Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal
New Scheme Based On AICTE Flexible Curricula
Civil Engineering, III-Semester
CE301 Construction Materials

UNIT-I

Stones, Brick, Mortar and Concrete:

Stones :Occurrence, Classification of Rocks, varieties, Characteristics and their testing, uses, quarrying and dressing of stones, Deterioration of Stones, Retardation of Decay of Stones, Preservation of Stones, Artificial Stones.

Brick : Manufacturing , characteristics, Classification and uses, Improved brick from inferior soils, Hand molding brick table, Clay-fly ash brick table

Concrete : Ingredients, Grades of Concrete ,Concrete Production ,Special Concrete

UNIT-II

Timber ,Glass , Steel and Aluminum :

Timber: Important timbers, their engineering properties and uses, defects in timber, seasoning and treatment, need for wood substitutes, ,Plywood, Particle Board ,Fibre Board, Applications of wood and wood products , Plaster Boards, Adhesives, types of Gypsum Board and their uses

Glass: What is glass , Nature of Glass, Structure of Glass, Macro Molecular Structure, Main Oxides in Glass, Thermal and Optical Properties ,Effect of Coating,

Steel : Physical Properties of Structural Steel, Grades of Steel

Aluminum : Properties ,Forms ,Uses, Advantages

UNIT-III

Flooring , Roofing ,Plumbing and Sanitary Material:

Flooring and Roofing tiles , Types of Flooring – Marble, Kota stone , wood etc. Type of Roofing , P.V.C. materials, CI , GI, Asbestos pipe , Stone ware pipes

UNIT-IV

Paints, Enamels and Varnishes:

Composition of oil paint, characteristic of an ideal paint, preparation of paint, covering power of paints, Painting: Plastered surfaces, painting wood surfaces, painting metal Surfaces. Defects, Effect of weather, enamels, distemper, water wash and colour wash, Varnish, French Polish, Wax Polish

UNIT-V

Miscellaneous Construction Materials:

Bitumen, Tar and Asphalt their characteristics and uses ,Ultra Poly Vinyl chloride Pipes, Thermal and sound insulating materials, and water proofing materials .

References Books:

1. Donald R Askeland, Pradeep P Fulay, Wendelin J Wright, The science and Engineering of Materials, Cengage Learning.
2. S K Duggal, Building Materials, New Age International.
3. P C Vaghese, Building Materials, PHI Learning.
4. S.C. Rangwala, Engineering Materials, Charotar.
5. M S Shetty, Concrete Technology, S. Chand Technical.
6. A M Neville, J J Brooks, Concrete Technology, Prentice Hall.

UNIT-1
Construction Materials

Stones: Occurrence, varieties, Characteristics and their testing, uses, quarrying and dressing of stones. Timber : Important timbers, their engineering properties and uses, defects in timber, seasoning and treatment, need for wood substitutes, Alternate materials for shuttering doors/windows, Partitions and structural members etc. Brick and Tiles: Manufacturing, characteristics, Classification and uses, improved brick from inferior soils, Hand molding brick table, Clay-fly ash brick table, Flooring tiles and other tiles and their characteristics

OCCURRENCE

BUILDING STONES

In order to be able to decide what kind of stone to use under given conditions, knowledge of the different kinds employed in the various types of construction is essential. It is not necessary for a mason to determine the exact composition of a stone to be used in a structure, but his knowledge should be sufficient to help him in selecting or specifying the stone that is best for the type of structure.
The properties of a stone that determine its fitness for construction purposes are durability, strength, hardness, density, and appearance. The quality of a stone can easily and approximately be known by studying its origin and chemical composition and from the results of tests and experiments.

Definitions.
The term rock is commonly defined as a hard mass of mineral matter having, as a rule, no definite external form. In engineering construction, the word stone is applied indiscriminately to all classes of hard rocks.

Description of Classes.
Rocks are classified as follows:

- **According to geological origin- igneous, sedimentary and metamorphic**
- **According to the physical form- stratified, unratified and foliated.**
- **According to their chemical composition–siliceous, argillaceous and calcareous.**

GEOLOGICAL CLASSIFICATION

This is classification of rocks based on their origin and formation. On this basis, rocks are classified as igneous, sedimentary and metamorphic.

IGNEOUS ROCK

Igneous Rock, rock formed when molten or partially molten material, called magma, cools and solidifies. The inner layers of the earth are at a very high temperature causing the masses of silicates to melt. The melted masses of silicates is called magma, which forced up and released on the surface of the earth. This release is called volcanic eruption. The magma that is released cools and solidify into a crystalline rock.
Geologists classify igneous rocks according to the depth at which they formed in the earth's crust. Using this principle, they divide igneous rocks into two broad categories: those that formed beneath the earth's surface, and those that formed at the surface.
Rocks formed within the earth are called intrusive or plutonic rocks because the magma from which they form often intrudes into the neighboring rock. Rocks formed at the surface of the earth are called extrusive rocks. In extrusive rocks, the magma has extruded, or erupted, through a volcano or fissure.
Geologists can tell the difference between intrusive and extrusive rocks by the size of their crystals: crystals in intrusive rocks are larger than those in extrusive rocks. The crystals in intrusive rocks are larger because the magma that forms them is insulated by the surrounding rock and therefore cools slowly. This slow cooling gives the crystals time to grow larger. Extrusive rocks cool rapidly, so the crystals are very small. In some cases, the magma cools so rapidly that crystals have no time to form, and the magma hardens in an amorphous glass, such as obsidian.

SEDIMENTARY ROCKS.

Sedimentary rocks are formed by the consolidation of particles deposited in any of the three following ways:
· By the mechanical destruction and subsequent deposition of other rocks, usually by water, as in the case

of sandstone or lime stone;

· By the action of animals and plants, as in the case of coral;

· By the chemical precipitation of mineral matter from water, as in the case of gypsum. The metamorphic rocks are formed by the transformation, of either igneous or sedimentary rocks through the influence of heat or chemical action. To this class belong marble, gneiss, and slate.

Most sedimentary rocks are characterized by parallel or discordant bedding that reflects variations in either the rate of deposition of the material or the nature of the matter that is deposited.

Sedimentary rocks are classified according to their manner of origin into mechanical or chemical sedimentary rocks.

· Mechanical rocks, or fragmental rocks, are composed of mineral particles produced by the mechanical disintegration of other rocks and transported, without chemical deterioration, by flowing water. They are carried into larger bodies of water, where they are deposited in layers. Shale, sandstone, and conglomerate are common sedimentary rocks of mechanical origin.

· The materials making up chemical sedimentary rocks may consist of the remains of microscopic marine organisms precipitated on the ocean floor, as in the case of limestone. They may also have been dissolved in water circulating through the parent rock formation and then deposited in a sea or lake by precipitation from the solution. Halite, gypsum, and anhydrite are formed by the evaporation of salt solutions and the consequent precipitation of the salts.

Due to the method of formation, sedimentary rocks are naturally soft and can be easily split up along the bedding. Their properties will vary depending on the nature of the sediment and type of bond.

METAMORPHIC ROCKS.

Metamorphic Rock is a type of rock formed when rocky material experiences intense heat and pressure in the crust of the earth.

Metamorphic rock forms when pre-existing rock undergoes mineralogical and structural changes resulting from high temperatures and pressures. These changes occur in the rock while it remains solid (without melting).

The changes can occur while the rock is still solid because each mineral is stable only over a specific range of temperature and pressure. If a mineral is heated or compressed beyond its stability range, it breaks down and forms another mineral. For example, quartz is stable at room temperature and at pressures up to 1.9 gigapascals (corresponding to the pressure found about 65 km [about 40 mi] underground). At pressures above gigapascals, quartz breaks down and forms the mineral cohesive, in which the silicon and oxygen atoms are packed more closely together.

In the same way, combinations of minerals are stable over specific ranges of temperature and pressure. At temperatures and pressures outside the specific ranges, the minerals react to form different combinations of minerals. Such combinations of minerals are called mineral assemblages.

In a metamorphic rock, one mineral assemblage changes to another when its atoms move about in the solid state and recombine to form new minerals. This change from one mineral assemblage to another is called metamorphism. As temperature and pressure increase, the rock gains energy, which fuels the chemical reactions that cause metamorphism. As temperature and pressure decrease, the rock cools; often, it does not have enough energy to change back to a low-temperature and low-pressure mineral assemblage. In a sense, the rock is stuck in a state that is characteristic of its earlier high-temperature and high-pressure environment.

The size, shape, and distribution of mineral grains in a rock are called the texture of the rock. Many metamorphic rocks are named for their main texture. Textures give important clues as to how the rock formed. As the pressure and temperature that form a metamorphic rock increase, the size of the mineral grains usually increases. When the pressure is equal in all directions, mineral grains form in random orientations and point in all directions. When the pressure is stronger in one direction than another, minerals tend to align themselves in particular directions. In particular, thin plate-shaped minerals, such as mica, align perpendicular to the direction of maximum pressure, giving rise to a layering in the rock that is known as foliation. Compositional layering, or bands of different minerals, can also occur and cause foliation. At low pressure, foliation forms fine, thin layers, as in the rock slate. At medium pressure, foliation becomes coarser, forming schist. At high pressure, foliation is very coarse, forming gneiss. Commonly, the layering is folded in complex, wavy patterns from the pressure.

VARIETIES

CLASSIFICATION BASED ON THE PHYSICAL FORM

Rocks are also classified as stratified and un-stratified, depending on their structure. Igneous and metamorphic rocks are un-stratified, that is, they are not arranged in any definite form in layers, or strata, but have the constituent parts mingled together.
The sedimentary rocks are stratified, or formed in a series of parallel layers, as they are deposited from water. The layers were originally horizontal, but in most cases they are found more or less inclined and curved on account of the action of disturbing forces. Sedimentary rocks are composed of grains bound together by a cementing medium, and their strength and durability depend on the nature of the cementing material.

CLASSIFICATION BASED ON THE CHEMICAL COMPOSITION.
Rocks may be further classified as siliceous, calcareous, and argillaceous, according to the chemical composition of the earth forming their main ingredients.

- In siliceous stones, silica is the principal earthy constituent;
- In calcareous stones, carbonate of lime is the predominating material;
- In argillaceous stones, alumina is the chief component.

QUARRYING OF STONES

The only operation involved in the production of natural stone is the quarrying process. The open part of the natural rock from which useful stone is obtained is known as quarry. While selecting a quarry site, the points to be borne in mind are availability of sufficient quantity of the stone of desired quality, proper transportation facilities, cheap local labor, problems associated with drainage of rain water, location of important and permanent structures in the vicinity and site for dumping refuse.

Stone Quarrying Tools
Some of the quarrying tools are wedge, pin, hammer, dipper or scraping spoon, tamping bar, priming needle, jumper, borer, claying iron, crow bar.

Methods of Quarrying

Rocks suitable for the manufacture of stone materials are called useful minerals and the operations involved in obtaining minerals are called mining. In the process of mining, voids formed are called excavations, and the mined deposits are the quarries. The purpose of quarrying is to

Obtain stones for various engineering purposes. A knowledge of various quarrying methods is essential but does not make one very much more competent to choose or specify a stone for building work. Depending upon the nature and surface of rocks and the purpose for which stones are needed, quarrying is done by excavating, wedging, heating or blasting.

Excavating: Stones buried in earth or under loose overburden are excavated with pick axes, crow bars, chisels, hammers, etc.
Wedging: This method of quarrying is suitable for costly, soft and stratified rocks such as sandstone, limestone, laterite, marble and slate.

About 10–15 cm deep holes, at around 10 cm spacing, are made vertically in the rock. Steel pins and wedges or plugs (conical wedges) and feathers (flat wedges) as shown in Fig. 3.4 are inserted in them. The latter arrangement of plugs and feather is better. These plugs are then struck simultaneously with sledge hammer. The rock slab splits along the lines of least resistance through holes. In case of soft rocks, dry wooden pegs are hammered in the holes and water is poured over them. The pegs being wet swell and exert pressure causing the rocks to crack along the line of holes. Then, the wedges are placed on the plane of cleavage (the joint of two layers) on the exposed face of rock and are hammered. The slab is completely detached and taken out with the help of crow bars and rollers. In this method, the wastage is minimum and the slabs of required size and shape can be quarried.

Heating is most suitable for quarrying small, thin and regular blocks of stones from rocks, such as granite and gneiss. A heap of fuel is piled and fired on the surface of rock in small area. The two consecutive layers of the rock separate because of uneven expansion of the two layers. The loosened rock portions are broken into

pieces of desired size and are removed with the help of pick-axes and crow-bars. Stone blocks so obtained are very suitable for coarse rubble masonry. Sometimes,
Intermediate layers are to be separated from the top and bottom layers. In such a case, the intermediate layer is heated electrically and the expansion separates it from the other two.

Blasting: Explosives such as blasting powder, blasting cotton, dynamite and cordite are used. The operations involved are boring, charging, tamping and firing.

Boring: Holes are drilled or bored in the rock to be dislodged. For vertical holes, jumper is used whereas for inclined or horizontal holes, boring bars are used. One person holds the jumper exactly in the place where hole is to be made. The other person strikes it up and down and rotates it simultaneously. Water is poured in the hole regularly during the operation to soften the rock and facilitate drilling. The muddy paste generated in the process is removed from holes by scrapping. For hard rocks, machine drilling is employed instead of hand drilling.

Charging The holes are dried completely and the required amount of charge is placed in the holes. For drying the holes, rag is tied in the scrapper and is moved in the hole from where it absorbs the moisture, if any. In case it is found that water is oozing into the hole, water-tightness is ensured inside thehole.

Tamping: After placing the charge in the hole, a greased priming needle, projecting a little outside the hole, is placed in the hole which is then filled up with damp clay or stone dust in layers tamped sufficiently with a braced tamping rod. The priming needle should be kept on rotating while tamping is going on. This is done so that the needle remains loose in the hole. The priming needle is then taken out and 60 to 75 per cent of space created by withdrawal of needle is filled with gun powder. A Bickford fuse, a small rope of cotton coated with tar, is placed just touching the needle. The other end of the fuse is kept of sufficient length so that the person igniting it can move away to a safe place. Blasting powder and cordite are ignited by means of a fuse, whereas gun cotton and dynamite are exploded by detonation.

<u>CHARACTERISTICS AND THEIR</u>

Precautions in Blasting: Accidents may take place during blasting. Following are some of the points which should be taken note of:

1. **Blasting should not be carried out in late evening or early morning hours. The blasting hours should be made public and a siren should warn the workmen and nearby public timely to retire to a safe distance.**

2. **The danger zone, an area of about 200 m radius, should be marked with red flags.**

3. **First aid should be available.**

4. **The number of charges fired, the number of charges exploded and the misfires should be recorded.**
5. **Explosives should be stored and handled carefully.**

6. **Detonators and explosives should not be kept together.**

7. **Cartridges should be handled with rubber or polythene gloves.**

8. **A maximum of 10 bore holes are exploded at a time and that also successively and not simultaneously.**

Types of Dressing of Stones:
The different types of dressing of stones are,
1. Hammer Dressed or Quarry-faced Surface
2. Rough tooled surface
3. Tooled Surface
4. Cut stone Surface

5. Rubbed Surface
6. Polished Surface
The details of types of dressing of stones are as follows,

1. Hammer Dressed or Quarry-faced Surface:
This is the roughest form of surface finish. Stone as removed from the quarry has large projections which are knocked off with the quarry hammer and it is finally broken up into blocks of suitable size and shape such as khandki, quoin, or rectangular blocks, The faces of the blocks arc roughly planned and the stone is rendered suitable to be used in masonry. When used in a wall, the roughly finished surfaces arc further modified by forming a 2 cm. to 5 cm. wide margin about the edges of the exposed face.

2. Rough tooled surface:
In this type of surface finish, the projection of the stone block are removed by means of chisels and the surface is nearly dressed true. The corners and the edges are made accurate, chisel draughted margins sunk and the side and bed joints roughly treated to ensure proper bonding.

3. Tooled Surface:
In this type of surface finish continuous parallel chisel marks are produced throughout the width of the stone. The parallel corrugations or chisel marks are made at closer intervals rendering the surface truly planned. Different types of tooled finishes are obtained by use of different chisel and marking patterns.

4. Cut stone Surface:
In this type of surface finish the surface is dressed by using a, sharp chisel so that the chisel marks are practically imperceptible. It is considered superior to tooled surface.

5. Rubbed Surface:
This type of surface finish is obtained by grinding or rubbing a cut stone surface by hand or machine until it gets perfectly smooth.

6. Polished Surface:
The rubbed surfaces of granite, marble of lime stones are polished to enhance their texture. Polishing may be done by manual labor using sand and water, pumice stone etc. or by rubbing machine.

USES OF STONES
Use of stone as building material depends upon the nature of the work, type of the structural element in which it is to be used and its quality, availability and transportation cost. For structural purpose, granite, gneiss, trap, sandstone, limestone, marble, quartzite and slate are most useful.

On the basis of the method of manufacture, items and materials from natural stones are classified as Sawn— obtained either from massive rocks by stone-cutting and stone-splitting machines (large stones) or from semi-product blocks by appropriate working (facing slabs, windows sill slabs, etc.); Split—obtained by splitting and finishing blocks (curb stones, paving blocks, etc.); Roughly split—manufactured by oriented splitting of blocks (bedded stone); Fractured—produced by blasting rocks and separating finer sizes (quarry stone); Crushed—produced by crushing and screening (crushed stone, artificial sand) and; Ground—obtained by grinding rocks (ground mineral powder, stone powder).

Foundation and Wall Items: Quarry, split and sawn stones from rocks are used to erect the substructure of buildings. Piece stones sawn and split from limestone, sandstone, dolomite and volcanic tuff are used for walls, piers, abutments, etc.

Facing and Architectural Items: Facing slabs and stones, stairs and landings, parapets, etc. are made of slabs sawn or split from semi-finished product blocks with glossy, dull, ground, sawn, pointed, fluted or rock finish. Facing slabs of granite, gabbro, basalt, marble, breccia, limestone, sandstone and volcanic tuff are generally used.

Building Items: Elements of stairs, landings, parapets and guard rails are manufactured from granite, marble, limestone, tuff, etc. Pedestal slabs and stones for farming doorways, cornices and window-sill slabs are made from the same material as the facing slabs.

Road Construction Items: Curb stones—intended to separate roadways from sidewalks; Paving blocks—used for pavements; Cobble stone—used to reinforce slopes of earth works and banks of water basins; Crushed stone—a mixture of jagged stone fragments (< 70 mm); Gravel—loose agglomeration of rock fragments (70 mm) and Sand—loose mass of mineral and rock particles (0.14–5 mm) obtained from natural stone are used in road construction.

