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PART - A

2 Marks Questions

Q.1

Sol.

(i) **The Flash Setting of Cement :**

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 sometime. Cement does not gain prominent strength during flash setting.

(ii) **The False Set :**

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.

Q.2

Sol.

The stone is always obtained from rock. The rock quarried from quarries is called stone. Quarried stone may be in the form of stone blocks, stone aggregate, stone slabs, stone lintels etc.

Q.3

Sol.

- For masonry work
- For lintels and vertical columns
- For covering floors and buildings
- For paving of roads and footpaths
- As an aggregate in cement as well as lime concretes.

Q.4

Sol.

1. Smith's test
2. Freezing and thawing test
3. Frost action test
4. Acid test
5. Water absorption test
6. Microscopic examination
7. Impact test
8. Attrition test
9. Crushing test
10. Hardness test

Q.5

Sol.

Cast stone or artificial stone is nothing, but hardened plain cement concrete, mould in suitable shape and size. Artificial stone consists of 1.5 parts of coarse aggregate of size 3mm to 6mm and 1.5 parts of coarse aggregate of size less than 3mm.

Q.6

Sol.

Stones obtained from quarry are in irregular sizes and shapes and cannot be used as such in masonry work, without dressing. Dressing of stones is a process, carried out with the help of hand tools, to give proper shape and surface to the stone, before its use in masonry or any other work

Q.7

Sol.

1. First class bricks
2. Second class bricks
3. Third class bricks
4. over burnt or Jhama bricks
5. Under burnt or pilla bricks

Q.8

Sol.

Pugging or tempering of clay means breaking up of prepared clay, watering and kneading till the



earth becomes a homogeneous mass.

Q.9

- Sol. 1. Hand Moulding - Ground moulded and table moulded bricks
2. Machine Moulding - Plastic clay method, Dry pressed clay method

Q.10

- Sol. 1. Absorption test
2. Crushing strength test
3. Hardness test
4. Shape and size test
5. Soundness test
6. Test for presence of soluble salts.

Q.11

- Sol. The process of heating the limestone to redness in the presence of atmospheric air is known as calcination.

Q.12

- Sol. The term refractory is used to indicate the materials which are able to withstand the effects of high temperatures, without affecting the structural strength of the material, by appreciable amount.

Q.13

- Sol. Surkhi, flyash, blast furnace slag, silica fume, rice husk ash, metakaoline.

Q.14

- Sol. Lime is one of the earliest binding materials used in buildings because its raw materials are rich and widely distributed, the production process is simple and low-cost and it is easy to use. That's why lime is still widely used in construction.

Q.15

- Sol. The lime obtained from the calcinations of pure limestone is known as quick lime.

Q.16

- Sol. When lime converted to paste form is exposed to atmosphere, it gradually hardens. This phenomenon of slow hardening of lime in exposed conditions is known as setting of lime.

Q.17

1. Fat lime
2. Hydraulic lime
3. Poor lime

Q.18

- Sol. 1. Stone lime - It is almost pure lime.
2. Kankar lime - It is impure or adulterated lime.
3. Shell lime - It is purest form of lime.

Q.19

- Sol. This lime has the property of setting under water. It is obtained by burning lime stone, containing lot of clay and other substances which develop hydraulicity. Hydraulicity of this lime depends upon the amount of clay and type of clay present in it.

Q.20

- Sol. Class A lime, Class B lime, Class C lime, Class D lime, Class E lime, Class F lime

Q.21

- Sol. Natural cement is manufactured by burning and then crushing the natural cement stones. Natural cement stones are such stones which contain 20 to 40% of argillaceous matter i.e. clay, and remaining content mainly calcareous matter which is either calcium carbonate alone or a mixture of calcium carbonate and magnesium carbonate.

Q.22

- Sol. Artificial cement is manufactured by burning approximately proportioned mixture of calcareous and argillaceous materials at a very high temperature and then grinding the resulting burnt mixture to a fine powder.

Q.23

- Sol. Artificial cement is manufactured by burning approximately proportioned mixture of calcareous and argillaceous materials at a very high temperature and then grinding the resulting burnt



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

Q.24

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

Q.25

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

Q.26

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

Q.27

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

Q.28

Sol. Grading of aggregate refers to the distribution of particles sizes within a sample of aggregate, often measured using sieve analysis.

Based on gradation, the aggregates are generally classified into four types. These are:

1. Uniform Graded Aggregate
2. Open Graded Aggregate
3. Gap Graded Aggregate
4. Dense or Well Graded Aggregate

Q.29

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

Q.30

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

Q.31

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

Q.32

Sol.

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

Q.33

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

Q.34

Sol.

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

Q.35

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

Q.36

Sol.

1. Quantity of water in the mix
2. Proper grading of the aggregate mix
3. Ratio of fine aggregate and coarse aggregate
4. Maximum size of coarse aggregates
5. Method of compaction of concrete



Q.37

- Sol.
1. Water cement ratio
 2. Cement content
 3. Temperature
 4. Age of concrete
 5. Size, shape and grading of aggregate
 6. Curing

Q.38

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

Q.39

- Sol.
1. Hand compaction - (i) Rodding (ii) Ramming (iii) Tamping
 2. Machine compaction - (i) Internal or Immersion vibrators (Needle vibrators) (ii) Form or Shutter vibrators (External vibrators) (iii) Surface vibrators

Q.40

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

Q.41

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

Q.42

- Sol.
1. Construction joints
 2. Expansion joints
 3. Contraction joints
 4. Working joints

Q.43

Sol. The standard apparatus for this test is the slump cone. It is used to measure the workability of concrete. Workability is used to define the ease or difficulty with which the concrete can be handled, transported and placed.

Q.44

- Sol.
1. Slump test
 2. Flow test
 3. Bleeding test
 4. Setting time test

Q.45

Sol. The wood which is suitable or fit for engineering construction or engineering purpose is timber. Timber denotes structural wood.

Q.46

Sol. The process by which timber is cut and sawn into suitable marketable sizes is known as conversion of timber.

Q.47

Sol. A freshly felled tree contains lot of moisture which is usually available in form of sap. The excess of moisture have to be removed, before timber can be used for any structural purposes. The process of removing excess surplus moisture from freshly converted timber is known as seasoning of timber.

Q.48

- Sol.
- 1 Dry rot
 - 2 Wet rot

Q.49

Sol. Artificial seasoning refers to methods of drying wood that utilized man-made processes to accelerate the drying time and the control the drying conditions.
The prevalent methods of artificial seasoning are as follows:
Water seasoning, Boiling seasoning, Kiln seasoning, Chemical seasoning, Electrical seasoning.



Q.50

Sol. It is a process of applying wash or coating like white-washing or color washing on the surface.

Q.51

Sol. Varnish is a solution of some resinous substance in alcohol, oil or turpentine. The process of covering the surface with varnish is known as varnishing. Varnishing is done on wooden surface.

Q.52

Sol. Resinous material, Driers and Solvents

Q.53

Sol. Veneers are thin sheets or slice of wood of superior quality having thickness varying from 0.4 mm to 0.6 mm or more.

Q.54

Sol. A pigment or strainer is a finely divided solid material which provides required shade and color to paint.

Q.55

Sol. It is a volatile substance that is added to paint which make its application easy and smooth.

Q.56

Sol. It is a substance which acts as catalyst and quickens the drying of the vehicle used in the paint

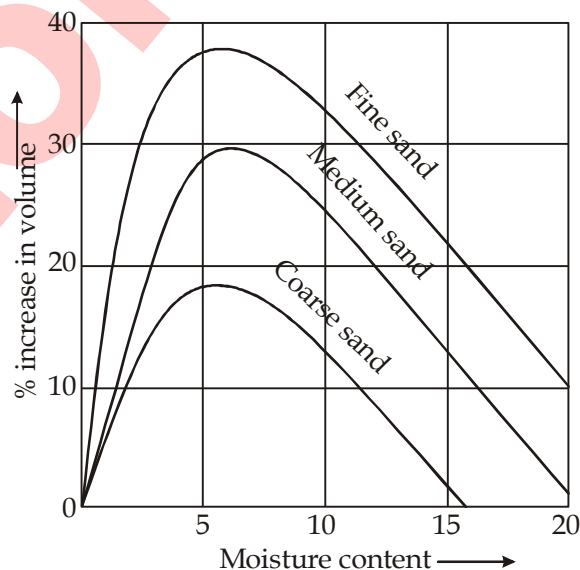
PART - B

5 Marks Questions

Q.57

Sol.

- The increase in the volume of given mass of sand caused by the presence of water is known as bulking. Free moisture forms a fine film around each particle. This film of moisture exert surface tension which keep particles away from each other resulting into bulking of the volume of sand.
- Bulking of sand depend upon the percentage moisture content and the particle size of sand. It is noted that the bulking increase with the increase in moisture content upto a certain limit and beyond that with further increase in the moisture content, it results in the decrease in volume and moisture content corresponding to maximum volume is known as saturation point. For most of the sand it is 4% to 6%.



- In volume batching, if the sand is measured by volume and no allowance is made for bulking,



then the actual quantity of sand in each batch will be less than the recommended volume and consequently the mix will be rich in cement i.e., the proportions of cement and sand to be provided will be different.

- This also increase the chances of segregation and honey-combing of concrete.
- It also increase water to cement ratio in mix as sand is having certain extra percentage of water above surface dry condition.

Q.58

Sol. **Fire-resistance of Timber**

With respect to the fire-resistance, the timber is classified as refractory timber and non-refractory timber. The refractory timber is non-resinous and it does not catch fire easily. The examples of refractory timbers are sal, teak, etc. The non-refractory timber is resinous and it catches fire easily. The examples of non-refractory timbers are chir, deodar, fir, etc.

To make timber more fire-resistant, the following methods are adopted:

(1) **Application of special chemicals**

The timber surface is coated with the solution of certain chemicals. It is found that two coats of solution of borax or sodium arsenate with strength of 2 percent are quite effective in rendering the timber fire-resistant.

