UNIT 1

Stones

Structure

1.1 Introduction
1.2 Classification of Rocks
1.3 Uses of Stones
1.4 Requirement of Building Stones
1.5 Selection of stone and their characteristic
1.6 Artificial stone
1.7 Introduction of aggregate

Learning Objectives

After studying this unit, you will be able to

- Know what are building stones and rocks
- Know the uses of stones
- Know the qualities of good buildings stone
- Understand the selection of stones and uses
- Understand the Artificial stones
- Understand the Grading and Aggregates
1.1 Introduction

Stone is a natural constructional material. It is obtained from rocks occurring in nature. A building stone is a piece of rock quarried and worked into a required size and shape for a particular purpose. There are different types of rocks and stones are classified into a number of ways.

1.2 Classification of Rocks

Buildings stone are obtained form Rocks. Rocks are classified in to the following type.

1. Geological classification
2. Physical classification
3. Chemical classification

1.2.1 Geological Classification

According to the geographical classification rocks may be classified in to the types.

Igneous Rocks

Igneous rocks are formed as a result of solidification molten lava below or the earth surface due to cooling effect. By the condition of cooling and crystallization these rocks may be divided into, plutonic, volcanic and hypabyssal rocks.

Plutonic rocks

Rock are formed when cooling of magma takes place at a very slow rate beneath the surface of earth under considerable pressure of the upper layers. The plutonic rocks include granite, diorite, labradorite etc.

Volcanic rocks

Rocks are formed when molten lava of magma gets exposed to the atmosphere at the surface of the earth magma cools very rapidly resulting infine grained structure of these rock.

The example of volcanic rocks are basalt, phryrite.

Hypabyssal rocks: Intrusive igneous rocks which form near the surface are known as hypabyssal rocks.

Sedimentary rocks: Sedimentary rocks are often referred to as a secondary rocks. These are formed by deposition of material like Sand, Clay,
Broken rocks with the help of weathering agencies at the earth surface and within bodies of water. The example of sedimentary rocks are sand stone, lime stone, shale etc.

**Metamorphic rocks:** Metamorphic rock are formed from Igneous and sedimentary rocks due to considerable changes of temperature, pressure and chemical environment. The process of change due to heat and pressure is known as metamorphism.

<table>
<thead>
<tr>
<th>Original Rock</th>
<th>Metamorphic rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone</td>
<td>Marble</td>
</tr>
<tr>
<td>Sandstone</td>
<td>Quartzite</td>
</tr>
<tr>
<td>Granite</td>
<td>Gneiss</td>
</tr>
<tr>
<td>Shale</td>
<td>Slate</td>
</tr>
</tbody>
</table>

### 1.2.2 Physical Classification

This classification on general structure rock may be classified into the following three types:

**Stratified Rock:** These rocks are having layered structure. They possess planes of stratification or cleavage. These rocks can be easily split along these planes. Limestone, slate, shale are the example of stratified rocks.

**Unstratified rock:** There possess crystalline and compact grains marble, Granite, Trap are the example of this type of rocks.

**Poliated rocks:** Poliated rock comprise of thin lamination and can be split in definite size and direction.

### 1.2.3 Chemical classification

This classification is based on chemical composition of rocks may be divided into the three categories.

**Silicious Rock:** Silicious rocks consist of silica ($\text{SiO}_2$) is the major constituent. These rock are hard, durable and easily effect by weathering agencies.

Ex: Granite, Quartzite etc.

**Argillaceous rocks:** Clay or alumina ($\text{Al}_2\text{O}_3$) is the major constituent of these rocks. These rocks may be dense and compact or may be soft.
Ex: Slate, Latrine etc.

**Calecareous Rock**: Calcium carbonate \((\text{CaCO}_3)\) is the major constituent of these rocks.

Ex: Limestone, Marble etc.

**1.3 Uses of Stones**

- Stone blocks are used in the construction of foundation, walls, column, lintels, arches, roofs, floors, abutments, piers of bridge etc.
- Blocks and slabs for face work of building requiring architectural treatment.
- These are used to cover floor of building all types. They are also adopted to from paving of roads, foothpaths etc.
- Stone ballast for railway track, road construction preparation of cement concrete etc.
- Crushed stone as substitute for sand
- Lime stone for the manufacture of lime and cement.
- Thin slabs for impervious stones for laying damp proof courses in building.