Underground Structures and Bridges are built of slabs and stones from igneous and sedimentary rocks. Tunnels and above-water elements of bridges are built of granite, diorite, gabbro and basalt. Face stones and facing slabs for tunnels and bridges are given rock face, grooved or fluted finishes.

Heat and Chemically Resistant Items are manufactured from non-weathered rocks. For high temperature working conditions, they are made from chromite, basalt, andesite and tuffs. Building elements are protected against acid (except hydrofluoric acid and fluosilicic acids) by using slabs made of granite, syenite, and siliceous stones. Lime stones, dolomites, marble and magnesite show excellent resistance against alkalis. When high temperature and chemical attack is expected, crushed stone and sand for concrete and mortar are used.

CHARACTERISTICS OF GOOD BUILDING STONE

A good building stone should have the following qualities.

Appearance: For face work it should have fine, compact texture; light-colored stone is preferred as dark colors are likely to fade out in due course of time.

Structure: A broken stone should not be dull in appearance and should have uniform texture free from cavities, cracks, and patches of loose or soft material. Stratifications should not be visible to naked eye.

Strength: A stone should be strong and durable to withstand the disintegrating action of weather. Compressive strength of building stones in practice range between 60 to 200 N/mm^2.

Weight: It is an indication of the porosity and density. For stability of structures such as dams. Retaining walls, etc. heavier stones are required, whereas for arches, vaults, domes, etc. light stones may be the choice.

Hardness: This property is important for floors, pavements, aprons of bridges, etc. The hardness is determined by the Mohr scale

Toughness: The measure of impact that a stone can withstand is defined as toughness. The stone used should be tough when vibratory or moving loads are anticipated.

Porosity and Absorption: Porosity depends on the mineral constituents, cooling time and structural formation. A porous stone disintegrates as the absorbed rain water freezes, expands, and causes cracking.

<u>TESTING</u>

Building stones are to be tested for their properties. Following are the tests conducted on stones:

1. Acid Test:

Here, a sample of stone weighing about 50 to 100 gm is taken. It is placed in a solution of hydrophobic acid having strength of one percent and is kept there for seven days. Solution is agitated at intervals. A good building stone maintains its sharp edges and keeps its surface free from powder at the end of this period. If the edges are broken and powder is formed on the surface, it indicates the presence of calcium carbonate

and such a stone will have poor weathering quality. This test is usually carried out on sandstones.

1. Attrition Test:

This test is done to find out the rate of wear of stones, which are used in road construction. The results of the test indicates the resisting power of stones against the grinding action under traffic.

The following procedure is adopted:

i. Samples of stones is broken into pieces about 60mm size.

ii. Such pieces, weighing 5kg are put in both the cylinders of Devil's attrition test machine. Diameter and length of cylinder are respectively 20cm and 34 cm.

iii. Cylinders are closed. Their axes make an angle of 30 degree with the horizontal.

iv. Cylinders are rotated about the horizontal axis for 5 hours at the rate of 30 rpm.

v. After this period, the contents are taken out from the cylinders and they are passed through a sieve of 1.5mm mesh.

vi. Quality of material which is retained on the sieve is weighed.

vii. Percentage wear worked out as follows:

Percentage wear = $\frac{\text{Loss in weight}}{\text{Initial weight}} \times 100$

1. Crushing Test:

Samples of stone is cut into cubes of size 40x40x40 mm. sizes of cubes are finely dressed and finished. Maximum number of specimen to be tested is three. Such specimen should be placed in water for about 72 hours prior to test and therefore tested in saturated condition.

Load bearing surface is then covered with plaster of Paris of about 5mm thick plywood. Load is applied axially on the cube in a crushing test machine. Rate of loading is 140 kg/sq.cm per minute. Crushing strength of the stone per unit area is the maximum load at which the sample crushes or fails divided by the area of the bearing face of the specimen.

1. Crystalline Test:

At least four cubes of stone with side as 40mm are taken. They are dried for 72 hrs. And weighed. They are then immersed in 14% solution of Na_2SO_4 for 2 hours. They are dried at 100 degree C and weighed. Difference in weight is noted. This procedure of drying, weighing, immersion and reweighing is repeated at least 5 times. Each time, change in weight is noted and it is expressed as a percentage of original weight.

Crystallization of $CaSO_4$ in pores of stone causes decay of stone due to weathering. But as $CaSO_4$ has low solubility in water, it is not adopted in this test.

1. Freezing and thawing test:

Stone specimen is kept immersed in water for 24 hours. It is then placed in a freezing machine at -12 dig for 24 hours. Then it is thawed or warmed at atmospheric temperature. This should be done in shade to prevent any effect due to wind, sun rays, rain etc. this procedure is repeated several times and the behavior of stone is carefully observed.

1. Hardness Test:

For determining the hardness of a stone, the test is carried out as follows:

i. A cylinder of diameter 25mm and height 25mm is taken out from the sample of stone.

ii. It is weighed.

iii. The sample is placed in Dorry's testing machine and it is subjected to a pressure of 1250 gm.

iv. Annular steel disc machine is then rotated at a speed of 28 rpm.

v. During the rotation of the disc, coarse sand of standard specification is sprinkled on the top of disc.

vi. After 1000 revolutions, specimen is taken out and weighed.

vii. The coefficient of hardness is found out from the following equation:

Coefficient of hardness = $20 - \dfrac{\text{Loss of weight in gm}}{3}$

1. Impact Test:

For determining the toughness of stone, it is subjected to impact test in a Page Impact Test Machine as followed:

i. A cylinder of diameter 25mm and height 25mm is taken out from the sample of stones.

ii. It is then placed on cast iron anvil of machine.

iii. A steel hammer of weight 2kg is allowed to fall axially in a vertical direction over the specimen.

iv. Height of first blow is 1 cm that of second blow is 2cm that of third blow is 3 cm and so on.

v. Blow at which specimen breaks is noted. If it is nth blow, 'n' represents the toughness index of stone.

1. Microscopic Test:

The sample of the test is subjected to microscopic examination. The sections of stones are taken and placed under the microscope to study the various properties such as

i. Average grain size

ii. Existence of pores, fissures, veins and shakes

iii. Mineral constituents

iv. Nature of cementing material

v. Presence of any harmful substance

vi. Texture of stones etc.

1. Smith's Test:

This test is performed to find out the presence of soluble matter in a sample of stone. Few chips or pieces of stone are taken and they are placed in a glass tube. The tube is then filled with clear water. After about an hour, the tube is vigorously stirred or shaken. Presence of earthy matter will convert the clear water into dirty water. If water remains clear, stone will be durable and free from any soluble matter.

1. Water Absorption Test:

The test is carried out as follows:

i. From the sample of stone, a cube weighing about 50gm is prepared. Its actual weight is recorded as W_1 gm.

ii. Cube is then immersed in distilled water for a period of 24 hrs.

iii. Cube is taken out of water and surface water is wiped off with a damp cloth.

iv. It is weighed again. Let the weight be W_2 gm.

v. Cube is suspended freely in water and its weight is recorded. Let this be W_3 gm.

vi. Water is boiled and cube is kept in boiling water for 5 hours.

vii. Cube is removed and surface water is wiped off with a damp cloth. Its weight is recorded. Let it be W_4 gm.

From the above observations, values of the following properties of stones are obtained.

Percentage absorption by weight after 24 hours = $\dfrac{W_2 - W_1}{W_1} \times 100$

Percentage absorption by volume after 24 hours = $\dfrac{W_2 - W_1}{W_2 - W_3} \times 100$

Volume of displaced water = $W_2 - W_3$

Percentage porosity by volume = $\frac{W_4 - W_1}{W_2 - W_3} \times 100$

Density = $\frac{W_1}{W_2 - W_3} kg/m^3$

Specific Gravity = $\frac{W_1}{W_2 - W_3}$

Saturation Coefficient = $\frac{\text{Water absorption}}{\text{Total porosity}} = \frac{W_2 - W_1}{W_4 - W_1}$

BRICKS

Manufacturing of bricks:-

Manufacturing of bricks is carried out in four distinct operation:-

1) **Preparation of clay**
2) **Moulding**
3) **Drying**
4) **Burning**

1) *Preparation of clay*:-Preparation of clay is carried out in following distinct operations:-

1) **Unsoiling**
2) **Digging**
3) **Cleaning**
4) **Weathering**
5) **Blending**
6) **Tempering**

1) Unsoiling:-**It is the process in which top 200 mm of the soil is removed as it is practically not possible to carry out the cleaning of this soil.**

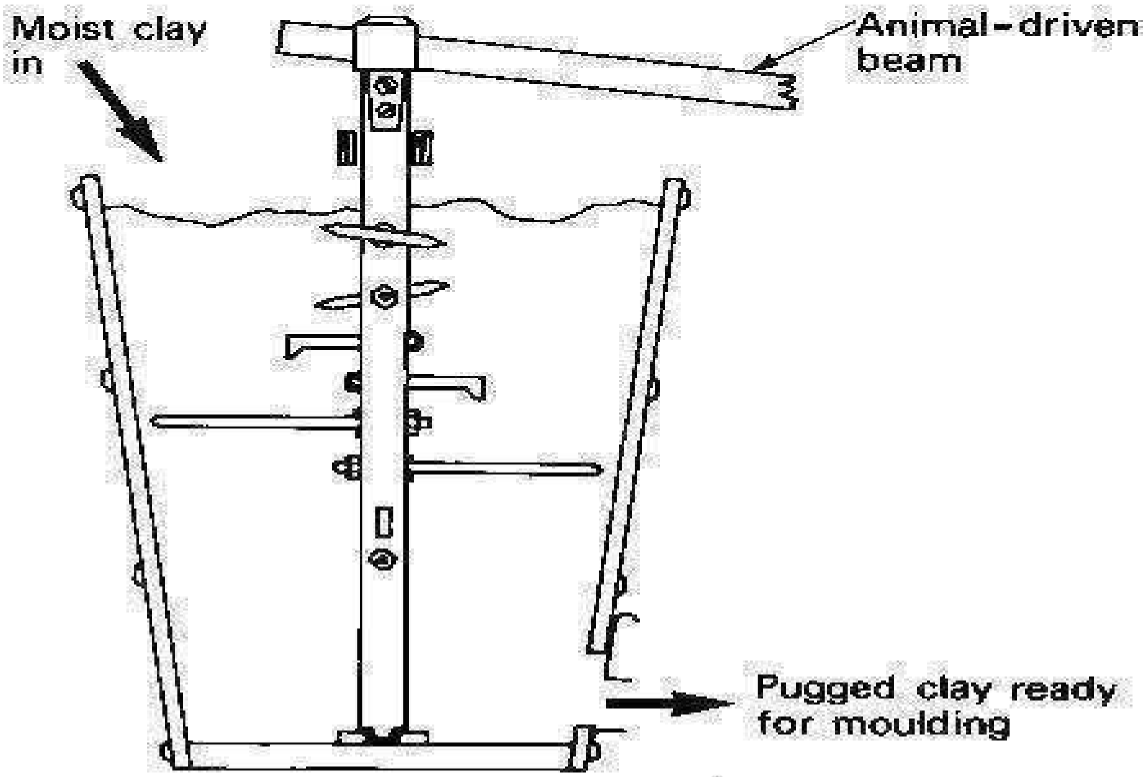
2) Digging: - **The remaining soil is dug out and spread over the level field this process is referred as digging.**

3) Cleaning**:-It is the process of removal of impurities from the soil in which it is being cleaned for the presence of stones, pebbles, organic matter or vegetative matter.**

4) Weathering:-**It is the process in which clean soil is exposed to the atmosphere for few weeks to few months in order to carry out its softening, mellowing or ripening.**

5) Blending:-**It is the process in which clay is made loose and any ingredient of it is in deficiency spread over it.**

6) **Tempering:-It is the process in which water is added in the clay in order to bring it up to required plasticity as is required for the next operation of moulding. Tempering is generally carried out in pug mill.**



2) ***Moulding: -*** It is the process of giving the required shape and size to the bricks. Moulding can be done either manually or mechanically. If moulding is done manually it is referred as hand moulding and if it is done mechanically it is referred as machine moulding. Moulding is done with the help of moulds which may be of steel or wood. The size of the mould is kept to be 8-12% greater than the actual size of brick in order to account for the shrinkage during drying and burning process. An indentation mark referred as Frog is left over the bricks during moulding that serves the following purposes:-

a) **It is used to indicate the trade name of the manufacturer.**

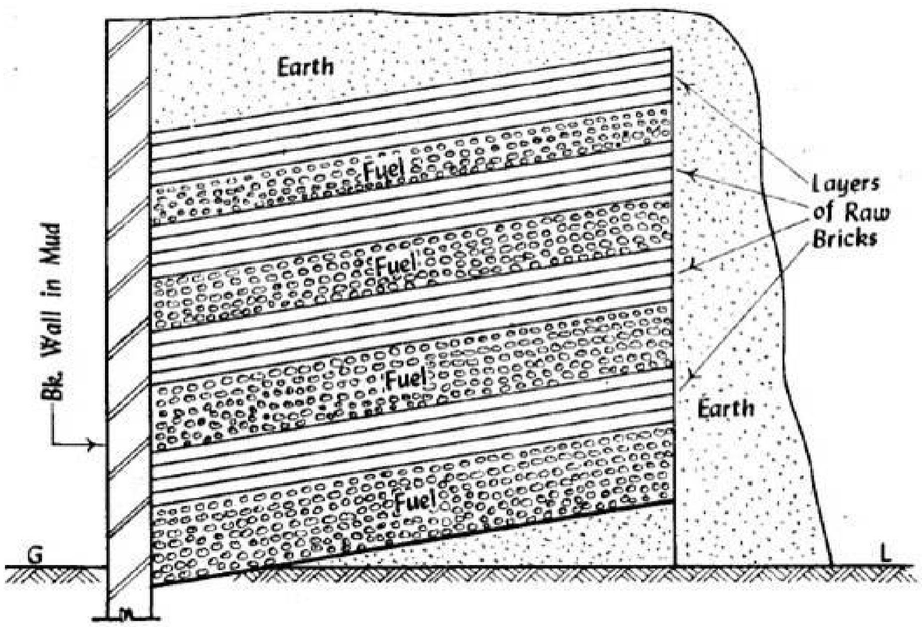
b) **It acts as a key for motor it is used in between the bricks.**
Increasing order of moulding is preferred as follows:-

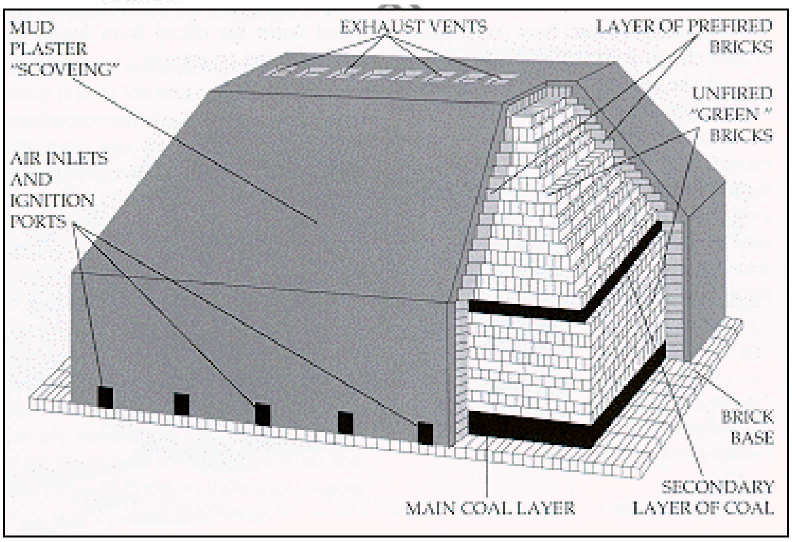
1) **Dry Clay moulding**
2) **Plastic Clay moulding**
3) **Table moulding**
4) **Ground moulding**

c) ***Drying: -*** **Damp bricks if burnt directly are liable to crack and disintegrate, hence after moulding bricks are subjected to drying before subjecting it to the next operation of burning. Drying can be carried out other naturally or artificially in such a way that moisture content of bricks is reduced up to 2%.During drying which must be placed along the edge and not along the surface.**

d) ***Burning:-*****It imparts strength and hardness to the brick and makes it more durable and dense Burning of bricks should be carried out properly as if bricks are over burnt, they become brittle and breaks easily, and if they are under burnt they remain soft and weak and are not able to carry the required load. Burning of the bricks takes place in the temperature range of 900 to 1200^{0}centigrade at which Alumina and silica fuse with each other thereby imparting strength to the bricks. Burning of the bricks can be carried out either in clamps or kilns**

A) ***Clamps:-*****In order to prepare the clamps, a suitable piece of land is selected which is generally trapezoidal in plan. The shorter side is kept in excavation and the longer side is raised by an angle of 15 degree. A brick wall in mud is constructed along the shorter side and a layer of locally available fuel of thickness 700 mm to 800 mm is applied over the area. Which is further followed by the application of brick over it in the layer of approximately 5-6 courses is further followed by the application of fuel over it.Hence the entire clamp consists of alternate layer of fuel and bricks. The total height of Clamp is in the range of 3-4 Mt. and when 1/3rd of the clamp is constructed, fuel in** the lower layer is burnt along with the subsequent construction of the clamp in upper layer. When the entire clamp is constructed it is covered with mud lining in order to avoid the escape of the heat through it.Bricks are allowed to burnt in it for the period of 2 to 4 weeks and further followed by the cooling of bricks for the same duration. As gradual burning and cooling of bricks is insured in this case bricks obtained from the clamps are comparatively stronger. More skilled supervision is required in this case and locally available fuel is used due to which this process is comparatively economical. Bricks obtained from the clamp are not of regular shape and size as there is no control over the burning in this case quality of brick obtained is not uniform. It is the time consuming process.**





B) *Kilns:-*Kilns are larger ovens which are used for the burning of the bricks. Depending upon the supply of the brick obtained from this kilns they are classified into two:-