(2) **Sir Abel's process**

In this process, the timber surface is cleaned and it is coated with a dilute solution of sodium silicate. A cream-like paste of slaked fat lime is then applied and finally, a concentrated solution of soda is applied on the timber surface. This process is quite satisfactory in making the timber fire-resistant.

Q.59

Sol. **Uses of Plaster of Paris:**

1. It is used as architectural decoration material for false ceiling, cornices and other decorative features in interior finish.
2. It is used for making casts for statues.
3. It is used for wall plasters, wall board etc.
4. Ornamental work.

Q.60

Sol. **Use of granite and marble polishing waste:**

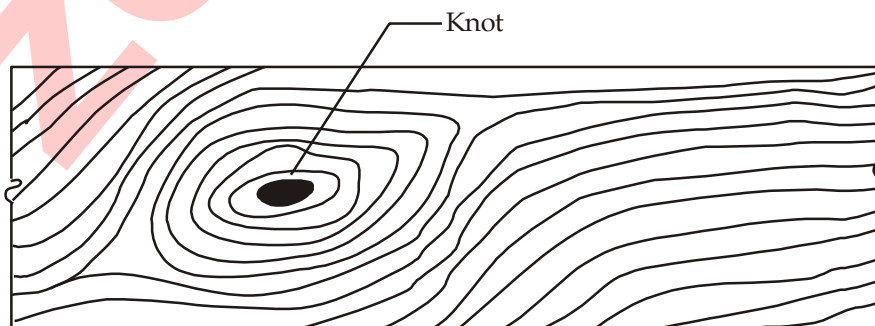
1. It is used in manufacturing of brick and tiles.
2. It is used for filling joints in flooring.
3. It is used in self-compacting concrete.

Q.61

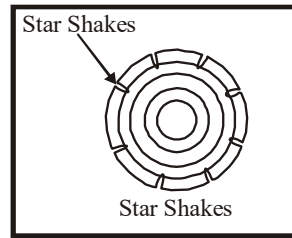
Sol. **Types of Defects in timber are grouped into the following divisions:**

The main natural forces responsible for causing defects in timber are abnormal growth and rupture of tissues.

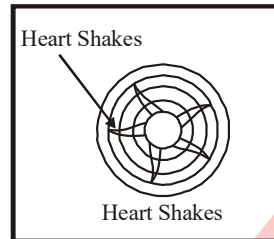
1. **Knots:** Bases of branches or limbs which are broken or cut off from the tree as shown in figure.



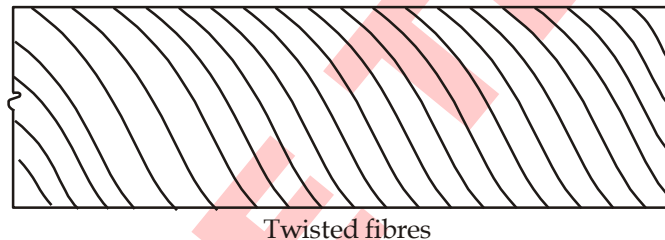
2. **Star Shakes:** These are radial splits or cracks widest at the circumference and get diminishing towards the center of the tress. These may arise mostly from severe frost and fierce heat of sun



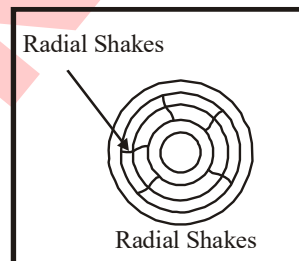
3. Heart Shakes: These are the splits or cracks widest at the center and diminishing towards the outside circumference, this defects usually occurs in overmatured tress and is probably caused due to the shrinkage of heart wood.



4. Twisted Fibers: Caused by twisting of young trees by fast blowing wind as shown in figure.



5. Radial Shakes: These are similar to star shakes but they are fine, irregular and numerous. They usually occur when tree is exposed to sun for seasoning after being felled down.



6. Rind galls: Rind means bark and gall indicates abnormal growth and peculiar curved swellings found on the body of a tree.

Q.62

Sol. Field tests performed on bricks for its suitability:

- (1) Shape and size: Brick is closely observed. It should be of standard size 190mm x 90mm x 90mm. Its shape should be truly rectangular with plane faces, sharp edges and right angles.
- (2) Water absorption test: A brick is weighed dry. It is then immersed in water for a period of 24 hours. It is weighed again and difference in weight indicates the amount of water absorbed by the brick. It should not be more than 20% of weight of dry brick.
- (3) Hardness: A scratch is made on brick surface with a finger nail. If no impression is left on the surface then brick is treated sufficiently hard.
- (4) Soundness: Two bricks are taken and they are struck with each other. Brick should not break and clear ringing sound should be produced.

- (5) Color Test: Brick should have deep red, cherry or copper colored and free from cracks, holes, and lumps.
- (6) Structure: A brick is broken and structure inside should be uniform, compact, and homogeneous.
- (7) 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 white deposits on its surface indicates absence of soluble salt.

Q.63

Sol. Uses of plywood:

- (i) Plywood is used for preparing door panels and shutters of cup boards.
- (ii) It is used for false ceilings for interior designing.
- (iii) For making chairs, tables, and other kitchen furniture, office cabins
- (iv) For making partitions between two rooms.
- (v) For paneling of walls
- (vi) For railway coaches
- (vii) For formwork for concrete.
- (viii) For packing cases.

Q.64

Sol. The bricks used in the construction works are burnt bricks and they are classified into the following four categories:

- (1) First class bricks
- (2) Second class bricks
- (3) Third class bricks
- (4) Fourth class bricks

First Class bricks: These bricks are table-moulded and of standard shape and they are burnt in kilns. The surfaces and edges of the bricks are sharp, square, smooth and straight. These bricks have all qualities of good bricks. These bricks are used for superior work of permanent nature.

Second class bricks: These bricks are ground - moulded and they are burnt in kilns. The surface of these bricks is somewhat rough and shape is also slightly irregular. These bricks may have hair cracks and their edges may not be sharp and uniform. These bricks are commonly used at places where brickwork is to be provided with a coat of plaster.

Third Class bricks: These bricks are ground - moulded and they are burnt in clamps. These bricks are not hard and they have rough surfaces with irregular and distorted edges. These bricks give dull sound when struck together. They are used for unimportant and temporary structure and at places where rainfall is not heavy.

Fourth class bricks: These are over burnt bricks with irregular shape and dark colour. These bricks are used as aggregate for concrete in foundation, floors, roads, etc. because of the fact that the over burnt bricks have a compact structure and hence they are sometimes found to be stronger than even the first class bricks.

Q.65

Sol. (i) The various uses of fly ash are as follows:

- (1) Concrete production, as a partial substitute material for Portland cement.
- (2) For the construction of embankments and other structural fills.
- (3) For grouting and flowable fill production.
- (4) Waste stabilization and solidification.
- (5) For cement clinkers production.
- (6) For mine reclamation.
- (7) For stabilization of soft soils.
- (8) For the road sub-base construction.
- (9) As fine aggregate substitute material.
- (10) For the manufacturing of bricks.

(ii) The various uses of Blast furnace slag are as follows:

- (1) As a supplementary cementations material either by premixing the slag with Portland cement or hydrated lime to produce blended cement or by adding the slag to Portland cement concrete as mineral admixture.
- (2) Air cooled blast furnace slag is used as aggregate material.

- (3) It is used as a concrete aggregate in construction of bridges.
- (4) It is used as an aggregate with asphalt for construction of damp proof course and water proofing.
- (5) It is used as insulation in mineral wool, in rail road ballast etc.

Q.66

Sol. Classification of Aggregates Based on Size:

Aggregates are available in nature in different sizes. The size of aggregate used may be related to the mix proportions, type of work etc. The size distribution of aggregates is called grading of aggregates. Following are the classification of aggregates based on size:

Aggregates are classified into 2 types according to size

- Fine aggregate
- Coarse aggregate

1. **Fine Aggregate:** When the aggregate is sieved through a 4.75mm sieve, the aggregate passed through it called fine aggregate.

Natural sand is generally used as fine aggregate, silt and clay also come under this category.

The soft deposit consisting of sand, silt, and clay is termed as loam.

The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent. Fine aggregate Size variation (mm) are as follows:

Coarse Sand → 2.0mm - 0.5mm

Medium sand → 0.5mm - 0.25mm

Fine sand → 0.25mm - 0.06mm

Silt → 0.06mm - 0.002mm

Clay → < 0.002mm

2. **Coarse Aggregate:** When the aggregate is sieved through 4.75mm sieve, the aggregate retained is called coarse aggregate. Gravel, cobble and boulders come under this category.

The maximum size aggregate used may be dependent upon some conditions. In general, 40mm size aggregate used for normal strengths, and 20mm size is used for high strength concrete

Q.67

Sol. Los-Angeles Test: This test has been covered by IS 2386 (Part-IV) 1963. In this test, aggregate of the specified grading is placed in a cylindrical drum of inside length and diameter of 500 mm and 700 mm respectively. This cylinder is mounted horizontally on stub shafts. For abrasive charge, steel balls or cast-iron balls of approximately 48 mm diameter and each weighting 390 grams to 445 gram are used. The numbers of balls used vary from 6 to 12 depending upon the grading of the aggregate. For 10 mm size aggregate 6 balls are used and for aggregates bigger than 20 mm size usually 12 balls are used. The abrasion value should not be more than 30% for wearing surfaces and not more than 50% for concrete used for other than wearing surface. The results of Los Angeles test show good correlation not only with the actual wear of aggregate when used in concrete, but also with the compression and flexural strength of concrete made with the given aggregate.

Q.68

Sol. Compressive Strength of Brick:

The compressive strength of the brick is the most essential property of the bricks because in the construction, bricks are widely used in masonry and it also plays a significant role as a load bearing component. When bricks are used in any structure, the bottom-most layer of the brick will be subjected to the highest compressive stress.