**1.4 Requirement of Building Stones**

### 1.4.1 Appearance

Good building stone should have uniform colour. They should be free of clay holes, bands. Goods building should be able to receive good polish also strength.

### 1.4.2 Strength

Stone should be able to withstand compression as the stones used in building construction are subjected to comprehensive stress.

### 1.4.3 Structure

A good building stone should show uniformity of texture. It should be closed grained or crystalline structure the fracture of stone should be sharp, even and clean.

### 1.4.4 Hardness

A good building stone should have sufficient hardness and durability. The coefficient of hardness should be more than 14.
1.4.5 Toughness

A good building stone should be sufficient tough. It should be able to withstand the stress developed due to vibration of the moving loads.

1.4.6 Durability

Good building should be able to resist various atmosphere agencies such as temperature, wind, rain etc.

1.4.7 Seasoning

Stones should be well seasoned before putting into use. A period of 6 to 12 month is sufficient for proper seasoning.

1.4.8 Dressing

Stones should have good dressing properties, i.e. easily moveable.

1.4.9 Porosity and Absorption

More porous stones are not suitable for construction. A good building stone should not be porous and should not absorb water when immered.

1.4.10 Specific gravity

The specific of a good building stone should be more than 2.7.

1.4.11 Resistance to Fire

Stone should be able to resist high temperature and offer resistance fire.

1.4.12 Availability

Stone should be easily and economically available.

1.5 Selection of stone and their characteristic

1.5.1 Granite

Coarse or fine grained stone obtained from igneous rock. Granite consist of fields pav, quartz, mica and other coloured materials.

Properties: It is the heavy, hard, strong durable and crystalline unstrafied stone. It is available in wide ranging colours usually in grey, green, brown and pink and red.

It has negligible porosity. Its water absorption is 0.1 - 0.6%.

The specific gravity of granite is between 2.65 and 2.75. Its compressive strength usually between 1000-1400 kg.
Granite is also resistant to many acids and other caustic chemical.

**Uses of Granite:** Granite is used in construction, piers, and abutments of bridges, light houses.

**Weirs and barrages:** Granite can be polished finely and used as a facing material for building some types at granite are used as road metal and railway also.

**Availability:** Granite are available in the states of Andhra Pradesh, Madhya Pradesh, Rajasthan, Karnatake, Gujarat and Kashmir.

**Sand stone:** Sand stone is a stratified sedimentary rock. It consist of grains of sand alumina and iron oxides etc. The colours of sand stone vary from white, yellow, light gray, brown, red, dark blue and black to pink.

Good Sand Stone is used as building materials this used for steps, pavings works, columns flouring and walls. Rough and coarse grained sand stone is good for rubble masonry work.

**Availability**

Good sand stone si found in Uttar pradesh, Madhya Pradesh, Rajasthan, Maharashtra, Andhra Pradesh,

**1.5.2 Lime stone**

Limestone is calcareous sedimentary rock formed at the both of lakes and sea with the accumulation of shell bones and other calcium rich goods. It is composed of calcite caco. The usually colours of limestone are white, grey, pink, red, blue, brown, yellow and black. Limestone slabs are used for flouring paving and roofing purposes. It is used in the manufacture at give and cement.

**Availability:** It is found is states of Madhya pradesh, Tamil Nadu, Rajasthan, Maharashtra, Andhra Pradesh and Gujarat also.

**1.5.3 Marble**

Marble is compact, crystalline, strongest and more durable type in stone. It is formed Metamorphic actions and fine to coarse grained. The hardness of marble is not high, hence it can easily be cut into this slabs ground and polished.

Marble is used for ornamental buildings, temples, Mosques and superior types of buildings. It is also used for Interior facing of walls and to manufacture of stair step units, window sills and other structural members. Mosaic concrete units are also produced from waste marble.
Availability: While Marble is found in Jodhpur, Ajmer, Jaipur and Jabalpur—Green Marble is found in Baroda. Pink Marble is found in kishangarh.