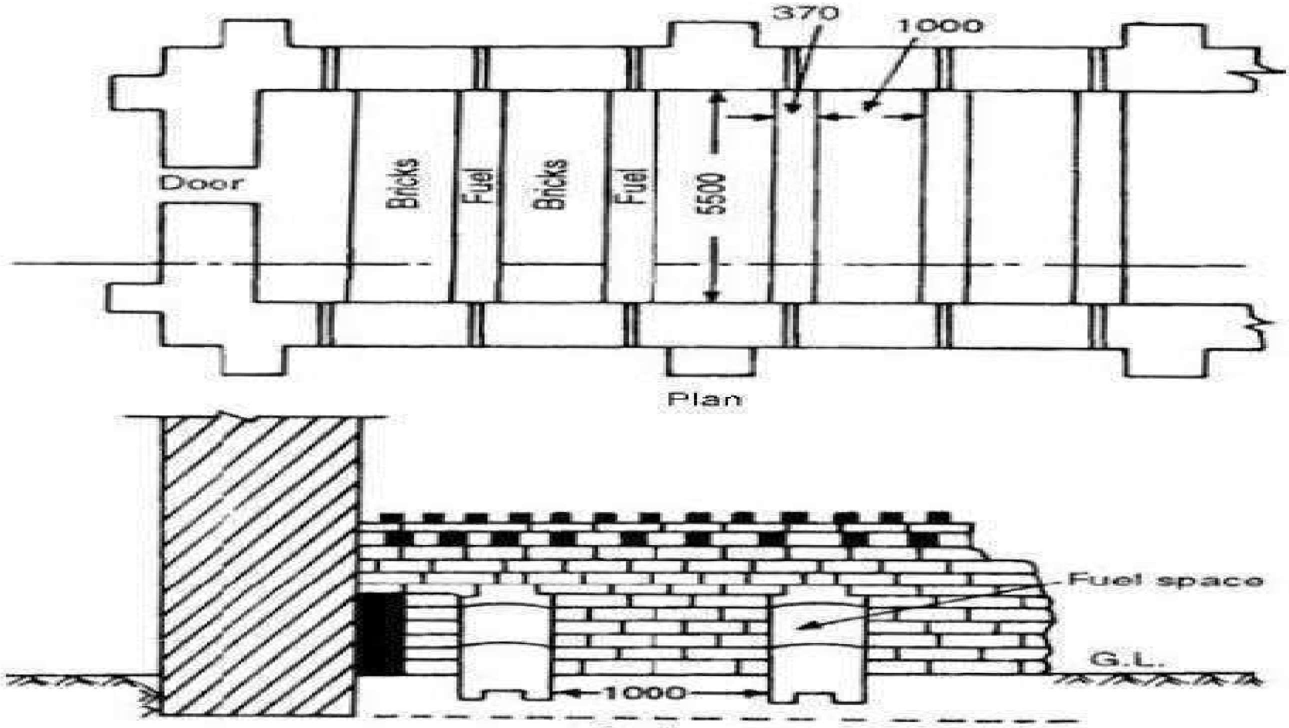
1) **Intermittent kilns**
2) **Continuous kilns**

1) *<u>Intermittent kiln:-</u>* These may be over ground or underground and they are classified into types:-

a) Intermittent up drought kiln

b) Intermittent down drought kiln

a) <u>Intermittent up-drought kiln</u>: **- These kilns are in the form of rectangular structure with thick outside walls. Flues are provided to carry Flames of hot gases through the body of kiln. Top course is finished with flat bricks. Other courses or formed by placing bricks on edge. Strong fire is maintained for period of 48 to 60 hours.3**



Section

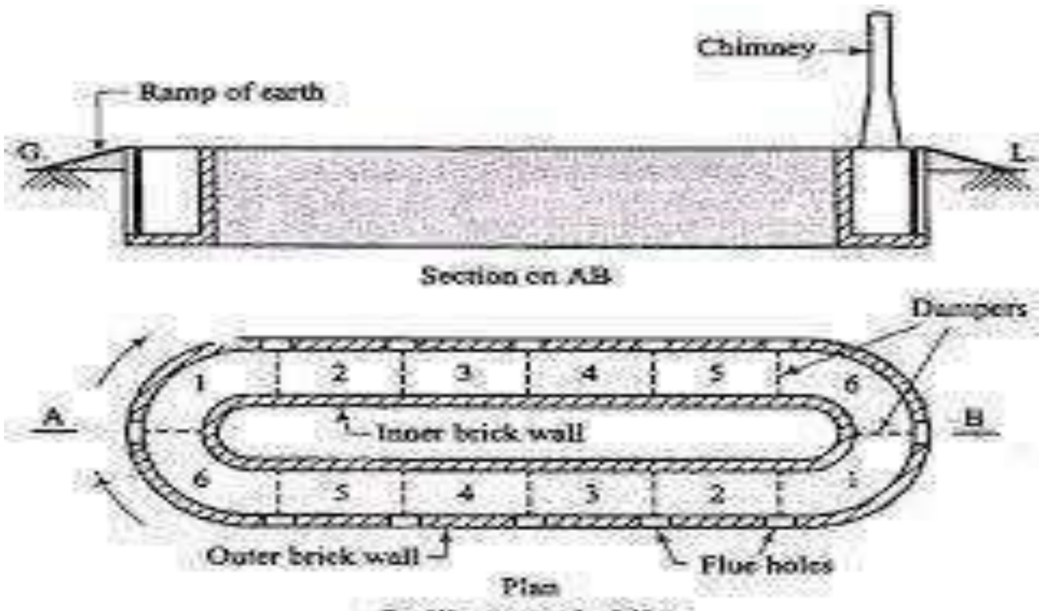
- **Disadvantage:-**
  1) **The quality of burnt brick is not uniform. The brick near the bottom are over burnt and those near the top are under burnt.**
  2) **The supply of brick is not continuous.**
  3) **There is wastage of heat as kiln is to be cool down every time after burning**

b) ***Intermittent down-drought kiln*:-These kilns are rectangular or circular in shape. They are provided with permanent walls and closed tight roof. The working of this is more or less similar to the up-drought kiln but it is so arranged in this kiln that hot gases are carried through vertical flues up to the level of roof and they are then released. These hot gases move downward by the chimney drought and in doing so, they burnt the bricks.**

- **Advantages:-**
  1) **Brick are evenly burnt.**
  2) **The performance of this kiln is better than that of up-drought kiln.**
  3) **There is closed control of heat and hence such kilns are useful for burning structural clay tiles, Terracotta etc.**

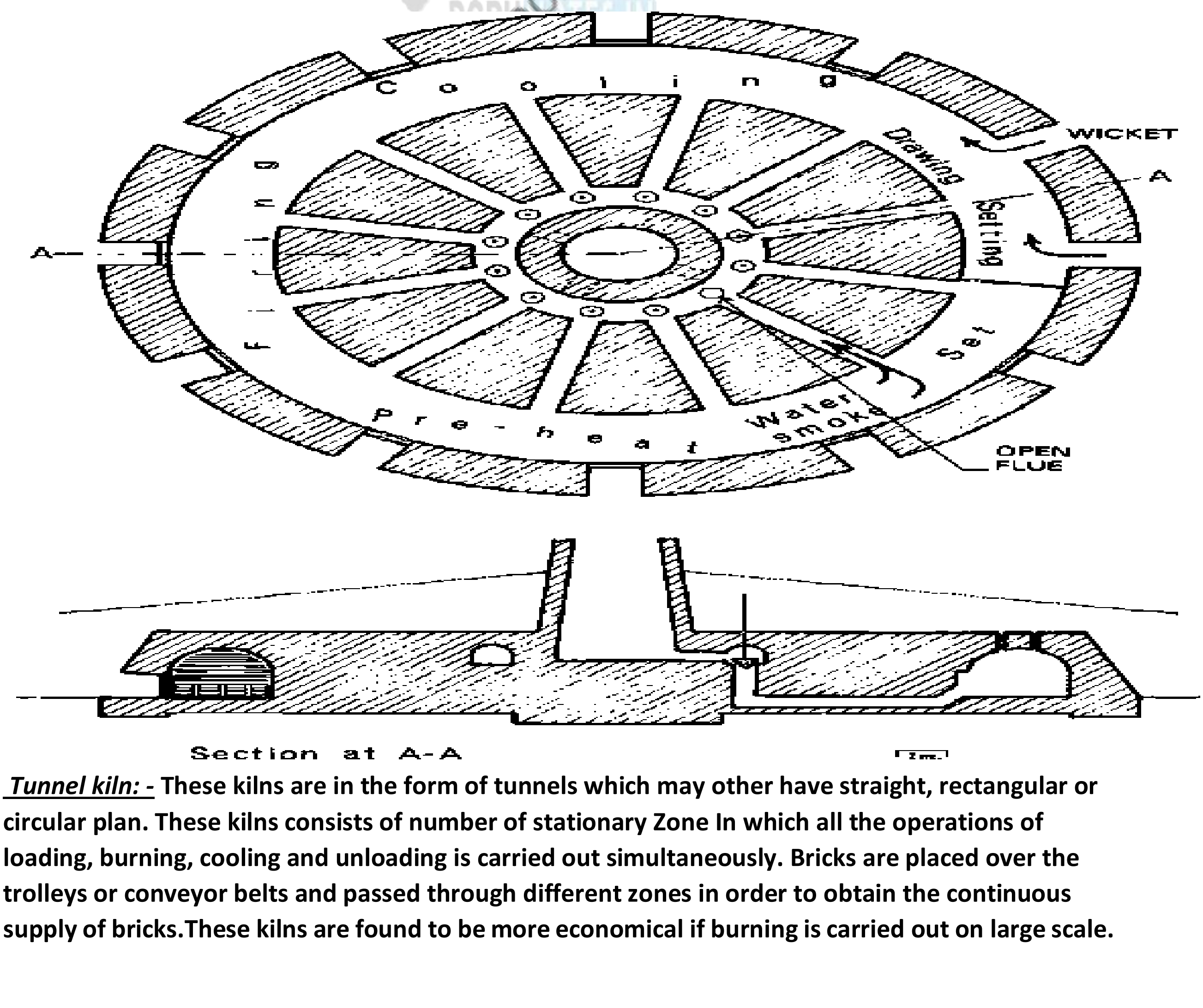
2) ***Continuous kilns:-*These are the type of kilns in which supply of the bricks is ensured to be continuous as all the operations of loading, burning, cooling and unloading are carried out simultaneously. These kilns are further of three types:-**
   1) **Bull Trench kiln**
   2) **Hoffman kiln**
   3) **Tunnel kiln**

1) ***Bull Trench kiln*:-These kilns are either rectangular, circular, oval in plan and are constructed in excavation either partially or fully. In these kilns continuous supply of the bricks is ensured by carrying out all the operations of loading, burning, cooling and unloading simultaneously in different sections. It consists of two sets of movable chimneys which are placed one section ahead of the section in which burning is to be carried out which ensures preheating of the brick placed in the section over which Chimney is kept.**

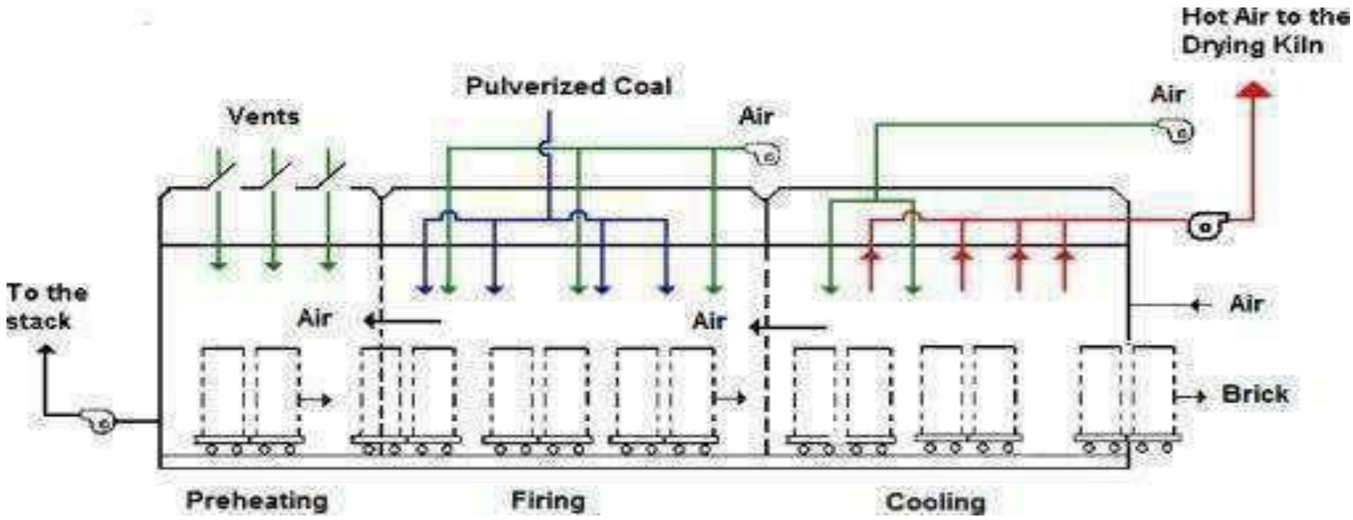


Bull's trench kiln
FIG. 4-6

2) ***Hoffman kiln:-*** **The Kilns are circular in plan constructed above the ground. In these kilns supply of the brick is ensure to be continuous by carrying out all the operations loading, burning, cooling and unloading simultaneously in different Chambers by effectively closing and opening different sets of Doors provided in a chamber the capacity of these kilns are comparatively greater than Bull Trench kiln.**



3) ***Tunnel kiln: -*** **These kilns are in the form of tunnels which may other have straight, rectangular or circular plan. These kilns consists of number of stationary Zone In which all the operations of loading, burning, cooling and unloading is carried out simultaneously. Bricks are placed over the trolleys or conveyor belts and passed through different zones in order to obtain the continuous supply of bricks.These kilns are found to be more economical if burning is carried out on large scale.**



CHARACTERISTIC OF GOOD BRICKS

1) **The bricks should be at least table molded, free from cracks and should have uniform bright colour.**
2) **The brick should be of uniform shape and size (Dimension test). Standard or modular size of the brick is 19 CM x 19 CM x 9 CM.**
3) **Size of conventional brick is 23 CM X 11.4 CM X 7.60 CM**
4) **Weight of 1m^3 of brick is approximately 1800 kilogram hence the weight of one brick is approximately 3-3.5 kilogram.**
5) **The bricks must produce clear ringing sound when struck with each other (soundness test)**
6) **The brick must have uniform structure across any section free from voids(structure test)**
7) **BRICKS must not absorb more than 20% of the water by weight when immersed in water for 24 hours. For 1st class brick and not more than 22 % for second class bricks(Absorption test)**
8) **The bricks must not show any sign of staining when immersed in water for 24 hours (alkali test)**
9) **The BRICKS must possess minimum compressive strength of 3.5 N/mm^2(strength test)**
10) **The brick must not break into pieces when dropped over the hard surface from the height of 1 M (toughness test).**
11) **The brick must not show any sign or indentation mark over its surface when is scratched with finger nail (hardness test).**

Note:-

- **With increase in percent of silica, resistance of the brick against the action of acids increases.**
- **With the increase in percentage of magnesia resistance of bricks against the action of bases increases.**
- **With the increase in percent of Alumina and chromite neutral bricks are formed.**

Use:-Bricks are used for building, block paving and pavement. Bricks in the metallurgy and glass industries are often used for lining furnaces, in particular refractory bricks such as silica, magnesia, chamotte and neutral (chromo magnesite) refractory bricks. This type of brick must have good thermal shock resistance, refractoriness under load, high melting point, and satisfactory porosity. Engineering bricks are used where strength, low water porosity or acid (flue gas) resistance are needed.

IMPROVED BRICK FROM INFERIOR SOILS

1) Manufacture of bricks from alumina red mud:-

Developed by the Central Building Research Institute (CBRI) Roorkee, India.

Alumina red mud as a raw material for the brick-manufacturing industry

Alumina red mud or bauxite reject is one of the important inorganic waste materials obtained in large quantities from aluminium production plants. For the production of aluminium, bauxite ore is digested with caustic soda when most of the aluminium passes into solution as aluminate. The red colour residue, consisting mainly of alumina, iron oxide and titania with small quantities of silica, calcium oxide and alkali is

left over as a major reject of the process.

In countries where there are huge reserves of bauxite there is the possibility of a manifold expansion of the aluminium industry. Thus, alumina red mud is going to create similar problems, due to serious pollution and indiscriminate disposal, in the very near future to those which flyash is creating today.

The physical properties of red mud, such as the colloidal nature of particles, plasticity, water absorption, mouldability and chemical composition showing the presence of alumina, iron oxide and fluxes, indicate the suitability of red mud to be disposed of in large quantities and used in the brick-making industry (or for flooring tiles). The suitability of red mud, to be used for the brick-making industry, is proved by the fact that only a slight modification, by incorporating some siliceous materials in the composition of red mud, is required. The Central Building Research Institute (CBRI) has carried out laboratory and field trials for making building bricks out of red mud supplied from three different aluminium plants in India. The test results show that the physical properties of bricks made by hand-moulding or extrusion are similar to normal building bricks. In many cases a very high compressive strength is obtained due to better fluxing action that is produced by the red mud. The bricks can be made and dried in the usual way and fired in any type of traditional brick kilns.

2) Manufacture of bricks from red murrum soil:-Developed by the Central Building Research Institute (CBRI), Roorkee, India. Red murrum soils present difficulties in producing good quality bricks due to their coarse, highly siliceous and non-plastic nature, short vitrification range and lime-bursting. Generally, bricks produced out of red murrum soils are porous and of low strength (20-25 kg/cm^2). The Central Building Research Institute (CBRI) has been studying the murrum soil of Hyderabad for some time and has developed processes for making bricks of a compressive strength in the range of 100 kg/cm^2 fromit.

CONCRETE

Concrete is a composite, manmade material and is most widely used building material in the construction industry. It is a mixture of binding material such as lime or cement, well graded coarse and fine aggregate, water and sometimes admixture. Basic requirements of good concrete is that it should be satisfactory in its hardened state and also in its fresh state while being transported from mixture and placed in formwork. In fresh state consistency of mix should be such that it can be compacted by Desire means without excessive effort and also the mix should be cohesive enough for the methods of transporting and placing used so as not to cause segregation. In hardened state satisfactory compressive strength and an adequate durability is required.

INGREDIENTS OF CONCRETE

Concrete is a mixture of cement, aggregate and water and the function of ingredients are as follows:-

a) *Cement:-*It imparts adhesive and cohesive property to concrete and binds various ingredients into a compact whole
b) *Aggregate:-*They form body of concrete and occupy 70 to 80% volume of concrete they further classified as fine and coarse aggregate
c) *Water:-*It causes hydration of cement for uniform strength of concrete.

