UNIT I

1. Building Stones

1.1 Sources of stones

1.1 INTRODUCTION

All the structures are composed of different types of materials. For a good civil engineer, a thorough knowledge about use of these building materials is necessary. An engineer must be able to choose the suitable type of material as per the conditions of environment, strength requirement and availability, simultaneously also be able to compare the economics of construction between different alternatives. Budling stones are obtained from rocks. Rocks are majorly classed based on the mode of their occurrence, also referred as Geological classification.

Igneous rocks

Rocks that are formed by cooling of Magma or lava (molten or pasty rocky material) are known as igneous rocks.

E.g., Granite, Basalt and Dolerite etc.

Sedimentary rocks:

These rocks are formed by the consolidation of the products of weathering obtained from the pre-existing rocks.

Examples: gravel, sandstone, limestone gypsum, lignite etc

Metamorphic rocks:

These rocks are formed by the change in character of the pre-existing rocks when subjected to great heat and pressure. The process of their transformation is called metamorphism.

Examples: Quartzite, Schist, Slate, Marble, and Gneisses

The racks can be further classified on physical and chemical basis

Physical Classification can be done as

Stratified rocks

These rocks possess planes of cleavage or stratification along which they can be split. Sedimentary rocks usually possess this property.
Un-stratified rocks:

The structure may be crystalline granular or compact granular.

Example- Igneous rocks

Foliated rocks:

These rocks have a tendency to split up in a definite direction only.

Ex- Metamorphic rocks

Chemical Classification

It is useful to predict the behaviour of rock under harsh environment conditions.

Siliceous rocks

In these rocks, silica is predominating. These rocks are hard, durable, and not easily affected by weathering agencies Example Granite, Quartzite etc.

Argillaceous Rocks

In these rocks clay predominates. These rocks may be dense and compacted or may be soft

Example: Slates, Laterites etc

Calcareous rocks

Calcium carbonates is the main constituent in these rocks. The durability to these rocks will depend upon the constituents present in surrounding atmosphere.

Ex Lime Stone, marble

1.2 Quarrying of stones by blasting and its effect on environment

Definition:

Stones occur in the form of natural rock masses or layers on the surface. The process of extraction of suitable stones from their natural rock beds or layers is commonly called Quarrying of Stones.

Methods of Stones Quarrying

The method used for quarrying of stones depends upon the types of stones its intended use and the type of its geological formation. For Example, when the rock formation consists of horizontal layers at shallow depth, we may be able to easily quarry them in layers. In other words, If the stone is one whole crystalline mass, we have may ballast them with explosives.

The method to be used for regular building blocks will be different from that used to produce stone ballast. We can easily methods of quarrying into the following three groups.

1. Quarrying with hand tools

2. Quarrying by use of channelling machines

3. Quarrying by ballast

Quarrying By Blasting

This is a common method of quarrying all types of rock. The main purposes of stone quarrying the stones by blasting are to loosen large blocks of rocks and not to violently blow up the whole mass to convert it into pieces.

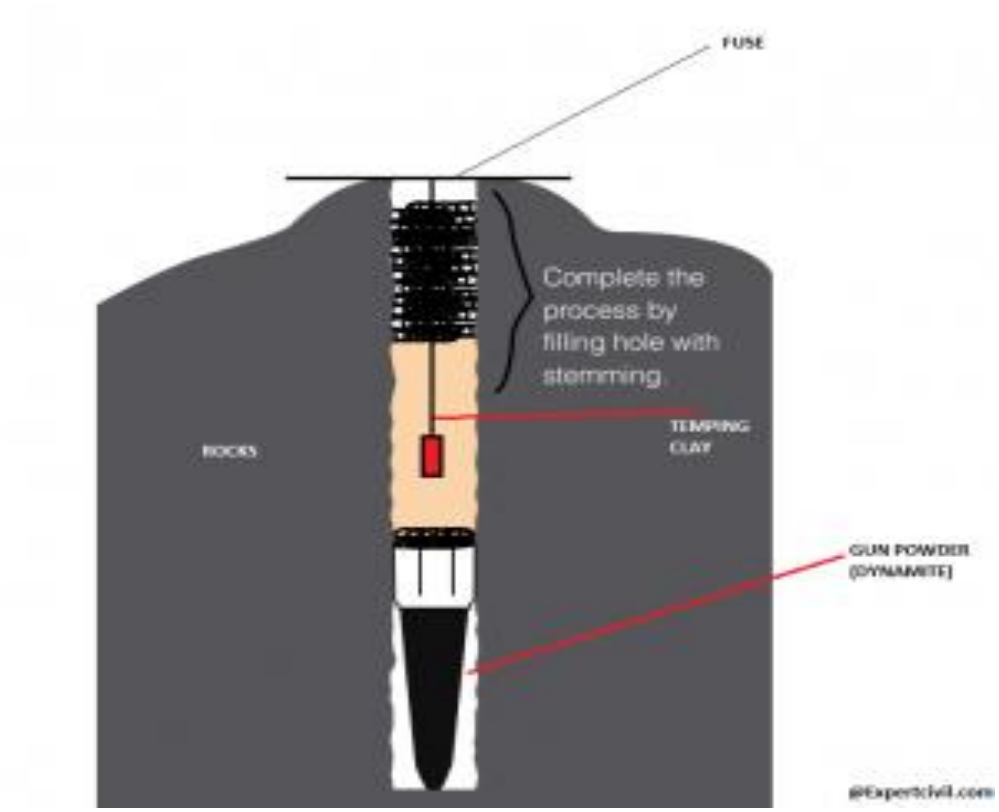
Following operations are involved in quarrying by blasting.

Boring: Blast holes of the required diameter and depth are made with a jumper. A little water is poured into the hole at intervals to soften the stone. The jumper is rotated each time it strikes the rock. When the hole is drilled to the required depth, it is cleared of the debris by scraper or spoon. If the holes are of the bigger size, or if the rocks are of harder variety, holes may be drilled by a pneumatic or percussion drilling machine.

Charging: The holes so drilled are dried thoroughly using a tag tried to a scrapper at the end. The Charge of gunpowder or gun-cotton (Dynamite) is put into the hole and a greased priming needle or fused cord is placed in position.

Tamping: The hole is filled up with damp clay and rounded hard with the help of a tamping rod. The priming needle is kept rotating during the tamping operation to facilitate it withdraw without disturbing the tamped clay, after the tamping operations are over, the priming needle is then taken out and 60 to 70% of the space is filled with fine gunpowder. A slow fuse is inserted into the hole, keeping about 1 M length of the fuse projecting out of the ballast hole. This will give sufficient time to the person firing it to move away to a safe place. Detonators are sometimes used in places of the fuse to explode the dynamite.

Firing: The charge present in the blast holes is fired either with help of a match or with the help of an electric spark. However, detonators are used when the explosives are dynamited.



Effect of blasting on environment

Environmental Damaged by Vibration

Professional explosive engineer's design their blast charges so the most of the energy released by the explosion is used up in breaking rock, however, is released as transient stress waves, in other words, ground vibration. This creates cracks in the base of the surrounding rocks near the blast site and travels at different rates through soil rocks and water until the energy of the vibration is dissipated.

Environmental Damaged by Dust and Noise

Blasting as well as other activities associated with mine development and operation can cause noise, dust, and vibration. The environmental effects of noise and dust vary depending not only on the size and location of the blast but also on atmospheric conditions such as wind and humidity. Dust or particulate matter suspended in the air, in an important component of air quality and is commonly generated by blasting. Noise, or air-over-pressure, as professional engineer calls it, is influenced by several factors; these include equipment used to drill rock in order to set the charges as well as transients air pressure changes set off by the explosions.

Damaged by Chemical Contamination of soil and water

If commercials explosives are spilled on the ground or left undetonated at a blast site, ammonium and nitrate can reach into ground and surface water. The Department of Environmental Protection also warns that perchlorate, which is present in some blasting agents and explosives, has contaminated a number of drinking water supplies near blasting activities.

1.3 Dressing of stones

Dressing of stone is a process of providing a proper shape, size and smooth finish to the rough-surfaced broken stone which is collected from a quarry. This process is done by either hand tools or machinery. Hand tools are used as a pickaxe, chisel etc. Stone dressing process is required more technical skilled labours and fair understanding of drawing, materials, and specifications.

1.4 Requirements of good building stones

The following are the qualities or requirements of a good building stone.

1.Crushing strength:

A good building stone should possess a crushing strength of at-least 100 N/mm^2.

2. Appearance.

A good building stone should have a good appearance and a uniform colour. Also, it must be capable of preserving the colour for longtime. Also, dark colour stones are found to be more susceptible to weathering.

3. 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.

4. Fracture:

For good building stone should possess a sharp, even and clear fracture.

5. 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 a hardness coefficient not less than 17. for medium hardness work a range of 14-17 is sufficient. Stones with hardness coefficient below 14 must not be used in road work.

6. Percentage wear.

The percentage wear, as determined in attrition test, of less than 3 percent is desirable.

7. Resistance to fire:

A good building stone be fire proof. Sandstone, Argillaceous stone resists fire quite well

8. Specific gravity.

For a good building stone, the specific gravity should not be less than 2.7.

9. 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.

10. Water absorption:

A good building stone shall not absorb water by more than 0.60 percent (of weight) in 24 hours.

11. 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.

Apart from these properties a good stone must have sufficient weathering resistance, should be well seasoned and facilitate dressing.

1.5 Various uses of stones in construction

1.STRUCTURE

Stones are very useful in foundations, walls, columns, lintels, arches, roofs, floors works mainly because of their strength and other relevant properties.

2. FACE-WORKS.

Stones have a unique usefulness in face-work for structures because of the ecstatic appearance they give. This type of work is also called as composite masonry.

3. PAVING PURPOSES:

By the virtue of good strength and good appearance, stones are also used for paving of plinths, boundaries, and pavements.

4. BASIC MATERIAL

Apart from the above-mentioned direct uses, stones also have indirect uses for making products to be used in construction.

E.g. cement, murum.

5.MISCELLANEOUS:

Stones possess usefulness in other related works as well, such as Ballast for railways , Flux in blast furnace, Blocks in the construction of bridges, piers, abutments, retaining walls, light houses, dams etc.

Artificial Stones: Procedure of making an artificial stone, forms of artificial stones, advantages of artificial stones.

Where durable natural stone is not available at reasonable cost, artificial stone, also known as cast stone becomes the choice. Artificial stone is made with cement and natural aggregates of the crushed stone and sand with desired surface finish. Suitable colouring pigments may be added. However, colouring should not exceed 15 per cent by volume. Cement and aggregates are mixed in proportion of 1:3. Artificial stone can be moulded into the most intricate forms, cast into any size, reinforced to have higher strength, are most suitable for face work, since grooves, rebates, etc., can be cast easily and are economical. Some of the artificial stones available are as follows:

CONCRETE BLOCK

These are cast at site in the construction of piers or cast in moulds for steps, window, sills, etc.

RANSOME STONE

These are prepared by mixing soda silicate with cement to provide decorative flooring. These are also known as chemical stones. These have compressive strength of about 32 N/mm^2

VICTORIA STONE

These are granite pieces with the surfaces hardened by keeping immersed in soda silicate for about two months.

BITUMINOUS STONE

Granite and diorite are impregnated with prepared or refined tar to form bituminous stone. These are used for providing noise, wear and dust resistant stone surfaces.

IMPERIAL STONE

Finely crushed granite is washed carefully and mixed with Portland cement. The mix is moulded in desired shape and then steam cured for 24 hours. The cured blocks are immersed in silicate tanks for three days. These stones are similar to Victoria stones.

ARTIFICIAL MARBLE

It can be either pre-cast or cast-in-situ. These are made from Portland gypsum cement and sand. In the precast variety, the cast-stone is removed after three days. On the fifth day of casting these are treated with a solution, liquid fluorite of magnesia. It is then washed and wrapped in paper for 24 hours and then once again treated with the liquid. After one month the stone is polished by rubbing emery over the surface with a linen rag ball dipped in mixture of lime water and silicate of potash and then the process is repeated without emery. It is used for external works. Cast-in-situ variety is made by laying the mix on canvas, in thickness about 1.5 mm more than the required thickness of the stone. The surface is rubbed over and the

airholes are filled with mix. Grinding is done by hand or machine. The surface is then rubbed with a polishing stone. Final rubbing is done with a ball of wool moistened with alum water dipped into a 1:3 mix of hartshorn powder and diatomite.

GARLIC STONE

This is produced by moulding a mixture of iron slag and Portland cement. These are used as flag stones, surface drains, etc.

2. Bricks

2.1 Introduction to bricks

Clay products are one of the most important classes of structural materials. The raw materials used in their manufacture are clay blended with quartz, sand, chamatte (refractory clay burned at 1000–1400°C and crushed), slag, sawdust and pulverized coal. Structural clay products or building ceramics* are basically fabricated by moulding, drying and burning a clay mass. Higher the bulk specific gravity, the stronger is the clay product. This rule does not hold good for vitrified products since the specific gravity of clay decreases as vitrification advances. Bulk specific gravity of clay brick ranges from 1.6 to 2.5. According to the method of manufacture and structure, bricks, tiles, pipes, terracotta, earthenwares, stonewares, porcelain, and majolica are well recognized and employed in building construction. Clay bricks have pleasing appearance, strength, and durability whereas clay tiles used for light-weight partition walls and floors possess high strength and resistance to fire. Clay pipes on account of their durability, strength, lightness, and cheapness are successfully used in sewers, drains and conduits.

2. Raw materials for brick manufacturing and properties of good brick making earth

For the preparation of bricks, clay or other suitable earth is moulded to the desired shape after subjecting it to several processes. After drying, it should not shrink and no crack should develop. The clay used for brick making consists mainly of silica and alumina mixed in such a proportion that the clay becomes plastic when water is added to it. It also consists of small proportions of lime, iron, manganese, sulphur, etc. The proportions of various ingredients are as follows:

Silica: It enables the brick to retain its shape and imparts durability, prevents shrinkage and warping. Excess of silica makes the brick 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.

Alumina: absorbs water and renders the clay plastic. If alumina is present in excess of the specified quantity, it produces cracks in brick on drying. Clays having exceedingly high alumina content are likely to be very refractory.

Lime: normally constitutes less than 10 per cent of clay. Lime in brick clay has the following effects: 1. Reduces the shrinkage on drying.

2. Causes silica in clay to melt on burning and thus helps to bind it.

3. In carbonated form, lime lowers the fusion point.

4. Excess of lime causes the brick to melt and the brick looses its shape.

5. Red bricks are obtained on burning at considerably high temperature (more than 800°C) and buff-burning bricks are made by increasing the lime content.

Magnesia: rarely exceeding 1 per cent, affects the colour and makes the brick yellow, in burning; it causes the clay to soften at slower rate than in most case is lime and reduces warping.

Iron: Iron oxide constituting less than 7 per cent of clay, imparts the following properties:

1. Gives red colour on burning when excess of oxygen is available and dark brown or even black colour when oxygen available is insufficient, however, excess of ferric oxide makes the brick dark blue.

2. Improves impermeability and durability.

3. Tends to lower the fusion point of the clay, especially if present as ferrous oxide.

4. Gives strength and hardness.

2.3 Manufacturing of bricks

Unsoiling: The soil used for making building bricks should be processed so as to be free of gravel, coarse sand (practical size more than 2 mm), lime and kankar particles, organic matter, etc. About 20 cm of the top layer of the earth, normally containing stones, pebbles, gravel, roots, etc., is removed after clearing the trees and vegetation.

Digging: After removing the top layer of the earth, proportions of additives such as fly ash, sandy loam, rice husk ash, stone dust, etc. should be spread over the plane ground surface on volume basis. The soil mass is then manually excavated, puddled, watered and left over for weathering and subsequent processing. The digging operation should be done before rains.

Weathering: Stones, gravels, pebbles, roots, etc. are removed from the dug earth and the soil is heaped on level ground in layers of 60–120 cm. The soil is left in heaps and exposed to weather for at least one month in cases where such weathering is considered necessary for the soil. This is done to develop homogeneity in the mass of soil, particularly if they are from different sources, and also to eliminate the impurities which get oxidized. Soluble salts in the clay would also be eroded by rain to some extent, which otherwise could have caused scumming at the time of burning of the bricks in the kiln. The soil should be turned over at least twice and it should be ensured that the entire soil is wet throughout the period of weathering. In order to keep it wet, water may be sprayed as often as necessary. The plasticity and strength of the clay are improved by exposing the clay to weather.