**1.6 Artificial stones**

When durable natural stone blocks are not available at a reasonable cost, the artificial stones are used. Hardened plain cement concrete moulded in suitable shapes and sizes is called artificial stones.

Artificial stone is prepared by mixing 1.5 parts of crushed stone having 3-6 mm size and 1.5 parts of crushed stone having less than 3 mm size 1 part of cement. The crushed stone of both the size is obtained from natural stone. A desired pigment is added to the mixture to get the exact colour of natural stone.

**Varieties of Artificial stones**

The following are some of the Varieties of Artificial stones:

1. **Cement Concrete blocks**: are cast inside for construction of piers, window sills etc.

2. **Mosaic Tiles**: The precast concrete tiles with marble chips at top surface known as mosaic tiles. They are different shades and widely used at present.

3. **Terrazo**: It is the mixture of marble chips while cement and desired pigments. Terrazo is used for bath rooms, residential buildings, temples etc.

4. **Victoria Stones**: These are granite pieces with the surfaces hardened by keeping immersed in soda silicate for about two months.

5. **Garlic stones**: is produced by moulding a mixture of Iron slag and Portland cement. These are used for flag stones, surface drain etc.

**1.7 Introduction of Aggregate**

Aggregates are inert mineral materials which are mixed with a binding material to form concrete. The commonly used aggregates include sand, gravel surkhi and crushed rocks, most of aggregates are naturally occurring aggregates.

**1.7.1. Classification of Aggregates**

Depending upon the size, aggregates may be classified into following three categories.

**Fine Aggregates**: The materials below 4.75mm size are called find aggregates. The particles of fine aggregates pass through a 4.75 mm mesh and retained on a 150 micro mesh.
Course Aggregates: The materials whose particles are bigger than 4.75 mm but smaller than 7.5 mm are called coarse aggregates. The commonly used coarse aggregates include stone ballast, gravel.

1.7.2 Grading of Aggregates

Grading of aggregates consists of pre portioning the fine and coarse aggregate in such a ratio, so as to get strongest and densest mix with the least amount of cement. It also refers to the amount of each size of particles used in the mix. Too large a particle size of coarse aggregate requires more cement paste to fill the voids aggregates that have “good grading” or “all well graded” have the same percentage of each size stone. It is the aggregate that give concrete its high compressive strength.

Grading the aggregates is so graded as to have minimum voids when mixed with all ingredients; and water should render a concrete mass of east workability.

The grading of aggregates is done by the following methods.

i. By trail: In this method, proportioning of aggregates is so done as to give heaviest weight for same volume to get the densest concrete.

ii. By Finess modules method: In this method, the samples of both coarse and fine aggregates are passed through set of fine standard sieve and the percentage of sample retained on each of the said sieve is determined. The total of these percentages divided by 100 gives the finesses modules of samples.

iii. By minimum voids method: This method is based on the fact that to obtain dense concrete the quantity of cement should also be slightly in excess of voids more than that of the fine aggregates. In the method the voids in the fine and coarse aggregates are separately found out with the help of graduated cylinder and water. The Percentage of voids in aggregates.

“X” given by the equation

\[ X = \frac{(V_1 - V_2)}{V_2} \times 100 \]

Where \( V_1 \) = volume of water filled.

\( V_2 \) = volume of aggregates.
## Summary

1. Rocks are classified into following types
   - Geological classification
   - Physical classification

2. According to geological classification rocks are classified as Igneous rock, sedimentary rocks, metamorphic rocks.

3. According to physical classification the rocks are classified into Stratified rocks, unstratified rocks, foliated rocks.

4. **Igneous rocks**: Rock formed by cooling and solidification of magma is known as igneous rock.

5. **Sedimentary rocks**: The rock formed by the deposition of material carried by the weathering agencies at the earth surface and with bodies or water known as sedimentary rocks.

6. **Metamorphic rock**: Metamorphic rocks form deep within the earth when heat and pressure are applied to either gneiss rocks or sedimentary rocks.