GRADES OF CONCRETE

M5 - 1:5:10	M7.5 - 1:4:8
M10 - 1:3:6	M15 - 1:2:4
M20 - 1:1.5:3	M25 - 1:1:2

PRODUCTION OF CONCRETE

The various stages of concrete production are:-

1) Batching or measurement of materials
2) Mixing
3) Transporting
4) Placing

5) Compacting
6) Curing
7) Finishing

1) ***Batching:-*** Aggregates cement and water should be measured with an accuracy of ±3% of batch quantity and the admixture by 5% of the batch quantity. Two methods of batching of materials
   1) Volume batching
   2) Weight batching

   For important works weigh batching is preferred. Volume batching is used for small jobs only. Volume of 1 bag of cement is 0.035 M^3or (sometimes also said 35litre)

2) ***Mixing***:-Mixing is done to obtain homogeneous and uniform colour concrete having desired strength. Mixing time depends on type and capacity of mixer but IS 456 suggest approximately mixing time as 2 minute. If mixing time is increased to 2 minutes the compressive strength of concrete produced is enhanced and beyond this time the improvement in compressive strength of concrete is insignificant and prolonged mixing may cause segregation as due to longer mixing period the water may get absorbed by the aggregates or evaporation resulting in loss of workability and strength. Mixing is done by hand or by machine mixing. Hand mixing is done for smaller jobs. Machine mixing is done for large work

3) ***Transporting:-*** Specifications states that process of mixing, transporting, placing and compacting of concrete should not take more than initial setting time of cement that is 30 minute if using OPC. It must also ensure that segregation not took place. The various methods of transporting of concrete are pans, wheelbarrows, power buggies, transit mixer, belt conveyor etc.

4) ***Placing:-*** Research has shown that delayed placing of concrete results in gain in ultimate compressive strength provided the concrete can be adequately compacted. For dry mixes in hot weather delay of half to one hour is allowed whereas for wet mixes in cold weather it may be several hours. for example:- Mass concreting:- when a concrete is laid in mass as for raft Foundation, Dam, Bridge, piers etc. concrete is placed in layers of 350 to 450 mm thickness.

5) ***Compaction:-*** The process of removal of entrapped air and of uniform placement of concrete to form a homogeneous dense mass is termed compaction. The density and consequently the strength and durability of concrete depends upon the quality of compaction. The presence of even 5% and 10% voids in hardened concrete left due to incomplete compaction may results in decrease in compressive strength by about 30% and 60% respectively.

   Compaction of concrete can be achieved by the following
   1) Hand rodding
   2) High pressure and shock
   3) Centrifugation or spinning
   4) Mechanical vibration

6) ***Curing***:-Cement gains strength and hardness because of chemical reaction between cement and water. The water in a concrete mix takes one of the following three forms as a consequence of hydration:-
   1) ***Combined water***:-Which is chemically combined with the products of hydration it is non evaporable.
   2) ***Gel water:*** - Which is held physically or absorbed on the surface area of the cement gel.
   3) ***Capillary water:*** - Which partially occupies the 'capillary pores' that constitute the space in the cement paste remaining after accounting for the volumes of cement gel and unhydrated cement. This water is easily evaporable.

Curing is name given to procedures that are employed for actively promoting the hydration of cement in a suitable environment during early stages of hardening of concrete. IS: 456 define curing as the process of preventing the loss of moisture from the concrete while maintaining a satisfactory temperature regime. Curing of freshly placed concrete is very important for optimum strength and durability. The major part of the strength in the initial period is contributed by the clinker compound C_3S and partly by C_2S and is completed in about 3 weeks. Curing must be done for at least three week and in no case for less than 10 days. Increase in strength of concrete is very rapid from 3 to 7 days and continues slowly for indefinite period. It has to be observed that moist cured concrete for 7 days is nearly 50% stronger than that which is

exposed to dry air for entire period. If concrete is cured for 1 month strength is nearly double than that of concrete exposed to dry air.

Objective of curing:-

1) To keep capillary pores saturated, to ensure hydration of cement to increase durability and impermeability of concrete and reduce the shrinkage.
2) It improves wear resisting and weather resisting qualities.
3) To improve the loss of moisture from concrete due to evaporation or any other reason. Supply additional moisture or heat and moisture to accelerate the gain of strength.

Method of curing:-

1) Shading concrete work.
2) Covering concrete surface with wet hessian or gunny bags.
3) Sprinkling water on concrete surface
4) Ponding method: - it is best method and generally used in practice.
5) Steam curing: - recommended for precast concrete members.
6) Applying curing compound.

- As per IS: 456 concrete members shall be kept under curing of minimum period of 7 days. For OPC (7 to 14 days) at 90% humidity.
- Curing temperature: 5 ^{0}Cto 28^{0}C.

- NOTE: - Lower temperature reduces the rate of setting and higher temperature reduces ultimate strength.

Steam curing:-For concrete mixes with water cement ratio ranging from 0.3 to 0.7, the increased rate of strength development can be achieved by resorting to steam curing. This method of curing is also known as *accelerated curing* since an increased rate of strength development can be achieved. Concrete members are heated by and steam at 93^{0}C either at lower pressure or high pressure. By low pressure steam curing about 70% of 28 days compressive strength of concrete can be obtained in about 16 to 24 hours and high pressure steam curing is usually applied to precast concrete members and given 28 days compressive strength at 24 hours. It also results in increased resistance to sulphate action and to freezing and thawing. Mixes with low water cement ratio respond more favourable to steam curing than those with higher water cement ratio. Early rise in temperature at the time of setting of concrete may be detrimental because the green concrete may be too weak to resist the air pressure setup in the pores by the increased temperature. Rate of increase or decrease of temperature should not exceed 10 to 20 degree centigrade per hour to avoid thermal shock. Steam curing should be followed by water curing for a period of at least 7 days. This supplementary wet curing is found to increase the later age strength of steam cured concrete by 20 to 35%. Rapid gain of strength can be obtained with the help of infrared radiation then even with steam curing. Rapid initial rise of temperature does not affect the ultimate strength.

Effect of improper curing:-

1) Chances of ingress of chlorides and Chemicals are very high.
2) The cracks are formed due to plastic shrinkage.
3) The rate of carbonation increases.
4) The durability decreases due to high permeability.

7) *Finishing: -* Finishing is defined as the process of levelling and smoothing the top surface of freshly placed concrete to achieve the desired appearance.

SPECIAL CONCRETES

1) concrete Lightweight concrete

Lightweight concretes can either be lightweight aggregate concrete, foamed concrete or autoclaved aerated concrete (AAC). Lightweight concrete blocks are often used in house construction.

Lightweight aggregate

Lightweight aggregate concrete can be produced using a variety of lightweight aggregates. Lightweight aggregates originate from either:

- **Natural materials, like volcanic pumice.**
- **The thermal treatment of natural raw materials like clay, slate or shale i.e. Leca.**
- **Manufacture from industrial by-products such as fly ash, i.e. Lytag.**
- **Processing of industrial by-products such as pelletised expanded slab, i.e. Pellite.**

The required properties of the lightweight concrete will have a bearing on the best type of lightweight aggregate to use. If little structural requirement, but high thermal insulation properties, are needed then a light, weak aggregate can be used. This will result in relatively low strength concrete.

2) HIGH STRENGTH CONCRETE

The definition of high strength concretes is continually developing. In the 1950s a cube strength of 35MPa was considered high strength, and in the 1960s compressive strengths of up to 50MPa were being used commercially. More recently, compressive strengths approaching 140MPa have been used in cast-in-place buildings. Eurocode 2 allows for concrete strengths of up to 105MPa cube strength. There is no definition of high strength concrete in Eurocode 2, but the measures and formulae change when the concrete strength is greater than C50/60 so this seems a reasonable working definition.

3) High workability concrete

The workability of fresh concrete should be suitable for each specific application to ensure that the operations of handling, placing and compaction can be undertaken efficiently.

BS EN 206 and BS8500 the European and UK standards for concrete give guidance on workability for different uses. The handling and placing properties of concrete mixes can be improved considerably by the use of cement replacement materials such as fly ash. Furthermore, the use of admixtures such as water reducers and superplasticisers has beneficial effects on workability without compromising other concrete properties.

On site productivity can be greatly increased by utilising highly workable concretes. They are especially suitable in the following applications:

- **Inaccessible locations**
- **Large flat areas**
- **Underwater applications**
- **Pumping concrete over long distances.**

4) No-fines concrete

No-fines concrete is obtained by eliminating the fine material sand, from the normal concrete mix. The single-sized coarse aggregates are surrounded and held together by a thin layer of cement paste giving strength of concrete.

The advantages of this type of concrete are:

- **Lower density.**

- **Lower cost due to lower cement content.**
- **Lower thermal conductivity relatively low drying shrinkage.**
- **No segregation and capillary movement of water.**
- **Better insulating characteristics than conventional concrete because of the presence of large voids.**

No-fines concrete is not suitable for use in reinforced concrete.

5) Self-compacting concrete (SCC)

Self-compacting concrete (SCC) is a flowing concrete that does not require vibration and, indeed, should not be vibrated. It uses super plasticisers and stabilisers to significantly increase the ease and rate of flow. It achieves compaction into every part of the mould or formwork simply by means of its own weight without any segregation of the coarse aggregate.

The consistence of the concrete is specified and measured as a flow rate rather than the normal slump test. SCC offers:

- **Health and safety benefits (as no vibration is required).**
- **Faster construction times.**
- **Increased workability and ease of flow around heavy reinforcement.**
- **Excellent durability.**

Having no need for vibrating equipment spares workers from exposure to vibration. No vibration equipment also means quieter construction sites.

Unit 2

Timber ,Glass , Steel and Aluminum : Timber: Important timbers, their engineering properties and uses, defects in timber, seasoning and treatment, need for wood substitutes, ,Plywood, Particle Board ,Fibre Board, Applications of wood and wood products , Plaster Boards, Adhesives, types of Gypsum Board and their uses Glass: What is glass , Nature of Glass, Structure of Glass, Macro Molecular Structure, Main Oxides in Glass, Thermal and Optical Properties ,Effect of Coating, Steel : Physical Properties of Structural Steel, Grades of Steel Aluminum : Properties ,Forms ,Uses, Advantages

TIMBER

A tree basically consists of three parts namely,trunk,crown and roots. The function of the trunk is to support the crown and to supply water and nutrients from the roots to the leaves through branches and from the leaves back to the roots .the roots are meant to implant the trees in the soil, to absorb moisture and the mineral substances it contains and to supply them to the trunk.

Details of structure:

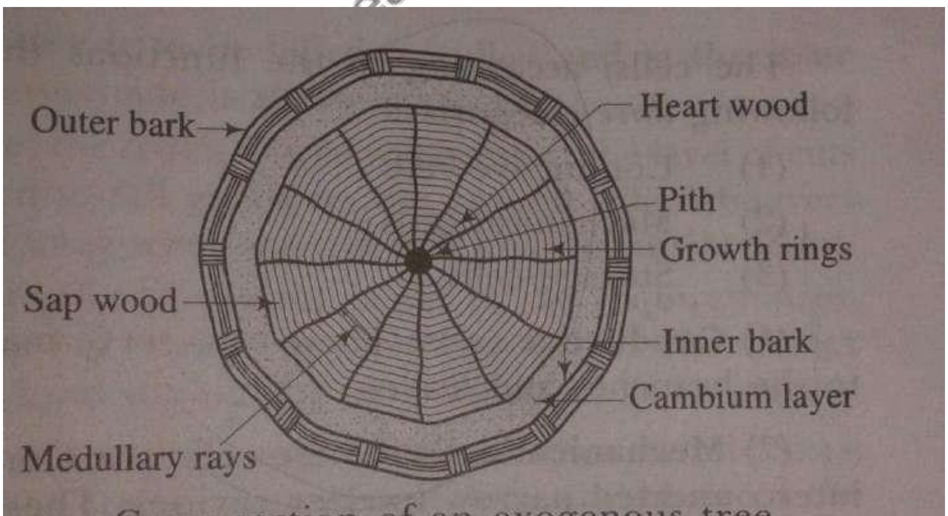
From the visibility aspect, the structure of tree can be divided into two categories :- (1).

Macrostructure

(2). Microstructure

Macrostructure:-

The structure of wood visible to the naked eye or at a small magnification is called the macrostructure. Following are its different components:



Cross-section of an exogenous tree

(1) Pith:

the innermost central portion of the core of the tree is called the pith or medulla. It varies in size and shape and for different types of trees. It consists entirely of cellular tissues and it nourishes its plant at its young age. When the plant becomes old, the pith dies up and decays and the sap is then transmitted by the woody fibers deposited round the pith. The pith of the branches is nothing but merely a prolongation of the stem.

(2) Heartwood:

The inner annular rings surrounding the pith constitute the heart wood. It is usually dark in color .as a matter of fact, it indicates the dead portion of tree and as such, it does not take active part in the growth of the tree. But it imparts rigidity to the tree hence it provides strong and durable timber for various engineering purposes.

(3) Sapwood:

The outer annular rings between heartwood and cambium layer is known as sapwood. It is usually light in color in light and weight. It indicates recent growth and it contains sap. The annual rings of sap wood are less sharply defined than those of heartwood. It takes active part in the growth of the tree and the sap moves in upward direction through it. The sapwood is also known as the laburnum.

(4) Cambium layer

The thin layer of sap between sapwood and inner bark is known as the cambium layer. It indicates sap which has not yet been converted into sap wood. If the bark is removed for any reason, the cambium layer gets exposed and the cells cease to be active resulting in the death of the fiber.

(5) Inner bark:

The inner skin or layer covering the cambium layer is known as the inner bark. It gives protection to the cambium layer from any injury.

(6) Outer bark

The outer skin or cover of the tree is known as the outer bark. It is the outermost protective layer and it sometimes contains cracks and fissures. It consists of cells and wood fiber and is also known as the cortex.

(7) Medullar rays

The thin radial fibers extending from pith to cambium layer are known as the medullar rays. The function of these rays is to hold together the annular rings of heartwood and sapwood. These rays are sometimes broken and in some varieties of trees, they are not very prominent.

Microstructure:

The structure of wood apparent only at great magnifications is called the microstructure.

A living cell consists of four parts namely membrane, protoplasm, sap and core. The cell membrane consists mainly of cellular tissues and cellulose. The protoplasm is a granular, transparent, viscous vegetable protein composed of carbon, hydrogen, oxygen, nitrogen and sulphur.The core of cell differs from protoplasm merely by the presence of phosphorus and it is generally oval.

The cells, according to the function they perform, are classified into the following three categories:

- Conductive cells

- Mechanical cells
- Storage cells

(1).conductive cells:

These cells serve mainly to transmit nutrient from root to the branches and leaves.

(2).mechanical cells

These cells are elongated, thickwalledand have tightly interconnected narrow interior cavities. These cells impart strength to the wood.

(3).storage cells:

These cells serve to store and transmit nutrients to the living cells in the horizontal direction and they are usually located in the medullar rays.

Defects in timber:

Various defects occurring in timber are grouped into following five **categories:**

(1) defects due to conversion
(2) defects due to fungi
(3) defect due to insects
(4)defects due to natural forces
(5)defects due to seasoning

Defects due to conversion:

During converting timber to commercial form the following defects may occur:

(i) **Chip *mark*:** this defect is indicated by marks placed by chips on the finished surface of timber .they may also be formed by parts of a planning machine.

(ii) **Diagonal grain**: this defect is formed due to improper sawing of timber. It is indicated by diagonal mark on straight grained surface of timber.

(iii) **Torn grain**: this defect is caused when a small depression is formed on the finished surface of timber by falling of a tool or so.

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

Defects due to fungi:

Fungi attack timber only when

(1) The moisture content of timber is above 20%.

(2) If there is a presence of air and warmth for the growth of fungi. Due

to attack of fungi following defects occur:

(i) **Bluestein:** the sap of the wood is stained to bluish colour by the action of certain type of fungi.

(ii) **Brown rot:** the fungi of certain types remove cellulose compound from wood and hence the wood assumes the brown colour. this is known as the brown rot.

(iii) **Dry rot:** the fungi of certain types feed on wood and during feeding ,they attack on wood and convert it into powder form. This is known as dry rot.

This type of defect occur in place where there is dampness and no free circulation of air.The dry rot may be prevented by using well seasoned timber free from sap.

(iv) **Heart rot:** this is formed when a branch has come out of a tree.It occurs when heart woodis exposed to atmospheric agent.

(v) **Sap stain:** certain types of fungi feed on cell contents of sap wood. In doing so ,the sap wood loses its colour. this is known as sap stain. It generally occurs when moisture content goes beyond 25 % or so.

(vi) **Wet rot:** some varieties of fungi cause chemical decomposition of wood of timber in doing so timber is converted into a grayish brown powder. This is known as wetrot.

(iv) **White rot:** this defect is opposite of brown rot. In this defect the wood assumes the appearance of a white mass consisting of cellulose compounds.

Defect due to insects:

Defects in timber occur due to various types of insects.

Such as:

(1) beetles

(2)marine borers

(3)termites

Decay of timber occurs due to the above insects.

Defect due to natural force:

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

(i) Burls: these are also known as the excrescences and they are particularly formed when a tree has received shock or injury in is young age. Due to such injury, the growth of tree is completely upset and irregular projections appear on the body of timber.

(ii) Callus: it indicates soft tissues or skin which covers the wound of a tree.

(iii) Chemical stain: the wood is sometimes discolored by the chemical action caused with it by some external agency.

(iv) Coarse grain: if a tree grows rapidly, the annual rings are widened. Such timber possesses less strength.

(v) Dead wood: the timber which is obtained from dead standing trees contains deadwood.

(vi) Druxiness: this defect is indicated by white decayed spots which are concealed by healthywood.

(vii) Foxiness: this defect is indicated by red or yellow tinge in wood or reddish brown stains or spots round the pith of tree discolouring the timber. It is caused due too poorventilation.

(viii) Knots: these are the bases of branches or limbs which are broken or cut off from the tree. The portion from which the branch is removed receives nourishment from the stem for a pretty long time and it ultimately results in the formation of dark hard rings which are known as the knots.

(ix) Rind galls: the rind means bark and gall indicates abnormal growth. Hence peculiar curved swelling found on the body of a tree known as the rind gall.

(x) Shakes: these are cracks which partly or completely separate the fibers of wood. Following are the different types of shakes: cup shake, heart shake, ring shake, star shake, radial shake.