Blending: The earth is then mixed with sandy-earth and calcareous-earth in suitable proportions to modify the composition of soil. Moderate amount of water is mixed so as to obtain the right consistency for moulding. The mass is then mixed uniformly with spades. Addition of water to the soil at the dumps is necessary for the easy mixing and workability, but the addition of water should be controlled in such a way that it may not create a problem in moulding and drying. Excessive moisture content may affect the size and shape of the finished brick.

Tempering: Tempering consists of kneading the earth with feet so as to make the mass stiff and plastics (by plasticity, we mean the property which wet clay has of being permanently deformed without cracking). It should preferably be carried out by storing the soil in a cool place in layers of about 30 cm thickness for not less than 36 hours. This will ensure homogeneity in the mass of clay for subsequent processing. For manufacturing good brick, tempering is done in pug mills and the operation is called pugging. Pug mill consists of a conical iron tube. The mill is sunk 60 cm into the earth. A vertical shaft, with a number of horizontal arms fitted with knives, is provided at the centre of the tube. This central shaft is rotated with the help of bullocks yoked at the end of long arms. However, steam, diesel or electric power may be used for this purpose. Blended earth along with required water, is fed into the pug mill from the top. The knives cut through the clay and break all the clods or lump-

clays when the shaft rotates. The thoroughly pugged clay is then taken out from opening provided in the side near the bottom. The yield from a pug mill is about 1500 bricks.

2.3.1 Preparation of clay (Manual and Mechanically)

2.3.2 Moulding: Hand moulding and machine moulding brick table; drying of bricks,

It is a process of giving a required shape to the brick from the prepared brick earth. Moulding may be carried out by hand or by machines. The process of moulding of bricks may be the soft-mud (hand moulding), the stiff-mud (machine moulding) or the drypress process (moulding using maximum 10 per cent water and forming bricks at higher pressures). Fire-brick is made by the soft mud process. Roofing, floor and wall tiles are made by dry-press method. However, the stiff-mud process is used for making all the structural clay products.

Hand moulding: Hand moulding is further classified as ground moulding and table moulding.

Groud moulding: In this process, the ground is levelled and sand is sprinkled on it. The moulded bricks are left on the ground for drying. Such bricks do not have frog and the lower brick surface becomes too rough. To overcome these defects, moulding blocks or boards are used at the base of the mould. The process consists of shaping in hands a lump of well pugged earth, slightly more than that of the brick volume. It is then rolled into the sand and with a jerk it is dashed into the mould. The moulder then gives blows with his fists and presses the earth properly in the corners of the mould with his thumb. The surplus clay on the top surface is removed with a sharp edge metal plate called strike or with a thin wire stretched over the mould. After this the mould is given a gentle slope and is lifted leaving the brick on the ground to dry.

Table moulding: The bricks are moulded on stock boards nailed on the moulding table. Stock boards have the projection for forming the frog. The process of filling clay in the mould is the same as explained above. After this, a thin board called pallet is placed over the mould. The mould containing the brick is then smartly lifted off the stock board and inverted so that the moulded clay along with the mould rests on the pallet. The mould is then removed as explained before and the brick is carried to the drying site.

Machine moulding

Plastic method: The pugged, stiffer clay is forced through a rectangular opening of brick size by means of an auger. Clay comes out of the opening in the form of a bar. The bricks are cut from the bar by a frame consisting of several wires at a distance of brick size.

Dry-process method: The moist, powdered clay is fed into the mould on a mechanically operated press, where it is subjected to high pressure and the clay in the mould takes the shape of bricks. Such pressed bricks are more dense, smooth and uniform than ordinary bricks. These are burnt carefully as they are likely to crack.

Drying

Green bricks contain about 7–30% moisture depending upon the method of manufacture. The object of drying is to remove the moisture to control the shrinkage and save fuel and time

during burning. The drying shrinkage is dependent upon pore spaces within the clay and the mixing water. The addition of sand or ground burnt clay reduces shrinkage, increases porosity and facilities drying. The moisture content is brought down to about 3 per cent under exposed conditions within three to four days. Thus, the strength of the green bricks is increased and the bricks can be handled safely. Clay products can be dried in open air driers or in artificial driers. The artificial driers are of two types, the hot floor drier and the tunnel drier. In the former, heat is applied by a furnace placed at one end of the drier or by exhaust steam from the engine used to furnish power and is used for fire bricks, clay pipes and terracotta. Tunnel driers are heated by fuels underneath, by steam pipes, or by hot air from cooling kilns. They are more economical than floor driers. In artificial driers, temperature rarely exceeds 120°C. The time varies from one to three days. In developing countries, bricks are normally dried in natural open air driers. They are stacked on raised ground and are protected from bad weather and direct sunlight. A gap of about 1.0 m is left in the adjacent layers of the stacks so as to allow free movement for the workers.

2.4 Burning of bricks: Bull's Trench Kiln, Hoffman's Kiln and Zig- Zag Kiln (only line diagram of kilns)

The burning of clay may be divided into three main stages.

Dehydration: This is also known as water smoking stage. During dehydration, (1) the water which has been retained in the pores of the clay after drying is driven off and the clay loses its plasticity, (2) some of the carbonaceous matter is burnt, (3) a portion of sulphur is distilled from pyrites. (4) hydrous minerals like ferric hydroxide are dehydrated, and (5) the carbonate minerals are more or less decarbonated. Too rapid heating causes cracking or bursting of the bricks. On the other hand, if alkali is contained in the clay or sulphur is present in large amount in the coal, too slow heating of clay produces a scum on the surface of the bricks.

Oxidation period: During the oxidation period, (1) remainder of carbon is eliminated and, (2) the ferrous iron is oxidized to the ferric form. The removal of sulphur is completed only after the carbon has been eliminated. Sulphur on account of its affinity for oxygen, also holds back the oxidation of iron. Consequently, in order to avoid black or spongy cores, oxidation must proceed at such a rate which will allow these changes to occur before the heat becomes sufficient to soften the clay and close its pore. Sand is often added to the raw clay to produce a more open structure and thus provide escape of gases generated in burning.

Vitrification: To convert the mass into glass like substance — the temperature ranges from 900–1100°C for low melting clay and 1000–1250°C for high melting clay. Great care is required in cooling the bricks below the cherry red heat in order to avoid checking and cracking. Vitrification period may further be divided into (a) incipient vitrification, at which the clay has softened sufficiently to cause adherence but not enough to close the pores or cause loss of space—on cooling the material cannot be scratched by the knife; (b) complete vitrification, more or less well-marked by maximum shrinkage; (c) viscous vitrification, produced by a further increase in temperature which results in a soft molten mass, a gradual loss in shape, and a glassy structure after cooling. Generally, clay products are vitrified to the point of viscosity. However, paving bricks are burnt to the stage of complete vitrification to achieve maximum hardness as well as toughness. Burning of bricks is done in a clamp or kiln. A clamp is a temporary structure whereas kiln is a permanent one.

Burning in clamp: The bricks and fuel are placed in alternate layers. The amount of fuel is reduced successively in the top layers. Each brick tier consists of 4–5 layers of bricks. Some space is left between bricks for free circulation of hot gasses. After 30 per cent loading of the

clamp, the fuel in the lowest layer is fired and the remaining loading of bricks and fuel is carried out hurriedly. The top and sides of the clamp are plastered with mud. Then a coat of cowdung is given, which prevents the escape of heat. The production of bricks is 2–3 lacs and the process is completed in six months. This process yields about 60 per cent first class bricks.

Kiln burning: The kiln used for burning bricks may be underground, e.g., Bull's trench kiln or overground, e.g., Hoffman's kiln. These may be rectangular, circular, or oval in shape. When the process of burning bricks is continuous, the kiln is known as continuous kiln, e.g., Bull's trench and Hoffman's kilns. On the other hand, if the process of burning bricks is discontinuous, the kiln is known as intermittent kiln.

Intermittent kiln: The example of this type of an over ground, rectangular kiln. After loading the kiln, it is fired, cooled and unloaded and then the next loading is done. Since the walls and sides get cooled during reloading and are to be heated again during next firing, there is wastage of fuel.

Continuous kiln: The examples of continuous kiln are Hoffman's kiln and Bull's trench kiln. In a continuous kiln, bricks are stacked in various chambers wherein the bricks undergo different treatments at the same time. When the bricks in one of the chambers is fired, the bricks in the next set of chambers are dried and preheated while bricks in the other set of chambers are loaded and in the last are cooled.

2.5 Sun dried bricks, Traditional bricks, Refractory bricks, Flyash bricks, Hollow bricks,

Mud bricks, dried in the sun, are the favorite building material of serbia. These bricks are much the same as the abode used in Arizona and New Mexico. Workmen simply dig a small hole in the clay and in the water, straw is worked into the mud by stamping it with bare feet. After the mud is tramped to the proper degree of firmness it is shoveled into open moulds and packed down. Then the moulds are lifted off and these bricks are allowed to bake in the sun until thoroughly dry. In a country of much rain these bricks would be useless as the buildings would quickly melt. The new hospital in Skoplje, erected by the government for the Red Cross of occupy was constructed almost entirely of these sun dried bricks with both the interior and exterior covered with a coating of cement of white wash. Sun dried are types of bricks used in construction that are less durable and used for temporary structure making. They are not that much strong, and they have less water and fire resistance.

Traditionally, the term bricks referred to a unit composed of clay, but it is now used to denote rectangular units of clay-bearing soil, sand and lime or concrete materials. Bricks can be joined together using mortar, adhesives, or by interlocking them. If bricks had not been discovered, it would have been difficult to imagine such big buildings.

Traditional bricks are those which have not been standardized in size. The dimensions of traditional bricks vary from place to place. The length varies from 20 to 25 cm, with varies from 10 to 13 cm and thickness varies from 5 cm to 7.5 cm.

2.6 Size and weight of standard brick

2.7 Classification and specifications of bricks as per BIS: 1077

Clay bricks are classified as first class, second class, third class and fourth class based on their physical and mechanical properties.

First class bricks

1. These are thoroughly burnt and are of deep red, cherry or copper colour.

2. The surface should be smooth and rectangular, with parallel, sharp and straight edges and square corners.

3. These should be free from flaws, cracks and stones.

4. These should have uniform texture.

5. No impression should be left on the brick when a scratch is made by a finger nail.

6. The fractured surface of the brick should not show lumps of lime.

7. A metallic or ringing sound should come when two bricks are struck against each other.

8. Water absorption should be 12–15% of its dry weight when immersed in cold water for 24 hours.

9. The crushing strength of the brick should not be less than 10 N/mm^2 . This limit varies with different Government organizations around the country.

Uses: First class bricks are recommended for pointing, exposed face work in masonry structures, flooring, and reinforced brick work.

Second class bricks

1. Small cracks and distortions are permitted.

2. A little higher water absorption of about 16–20% of its dry weight is allowed.

3. The crushing strength should not be less than 7.0 N/mm^2

Uses: Second class bricks are recommended for all important or unimportant hidden masonry works and centering of reinforced brick and reinforced cement concrete (RCC) structures.

Third class bricks are underburnt. They are soft and light-coloured producing a dull sound when struck against each other. Water absorption is about 25 per cent of dry weight.

Uses : It is used for building temporary structures.

Fourth class bricks are overburnt and badly distorted in shape and size and are brittle in nature. Uses: The ballast of such bricks is used for foundation and floors in lime concrete and road metal.

2.8 Stacking of bricks and tiles at site

1. Bricks shall be stacked in regular tiers as and when they are unloaded to minimize breakage and defacement. These shall not be dumped at site.

2. In the case of bricks made from clays containing lime KANKAR, the bricks in stack should be thoroughly soaked in water (docked) to prevent line bursting.

3. Bricks stack shall be placed close to the site of work so that least effort is required to unload and transport the bricks again by loading on pallets or in barrows. Building bricks shall be loaded or unloaded a pair at a time unless pelletized. Unloading of building bricks or handling in any other way likely to damage the corners or edges or other parts of bricks shall not be permitted.

4. Bricks shall be stacked on dry firm ground. For proper inspection of quality and ease in counting, the stacks shall be 50 bricks long, 10 bricks high and not more than 4 bricks in width, the bricks being placed on edge, two at a time along the width of the stack. Clear distance between adjacent stacks shall not be less than 0.8 m. Bricks of each truck load shall be put in one stack.

5. Bricks of different types, such as, clay bricks, clay fly ash bricks, fly ash lime bricks sand lime (calcium silicate) bricks shall be stacked separately. Bricks of different classifications from strength consideration and size consideration (such as, conventional and modular) shall be stacked separately.

All bricks of different types such as, solid, hollow and perforated shall be stacked separately.

UNIT II

3. Tiles

3.1 Brick tiles and their uses

It is also called thin brick or brick veneer. It can be installed any place a that stone veneer or siding is used, such as home exteriors, floors, patios, fireplaces, or walls. Brick tile is made either from salvaged brick shaved into thin slices, or from new clay that is molded into tiles. Brick tile is becoming increasingly popular in the US because it is sturdy, fireproof, and easy to maintain, as well as having the classic appearance of real brick at a fraction of the cost. Most brick homes built in the last 40 years are actually sided with brick tile rather than built with solid brick, because solid bricks are expensive and work-intensive to build with. A house with brick laid in a uniformly horizontal pattern is not built with real brick, because solid brick walls have rows where the bricks are laid with the ends facing outwards in order to maintain structural integrity. However, brick tile has some of solid brick's advantages. It does not need to be painted or stained, and it helps insulate the home and protect it from fire, weather, and water damage.

USES OF BRICK TILES

Kitchens: Use smooth brick slips to create a warm and inviting environment in your kitchen.

Bathrooms: Accent a bathroom wall with brick tiles or outline a door frame.

Living Room: Add an interior exposed brick feature wall to enhance the character and warmth of your living room.

Outside: Use brick slips to protect the outside portions of your house. They can be used to patch chimneys, fire pits and exterior walls while improving visual appeal.

3.2 Ceramic tiles and their uses

Ceramic tile is a type of tile that is typically made from red or white clay. Ceramic tile can be used in several areas throughout the house. Ceramic tile is made of clay that has been fired in a kiln. Ceramic tile is similar to porcelain tile, and while some companies use the terms interchangeably, they are actually very different. Ceramic tile is not as dense and has a higher absorption rate. This means that it is not frost-proof, and it may chip or damage more easily than porcelain tile. Despite these differences, ceramic tile is a very popular choice for floors, counter-tops and walls. The tile is coated with a special glaze that protects and seals it. This keeps the tile from absorbing stains while improving the durability of each piece. The glaze is also what gives ceramic tile its color and pattern. Several ceramic tile designs and sizes are available.

USES OF CERAMICS

Ceramic tiles are a mixture of clays and other natural materials, such as sand, quartz and water. They are primarily used in houses, restaurants, offices, shops, and so on, as bathroom wall and kitchen floor surfaces. They are easy to fit, easy to clean, easy to maintain and are available at reasonable prices.

3.3 Vitrified tiles and their uses

Vitrified tiles are almost similar to ceramic tiles; the only difference is that it is better than that. It is a type of tile that has been through the process of vitrification which avails it really low

porosity making it very lower water absorption rate. Vitrified tiles are very strong and hard and not to forget it's one of the best qualities. Coming to the comparative point of view, highly qualitative vitrified tiles have a competitive edge over natural granite or marble tiles making it a really commendable choice for the residential places these days. Well, however good and beneficial any of the things are, nothing can be totally perfect. Everything has some of the glittering parts along with having their bad ones as well. Let us explore both the sides to make an informed decision for your home flooring.

USES OF VITRIFIED TILES

Since Vitrified tiles can withstand pressure, they can be used in both indoors and outdoors, on rooftops, in the garden and as your kitchen's backsplash. Vitrified flooring tiles can also be used as a bathroom floor.

3.4 PVC Tiles and uses,

PVC tile is actually just another name for vinyl tile. And just like vinyl tiles, they combine exceptional durability and practicality with the authentic beauty of materials like stone and concrete. There is a wide choice of PVC (or vinyl) tile floors in a range of styles, colours, and finishes. They also come in flexible and rigid variants, making PVC tiles the perfect floor for any project. PVC tile is actually just another name for vinyl tile. And just like vinyl tiles, they combine exceptional durability and practicality with the authentic beauty of materials like stone and concrete. There is a wide choice of PVC (or vinyl) tile floors in a range of styles, colours, and finishes. They also come in flexible and rigid variants, making PVC tiles the perfect floor for any project.

USES OF PVC TILES

Rubber tiles also are known as PVC tiles are manufactured using high compact injection pressure and are used for flooring of industrial areas**.** There are many uses that rubber tiles can be used for. Will dwell on 20 most uses of rubber tiles.