Therefore, it is essential to know that any particular brick will be able to withstand that load or not

(a) Use of Compressive Strength of Brick:

This test is performed to know the strength of bricks because it affects the overall structure in the way of quality, durability and serviceability.

(b) Recommended Result of Compressive Strength Test of Brick: Test result recommendations are as follows:

- For first class bricks, it should not less than 10 N/mm² (102 kg/cm²).
- For second class bricks, it should not less than 7 N/mm² (71 kg/cm²).
- For third class bricks, it should not less than 3.5 N/mm² (36 kg/cm²).

In India, the northern and the eastern region produce bricks having good compressive strength than the western region because the western region has black cotton soil, while the soil is good in Gangetic



region.

Q.69

Sol. **Portland Pozzolana Cement (PPC):**

PPC is a type of cement made by blending Portland cement with pozzolanic materials, such as fly ash or silica fume. The pozzolanic materials improve the workability and durability of the cement, making it suitable for various construction applications. PPC is commonly used in home construction and mass concrete structures, such as dams and bridges, where durability is critical.

Rapid Hardening Cement:

Rapid hardening cement is a type of hydraulic cement specially designed to gain strength quickly. It is used when fast-setting concrete is required, such as in the construction of pavements, precast concrete products, and repair work. It has a higher early strength than OPC, allowing structures to be delivered faster.

Quick Setting Cement:

Quick Setting Cement (QSC) is a special cement formulation that develops a rapid compressive strength and significantly reduces the Waiting on Cement (WOC) time compared to traditional cement systems. This cement loses its plasticity quicker than ordinary Portland cement, but does not achieve a higher rate of strength.

Low Heat Cement:

Low-heat cement is a type of hydraulic cement specially designed to produce less heat during hydration. It's made by reducing the amount of tricalcium aluminate by 6%. This results in slower strength gain and lower heat of hydration, making it ideal for use in large concrete structures prone to cracking due to heat buildup. This cement type is commonly used to construct dams, nuclear power plants, and large-mass concrete structures.

Sulphate resisting cement:

The sulphate resisting cement is the cement which has the capability to resist against sulphate attack by introducing low C_3A and relatively low C_4AF content in the cement. The specification for sulphate cement content should not allow C_3A content more than 5 percent.

Q.70

Sol. When water is added to the cement, the ingredients of cement react chemically with water and form various complicated chemical compounds known as Bogue's compounds.

The formation of these compounds is not simultaneously.

It is found that ordinary cement achieves about 70 - 80% of its final strength in 28 days & about 90% of its final strength in one year and so.

Following are the various Bogue's Compounds:

1. **Tri-calcium aluminate** : $(3CaO.Al_2O_3)$ (C_3A) (Celite) (4 - 14%)
2. **Tetra-calcium aluminoferrite** : $(4CaO.Al_2O_3.Fe_2O_3)$ (C_4AF) (Felite) (10 - 18%)
3. **Tri-calcium Silicate** : $(3CaO.SiO_2)$ (C_3S) (Alite) (45 - 65%)
4. **Di-Calcium Silicate** : $(2CaO.SiO_2)$ (C_2S) (Belite) (15 - 35%)

Q.71

PLYWOOD'S:

Plywood is an engineered wood sheet material made up of fine layers or flimsy strands of wood veneers attached together placing wood grains 90 degrees to one another. It is one type of manufactured board which can be described as a mixture of Medium Density Fibreboard (MDF) and Chip Board (Particle Board). It is a complex material and attaches resin and fiber sheets of wood. Plywood has become popular through this decade because it's relatively low moisture content which makes various tasks easy to perform with this. Mostly for outdoor uses plywood has become very important to use.

Following are the different types of Plywood.

- Softwood Plywood
- Hardwood Plywood
- Tropical Plywood
- Aircraft Plywood
- Decorative Plywood
- Flexible Plywood



- Marine Plywood

PART - C

20 Marks Questions

Q.72

Sol. When water is added to the cement, the ingredients of cement react chemically with water and form various complicated chemical compounds known as Bogue's compounds. The formation of these compounds is not simultaneously.

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Following are the various Bogue's Compounds:

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2. **Tetra-calcium alumino-ferrite** : $(4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3)$ (C_4AF) (Felite) (10 - 18%)
3. **Tri-calcium Silicate** : $(3\text{CaO} \cdot \text{SiO}_2)$ (C_3S) (Alite) (45 - 65%)
4. **Di-Calcium Silicate** : $(2\text{CaO} \cdot \text{SiO}_2)$ (C_2S) (Belite) (15 - 35%)

(1) **Tri-calcium aluminate (C_3A)**

- It is formed within 24 hours after addition of water to the cement.
- This compound react quickest with the water and liberates maximum amount of heat.
- Increase the C_3A content reduces the setting time, weakens resistance to sulphate attack & lowers the ultimate strength.
- Heat of hydration is 860 J/gm.

(2) **Tetra-calcium alumino-ferrite (C_4AF)**

- This compound is also formed within about 24 hours after addition of water to the cement.
- It has poorest cementing value.
- Increasing the C_4AF content reduces the strength slightly.
- Heat of hydration is 420 J/gm

(3) **Tri-calcium silicate (C_3S)**

- This compound is formed within a week after addition of water to the cement.
- It is mainly responsible for early strength of cement.
- It is best cementing material.
- It increases resistance to freezing & thawing.
- Heat of hydration is 500 J/gm.

(4) **Di-calcium silicate (C_2S)**

- This compound is formed very slowly that is within a year or so after addition of water to the cement.
- It is responsible for giving progressive strength to the cement.
- It liberates minimum amount of heat.
- It hydrates slowly.
- It imparts resistance to chemical attack.
- Increasing amount of C_2S content reduces early strength, decreases resistance to freezing & thawing at early age.
- Heat of hydration is 260 J/gm.

Note :- For ordinary portland cement, heat of hydration after 7 days is approximately 89 - 90 cal/gm & after 28 days it is approximately 90 - 100 cal/gm.

Water Requirement Of Cement

- $\text{C}_3\text{S} \rightarrow$ Requires 24% of water by weight for its complete hydration.
- $\text{C}_2\text{S} \rightarrow$ Requires 21% of water by weight for its complete hydration.
- Hence, about an 23% of water by weight of cement is required for complete hydration of cement. This is known as bound water.
- It is further observed that about 15% of water by weight of cement is required to fill the gel pores.
- Hence a total of 38 percent of water by weight of cement is required to complete the chemical



reaction & to occupy the space within gel pores.

Q.73

Sol. Bricks are obtained by moulding clay in rectangular blocks of uniform size & then by drying and burning these blocks.

Composition of Bricks:			
S. No.	Constituents	Formula	Range
1	Alumina	(Al ₂ O ₃)	20 - 30 %
2	Silica	(SiO ₂)	50 - 60 %
3	Lime	(CaO)	4 - 5 %
4	Iron Oxide	(Fe ₂ O ₃)	5 - 6 %
5	Magnesia	(MgO)	>1 %

(1) **Alumina (Al₂O₃)**

- A good brick earth should contain about 20% to 30% of alumina.
- It is the main ingredient of brick.
- It imparts plasticity to the brick earth so that it can be moulded in any shape.
- If it is in excess amount it will cause shrinkage & warping of bricks during drying & becomes too hard when burnt.

(2) **Silica (SiO₂)**

- A good brick earth should contain about 50-60% of silica.
- It prevents the cracking & shrinkage & warping of the bricks hence helps in giving the uniform shape to the bricks.
- If amount of silica is in excess, it destroys the cohesion between the particles of the brick earth & results in formation of brittle bricks.

(3) **Lime (CaO)**

- A small quantity of lime not exceeding 5% is desirable in good brick earth.
- It prevents shrinkage of the bricks.
- If it is in excess amount it causes the bricks to melt during burning process & results in loss of shape of bricks.

(4) **Iron Oxide (Fe₂O₃)**

- A small quantity of iron oxide about 5 to 6% is desirable for good brick earth.
- It helps in fusing (joining) lime with silica and also imparts strength & colour to the bricks.
- Iron oxide gives reddish brown colour to the bricks.
- If iron oxide is present in excess amount then it gives dark blue colour to the bricks.

(5) **Magnesia**

- A small amount of magnesia gives yellow tints to the bricks & decreases shrinkage.
- If magnesia is present in excess amount it will lead to the decay of the bricks.

Q.74

Sol. The defects occurring in the timber are grouped into the following five divisions:

- (1) Defects due to conversion
- (2) Defects due to fungi
- (3) Defects due to insects
- (4) Defects due to natural forces
- (5) Defects due to seasoning

(1) **Defects due to conversion** : During the process of converting timber to the commercial form, the following defects may occur :

- **Chip mark** : This defect is indicated by the marks or signs placed by chips on the finished surface of timber. They may also be formed by the parts of a planing machine.
- **Diagonal grain** : This defect is formed due to improper sawing of timber. It is indicated by diagonal mark on straight grained surface of timber
- **Torn grain** : This defect is caused when a small depression is formed on the finished surface of



timber by falling of a tool or so.

- **Wane** : This defect is denoted by the presence of original rounded surface on the manufactured piece of timber.

(2) **Defects due to fungi:**

- **Blue stain** : The sap of wood is stained to bluish colour by the action of certain type of fungi.
- **Brown rot** : The term rot is used to indicate decay or disease of timber. The fungi of certain types remove cellulose compounds from wood and hence the wood assumes the brown colour. This is known as the brown rot.
- **Dry rot** : The fungi of certain types feed on wood and during feeding, they attack on wood and convert it into dry powder form.
- **Heart rot** : This is formed when a branch has come out of a tree. In such a case, the heart wood is exposed to the attack of atmospheric agents. Ultimately the tree becomes weak and it gives out hollow sound when struck with a hammer.
- **Sap stain** : The fungi of certain types do not bring about the complete decay of timber. But they feed on cell contents of sap wood. In doing so, the sap wood loses its colour. This is known as the sap stain and it generally occurs when moisture content goes beyond 25 percent or so.
- **Wet rot** : Varieties of fungi cause chemical decomposition of wood of the timber and in doing so, they convert timber into a greyish brown powder. This is known as the wet rot.
- **White rot** : This defect is just the opposite of brown rot. In this case, certain types of fungi attack on lignin of wood and the wood assumes the appearance of a white mass consisting of cellulose compounds.