(xi) Twisted fibres: these are also known as the wandering hearts and they are caused by twisting of young trees by fast blowing wind.

(xii) Upset: these are also known as the ruptures and they indicate the wood fibers which are injured by crushing or compression.

(xiii) water stain: the wood is sometimes discolored when it comes into contact with water. The defect is usually found in converted timber.

(xiv) Wind cracks: if wood is exposed to atmospheric agencies, its exterior surface shrinks. These are known as the wind cracks.

Defects due to seasoning:

Following defects occur in the seasoning process of wood.

(i) Bow: the defect is indicated by the curvature formed in the direction of length of timber.

(ii) case-hardening: the exposed surface of timber dries very rapidly. It therefore shrinks and is under compression. The interior surface which has not completely dried under tension. This defect is known as the case-hardening.

(iii) Check: a check is a crack which separates fibers of wood. It does not extend from one end to the other.

(iv) Collapse: due to uneven shrinkage, the wood sometime flattens during drying. This is known as collapse.

(v) Cup: this defect is indicated by the curvature formed in the transverse direction of timber.

(vi) Honey-combing: due to stresses developed during drying, the various radial and circular cracks in the interior portion of timber. This defect is known as honey-combing.

(vii) Radial shake: these are radial cracks.

(viii) Split: when a check extends from one end to the other, it is known as a split.

(ix) Twist: when a piece of timber has spirally distorted along its length, it is known as a twist.

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

TIMBER

TIMBER is the oldest material used by humans for construction after stone. Despite its complex chemical nature, wood has excellent properties which lend themselves to human use. It is readily and economically available; easily machinable; amenable to fabrication into an infinite variety of sizes and shapes using simple on-site building techniques;

- Exceptionally strong relative to its weight
- A good heat and electrical insulator
- It is a renewable and biodegradable resource.

However, it also has some drawbacks of which the user must be aware. It is a "**natural**" material and is available in limited amount.

Preservation:

Preservation of timber means protecting timber from fungi and insects attack so that its life is increased. Timber is to be seasoned well before application of preservatives. The following are the widely used preservatives:

1.Tar
2.Paints
3.Chemicalsalt
4.Creosote
5. ASCO

1. Tar

Hot coal tar is applied to timber with brush. The coating of tar protects the timber from the attack of fungi and insects. It is a cheapest way of protecting timber. Main disadvantage of this method of preservation is that appearance is not good after tar is applied it is not possible to apply other attractive paints. Hence tarring is made only for the unimportant structures like fence poles.

2. Paints

Two to three coats of oil paints are applied on clean surface of wood. The paint protects the timber from moisture. The paint is to be applied from time to time. Paint improves the appearance of the timber. Solignum paint is a special paint which protects the timber from the attack of termites.

3. Chemical salt

These are the preservatives made by dissolving salts in water. The salts used are copper sulphate, masonry chloride, zinc chloride and sodium fluoride. After treating the timber with these chemical salt paints and varnishes can be applied to get good appearance.

4. Creosote

Creosote oil is obtained by distillation of coal tar. The seasoned timber is kept in an air tight chamber and air is exhausted. Then creosote oil is pumped into the chamber at a pressure of 0.8 to 1.0 N/mm2 at a temperature of 50°C. After 1 to 2 hours timber is taken out of the chamber.

5. ASCO

This preservative is developed by the Forest Research Institute, Dehradun. It consists of 1 part by weight of hydrated arsenic pentoxide (As_2O_5, 2 H_2O), 3 parts by weight of copper sulphate. ($CuSO_4 \cdot 5\ H_2O$) and 4 parts by weight of potassium dichromate ($K_2Cr_2O_7$) or sodium dichromate ($Na_2Cr_2O_7 \cdot 2\ H_2O$). This preservative is available in powder form. By mixing six parts of this powder with 100 parts of water, the solution is prepared. The solution is then sprayed over the surface of timber. This treatment prevents attack from termites. The surface may be painted to get desired appearance.

Physical Properties:

Specific Gravity (SG):

Generally, specific gravity (SG) and the major strength properties of wood are directly related. SG for the major , usually used structural species ranges from roughly 0.30 to 0.90. Higher allowable design values are assigned to those pieces having narrower growth rings (more rings per inch) or more dense latewood per growth ring and, hence, higher SG.

Thermal Properties/Temperature Effects:

Although wood is an excellent heat insulator, its strength and other properties are affected adversely by exposure for extended periods to temperatures above about 100°F. The combination of high relative humidity or MC and high temperatures, as in unventilated attic areas, can have serious effects on roof sheathing materials and structural elements over and above the potential for attack by decay organisms. Simple remedies and caution usually prevent any problems.

At temperatures above 220°F, wood takes on a thermoplastic behavior. This characteristic, which is rarely encountered in normal construction, is an advantage in the manufacture of some reconstituted board products, where high temperatures and pressures are utilized.

Environmentally friendly

Timber is the most environmentally responsible building material. Timber has low production energy requirements and is a net carbon absorber. Timber is a renewable resource. Well- managed forests produce timber on a sustained continuous basis, with minimal adverse effects on soil and water values.

In plentiful and growing supply

Timber is readily available. Australia has significant forest resources including a plantation estate covering more than 1.6 million hectares, and the area is growing rapidly.

Strong and lightweight

Timber is strong, light and reliable making timber construction simpler and safer than steel or concrete construction. A comparison with steel and concrete shows that radiata pine structural timber, for example, has a strength for weight ratio 20 percent higher than structural steel and four to five times better than unreinforced concrete in compression. The lightweight structures possible in wood confer flow-on advantages in terms of reduced foundation costs, reduced earthquake loading and easier transport. Building components and complete constructions are simple and safe to erect, and cheaper to deconstruct or reuse at the end of a buildingís useful life.

Chemical Properties

Though, would is chemically inert as compared to other materials but is affected by some acids and bases. Some species have proven very useful for food containers (berry boxes and crates) because they are nontoxic and impart no taste to the foods contained therein. Wood structures have also found widespread use as storage facilities for salt and fertilizer chemicals

DRY ROT

The turning of timber tissues to almost dry powder by fungi is called dry rot.The fungus feed upon the wood and eats the wood tissue, thus penetrating the wood fibres from all direction.

Prevention:

1. well seasoned timber should be used.
2. timber should be used where there is free circulation and access of air.

Remedy:

1. the timber should be painted with a solution of copper sulphate

2.the high temperature of seasoning of kiln helps in killing the Fungi.

'**WET ROT** The disintegration of tissue of timber due to alternate wetting

and drying is called wet rot. The attacks take place through the wounds in

bark by the access of water.

Prevention:

All timber for exterior or underground work should
be first properly seasoned and then coated with tar to keep out the dampness.

Remedy:

The best remedy for treating wet rot is by using a suitable preservative Seasoning of

Timber

From day to day, most people have some contact with "seasoned" timber. From childhood days wooden cots and toys, to school desks and, eventually, to wooden furniture and flooring in homes or places of employment - seasoned timber is to be found. Yet how many people really understand what seasoned timber is?

Only when cracks appear in furniture or floor, or when a door shows some degree of warping, is any thought given to this concept. It is to be regretted that even some people associated with the timber trade have little knowledge of what seasoned timber is and the best method of obtaining it.

What is "seasoned" timber?

The process of drying out the water from "wet" or" green" timber is termed "seasoning", or more simply" drying". Water is just as essential to the life of a tree as it is for all living matter. Together with the various minerals, it enters through the roots of the tree and is carried in the sapwood - the outer woody part to the leaves. The food, that is the sugars and starch, are made in the leaves by photosynthesis and are transported in solution down the inner bark to the growing cells. The whole trunk of the tree is made up of cells, which are like small tubes, having walls of cellulose and a more or less hollow' cavity filled with water and other materials known as sap. Consequently, when the tree is felled and the resulting log is sawn into timber, the sawn sections consist of innumerable small cells containing water. Drying the moisture out of wood enhances its properties to such an extent that the resulting timber is given the special name "seasoned" rather than "dried" although the terms are identical.

Why is timber seasoned?

Seasoning timber causes many changes in its properties, and in practically every case the change is an improvement. There is only one principal disadvantage in drying timber, namely, the loss in volume due to shrinkage. However, by a correct understanding of the shrinkage of timber this effect can be minimized, and timber can then be confidently used without fear of adverse behavior subsequently in service.

Types of Seasoning

(i) Natural Seasoning**:** It may be air seasoning or water seasoning. Air seasoning is carried out in a shed with a platform. On about 300 mm high platform timber balks are stacked as shown in Fig. 1.8.

(ii)

Care is taken to see that there is proper air circulation around each timber balk. Over a period, in a natural process moisture content reduces. A well-seasoned timber contains only 15% moisture. This is a slow but a good process of seasoning. Water seasoning is carried out on the banks of rivers. The thicker end of the timber is kept pointing upstream side. After a period of 2 to 4 weeks the timber is taken out. During this period sap contained in the timber is washed out to a great extent. Then timber is stalked in a shed with free air circulation.

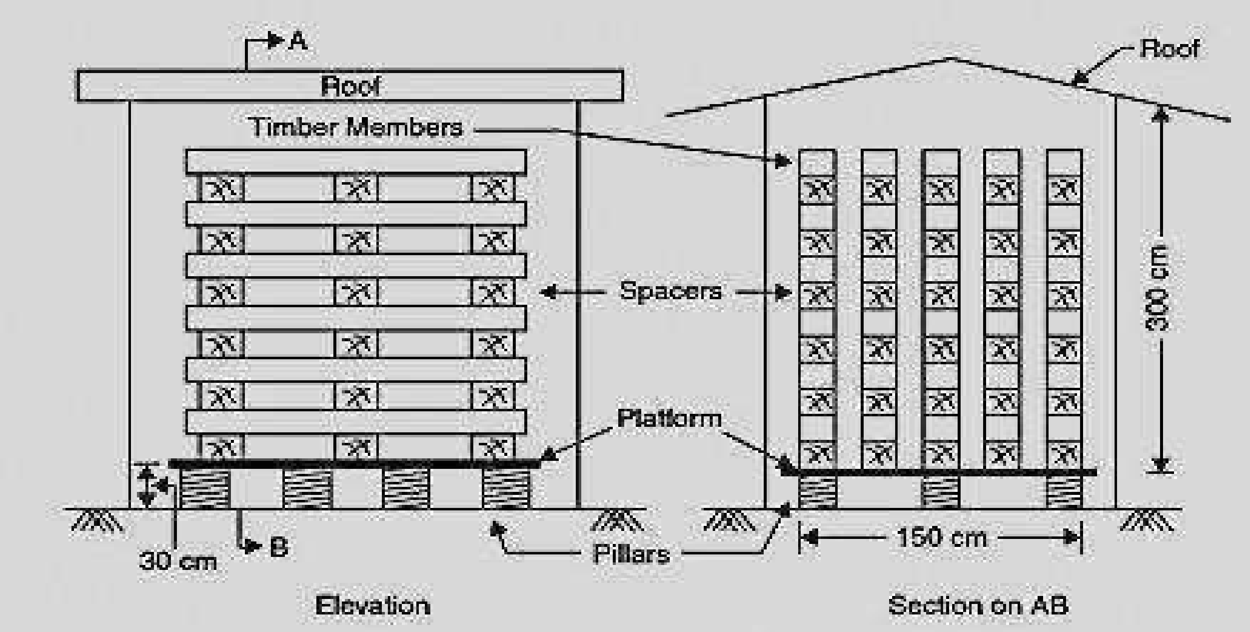


Fig. 1.8. Air seasoning

(iii) **Artificial Seasoning**: In this method timber is seasoned in a chamber with regulated heat, controlled humidity and proper air circulation. Seasoning can be completed in 4 to 5 days only.The different methods of seasoning are:

(a) Boiling
(b) Kiln seasoning
(c) Chemical seasoning
(d) Electrical seasoning.

(a) Boiling: In this method timber is immersed in water and then water is boiled for 3 to 4 hours. Then it is dried slowly. Instead of boiling water hot steam may be circulated on timber. The process of seasoning is fast, but costly.

(b) Kiln Seasoning: Kiln is an airtight chamber. Timber to be seasoned is placed inside it. Then fully saturated air with a temperature 35°C to 38°C is forced in the kiln. The heat gradually reaches inside timber. Then relative humidity is gradually reduced and temperature is increased, and maintained till desired degree of moisture content is achieved. The kiln used may be stationary or progressive. In progressive kiln the carriages carrying timber travel from one end of kiln to other end gradually. The hot air is supplied from the discharging end so that temperature increase is gradual from charging end to discharging end. This method is used for seasoning on a larger scale.

(c) Chemical Seasoning: In this method, the timber is immersed in a solution of suitablesalt.Then the timber is dried in a kiln. The preliminary treatment by chemical seasoning ensures uniform seasoning of outer and inner parts of timber.

(d) Electrical Seasoning: In this method high frequency alternate electric current is passed through timber. Resistance to electric current is low when moisture content in timber is high.

As moisture content reduces the resistance reduces. Measure of resistance can be used to stop seasoning at appropriate level.

However it is costly process. This technique has been tried in some plywood industries but not in seasoning of timber on mass scale.

Different methods of seasoning:

Air Seasoning

The traditional method for drying wood, air seasoning is also the longest, taking six to nine months. To air season wood, stack logs or planks outside on pallets in such a manner that air can circulate vertically and horizontally through the timbers. The raised pallets also keep wood away from vegetation and damp ground. Plank and log ends are often wrapped or sealed to prevent excessive moisture loss through these areas. Protect the drying wood from the elements with an overhead canopy.

Kiln Seasoning

The most common and effective commercial process for drying wood is kiln seasoning, which accelerates the process of removing moisture through the use of external energy. Drying takes two days to one weekend, depending on the type of wood. Two methods, progressive and compartmental, are used for kiln seasoning. In a progressive kiln, timber enters at one end and travels on a trolley through chambers with different air conditions to progressive dry the wood. This method produces a constant flow of seasoned timber. Wood seasoned via the compartmental process remains in a single building where it is subjected to a program of varying conditions until the moisture content is removed. This process is used for hard-to-dry or expensive wood.

Solar Kiln

This method combines the speed of kiln seasoning with the low energy of air drying. Solar kilns have single-thickness windows on the south side of the structure that work as collectors to trap the sun's energy. Heat collectors, made from black metal are attached near the top of the window sashes. Various methods force the heated air to circulate through the kiln to dry the wood. Some solar kilns have insulation to retain heat at night. This process takes approximately twice as long as traditional kiln seasoning. Because of its gentle nature, it is well suited to producing wood for furniture fabrication.

Microwave Seasoning

Microwave seasoning uses pulsed energy directed into timbers to drive out moisture in a manner that will not cause seasoning degrade. This method also provides advantages such as high speed and high quality and is well suited for seasoning lumber, blocks, veneer, chips, paper and wood-based composite materials. Areas in the wood with the most moisture absorb the most energy resulting in even temperature during the drying process and a uniform moisture content. These factors enhance quality and reduce timber checking and warping.

Advantages of seasoning:

Three most important advantages of seasoning have already been made apparent:

1. Seasoned timber lasts much longer than unseasoned. Since the decay of timber is due to the attacks of wood-destroying fungi, and since the most important condition of the growth of these fungi is water, anything which lessens the amount of water in wood aids in its preservation.

2. In the case of treated timber, seasoning before treatment greatly increases the effectiveness of the ordinary methods of treatment, and seasoning after treatment prevents the rapid leaching out of the salts introduced to preserve the timber.

3. The saving in freight where timber is shipped from one place to another. Few persons realize how much water green wood contains, or how much it will lose in a comparatively short time. Experiments along this line with lodge-pole pine, white oak, and chestnut gave results which were a surprise to the companies owning the timber.

Freight charges vary considerably in different parts of the country; but a decrease of 35 to 40 per cent in weight is important enough to deserve everywhere serious consideration from those in charge of timber operations.

When timber is shipped long distances over several roads, as is coming to be more and more the case, the saving in freight will make a material difference in the cost of lumber operations, irrespective of any other advantages of seasoning.

GLASS

TYPES OF GLASS:

(1) Soda-lime glass
(2) Potash-lime glass
(3) Potash-lead glass
(4) Common glass

(1) Soda-lime glass:

This is also known as soda-glass or soft glass. It is mainly a mixture of sodium silicate and calcium silicate.

Properties:

(i) It is available in clean and clear state.
(ii) It is cheap.
(iii) It is easily fusible at comparatively low temperature.

Uses: It is used in the manufacture of glass tubes and laboratory apparatus, plate glass, window glass, etc.
(2) Potash-lime glass:

Also known as bohemian-glass or hard glass. It is mainly a mixture of potassium silicate and calcium silicate.

Properties:
(i) it fuses at high temperature.

(ii) it is not easily affected by water and other solvents.
(iii) it does not melt so easily.
Uses: used in manufacture of glass articles.

(3) Potash-lead glass:
Also known as flint glass. It is a mixture of potassium silicate and lead silicate.

Properties:

(i) Fuses very easily.
(ii) Easily attacked by aqueous solution.
(iii) Posses great refractive power.
(iv) Specific gravity is about 3 to 3.50.
(v) Turns black and opaque.

Uses: used in the manufacture of artificial gems, electric bulbs, lances, prisms etc.

(4) Common glass

Also known as bottle glass. Manufacture of sodium silicate, calcium silicate and iron silicate.

Properties:

(i) Fuses with difficulty.
(ii) It is brown, grey or yellow in colour.
(iii) easily attacked by acids.

Uses: it is mainly used for medicine bottles.

MANUFACTURING OF GLASS:

1. Batch processing system (batch house):

Batch processing is one of the initial steps of the glass-making process. The batch house simply houses the raw materials in large silos (fed by truck or railcar) and holds anywhere from 1–5 days of material. Some batch systems include material processing such as raw material screening/sieve, drying, or pre-heating (i.e. cullet). Whether automated or manual, the batch house measures, assembles, mixes, and delivers the glass raw material recipe (batch) via an array of chutes, conveyors, and scales to the furnace. The batch enters the furnace at the 'dog house' or 'batch charger'. Different glass types, colors, desired quality, raw material purity / availability, and furnace design will affect the batch recipe.

The hot end of a glassworks is where the molten glass is formed into glass products, beginning when the batch is fed into the furnace at a slow, controlled rate by the batch processing system (batch house). The furnaces are natural gas- or fuel oil-fired, and operate at temperatures up to 1,575°C. The temperature is limited only by the quality of the furnace's superstructure material and by the glass composition. Types of furnaces used in container glass making include 'end-port' (end-fired), 'side-port', and 'oxy-fuel'. Typically, furnace "size" is classified by metric tons per day (MTPD) production capability.