INDUSTRIAL WAREHOUSING FLOORING

Warehouse Flooring usually involving covering a very large area and the best and cheapest way of flooring is to use rubber tiles whilst at the same time fortifying the floor. Usually, warehouses are areas where forklifts and have a lot of moving objects such as **pallet jacks and even small trucks.** Rubber Tiles are **the most useful floor tiling procedure**. Flooring using the normal ceramic tiles in warehouses is usually a waste of resources and exposes the tiles from breaking, hence **using rubber tiles** in this regard is recommended.

HOME GARAGE FLOORING

Home garages are usually smaller in sizes and normally are built to accommodate one or two vehicles. **The best flooring tiles for the garages** are **interlocking rubber tiles.** These are needed to withstand the high traction and force that is usually exerted by moving wheels. Because of the small area needed to be covered by the tiles, an individual can do color styles without increasing the cost too much. **Rubber tiles** would act as a cushioning factor on the original floor and prevent damages to it.

COMMERCIAL GARAGE FLOORING

Commercial garages are those businesses that are involved **in repairs and maintenance of vehicles**, tire repairs and **any heavy-duty related floors for vehicles.** On these floors the thicker **the interlocking rubber tiles** the stronger the floor becomes. It is recommended to

apply adhesives when doing the installation for commercial use in order to secure it better. **Rubber tiles** are known for being so durable that in some light duty areas, they carry a lifetime warranty. Normally the garage is high traffic areas, it takes **between 20 to 30 years** in order to do a new installation.

GYM RUBBER FLOORS

Virtually all gyms have rubber tile flooring on which **the heavy gym equipment** is secured. The rubber helps secure equipment because of the extra grip it offers better than any other floor. **Rubber flooring has high non-slip properties** than any other flooring thus giving it more preference in this industry than any other floor type. In Gyms grip for users is paramount importance, hence giving the floor that property **makes the floor more preferred.**

HEALTH CLUB FLOORS

Health club floors such as yoga clubs, karate clubs, self-defense clubs prefer their flooring to be done using **rubber mats or rubber rolls.**

STORAGE FACILITY FLOORS

Storage facility floors are usually installed with **rubber mats** for the simple reasons that **rubber flooring is cheaper and very durable.**

Rubber tiles are also easy to uninstall than all other **conventional types of flooring.**

3.5 Paver blocks, interlocking tiles

Paver block or Paving block is one of the most popular flexible surface treatment options for exterior pavement applications. These blocks are aesthetically pleasing, comfortable to walk on, extremely durable, and easy to maintain.

Types of Paver Blocks

There are two types of paver blocks

1.Concrete Paving Block

Concrete blocks are mass manufactured to standard sizes. Hence, they can be easily interchanged. A typical concrete block has two surfaces - one is smooth, and the other is a rough surface. The concrete paving blocks are most suitable for heavy-duty applications, able to support substantial loads and resist shearing and braking forces. The concrete blocks come in various colors. The colors typically come from metallic oxides. However, there is a possibility of these colors to fade away. Hence one needs to be very careful while choosing the color of the block. Concrete paving blocks are the most preferred choice for laying of pavements, driveways, etc

2. Clay Paving Blocks

Clay paving blocks are also called bricks or cobbles. These blocks are generally available as typical, rectangular brick-shaped. Although custom shapes can be made for specific projects. Unlike the concrete paving blocks, either side of clay paving blocks can be used. So both sides are interchangeable. Clay blocks are available in natural color only; hence the possibility of color fading is not there in these blocks. These blocks are mostly used for walls or pillars.

INTERLOCKING TILES

Interlocking tiles are tiles that interlock each other to form a floating floor. This means that the tiles are not glued down to the main floor. They are interlocked using an interlocking system over a flat surface and are held by the gravity of their own weight.

USES OF INTERLOCKING TILES

Entrance:

A great way to enhance the look of your entryway and make a lasting first impression is by using interlocking tiles at the entrance.

Steps:

Interlocking tiles also look great on steps, making them easy to install and maintain too.

Flower beds:

Adding interlocking tiles to flower beds enhances the look and functionality of the space. It can make the flower bed an attractive spot in your home.

Walls:

Using interlocking tiles in retaining walls is a great way to that extra appeal to your homes. The good thing about this is that you get to be creative and use the tiles as per your preference.

Driveway:

Interlocking tiles in the driveway not only create a captivating driveway but also adds value to your home. It is a great update from the conventional paved driveway and adds a beautiful aesthetic.

4. Cement

4.1 Introduction, raw materials, flow diagram of manufacturing of cement

Cement is the binding material used to bind fine aggreagtes and coarse aggregates. This binding property inculcate in it because of its fineness from ither building materials.

It is made up of naturally available cementing material or proortionate combination of calcareous (containing Calcium and its compunds- lime, chalk etc.) and argillaceous (conatining silica- clay etc.) materials.

Cements are widely classified into two types: (i) hydraulic cement- which sets in presence of water. eg.- Portland Cement, (ii) non-hydraulic cement- which does not sets or hardens in water. eg.- Plaster of Paris. Most commonly used cement is hydraulic cement.

Raw materials

The table below shows the ingredients required for the preparation of cement along with their proportions.

Ingredients	**Chemical formula**	**Composition (%)**
Lime	CaO	62-67
Silica	SiO_2	17-25
Alumina	Al_2O_3	3-8
Calcium sulphate	$CaSO_4$	3-4
Iron oxide	Fe_2O_3	3-4
Magnesia	MgO	2-3
Sulphur	S	2-3
Alkalies	Na_2O, K_2O	0.2-1

Functions

Lime- It imparts strength and soundenss to the cement. If it is in excess it makes the ecemnt unsound causes it to expand and finally disintegrate. If it is deficit it reduces the strength of the cement and causes it sets quickly.

Silica- it is also responsible for strength of the cement. Excess of it increases cement strength and setting time.

Alumina- It imparts quick setting property to the cement. If it is in excess it weakens the cement.

Calcium Sulphate- It is generally added in the form of Gypsum. It helps in increasing the initial setting time of cement.

Iron Oxide- It imparts strength, hardness and color to the cement.

Magnesia- It is also responsible for strength, hardness and color of the cement. Excess of it makes the cement unsound.

Sulphur- It makes cement sound as excess of it is responsible for the volcume changes in cement.

Alkali- These are residues and if in excess cause efflorescence and cracking.

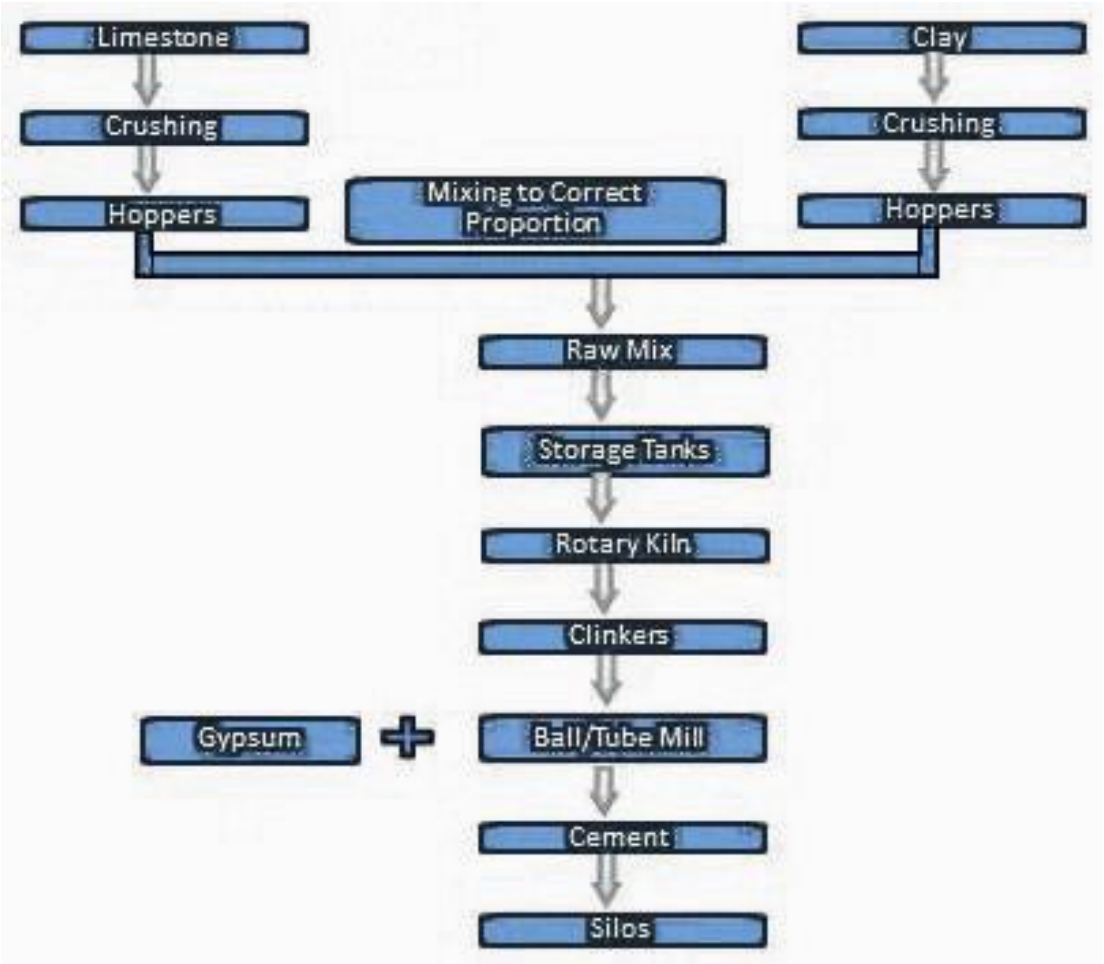
Flow diagram for manufacturing of cement

Cement can be manufactured from either of the two processes-

(i) Dry process

(ii) Wet Process

Dry process



Various stages of dry process of manufacturing cement are described below:

1. Crushing & Storage

- The limestone and clay are ground separately to a size of about 25 mm in crushers.
- Then it is pulverized into fine powder in ball mills and tube mills.
- The crushing and pulverizing process is carried out separately for each material.
- After grinding, each of the materials is stored in hoppers.

2. Mixing & Storage

- The raw materials are then mixed in correct proportions in dry powdered form with the help of compressed air.
- This finely ground powder of the raw materials is called raw mix.
- Raw mix is stored in storage tanks.

3. Burning & Cooling

Calcination takes place in a rotary kiln and the final product formed is called clinkers.

- The raw mix is then fed into the rotary kiln, made up of steel tubes.
- The raw mix is introduced at the upper end of the kiln, which is called the dry zone.
- Through the lower end of the kiln, hot gases and flames are passed into the kiln.
- The water from the water slurry evaporates in the dry zone itself.
- As the raw mix descends the rotary kiln, the temperature keeps on rising. The absorption of moisture decreases the setting of cement.
- Carbon dioxide evaporates in the next section forming small nodules. The absorption of CO_2 increases the setting of cement.
- Nodules then reach the lowest part of the kiln – the burning zone. Here the temperature is about 1500-1700 ° C. Calcination takes place in the burning zone.
- Nodules are converted into hard stones called clinkers in the burning zone.
- These clinkers are about 5-10 mm in size and are very hot when they come out of the rotary kiln.
- A small rotary kiln for cooling is laid in the opposite direction to cool the clinkers rapidly so that metastable compounds and their solid solutions are preserved. The cooling of clinkers is done in controlled conditions.
- Cooled clinkers are then stored.

4. Grinding

- Clinkers are ground in ball mills and tube mills after controlled cooling.
- The cooling rate of clinkers affects the strength-gaining properties of cement.
- About 3-5 % gypsum is added during grinding to the cooled clinkers to prevent flash set.
- Closed-circuit grinding is done in tube mills. A cyclonic separator ensures proper particle size distribution.
- After grinding the cement into a fine powder, it is stored in silos.
- With the help of an automatic machine, the cement is then weighed and packed in bags of 50 kg.
- The volume of 1 cement bag, i.e., 50 kg of cement has a volume of 0.035 m^3.

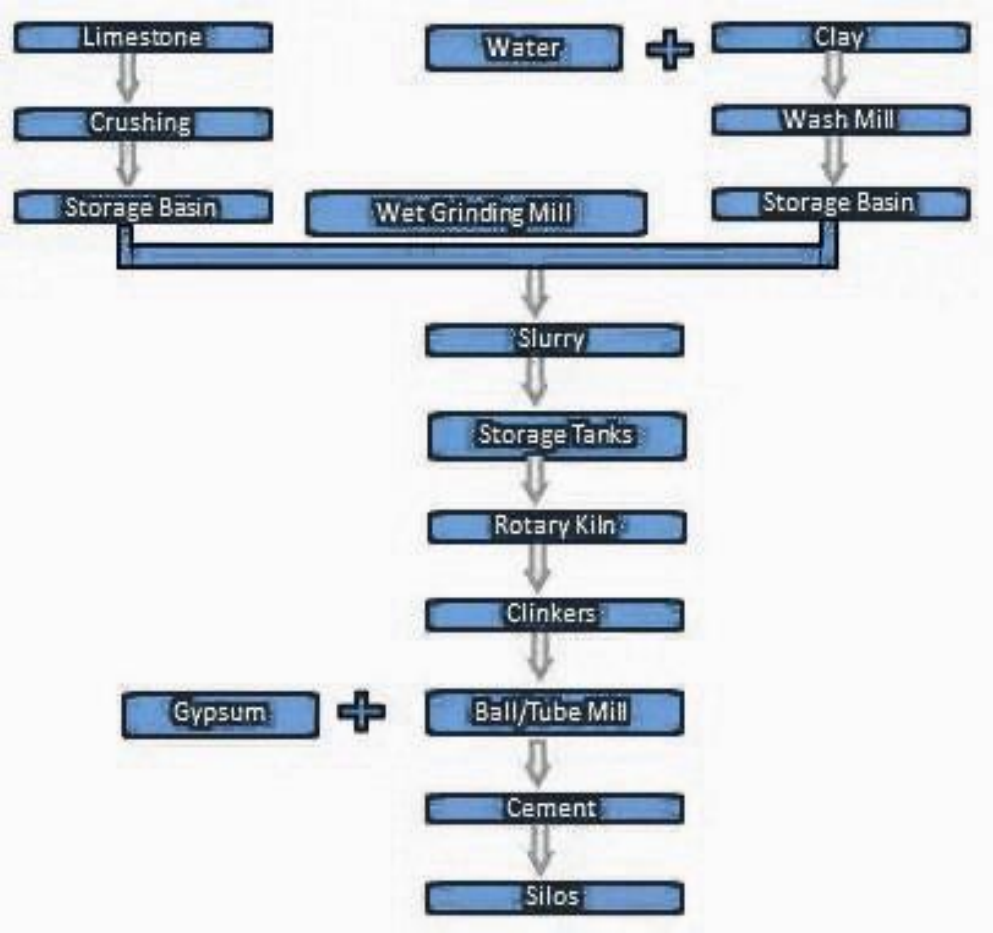
Advantages of Dry Process of Cement Manufacture

- Labour productivity is increased
- Low capital is required
- Fuel consumption is reduced
- Modern-day technology can help with the proper mixing of materials in dry form.

Disadvantages of Dry Process of Cement Manufacture

- The dry process of cement manufacture is a slow process
- It is costly
- The cement produced is of inferior quality to that produced by the wet process

Wet Process



Various steps of manufacture of cement through the wet process are described below:

Crushing & Storage

- Limestone and other calcareous materials are crushed and stored in silos or storage tanks.
- Clay and other argillaceous materials are mixed with water thoroughly in a wash mill and stored in basins.
- Crushed limestone from the silo and wet clay from the basin is then made to fall in a channel in specified proportions.
- The channels carry these materials to the grinding mill where they are brought in intimate contact to form the slurry. (Grinding is done in a tube mill or ball mill)
- The slurry is fed into the correcting basin where continuous stirring is done and chemical composition is adjusted. Constant agitation ensures the slurry remains in a homogenous mix.
- The slurry is then stored in storage tanks under constant agitation and then fed into the rotary kiln.

Burning, cooling & Grinding is done in the same manner as done in the dry process of cement manufacture.

Testing of Cement

Testing of cement is carried out in order to check its engineering performance when used for construction. Testing of cement can be done by following methods:

(i) Field tests
(ii) Laboratory tests

Field Test

These are the tests which are done at field. Tests done under field tests are Physical Property Test and strength test.

(a) **Physical property test:** some points to be considered under the test are:

- The given sample of cement under test should posses uniform grey color.
- The given sample of cement should be free from presence of air lumps.
- The given sample of cement should feel smooth when rub in between fin gers.
- A thin paste of cement should feel sticky in between the fingers.
- The given sample of cement when thrown in the bucket of water should sink and not float over the water surface.
- The given sample of cement should be cool not warm.
- A thick plaster of cement prepared on the glass plate when immersed in water for 24 hours should set, it does not show any sign of crack.