7. A good building stone should have the following qualities
   - Appearance
   - Strength
   - Structure
   - Hardness
   - Roughness
   - Durability
   - Seasoning
   - Dressing
   - Porosity and water absorption
   - Frost Resistance etc.

8. The stone are used for Structural work, face work, paving work,
basic materials, other purpose like ballash for Railways.

9. Varieties of stones Granite, Basalt, Limestone, sandstone, marble, quartzite, folpar etc.

10. The artificial stones are Cement concrete
    • Mosaictites
    • Terrazo

11. Depending upon their size, the aggregates are classified
    • Fine aggregates
    • Coarse aggregates

Short Answer Type Questions
1. State the classification of stones.
2. Name the type of rocks according to geological classification.
3. Define igneous rocks.
4. Define sedimentary rocks.
5. Define metamorphic rock.
6. List out the uses of Granite.
7. List out the used of Marble.
8. Name any four building stones.
9. Name any four qualities of stones.
10. What are artificial stones?

Long Answer Type Questions
1. Explain the classification of stones.
2. Explain the geological classification of stones.
3. Explain the qualities of good building stones.
4. Explain the physical classification of stones.
5. Explain the advantages of artificial stones.
6. Explain the grading of aggregates.
7. Write the uses of following building.
   (a) Marble (b) Granite (c) Basalt (d) Sand stone
Structure

2.1 Introduction
2.2 Classification of Bricks
2.3 Properties of Good Bricks
2.4 Special type of Bricks
2.5 Grade of Bricks as per B.I

Learning Objectives

After studying this unit, the student will be able to understand

- Know the composition of good brick earth.
- Know the manufacturing of process of Bricks.
- Know the classification of Bricks and its Properties.
- Know about the properties of good bricks.
- Know about special types of Bricks and their uses
- The grades of bricks as per B.I.

2.1 Introduction

The bricks are defined as artificially moulded clay blocks with the mass of natural clay, with uniform size and shape.
Bricks are obtained by moulding clay in rectangular blocks of uniform size and then by drying and burning these bricks.

**Composition of Good Brick Earth**

According to IS: 2117-1975 they clay for bricks should preferably conform to the following composition for good result:

1. **Alumina (clay)**: 20 to 30% by weight
2. **Silt**: 20 to 35% by weight
3. **Silica (sand)**: 35 to 50% by weight
4. **Other Ingredients**: 1 to 2% by weight
   - Lime (cao)
   - Iron oxide (Feo)
   - Manesiaoxide (mgo)
   - Maganese (Mn)
   - Sodium, potashere

**Manufacture of bricks**

The manufacturing of brick involved the following operations:

1. Preparation of clay
2. Moulding
3. Drying &
4. Burning

![Fig 2.1 Brick Faces](image)
1. Preparation of Clay

The preparation of clay involves following operations:

a. **Unsoiling**: Top layer of 20 cm depth is removed as it contain impurities.

b. **Digging**: Clay dug out from ground is spread on level ground about 60 cm to 120 cm heaps.

c. **Cleaning**: Stones, pebbles, vegetable matter etc removed and converted into powder form.

![Pug mill diagram]

Fig 2.2 Pug mill
Weathering: Clay is exposed to atmosphere from few weeks to full season.

e. **Blending**: Clay is made loose and any ingredient to be added is spread over the top by turning it up and down in vertical direction.

f. **Tempering**: Clay is brought to a proper degree of hardness, then water is added to clay and whole mass is kneaded or pressed under the feet of men or cattle. For large scale, tempering is usually done in a pug mill.

g. **Process**: Clay with water is placed in pug mill from the top. When the vertical staff is rotated by electric power, steam or diesel or turned by paid of bullocks, clay is thoroughly mixed up by the actions of horizontal arms and knives. When clay is sufficiently pugged, hole at the bottom of tub, is opened out and the pugged earth is taken out from ramp for the next operation of moulding.

2. Moulding

Clay, which is prepared from pug mill, is sent of the next operation of moulding.