Q.75

Sol.

(i) **Dry Process (Modern Technology)**

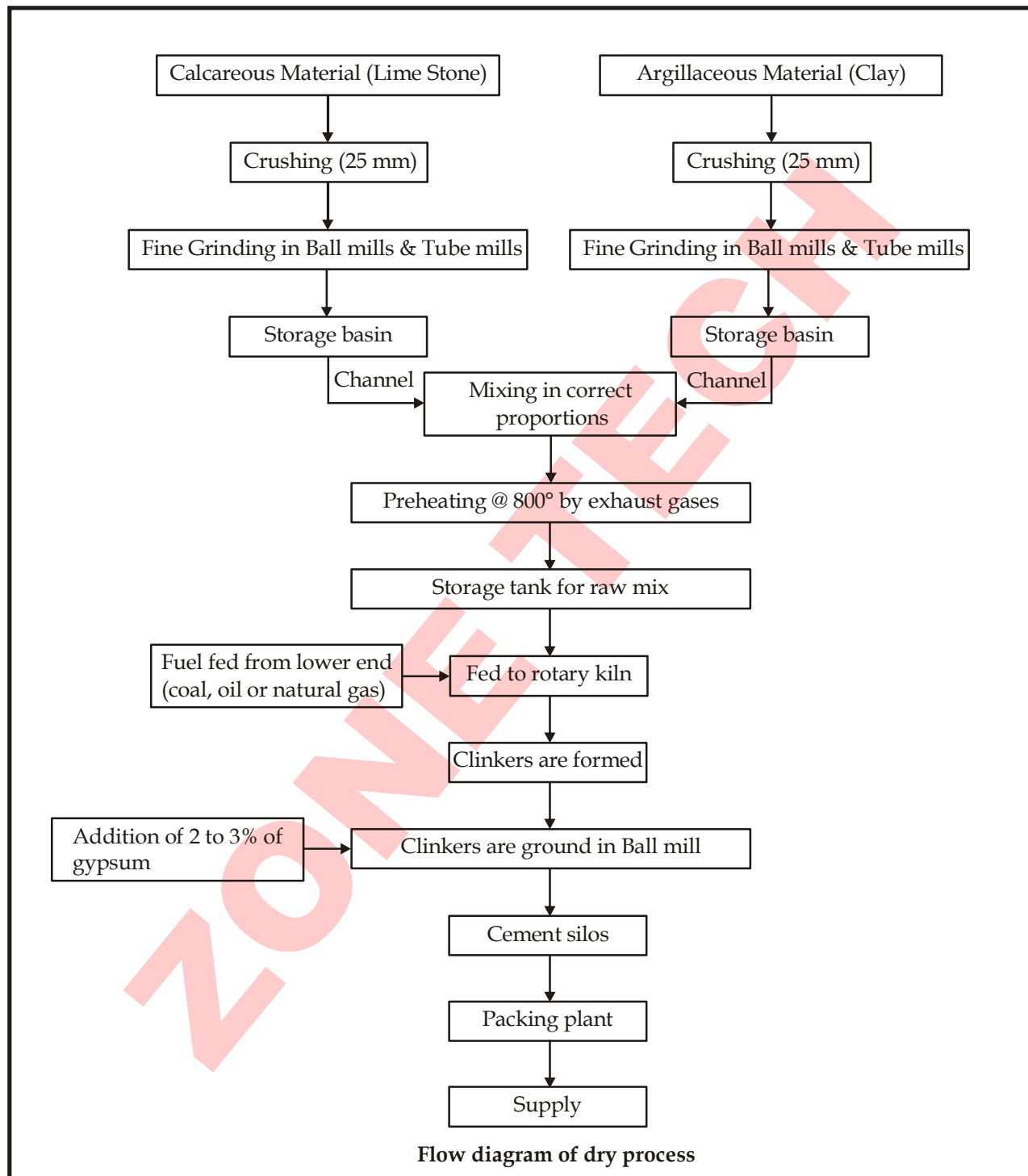
- In this process, the raw materials are first reduced in size of about 25mm in crushers. Then they are pulverised into powder in ball mills and tube mills. All these operations are done separately for each raw material & they are stored in hoppers. They are then mixed in correct proportions and made ready to feed to rotary kiln. Clinkers are formed in rotary kiln. Then clinkers are ground in ball mill to make cement.
- To produce one tonne of cement, 100 kg coal is used.
- All cement plants after 1980's use the dry process for manufacturing of cement.

Note :-

Pulverise means to make into a powder by breaking up or cause to become dust.

Manufacturing Process By Flow Diagram :



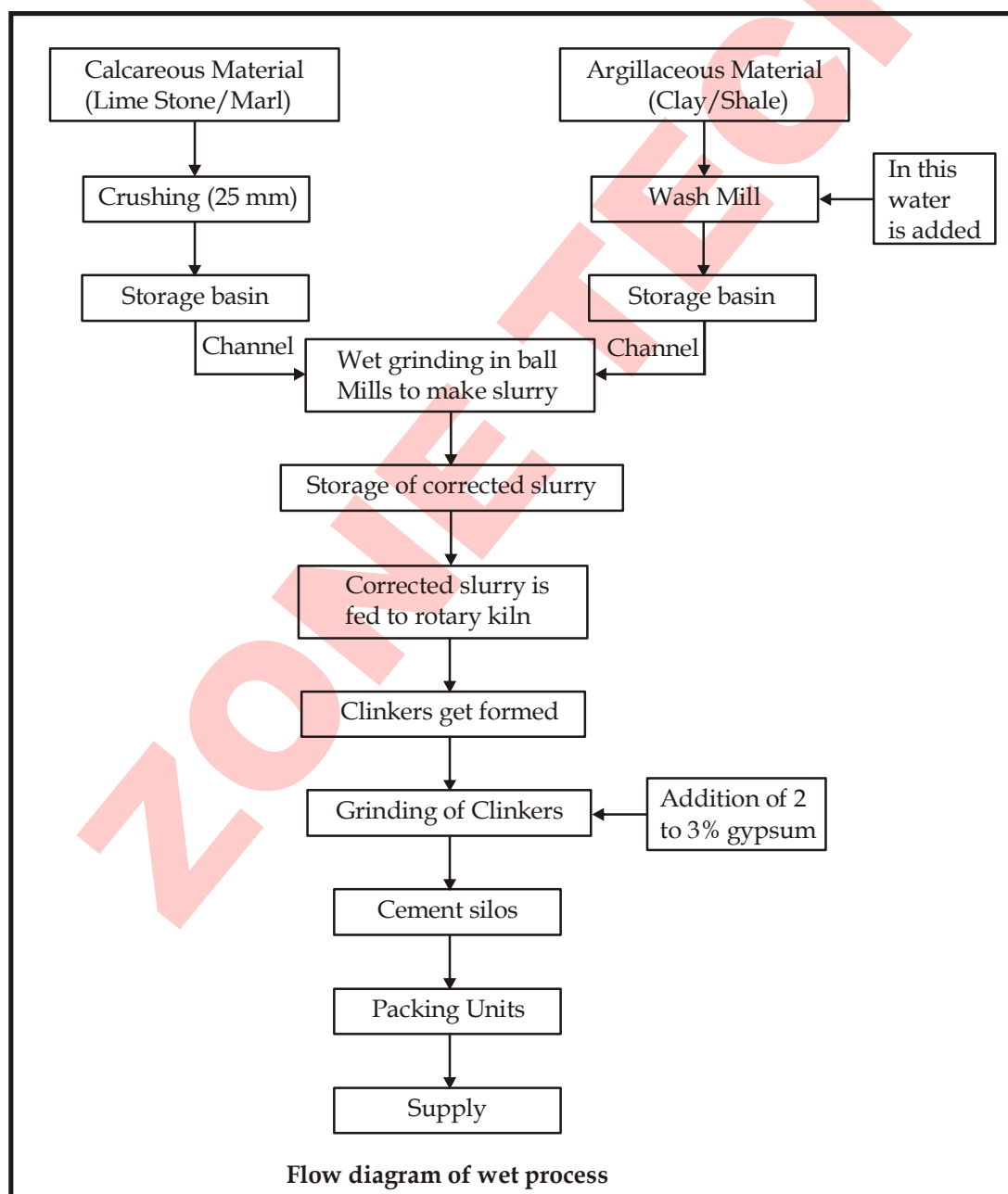


(ii) **Wet process (Old Method)**

- In earlier time i.e. from 1913 to 1960, the wet process was used for the manufacture of cement.

- In this process, the calcareous materials such as limestone are crushed & stored in tanks or silos. The argillaceous material such as clay is thoroughly mixed with water in a container known as wash mill. This washed clay is stored in basin.
- Now the crushed lime stone from tanks & wet clay from basins are allowed to fall in a channel in correct proportions. This channel helps both material to come in contact & make slurry. The grinding of slurry is carried out in ball mill or tube mill or both. The slurry is continuously stirred to make corrected slurry. The corrected slurry is stored in storage tank and then feed to rotary kiln. Then slurry is converted into clinker & then clinker are ground in ball mill. Then stored in cement silos.
- Burning & grinding process remains same for both dry & wet process.
- In wet process to make one tonne of cement, 350 kg of coal is used.

Manufacturing Process By Flow Diagram :



Q.76

Sol. Paint consists of following constituents:

- (a) Base
- (b) Vehicle
- (c) Drier
- (d) Pigment
- (e) Solvent
- (f) Extender

(a) **Base**

- A base is a solid substance found in a state of fine division.
- It forms the bulk of paint
- It determines the character of the paints & imparts durability to the surface.
- It reduces shrinkage cracks.
- It forms an opaque layer to the surface of material which is painted.

Ex. :- White lead, Red lead etc.