(b) Strength Test:

- Prepare a block of 25x14x200 mm^2 of the given sample of cement and immersed in water for 7 days.
- The sample is removed from the water and placed over the spports having the spacing of 150mm.
- The sample is then subjected to centre point loading of 340N. It must not show any sign of failure under the given loading.

Lab tests

(a) **Fineness test:** Fineness refers to the particle size of the cement and is typically measured by the surface area of the cement particles per unit weight. The finer the cement particles, the greater the surface area, and the higher the reactivity of the cement. Fineness of the cement can be tested by any of the following methods.

1. Sieve test: in this method 100 gm of cement sample is palced over IS sieve no. 9 (90 micron) and sieving is done continuously for 15 minutes along with the beaking of air set lumps. For OPC, weight of residue left over the sieve must not be greater than 10%. To determine the fineness of cement by using a 90 µm IS sieve as per IS: 4031 (Part 1) – 1996.
2. Air permeability test: the principle of this test is based upon relation between the flow of air through the bed of cement particles and surface area of the particles forming the cement bed. Generally, Blaine's Air permeability Apparatus is used. The fineness of the cement in this case is expressed in terms

of parameter secific surface area i.e. surface area per unit mass. For OPC, specific area must not be less than 2250 cm^2/gm.

(b) Specific Gravity Test: This test is performed in order to find the specific gravity of the cement. In order to perform this test LeChatlier's Flask is placed inside the constant temperature water bath. A non-polarising liquid like kerosene or naphthalene is filled in the flask and level of the liquid in the flak is noted (X). 64 gm of the sample of cement is to tested is then added in the flask and is rolled continuously to permit the escape of air through it. The final level of the liquid in the flask is again noted(Y) which is further used to find the specific gravity of cement.

LeChatelier's Flask

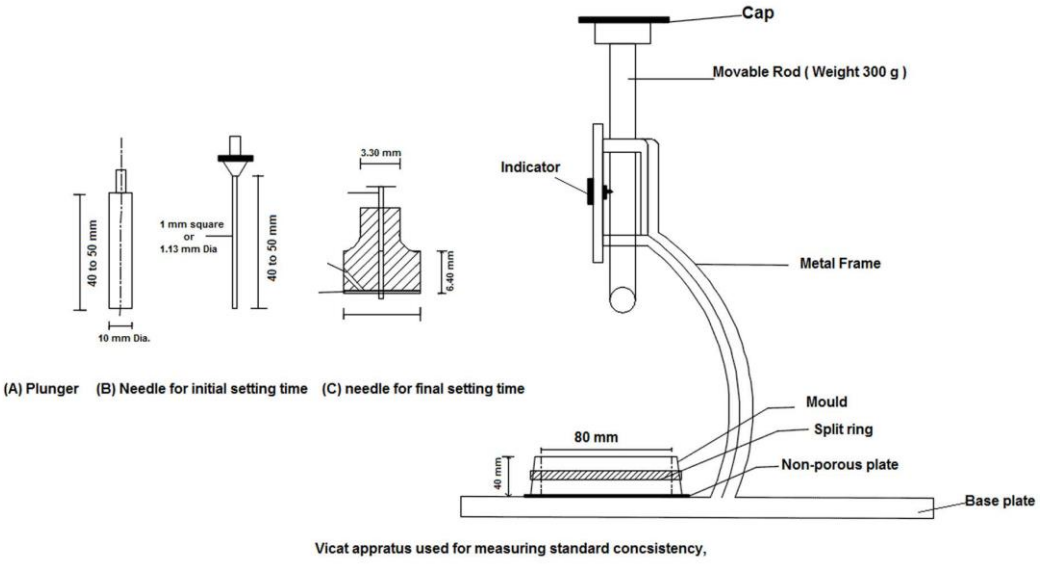
(c) Consistency test: In order to find initial setting time, final setting time Strength & soundness of cement a parameter refered as "standard consistency" is required. Standard consistency is defined as the consistency of cement paste which permits the vicat's plunger of dia 10mm & 50mm height to penetrate into the mould upto the depth of 33-35 mm from the top and 5-7mm from the bottom. The purpose of this test is to find the water content which is required to prepare the cement paste of standard consistency. In order to perform this test 500 gm of cement is taken and guaged with 24% of w/c in the first trial and paste formed is filled in the mould. The depth of penetration of Plunger in the mould is noted. The test is repeated at different water contents upto an extent penetration of 33-35mm from the top is obeserved. This water content is noted as 'p'. This test is performed at the temperature of 27±2℃ and humidity of 90%.

(d) Setting Time Test:

Setting time of cement further classified as: (i) Initial setting time (ii) final setting time

Initial setting time, which is measured with water into the cement upto the time it looses its viscosity. And the final setting is measured from the instant water added into cement upto the time it completely looses its plasticity and attain sufficient firmness.In order to do this test, 500 gm of cement is guaged with 0.85P and the cement paste formed is

filled in the mould. Initial setting time is referred as the time at which square needle of size 1 mm Penetrates into the mould upto the depth of 33-35mm from the top and final setting time is referred as the time in which needle at the centre of annular collar to make the impression into the mould but annular collar fail to do so. For opc, initial setting time is 30 min and final setting time is 600 min.



Vicat appratus used for measuring standard concsistency,

(e) Strength test:

i) **Compressive strength test**: This test is performed in order to find the compressive Strength of cement. In order to perform this test mortar of cement and Standard sand (Ennore sand) is prepared in the proportion of (1:3) (Generally 185 gm cement, 555 gm of sand is taken) and water in the propotion of p/4+3% by the weight of water is added in it. The paste formed is filled in the cubical mould of area 500 mm² (size 70.6 mm). The sample is immersed in water for sufficient duration. At a particular age of testing sample is remove from the water and is tested for its compressive strength subjected it to a uniform compressive loading of 35 N/mm²/min up to failure in Universal Testing Machine. An avg of 3 results having max" deviation of ±15% is considered as compressive strength.

ii) **Tensile strength test**: This test is performed in order to find the tensile Strength of the cement. In order perform this test, cement-sand mortar is prepared same as above with only change that water added in this case is p/5+2.5% by weight of mortar. The paste formed is filled in the standard briquitte and is subjected to uniform tensile loading of 3.5N/mm^2/min upto failure. An avg of 12 results is taken as tensile strength in this case.

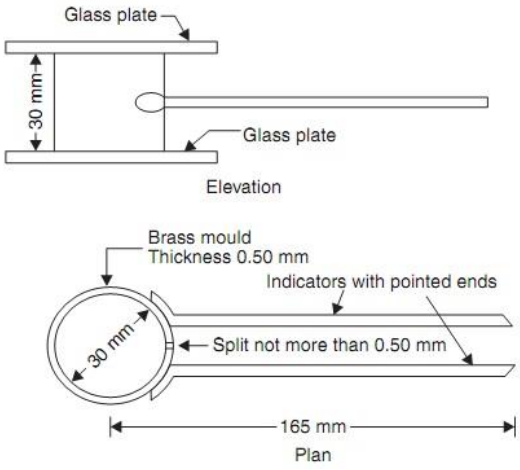
(f) Soundness test: Soundness test of cement is done to ensure that cement doesn't show any expansion after hardening and to find out the uncombined lime in cement (excess lime). In simple words, this test is conducted to check "unsoundness of cement".

As per **IS 4031 – Part 3 – 1988** Soundness of cement is calculated by using **Lechatelier's apparatus.** It consists of a small split cylinder forming a mould having dimensions of internal dia 30mm and height 30mm. On either side of the split cylinder, two parallel indicating arms with pointed ends of length 165mm is attached. Remember, Lechatlier mould is a split cylinder (opened Cylinder).Indicator arms determine the expansion of cement.

Procedure: unsoundenss due to lime is determined by LeChatelier's apparatus

1. Before Performing the test, calculate the standard consistency of cement to find out the water required to obtain the normal consistency(P).
2. Now add 0.78 times of water to the cement to give a paste of standard consistency (0.78P).
3. Lightly apply oil to the Lechatelier mould and place it on a glass plate.
4. Now pour the cement paste into mould and close the mould using lightly oiled glass plate and to avoid misplacement place a weight on it.
5. Then, submerge the whole assembly for 24Hrs in water bath at a temperature of 27^0C
6. Remove the entire apparatus from water and then calculate the distance separating two indicator points using measuring scale and note it as **L1.**
7. Again submerge the whole assembly in a water bath at a temperature of boiling point for 3hours.
8. After completion of 3 hours remove the assembly from the bath and measure the distance between two indicator points and note it as **L2.**

A good cement (OPC, PPC, Rapid hardeneing etc) should have not more than below expansion limits.



LeChatelier's Apparatus

The above test is conducted when there is unsoundenss due to lime. If there is unsoundness due to magnesia then autoclave test is performed.

Autoclave test: This test is sensitve to both lime and magnesia. In order to perform this test block of 25x25x282 mm^3 is prepared from the given sample of cement and is pasted inside

the autocleve steam pressure at such a rate that guage pressure of 21kg/cm^2 is attained within one hour and it is maintained for next 3 hours and then sample is removed from autoclave and is tested for its size. For OPC, increase in size for any time must not exceed 0.8%.

4.2 Various types of cements, their uses and testing: Ordinary Portland cement, rapid hardening cement, White cement, Portland pozzolana cement

- Ordinary Portland cement
- Rapid hardening cement
- White cement
- Portland pozzolana cement
- Quick setting cement
- Low heat cement
- Sulphate resisting cement
- High alumina cement

Ordinary Portland cement

Cement obtained from the wet or dry process is ordinary portland cement. Based on the compressive strength of cement obtained after 28 days it is further classified into three grades: OPC 33, OPC 43 and OPC 53 grade cement. Their respective IS Codes are: **IS 269** : 1989, **IS 8112**: 1989 and **IS 12269** : 1987. Initial setting time- not less than 30 minutes, final setting time- not more than 600 minutes. Compressive strength of OPC 33 grade cement is 33Mpa, OPC 43 grade cement is 43Mpa and OPC 53 grade cement is 53Mpa.

Rapid Hardening Cement (IS 8041)

It is the type of cement which attains higher rate of ain of strength than OPC and must not be confused with quick setting cement. The strength of cement obtained at the age of 3 days is equal to that of OPC at the age of 7 days. The cement is produced by fine grinding of cement clinkers and increasing the proportion of C_3S. RHC finds its application in cold weather concreting, pavement construction, pre-fabricated structures, where formwork is to be re-used for speedy construction. Initial setting time- 30 minutes, final setting time- 10 hours.

Portland Pozzolana Cement (IS 1489 Part-1)

This cement is obtained by inter-grinding cement clinkers with 10-15% pozzolanic material. Pozzolanic material is essentialy made of silica and alumina compunds which in itself does not posses any binding property but when finely grinded reacts with the lime realeased during hydration process in the cement. In the presence of water, lead to the formation of cementaceous property. Eg. Slag, fly-ash, rice-husk.

This cement offers higher resistance against attack of sulphur and chloride, higher water tightness, low cost, low heat of hydration, slower rate of gain of strength, higher resistance against volume changes.

Quick Setting Cement

It is the type of cement which looses its plasticity comparatively faster than OPC but does not attain early strength. The cement is produced by increasing the proportion of gypsum. This

cement finds its application in underwater concreting, grouting operations. Initial setting time- 5 minutes, final seting time- 30 minutes.

White Cement

It is manufactured from pure white chalk and clay free from iron oxide. Greyish colour of cement is due to iron oxide. So, the iron oxide is reduced and limited below 1 percent. These cements have same properties as that of ordinary Portland cement and are non-staining because of low amount of soluble alkalis. These cements are used for making terrazzo flooring, face plaster of walls (stucco), ornamental works, and casting stones. (**IS: 8042)**

4.3 Properties of cement

- Cement provides good strength to masonary.
- It posesses good plasticity.
- Cement is easily workable.
- Initial setting time of OPC should not be more than 30 minutes.
- Final setting time of cement should not be less than 600 minutes (10 hours).
- OPC is resistant to fire, water upto some extent.

4.4 Storage of Cement at site

Portland cement is kept in bags of 50 kgs capacity for local use. These are stored for short period of time in air tight room avaiding moisture and dampnes, placed some distance from the walls and at some height from floors. The stack should be covered with suitable coverings to avoid circulation of air through the stack. Not more than 10 bags should be stacked one over another.

UNIT III

5. Timber and Wood Based Products

Timber is one of the most useful and important material for constructions. Selecting timber is not an easy task, because timber has different types out of which selecting the right material is an important key. Timber is an expensive material to be incorporated in a building for different purpose therefore it should necessarily be strong, tough, and durable. Timber doors or windows etc. contribute a lot in the beautification and overall look of interiors. Timber is used in doors, windows, cabinet, cupboards, shelves, tables, and railings etc. Timber is also popularly used in the form of plywood & raw wood. Products like ply blocks and ply boards. Heavy patterned doors and windows are made of solid wood/Timber to provide the strength, toughness, and durability.

Type of timber to be used for right purpose is important because if timber used in construction is of low quality, then this may need replacement. While selecting timber one should consider its quality aspect as timber must be free from decay like rotten, fungi and termite.

5.1 Identification and uses of different types of timber

There are multiple ways of Timber identification, which work best when used combinedly.

5.1.1. Identifying Wood Based on Solidity

Solidity is the characteristic of how solid the lumber is. Before we begin to identify the wood species, it is important to first confirm that it is solid wood or natural wood, and not manufactured by men. Here are some ways to do that:

• The end grain of man-made or manufactured lumber is easily distinguishable from the end grain of natural lumber.

• Real wood has growth rings clearly visible on freshly sawn surfaces.

• Veneered wood usually has repeating grain patterns.

• Check if it is plastic painted or printed to give a wood-like appearance.

5.1.2. Timber Identification Based on Colour

Another quick and easy way of lumber identification is through its colour and appearance. Here is how.

• Natural timber colour vs stained: First, verify whether the colour on the wood you are trying to identify is natural or not.

• Weathered wood: Mostly, wood gets darker with age. So, if you are trying to identify an aged/old wood, chances are the colour would be darker (or occasionally lighter) than the original lumber colour. The best way to confirm this is by sanding a corner of the wood item to unveil its original colour.

5.1.3. Identify Wood Type Based on Grain

If the lumber is fresh or unfinished, it is possible to identify the type by looking at the wood grain. Here is how. While most hardwoods have an open, porous texture (some exceptions such as maple are there), softwoods will generally have a perfectly smooth surface.

Quartersawn vs plainsawn: Many times, it's possible to identify wood grain patterns based on how the timber has been cut. Some wood species have unusual or specific figures on their freshly sawn surfaces, which make them easy to identify. Soft maple, for instance, has curly grain patterns located closely together.

5.1.4. Timber Identification Based on Weight & Hardness

The weight of one wood species will almost always be different from the weight of other species. So, you can identify timber based on its dry weight, hardness, and density.

• If possible, try to weigh the wood and then compare it to commonly known wood species based on weight.

• Measure the lumber length, width, and thickness, and calculate its density in order to figure out weight per unit volume.

• To get an idea of the wood hardness, try cutting a corner with your fingernail.

5.1.5. Timber Identification Based on Origin & History

It is also completely possible to identify a wood based on its origin and history. So, ask yourself questions like where did the lumber come from and how old is it in order to find out the type

• Based on the wood origin, it is possible to identify whether the wood was processed locally or imported from someplace else.

• If the wood came from a certain timber mill or carpenter, it is likely to identify the type based on the common types of wood that the mill or carpenter uses.

• Similarly, wood can be identified based on its age. Some species such as Brazilian Rosewood, for instance, are no longer commercially available because of CITES restrictions.

5.2 Seasoning of timber: Purpose, methods of seasoning as per BIS Code

Seasoning is the process of reducing the moisture content by drying under controlled conditions as nearly as possible at uniform rate from all parts of timber in order to prevent the timber from possible fermentation and making it suitable for use. Timber needs to be seasoned at the same moisture content as it will be in its final use so it will not move or bend once in place because after seasoned process drying or absorption will not be uniform will not be uniform and to have sugars in the sap reduced to prevent fungal attack. Remaining moisture after seasoning, is uniformly distributed throughout the mass. If drying is irregular, the shrinkage will also be irregular and it will set internal stresses between the fibres. These stresses when become excessive and overcomes the cohesion of fires, the timber warps and shakes are formed. A well-seasoned piece of timber contains moisture content in the range of 10 - 12%.