Following are the two ways of moulding

Moulding: Moulds are rectangular boxes of wood or steel, which are open at top and bottom. Steel moulds are more durable and used for manufacturing bricks on large scale as shown in figure. 3.2.3

Bricks prepared by hand moulding are of two types:

a. Ground moulded bricks

b. Table moulded bricks

![Fig.2.3 Wooded mould & steel Mould](image)
a. Ground moulded bricks: ground is first made level and fine sand is sprinkled over it. Mould is dipped in water and placed over the ground to fill the clay. Extra clay is removed by wooden or metal strike after the mould is filled forced mould is then lifted up and raw brick is left on the ground. Mould is then dipped in water every time lower faces of ground moulded bricks are rough and it is not possible to place from on such bricks.

Ground moulded bricks of better quality and with frogs on their surface are made by using a pair of pallet boards and a wooden block.

b. Table-moulded bricks: Process of moulding these bricks is just similar to ground bricks on a table of size about 2m x 1m.

1. Machine moulding: This method proves to be economical when bricks in huge quantity are to be manufactured at the same spot. It is also helpful for moulding hard and string clay. These machines are broadly classified in two categories

   a. Plastic clay machines

   b. Dry clay machines

   a. Plastic clay machines: This machine containing rectangular opening of size equal to length and width of a brick. Pugged clay is placed in the machine and as it comes out through the opening, it is cut into strips by wires fixed in frames, so there bricks are called wire cut bricks.

   b. Dry clay machines: In these machines, strong clay is first converted into powder form and then water is added to form a stiff plastic paste. Such paste is placed in mould and pressed by machine to form hard and well shaped bricks. These bricks are behaviour than ordinary hand moulded bricks. They carry distinct frogs and exhibit uniform texture.

3. Drying

The damp bricks, if burnt, are likely to be cracked and distorted. Hence moulded bricks are dried before they are taken for the next operation of burning. Bricks are laid along and across the stock in alternate layers. The drying of brick is by the following means.

   i. Artificial Drying: Drying by tunnels usually 120°C about 1 to 3 days

   ii. Circulation of air: Stacks are arranged in such a way that sufficient air space is left between them free circulation of air.

   iii. Drying yard: Special yards should be prepared slightly higher level prevent the accumulation of rain water.
iv. Period of drying: usually about 3 to 10 days to bricks to become dry.

v. Screens: Screens are necessary, may be provided to avoid direct exposure to wind or sun.

4. Burning

This is very important operation in the manufacturing of bricks to impart harness, strength and makes them dense and durable. Burning of bricks is done either in clamps or in kilns. Clamps are temporary structures and they are adopted to manufacture bricks on small scale. Kilns are permanent structures and they are adopted to manufacture bricks on a large scale. A typical clamp is as shown in figure below.

1. A trapezoidal shape in plan with shorter is slightly in excavation and wider end raised at an angle of 150 from ground level.

2. A bricks wall with mud is constructed on the short end a layer of 70cm to 80cm thick fuel (grass, cow dung, ground nuts, wood or coal) laid on the floor.

3. A layer consists of 4 or 5 courses of raw bricks laid on edges with small spaces between them for circulation of air.

4. A second layer of fuel is then placed, and over it another layer of raw bricks is putap. The total height of clamp in alternate layers of bricks is about 3 to 4m.

5. When clamp is completely constructed, it is plastered with mud on sides and top and filled with earth to prevent the escape of heat.

6. The period of burning is about one to two months and allow the same time for cooling.

7. Burnt bricks are taken out from the clamp

Advantages

1. The bricks produced are tough and strong because burning and cooling are gradual.

2. Burning in clamps proves to be cheap and economical.

3. No skilled labour and supervision are required for the constriction of clamps.

4. There is considerable saving of clamp fuel.
Disadvantages

1. Bricks are not required shape
2. It is very slow process
3. It is not possible to regulate fire in a clamp
4. Quality of brick is not uniform

Kilns

A kiln is a large oven, which is used to burnt bricks by

1. Intermittent kilns
2. Continuous kilns
Intermittent kilns: These intermittent in operation, which means that they are loaded, fired, cooled and unloaded.

a. Intermittent up-draught kilns

b. Intermittent down-draught kilns

a. Intermittent up-draught kiln

This is in the form of rectangular with thick outside walls as shown in the figure below; wide doors are provided at each end for loading and unloading of kilns. A temporary roof may be installed to protect from rain and it is removed after kiln is fired. Flues are provided to carry flames or hot grass through the body of kiln.