Forming process

There are, currently, two primary methods of making a glass container: the blow and blow method, used for narrow-neck containers only, and the press and blow method used for jars and tapered narrow-neck containers.

In both methods, a stream of molten glass, at its plastic temperature (1050°C-1200°C), is cut with a shearing blade to form a solid cylinder of glass, called a gob. Both processes start with the gob falling, by gravity, and guided, through troughs and chutes, into the blank moulds, two halves of which are clamped shut and then sealed by the "baffle" from above.

In the blow and blow process the glass is first blown through a valve in the baffle, forcing it down into the three piece "ring mould" which is held in the "necking arm" below the blanks, to form the "finish", [The term "finish" describes the details (such as cap sealing surface, screw threads, retaining rib for a tamper-proof cap, etc.) at the open end of the container.]

Containers are made in two major stages. The first stage moulds all the details ("finish") around the opening, but the body of the container is initially made much smaller than its final size. These partly manufactured containers are called prisons, and quite quickly, they are blow-molded into final shape.

Referring to the mechanism, the "rings" are sealed from below by a short plunger. After the "settle blow" finishes, the plunger retracts slightly, to allow the skin that's formed to soften. "Counterblow" air then comes up through the plunger, to create the prison. The baffle rises and the blanks open. The prisons inverted in an arc to the "mould side" by the "necking arm", which holds the prison by the "finish".

As the necking arm reaches the end of its arc, two mould halves close around the prison. The necking arm opens slightly to release its grip on the "finish", then reverts to the blank side. Final blow, applied through the "blow head", blows the glass out, expanding into the mould, to make the final container shape.

In the press and blow process, the prison is formed by a long metal plunger which rises up and presses the glass out, in order to fill the ring and blank moulds.[5] The process then continues as before, with the parson being transferred to the final-shape mould, and the glass being blown out into the mould.

The container is then picked up from the mould by the "take-out" mechanism, and held over the "dead plate", where air cooling helps cool down the still-soft glass. Finally, the bottles are swept onto a conveyor by the "push out paddles" that have air pockets to keep the bottles standing after landing on the "dead plate"; they're now ready for annealing.

The forming machines hold and move the parts that form the container. The machine consist of basic 19 mechanisms in operation to form a bottle and generally powered by compressed air (high pressure - 3.2 bar and low pressure - 2.8 bar), the mechanisms are electronically timed to coordinate all movements of the mechanisms. The most widely used forming machine arrangement is the individual sectionmachine (or IS machine). This machine has a bank of 5–20 identical sections, each of which contains one complete set of mechanisms to make containers. The sections are in a row, and the gobs feed into each section via a moving chute, called the gob distributor. Sections make either one, two, three or four containers simultaneously. (Referred to as single, double, triple and quad gob). In the case of multiple gobs, the shears cut the gobs simultaneously, and they fall into the blank moulds in parallel.

COMPOSITION OF GLASS

The following is a list of the more common types of silicate glasses, and their ingredients, properties, and applications:

1. Fused quartz, also called fused silica glass, vitreous silica glass, is silica (SiO_2) in vitreous or glass form (i.e., its molecules are disordered and random, without crystalline structure). It has very low thermal expansion, is very hard, and resists high temperatures (1000–1500 °C). It is also the most resistant against weathering (caused in other glasses by alkali ions leaching out of the glass, while staining it). Fused quartz is used for high temperature applications such as furnace tubes, lighting tubes, melting crucibles, etc

2. Soda-lime-silica glass, window glass: silica 72% + sodium oxide (Na_2O) 14.2% + lime (CaO) 10.0% + magnesia (MgO) 2.5% + alumina (Al_2O_3) 0.6%. Is transparent, easily formed and most suitable for window glass (see flat glass). It has a high thermal expansion and poor resistance to heat (500–600 °C). It is used for windows, some low temperature incandescent light bulbs, and tableware. Container glass is a soda-lime glass that is a slight variation on flat glass, which uses more alumina and calcium, and less sodium and magnesium which are

more water-soluble. This makes it less susceptible to water erosion.

3. Sodium borosilicate glass, Pyrex: silica 81% + boric oxide (B_2O_3) 12% + soda (Na_2O) 4.5% + alumina (Al_2O_3) 2.0%. Stands heat expansion much better than window glass. Used for chemical glassware, cooking glass, car head lamps, etc. Borosilicate glasses (e.g. Pyrex) have as main constituents silica and boron oxide.

   They have fairly low coefficients of thermal expansion (7740 Pyrex CTE is 3.25×10^{-6}/°C[4] as compared to about 9×10^{-6}/°C for a typical soda-lime glass[5]), making them more dimensionally stable. The lower CTE also makes them less subject to stress caused by thermal expansion, thus less vulnerable to cracking from thermal shock. They are commonly used for reagent bottles, optical components and House hold cook ware.

4. Lead-oxide glass, crystal glass: silica 59% + lead oxide (PbO) 25% + potassium oxide (K_2O) 12% + soda (Na_2O) 2.0% + zinc oxide (ZnO) 1.5% + alumina 0.4%. Because of its high density (resulting in a high electron density) it has a high refractive index, making the look of glassware more brilliant (called "crystal", though of course it is a glass and not a crystal). It also has a high elasticity, making glassware 'ring'. It is also more workable in the factory, but cannot stand heating very well.

5. Aluminosilicate glass: silica 57% + alumina 16% + lime 10% + magnesia 7.0% + barium oxide (BaO) 6.0% + boric oxide (B_2O_3) 4.0%. Extensively used for fiberglass, used for making glass-reinforced plastics (boats, fishing rods, etc.) and for halogen bulb glass.

6. Oxide glass: alumina 90% + germanium oxide (GeO_2) 10%. Extremely clear glass, used for fiber-optic waveguides in communication networks. Light loses only 5% of its intensity through 1 km of glass fiber.[6] However, most optical fiber is based on silica, as are all the glasses above.

PROPERTIES OF GLASS

The properties of glass are mainly governed by factors like composition of the constituents, state of surface, thermal treatment conditions, dimension of specimen etc.

Following are the properties of glass which have made the glass popular and useful:

I. It absorbs, refracts or transmits light.
II. It can take up a high polish and may be used as substitute for every costly gems.
III. It has no definite crystalline structure.
IV. It has no sharp melting point.
V. It is affected by alkalis.
VI. It is an excellent electrical insulator at elevated temperatures due to the fact that glass can be considered as an ionic liquid. The lions are not easily moved at room temperature because of the high viscosity. But when the temperature rises, the ions are permitted to flow and thus they will sustain an electric current.
VII. It is available in beautiful colors.

It behaves more as a solid than most solids in the sense that it is elastic. but when the elasticlimit is exceeded, it fractures instead of deforming.

VIII. It is capable of being worked in many ways. it can be blown,drawn,or pressed. But it is strange to note that it is difficult to cast in large pieces.
IX. It is extremely brittle.
X. It is not usually affected by air and water.

XI. It is not attacked by ordinary chemical reagents.

XII. It is possible to intentionally alter some of its properties such as fusibility, hardness, refractive power etc. To suit different purposes.

XIII. It is possible to obtain glasses with diversified properties. The glass may be clear, colourless, diffused and stained.

XIV. It is possible to weld pieces of glass by fusion.

XV. It is transparent and translucent. Transparency is the most used characteristic of glass and it is due to the absence of the free electron. For the same reason it also works as a good insulator.

XVI. When it is heated, it becomes soft and soft with rise in temperature . it is ultimately transformed into a mobile liquid. The liquid when allowed to cool , passes to all degrees of viscosity. The property of glass has made its manufacturing process easy. It can also be formed into articles of desired shape. Thus the amorphousness of glass permits it to be blown, drawn from furnaces and continuously worked.

XVII. Due to advancement made in the science of the glass production, it is possible to make glass lighter than cork or softer than cotton or stronger than steel. The presence of glass however is considerably affected by foreign inclusions, internal defects and cords or chemically heterogeneous areas.

XVIII. The glass panes can be cleaned easily by anyone of the following methods- [i]By applying methylated spirit
[ii] Painting the glass panes with lime wash and leaving it to dry and then washing with clean water.
[iii] rubbing damp salt for cleaning paint spots and;
[iv]rubbing finely powdered chalk

Steel

Steel is manufactured by mixing iron and carbon in a specific ratio, in which the percentage of carbon may range from 0.2 percent to 2.14 percent of the total weight. Other than carbon, the alloying materials used in manufacturing steel include chromium, manganese, vanadium and tungsten. Of these materials, carbon is the most cost-effective element. And any of the alloying elements help in altering the mechanical property of steel.

Steel differs from wrought iron and cast iron, only in the percentage of carbon content. Steel contains more iron than wrought iron and lesser iron than cast iron. It is because of this reason steel is considered to occupy a position between these two metals. However, the properties of steel, wrought iron and cast iron differ tremendously.

Steel: Physical Properties

- The physical properties of an alloy depend on the percentage composition of the constituent elements and the manufacturing process. The properties of steel are totally different from its component elements - iron and carbon. One of its major properties is the ability to cool down rapidly from an extremely hot temperature after being subjected to water or oil. And a particular amount of carbon can be dissolved in iron at a specific temperature.
- The physical properties of steel include high strength, low weight, durability, ductility and resistance to corrosion. Steel, as we all know, offers great strength though it is light in weight. In fact, the ratio of strength to weight for steel is the lowest than any other building material available to us. The term ductility means steel can be molded easily to form any desired shape.
- Unlike the constituent element iron, steel does not corrode easily, on being exposed to moisture and water. The dimensional stability of steel is a desired property; it is found that the dimension of steel remains unchanged even after many years, or after being subjected to extreme environmental conditions. Steel is a good conductor of electricity, i.e., electricity can pass through steel.
- Steel grades are classified by many standard organizations, based on the composition and the physical properties of the metal. The deciding factor for the grade of steel is basically its chemical composition and the

supplied condition. The higher the carbon content, the harder and stronger is the steel metal. On the contrary, a high quality steel containing less carbon is more ductile.

- Earlier forms of steel consisted of more carbon, as compared to the present day steel. Today, the steel manufacturing process is such that less carbon is added and the metal is cooled down immediately, so as to retain the desirable physical properties. Rapid cooling (or quenching) of steel also alters the grain structure.

Aluminum: -

Aluminum or aluminum is a chemical element with symbol Al and atomic number 13. It is a silvery-white, soft, nonmagnetic and ductile metal in the boron group. By mass, aluminum makes up about 8% of the Earth's crust; it is the third most abundant element after oxygen and silicon and the most abundant metal in the crust, though it is less common in the mantle below. The chief ore of aluminum is bauxite. Aluminum metal is so chemically reactive that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals.

Aluminum is remarkable for its low density and its ability to resist corrosion through the phenomenon of passivation. Aluminum and its alloys are vital to the aerospace industry. And important in transportation and building industries, such as building facades and window frames. The oxides and sulfates are the most useful compounds of aluminum.

Background

Physically, chemically and mechanically aluminum is a metal like steel, brass, copper, zinc, lead or titanium. It can be melted, cast, formed and machined much like these metals and it conducts electric current. In fact often the same equipment and fabrication methods are used as for steel.

Light Weight

Aluminum is a very light metal with a specific weight of 2.7 g/cm^3, about a third that of steel. For example, the use of aluminum in vehicles reduces dead-weight and energy consumption while increasing load capacity. Its strength can be adapted to the application required by modifying the composition of its alloys.

Corrosion Resistance

Aluminum naturally generates a protective oxide coating and is highly corrosion resistant. Different types of surface treatment such as anodizing, painting or lacquering can further improve this property. It is particularly useful for applications where protection and conservation are required.

Electrical and Thermal Conductivity

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Aluminum is an excellent heat and electricity conductor and in relation to its weight is almost twice as good a conductor as copper. This has made aluminum the most commonly used material in major power transmission lines.

Reflectivity

Aluminum is a good reflector of visible light as well as heat, and that together with its low weight, makes it an ideal material for reflectors in, for example, light fittings or rescue blankets.

Ductility

Aluminum is ductile and has a low melting point and density. In a molten condition it can be processed in a number of ways. Its ductility allows products of aluminum to be basically formed close to the end of the product's design.

Impermeable and Odourless

Aluminum foil, even when it is rolled to only 0.007 mm thickness, is still completely impermeable and lets neither light aroma nor taste substances out. Moreover, the metal itself is non-toxic and releases no aroma or taste substances which makes it ideal for packaging sensitive products such as food or pharmaceuticals.

Recyclability

Aluminum is 100 percent recyclable with no downgrading of its qualities. The re-melting of aluminum requires little energy: only about 5 percent of the energy required to produce the primary metal initially is needed in the recycling process.

The Glass is the magical building material as it is used in doors, windows, and building façades according to characteristics & properties of glass. The People have many choices depending on safety, security, functions related to environment (self-cleaning, sunlight and heat transparency, visibility) and qualities like scratch resistance etc.

Based on the important characteristics & properties, it is considered as best future material for building construction. Following are the properties and characteristics of the glass.

Characteristics of glass as Building Material:

Hardness and Brittleness:

It is a hard material as it has greater impact resistance against applied load. But at the same time it is brittle material as its breaks immediately when subjected to load.

Weather Resistance:

It is weather resistant as it can withstand the effect of rain, sun and wind. It can absorb, reflect and refract light as it enables us to control and manipulate natural light to influence our daily activities and frame of mind.

It has greater dimensional stability as it has low thermal expansion value. (I.e. Its change in volume with respect to temperature change as compared to other materials is very low.)

Insulation:

It is an excellent insulator against heat, electricity and electromagnetic radiation. It has a good insulating response against visible light transmission.

Certain special type of glass has high resistance against ultra-violet, infrared and x-ray transmission. It has an excellent resistance against sound transmission, provided used with proper thickness.

Chemical Resistance:

It can withstand the effect of the chemical reaction under different environment conditions or acidic effects.

It has excellent resistance to most chemicals, including solutions of inorganic alkalies and acids, such as ammonia and sulfuric acid.

Colour and Shape Varieties:

It can be blown, drawn and pressed to any colour, shape, and varieties.

Nowadays so many colour and shape varieties are available in the market depending upon their use, dimensional requirements, and safety requirement.

Property Modification:

It is also possible to change some of its properties to suit different purposes. The major surface modification processes are listed below, and their names itself suggest the different properties of glass to which it can be modified depending upon their use in the building.

List of Surface modification Process of Glass:

Anti-fogg coating

Anti-reflective coating

Chemically strengthened glass (Safety glass, toughened glass, wire-mesh glass, and laminated glass)

Anti-corrosion coating (Resistance to water)

Dealkalization coating (Surface layer that has a lower concentration of alkali ions)

Hydrogen darkening layer (Chemical process that interferes the passage of light)

Insulated coating or double glazing or double pane (for heat and or sound insulation)

Sand blasting or acid etching process (Frosted Glass)

Low emissivity coating (Coating helps to reduce heat transfer)

Pyrolytic coating (Coating for excellent performance)

Self-cleaning coating

Sandwichable film or Smart film coating (Alter the light transmission property when voltage, light or heat is applied)
Water repellent coating (Making hydrophilic surface)
Sol-gel coating (Preparation of thermally stable, transparent super-hydrophobic silica films)

UNIT-III Flooring , Roofing ,Plumbing and Sanitary Material: Flooring and Roofing tiles , Types of Flooring – Marble, Kota stone , wood etc. Type of Roofing , P.V.C. materials, CI , GI, Asbestos pipe , Stone ware pipes

FLOORING

The job of protecting slabs of roofs on the different floors in building and providing suitable finish of floor surfaces is known as flooring. There are many types of floors according to their uses, economy and required level of finishing.

OBJECTIVES

After reading this lesson you will be able to:

- explain types of flooring;
- differentiate among different process of flooring;
- describe reasons for laying panels on ordinary floors of cement;
- provide explanations for grinding of special types of floors.

PRECAUTION BEFORE FLOORING

Before constructing the flooring, levelling should be done and marking should be done on wall at 30 cm above from required level. For this purpose spirit level or mercury level should be used. For better accuracy, water level used by mason (mistry), should not be used. Due to more length of pipe and friction inside the pipe, results are not accurate. One should use long wooden patty while making floors so that floor surface can be flat.

LAYING OF SUBGRADE In some places concrete is used before flooring. This concrete is known as sub grade. The places where flooring is done directly on soil, surface should be crammed with the help of wooden hammer, so that the surface should not be settled down. If concrete is used after 24 hours, cement slurry (2 kg cement per square meter) should be laid and then flooring is done. If this concreting is done on ground it is known as base concrete. If it is done on RCC slab, it is known as Kasson of size 100 mm and 40 mm respectively.

TYPES OF FLOOR

1. Bricks or interlocking tiles flooring
2. Cement concrete floor
3. Marble chips or crazy marble flooring
4. Readymade marble tiles flooring
5. Glazed tiles flooring 6. Kota stone, Agra stones etc stone flooring
7. Wooden flooring

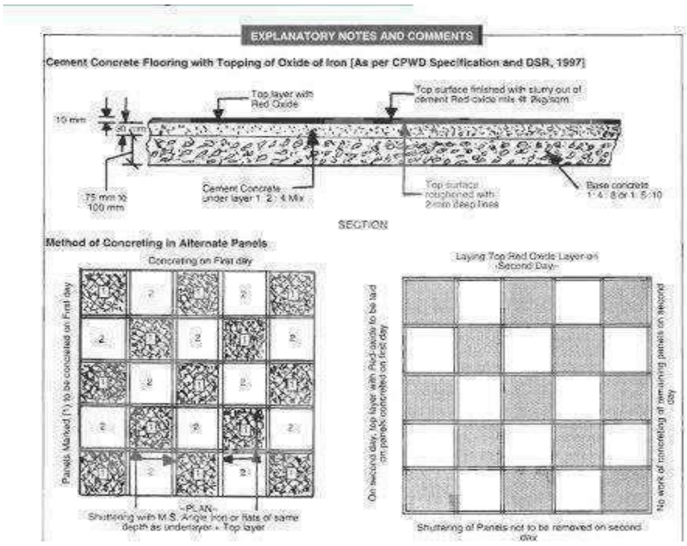
Bricks or interlocking of tiles flooring High quality materials should be used. If mortar is not used or even sub grade in lower surface, thick layer of sand is spread, and joints with space 6 mm wide are filled with sand. Normally brick flooring is done as harry bonding in which joints are not continuous.