5.2.1. PURPOSE

I. Reduce the shrinkage and warping after placement in structure.
II. Increase strength, durability, resilience and workability and dimensional stability.
III. Reduce its tendency to split and decay.
IV. Make it suitable for painting.
V. Reduce its weight.
VI. Make timber burn readily if used as fuel. (vii) Make it suitable for gluing.

5.2.2. METHODS OF SEASONING

Seasoning methods can be basically classified into two groups, namely:

1. Natural Seasoning

2. Artificial Seasoning

Natural Seasoning

- It is very cheap and simple method in which natural air is used to remove moisture.
- The basic principle is to stack the timber so that plenty of air can circulate around each piece.
- The timber is stacked with wide spaces between each piece horizontally, and with strips of wood between each layer ensuring that there is a vertical separation too.
- Air can then circulate around and through the stack, to slowly remove moisture. In some cases, weights can be placed on top of the stacks to prevent warping of the timber as it dries.
- Over-head cover from effects of direct sunlight and driving weather must be provided.
- It is a very slow process, drying of different slow process may not be uniform and duration of drying deeds upon the type and size of planks and climatic conditions.

Advantages of Natural Seasoning

I. Depending upon the climatic conditions, the moisture content of wood can be brought down to about 20 to 25%.
II. Does not required skilled supervision.
III. It is uneconomical to provide artificial seasoning to timber sections thicker than 100mm as such section dry very slowly. Therefore, thicker timber sections are usually seasoned by the process of air seasoning. However slow drying yields stronger timber.
IV. It is cheap, simple and reduces harmful atmospheric emission.

Disadvantages of Natural Seasoning

I. As the process depends on the natural air circulation it becomes difficult to control it.
II. Drying of different surfaces may not be even and uniform. Thick member may develop split ends because the ends of such timbers dry rapidly in comparison to the central portions.
III. Fungi and insects may attack timber during seasoning therefore protection from rain and avoidance its contact with ground is necessary.
IV. Moisture content less than 18% is difficult to attain.
V. Space required for this process will be more and represent a potential fire hazard.

Artificial Seasoning

Artificial methods are adopted for faster drying and to attain desired moisture content. In this method timber is seasoned in a chamber with regulated heat, controlled humidity, and proper air circulation. Therefore, specific conditions for different species can be maintained.

Methods of Artificial Seasoning

1. Kiln Seasoning

In this method, the drying of timber is carried out inside an airtight chamber of oven.

Process of seasoning is as follows:

I. Timber is arranged inside chamber such that spaces are left for free circulation of air.
II. Then fully saturated air with temperature of 35°C to 38°C is forced inside the chamber.
III. Relative humidity is now gradually reduced. Temperature is then raised and maintained till the desired degree of moisture content is attained.

Timber drying kilns are of basically two types:

(i) Progressive Kiln

In this kiln a carriage carrying timber sections travels slowly from one end to the other and in doing so, it gets seasoned. Hot air is supplied from the discharging end such that temperature increases gradually from charging to the discharging end. It is used for seasoning timber on a large scale.

(il) Compartment (Stationary) Kiln

Most used by timber companies.

A compartment is filled with static batch of timber through which ar is circulated. In this type of kilns timber remains stationary. The drying conditions are successively varied from time to time. This drying method is well suited to the need of companies, which must dry timbers of varied species

2. Electrical Seasoning

In this method, use of high frequency alternating currents is done. The timber when green offers little resistance to flow of current, but the resistance increases at the timber dries internally and leads to production of heat. It is the most rapid method of seasoning. Due to uniform rise in temperature and consequently uniform evaporation of moisture, results in uniform quality of timber. However, the capital and running costs are very high. So, it is uneconomical to season timber on commercial base.

3. Boiling

The method consists of immersing the timber completely in water and then boiling it for three to four hours, then timber is than taken out and allowed to dry very slowly under a shed or using steam. The method is very quick and causes lesser shrinkage, but it reduces the strength and elasticity of timber. The procedure is expensive and cumbersome and cannot be adopted on a large scale.

4. Chemical Seasoning (Salt Seasoning)

in this method, the timber is immersed in a solution of suitable salt e.g., Urea, Sodium nitrate or sodium chloride (dehydrating agents) and then taken out and air dried. Interior surface of timber dries in advance of exterior one and chances of formation of external cracks are reduced.

5. Water seasoning

Timber is completely immersed in running stream of water, with their large ends pointing upstream. Therefore, the sap, sugar, and gum are leached out and are replaced by water. Then the timber is dried. It is a quick process but the elasticity and strength are reduced.

5.3 Properties of timber and specifications of structural timber

Durability

Durability is the priority for any kind of engineering material. A good timber should be durable enough to resist the actions of chemical agents, biological agents, physical agencies, etc. However, wood is weak against the actions of strong acids and alkalis but it can withstand weak acids and alkali solution.

Strength

Strength is the resistance against failure. A good timber should not fail easily and it should be strong enough to take loads acting on it. The strength of timber varies depending on the direction (transverse or direct) it is loaded. Strength is considered as an important property while designing structural wood members such as wooden beams, joists, rafters, etc.

Permeability

The permeability of timber should be less. A good timber should not absorb more than 8 to 12% of water by its weight when placed in water. The water permeability of timber depends upon various factors such as moisture content of timber, age of timber, type of timber, type of cut, etc.

Hardness

Hardness is the resistance against penetration. Good timber should be hard and workable. The hardness of timber depends upon its density and heartwood properties. Stronger is the heartwood higher is the hardness of timber.

Toughness

Toughness is the resistance against sudden shocks and vibrations. A good timber should be tough enough to resist sudden impact loads and vibrations. The toughness of timber is improved by the good interlocking of grains in its structure. A good tough timber is used to make handles of different tools, parts of automobiles, etc.

Elasticity

A good timber should be elastic. Elasticity is the property of regaining its original shape after deformation causing loads are removed. A good elastic timber is used to make sports items, shafts, bows, etc.

Workability

Workability of timber is the ease with which it can cut into the required shape. A good timber is easily workable. It should not damage or block the teeth of the saw during cutting.

Weight

The timber should be heavy as much as it looks. A timber is said to be good if it weighs heavy. Lightweight timbers are less in strength and unsound.

Structure

A timber with uniform structure is said to be a good timber. The fibers of timber should be straight and firm. The annual rings of timber should be closely located indicating the fact that the tree is mature enough to use it for making timber products. The medullary rays should be

hard and compact. In general, an age of 50 to 100 years is considered a good age for felling of trees.

Fire resistance

Fire-resistance of timber is very low. Of all the timber types, dense wood offers the most resistance against fire but up to certain limit only. The thermal conductivity of timber depends upon various factors such as moisture content, density, porosity, etc.

5.4 Preservation of timber and methods of treatment as per BIS

The durability of wood is decidedly variable property. If well-seasoned and kept in a dry place, if immersed in water, or if buried in ground, wood often lasts for centuries. When, however, unprotected wood can easily decay by swelling (when it gets wet), fungi, insects, fire, etc. The rapidly with which it decays depends on external conditions, the species of the wood, its preliminary conditioning, and its structure. One of the basic approaches to protect it is to create conditions unfavourable to fungi. Low humidity, heat and water insulation, etc. help to maintain the timber dry and thus make it insusceptible to damage by fungi. Water absorption, decay and other undesirable effects can be minimized by coating the surface of wood with polymer films or drying oils, oil base paints, varnishes, and synthetic enamels. Preservative treatment of timber is not supposed to improve its basic properties like mechanical, electrical, or chemical properties. Some of the methods used to poison the food supply to fungus are as below.

Oil type preservatives (type-1) applied over outside of exposed timber, give unpleasant smell and are not suitable when timber is to be painted. The types in use are creosote, carbolineum, solignum etc. with or without admixture with petroleum or suitable oils having a high boiling range.

Organic solvent preservatives (type-2) (Preservatives Insoluble in Water) consist of toxic chemical compounds, e.g., pentachlorophenol, benzene-hexa-chloride, dichlorobiphenyl trichloro-ethane (D.D.T) and copper naphthenate. These are dissolved in suitable organic solvents like naphtha, or in petroleum products such as kerosene, spirit, etc. The treated timber can be painted, waxed, or polished.

Acetic anhydride treatment is used for protection of veneers, plywood and light lumbers against decay by acetylation. They are treated with acetic anhydride vapour, which minimises swelling and improves resistance to decay and attack by insects.

Water soluble preservatives (type -3) are odourless organic or inorganic salts and are adopted for inside locations only. If applied over outside surfaces, the salts can be leached by rainwater. Examples of leachable (3A-water soluble) type of preservatives are zinc chloride, boric acid (borax), etc. Zinc chloride, sodium fluoride and sodium-penta-chloro-phenate are toxic to fungi. These are expensive and odourless (except for sodium-penta-chloro-phenate). Benzenehexa-chloride is used as spray against borers. Boric acid is used against Lyctus borers and to protect plywood in tea chests.

Various treatment processes:

Surface application is done either by spraying, dipping or by brushing the preservative for a short period on thoroughly debarked timber. For the oil type preservatives, the moisture content in timber should not be more than 14 percent. With water soluble preservatives, a moisture content of 20 to 30 percent is permissible. At least two coats should be applied. The second and subsequent coats should not be applied until the first one has dried or soaked into

the wood. Where possible, the treatment is done hot. Surface treatment is used mostly for treating timber at site and for retreatment of cut surfaces.

Soaking treatment consists in submerging debarked timber in the preservative solution for a sufficiently long period until the required absorption of the preservative is obtained. For dry veneers 15–30 minutes of soaking are enough.

Hot and cold process ensures sterilisation against fungi and insects. The timber is submerged in the preservative solution. Which is then heated to about 90° to 95°C and maintained at this temperature for a suitable period depending on the charge. It is then allowed to cool until the required absorption is obtained. During the heating period, the air in the timber expands and is partially expelled. While cooling, the residual air in the timber contracts and creates a partial vacuum which causes the preservative to be sucked into the timber. Generally, two baths are used, the first containing water where the hot treatment is given and the second the cold bath containing the preservatives into which the timber is transferred immediately after heating. This overcomes the danger of precipitation of chemicals at high temperatures. This arrangement also helps to make the process continuous in case the quantity of timber is large.

Boucherie process Sapwood of almost all green timbers with the bark on and of bamboos in green condition, soon after felling, can be treated using any of the inorganic water soluble preservatives by this process. The log of wood attached to the hose pipe and connected to the reservoir containing preservative at an air pressure of 0.1–0.2 N/mm^2 on its surface. Due to hydrostatic pressure, the preservative displaces the sap in the wood. The treatment is stopped when the concentration of preservative at the lower end of the log is the same as that in the reservoir.

Full cell or Bethel process is essentially a pressure process and is used when maximum absorption of the preservative is desired. The timber charge is introduced into the cylinder. The door is tightly closed and then a vacuum of at least 560 mm of mercury is created and maintained for half an hour to remove as much air as possible from the wood cells. At the end of the vacuum period, the preservative is introduced into the cylinder, with the vacuum pump working. When the cylinder has been filled with the preservative, the vacuum pump is stopped and the cylinder is subjected to an antiseptic pressure of 0.35 to 1.25 N/mm^2 depending on the species, size, refractory nature of timber, etc. to inject the preservative into the timber. The pressure is held until the desired absorption is obtained. The preservative is then withdrawn from the cylinder and finally a vacuum of 380 to 560 mm of mercury for about 15 minutes is once again applied to free the timber from dripping preservative. Specified retention of toxic chemicals in the timber during the treatment can be had by a proper selection of the concentration of the toxic material in the treating solution. Desired absorption of the preservative solution is controlled by the duration of pressure and vacuum period.

Empty cell processes are also known as pressure processes and are aimed at a maximum penetration of the preservative with a minimum net retention. The Lawry process and the Rueping process are commonly used.

Lawry process: The cylinder is loaded with timber and closed, followed by filling with the preservative. An antiseptic pressure of 0.35 to 1.25 N/mm^2 depending on the timber species, size, etc. is applied until the required absorption is obtained. The pressure is released when a certain part of the preservative injected into the timber is expelled due to the expansion of the entrapped air in the cells. The cylinder is then drained off and finally, a vacuum is applied as described in full cell process.

Rueping process: In this process, the cylinder is charged with timber and closed. An air pressure of 0.175 to 0.5 N/mm^2 is applied for a specified period depending upon the sapwood content of the timber and is maintained during the subsequent stage of filling up the cylinder with the preservative. When the cylinder is filled, an antiseptic pressure of 0.5 to 1.25 N/mm^2 depending on species, size, etc. is applied until the desired absorption is obtained. This is followed by a vacuum as described under full cell process. In this process, the preservative expelled on the release of the antiseptic pressure is considerable, yielding a low net absorption. This process is specially recommended for treating timber of mixed species and timbers containing sapwood and heartwood.

Diffusion process The diffusion process is a method of treatment of timber (poles and planks) and other plant material like bamboos, canes, palm leaves, veneers etc., in green condition. It lends itself best in the case of timbers which are not easy to impregnate under pressure in dry condition, and also, where there is danger of timber getting deteriorated during seasoning, particularly if air-seasoning is adopted. It may be employed in any of the following manners:

(a) Momentary dipping in concentrated solution and then close stacking under cover. For refractory veneers over 1.6 mm, 15 minutes soaking and 1 to 2 hours stacking is necessary. It is essential that the glue used for subsequent bonding is compatible with the preservative.

(b) Prolonged immersion in dilute solution and then close stacking under cover.

(c) Application of a paste of the preservative over all the surfaces of the timber and then close stacking under cover. This is specially recommended for treatment of refractory species like fir generally used as railway sleepers.

(d) Injecting the paste into timber through incisions interspersed on the surfaces of timber.

5.5 Other wood based products, their brief description of manufacture and uses: Laminated Board, Block Board, Fibre Board, Hard board, Sunmica, Plywood, and Veneers

Black board

The core of black boards is made up of strips of wood each not exceeding 25 mm in width, forming a slab, glued between at least two surface veneers. Veneers used for cross bands and faces are either rotary cut or sliced and should be reasonably smooth. Cross band thickness varies between 1–3 mm and face veneers between 0.5 to 1.5 mm in thicknesses. These are available in thicknesses of 12, 15, 19, 25, 30, 35, 40 and 50 mm. The directions of the grains of the core blocks run at right angles to that of the adjacent outer veneers.

Fibre board

These boards built up of felting from wood or vegetable (wood wastes, waste paper, agricultural wastes, etc.) are classified by the process of their moulding. If the boards are moulded by wet process, the main bond is by the felting of woody fibres and not by added glue. For the boards moulded by dry process, the bond between the predried fibres is improved by adding 4–8% of synthetic resin. For better performance wood preservatives and other admixtures are often added to the pulp. Insulating boards are not compressed during manufacture. Fibre boards are manufactured in various densities like soft, medium, and hard. The soft boards are used for walls and ceilings. Medium boards find their application in panelling, partition walls, doors, and windows. Hard boards have one surface smooth and the other one textured. These have higher densities, better mechanical properties, and improved moisture and termite resistances. The strength and weather properties of hard boards can be

improved by oil tempertering and such boards are known as tempered hard boards. Some of the trade names of hard boards are Masonite. Celotex. Essex boards, etc.

Veneers

The primary process in the manufacture of wood-based products is veneering which produces thin sheets of wood known as veneers. The thickness of veneers varies from 0.4 to 0.6 mm. In no case it should exceed 1 mm. The most suitable wood for this purpose is walnut. However other species like teak, sissoo, rose wood, etc. are also used. The logs to be used for this purpose are kept in wet storage to avoid end splitting and are softened by heating with hot water or steam and the bark is removed. The log is then cut to veneers. Depending on the cutting process, the veneers are classified as rotary veneers and sliced veneers. These are used in the manufacture of plywood and other laminated boards.

Plywood

A wood panel glued under pressure from an odd number (usually 3 to 13) of layers/piles of veneers is known as plywood. The outer most veneer sheets in a plywood panel are called/faces. The interior ply/plies which have their grain directions parallel to that of the faces are termed as core/centre. Other piles which have grain directions perpendicular to that in the face are termed as cross bands.

6. Paints, Varnishes and Distempers:

6.1 Paints

Paint is a liquid surface coating. On drying it forms a thin film (60–150 micron) on the painted surface. Paints are classified as oil paints, water paints, cement paints, bituminous paints, and special paints such as fire proof paints, luminous paints, chlorinated rubber paints (for protecting objects against acid fumes), etc.

6. 1.1 Purpose and use of paints

The functions of the paints are: to protect the coated surface against possible stresses—mechanical or chemical; deterioration—physical or environmental; decorate the structure by giving smooth and colourful finish; check penetration of water through R.C.C; check the formation of bacteria and fungus, which are unhygienic and give ugly look to the walls; check the corrosion of the metal structures; check the decay of wood work and to varnish the surface to display it to better advantage.