![Diagram of Intermittent Kiln](image)

Fig 2.5 Intermittent kiln

i. Raw bricks are laid in the row of thickness equal to 2 to 3 bricks and height 6 to 8 bricks and 2 bricks spacing between rows.

ii. Fuels are filled with brush wood which takes up a free easily.

iii. Loading of kiln with raw bricks with top course is finished with flat bricks and other courses are formed by placing bricks on edges.

iv. Each door is built up with dry bricks and is covered with mud or clay.
v. The kiln is then fired for a period for 48 to 60 hours fraught rises in the upward direction from bottom of kiln and brings about the burning of bricks.

vi. Kiln is allowed to fool down and bricks are then taken out.

vii. Same procedure is repeated for the next burning

Bricks manufactured by intermittent up draught kilns are better than those prepared by clamps but bricks burnt by this process is not uniform, supply of bricks is not continuous and wastage of fuel heat.

b. Intermittent down-draught kilns

These kilns are rectangular or circular in shape. They are provided with permanent walls and closed tight roof. Floor of the kiln has opening which are connected to a common chimney stack through flues. Working is same as up-draught kiln. But it is so arranged in this kiln that hot gases are carried through vertical flues upto the level of roof and they are then released. These hot gases move down ward by the chimney draught and in doing so, they burn the bricks.

Advantages

1. Bricks are evenly burnt
2. Performance of this kiln is better than that of up-draught kiln
3. This kiln is suitable for burning of structural clay tiles, terra cota because of close control of heat.

Continuous kilns

These kilns are continuous in operations. This means that loading, firing, Cooling and unloading are carried out simultaneously in these kilns. There are three types of continuous kilns.

a. Bull’s trench kiln

b. Hoffman’s kiln

c. Tunnel kiln

2.2 Classification of Bricks

There are broadly into the categories

(i) Un burn bricks

(ii) Burn Brick
(i) **Unburn Bricks**: These bricks are dried with the help of heat of the sun after moulding these bricks are used in the construction of temporary structure.

(ii) **Burn Bricks**: These bricks are classified into the following four categories

**First class bricks**: These bricks are table moulded and standard shape. The surface and edges of the bricks are sharp, square, smooth, straight and well burnt; these bricks are used for superior work of permanent nature.

**Second class bricks**: These are not perfectly rectangular in shape and have a rough surface. These also give a ringing sound when struck together. Water absorption should not be more than 22 percent of its weight in 24 hours immersion in cold water.

**Third class brick**: These bricks are not burnt and may be over burnt. These are soft and can be easily broken. They are light blue in colour. These bricks should not absorb more than 25 percent water of their weight in 24 hours immersion in cold water. These bricks are used for temporary structures and in places where rain fall is not heavy.

**Over burnt brick**: Due to excessive temperature, bricks get over burnt. The lose their sharp edges and get furnished.

These bricks are dark bluish in color.

### 2.3 Properties of good bricks

(i) Good bricks should be truly rectangular in shape, compact in texture and uniform through with sharp edge.

(ii) They should be found, hard, well burnt and have uniform red colour.

(iii) They should give metallic ringing sound on striking with each other.

(iv) They should be free from holes, bumps, stones, and particles of uncombined lime.

(v) “Bricks” When soaked in water for 24 hours should not show deposit of white salts when allowed to dry in shade.

(vi) Bricks should not absorb water more than 20 percent by weight for first class bricks.
(vii) Bricks should not break when dropped flat on hard ground from weight of about one meter.

(viii) Bricks should not hard no impression should be deft on bricks surface when scratched with finger nail.

(ix) No brick should have crushing strength below 53 kg/cm².

### 2.4 Special types of Bricks

#### 2.4.1 Ply ash bricks

Ply ash is a residue from thermal power plants in which. Coal is used as fuel to generate Electricity ply ash contains oxides of calcium, aluminium and silicon. They are lighter in weight then ordinary bricks.

