period which should be sufficiently long so that the succeeding lifts can be placed without the development of cold joints or discontinuities in a structural unit. Thus, a retarding admixture holds back the hydration process, leaving more water for workability and allowing concrete to be finished and protected before drying out. The most commonly known retarder is calcium sulphate. Other retarders are sugar, lignosulphonic acids and their salts, hydroxylated carboxylic acids and their salts etc.

(iii) **Air-entraining Admixtures:** These admixtures help to incorporate a controlled amount of air, in the form of millions of minute non-coalescing bubbles distributed throughout the body of concrete during mixing, without significantly altering the setting or the rate of hardening of concrete. It is generally recognized that a proper amount of entrained air results in improved properties of plastic concrete like workability, easier placing and finishing, increased durability, better resistance to frost action and reduction in bleeding and segregation. The compounds used for air-entrainment are a number of natural wood resins containing abietic and pimeric acid salts, various sulphonated compounds and some animal and vegetable fats and oils such as tallow, olive oil and their fatty acids such as stearic and oleic acids.

(iv) **Water reducing admixtures or Plasticizers:** To achieve the desired workability and hardened physical properties, it is often necessary to add a water reducer to disperse the ingredients and reduce the amount of water to be added during mixing. Plasticizers enable a given fresh concrete mix to have higher flowability (workability) without increasing the water content. Benefits of water reduction in hardened state of concrete are increased strength, density, durability, volume stability, abrasion resistance, reduced permeability and cracking. The most commonly used plasticizer is lignosulphonic acid in the form of either its calcium or sodium salt.

Solution : 6

Flaky aggregates are those aggregates whose least lateral dimension should be less than 0.6 times the mean dimension.

Elongated aggregates are those aggregates whose greatest dimension/length is greater than 1.8 times their mean dimension.

The test is conducted first for flaky aggregates that is flakiness index test. Then flaky material is removed from the sample and the remaining portion is tested far elongation index.

The combined flakiness and elongation index so obtained should not exceed 40% for uncrushed or crushed aggregate.

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3 Concrete

LEVEL 1 Objective Questions

1. (d)
2. (b)
3. (d)
4. (a)
5. (d)
6. (a)
7. (d)
8. (d)
9. (d)
10. (a)
11. (b)
12. (d)
13. (d)
14. (b)
15. (a)

LEVEL 2 Objective Questions

16. (c)
17. (b)
18. (c)
19. (c)
20. (a)
21. (a)
22. (d)
23. (c)
24. (c)
25. (d)
26. (b)
27. (a)

LEVEL 3 Conventional Questions

Solution : 1

Weight of cement = 376.57 kg
Weight of sand = 597.48 kg
Weight of coarse aggregate = 1124.68 kg

Solution : 2

Hundred per cent compaction is required for contributing to the **maximum strength**. To enable the concrete to be fully compacted with given efforts, normally a higher water/cement ratio than that calculated by theoretical considerations may be required. That is to say the function of water is also to lubricate the concrete so that the concrete can be compacted with specified effort forthcoming at the site of work. The lubrication required for handling concrete without segregation, for placing without loss of homogeneity, for compacting with the amount of efforts forthcoming and to finish it sufficiently easily, the presence of a certain quantity of water is of vital importance. The quality of concrete satisfying above requirements is termed as workable concrete. It is very difficult to define precisely all the aspects of the workability in a single definition. **IS : 6461 (Part VII)-1973** defines workability as that property of freshly mixed concrete or mortar which determines the ease and homogeneity with which it can be mixed, placed, compacted and finished. The optimum workability of fresh concrete varies from situation to situation e.g., the concrete which can be termed as workable for pouring into large sections with minimum reinforcement may not be equally workable for pouring into heavily reinforced thin sections.

Sometimes the terms "consistency" and "plasticity" are often used loosely for workability. Consistency is a general term to indicate **degree of fluidity or the degree of mobility**. A concrete which has high consistency and which is more mobile, need not to be of right workability for a particular job. On the other hand, plasticity is the cohesiveness of the mix to hold the individual grains together by cement matrix.

The following tests are commonly employed to measure workability:

(i) Slump test
(ii) Compacting factor test
(iii) Flow test
(iv) Kelly ball test
(v) Vee Bee consistometer test

The insitu determination of workability can be carried out by **slump test**. The test is carried out with a mould called the slump cone. The slump cone is placed on a horizontal and non-absorbent surface and filled in three equal layers of fresh concrete, each layer being tamped 25 times with a standard tamping rod. The top layer is struck off level and the mould lifted vertically without disturbing the concrete cone. The subsidence of concrete in millimeters is termed as the slump. The concrete after the test when slumps evenly all round is called true slump. In the case of very lean concrete, one half of the cone may slide down the other which is called a shear slump, or it may collapse in case of very wet concretes. The slump test is essentially a measure of consistency or the wetness of the mix. The test is suitable only for concretes of medium to high workabilities (i.e. having slump values of 25 mm to 125 mm). For very stiff mixes having zero slump, the slump test does not indicate any difference in concrete of different workabilities.

A concrete with slump value between 25 mm and 75 mm can be used in mass concrete foundations without vibration or lightly reinforced sections with vibration. For a slump value of 50 mm-100 mm concrete

can be used in normal reinforced sections manually compacted and heavily reinforced sections with vibrations. For a slump value of 100 mm-150 mm, concrete can be used for sections with congested reinforcement. It can be used for pumping and tremie placing.