6.1.2 Characteristics of an ideal paint

The requirements are uniform spread as a thin film, high coverage, good workability and durability, sufficient elasticity to remain unaffected by expansion or contraction of the surface to be painted or by weathering action of atmosphere. The paints should also be: impervious to air and water, cheap and economical to form a hard surface.

6.1.3 Types of paints: Oil paints, Water paints, Cement paints and Enamel paint

Oil paint

This type of paint has a white lead base and is typically applied in three coats: primer, undercoat, and finish. This paint is available in two finishes: matte and glossy. Oil paint is a popular choice since it is long-lasting and inexpensive, and it is simple to apply and clean. This paint is often used on walls, doors, windows, and metal items. Despite their numerous advantages, these also have significant drawbacks. Oil paint does not work well in humid environments and takes longer to cure entirely.

Water paint

The bulk of wall paint sold now is water-based, owing to its ease of application. If your surface has previously been covered with an oil-based solution, be cautious when converting to water-based paint since it may not adhere properly. In this case, cleaning the surface and then roughening it all over with a medium to smooth grain sandpaper can prevent the fresh coat from flaking. Several firms have produced waterborne enamels or alkyds for situations where an oil-based paint would normally be desirable, but you want a water-based solution. These paints have the appearance and behaviour of oil paints.

Cement paint

When cement is the most important component of paint, it can provide maximum sturdiness and hardness. These paints are a superior alternative for both interior and outdoor walls. This type of paint no longer necessitates the use of any exclusive natural count or oil. It may also be an excellent choice for an external surface because it can reduce dirt collection and prevent water penetration. Cement paint may be one of the best options for an exterior or interior wall, as well as a concrete wall construction.

Enamel paint

This type of paint is typically made by adding zinc or lead directly to varnish. Pigments will be added to it in order to produce a wide range of hues. Enamel paints have been shown to produce harder, glossier coats that are extremely easy to clean. Furthermore, the paint is chemically resistant and waterproof, resulting in great colour retention and coverage. Subcontractors must carefully supervise the application of this paint. Some of the most popular applications for enamel paints are – windows, staircases, walls both interior and external, wood trim, flooring, and doors, and surfaces such as brick, metals, wicker, glass, and plasters. The main drawbacks of enamel paint are the need for titanium coating and delayed drying before application.

6.1.4 Covering capacity of paints

The covering power is the capacity, of a given quantity of the paint of the suitable consistency for application, to cover the extent of area. The covering power, also known as spreading capacity of paints and varnish depends upon the type of paint and its constituents, type of surface to be painted, and number of coats to be applied. The area covered by different paints is given in Table.

Type of paint or varnish	Type of surface	Area covered in sq. m/l
Lead priming coat	Wood work Metal work	10 11
Under coat	Flat surface	11
Gloss paint	Flat surface	11
Enamel	Flat surface	11
Varnish (first coat)	Flat surface	12
Varnish (second coat)	Flat surface	15

6.2 Varnishes

Varnish is a nearly homogeneous solution of resin in oil, alcohol, or turpentine. The type of solvent depends upon the type of resin used and is given in Table. The oil dries with time and the other solvents evaporate leaving behind a solid transparent resin film over the surface. For rapid drying, driers such as letharage, lead acetate, etc. are used.

Resin	Solvent
Amber, copal, gum anime	Boiled linseed oil
Common resin, gum dammer, mastic	Turpentine
Lac, shellac, sandarch	Methylated spirit
Raw copal, cheaper types of resins	Wood naptha

6.2.1 Purpose and use of varnishes

Varnishes provide a protected coating and gloss to the surface and intensify the wood grains. The objects of varnishing a surface are to:

1. Brighten the appearance of the grain in wood.

2. Render brilliancy to the painted surface.

3. Protect painted surface from atmospheric actions.

6.2.2 Characteristics of an ideal varnish

Characteristics of an ideal varnish:

1. It should render the surface glossy.

2. It should dry rapidly and present a finished surface which is uniform in nature and pleasing in appearance.

3. The colour of varnish should not fade away when the surface is exposed to atmospheric actions.

4. The protecting film developed by varnish should be tough, hard, and durable.

5. It should not shrink or show cracks after drying.

6.2.3 Types of varnishes

Varnishes are classified as oil, spar, flat, spirit and asphalt varnishes.

Oil varnish uses linseed oil and takes about 24 hours to dry. Hard resins such as amber and copal are dissolved in linseed oil. If the varnish is found unworkable, a small amount of turpentine oil may be added. It is suitable both for interior and external works.

Spar varnish derives its name from its use on spars and other parts of ships. It gives sticky effect in warm weather and is not used indoors.

Flat varnish materials such as wax, metallic soap or finally divided silica when added to varnish produce a dull appearance on drying and are known as flat varnish.

Spirit varnish is resins of soft variety such as lac or shellac dissolved in spirit. The examples are French polish, lacquer, and shellac varnish. It dries very quickly. These are not durable and are easily affected by weathering action.

Asphalt varnish is made by dissolving melted hard asphalt in linseed oil with a thinner such as turpentine or petroleum spirit. It is used over shop fabricated steel works.

Water varnish is shellac dissolved in hot water to which enough quantity of either ammonia, borax, soda, or potash is added. These are used for varnishing maps and pictures.

6.3 Distemper

Distemper is made with base as white chalk and thinner as water. Some colouring pigments and glue are added. They are available in powder and paste forms and are substantially cheaper than paints. They are most suitable for plastered surfaces as well as white washed surfaces of interior walls. Oil bound washable distemper, washable oil free distemper, and non-washable distemper or emulsion paints are some of the types of distemper. In the oil bound distemper, the drying oil is rendered mixable with water. While using they are thinned by adding water. On drying, the oil content in distemper hardens and yields a comparatively durable coating.

6.3.1 Properties of distemper and process of distempering.

1. The coatings are thick and more brittle compared to paints.

2. They are workable, easy in application but less durable.

3. The film being porous can be applied on even newly plastered surface.

Distempers are applied in the following manner:

Preparation of surface: The surface is thoroughly rubbed and cleaned. In case of a new plastered surface, the surface is kept exposed, to weather, for drying before the application of distemper. If an existing (old) distempered surface is to be redone, surface is cleaned with profuse watering. The effloresecence and patches, if any, should be wiped out by a clean cloth. Cracks, etc. if any should be filled with putty.

Priming coat: A priming coat as recommended by the manufacturer is applied on the prepared surface.

Final coat: Two or three coats of distemper are applied. Each coat should be applied only after the previous coat has dried.

UNIT IV

7. Metals and Non Metals

7.1 Ferrous metals: Composition, properties and uses of cast iron, mild steel, HYSD steel, high tension steel as per BIS.

The metals are also employed for various engineering purposes such as structural members, roofing materials, damp-proof courses, pipes, tanks, doors, windows, etc.

Out of all the metals, the iron is the most popular metal and it has been used in the construction activity since pre historic times. It is also available in abundance and it is estimated that it constitutes about 4.60 per cent of the crust of the earth.

As a matter of fact, it is contained in the green leaves of plants and it forms the red colouring matter of blood of the animals.

In Latin, the iron is known as the ferrum and its chemical designation is Fe.

For the purpose of study, the metals will be grouped in the following two categories:

(i)Ferrous metals

(i) Non-ferrous metals.

The ferrous metals contain iron as their main constituent. There are three important ferrous metals, namely, cast-iron, wrought-iron and steel.

The non-ferrous metals do not contain iron as their main constituent. Some of the non-ferrous metals such as aluminium, copper, etc. have limited use for the engineering purposes.

CAST IRON

The cast-iron is manufactured by re-melting pig-iron with coke and limestone

This re-melting is done in a furnace known as the cupola furnace. It is more or les same as the blast furnace, but it is smaller in size. Its shape is cylindrical with diameter of about 1 m and height of about 5 m.

The working of cupola furnace is also similar to that of blast furnace. The raw materials are fed from top. The cupola furnace is worked intermittently and it is open at top. After the raw materials are placed, the furnace is fired and blast of air is forced through tuyeres. The blast of air is cold as the impurities in pig iron are removed by the oxidation.

The impurities of pig-iron are removed to some extent and comparatively pure iron is taken out in the molten stage from the bottom of furnace. The slag is also removed from top of cast-iron at regular intervals. The molten cast-iron is led into moulds of required shapes to form what are known as the cast-iron castings.

COMPOSITION OF CAST IRON

The cast-iron contains about 2 to 4 per cent of carbon. In addition, it contains the various impurities such as manganese, phosphorus, silicon and sulphur.

The manganese makes cast-iron brittle and hard. Its amount should therefore be kept below 0.75 per cent or so.

The phosphorus increases fluidity of cast-iron. It also makes cast-iron brittle and when its amount is more than 0.30 per cent, the resulting cast-iron is lacking in toughness and workability. Its percentage is sometimes kept as about 1 to 1.5 to get very thin castings.

The silicon combines with part of iron and forms a solid solution.

It also removes combined carbon from graphite form. If its amount is less than 2.50 per cent, it decreases shrinkage and ensures softer and better castings.

The sulphur makes cast-iron brittle and hard. It also does not allow smooth cooling in sand moulds. Its presence causes rapid solidification of cast-iron and it ultimately results in blow-holes and sand holes. The sulphur content should be kept below 0.10 per cent.

PROPERTIES OF CAST IRON

Following are the properties of cast-iron:

(i)If placed in salt water, it becomes soft.

(ii)It can be hardened by heating and sudden cooling, but it cannot be tempered.

(iii)It cannot be magnetised.

(iv)It does not rust easily.

(v)It is fusible.

(vi)It is hard, but it is brittle also.

(vii) It is not ductile and hence it cannot be adopted to absorb shocks and impacts.

(viii) Its melting temperature is about 1250°C.

(ix)It shrinks on cooling. This fact is to be considered while making patterns or moulds for foundry work.

(x)Its structure is granular and crystalline with whitish or greyish tinge.

(xi)Its specific gravity is 7.5.

(xii) It lacks plasticity and hence it is unsuitable for the forging work.

(xiii) It is weak in tension and strong in compression. The tensile and compressive strengths of cast-iron of average quality are respectively 150 N/mm2 and 600 N/mm2.

(xiv) The two pieces of cast-iron cannot be connected by the process of riveting or welding. They are to be connected by nuts and bolts which are fixed to the flanges. The holes for bolts, etc. are either drilled out or cast in the casting.

USES OF CAST IRON

The use of cast-iron is not recommended in horizontal direction either for heavy or variable loads or at places where there are chances for the slightest shock to exist. The cast-iron cracks and snaps suddenly when subjected to the shocks, overloading or fire without giving any warning of approaching failure under such stresses. The cast-iron to be used on the works should be tough, close-grained grey metal, free from air holes, sand holes, flaws and with an even surface. It should be sufficiently soft to admit of being easily cut either by a chisel or a drill.

Following are the important uses of cast-iron:

(i) For making cisterns, water pipes, gas pipes and sewers, manhole covers and sanitary fittings.

(ii) for making ornamental castings such as brackets, gates, lamp posts,

spiral staircases, etc.

(iii) for making parts of machinery which are not subject to heavy shocks. (iv) For manufacturing compression members like columns in buildings ,bases of columns, etc.

(V) For preparing agricultural implements.

(VI) For preparing rail chairs, carriage wheels, etc.

Steel

It is the most suitable building material among all the metallic materials.

By suitably controlling the carbon content and other alloying elements and heat treatment, a desired combination of strength and ductility can be obtained.

On the basis of carbon content, steel is classified as follows:

Sr No.	Type of Steel	Carbon content)%)
1.	Dead mild steel	<0.15
2.	Mild Steel	0.15-0.3
3.	Medium carbon Steel	0.3-0.8
4.	High carbon Steel	0.8-1.5

Properties and Uses of Various Types of Steel

1 Mild Steel

It is also known as low carbon steel or soft steel.

It is malleable, ductile, tough and more elastic than wrought iron.

It can be forged and welded.

It rusts quickly and can be magnetised permanently.

Its specific gravity is 7.3, ultimate compressive strength is 800 - 1200 N/mm? and ultimate tensile strength is 600 - 800 N/mm?.

It is used for manufacturing rolled sections, reinforcing bars, roof coverings, sheet plies and rails.

2 High Carbon Steel

Carbon content varies from 0.55 - 1.5%.

It is also called as hard steel.

It is tougher and more elastic than mild steel.

It is difficult to forge and weld.

Its ultimate compressive strength is 1350 N/mm? and ultimate tensile strength is about 1400-2000 N/mm2 and specific gravity 7.9.

It is used in pre-stressed concrete members and in RCC.

Due to its ability to take shocks and thus it is used for making tools and machine parts.

3 High Tensile Steel

Here the carbon content is about 0.6 - 0.8%, manganese 0.6%, silicon 0.2%, sulphur 0.05% and phosphorous 0.05%.

It is a medium carbon steel.

Its ultimate tensile strength is about 2000 N/mm2 and minimum elongation of 10%.

It is used in pre-stressed concrete construction.

7.2 Commercial forms of ferrous, metals.

Types of Reinforcing Steel Bars

Mild Steel

Plain mild steel (designated as Fe 250) is more ductile than HYSD bars and absorbs shocks better.

It is supplied as plain, round bars.

IS 432 (Part - I): 1982 lays down specifications for mild steel bars.

These bars are usually available in diameters ranging from 6 mm to 50 mm.

High Yield Strength Deformed (HYSD) Bars

These bars have ribs i.e. deformations on its surface which checks the longitudinal movement of bar in concrete.

These bars form better bond with concrete.

These do not have a definite yield point.

HYSD bars result in higher tensile strength, bond strength and yield when twisted either hot or cold.

Cold twisted bars are more suitable for building purposes.

Cold twisted deformed bars are referred to as TOR steel bars.

TOR steel is high strength deformed bars with high yield point and bond strength.

Thermo-mechanically Treated (TMT) Bars

These are extra strength reinforcing bars.

Here steel bars receive a short intensive cooling as they pass through water cooling system after the last rolling mill stand.

The lower temperature makes the outer surface hard

The process of intensive cooling is followed by cooling in atmosphere so that temperature of core is still hot.

Thus the surface gets tempered by the heat coming from the core.

Due to improved properties of high strength along with toughness and ductility, TMT bars are better than mild steel bars.

TMT bars can resist temperature up to 50°C without any loss of strength.

TMT bars are more ductile than cold twisted deformed bars.

7.3 Properties and use of Aluminium

The aluminium occurs in abundance on the surface of earth. It is available in various forms such as oxides, sulphates, silicates, phosphates, etc. But it is commercially produced mainly from bauxite (Al,03, 2H20) which is hydrated oxide of aluminium.

MANUFACTURE OF ALUMINIUM

The aluminium is extracted from bauxite ores as follows:

(i)The bauxite is ground and then it is purified.

(ii) It is then dissolved in fused cryolite which is a double fluoride of

aluminium and sodium, AlFg, 3NaF.

(iii) This solution is then taken to an electric furnace and the aluminium is

separated out by electrolysis.

PROPERTIES OF ALUMINIUM

Following are the properties of aluminium:

(i)It is a very good conductor of heat and electricity.

(ii) It is a silvery white metal with bluish tinge and it exhibits bright lustre on a freshly broken surface.

(iii) It is a non-magnetic substance.

(iv) It is rarely attacked by nitric acid, organic acid or water. It is highly resistant to corrosion.

(v) It is light in weight, malleable and ductile.

(vi) It is very soft.

(vii) It melts at 660°C and its boiling point is 2056°C.

(viii) It possesses great toughness and tensile strength.

(ix) It readily dissolves in hydrochloric acid.

(x)Its specific gravity is about 2.70.

USES OF ALUMINIUM

This metal is chiefly used for making parts of aeroplane, cooking utensils, electric wires, window frames, glazing bars, corrugated sheets, structural members, foils, posts, panels, balustrades, bathroom fittings, precision surveying instruments, furniture, etc. Its other uses can be mentioned as follows:

It is used as a reducing agent in the manufacture of steel.

(ii) It is used for making aluminium alloys, automobile bodies, engine parts and surgical instruments.

(iii) It is used in the casting of steel.

(iv) It is used in the manufacture of electrical conductors.

(v) It is used in the manufacture of paints in powder form.