The raw material that is used ply ash bricks are ply ash sand, lime, Gypsum.

The blocks are removed from block after 24 hours and immersed in water for curing about 28 days.

**Advantages**

1. Due to high strength, no breakage during transform

2. Due to uniform size of bricks mortar required of joints and plaster reduces almost by 50%.

3. Plaster of part can be directly applied on these bricks without a backing coat of plaster.

4. Comprehensive strength of ply and sand lime bricks is 91/.

**Disadvantage**

Poor quality and outlook in colour without plastering.

Limitation of size, only modular size can be produces will have more breakages.

#### 2.4.2 Pre cast concrete blocks

Due to various advantages over traditional bricks and stones, concrete blocks are extensively used now a days. They can be made solid or hollow.

Solid blocks are used for loading bearing walls and hollow blocks are used for non-load bearing walls.

The sizes of common concrete blocks are
Advantages of concrete blocks

- Width of wall can be reduced compared to brick walls.
- It provides better heat and sound insulation and fire resistance property.
- Construction will be much faster.

2.4.3 Fire clay Bricks or Refractory Bricks

Refractory bricks are defined as non-metallic material suitable for the construction of lining of surface operated high temperature. These are made up of refractory clays, which can withstand very high temperature without becoming soft on melting. The refractory clay is composed of heat resisting materials, such as silica, alumina, bauxite, magnesite, chromite etc and does not contain oxide iron, lime and alkalies.

Properties

- The colour is whitish, yellow or light brown.
- The water absorption varies 4 to 10%.
- The compressive strength ranges between 150 to 200 kg/cm².

Uses

These bricks used for lining of blast furnaces, oven, kilns, boilers and chimneys etc.

2.5 Grade of bricks as per B.I.S

As per ISI 19557 and 1970 code specification

(a) Bricks with compressive strength not less than 140 kg/cm²- Grade A- class A.

(b) Bricks with compressive strength not less than 105 kg/cm²- First class Bricks- Grade A.

(c) Bricks with compressive strength not less than 70 kg/cm²- Second class bricks-Grade B.
(d) Bricks with compressive strength not less than the average value 35 kg/cm² - Class III Bricks Grade C.

**Summary**

1. Brick is a building material composed of following material:
   - Alumina, Silica, Lime, Oxide of Iron and Magnesia.
2. Manufacturing of bricks carried out by the following operations:
   - Preparation of clay
   - Moulding
   - Drying
   - Burning
3. Bricks are classified as:
   - Un-burnt bricks
   - Burnt bricks
   - First class bricks
   - Second class bricks
   - Third class brick
   - Fourth class bricks
4. A good brick should be moulded, well burnt, uniform in shape and size. It should give a clear ringing sound, be hard, have water absorption not more than 20% for 24 hours.
5. The raw material used for fly ash bricks are:
   - Fly ash, sand, stone dust, lime, Gypsum and cement.
6. Fire bricks are made from:
   - Fire clay (30%)
   - Silica (75%)
   - Small percentage of alkalies.
7. Fire bricks are used for lining the interior surfaces of ovens, Kilns, Chimneys and furnaces.

**Short Answer Type Questions**

1. State the composition of good brick earth.
2. What are the steps involved in the manufacture of brick?
3. State the uses of fire bricks.
4. Give the general classification of bricks.
5. Write the grades of bricks as per B.I.S.

**Long Answer Type Question**

1. Explain the manufacture of bricks, in detail.
2. Explain the classification of bricks.
3. Explain the characteristic of good bricks.
4. What are fly ash bricks? Explain their advantages and disadvantages.
5. Explain the Fire clay bricks.
Structure

3.1 Introduction
3.2 Types of Cement
3.3 Grades of Cement
3.4 Uses of Cement
3.5 Admixtures
3.6 Lime

Learning Objectives

After learning this unit the student will able to understand

- Know the what is cement and its chemical composition
- Know the different types of cement and is properties
- Know the grades of cement
- Known the uses of cement
- Known what are admixtures and uses.
- Know the what is lime and classification
3.1 Introduction

The cement is a product obtained by crushing of clinkers formed by burning of desired proportion of calcareous and orgillaceous material at high temperature when it is mixed with water, it forms a paste, durable mass called concrete.