Solution : 3

Light weight or foam concrete is broadly classified into three categories:

1. **Light weight aggregate concrete:** Naturally available light weight aggregates are Pumice, diatomite, Scoria, Volcanic cinders, rice husk and Sawdust. And artificially light weight, aggregates are cinder, foamed slag, sintered flyash, exfoliated vermiculite, bloated clay and expanded perlite. These light weight aggregates are used to form light weight concrete.
2. **Aerated concrete:** It is manufactured by Raw materials using calcarious and Silicious materials like cement, lime, pulverized sand, flash; by entrapping air cells. It is also known as foam/gas/cellular concrete.
3. **No Fines concrete:** Here, the fine aggregate fraction is omitted in concrete manufacturing. The aggregated/cement ratio ranges from 6 : 1 to 10 : 1 and the w/c ratio ranges from 0.38 to 0.52.

■■■■

4 Timber

LEVEL 1 Objective Questions

1. (d)
2. (a)
3. (b)
4. (c)
5. (d)
6. (a)
7. (c)
8. (c)
9. (a)
10. (a)
11. (a)
12. (a)

LEVEL 2 Objective Questions

13. (d)
14. (a)
15. (a)
16. (b)
17. (b)
18. (a)
19. (a)
20. (b)
21. (b)
22. (a)
23. (c)
24. (b)
25. (b)
26. (d)
27. (b)
28. (a)
29. (d)
30. (a)

LEVEL 3 Conventional Questions

Solution : 1

Seasoning of Timber: It is a process by which the moisture content of timber is reduced to a suitable level depending upon the use. Seasoned timber is definitely superior to unseasoned timber. While seasoning does not make timber safe from all destructive agencies, this is a prime process before timber can be put to use. By nature timber is hygroscopic and takes in moisture from air depending upon many factors. Timber should be seasoned as early as possible after felling because felled timber is nothing but dead vegetation that will rot and decay due to many environmental agencies.

The reasons or objectives for which seasoning is done are:

(i) To reduce the tendency to split, warp and shrink.

(ii) To make it immune from attack by insects.

(iii) To increase the strength, durability, workability and resilience.

(iv) To make the timber receptive to finish like preservative, paints and varnish.

(v) To reduce the weight and minimise cost of transportation.

(vi) To make the timber burn readily, if used as a fuel.

Seasoning methods can be basically classified into two groups namely, natural seasoning and artificial seasoning:

Natural Seasoning: In this method, the seasoning of timber is carried out by natural air and hence it is also sometimes referred to as air seasoning. The timber has to be stacked properly depending upon the species of timber and the environmental conditions. The timber log is cut and sawn into suitable section of planks or scantlings. Then they are stacked either horizontally or vertically. The stack is to be protected from fast blowing wind, rain and extreme heat of sun. Hence the stack should preferably be covered by a roof material. The advantage of natural seasoning is that it does not require skilled supervision. This method of seasoning timber is cheap and simple. The disadvantage of natural seasoning is that, as the process depends on the natural air, it some times become difficult to control it as well as the drying of different surface may not be even and uniform.

Artificial Seasoning: It is a quicker method of seasoning timber to the desired moisture content under controlled conditions. The drying conditions required for different species of timber are different and artificial seasoning makes it possible to provide conditions cited to each species. The advantages of artificial seasoning are speed, adaptability and precision.

The various methods of artificial seasoning are boiling, chemical seasoning, electrical seasoning and water seasoning which are as follows:

(i) **Boiling :** In this method of artificial seasoning, the timber is immersed in water and water is then boiled. This is a very quick method. The timber is thus boiled with water for about three to four hours. It is then dried very slowly under a shed. The periods of seasoning and shrinkage are reduced by this method, but it affects the elasticity and strength of wood. In place of boiling water, the timber may be exposed to the action of hot steam. This method of seasoning proves to be costly.

(ii) **Chemical Seasoning :** This is also known as salt seasoning. In this method, the timber is immersed in a solution of suitable salt. It is then taken out and seasoned in the ordinary way. The interior surface of timber dries in advance of exterior one and chances of formation of external cracks are reduced.

(iii) **Electrical seasoning :** In this method, the use is made of high frequency alternating currents. The timber, when it is green offers less resistance to the flow of electric current. The resistance increases as the wood dries internally which also results in the production of heat. This is the most rapid method of seasoning. But the initial and maintenance costs are so high that it becomes uneconomical to season timber on commercial basis by this method.

(iv) **Kiln Seasoning:** In this method, the drying of timber is carried out inside an airtight chamber or oven. Depending upon the mode of construction and operation, the kilns are of two types namely stationary kilns and progressive kilns. Stationary kiln is adopted for seasoning timber which requires a close control of humidity and temperature. It gives better results. Progressive kiln is used for seasoning timber on a large scale. If not properly attended the drying in this kiln may prove to be unsatisfactory. The kiln seasoning though costly gives well seasoned timber as it controls three important conditions namely circulating air, relative humidity and temperature.

(v) **Water seasoning:** The water seasoning is a quick method and it renders timber which is less liable to shrink or warp. It also removes organic materials contained in sap of timber. It however weakens the timber and make it brittle.

Solution : 2

Preservation of Timber: No timber is immune to deterioration and ultimate disintegration if exposed for a sufficiently long period to ordinary atmospheric conditions. The principal causes of deterioration of wood in service are fungal infection, termite and other insects attack, mechanical failure and fire. The resistance of wood to these agents of destruction may be increased by the application of a suitable chemical to the wood. This application of chemicals to woods in order to enhance their resistance against decay, fire etc. is known as preservation of timber.

Preservation can basically be classified into the following four types:

(i) **Oil type:** Coal tar creosote with or without admixture of petroleum, coal tar, fuel oil or other suitable oils having high boiling range. This group includes creosote, a complex substance derived from coal or wood distillation. The advantages of creosote as a wood preservative are that it is an indigenous product with high toxicity, has relatively high performance and is non-corrosive. The disadvantages of creosote are that it has an unpleasant odour, not clean to handle and the treated timber is not very receptive to other finishes. This limits its use to timber for external use.