Cement concrete flooring monolithically cement concrete flooring Due to technical reason any flooring of cement concrete should not be laid together. In this type of flooring, the surface is divided into rectangular panels. Alternate panels are laid first. Before concreting in panels, cement slurry is used.

Where this type of flooring is laid, first surface is compacted with wooden hammer and then 10 cm thick sand layers are spread. Then after watering and compaction, cement flooring laid. Flooring is laid in two parts, upper portion of size 10 mm is known as topping made of cement and sand. After leveling with the help of a straight edge steel trowel is used for smoothening and finishing its top surface. Dry cement or mortar should not be used if some water comes at surface. Because this layer may be stripped out. The surface is then properly cured for a period of 14 days.

Non monolithic flooring in two layers:- In this method lower concrete layer of 1: 2:4 and upper layer of

1:2 ratio of cement and sand mortar of 5 mm to 10 mm is made. In this polish can be done later



Heavy duty concrete flooring: This type of flooring is made for railway platform or where heavy machines are used. In this, flooring base is 50 mm and total thickness is 125-150 mm. 14.5.3 Marble chips or crazy marble flooring There are three parts of flooring: Base concrete, under layer and topping. This types of flooring is just like the cement concrete, except that toping layer is made of marble chips and cement of ratio 1: 1 ½ or 1: 2. To avoid cracks, partitions are made of not more than 25 gm size. Lower layer made of 30 to 40 mm size aggregate of 1: 2: 4 cement sand and aggregate. Glass or aluminium stripes are used for partition from lower layer to upper top layer. The thickness of top layer is 10 mm and it is made of marble powder and cement in 1: 3 ratio and then powder and marble chip in 1: 2 ratio.

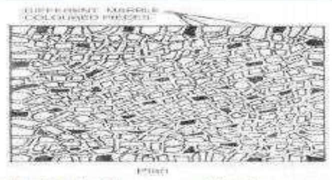


Fig 14.4: Crazy marble flooring

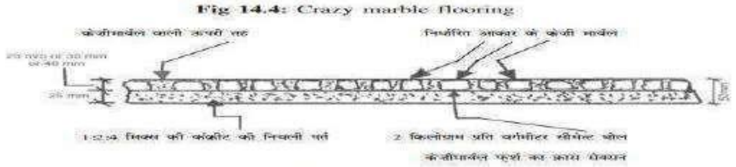


Fig. 14.5: Method of crazy marble flooring

Curing: Floor is left in atmosphere for 12 to 18 hrs, and cured for more than 4 days by water filled in small partitions.

Grinding and Polishing: After seven days of flooring is laid, grinding is done. Grinding stones are available in different grade. At the end polishing is done.

Readymade marble tile flooring readymade marble tiles are available in market. For this flooring, firstly sub grade is prepared and then on the mortar, tiles are laid. Mortar surface is prepared with 1:6 ratio of cement and sand. The thickness of mortar is 20 mm. Laying of marble tiles: Before laying the tiles thin paste of cement slurry (4.5 kg/m2) is spread and tiles are lid flat over it by gently pressing them into the bedding mortar with the help of wooden mallet till leveled surface is obtained. The flooring is then cured for seven days, then grinding and polishing is done in the same manner. These days glazed tiles are commonly used in houses.

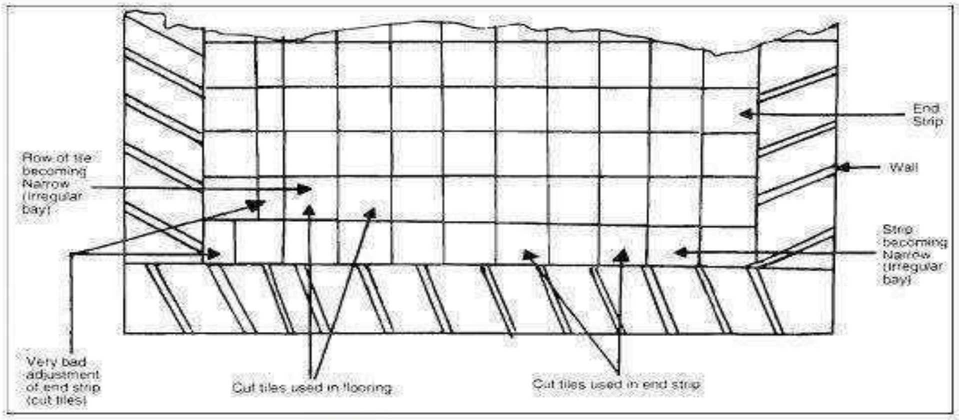


Fig 14.7: Laying of marble tiles

Glazed tiles flooring, skirting and dedo

Glazed tiles, skirting and dedo are made on sub grade with thickness 13 mm by cement and sand in the ratio of 1: 3. These are following types of glazed tile, vitrified, semi vitrified, or normal glazed tiles.

Vitrified tiles are of 10-12 mm thick in which upper layer is of 3-4 mm having long durability and shining whereas semi vitrified are of medium quality.

Laying of tiles: After laying mortar, tiles are laid and pressed by wooden mallet as in marble tile flooring. Before using, tiles should be clean and dried. Skirting and dedo are laid in same manner. In the end all joints are filled with white cement pigment of tile colour.

Kota Stone Flooring This is available in size of 600 × 600 mm which after dressing becomes of size 500 × 500 mm and thickness 25-40 mm. Flooring is done in same manner as in tiles flooring except bed is made in 1: 4 ratio and bed thickness of 40 mm.

Roofs

Roof is one of the most important elements of a building structure to provide protection to the inmates from the sun, rain, wind, etc.

• The roof also protects the interior of a building from direct exposure to the weather

1) Roof: the entire covering assembly
2) Roofing: that part of the roof which is exposed to the elements.
3) Pitch: rise over run
4) Substrate: the decking that carries the roofing material.
5) Eaves: roof overhangs
6) Ridge: the peak of two or more roof slopes
7) Valley: an inverse ridge
8) Ceiling: the finish material attached to the underside of the roof.

The selections of roofs for buildings depend on factors below:

1. Type of building.
2. Type of foundation.
3. Roof d Loads
4. Light exposure
5. Conduits
6. Future renovations.
7. Time taken to construct the roof
8. Maintenance
9 Economy
10. Aesthetic
11. To avoid dampness, heat, sound, etc...

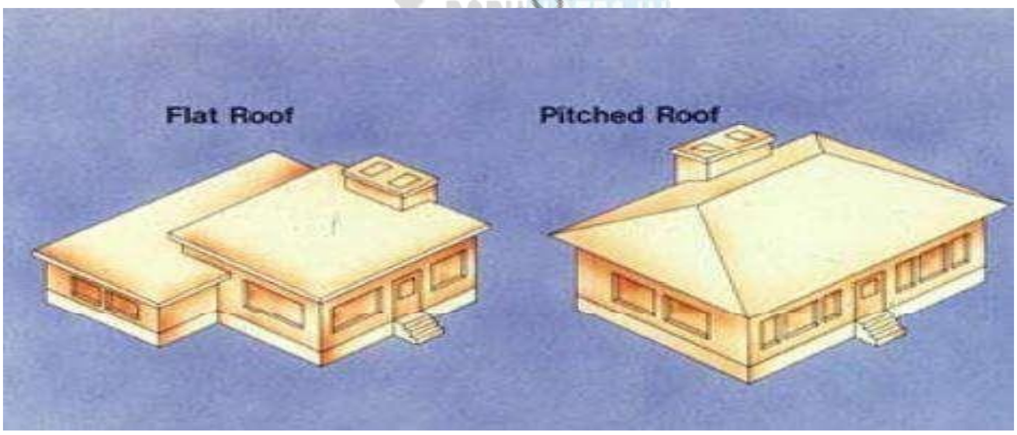
Functions of roofs are as follows.

1. The identity of the building.
2. To prevent from dampness, heat, sound, etc...
3. To carry loads from the roofs, live load and dead load.
4. To provide protection from weather for workers working under any construction.
5. To allow light and air in and out of the building.
6 To place conduits.
7. For future renovations

Types of Roof

A. Sloping roof 1. Cable roof : slope in two directions, used for larger span.
2. Gambrel roof : slope in two directions, mostly used for buildings in hilly area.
3. Hipped roof : slope in four directions, mostly used in hilly areas.
4. Mansard roof : slope in four directions with a break in the slope, used in hilly areas and commercial buildings.
5. Shed roof/Lean-to-roof (single and double) : consists of common rafters which are inclined at 300. One end of each common rafter is placed on wooden wall plates and the other end is nailed to wooden post plates. Used on sheds and veranda openings and suitable for spans up to 2.5m.
6. Saw-tooth or North-light roof : a sloping roof having glazing fixed on the steep sloping sides its steep sloping side is kept towards north Syazli 2005 the steep sloping sides, its steep sloping side is kept towards north direction. Generally used in factories where more light is required.

B. Shells : Shell Barrel Vault, domes.
C. Flat roof : slope of not more than 7 ½0 extensively used in plain areas where the rainfall is meager. Common flat roof is of reinforced cement concrete slab.



In any building construction piping systems are designed to serve the following primary purposes.

- To supply water everywhere in the building
- For the disposal of rain water above the ground
- To dispose water from water closets and washbasin etc
- To drain soil & waste water to septic tanks or town sewers.

The principal types of pipes that are available in the market to serve the above mentioned purposes are as follow.

1. Cast iron pipes and fitting
2. Plastic or PVC pipes
3. Galvanized steel (GI) pipes
4. Stoneware pipes
5. Asbestos Cement (AC) pipes
6. Concrete pipes

1. CAST IRON PIPES

Cast iron pipes and fitting are primarily used for designing of soil and rain water disposal systems. These pipes are made by the sand cast process or by spinning.

Sand cast pipes are made by pouring molten cast iron into vertically mounted sand moulds. They are available in 1.5, 1.8 & 2 metre length and 5 & 6 mm thickness.

Spun pipes are made by pouring molten grey cast iron into a revolving water cooled mould, producing a seamless pipe in length upto 3 metre with thickness less than sand cast pipes.

2. PLASTIC OR PVC PIPES

There are 3 common types of plastic pipes are available in market, as given below.

1. Unplasticized PVC (UPVC) or rigid pipes for use with cold water
2. Plasticized PVC pipes which are plasticized with addition of rubber. It has lower strength and lower working temperature than UPVC pipes.
3. Chlorinated PVC (CPVC) pipes which can withstand higher temperatures upto 120^0 (used to carry hot water)

For pipes used in soil and waste water discharge systems, the thickness of the wall will be larger than that of used for roof drainage.

Rigid PVC pipes are used for distribution of water with temperature below 45^0C.

At higher temperature, the strength of the pipes decreases. Similarly ultraviolet radiation from sunlight as well as frequent changes in temperature reduces the life of PVC pipes.

These pipes are costlier than AC pipes but cheaper than GI pipes.

3. GALVANIZED STEEL (GI) PIPES

GI pipes are made from steel pipes. The galvanizing process deposits a thin coating of zinc which protects it from corrosion.

They are available in light, medium and heavy grades depending on the thickness of the metal. For a 15 mm GI pipe, the thicknesses are 2.0, 2.65 & 3.25 for the light, medium and heavy grades, respectively. Generally the medium grade pipes are used for internal plumbing in building.

These pipes corrode easily if it carries brackish water or concealed in lime concrete and brickwork or buried under the ground.

These pipes are costlier than PVC pipes.

4. STONEWARE PIPES

These pipes are available in the form of internal diameters 10 mm to 600 mm with thickness varying from 12 mm to 43 mm.

A good stoneware pipe should give a sharp clear tone when struck with a light hammer.

These pipes are extensively used as underground drainage pipes in low cost construction buildings. Usually these pipes are laid on an even bed of concrete and further treated as specified for laying in different types of soils. However laying of these pipes requires experienced workmen and good supervisor. Therefore PVC pipes are being preferred to these pipes in many places.

These pipes are cheap.

5. ASBESTOS CEMENT (AC) PIPES

These pipes are used for drainage of rainwater from roofs, soil and waste and also for ventilation. They come in two profiles – one with beading around socket (WB) and the other without beading around socket (WOB). The latter type is more common than the former.

The pipes come in lengths of 3 meters.

The principal defects of these pipes are that they are heavy and they break easily.

These pipes are cheaper than PVC pipes.

6. CONCRETE PIPES

Unreinforced pipes of small diameters as well as reinforced and prestressed concrete pipes of large diameters are available for water supply and other uses.

Small unreinforced concrete pipes are very much used for drainage of rain water.

Large diameter pipes are generally used for major water supply works.

UNIT-IV Paints, Enamels and Varnishes: Composition of oil paint, characteristic of an ideal paint, preparation of paint, covering power of paints, Painting: Plastered surfaces, painting wood surfaces, painting metal Surfaces. Defects, Effect of weather, enamels, distemper, water wash and colour wash, Varnish, French Polish, Wax Polish

PAIN

Paint is a liquid surface coating. On drying it forms a thin film 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. The paintings are the coating of fluid materials

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 woodwork and to varnish the surface to display it to better advantage

Defects in Painting:

- A painted building with full colour effects gives complete satisfaction. But the appearance of defects becomes a ready source of complaint. Unfortunately painting defects are by no means uncommon. They may arise from a variety of causes but the principal reasons behind them are incorrect choice of paint in relation to backing materials, application of paint to a damp surface or one to which moisture may have access and; poor workmanship.

Effects of background:

- The factors affecting durability are dampness, cleanliness, movements, chemical reactions, etc. The traditional construction in brick, cement, etc. involves the use of wet procedures. If paint is applied on an insufficiently dry background the moisture is trapped and in the process of subsequent drying the adhesion of the paint breaks down. Emulsion paints are somewhat better in this respect. The painting processes can be delayed for proper results for movements caused by shrinkage and special paints should be used for thermal movements.
- Chemical reaction between backing material and paint film may push the paint off the backing material and lead to softening or decolorizes the paint. This effect generally occurs only if moisture is present and is noticeable in oil paints over materials containing cement or lime. The breakdown of bond is because of the crystallization of salts below the paint film and the discoloration is usually due to action of free lime on thepigments.

Effects of weather:

The paint film is subjected to chemical attack of atmosphere, sunlight and heat, all deteriorating it. Special chemical resistant paints should be applied in industrial areas. Alkali resistant paints weather well in coastal areas. Blue and green colors tend to fade when exposed to bright light. In addition the fierce heat of sun may breakdown the paint film because of the disintegration of the material itself and also because of the thermal movement. The most common defects noticed after paintings are as follow:

Blistering and peeling are swelling of the paint film and can be defined as localized loss of adhesion between one or more coatings or between primer and parent surface. When swelling is because of oil or grease on the surface it is known as blistering and in case of moisture it is called peeling. It occurs in nonporous coatings such as oil based paints and enamels. A special heat-resisting type of paint should be used for hot surfaces such as radiators. It is brought about by moist air, oily or greasy surface, or imprisoned gases between the painted surface and the paint film, which expand under the influence of heat. Emulsion paints provide a porous coating and allow the moisture to pass through.

Checking is a mild form of cracking. If hair cracks produced enclose small area it is known as crazing. In case the enclosed area is large the defects is called crocodiling. It is caused when the paint film lacks in tensile strength and occurs when paint is applied during very cold weather or because of insufficient drying of undercoat. When cracks are very small and do not enlarge with time, the top coating is flattened with emery paper and a fresh coat of paint is applied.

Cracking: The cracks extend throughout the entire paint system extending right down to the original surface. Cracks in the plaster or masonry do not let the paint to remain intact.

Paint applied on glossy surface. Premature application of top coat before the previous coat has completely dried. Painting improperly seasoned wood.

Flaking: It is detachment of paint film from the surface. The moisture penetrates through the cracks on the coatings and the bond between surface and paint film is lost. The curing methods are: Use of plastic emulsion paints, Surface should be rubbed with emery paper before applying a fresh coat and All dirt or dust on surface should be removed prior to painting.

Chalking: Paint film becomes powder due to insufficient oil in primer.

Alligatoring: One layer of paint films sliding over the other one, when a hard paint is applied over a soft one or vice versa.

Wrinkling: or crawling appears when the paint film is quite thick or the oil in the paint is more than required. The lower portion of the paint does not dry due to greater thickness of the paint film which shrinks due to drying in course of time.

Running and sagging: Paints applied over smooth and glossy surface do not stick and flow back or towards the unpainted area. This is known as running and sagging. The surface to-be painted should, therefore, be rubbed with an emery paper before painting.

Bloom: is identified as dull patches on the finished, polished or painted surface due to defect in the quality of paint or poor ventilation.

Flashing: is characterized by the appearance of certain glossy patches on the painted surface. The reasons attributed to this defect are weathering actions, use of cheap paint, and poor workmanship.

Grinning: it is due to the imperfect opacity of the paint film even after the final coat. The background and its defects can be clearly visible in such a case.

Failure of Painting: The main causes of failure of painting are:

• Bad workmanship	• Conditions for painting
• Moisture	• Salt and alkalies
• Unsuitable surfaces	• Wrong choice of paint

Painting of various surfaces:

A. New plastered surface:

The procedures for paining a new plastered surface are:

1. **Surface preparation**: Paint cannot take care of construction defects. Before applying the paint, it is ensured that the surface is free from dust, dirt, loose matter, grease etc. and is rubbed with an emery paper, to provide a mechanical key between surface and paint for satisfactory adhesion.
2. **Sequence of Painting:** The primer (first coat) is applied with brush or spray on the prepared surface. It should be thinned with water or thinner in the recommended manner and proportion before application. After drying it is rubbed with emery paper. Dents and cracks, if any, are filled with putty using a knife applicator. Putty should not be applied thick. If the required thickness is large, it should be applied in two coats. After the putty has dried, the whole surface is rubbed down well in order to smoothen the putty andprovide a mechanical key to the finished coats. Two or three finish coats are applied. Each coat is allowed to dry before the application of next coat.

B. Old plastered surface

The procedure depends on the state of the existing coating. If any of the defects discussed below is very much pronounced it is completely removed and the surface is painted as a new surface.

C. Painting of new woodwork

Painting of woodwork should be done with great care. Normally 3–4 coats are sufficient for wood work.

- **Surface preparation:** The wood should be well seasoned, dried, cleaned and the surface made smooth with an emery paper. Nails, if any, should be driven down the surface by at least3 mm.
- **Knotting:** Knots in the wood create lot of problems. These excrete resin which causes defects such as cracking, peeling and brown discoloration. Knotting is done so that resin cannot exude from the knots. Any of the following methods may be used suitably.