Note :- White lead is used for woodwork & Red lead is used for Iron work.

(b) **Vehicle**

- The vehicles are the liquid substance which holds the ingredients of paint in liquid state.
- They are also called carrier.
- They are provided for two reasons.
 - (i) To spread the paint evenly and uniformly on the surface.
 - (ii) To provide a binder for the ingredients of a paint.

Ex. :- Linseed oil, Nut oil, Tung oil etc.

(c) **Driers**

- These are those substances which accelerate the process of drying.

Ex. :- Cobalt, Lead acetate, Zinc sulphate etc.

(d) **Pigments**

- These are those substances which give colour to the paint other than base colour.
- The pigments are available in the form of fine powders in various colours & qualities.

(e) **Solvents**

- The function of solvent is to make paint thin so that it can be easily applied on the surface.
- It also helps the paint in penetrating through the porous surface.
- Also known as thinner.

Ex. :- Naphtha, Turpentine, Methylated spirit, Kerosene etc.

(f) **Extender**

- These are those substances which increase the volume of the paint.

Ex. :- Aluminium silicate, Magnesium silicate (talc), Silica etc.

Q.77

Sol. The term varnish is used to indicate the solution of resins or resinous substances prepared either in alcohol, oil or turpentine.

Object of applying varnish :

1. It brightens the appearance of the wood.
2. It renders brilliancy to the painted surface.
3. It protect the painted surface from atmospheric action.
4. It protects the unpainted wooden surfaces of doors, windows, roof trusses, floors etc, from actions of atmospheric agencies.

Characteristics of an ideal varnish :

1. It makes the surface glossy.
2. It should dry rapidly & present a finished surface which is uniform in nature.
3. It should give pleasing appearance.
4. The colour of varnish should not fade away when surface is exposed to atmospheric actions.
5. It should not shrink or show crack after drying.

Ingredients of A Varnish :-

Following are the ingredients of a varnish :



- (1) Resins or resinous substances
- (2) Driers
- (3) Solvents

1. **Resins or resinous substances**

- The commonly used resins are copal, lac or shellac and rosin.
- Copal is a hard substance & is available from the earth at places where pine trees existed in past.
- The lac or shellac is obtained by exudation of some type of insects in India.
- The rosin is obtained from pine tree.
- Other resins are amber, mastic, gum, dammer etc.

2. **Drier**

- The function of a drier in varnish is to accelerate the process of drying.
- The common driers used in varnishes are white copper & lead acetate.

3. **Solvents**

- Depending upon the nature of resin, the type of solvent is decided.

S.No.	Solvent	Resins
1	Boiled Linseed Oil	Amber, Copal
2	Methylated Spirit	Lac or shellac
3	Turpentine	Mastic, Gum, Dammar, Rosin
4	Wood Naphtha	Cheap Varieties of Resins

Types Of Varnishes :-

Depending upon the solvent, the varnishes are classified into the following four categories:

- (1) Oil varnishes
- (2) Spirit varnishes
- (3) Turpentine varnishes
- (4) Water varnishes

(1) **Oil varnishes**

- The linseed oil is used as solvent in this type of varnish.
- The hard resins such as amber and copal are dissolved in linseed oil.
- The oil varnishes dry slowly, but they form hard and durable surface.
- These are the hardest and the most suitable varnishes.
- They are specially adopted for exposed works which require frequent cleaning.
- They are used on coaches and fittings in houses.

(2) **Spirit varnishes**

- The methylated spirits are used as solvent in this type of varnish.
- The resins are of soft variety such as lac or shellac.
- The spirit varnishes dry quickly. But they are not durable and are easily affected by weathering actions.
- They are generally used for furniture. The French polish is a variety of this class of varnish.

(3) **Turpentine varnishes**

- The turpentine is used as solvent in this type of varnish.
- The resins adopted are of soft variety such as gum, dammer, mastic and rosin.
- These varnishes dry quickly and possess light colours.
- They are not durable and tough as oil varnishes.

(4) **Water varnishes**

- The shellac is dissolved in hot water and enough quantity of either ammonia or borax or potash or soda is added such that shellac is dissolved.
- These varnishes are used for varnishing maps, pictures, etc. they are also used for internal work and as a covering for wallpaper.

Q.78

Sol. **QUARRYING**

- Quarrying is the process of extraction of rocks, sand, gravel or other mineral from the ground in order to use them to produce material for construction or other uses.



- The term 'quarrying' is often associated with a place where natural stone is extracted to produce building stone or dimension stone.
Following are the qualities or requirements of a good building stone :
- (i) **Crushing Strength :**
 A good building stone should have a crushing strength of atleast 100 N/mm^2 .
- (ii) **Appearance :**
 A good building stone should have good appearance and uniform colour. Also, it must be capable of preserving the colour for long time. Also dark colour stones are found to be more susceptible to weathering.
- (iii) **Durability :**
 A good building stone should be durable against the actions of alternate drying and wetting, heat and cold, vegetation growth, chemicals, frost and high velocity winds.
- (iv) **Fracture :**
 Good building stone should possess a sharp, even and clear fracture.
- (v) **Hardness :**
 The coefficient of hardness, obtained from the hardness test is used to classify the usefulness of a stone. A stone to be used in road work must have hardness coefficient not less than 17, for medium hardness work a range of 14 - 17 is sufficient.
- (vi) **Percentage Wear :**
 The percentage wear (determined in attrition test) less than 3 percent is desirable.
- (vii) **Resistance to fire :**
 A good building stone should be fire proof. Sandstone, Argillaceous stone resists fire quite well.
- (viii) **Specific gravity :**
 For a good building stone the specific gravity should not be less than 2.7.
- (ix) **Texture :**
 A compact fine crystalline structure (should be free from cavities, cracks or patches of stuff or loose material) is desirable for a good building stone.
- (x) **Water absorption :**
 A good building stone shall not absorb water by more than 0.60 percentage (of weight) in 24 hours.
- (xi) **Toughness Index :**
 Impact test determines the toughness index of a stone. On the basis of this the stone is classified as
 - (a) High toughness for toughness index more than 19.
 - (b) Moderate toughness for toughness index between 13 - 19.
 - (c) Not tough for toughness index less than 13.

Q.79

Sol. **Sulphate Resisting Cement :**

- Ordinary portland cement is vulnerable to sulphate attack. Sulphate attack is greatly accelerated if accompanied by alternate wetting and drying which normally takes place in marine structures in the zone of tidal variations.
- To prevent the sulphate attack, the use of cement with low C_3A content is found to be effective. Such a cement with low C_3A content and comparatively low C_4AF content is known as sulphate resisting cement. In other words, this cement has a higher silicate content than OPC.
- It is not often possible (feasible) to reduce the Al_2O_3 content of the raw materials. So Fe_2O_3 may be added to the mix so that C_4AF content increase at the expense of C_3A . Many of the physical properties of sulphate resisting cement are similar to ordinary portland cement.

The use of sulphate resistant cement is recommended under the following conditions :

- (i) Concrete to be used in marine conditions.
- (ii) Concrete to be used in foundation and basement, where soil is infested with sulphates.
- (iii) Concrete used for fabrication of pipes which are likely to be marshy region or sulphate bearing soils.
- (iv) Concrete to be used in the construction of sewage treatment works.

Rapid Hardening Cement :

- This cement is similar to OPC but with higher C_3S content and finer grinding. It gains strength more quickly than OPC, though the final strength is only slightly higher. The one day strength of this cement is equal to three day strength of OPC with the same water-cement ratio. This cement is used where a rapid strength development is required. The rapid gain of strength is accompanied by a higher rate of heat development during the hydration of cement. It is about 10 percent costlier than OPC.

The use of rapid hardening cement is recommended in the following situations :

- (i) In prefabricated concrete construction.
- (ii) Where formwork is required to be removed early for reuse elsewhere.
- (iii) Road repair works.
- (iv) In cold weather concrete where the rapid rate of development of strength reduces the vulnerability of concrete to the frost damage.

Q.80

Sol. **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 sometimes 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 :

Electrical Seasoning of timber uses high frequency alternating currents to generate heat and dry the wood. 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.

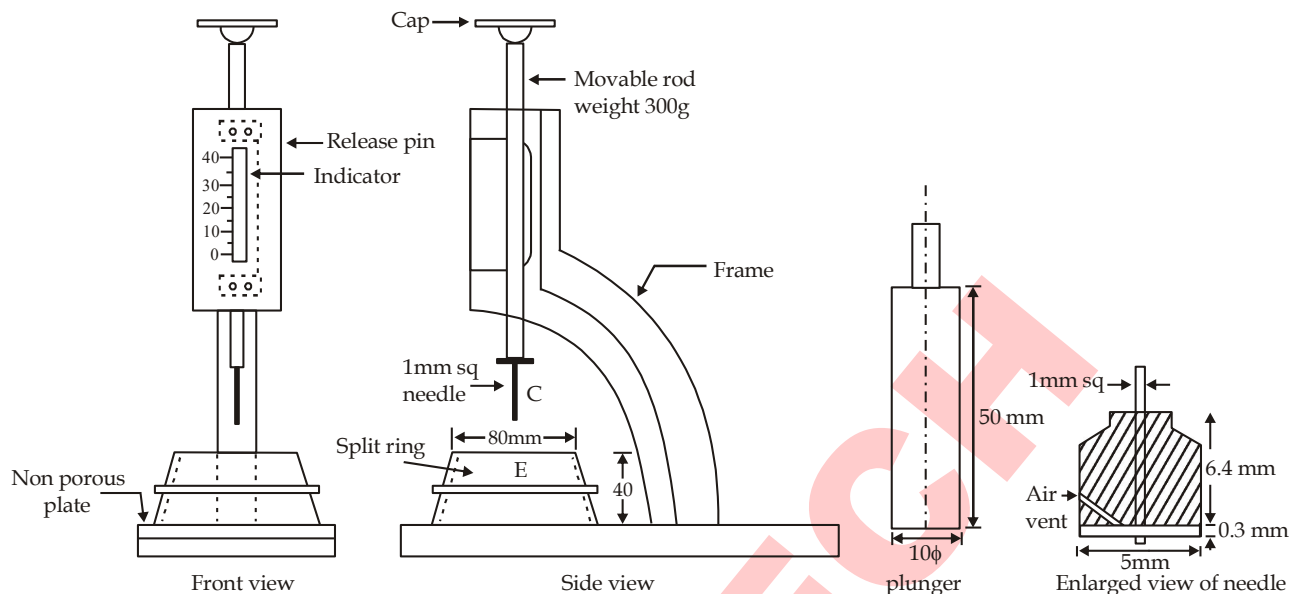
Q.81

Sol. **Initial and Final Setting Time of Cement :**

- On addition of water to cement, the paste thus resulted undergoes stiffening and starts to gain strength and lose consistency simultaneously.
- This stiffening occurs in two stages and these stages are referred as initial and final setting times.
- The time elapsed between the moments the water is added and the paste starts losing its plasticity, is regarded as initial setting time. As per Vicat's test (Refer Fig. below), it is the time elapsed till the paste stiffens to such an extent that the Vicat's needle cannot go into it within $5 \pm .05$ mm measured from the bottom of the mould.
- The time elapsed between the moments the water is added and the paste completely loses its plasticity is regarded as Final setting time. As per Vicat's test, it is the time elapsed till the paste attains such firmness that the attachment to the needle fails to leave any mark on it (though the needle will make an impression).