(ii) **Organic solvent type:** These consist of toxic chemical compounds dissolved in a non-aqueous solvent like volatile oils, spirits, naphtha etc.

Some of the compounds are:

(i) Copper and zinc naphthanates
(ii) Pentachlorophenol
(iii) Benzene hexachloride
(iv) DDT
(v) Dieldrin

These are clean to handle and are permanent. The timber after treatment can be painted, waxed or polished in most cases. The only disadvantage is that some of these are inflammable and hence require great care in handling and application.

(iii) **Water soluble (leachable) type:** These preservatives are inorganic or organic salts soluble in water. Some of these are zinc chloride, boric acid and borax, sodium fluoride, sodium pentachlorophenol and benzene hexa-chloride. These preservatives are non-creeping, non-staining and non-inflammable. Timber treated with such preservatives can be painted or varnished when dry. But these are subject to leaching, hence not satisfactory for external use.

(iv) Water soluble (fixed) type: These consist of the various salts described in water soluble (leachable) type preservatives with the addition of a fixative salt usually sodium or potassium dichromates. The effect of chromium is to fix the toxic elements such as arsenic, copper, zinc, etc. to the wood so that these are not leached out by water. These should be applied cold as they are liable to get precipitated when heated.

Some of the preservative compositions are:

(i) Copper chrome arsenic composition
(ii) Acid cupric chromate composition
(iii) Chromated zinc chloride
(iv) Copper chrome borax composition
(v) Zinc meta arsenite
(vi) Zinc chrome boric composition

Timber treated with such chemicals can be used for outside locations and can be painted over also.

Characteristics of a good preservative are:

(i) It should be strongly toxic to insects, fungi, etc.
(ii) It should penetrate readily into the timber.
(iii) It should cover a large surface area with a comparatively small quantity.
(iv) It should have no destructive influence on the strength of the timber.
(v) It should be highly resistant to water and dampness.

Some of the methods of treatment of timber are:

(i) Surface application by brushing, spraying or dipping
(ii) Soaking
(iii) Hot and cold process
(iv) Boucherie process
(v) Diffusion process
(vi) Pressure or pneumatic process
(vii) Full cell or Bethel process
(viii) Empty cell process which consists of Lawry process or Rupeing process.

Solution : 3

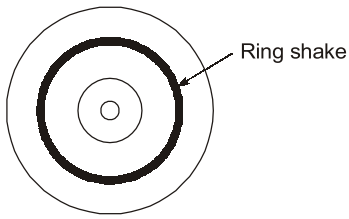
(i) **Balten :** This is a timber piece whose breadth and thickness do not exceed 50 mm.

(ii) **Baulk :** It is a roughly squared timber piece and it is obtain by removing bark and sap wood . One of the cross-sectional dimension exceeds 50 mm, while the other exceeds 200 mm.

(iii) **Scantling :** This is a timber piece whose breadth and thickness exceed 50 mm, but are less than 200 mm in length. These are the pieces of miscellaneous sizes of timber sawn out of a log.

(iv) **Warp :** When a piece of timber has twisted out of shape, it is said to have warped.

(v) **Ring shakes :** When cup shapes cover the entire ring, they are known as ring shakes. These are caused by the rupture of tissue in a circular direction.



(vi) **Medium knot :** These are the bases of branches or limbs which are broken or cut off from the tree.The portion from which the branch is removed receives nourishment from the stem for a pretty long time and it ultimately results in the formation of dark hard rings which are known as the knots. Medium knot has diameter between 20 and 40 mm.

Solution : 4

1. Decay due to fungal and bacterial attacks:

   Wood is essentially organic substance made of skeleton of cellulose impregnated with lignin. Fungi are system of plant organism which live in and attack timber causing rot and decay. Fungi reproduce through spores. Which send out Mycelia which is turn destroy the wood tissue by secretions of solvents and enzymes. The existence of fungi are moisture, suitable temperature and food supplies.

   Control of fungal and bacterial attack:

   - Dryness of timber and it should not be subjected to alternate wet and dry conditions.
   - Felled trees should be air dried as early as possible and shown timber should be kiln seasoned, in accordance with good air seasoning practice.
   - Adequate ventilation around the timber to prevent fungal attack.

2. Damages due to insects:

   Termites: While ants are most destructive agencies. They completely excavate the wood at the centre leaving the out shall insects. They also attack furniture and wood work in houses and railway sleepers etc.

   Beetles: these are small insects and they cause rapid decay of timber by converting them into fine powder. Usually, the outer shell of timber remains intact and hence the timber looks sound until it fails complete.

   Carpenter ants: They are usually black in colour and very in size within the same nest. They do not eat wood but merely tunnel it out for habitation. They normally attack slightly related or water softened wood.

   Control of insects:

   - Large scale fornication is carried out using powerful hydrocyanic acid gas.
   - The best alternative is very common turpentine mixed with a small quantity of ortho-dichlori-benzene. This vapour is very deadly to insects.