7.4 Properties and use of Stainless Steel.

Stainless steel has different corrosion properties which include being non-corrosive, rust-resistant steel, which is simply designated as stainless steel. In comparison with aluminium, stainless steel is approximately 3 times heavier. Stainless steel, like steel itself, is an alloy. An alloy always consists of different materials. Among the most frequent alloying elements in non-corrosive stainless steel is chrome, where nickel, molybdenum and further elements are used for special requirements. The magnetizability, as well as the corrosion resistance, are two of these requirements which are controlled by the different alloys.

Uses and properties

Steel with a chromium content of more than 10.5%, as well as various other elements in smaller quantities, is considered to be stainless. In combination with oxygen chromium forms a thin, sealed, fixed-adhering, chromic-oxide layer – the so-called passive layer. It is exactly this passive layer which is responsible for the resistance of the material. Due to its corrosion resistance, the metal is used for example for washing drums.

Stainless steel applications

Automotive and transportation

Stainless steel was introduced in automotive in the 1930s by Ford to manufacture their concept cars. Since then, it is used to produce a variety of automotive parts such as exhaust systems, grills, and trims. With advancing technology, stainless steel is being favoured by manufacturers to make structural components.

It is also heavily featured in other fields of transportation like freighting to make shipping containers, road tankers and refuse vehicles. It’s resistance to corrosion makes it ideal to transport chemicals, liquids and food products. The low maintenance of stainless steel also makes it an easy and cost-effective metal to clean and sustain.

Medical technology

Stainless steel is preferred in clean and sterile environments as it is simple to clean and does not easily corrode. Stainless is used in the production of a wide range of medical equipment, including surgical and dental instruments.

It is also used in building operation tables, kidney dishes, MRI scanners, cannulas, and steam sterilizers.

Most surgical implants, such as replacement joints and artificial hips are made from stainless steel, as well as some joining equipment like stainless steel pins and plates to repair broken bones.

Building trade

Due to its strength, resistance, and flexibility, stainless steel application has become a vital element of the building trade. It is commonly featured in the interior on countertops, backsplashes, and handrails, and is also used externally in cladding for high impact buildings.

It is a common feature in modern architecture due to its weldability, easy maintenance and attractive finish, which is used in the Eurostar Terminal in London and the Helix Bridge in Singapore.

With the movement towards sustainable building, stainless steel, which is a highly recyclable metal, is becoming increasingly preferable to use in construction. With a polished or grain finish, it has aesthetically pleasing properties and can aid in improving natural lighting in the building.

Aircraft construction

The aviation industry also has a preference for stainless steel. It is used in various applications including the frames of aeroplanes because of its strength and ability to withstand extreme temperatures. It can also be applied in jet engines as it can help prevent against its rusting. Why not also read aircraft grade aluminium.

Stainless steel is also an essential part of the landing gear. Its strength and rigidity can handle the weight of the landing aircraft.

Food and the catering industry

In the food and catering industry, stainless steel is used to manufacture kitchen accessories, cookware, and cutlery. Utensils such as knives are made using less ductile grades of stainless steel. The more ductile grades are used to make grills, cookers, saucepans, and sinks.

Stainless steel can also be used to finish freezers, dishwashers, refrigerators, and countertops. In food production, stainless steel is ideal because it doesn’t affect the flavour of the food. It is also corrosion resistant, and hence able to hold acidic drinks including orange juice. The ease of cleaning stainless steel makes it difficult to harbour bacteria, adding to its usefulness in food storage.

Tanker manufacture

Vessel manufacture

8. Plastics

8.1 FRP: Introduction, Properties of FRP and Applications of FRP in Building Industry

The fibre glass reinforced plastic or FRP is formed by using two materials in conjunction with each other to form a composite material of altogether different properties. It is also sometimes referred to as the glass fibre reinforced plastic or GRP. In FRP or GRP, the glass fibres provide stiffness and strength while resin provides a matrix to transfer load to the fibres. The use of various additives lends special properties to the FRP. The combination of glass fibres, resins and additives to fabricate the FRP can be done in a number of ways.

Following are the five principal methods of fibre glass reinforced plastic:

(i)Filament winding (ii) Hand lay-up (iii) Pultrusion

(iv) Resin transfer moulding

(v) Spray-up.

The FRP offers a combination of properties not easily found in the traditional materials and it has come as a boon especially for the building and construction industry.

PROPERTIES OF FRP

Following are the properties which have made the FRP the most commercial successful composite material of construction:

Aesthetic appeal: It is available with superb finish and can be adopted for eye catching aesthetics.

Corrosion resistance: The FRP has excellent resistance to moisture and chemicals over a large temperature range. It does not rust, rot, corrode or swell the cost of replacing the corroded equipment has reached the staggering proportions especially with the growth in the chemical and petrochemical industries. It is estimated that about 40% of the world's steel production is used to replace other steel which has been destroyed by corrosion. Thus, the FRP has found more and more use in the environment where the corrosion is the main concern.

Dimensional stability: The FRP component holds its form and shape even under severe mechanical and environmental stresses.

Durability: The performance of FRP under fatigue or creep is known to be superior to that of metals. It is therefore durable and has a long working life.

Easy to repair: The damaged portion of FRP can be repaired very easily and quickly. It requires common skill and little or no equipment. The strength imparted to the repaired portion is the same as that of the parent body.

Effect on health: The fibre glass is itself inorganic in nature and hence the FRP is one of the safest materials and its products can be used to virtually store anything as they have no ill effects even after prolonged usage. For instance, the FRP containers, both large and small, are used to store milk.

Energy saving: It requires far less energy for production. For instance, it requires only two-third of the energy required to make identical steel part and only one-third of the energy required to make identical aluminium part.

Freedom of design: As the constituents of FRP have no inherent shape, they can be easily fabricated in any desired shape with necessary properties. It is thus possible to make use of efficient structural shapes requiring a minimum o material for maximum strength and stiffness.

Light transmission: In thinner sections, the FRP products transmit a great deal of light. They can therefore provide a unique combination of a strong enclosure with adequate day lighting

Light weight: The FRP product weighs roughly half the steel component for bearing the same load. It results in the reduction of dead load to be carried by the supporting members and foundations.

Low investments in tooling: The tooling for FRP is inexpensive and fast. It permits quick styling changes from building to building or an inexpensive mould for a single highly creative design

Maintenance: The FRP products require the least maintenance as they are pigmented and are unaffected by changing weather conditions.

APPLICATIONS OF FRP IN BUILDING INDUSTRY

The FRP is an ideal material for the building industry as seen from its various applications which may be listed as follows:

Concrete shuttering: The moulds and forms of FRP give the cast concrete shapes of very high quality. The complicated concrete shapes can be moulded in the FRP eliminating in most cases, the need for final finishing.

Domes: The domes in enchanting shapes and unique designs with wide dimensions can be created for eye catching aesthetics. The translucent FRP dome-lights can be used on industrial, commercial, and public utility buildings and as the structure is self-supporting, it requires less support.

Doors and window frames: The lightweight flush doors and factory-made standard window frames of FRP can be suggested for housing schemes due to their long life, easy maintenance, and overall reduction in cost. The use of FRP doors for bathrooms and toilets eliminates the problems of rotting and warpage as well as swelling.

Internal partitions and wall panelling: It is possible to adopt flat, corrugated, or fancy FRP sheets for internal partitions of industrial and commercial buildings. The various designs of FRP for wall panelling and ceilings can be made in shape, form, and colour for a long-lasting trouble-free effect.

Roof sheets: The translucent FRP sheets provide a versatile medium of lighting. The sheets are available in a variety of forms with the corrugated type being very common. The corrugated sheets are made in a range of profiles which match corrugated steel and asbestos sheets. Thus, they permit an interchange of material to give the desired degree of lighting. If the covered area of FRP translucent roofing system is about 15%, it eliminates the need for electric lighting inside the industrial shed during day time.

Structural sections: The available cross-section profiles in steel, aluminium or PVC can also be made in FRP with advantage of equal strength at low weights. The FRP sections have much better properties in flexure and tension. They are Corrosion-resistant and grant a choice of colours. They can be machined, bolted, riveted, and tapped just like steel sections.

Temporary shelters: The FRP modular systems are ideally suited for temporary shelters at project sites, watchman cabins, green houses, defence shelters, vehicles parking sheds, etc.

They can be constructed with or without thermal insulation. They may be easily dismantled, carried and re-erected at the next site with minimum labour cost.

8.2 PVC wall panelling

The PVC Wall Panels is the most popular wall panel. They can be used to improve the appearance of your interiors, as well as the floor and furnishings. PVC panels are an eco-friendly product that is in high demand due to their many properties, including flexibility, impact resistance, and durability. These panels are lightweight and affordable

Types of PVC Wall Panels for Interiors

PVC Foam Board

PVC Sheets

3D PVC Wall Panels

8.3 ACP and HPL Sheets

ACP Sheet Aluminium Composite Panel (ACP) sheet is one of the popular cladding options available. The material is being used in various spaces, including commercial and residential. However, it is used mostly in commercial spaces. Talking about the sizing, you will find ACP sheets in 3mm to 4mm range. One of the main reasons behind the popularity of ACP sheets is its cost. The material is less costly as compared to HPL. When installing an ACP sheet, it can be moulded to 90-degree and even 45-degree.

HPL Sheet When it comes to cladding, another option you have is HPL. High-pressure Laminate or HPL is perfect for residential as well as commercial spaces. Although HPL sheets are costly (as compared to ACP sheets), the upside is they are highly durable. Therefore, you do not have to worry about getting it damaged. It will be durable enough to last longer. Unlike ACP sheets, HPL sheets cannot be moulded to 90-degree / 45-degree.

ACP Sheet vs HPL Sheet: Differences Let us take a look at points of differences between ACP and HPL sheets:

Durability The first and crucial factor to consider when it comes to interior or exterior cladding is – durability. Getting your house or commercial property cladding with durable material will ensure longer lifespan. If we compare durability of both these sheets, HPL is comparatively more durable. This makes it perfect material for all the spaces, be it commercial or residential. This also makes it ideal for different weather conditions. Talking about thickness of both these types of sheets, you will find ACP sheet in the 3mm to 4mm thickness range. And HPL sheet is available in 6mm thickness.

Usage Depending on whether it's HPL or ACP, both have different usages. Aluminium composite panels are popular due to their cost-effectiveness and they are used mostly in commercial spaces. On the other hand, high pressure laminate sheets are used in commercial as well as residential spaces.

Cost is one of the significant factors a buyer considers before choosing between both the materials. If you are finding a cost-effective solution, then ACP sheets are for you. Although ACPs are comparatively less costly, note that they are comparatively less durable as well. If you are looking for highly durable material, then HPL is for you.

Molding As both materials are different in terms of durability, one can be molded when installing, while the other cannot. When installing, the ACP sheet can be molded to 90-degree

or even 45-degree. On the other hand, molding HPL sheets is not possible. Talking about HPL sheet, they cannot be molded. It needs to be installed straight.

Lifespan When it comes to lifespan, HPL wins. It ensures a longer lifespan of more than 10-20 years. Majority of companies provide 10 or more years of warranty with their HPL sheets. Aluminium composite panels are less durable and they have a shorter lifespan (compared to HPL sheets). The average lifespan of ACP sheets is around 5 years.

UNIT V

9. Miscellaneous Materials

9.1 Asbestos: Introduction, properties, and use of asbestos.

Asbestos is the name for a group of natural occurring mineral fibres which are strong and both heat and chemically resistant. Due to these properties, asbestos was commonly used in the past as insulation and fire proofing. It was also used as a component in other building materials.

Asbestos was nicknamed "the magic mineral" because its unique chemical composition and physical properties made it suitable for use in thousands of products from floor tiles to road signs, from sewage pipes to insulating mattresses. Historical records show that asbestos has been used by man for over 4,000 years; in this century it has been used in over 3,000 products including cement building materials, pipework lagging, insulating mattresses and rope, fire resistant insulation boards, sprayed fire-proofing products, floor tiles and coverings, water and sewage pipes, gas masks, friction materials for vehicle brakes and clutches, lifts and machinery. Boilers and pipework were lagged with asbestos products in hospitals, power stations and throughout heavy industry. Asbestos insulation products were popular in the shipbuilding and railway industries and in the dockyards etc. The Royal Yacht Britannia, built in 1952, was riddled with asbestos insulation which was stripped out upon discovery in 1980. Sprayed asbestos insulation containing crocidolite was used in the roof space of the House of Commons Chamber; linings of the ventilation ducts in the House of Commons were insulated with chrysotile (white asbestos).

Use of Asbestos

Asbestos products have been used on a large scale in British buildings for fireproofing, acoustic and thermal insulation, condensation protection and reinforcement in asbestos-cement products. According to The Final Report of the Advisory Committee on Asbestos, the use of chrysotile (white asbestos) was by far the most widespread in Britain. Nearly 40% of the chrysotile imported into Britain in 1976 was incorporated into asbestos cement building products, 22% was used in fillers and reinforced cements and 12% went into floor tiles and flooring. Other asbestos-containing materials used in British buildings were: sprayed asbestos coatings, asbestos lagging, insulation partition boards, ropes and yarns, cloth, millboard and paper, asbestos cement sheets and partition boards, textured coating, mastics, sealants, putties, adhesives, wall plugging compound, pipework and so on.

9.2 Types and uses of insulating materials for sound and thermal insulation

TYPE	MATERIAL	WHERE APPLICABLE	INSTALLATION METHODS	ADVANTAGES
Blanket: batts and rolls	Fiberglass Mineral (rock or slag) wool Plastic fibers Natural fibers	Unfinished walls, including foundation walls Floors and ceilings	Fitted between studs, joists, and beams.	Do-it-yourself. Suited for standard stud and joist spacing that is relatively free from obstructions.

				Relatively inexpensive.
Concrete block insulation and insulating concrete blocks	Foam board, to be placed on outside of wall (usually new construction) or inside of wall (existing homes): Some manufacturers incorporate foam beads or air into the concrete mix to increase R-values	Unfinished walls, including foundation walls New construction or major renovations Walls (insulating concrete blocks)	Require specialized skills Insulating concrete blocks are sometimes stacked without mortar (dry-stacked) and surface bonded.	Insulating cores increases wall R-value. Insulating outside of concrete block wall places mass inside conditioned space, which can moderate indoor temperatures. Autoclaved aerated concrete and autoclaved cellular concrete masonry units have 10 times the insulating value of conventional concrete.
Foam board or rigid foam	Polystyrene Polyisocyanurate Polyurethane Phenolic	Unfinished walls, including foundation walls Floors and ceilings Unvented low-slope roofs	Interior applications: must be covered with 1/2-inch gypsum board or other building-code approved material for fire safety. Exterior applications: must be covered with weatherproof facing.	High insulating value for relatively little thickness. Can block thermal short circuits when installed continuously over frames or joists.
Insulating concrete forms (ICFs)	Foam boards or foam blocks	Unfinished walls, including foundation walls for new construction	Installed as part of the building structure. Cores in the blocks are typically filled with concrete to create the structural component of the wall.	Insulation is literally built into the home's walls, creating high thermal resistance.
Loose-fill and blown-in	Cellulose Fiberglass Mineral (rock or slag) wool	Enclosed existing wall or open new wall cavities Unfinished attic floors	Blown into place using special equipment and, although not recommended, sometimes poured in.	Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions.

		Other hard-to-reach places		
Reflective system	Foil-faced kraft paper, plastic film, polyethylene bubbles, or cardboard	Unfinished walls, ceilings, and floors	Foils, films, or papers fitted between wood-frame studs, joists, rafters, and beams.	Do-it-yourself. Suitable for framing at standard spacing. Bubble-form suitable if framing is irregular or if obstructions are present. Most effective at preventing downward heat flow, effectiveness depends on spacing and number of foils.
Rigid fibrous or fiber insulation	Fiberglass Mineral (rock or slag) wool	Ducts in unconditioned spaces Other places requiring insulation that can withstand high temperatures	HVAC contractors fabricate the insulation into ducts either at their shops or at the job sites.	Can withstand high temperatures.
Sprayed foam and foamed-in-place	Cementitious Phenolic Polyisocyanurate Polyurethane	Enclosed existing wall Open new wall cavities Unfinished attic floors	Applied using small spray containers or in larger quantities as a pressure sprayed (foamed-in-place) product.	Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions.
Structural insulated panels (SIPs)	Foam board or liquid foam insulation core Straw core insulation	Unfinished walls, ceilings, floors, and roofs for new construction	Construction workers fit SIPs together to form walls and roof of a house.	SIP-built houses provide superior and uniform insulation compared to more traditional construction methods; they also take less time to build.

9.3 Construction chemicals like water proofing compound, epoxies, polymers

Construction chemicals have always been playing important roles in virtually all sorts of construction projects, be it industrial projects, residential building projects, commercial building projects and so on. These chemicals are often used in various elements of projects in order to achieve various important qualities such as workability, durability etc. Construction chemicals exist in many varieties from a large number of manufacturers worldwide.