Experimental Determination :

- The setting times are determined through Vicat's test. The apparatus used is as below



- A cement paste is prepared by gauging cement with 0.85 times the water required to prepare a paste of standard consistency.
- The stop watch is started at the instant water is added.
- The mould rests on a non-porous plate and it is completely filled with the paste and its surface is leveled smooth with the top of the mould.
- The mould is then placed on Vicat's apparatus and the needle is lowered to contact that test block and is quickly released. The needle penetrates the test block completely at the beginning (40 mm from the top).
- After sometime the needle is unable to pierce the block for more than 33-35 mm from the top as the paste starts to lose its plasticity.
- The stop watch is stopped and the time elapsed gives the initial setting time.
- A circular attachment with needle is provided for determining the final setting time.
- This arrangement is gently lowered onto the surface of the test block and released. If the needle makes an impression (not more than 0.5mm) but the edge of the circular arrangement fails to do so, the paste is finally set.
- The time elapsed till this moment, as given by stop watch, will be the final setting time.

Reason of using Gypsum and Calcium Chloride :

(i) Gypsum :

During grinding of clinkers, 3 to 4 percent to Gypsum is added. It controls the initial setting time of cement, otherwise the cement would set as soon as water is added. Hence, the gypsum acts as a retarding agent, delaying the setting action of cement, making it workable.

(ii) Calcium Chloride :

Calcium chloride (CaCl_2) has the ability to accelerate cement hydration and reduce set time by as much as two thirds. In addition to the important contributions of cold weather protection and early strength of concrete, it also has following benefits.

- Improves workability - regardless of mixture design, less water is required to produce a given slump when calcium chloride is used.
- Improves strength of air entrained concrete. Calcium chloride compensates for the reduction in strength with a higher cement factor concrete.
- Reduces bleeding this is due to the early stiffening produced by acceleration and allows earlier final finishing.

Q.82

Sol.

(i) Absorption Test

- A brick is taken and measured its dry weight. It is then immersed in water for a period of 24 hours and then weighted again and the difference in weights should not, in any case, exceed
 - (a) 20 percent of weight of dry brick for first class bricks.
 - (b) 22.5 percent for second class bricks.
 - (c) 25 percent for third class bricks.

(ii) Crushing Strength Test

- Minimum crushing strength for first class bricks $\geq 10 \text{ N/mm}^2$ and for second class bricks $\geq 7.5 \text{ N/mm}^2$.

(iii) Hardness Test

- In this test, a scratch is made on brick surface with the help of a finger or nail. If no impression is left on the surface, brick is treated to be sufficiently hard.

(iv) Presence of Soluble Salts Test

- Soluble salts, if present in bricks, will cause efflorescence on the surface of bricks.
- It is immersed in water for 24 hours. It is then taken out and allowed to dry in shade. Absence of grey or white deposits on its surface indicates absence of soluble salts.
- If the white deposits cover about 10% surface, the efflorescence is said to be slight.
- When white deposit cover about 10%-50% of surface then it is said to be moderate efflorescence.
- If grey or white deposits are found on more than 50% of surface, the efflorescence becomes heavy and it is treated as serious efflorescence.

(v) Shape and Size Test

- Its shape should be truly rectangular with sharp edges.
- 20 bricks are randomly selected of standard size ($19 \times 9 \times 9 \text{ cm}$). For good quality bricks, the results should be within the following permissible limits :
 - Length - 368 cm to 392 cm
 - Width - 174 cm to 186 cm
 - Height - 174 cm to 186 cm

(vi) Soundness Test

- In this test, two bricks are taken and they are struck with each other. Bricks should not break and a clear ringing sound should be produced.

(vii) Structure Test

- It should be homogeneous, compact and free from any defects such as holes, lumps, etc.
- High duty fireclays can resist temperature range of 1482°C to 1648°C ; medium duty fireclays can resist temperature range of 1315°C to 1482°C and low duty fireclays can resist temperature up to 870°C only.

Q.83

Sol.

Following are the standard tests for cement :

- Chemical composition test
- Fineness test
- Compressive strength test
- Tensile strength test
- Consistency test
- Setting time test
- Soundness test

Setting Time Test :

This test is used to detect the deterioration of cement due to storage. It may however be noted that this is purely a conventional type of test and it has got no relation with the setting or hardening of actual concrete. The test is carried out to find out initial setting time and final setting time.

(i) Initial setting time :

Following procedure is adopted :

- The cement weighing 300 gm is taken and it is mixed with 0.85 p amount of water where p is amount of water required for standard consistency.
- The cement paste is filled in the Vicat mould.



- The square needle of cross-section 1 mm × 1 mm is attached to the moving rod of the Vicat apparatus.
- The mould is then placed on Vicat's apparatus and the needle is lowered to contact that test block and is quickly released. The needle penetrates the test block completely at the beginning (40 mm from the top).
- After sometime the needle is unable to pierce the block for more than 33-35 mm from the top as the paste starts to lose its plasticity.
- The stop watch is stopped and the time elapsed gives the initial setting time.

(ii) Final setting time :

Following procedure is adopted :

- The cement paste is prepared as above and it is filled in the Vicat mould.
- The needle with annular collar is attached to the moving rod of the Vicat apparatus. This needle has a sharp point projecting in the centre with annular collar.
- The needle is gently released. The time at which the needle makes an impression on test block and the collar fails to do so it noted.
- The final time is the difference between the time at which water was added to cement and time and when cement completely losses its plasticity and became hard. This time should be about 10 hours.

Q.84
Sol.

- Cement is a mixture of compounds made by burning limestone and clay together at a very high temperature ranging from 1300°C to 1500°C.
- Cement is invented by Joseph Aspdin of England (UK) in 1824.
- Cement is a binding material which has property of both adhesion and cohesion in presence of water.
- Cement can be classified as Hydraulic & Non Hydraulic.
- Hydraulic cement set and harden extremely fast in presence of water and result in waterresistant product which is stable. This allows setting in wet condition or underwater and protect the hardened material from chemical attack. Eg. Portland Cement.
- Non Hydraulic cements are derived from calcination of gypsum or limestone and resulting in products of hydration that are not resistant to water. Eg. POP.

Chief chemical ingredients of cement are as follows:

Composition of Cement				
S. No.	Constituents	Formula	Range	Average
1	Lime	(CaO)	62 - 67%	63 %
2	Silica	(SiO ₂)	17 - 25%	20 %
3	Alumina	(Al ₂ O ₃)	3 - 8%	6%
4	Calcium Sulphate	(CaSO ₄)	3 - 4%	3%
5	Iron oxide	(Fe ₂ O ₃)	3 - 4%	3%
6	Magnesia	(MgO)	1 - 2%	1%
7	Sulphur	(S)	1 - 2%	1%
8	Alkalies	(K ₂ O, Na ₂ O)	0.2 - 1%	1%

Functions of following ingredients/constituents of cement are as follows:

(1) Lime

- This is the important ingredient of cement and its proportion should be between 62 - 67%.
- Lime imparts strength and soundness to the cement (In cement, Soundness means resistance against change in volume).
- If lime is present in less amount then it will decrease the strength of cement & causes quick setting to the cement.

- If it present in excess amount then it imparts unsoundness to the cement which leads to disintegration.
 - (2) Silica
 - Silica is also an important constituent of the cement and its proportion should be between 17-25%.
 - Silica also imparts strength to the cement due to the formation of di-calcium and tri-calcium silicates.
 - If silica is present in excess amount then it will increase the strength of the cement but at the same time prolong the setting time.
 - (3) Alumina
 - Alumina imparts quick setting property to the cement.
 - Alumina also acts as a flux & help in lowering the clinkering temperature.
 - However the high temperature is essential for the formation of suitable type of cement so it should not be present in excess amount.
 - If it present in excess amount then it weakens the cement.
 - (4) Calcium sulphate
 - This ingredient is present in the form of gypsum and its function is to increase the initial setting time of cement.
 - (5) Iron Oxide
 - This ingredient imparts colour, hardness and strength to the cement.
 - The grey colour of cement is due to the presence of iron oxide.
 - (6) Magnesia
 - This ingredient imparts colour, hardness & soundness to the cement.
 - A high content of magnesia makes the cement unsound.
 - (7) Sulphur
 - A very small quantity of sulphur is useful in making sound cement.
 - If it is in excess, it imparts unsoundness to the cement.
 - (8) Alkalies
 - Alkalies are present in raw material in small amount.
 - If it present in excess, it will cause a number of troubles such as alkali-aggregate reaction, efflorescence & staining when used in concrete, brick work or masonry mortar.
- Note :-** Alkali Oxides (i.e. K_2O & Na_2O) should not exceed 1%. Magnesium oxide (i.e. MgO) should not exceed 5%.