■■■■

5 Brick & Brick Masonry

LEVEL 1 Objective Questions

1. (c)
2. (b)
3. (d)
4. (b)
5. (a)
6. (d)
7. (d)
8. (c)
9. (b)
10. (b)
11. (c)
12. (c)

LEVEL 2 Objective Questions

13. (d)
14. (a)
15. (a)
16. (a)
17. (d)
18. (a)
19. (d)
20. (c)

LEVEL 3 Conventional Questions

Solution : 1

The principal constituents of brick earth are as follows:

(i) **Silica:** It exists in clay either as free or combined. A good brick earth should contain about 50 to 60% of silica. It enables the brick to retain its shape and imparts durability, prevents shrinkage and warping. The durability of bricks depends on the proper proportion of silica in brick earth. The excess of silica destroys the cohesion between particles and the bricks become brittle and weak on burning. A large percentage of sand or uncombined silica in clay is undesirable. However, it is added to decrease shrinkage in burning and to increase the refractoriness of low alumina clays.

(ii) **Alumina:** A good brick earth should contain about 20 to 30% of alumina. It absorbs water and imparts plasticity to the earth so that it can be moulded. If alumina is present in excess of the specified quantity, it produces cracks in bricks on drying and the bricks become too hard when burnt. Clays having exceedingly high alumina content are likely to be very refractory.

(iii) **Lime:** It normally constitutes less than 10% of clay. The lime prevents shrinkage of raw bricks on drying. The sand alone is infusible, but it slightly fuses at kiln temperature in presence of lime. In carbonated form, lime lowers the fusion point. Excess of lime causes the brick to melt and the brick looses its shape.

(iv) **Oxide of iron:** A small quantity of iron oxide to the extent of about 5 to 6% is desirable in good brick earth. Like lime, it also helps to fuse sand. It also imparts red colour to the bricks. However the excess of oxide of iron makes the bricks dark blue or blackish. If on the other hand, the quantity of iron oxide is comparatively less, the bricks will be yellowish in colour. It improves impermeability and durability of bricks. Its also imparts strength and hardness to bricks.

(v) **Magnesia:** It rarely exceeds 1 per cent, affects the colour and makes the brick yellow in colour. On burning, it causes the clay to soften at slower rate than in most cases as lime and reduces warping. Excess of magnesia leads to decay of bricks.

Solution : 2

Absorption of bricks depends upon their porosity which is due to voids of various sizes present in the bricks. Absorption can be broken into two distinct categories viz. absorption and initial rate of absorption (IRA).

Absorption of a brick is expressed as a percentage and is defined as the ratio of weight of water that is taken up in its body divided by the dry weight of the unit.

It is measured in two ways:

(i) **Cold water test:** The specimen is dried in a ventilated oven at a temperature of 105 to 115°C till it attains substantially constant mass (M_1). It is then kept immersed in clean water at a temperature of 27 ± 2°C for 24 hours. The specimen is removed and weighed (M_2) to determine the weight of water absorbed and water absorption is given by

$$\text{24 hour water absorption by weight } (W_{24}) = \frac{M_2 - M_1}{M_1} \times 100$$

(ii) **Boiling water test:** The specimen is dried in a ventilated oven at a temperature of 105 to 115°C till it attains substantially constant mass (M_1). The dried specimen is immersed in a tank such that the water can circulate freely on all sides of the specimen. Water is heated to boiling in one hour and boiled continuously for five hours. The water is allowed to cool to 27°C by natural loss of heat for 16 to 19 hours. The specimen is again weighed (M_3) and the water absorption percentage is given by

$$\text{5 hour water absorption by weight } (W_5) = \frac{M_3 - M_1}{M_1} \times 100$$

These tests are carried out to calculate the saturation factor, which is given by

$$\text{Saturation factor} = \frac{W_{24}}{W_5}$$

The saturation factor is helpful in predicting the durability of brick. The average water absorption (W_{24}) of common building bricks should not be more than 20% by weight upto class 12.5 MPa and 15% by weight for higher classes.

The initial rate of absorption (IRA) or suction is the rate of how much water a brick draws in during first minute after contact with water. The suction has a direct bearing on the bond between brick and mortar.

Solution : 3

As per **IS:1077-1992** code bricks are classified on the basis of **minimum compressive strength** which has been kept at 3.5 MPa. Each class of bricks which have been already divided based on compressive strength shall further be divided into subclasses *A*, *B*, etc.

The properties which are associated with this classification are:

(i) **General quality of bricks:** Bricks having smooth rectangular faces and sharp corners and emitting a clear ringing sound when struck against each other are classified under subclass A. Bricks having a slight distortion and round edges, provided no difficulty arise on this account in laying of uniform courses have been classified under subclass *B*.

(ii) **Dimensions and tolerance:** According to **IS:1077-1992**, the standard size of common building bricks is as follows:

19 cm × 9 cm × 9 cm

19 cm × 9 cm × 4 cm

The dimension of bricks when tested by stacking 20 bricks should be within the limits specified by **IS:1077-1992**.

(iii) **Water absorption of bricks:** When tested in accordance with the procedure laid down in **IS:3495-1992**, after immersion in cold water for 24 hours the average water absorption of common building bricks should not be more than 20% by weight upto class 125 and 15% by weight for higher classes.

(iv) **Efflorescence:** According to **IS:3495-1992,** the rating efflorescence should not be more than moderate upto class 12.5 MPa and slight for higher classes.

(v) **Strength of bricks:** As per **IS:1077-1992** common building bricks should have a minimum strength of 3.5 MPa. Also, the compressive strength of any individual brick should not fall below the average compressive strength specified for the corresponding class of brick by more than 20%.

Solution : 4

Factors affecting design :

(1) Adequate strength to support imposed loads
(2) Sufficient water tightness
(3) Sufficient visual privacy and sound transmission
(4) Appropriate fire resistance
(5) Ability to receive various finish materials
(6) Ability to provide openings such as doors and windows

- IS : 1905-1987 recommends following :
- Effective height of a wall shall be taken as :

Condition of Support	Effective height
1. Lateral as well as rotational restraint at top and bottom	0.75 H
2. Lateral and rotational restraint at top and only lateral at other end	0.85 H
3. Lateral restraints without rotational restraint on both ends	1.00 H
4. No restraint at top but lateral as well as rotational restraint at bottom	1.50 H

- For solid walls, faced walls or columns, effective thickness shall be actual thickness.
- For solid walls adequately bonded into piers /buttresses, effective thickness for determining slenderness ratio based on effective height shall be the actual thickness of wall multiplied by stiffening coefficient.