  Ordinary knotting: This is also known as size knotting. The knot is treated with a coat of hot red lead ground with a strong glue size in water. Then a coat of red lead ground in boiled linseed oil is applied.

  Lime knotting: The knot is covered with hot lime for 24 hours after which it is scrapped off. Thereafter, the process described in ordinary knotting is followed.

  Patent knotting: Two coats of varnish or shelac are applied.
- **Priming coat:** The main function of priming coat or primer is to form the base for subsequent ones. After knotting priming coat is applied over the entire surface to fill all the pores. A second priming coat is applied after first has dried. In general the ingredients are same as those of the subsequent coats but with a difference in proportion.
- **Stopping:** After the priming coat putty is applied to fill the pores of the surface. Then it is rubbed smooth. Colouring pigment is also added to it to match the shade of the finished coat. On drying, the selected paint is applied with brushes to bring smoothness and uniformity in colour. After painting the surface in one direction, the brush is worked in the perpendicular direction to eliminate brush marks. This is known as crossing. All the successive coats are applied after drying and slight rubbing of previous coats for proper bond.

D. Painting of old woodwork:

The old paint is removed with a sharp glass piece, sand paper, paint remover or with a blow lamp. Any smoky or greasy substance should be washed with lime and subsequently rubbed with pumice stone. The surface is then washed with soap and water and dried completely. Then two coats of paints are applied in a way similar to that described in painting new surfaces.

E. Painting metal surfaces:

- New ironwork: The surface should be free from scales, rust and grease. Scales and rust are cleaned by hard wire brush. Grease is removed by using petroleum or by hot alkaline solution of Na_2CO_3 or NaOH, benzene, and lime water. A priming coat of red lead with barytes and raw linseed oil is then applied over the prepared surface. After drying of the priming coat, one or more undercoats with desired paint are applied. The second coat is given only after the first coat has dried. The finishing coat is applied carefully to produce a smooth fine surface.

- Old ironwork: The surface is prepared by scraping properly all the scales and rust with emery paper. The greasy substances are removed with lime water. The old paint may be burned with a blow lamp or by suitable solvents. After this the surface is brushed with hot linseed oil and painted as for new iron work.
- Structural steel: The major problem to overcome in painting iron and steel is corrosion due to electrolysis caused by the presence of air and moisture. Red lead is considered to be the best priming coat; it produces a tough elastic film, impervious to air and moisture. Pure linseed oil priming coat is detrimental in that it stimulates corrosion. The linseed oil film is rendered more impervious by the use of spar varnish. Graphite paint used for black colour, is very durable and is not affected by sulphur films, ammonia or chlorine gases. Silica-graphite paints are best; they do not crack and blister in course of time. Aluminium paint is also gaining popularity because of its shining and contrast properties and heat and chemical resistance. Bituminous paints may be very well adopted to paint inside of pipes, iron under waters, piles, ships and boats; they are unsatisfactory when exposed to sunlight. Lead or zinc paint should never be applied directly over the iron surface as it encourages galvanic action destroying the paint.

F. **Painting of floor surfaces:** The enamels are used for painting of floor surfaces. The selected enamel should be strong enough to resist abrasion, moisture, and alkali actions. It should be of shinning nature and quick drying type.

G. **Painting of concrete surfaces:** The cement paint is used to paint concrete surfaces. The paint is available in a powder form and it is dissolved in water to workable consistency. The paint thus prepared should be consumed with in 2 to 3 hours. The two coats are applied at an interval to provide curing of painted surface.

UNIT-V Miscellaneous Construction Materials: Bitumen, Tar and Asphalt their characteristics and uses, , Thermal and sound insulating materials, and water proofing materials

BITUMEN AND TAR:

Origin, preparation, properties and chemical constitution of bituminous road binders; requirements.

Bituminous binders used in pavement construction works include both bitumen and tar. Both bitumen and tar have similar appearance, black in color though they have different characteristics.

Origin Naturally occurring deposits of bitumen are formed from the remains of ancient, microscopic algae and other once-living things. When these organisms died, their remains were deposited in the mud on the bottom of the ocean or lake where they lived. Under the heat and pressure of burial deep in the earth, the remains were transformed into materials such as bitumen, kerosene, or petroleum. Deposits at the Labret Tar Pits are an example. There are structural similarities between bitumen's and the organic matter in carbonaceous meteorites. However, detailed studies have shown these materials to be distinct. Asphalt or bitumen can sometimes be confused with "tar", which is a similar black, thermoplastic material produced by the destructive distillation of coal. During the early and mid20th century when town gas was produced, tar was a readily available product and extensively used as the binder for road aggregates. The addition of tar to macadam roads led to the word tarmac, which is now used in common parlance to refer to road-making materials. However, since the 1970s, when natural gas succeeded town gas, asphalt (bitumen) has completely overtaken the use of tar in these applications. BITUMEN is a petroleum product obtained by the distillation of petroleum crude. TAR is a thermoplastic material obtained from the destructive distillation. The grade of bitumen used for pavement construction work of roads and airfields are called paving grades and used for water proofing of structures and industrial floors etc. are called industrial grades. The paving bitumen available in India is classified into two categories

1) Paving bitumen from Assam petroleum denoted as A-type and designated as grades A35, A 90.etc.
2) Paving bitumen from other sources denoted as S-type and designated as grades S35, S90 etc.

The viscosity of bitumen is reduced some times by a volatile diluents this material is called Cutback. The bitumen is suspended in a finely divided condition in an aqueous medium and stabilized with an emulsifier; the material is known as Emulsion.

Difference between Bitumen and Tar

Sl. No.	Bitumen	Tar
1	Bitumen is found in black to brown in colour	Tar is usually found in brown colour
2	Bitumen is obtained from fractional distillation of crude oil	Tar is obtained by destructive distillation of coal or wood
3	Bitumen is soluble in carbon disulphide and carbon tetra chloride	Tar is soluble in toluene
4	Molecular weight range for road bitumen is 400 to 5000	Molecular weight range for road tar is 150 to 3000
5	Bitumen consists of large amount of aromatic hydrocarbon	Tar consist of large amount of oily matter with lower molecular weight
6	Bitumen show resistance to coating road aggregate and also does not retain in presence of water	Tar coats more easily and retain it better in presence of water
7	Free carbon content is less	Free carbon content is more
8	It shows more resistance to weathering action	It shows less resistance to weathering action
9	Less temperature susceptibility	More temperature susceptibility

Bitumen

The source of road bitumen is either formed from petroleum or by natural processes as a result of geological forces. Different forms of bitumen Cutback bitumen Normal practice are to heat Bitumen to reduce its viscosity. In some situations preference is given to use liquid binders such as cutback bitumen. In cutback bitumen Suitable solvent is used to lower the viscosity of the bitumen. From the environmental point of view also cutback bitumen is preferred. The solvent from the bituminous material will evaporate and the bitumen will bind the aggregate. Cutback bitumen is used for cold weather bituminous road construction and Maintenance. The distillates used For preparation of cutback bitumen are naphtha, kerosene, diesel, oil and furnace oil. There are different types of cutback bitumen Like rapid curing (RC), medium curing (MC), And slow curing (SC).RC is recommended for Surface dressing and patchwork. MC is recommended for premix With less quantity of fine aggregates.SC is used For premix with appreciable quantity of fine aggregates.

Bitumen Emulsion

Bitumen emulsion is a liquid product in which bitumen is suspended in a finely divided condition in an aqueous medium and stabilized by suitable material. Normally cationic type emulsions are used in India. The bitumen content in the emulsion is around 60% and the remaining is water. When the emulsion is applied on the road it breaks down resulting in release of water and the mix starts to set. The time of setting depends upon the grade of bitumen. The viscosity of bituminous emulsions can be measured as per IS:8887-1995.Threetypes of bituminous emulsions are available, which are Rapid setting(RS),Medium setting (MS),And Slow setting (SC).Bitumen Emulsions are ideal binders for hill road construction. Where Heating of bitumen or aggregates are difficult. Rapid Setting emulsions are used for surface dressing work. Medium Setting emulsions are preferred for premix jobs and patch repairs work. Slow setting Emulsions are preferred in rainy season.

Bituminous primers

In bituminous primer the distillate is absorbed by the road surface on which it is spread. The absorption there for depends on the porosity of the surface. Bitumen primers are use full on the stabilized surfaces and water bound macadam base courses. Bituminous primers are generally prepared on road sites by mixing penetration bitumen with petroleum distillate.

Modified Bitumen Certain additives or blend of additives called as bitumen modifiers can improve properties of Bitumen and bituminous mixes. Bitumen treated with these modifiers is known as modified bitumen. Polymer modified bitumen(PMB)/crumb rubber modified Bitumen (CRMB) should be used only in wearing course depending upon the requirements of extreme climatic variations. The detailed specifications for modified bitumen have been issued by IRC: SP: 53-1999. It must be noted that the performance of PMB and CRMB is dependent on strict Control on Temperature during construction. The advantages of using modified bitumen are as follows:

1. Lower susceptibility to daily and seasonal temperature variations
2. Higher resistance to deformation at high pavement temperature
3. Better age resistance properties
4. Higher fatigue life for mixes
5. Better adhesion between aggregates and binder
6. Prevention of cracking and reflective cracking.

Types

1) Rock Asphalt

a) It consists of limestone, sand stone naturally impregnated with bitumen.

b) The mineral matter will be about 90% and bitumen content of 10%.

2) Lake Asphalt
a) Mineral matter will be finely divided and dispersed through the bitumen
b) The whole mass is capable of flow
c) Type of lake asphalt used in road making in United Kingdom is Trinidad lake asphalt.
d) It is used in flexible road construction and also in rolled asphalt wearing courses.

Desirable Properties of Bitumen
1) **Viscosity** The viscosity of the bitumen at the time of mixing and compaction should be adequate. This is achieved by heating the bitumen and aggregate prior to mixing or by use of cutbacks or emulsions of suitable grade.
2) **Temperature** Susceptibility The bituminous material should not be highly temperature susceptible. During the hottest weather of the region the bituminous mix should not become too soft or unstable. During cold weather the mix should not become too hard and brittle, causing cracking. The material should be durable.
3) Adhesion Property In presence of water the bitumen should not strip off from the aggregate. There has to be adequate affinity and adhesion between the bitumen and aggregate used in the mix.

Tests on bitumen There are a number of tests to assess the properties of bituminous materials.
The following tests are usually conducted to evaluate different properties of bituminous materials.
1. Penetration test
2. Softening point test
3. Ductility test
4. Viscosity test
5. Specific gravity test
6. Heat stability test a. Flash point test b. Fire point test c. Loss on heating test
7. Solubility test
8. Thin film oven test
9. Float test
10. Water content test

Tar
Tar is the viscous liquid obtained when natural organic materials such as wood and coal carbonized or destructively distilled in the absence of air. Based on the materials from which tar is derived, it is referred to as wood tar or coal tar. It is more widely used for road work because it is superior.
There are five grades of roads tar: RT-1, RT-2, RT-3, RT-4 and RT-5, based on their viscosity and other properties.
RT-1 has the lowest viscosity and is used for surface painting under exceptionally cold weather as this has very low viscosity.
RT-2 is recommended for standard surface painting under normal Indian climatic conditions. RT-3 may be used for surface painting, renewal coats and premixing chips for top course and light carpets.
RT-4 is generally used for premixing tar macadam in base course.
RT-5 is adopted for grouting purposes, which has highest viscosity among the road tars.
The various tests carried out on road tars are:
a) Specific gravity test
b) Viscosity test on standard tar viscometer
c) Equiviscous temperature (EVT)

d) Softening point
e) Softening point of residue
f) Float test
g) Water content
h) Phenols, percent by volume
i) Naphthalene, percent by weight
j) Matter insoluble in toluene, percent by weight
k) Distillation fraction on distillation upto 200°C, 200°C to 270°C and 270°C to 330°C

Introduction to the Insulation Materials

There are many benefits of home insulation. Insulating will add the comfort to the building, create a healthier home environment, reduce the energy bills and have a positive environmental impact. Adding home insulation to an existing home will regulate the temperature, making the living environment more enjoyable, especially in places of extreme weather. With insulation the home will become more energy efficient. Insulation will keep the home cooler in the summer and warmer in the winter. This will reduce the amount of heating and cooling appliances that is needed to keep the house comfortable. Because of this, home insulation will reduce the energy bills and the costs of cooling and heating. Adding acoustic insulation will also enhance the sound control. Insulation creates a sound barrier, keeping unwanted sounds out and protecting the privacy by keeping the sounds inside from being audible outside. Insulating the home also creates a moisture barrier, keeping undesirable moisture out and offers much comfortable living environment inside. Insulating the electrical outlets and the corresponding components will protect home against any electrical shock. The benefit of home insulation is not related to the occupants inside the house only but it is also extended to keep the environment out of pollutants. The insulated building will contribute to use less energy for air conditioning. This will reduce the carbon footprint, and also reduce the amount of chemicals released into the environment from air-conditioning units. Therefore, insulation is a key element in the so-called "green home policy".

Insulation Materials

Insulation materials are made to maintain the building components and facilities as long as possible. There are many types of insulation materials according to the purpose and the structure.

Types of Insulators
1. Thermal insulators
2. Acoustic insulators
3. Waterproofing insulators
4. Radiation insulators
5. Electrical insulators

Thermal Insulators

Thermal insulators are those materials that prevent or reduce various forms of heat transfer (conduction, convection and radiation). Insulator resists the heat transfer from out to in or in opposite direction whether the environment temperature is high or low. There are many advantages of thermal insulation that isolates the building from the heat and reduces the energy consumption as well as the costs of air-conditioning operation. Also, it makes the indoor temperature of the building stable and non-volatile. To reduce the transmission of the heat, buildings must be isolated in order to protect it from heat loss in winter and heat gained in the summer. It is found that about 60% of heat losses directly through the ceilings and walls of the building and that about 15% through the glass and about 25% of the heat infiltrates through cracks, openings and doors. To make the thermal insulation of the building an economical process, the following factors should be chosen carefully: - The amount of insulation material and thickness - The cost of insulation material and labor costs for installation. - The amount of energy saving and the reduction in greenhouse emissions. 6 Location of thermal insulation It is used to choose a quality of insulation material that satisfies the balance between the economic saving and the energy saving. Buildings are divided in terms of thermal insulation location into two types, buildings in warm climates and buildings in cold climates. Most of the heat that is gained in hot climates come through the outer shell of the building due to high solar intensity and the temperature differences between indoor and outdoor environment. The heat gained from external sources is higher than that comes from the internal heat generated by the various activities. The increase in thermal insulation in the outer shell of the building will lead necessarily to reduce the amount of heat gained and this consequently leads to reduce the energy needed for cooling. The U-value is a dominant factor to find the optimal thickness of the insulator in building. The amount of the total cost is equal to the total cost of insulating material plus the cost of energy saved in the building for a certain period. In cold climates, heat is transferred from inside to out, so the insulating layer should be located in the internal face of the surfaces in order to reduce the heat losses. Types of thermal insulators The thermal insulation refers to all isolators systems that reduce the heat transfer. Thermal insulation in buildings prevents the heat loss in winter and resists the heat from out in summer. It is looked to use best thermal insulation materials that reduces all types of heat transfer modes like conduction, convection and radiation. Glass wool is one of the most common thermal insulators as well as polyurethane, cork, polymers and many other materials. 7 1.5 Acoustic Insulators Acoustic isolators prevent the permeability of sound and absorb it or try to disperse it. Sounds transmit through the air so we can distinguish the different types of voices as well as the noise. Sounds also travel as a waves through solid objects of the building specially the concrete bodies, so it should be isolated to prevent the transmission of sound from out to the inside or from one place to another.

Objective of acoustic insulation

1. Prevent transmission of sound from the outside and between the partitions through walls and ceilings.
2. Prevent the transmission of sounds and vibrations of machines.
3. Absorption of sound inside.

Architectural procedures to control the acoustics

1. Planning methods of determining the home position relative to sources of external sounds such as streets, markets and factories as well as the correct orientation of windows, doors, etc.
2. Design methods for internal spaces of the building.
3. Methods of choosing perfect soundproof material.

Types of acoustic insulators

1. Acoustic tiles and sound-absorbing tiles, made up of two sides often be grainy and of colored quartz and assembled by resin. it is characterized by its ability of durability and easy cleaning.
2. Glass wool panels which could be covered by aluminum foil to absorb sound and reject heat. It could be installed on the walls, floors and ceilings
3. Plastic layers that might be perforated or grainy face.

4 Sheets of cellulose compressed and perforated face.

5. Slabs of gypsum with the possibility of adding glass fibers.
6. Polymers like rubber, cork (EPS), foam.
7. Rocks like Perlite.

Waterproofing Insulators

All buildings need insulation from moisture, rain, groundwater and surface water because the moisture helps to damage the elements of construction and there materials and release undesired smells with the breeding of insects and mice and bring diseases. The walls that exposed to the rain without sufficient amount of sunlight are more susceptible to moisture.

Effect of dampness

- Damage of building materials and elements of the house
- Efflorescence of the walls, floors and ceilings.
- Damaging the paint.
- The failure in the timber used and wooden décor
- Corrosion of metallic parts.
- Proliferation of fungi and unhealthy situation for users in the building

. Causes of dampness

1. Rain water: The rain water has the ability to penetrate the poor surfaces of the roof especially in absence of gutters. Rain could penetrate the external windows in absence of overhangs.
2. Surface water: This means river, sea or pond, where the water mixes with the soil close to the building and be clay near the foundations then moisture seeps to the foundations or inside through the capillary action.
3. Underground water: which formed by the accumulated water under the earth's surface. Water transmits through the pores in the soil by the osmosis phenomenon and reaches the foundations of the building.

4. Condensation: it noticed in winter days a layer of dew formed on the window or even wall, and this phenomenon is called "condensation". The accumulated moisture on windows, walls, ceilings and floors seeps into parts of the house after a period of time and leads to the fragility of construction materials and the appearance of rust, mildew and odors.

1. Poor sewage drainage: When wastewater gathers under the building and it was hard to flow downstream because of some restrictions then dampness could be occurred in the nearby elements of the building.

2. Modern construction: the walls newly constructed remain in the wet state for a certain period. Types of waterproofing insulators It is advised to use and install barriers to prevent water leakage into the different parts of building elements.
3. The common waterproofing materials are: asphalt, flan coat, bitumen, polyethylene White cement, asbestos and acrylic 1