Q.85
Sol.

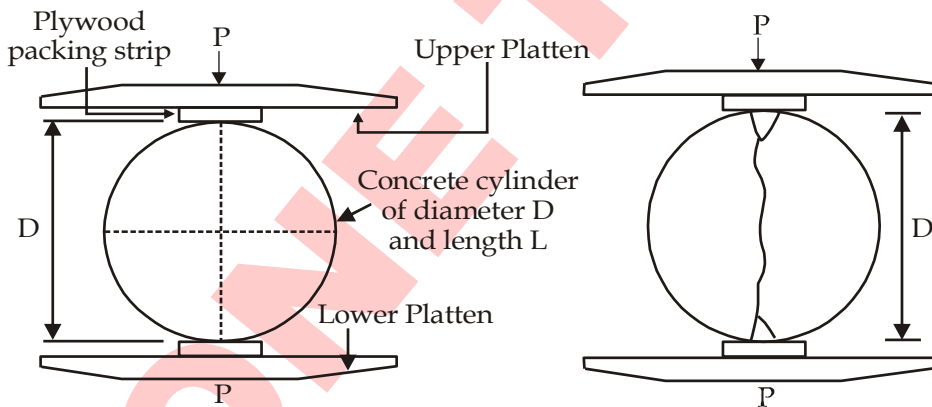
- (i) Rebound Hammer Test :
1. It is done to find out the compressive strength of concrete by using rebound hammer.
 2. The principle of the test is that rebound of an elastic mass depends on the hardness of the surface against which it strikes.
 3. When the plunger of the rebound hammer is pressed against the surface of the concrete, the spring-controlled mass rebounds and the extent of the rebound depends upon the surface hardness of the concrete.
 4. The surface hardness and therefore the rebound are taken to be related to the compressive strength of the concrete.
 5. The rebound value is read from a graduated scale and is designated as the rebound number or rebound index. The compressive strength can be read directly from the graph provided on the body of the hammer.
 6. The procedure :
 - The rebound hammer should be tested against the test anvil before commencing the test to verify the results.
 - Apply light pressure on the plunger it will release it from the locked position and allow it to extend to the ready position for the test.
 - Press the plunger against the surface of the concrete, keeping the instrument perpendicular to the test surface. Apply a gradual increase in pressure until the hammer impacts.



- The spring controlled mass when rebounds, it takes with it a rider which slides along a graduated scale. It can be held in position of the scale by depressing the locking button.
- A calibration curve relating to compressive strength of the concrete with the rebound number is plotted.
- The test provides useful information for surface layer up to 30 mm depth and is suitable for concrete having strength of 20 - 60 MPa.
- The concrete surface must be smooth and loose material should be ground off.

(ii) Cylinder Splitting Test :

1. Due to difficulty in applying uniaxial tension to a concrete specimen, the tensile strength is determined by indirect methods.
2. It is the standard test to determine the tensile strength of concrete in indirect way in accordance with IS : 5816-1970.
3. A standard test cylinder of concrete specimen of 300 mm × 150 mm diameter is placed horizontally between the loading surfaces of compression testing machine.
4. The compression load is applied diametrically and uniformly along the length of cylinder until the failure of the cylinder along vertical diameter.
5. On application of load, a uniform tensile stress acts over two-third of the loaded diameter.
6. The magnitude of the tensile stress is obtained by : $\sigma = 2P / \pi DL$ Where, P = Applied load, D = Diameter of the cylinder and L = Length of the cylinder
7. The load is applied gradually and increased continuously until failure at a rate within the range of 1.2 MPa/min to 2.4 MPa/min.
8. Between the loading platens and the specimen cylinder, packing strips of plywood are placed for uniform distribution of load and to avoid high compression stresses near the point of application.



$$f_v = \frac{-6P}{\pi LD} \text{ Compressive, } f_t = \frac{2P}{\pi LD} \text{ Tensile}$$

Loading Arrangement of Split Tensile Test

(iii) Limitations of the Test:

1. The test calculates the maximum tensile stress assuming line loads and a uniform distribution of tensile stresses, but concrete has a non-linear stress-strain distribution.
2. The strength of specimen depends upon the diameter of the specimen and hence it is not necessarily a material property, but a reliable value that can be used for comparison and design.

Q.86

Sol.

- Workability is referred to as the ease with which concrete can be transported, placed and consolidated without excessive bleeding or segregation.
- Workability can also be defined as the internal work done in overcoming the frictional forces between concrete ingredients for full compaction.
- The optimal workability of concrete will depend upon the given job and hence will vary from situation to situation.

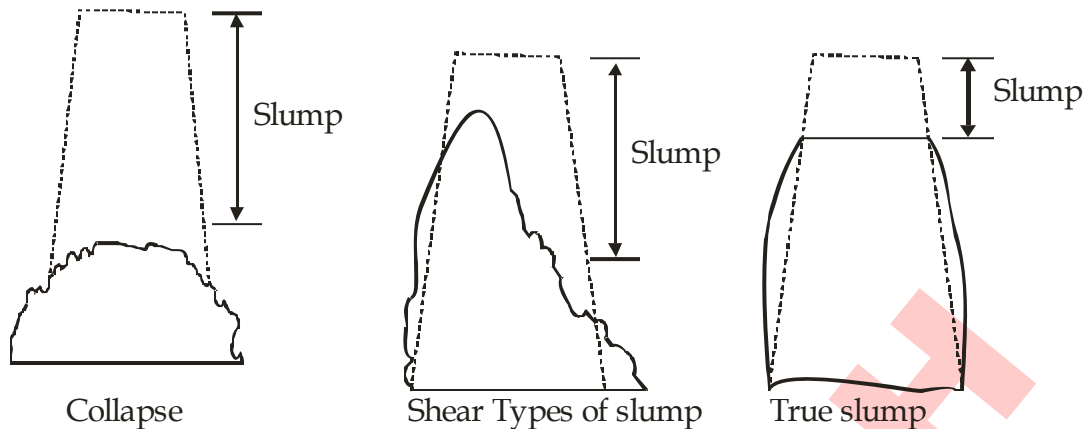
FACTORS AFFECTING WORKABILITY :

- (i) Water Content :
 - In order to obtain higher degree of workability higher water content is required but with the increase in water-cement ratio, the strength of the cement concrete is decreased hence in order to maintain the strength, along with water content, proportion of cement should be increased.
- (ii) Mix Proportions :
 - Aggregate-cement ratio influences the workability to a large extent. The higher the ratio leaner will be the concrete, hence the workability is less
- (iii) Aggregate Size :
 - For big size aggregates the total surface area to be wetted is less, also less paste is required for lubricating the surface to reduce internal friction. So, for a given water content big size aggregates give high workability.
- (iv) Shape of Aggregates :
 - At a given water content, round and cubical shape aggregates are more workable than rough, angular or flaky aggregates, because the former type of aggregates require less cement paste for lubrication as these have less surface area and lesser voids.
 - In round aggregates frictional resistance is small, so less lubrication is required. For this reason, river sand and gravel provide greater workability than crushed sand and aggregates.
- (v) Surface Texture :
 - Rough surface aggregates will have more surface area than a smooth round textured aggregate. Therefore smooth textured aggregates will be more workable.
- (vi) Grading of Aggregates :
 - Well graded aggregates are more workable. Because, such a mix will have least voids and thus excess cement paste will be available as lubricant.
- (vii) Admixtures :
 - At given water content, air-entraining admixtures improve the consistency and cohesiveness of the concrete by increasing the volume of paste.
 - Air entrained concrete is more workable. Because air forms bubbles, on which the aggregates slide past each other increasing the workability.
 - For a given water content and strength, workability can be increased by addition of water reducers (plasticizers or super plasticizers)
 - Pozzolanic admixtures tend to improve the cohesiveness of concrete. Fly ash, when used as partial replacement for fine aggregate, generally improves the workability at given water content.

SLUMP TEST : Slump test is used for in-situ determination of workability.

The procedure is as follows :

- The apparatus used is a metallic mould in the form of frustum of a cone having internal dimensions as : Top diameter – 10 cm Bottom diameter – 20 cm Height – 30 cm
- A steel tamping rod of 16 mm dia, 0.6 m long with bullet end is used.
- The mould is placed on a smooth, horizontal, rigid and non-absorbent surface.
- It is then filled in 4 layers, each approximately $\frac{1}{4}$ of height of mould.
- Each layer is tamped 25 times by the tamping rod evenly.
- After the top layer has been rodded, the concrete is struck off level with a trowel and tamping rod.
- The mould is removed immediately by lifting it vertically carefully.
- The difference between the height of mould and the highest point of subsided concrete in mm is taken as slump of concrete.
- The pattern of slump also indicates the characteristics of concrete.
- An even slump is called true slump, and if one half of concrete slides down, it is called shear slump. It may collapse in case of very wet concretes.
- In case of shear slump, the slump value is measured as difference between the height of mould and average value of subsidence.
- Shear slump indicates a non-cohesive concrete and may lead to segregation.



Degree of Workability	Slump (in mm)	Use of Concrete
Low	25-75	• Roads vibrated by hand operated machines.
		• Mass concrete foundation without vibration or lightly reinforce sections with vibration.
Medium	20-100	• Manually compacted flat slabs using crushed aggregates.
		• Normal reinforced concrete, manually compacted and heavily reinforced sections with vibration.
High	100-150	• For sections with congested reinforcement.

Q.87

Sol.

Qualities of a good building stone:

Following are the qualities or characteristics or requirements of a good building stone :

(1) Crushing strength:

For a good structure stone, the crushing strength should be greater than 100 N/mm^2 .

(2) Appearance:

The stones which are to be used for face work should be decent in appearance and they should be capable of preserving their colour uniformly for a long time. The colour of the stones for face work should be chosen by keeping in mind the general set up of the surrounding area. It is desirable to prefer light coloured stones as compared to dark coloured stones because there are chances of the latter variety to be attacked easily by weathering agents. A good building stone should be of uniform colour and free from clay holes, spots of other colour, bands, etc.