No. of storeys	Maximum slenderness ratio	
	Using portland cement in mortar	Using lime mortar
Not exceeding 2	27	20
Exceeding 2	27	13

- The angle of dispersion of vertical load on walls shall be taken as not more than 30° from vertical.

Solution : 5

Constituents of a good brick earth :

1. Alumina : 20% to 30%
2. Silica : 50% to 60%
3. Lime : not exceeding 5%
4. Oxides of iron : 5% to 6%
5. Magnesia : Small quantity.

Properties of a first class brick :

- Burnt uniformly in kilns
- Uniform color throughout the brick.
- The surfaces and edges of the bricks are sharp, square, smooth and straight.
- These are used for superior work of permanent nature.
- They comply with all the qualities of good bricks.

Test for bricks :

(1) Absorption :

- A brick is taken and it is weighted dry. It is then immersed in water for a period of 16 hours. It is weighed again and the difference in weight indicates the amount of water absorbed by the brick.
- It should not exceed 20% of weight of dry brick.

(2) Crushing strength :

- It is found out by placing it in compression testing machine. It is pressed till it breaks.
- As per IS : 1077 - 1970, the minimum crushing strength of bricks is 3.50 N/mm^2.

(3) Hardness :

- A scratch is made on brick surface with finger nail. if no impression is left on the surface, the brick is treated to be sufficiently hard.

(4) Presence of soluble salts:

- Brick is immersed in water for 24 hours. It is then taken out and allowed to dry in shade. The absence of grey or white deposits on its surface indicates absence of soluble salts.

(5) Shape and Size :

- Brick is closely inspected. It should be of standard size and its shape should be truly rectangular with sharp edges.

(6) Soundness :

- Two bricks are struck with each other. The bricks should not break and clear ringing sound should be produced.

(7) Structure :

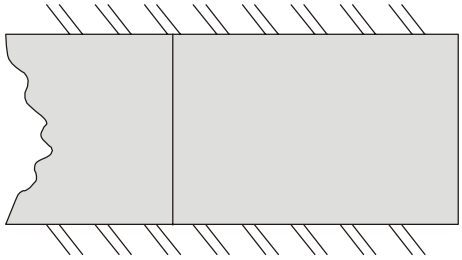
- A brick is broken and its structure is examined. It should be homogeneous, compact and free from any defects such as holes, lumps, etc.

Solution : 6

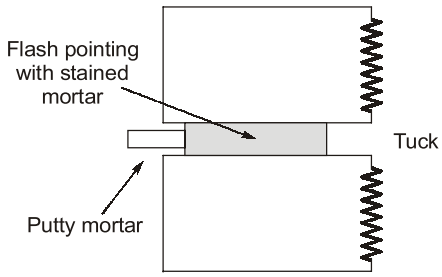
In exposed masonry, joints are considered to be weakest and most vulnerable spots from which rain water or dampness can enter. pointing means implementing the joins to a depth of 10 mm to 20 mm and filling it with better quality mortar in desired shape.

Type of Pointing :

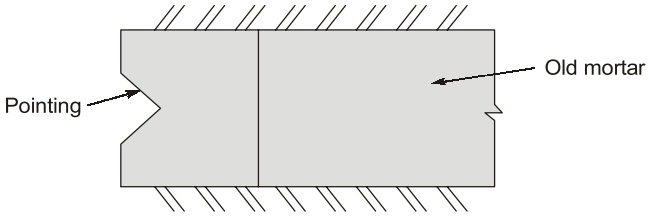
1. Flush Pointing : Mortar is pressed hard in the raked joints and by finishing off flush with the edge of masonry units. The edges are neatly trimmed with trowel and straight edge. It doesn't give good appearance but is more durable.
2. Recessed Pointing : Mortar is pressed back by 5 mm or more from edges. During placing of mortar the face of pointing is kept vertical, by a suitable tool. It gives very good appearance.
3. Beaded Pointing : It is a special type of pointing which is formed by a steel or ironed with a concave edge. It gives good appearance, but it will damage easily when compared to others.
4. Struck Pointing : It is a modification of flush pointing in which the face of the pointing is kept inclined, with its upper edge pressed inside the face by 10 mm. It drains water easily.
5. Rubbed, Keyed or Grooved Pointing : It is also a modification of flush pointing in which groove is formed at its mid height, by a pointing tool. It gives good appearance.



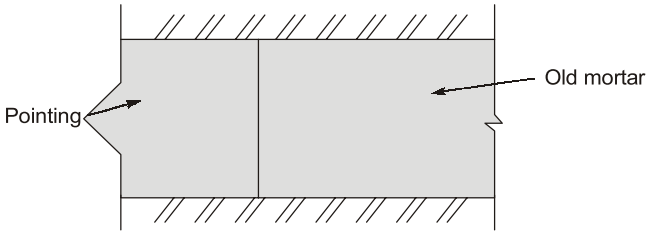
6. **Tuck Pointing :** Mortar is pressed in the racked joint first and finishing flush with the face. While the pressed mortar is green, groove or narrow channel is cut in the center of groove which is having 5 mm width and 3 mm depth. This groove is then filled with white cement putty, kept projecting beyond the face of the joint by 3 mm. If projection is done in mortar, it is called pointing or half tuck pointing



7. **V-Pointing :** It is formed by V-groove in flush-finishing face.