Increasing demand for public, commercial and residential buildings combined with an increasingly urban population is driving the global construction chemical market. Demand for buildings, roads, bridges, tunnels and dams is further driving the market.

Discussed below are different types of construction chemicals used on hardened concrete either as surface application, coating or as repair materials.

Concrete curing compounds

Concrete curing compound consists essentially of waxes, natural and synthetic resins, and solvents of high volatility at atmospheric temperatures. The compound forms a moisture retentive film shortly after being applied on a fresh concrete surface. White or gray pigments are often incorporated to provide heat reflectance, and to make the compound visible on the structure for inspection purposes. Curing compound should not be used on surfaces that are to receive additional concrete, paint, or tile which require a positive bond, unless it has been demonstrated that the membrane can be satisfactorily removed before the subsequent application is made, or that the membrane can serve satisfactorily as a base for the later application.

Polymer bonding agents

Polymer Bonding Agent is an aqueous emulsion of a polymer and chemical admixtures. It is designed for use as a bonding agent with concrete and cement-based products in interior or exterior applications. Polymer Bonding Agent is also designed for use as a polymer modifier in mortars and concretes to develop increased tensile, flexural and bond strengths. The use of Polymer Bonding Agent in concrete and shotcrete also gives significant improvements in resistance to penetration by chlorides and de-icing salts.

Mould releasing agents

Mould release agents come in handy when you have materials that are shaped and constructed in moulds. Without the releasing agent, your mould may become damaged or even break when it is time to remove it. Mould release agents come in a variety of textures with the most commonly used one being an oil type base. If you have never used a releasing agent before, it is similar to placing oil or butter in the bottom of a dish to remove your final baking product. Below, you will find the three most commonly used types and their purpose in the manufacturing industry.

Concrete curing compounds Polymer bonding agents Mould releasing agents

Form release agents

These compounds are applied on the inner surfaces of forms, not only facilitate stripping of formwork but also render concrete surfaces smoother. They also help enhance the life-span of the forms. Form releasing agents can be oil based, resin based, water based, organic chemical based etc.

Protective and decorative coatings

A protective coating is a layer of material applied to the surface of another material with the intent of inhibiting or preventing corrosion. A protective coating may be metallic or non-metallic. Protective coatings are applied using a variety of methods, and can be used for many other purposes besides corrosion prevention. Commonly used materials in non-metallic protective coatings include polymers, epoxies, and polyurethanes. Materials used for metallic protective coatings include zinc, aluminium, and chromium. Special materials are used in the finishing coats of plastering or over the plastered surfaces to meet one or more of specific requirements such as decorative appearance, high durability, fire – proofing, heat insulation, sound insulation, early completion, high strength etc.0

Concrete floor hardeners

These are chemicals added in floor concrete in order to render it denser and more durable. They also usually enhance chemical resistance, impact & abrasion resistance, waterproofing capability etc. besides reducing dusting. All these are required attributes especially for industrial, commercial or factory floors. Ultimately good quality floor hardeners reduce repairs and maintenance of concrete floors drastically besides making them long lasting thus adding to cost effectiveness as well. Floor hardeners can be liquid or solid, metallic or non metallic. Metallic floor hardeners (solid) are well graded ferrous aggregates. Liquid floor hardeners are water, silicate etc. based solutions. Pigmented floor hardeners also improve the appearance of floor surfaces. Floor hardeners are usually applied as per manufacturer's specifications This construction chemical Improves the abrasion resistance of dusty or poorly cured concrete by up to 3 times. Has good resistance to alkali solution and petroleum solvents but poor resistance to strong acids.

Form release agents Protective and decorative coatings Concrete floor hardeners

Non-shrink High Strength Grout

Non-shrink grout is a hydraulic cement grout that, when hardened under stipulated test conditions, does not shrink, so its final volume is greater than or equal to the original installed volume. It is often used as a transfer medium between load-bearing members. It is specially formulated to provide extended working time even at high ambient temperatures when mixed and placed at any recommended consistency. Its compressive strength is often very high. Typical compressive strength values are 8,000 psi to 14,000 psi at 28 days, with 1 day strengths in excess of 3,000 psi.

Surface retarders

Surface retarders, also called surface "deactivators," are applied to fresh concrete to chemically delay the set of the surface mortar. Unlike concrete set retarders, they allow the rest of the concrete to cure normally, without affecting the setting rate or strength gain. Because surface retarders work their magic by stopping the hydration process down to a controlled depth, the underlying concrete will harden properly while allowing easy removal of the surface paste later. When you are ready to expose the aggregate by hosing or high-pressure washing, the depth of aggregate reveal is more uniform with minimal pop-outs. The best time to apply surface retarder is after you've completed all finishing operations and the bleedwater has dissipated.

Bond-aid for plastering

Almost all surface applied bonding agents are compounded from polyvinyl acetate emulsions. These water-based adhesives are very safe to use because they are non-toxic, non-hazardous and non-flammable. They meet even the most stringent VOC requirements. As

with any coating, surface preparation is essential for a successful application. The surface must be structurally sound and clean, which means free from dust, dirt, oil and efflorescence. On new concrete it is important to determine whether the form release and/or curing compound can be coated. Almost all manufacturers of these types of products will include a statement in their directions regarding compatibility with various coatings. If the surface can be painted, it can be coated with a surface applied bonding agent.

Non-shrink High Strength GroutSurface retarders Bond-aid for plastering

Ready-mix plaster

Ready mix plaster is a factory mixed/premixed sand-cement based plaster. All the activities that are generally undertaken on-site are performed in a quality-controlled environment at plant to ensure no-batch variation and optimum sand gradation, which is of utmost importance for any plaster. Other additives such as fly ash and polymers are also added to it, to improve its performance and various other properties. These are generally used for building houses or making solid structures of any sort. Apart from these, they can also be used for various other purposes that require you to put two or more things together that will hold strong for long. You can also use ready mix plaster to make models.

Polymer modified mortar for repair and maintenance

Polymer-modified mortar is made by replacing a portion of the traditional binders with polymers. Polymers are added to mortar to increase characteristics that may include adhesion, toughness, flexural or tensile strength, and resistance to chemicals. Polymers act to improve the workability and adhesion of non-hardened mortar and often require less added water than does traditional mortar, which results in fewer pores and stronger cements, subsequently reducing water ingress and permeability to salts. Polymer-modified mortar is often commercially available with all ingredients already included in the mixture.

Tile fixing

Tile fixers and tile adhesives form the backbone of your home. A quality tile fixer connects all your tiles together, to create a beautiful canvas from individual pieces. Tile fixing products are used for floorings, bathtubs, washbasins, kitchen tops and any other area where two surfaces need to stick together.

Ready-mix plaster Polymer modified mortar for repair and maintenance Tile fixing

Guniting aid

The guniting is the most effective process of repairing concrete work which has been damaged due to inferior work or other reasons. It is also used for providing an impervious layer. The gunite is a mixture of cement and sand, the usual proportion being 1:3. A cement gun is used to deposit this mixture on the concrete surface under a pressure of about 20 to 30 N/cm2. The cement is mixed with slightly moist sand and then necessary water is added as the mixture comes out from the cement gun. A regulating valve is provided to regulate the quantity of water. The surface to be treated is cleaned and washed. The nozzle of the gun is generally kept at a distance of about 750 mm to 850 mm from the surface to be treated and the velocity of the nozzle varies from 120 to 160 m/sec.

Water repellents

These chemicals have water repelling properties which are exploited to protect masonry and concrete alike from the ill effects of moisture or water. Some examples amongst many types

of water repellent are acrylic protective coating, water based silane siloxane water repellent sealer for tiles, stone masonry etc.

Swelling water stops

These are primarily used in construction joints. Quite easy to install, good quality swelling water stops can be a more efficient and economic option to the conventional PVC water stops in many cases. These chemicals seal the joints by their swelling action when they come in contact with the water of freshly poured concrete. Examples are polyurethane foams and grouts. Swelling PU resins, which turn foamy and expand when coming to contact with water, are used for sealing leaking cracks as well by injecting the chemicals into the cracks.

Guniting aid Water repellents Swelling water stops

9.4 Water proofing and termite proofing materials - types and uses

These chemicals can be quite useful when a structure's waterproofing capability is to be given a boost which is especially required for structures constantly dealing with liquids. There are many varieties. Some of them are crystalline waterproofing chemicals, liquid acrylic elastomeric waterproofing compounds, polymer modified waterproofing compounds, cementitious waterproofing compounds etc. Many of these compounds form membranes on the concrete surfaces to protect them from ingress of water.

Adhesives

These construction chemicals are readily used in all sorts of projects, be it commercial, residential, industrial etc. construction projects. Adhesives are expected to have strong bonding capacity besides good waterproofing, weatherproofing etc. qualities. These are also expected to be elastic enough to accommodate repeated expansion and contraction likely to be caused by temperature fluctuations. Adhesives make their ways to a myriad of construction works ranging from floor covering, panel fixing to tile fixing and so on. Various types of adhesives are PU based adhesives, silicone adhesives, acrylic adhesives, UV adhesives etc

Rebar coating

Coatings for reinforcing steel bars can be quite useful when the bars have to be stored or kept exposed to weather for considerable time. They prevent formation of rust on the bar surface which otherwise needs to be removed by sand or grit blasting. A common and effective type of rebar coating is fusion-bonded epoxy coating. Bars can be galvanised as well.

Waterproofing chemicals Adhesives Rebar coating

Epoxy grouts

Epoxy grouts have an edge over ordinary grouts especially in harsh environmental conditions such as exposure to extreme temperatures, oil, grease, acids, chemicals and so on. Besides, they are much more durable and abrasion, impact, stain resistant as compared to ordinary grouts. However, they are more expensive too. Having good vibration damping characteristics, epoxy grouts are quite suitable for grouting of industrial equipment or machine foundations.

Epoxy coatings

These can come as water or oil-based solutions or as solvent-free. They can be single or two-component. Single-component epoxy paints are usually oil based. Two-component epoxy coatings are mixed in situ in proportions as prescribed by their manufacturers and they are quite suitable for factory, industrial or commercial building applications by dint of their excellent

chemical & thermal resistant characteristics, hardness, durability, waterproofing characteristics etc. They are solvent-free. Epoxy coatings are also used in flooring for decorative purposes.

Chemical for high performance concrete

Construction chemical is now being used to gain the proper attribute of mechanical strength of high performance concrete. HPC mixtures are composed of essentially the same materials as conventional concrete mixtures, but the proportions are designed, or engineered, to provide the strength and durability needed for the structural and environmental requirements of the project. High-strength concrete is defined as having a specified compressive strength of 8000 psi (55 MPa) or greater. Special care is required for production and testing of the concrete and at which special structural design requirements may be needed.

Epoxy grouts Epoxy coatings Chemical for high performance concrete

Interior decoration materials

9.5 Materials used in interior decoration works like POP, methods of doing POP

Pop is commonly used material to make false ceiling

As far as making impressions go, custom wall and ceiling designs can make the grade instantly and become statement pieces of your stunning and creative home décor. Of all the materials used to create these eye-catching showstoppers, a house POP ceiling design is certainly the most popular.

POP is a quick-setting white powder made from semi-dehydrated gypsum that hardens when allowed to dry after mixing with water. Hence, you can use it to make a false POP design for ceilings, designer trims and accent décors for your home interiors.

What are the advantages of false ceiling

Getting a POP false ceiling design for a home is a good idea because Plaster of Paris (POP) has the following characteristics and benefits:

It is durable, lightweight, and fire-resistant

POP has low thermal conductivity, thus making it a good insulating material

It is easy to colour POP surfaces

POP shows no shrinkage while setting and hence you won’t find any cracks in the surface

It is easy to mould POP into any required shape, including curved ones

It provides a high gloss and smooth finish to the final design

Due to these distinct features, POP also offers a lot of scope for experimentation. Additionally, a POP design for ceilings helps hide unsightly cables.

What are the disadvantages of pop ceiling

Here are the disadvantages of opting for a POP false ceiling design:

It is expensive as compared to gypsum

Requires maintenance

There is a possibility of cracks in POP ceilings

Requires skilled craftsmanship and can take time to install

9.6 Eco friendly materials for construction of buildings.

Living in a stone structure is low maintenance and eco-friendly, and any extra stone leftover from the build can be used for home finishings such as countertops or tile.

Building with stone does not release harmful chemicals or toxins into the interior of your home, and because it occurs naturally, you do not need any other resources to create the material itself. Because stone is stunning on its own, you will also save on paint and finish, and the reliability of stone structures makes it an easy building to insure.

Benefits of stone:

Low maintenance: Stone requires little maintenance and cleaning over time, so upkeep costs for homeowners will be low.

Durable: This material works well in various climates, is fire-resistant and should fare well during a natural disaster.

2. Cob

If you want to build your own eco-friendly home, cob is a natural material that is easy to work with, even for beginners. Cob is a mud mixture made of multiple natural ingredients such as soil, sand, straw and sometimes even lime.

Homes constructed using cob tend to look whimsical and enchanting, resembling the Hobbit homes from *Lord of the Rings*. Cob houses do take longer to construct than traditional builds, and you will also want to monitor the humidity in your cob home to prevent mold and related health problems.

Most home insurers consider cob homes high-risk, so it may be more difficult to obtain coverage from traditional carriers.

Benefits of cob:

Cheap: Building a homemade of cob can end up being nearly one-tenth of the cost of a traditional build.

Energy-efficient: Cob homes slow down the rate of heat transfer, which helps to regulate their internal temperature, in turn letting homeowners save on monthly electric bills.

3. Bamboo

Ever dreamed of living in a bamboo treehouse? If so, you might be on to something. While the idea of using bamboo as a construction material is nothing new — humans have been doing this for centuries — this unique wood is resurging in popularity thanks to its eco-friendly qualities and dreamy bohemian design.

The strength and look of bamboo can help you achieve a distinctive style to make your home stand out. It’s also one of the fastest-growing plants on the planet, so it’s more sustainable than most! Because home insurers classify bamboo homes as frame construction by home in, insurance rates are higher than other builds, such as stone and adobe, due to fire concerns.

Benefits of bamboo:

Durable: Bamboo has greater tensile strength than steel, and can withstand compression better than concrete.

Lightweight: Bamboo is easy and cheap to transport to a construction site thanks to its hollow sections, saving money during the build.

4. Cork

Cork is not just good for keeping your wine fresh — it is also a great insulator for home construction. This sustainable material has been used in construction in Europe for many years but is beginning to gain traction in the U.S. as well. Because 50 percent of cork cell volume consists of air, cork is one of the lightest solid substances.

Cork comes from cork oak trees, which are mainly harvested in Europe (in fact, nearly 60 percent of all cork oak tree production is in Portugal). Harvesting cork is done by hand, and the bark can be removed without killing the tree!

A home built using cork insulation will likely be classified as a frame home, so while you can obtain insurance, you should expect to pay more than you would for other building classifications.

Benefits of cork:

Thermal insulation: Cork is one of the best materials in the world for thermal insulation due to its air cushion design.

Mold-resistant: Its impermeable yet porous nature helps make cork resistant to mold and mildew.

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7. Cordwood

If you are looking for a cozy cottage, you might want to consider cordwood construction. This spin on a log cabin is made up of anywhere from 40 to 60 percent wood, which is chopped into evenly sized logs. The rest of the build material is a mortar mix to provide insulation.

While you can build a cordwood home without hiring a general contractor, problems may arise when you try to obtain insurance and do not have the correct permits. Make sure you are building your home in compliance with masonry home requirements and you shouldn't have a problem getting insurance from most carriers.

Benefits of cordwood:

Affordable: Cordwood is known for its low cost. In fact, cordwood masonry was popular during the Great Depression because of its cheap and easy construction.

Thermal efficiency: When done correctly, cordwood homes can have great insulation both from the heat and cold, and can be easily adapted for passive solar home design.

8. Earth bags

Also known as sandbags, this natural material is made of (mostly) earth that is then filled into bags and piled on top of each other in a method similar to bricklaying. Earth bag homes, or rammed earth homes, typically begin in a trench and are built up from there, and then finished with a plaster, like stucco or adobe.

Because earth bag homes are considered alternative buildings, some of the biggest challenges around these structures are the legality and permits needed for construction, along with finding an insurer willing to cover your home.

Benefits of earth bags:

Insulation: Earth bag homes filled with lightweight materials (such as rice hulls or crushed volcanic stone) and provide natural insulation, which is better for the homeowner's health.

Locally sourced: Since these homes are made of bags of earth, you can (and should!) use local earth for the natural mixture to make the build as eco-conscious as possible.