(3) Durability:

A good building stone should be durable. The various factors contributing to durability of a stone are its chemical composition, texture, resistance to atmospheric and other influences, location in structure, etc.

(4) Facility of dressing:

The stones should be such that they can be easily carved, moulded, cut and dressed. It is an important consideration from the economic point of view. However this property of stone is opposed to its strength, durability and hardness.

(5) Fracture:

For a good building stone, its fracture should be sharp, even, bright and clear with grains well cemented together. A dull, chalky and earthy fracture of a stone indicates signs of early future decay.

(6) Hardness:

The coefficient of hardness, as worked out in hardness test, should be greater than 17 for a stone to be used in road work. If it is between 14 and 17, the stone is said to be of medium hardness. If it is less than 14, the stone is said to be of poor hardness and such stone should not be used in road work.

(7) Percentage wear:

In attrition test, if wear is more than 3 percent, the stone is not satisfactory. If it is equal to 3 percent, the stone is just tolerable. For a good building stone, the wear should be equal to or less than 3 per cent.

(8) Resistance to fire:

The minerals composing should be such that shape of stone is preserved when a fire occurs. The failure of stones in case of a fire is due to various reasons such as rapid rise in temperature, sudden cooling, different coefficients of linear expansions of minerals, etc

(9) Seasoning:

The stones should be well seasoned before putting into use. The stones should be dried or seasoned before they are used in structural work. A period of about 6 to 12 months is considered to be sufficient for proper seasoning.

(10) Specific gravity:

For a good building stone, its specific gravity should be greater than 2.7 or so.

(11) Texture:

A good building stone should have compact fine crystalline structure free from cavities, cracks or patches of soft or loose material. The stones with such texture are strong and durable.

(12) Toughness index:

In impact test, if the value of toughness index comes below 13, the stone is not tough. If it comes between 13 and 19, the stone is said to be moderately tough. If it exceeds 19, the toughness of stone is said to be high.

(13) Water absorption:

All the stones are more or less porous, but for a good stone, percentage absorption by weight after 24 hours should not exceed 0.60. The porous stones seriously affect the durability of stones.

(14) Weathering:

A good building stone should possess better weathering qualities. It should be capable of withstanding adverse effects of various atmosphere and external agencies such as rain, frost, wind etc

Q.88

Sol.

Stone is a naturally available building material which has been used from the early age of civilization. It is available in the form of rocks, which is cut to required size and shape and used as building block i.e. the building stones are obtained from the rocks. Stone are natural products of rocks and directly used in building.

Classification Of Stones:-

The building stones are classified in the following three ways:

(1) Geological Classification

(2) Physical Classification

(3) Chemical Classification

1. Geological Classification According to this, rocks are of three types:-

(a) Igneous rocks

(b) Sedimentary rocks

(c) Metamorphic rocks

(a) Igneous Rocks

- The molten or pasty rocky material is known as magma and this magma occasionally tries to come out to the earth's surface through cracks or weak portions.
- The rocks which are formed by the cooling of the magma are known as igneous rocks. Eg. Granite, Trap, Basalt, Dolerite, Syenite, Rhyolite etc.
- The igneous rocks are classified into three classes. (i) Volcanic rocks
- Such rocks are formed due to cooling of magma at the earth surface.
- In this case, cooling is very rapid.
- These rocks are extremely fine grained in structure. Eg ? Basalt etc. (ii) Hypabyssal rocks
- Such rocks are formed due to cooling of magma at a relatively shallow depth from the earth's



surface.

- Cooling is quick
 - These rocks possess finely grained crystalline structure. Eg ? Dolerite etc. (iii) Plutonic rocks
 - Such rocks are formed due to cooling of magma at a considerable depth from earth's surface.
 - Cooling is slow.
 - These rocks possess coarse grained crystalline structure. Eg ? Granite, Syenite etc.
- (b) Sedimentary Rocks
- These rocks are formed due to deposition of weathering products on the pre-existing rocks.
 - Weathering agents are frost, rain, wind, flowing water etc. Eg?? Gravel, Sandstone, Limestone, Chalk, Gypsum, Lignite etc.
- (c) Metamorphic Rocks
- These rocks are formed by the change in character of the pre-existing rocks.
 - The igneous rocks as well as sedimentary rocks are changed in character when they are subjected to great heat and pressure.
 - The process of change is called Metamorphism.
 - There are three agents of metamorphism, namely heat, pressure and chemically acting fluids. Eg → Marble, Gneiss, Slate etc.
2. Physical Classification
- This classification is based on general structure of rocks. According to this, rocks are of three types:- (i) Stratified rocks (ii) Unstratified rocks (iii) Foliated rocks (iv) Stratified rocks
 - In these rocks, layers are present.
 - Generally found in sedimentary rocks. Eg. → Limestone, sandstone, shale etc. (ii) Unstratified rocks In these rocks, layer property is absent.
 - Generally found in igneous rocks Eg → Granite, Basalt, Trap, Marble etc. (iii) Foliated rocks
 - These rocks have a tendency to split into a definite direction only.
 - Foliated structure is very common in metamorphic rocks except Marble & Quartzite
3. Chemical Classification This classification is called scientific or engineering classification.

According to this classification, the rocks are of three types :-

- (i) Siliceous rocks
 - (ii) Argillaceous rocks
 - (iii) Calcareous rocks
- (i) Siliceous rocks
- In these rocks, the silica predominates.
 - They are hard and durable
 - Not easily affected by weathering agencies. Eg. ? Granite, Gneiss, Quartzite, Sandstone etc.
- (ii) Argillaceous rocks
- In these rocks, the argil or clay predominates.
 - These rocks may be dense and compact or they may be soft.
 - These stones are hard and durable but brittle. Eg. → Slate, Kaolin, Laterite etc.
- (iii) Calcareous rocks
- In these rocks, the calcium carbonate predominates. Eg. → Limestone, Marble, Chalk etc.

Note :- Monomineralic Rock : These are those rocks in which only one mineral is present. Eg. → Quartz sand, Chemically pure gypsum, Magnesite etc.

Polymineralic Rock :

These are those rocks which contains several minerals. Eg. ? Basalt, Granite etc.

Q.89

Sol. Bricks are obtained by moulding clay in rectangular blocks of uniform size & then by drying and burning these blocks.

Chief chemical ingredients of brick are as follows:



Composition of Bricks:			
S. No.	Constituents	Formula	Range
1	Alumina	(Al ₂ O ₃)	20 - 30 %
2	Silica	(SiO ₂)	50 - 60 %
3	Lime	(CaO)	4 - 5 %
4	Iron Oxide	(Fe ₂ O ₃)	5 - 6 %
5	Magnesia	(MgO)	>1 %

Functions of following ingredients/constituents of brick are as follows:

- (1) **Alumina (Al₂O₃)**
 - A good brick earth should contain about 20% to 30% of alumina.
 - It is the main ingredient of brick.
 - It imparts plasticity to the brick earth so that it can be moulded in any shape.
 - If it is in excess amount it will cause shrinkage & warping of bricks during drying & becomes too hard when burnt.
- (2) **Silica (SiO₂)**
 - A good brick earth should contain about 50-60% of silica.
 - It prevent the cracking & shrinkage & warping of the bricks hence helps in giving the uniform shape to the bricks.
 - If amount of silica is in excess, it destroys the cohesion between the particles of the brick earth & results in formation of brittle bricks.
- (3) **Lime (CaO)**
 - A small quantity of lime not exceeding 5% is desirable in good brick earth.
 - It prevent shrinkage of the bricks.
 - If it is in excess amount it cause the bricks to melt during burning process & results in loss of shape of bricks.
- (4) **Iron Oxide (Fe₂O₃)**
 - A small quantity of iron oxide about 5 to 6% is desirable for good brick earth.
 - It helps in fusing (joining) lime with silica and also imparts strength & colour to the bricks.
 - Iron oxide gives Reddish brown colour to the bricks.
 - If iron oxide present in excess amount then it gives dark blue colour to the bricks.
- (5) **Magnesia (MgO)**
 - A small amount of magnesia gives yellow tints to the bricks & decrease shrinkage.
 - It magnesia is present in excess amount it will lead to the decay of the bricks.

Q.90

Sol. Distemper is the water-based paint which is a combination of powdered chalk, pigments and lime. Distempered surfaces can be easily marked and discoloured and cannot be washed down. The main object of applying distemper to the plastered surfaces is to create a smooth surface. The distempers are available in the market under different trade names. They are cheaper than paints and varnishes and they present a neat appearance. They are available in a variety of colours.

Properties of Distemper:-

Following are the properties of distemper:

- (i) On drying, the film of distemper shrinks. Hence it leads to cracking.
- (ii) The coatings of distemper are usually thick and they are more brittle than other types of water paints.
- (iii) The film developed by distemper is porous in character and it allows water vapour to pass through it.
- (iv) They are generally light in colour and they provide a good reflective coating.
- (v) They are less durable than oil paints but are cheaper.
- (vi) They are treated as water paints and they are easy to apply.
- (vii) They can be applied on brickwork, cement plastered surface, lime plastered surface, insulating



boards, etc.

(viii) They exhibit poor workability.

(ix) They prove to be unsatisfactory in damp locations such as kitchen, bathroom, etc.

Ingredients of a Distemper :

- A distemper is composed of base, carrier, colouring pigments and size. For base, the whiting or chalk is used and for carrier, the water is used.
- The distempers are available in powder form or paste form. They are to be mixed with hot water before use. The oil-bound distempers are a variety of an oil paint in which the drying oil is so treated that it mixes with water. The emulsifying agent which is commonly used is glue or casein. As the water dries, the oil makes a hard surface which is washable.

Note:-

It should be remembered that most of the manufacturers of readymade distempers supply complete directions for use of their products. These directions are to be strictly followed to achieve good results.

Q.91

Sol.

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