8. **Weathered Pointing :** It is made by making a projection in the form of V-shape.



Solution : 7

Weight of cement,	W_c = 304.391 kg
Weight of sand,	$2W_c$ = 608.782 kg
Weight of coarse aggregate,	$4W_c$ = 1217.564 kg
Number of bricks	=100 bricks

■■■■

6 Miscellaneous

LEVEL 1 Objective Questions

1. (a)
2. (a)
3. (b)
4. (c)
5. (b)

LEVEL 2 Objective Questions

6. (d)
7. (d)
8. (b)
9. (a)
10. (c)

LEVEL 3 Conventional Questions

Solution : 1

Distempers :

- The main object of applying distemper to the plastered surfaces is to create a smooth surface.
- They are cheaper than points and varnishes and they present a neat appearance. They are available in variety of colours.
- The coatings of distemper are usually thick and they are more brittle than other types of water paints.
- They are less durable than oil paints.
- They can be applied on brickwork, cement and lime plastered surface, etc..
- They exhibit poor workability.
- They prove to be unsatisfactory in damp locations such as kitchen, bathroom, etc.
- A distemper is composed of base, carrier, colouring pigments and size. For base the whiting or chalk is used and for carrier water is used.

Enamels :

- This paint is available in different colours.
- It contains white lead or zinc white, oil, petroleum spirit and resinous matter.
- It dries slowly and forms a hard and durable surface.
- The surface provided with this paint is not affected by acids, alkalies fumes of gas, hot and cold water, steam, etc.
- It can be used for both internal and external walls.
- In order to improve the appearance it is desirable to apply a coat of enamel paint.

Varnish :

- The terms varnish is used to indicate the solutions of resins or resinous substances prepared either in alcohol, oil or turpentine.
- It brightens the appearance of the grain in wood.
- It renders brilliancy to the painted surface.
- It protects the painted surface from atmospheric actions.
- It protects unpainted wooden surfaces of doors, windows, floors, etc. from the actions of atmospheric agencies.
- Resins, like lac, amber, mastic etc, Driers like litharge, white copper and lead acetal, and solvents like linseed oil, methylated spirits of wine, turpentine and wood naptha are ingredients of varnish.

Solution : 2

The mortars are classified into the following five categories :

1. Lime Mortar :
   - In this type of mortar, the lime is used as a binding material.
   - The lime may be fat lime or hydraulic lime
   - The fat lime shrinks to a great extent and hence it requires 2 to 3 times its volume of sand. The lime should be slaked before use.
   - It is generally used for lightly loaded above-ground parts of buildings.

2. Surkhi Mortar :
   - It is prepared by using fully surkhi instead of sand or by replacing half of sand in case of fat lime mortar.
   - The powder of surkhi should be fine enough to pass BIS No. 9 sieve and the residue should not be more than 10% by weight.
   - It is used for ordinary masonry work of all kinds in foundation and superstructure.
   - It cannot be used for plastering or pointing.
3. Cement mortar :
   - Cement is used as a binding material.

     Depending upon the strength required and importance of work, the proportion of cement to sand by volume varies from 1 : 2 to 1 : 6 or more.
   - Surkhi and cinder cannot be used as adulternts with matrix as cement.
   - It is used where a mortar of high strength and water-resisting properties is required such as underground constructions, water saturated soils, etc.
4. Gauged Mortar :
   - To improve the quality of lime mortar and to achieve early strength, the cement is sometimes added to it. This process is known as gauging.
   - It makes lime mortar economical, strong and dense.
   - The usual proportion of cement to lime by volume is about 1 : 6 to 1 : 8.
   - It is also known as composite mortar or lime-cement mortar and it can also be formed by the combination of cement and clay.
   - The mortar may be used for bedding and for thick brick walls.
5. Gypsum Mortar :
   - These mortars are prepared from gypsum binding materials such as building gypsum and anhydrite binding materials.

Solution : 3

- Tiles can be classified in the following two groups:
  (i) **Common tiles :** These have different shapes and sizes. They are mainly used for paving, flooring and roofing.
  (ii) **Encaustic tiles :** These tiles are used for decorative purposes in floors, walls, ceilings and roofs.
- Depending upon the use to which tiles are put, following are the different types of common tiles:
  (i) **Drain tiles :** They are used to convery irrigation water. These are rarely adopted in modern times.
  (ii) **Floor or paving tiles :** The floor tiles of thin section can be adopted for ceiling also. The floor tiles of comparatively less strength can be used for fixing on walls.
  (iii) **Roof tiles :** These are used as covering for pitched roof.

Their varieties are :

(a) **Allahabad tiles :** These tiles are provided with projections so that they interlock with each other. These are extensively used in North-western India.

(b) **Corrugated tiles :** The placing of these tiles on roof gives an appearance of corrugated galvanised iron sheets. They can be easily blown away by a violent wind.

(c) **Flat tiles :** These are ordinary floor tiles.

(d) **Flemish tiles :** These tiles do not form good covering as the plain tiles and they are used only for sheds.

(e) **Guna tiles :** These are hollow tapered burnt clay tiles. These tiles can be manufactured on potter's wheel.

(f) **Manglore tiles :** These are of flat pattern and are provided with suitable projections. The manglore pattern roofing tiles are becoming popular in rural and semi-urban areas and they are used by middle and low income group people because of various reasons such as architectural effect, scarcity and rising prices of other substitues.

(g) **Pan tiles :** These are short and heavy. Such tiles are moulded flat fist and then they are given the required curvature by moulding in suitable forms.

(h) **Pot tiles :** These are ordinary half round country tiles and are known as locking tiles. Good drainage is ensured by these even if slope of roof is less. These may be used as a sole covering to roof.

Solution : 4

Test to which a stone is subjected :

(1) Acid test
(2) Attrition test
(3) Crushing test
(4) Crystallisation test
(5) Freezing and thawing test
(6) Hardness test
(7) Impact test
(8) Microscopic test
(9) Smith's test
(10) Water absorption test

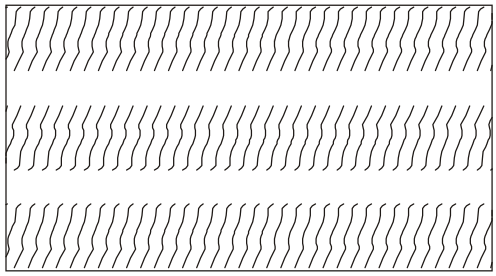
- **The stones, after being quarried, are to be cut into suitable sizes and with suitable surfaces.** This process is known as the dressing of stones and it is carried out for the following purposes :
  (i) to get the desired appearance from stone work
  (ii) to make the transport from quarry easy and economical
  (iii) to suit to the requirements of stone masonry
  (iv) to take advantage of local men near quarry who are trained for such type of work, etc.
- Advantages of quarry dressing :
  (i) At quarry site, it is possible to get cheap labour for the process of dressing of stones.
  (ii) It is possible to sort out stones for different works, if quarry dressing is practised.
  (iii) The irregular and rough portions of the stone are removed which decrease the weight of stones and it also facilities easy transportation of the stones.
  (iv) the natural bed surface of stones can be made prominent during the quarry dressing.
  (v) The stones when quarried freshly contain quarry sap and hence they are comparatively soft and can be easily dressed.

Solution : 5

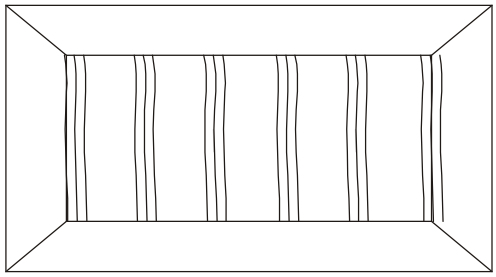
Purposes of dressing:

1. To get desired appearance
2. To make the transport from quarry easy and economical.
3. To suit to the requirements of stones masonry.
4. to take advantage of local men near quarry who are trained for such type of work, etc.

Types of finishes :



Boasted or droved finish



Furrowed finish

1. Axed finish
2. Boasted or droved finish
3. Chisal-draughted marings
4. Circular finish
5. Dragged or combed finish
6. Furrowed finish
7. Moulded finish
8. Hammer-dressed finish
9. Plain finish
10. Polished finish
11. Punched finish
12. Reticulated finish
13. Rubbed finish
14. Scabbling finish
15. Tooled finish
16. Self-faced or rock-faced or quarry-faced finish.
17. Sunk finish
18. Vermiculated finish

Solution : 6

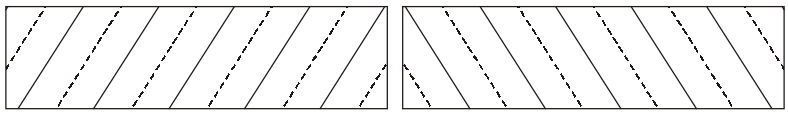
Following are the qualities of a good building stone :

1. The crushing strength should be greater than 100 N/mm^2.
2. The stone should be decent in appearance and should be capable of preserving their colour uniformly for a long time.
3. The stone should be durable
4. The stone should be such that they can be easily carved, moulded, cut and dressed.
5. Its fracture should be sharp, even, bright and clear with grains well cemented together.
6. The coefficient of hardness, should be greater than 17 for stone to be used in road work. If it is less than 14, the stone is said to be of poor hardness.
7. The wear in attrition test, should be equal to or less than 3%.
8. The minerals composing stone should be such that shape of stone is preserved when a fire occurs.
9. The stones should be will seasoned before putting into use.
10. It specific gravity should be greater than 2.7 or so.
11. It should have compact fine crystalline structure free from cavities, cracks or patches of soft material.
12. If the toughness index comes below 13, the stone is not tough.
13. Percentage absorption by weight after 24 hours should not exceed 0.60.
14. A good building stone should posses better weathering qualities.

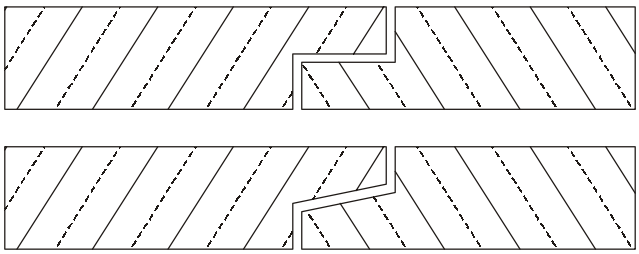
Solution : 7

Following are the common types of joints provided in stones masonry to secure stones firmly

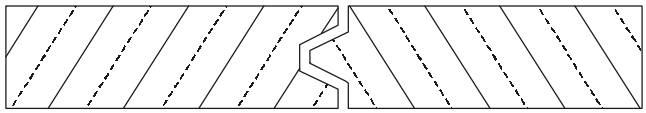
1. **Butt joint or square joint :** This is most commonly used joint in stone masonry. The dressed edge of two adjacent stones are placed side by side.



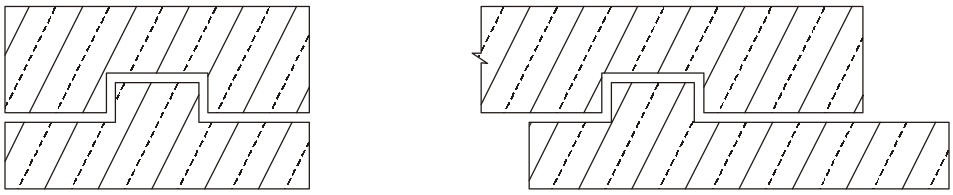
2. **Rebated or lapped joint :** This type of joint is provided in arches, gables, copings, etc. to prevent the possible movement of the stones. The length should not be less than 70 mm.



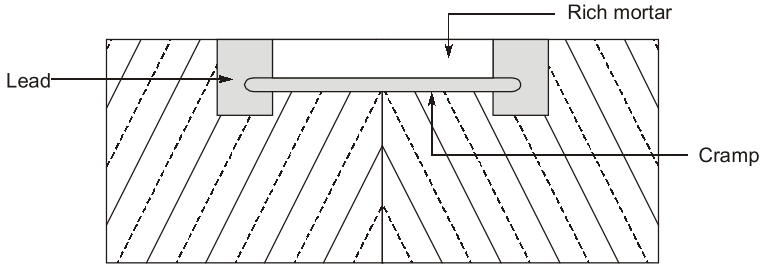
3. **Tongue and grooved joint or joggle joint :** This type of joint is provided to prevent sliding along the side joints. The joint is made by providing projection or tongue in one stone and corresponding groove or sinking on the adjacent stone.



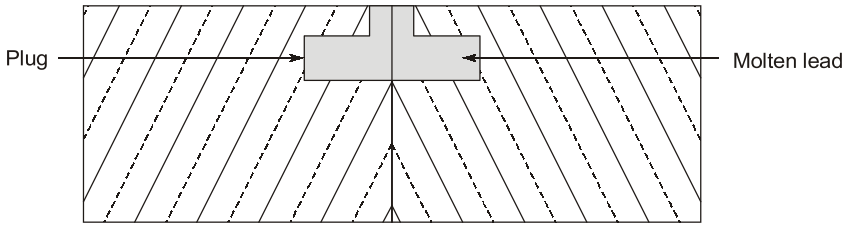
4. **Tabled or bed joint :** This joint is used to prevent lateral movement of stones such as in sea walls where the lateral pressure is heavy. The joint is made by forming a joggle in the bed of the stone. The height of the projection is kept about 30 – 40 mm, while the width is kept equal to above 1/3 the breadth of stone.



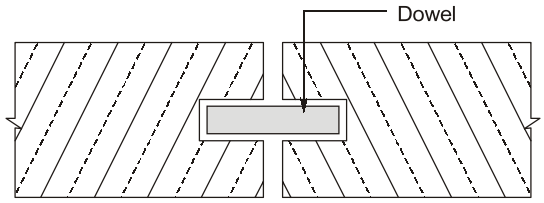
5. **Cramped joint :** The joint uses metal cramp instead of towels. Cramps prevent the tendency of the joints to open out due to slippage of stones.



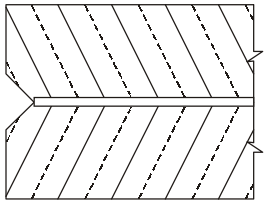
6. **Plugged joint :** This is an alternative to cramped joints.



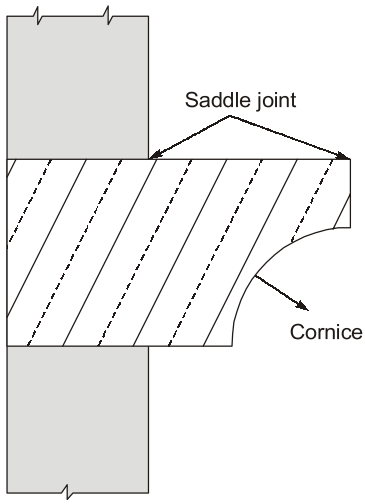
7. **Dowelled joint :** It is a simple type of joint used to ensure stability of adjacent stones against displacement or sliding.



8. **Rusticated joint :** This is used in stones whose edges edges are sunk below the general level, such as for plinth, quoin, etc.



9. **Saddled or water Joint :** It is used in cornices and such other weathered surfaces, to divert the water moving on the weathered surface away from the joint.



Solution : 8

The following are the constituent parts of paint:

(i) **Base:** It is very finely grounded metallic oxide and acts as the body of paint. Because of film of base, the paint becomes hard and resistive to weathering action.

The most commonly used bases in paints are:
White lead, lead sulphate, zinc oxide and titanium oxide.

(ii) **Vehicle:** It is used in paints to help it to spread the base over the surface. It acts as a binder between base and pigment and causes it to adhere to the surface to be painted. Vehicle is mixed with the bases to form a paste.
The most commonly used vehicles are:
- Raw linseed oil
- Refined linseed oil
- Pale boiled linseed oil

(iii) **Colouring pigment:** It is added to the paints to obtain desired final colour of the paint different from that of the base.

(iv) **Thinner:** It is used in paints to reduce its consistency. It enables the paint to be spread over the surface to be painted with the brush and to penetrate into the surface. Most commonly used thinner is turpentine oil which dries up rapidly and helps to dry the paint soon.

(v) **Drier:** It is used in paints to accelerate the action of drying. Paints need to be dried soon to avoid the risk to catch dust and dirt. Most commonly used drier is litharge.

(vi) **Adulterants:** These are used to reduce the cost of paints and also to reduce the weight and to increase its durability. Barium sulphate is widely used as an adulterant because of its cheapness and its property of not reacting with paint.

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