3.1.1 Composition of portland and cement

The standard ordinary portland cement contain the following chemical ingredients.

The proportion of ingredients as follow

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime (Cao)</td>
<td>60-67</td>
</tr>
<tr>
<td>Silica (Sio2)</td>
<td>17-25</td>
</tr>
<tr>
<td>Alumina or clay (Al₂O₃)</td>
<td>3-8</td>
</tr>
<tr>
<td>Ferrous oxide (Fe₂O₃)</td>
<td>2-6</td>
</tr>
<tr>
<td>Magnesium oxide</td>
<td>1-3</td>
</tr>
<tr>
<td>Alkalies (soda and potash)</td>
<td>0.5-1</td>
</tr>
<tr>
<td>Gypsum (CasO₄)</td>
<td>3-5</td>
</tr>
<tr>
<td>Sulphur trioxide</td>
<td>1-2-75</td>
</tr>
</tbody>
</table>

3.1.2 Functions of the ingredients of cement

The following of various ingredients of cement are as follow

Lime is the most important ingredient of cement. It provides high strength and hardening to cement. Excess lime causes cement to expand and disintegrate if the proportion of lime is less the strength of cement decrease.

Silica (Sio2) : silica gives strength to the cement.

Alumina (Al₂O₃) : Alumina imparts quick setting property of cement. Alumina in excess reduces the strength of cement.

Ferrous oxide (Fe₂O₃) : It imparts colour to cement. It also helps in increasing the strength and improving the hardness of cement.

Magnesium oxide (Mgo) : If magnesia is present is small amount, it imparts hardness and colour to cement.
Alkalies: Alkalies are harmful substances present in cement. Hence as per as possible their presence should be avoided or minimized.

Gypsum (Cas$\text{O}_4$): Gypsum control the rate of setting and hardening of cement.

Sulphur trioxide: When present in a small quality, imparts soundness to cement.

### 3.2 Types of Cement

As per the composition its properties cement is classified as follows

- Ordinary Portland Cement
- Quick setting cement
- Rapid hardening cement
- White cement
- Blast furnaces lag cement
- Portland pozzolan cement
- Low heat cement
- High alumina cement

#### 3.2.1 Ordinary Portland Cement (opc)

It is obtained by burning cash calcareous and algilaceous material at high temperature. The colour of the cement is grey with greenish shade. Its initial setting time is not less than 30 minutes and final setting time is 10 hours. It has low resistance to sulphate reaction. It is commonly used for all important structures, where great strength is required such as heavy buildings, bridges, Dams, weirs, water tanks RCC works and preparation of mortar etc.

#### 3.2.2 Quick Setting Cement

This cement sets at a much faster rate than ordinary portland cement. Its initial setting time five minute and final setting time is about 30 minutes this action can be achieved by adding little amount of aluminium sulphate to the cement during the process of grinding of clinkers. This cement is used where concrete is to be laid under water, in ruined water, or water logged areas. Repair works of piers of bridges etc.
3.2.3 Rapid hardening cement

This cement attains high strength in the early stage because of increased lime content composition, burning at a higher temperature and finer grinding of clinkers. The strength developed by this cement in four days equal the acquired by ordinary portland cement in 28 days. It is costlier than OPC. It is used for such structure which are loaded in the short time. This cement used in making of precast elements and repair works. It is used in the case of where speedy execution is very much essential.

3.2.4 White cement

It is manufacture from white chalk and clay the proper of this cement are same as those portland cement and in white colour it is used for face plaster of walls, terrazzo flooring, traffic curbs, aerodrome markings and other ornamental works. It is available in the market under various trade names such as show crater Birla white etc.

3.2.5 Blast Furnace slag cement

The blast furnace slag is a waste product obtained during the manufacture of iron. The slag is first crushed to granulated form and then thoroughly mixed with cement clinker.

Blast furnace slag cement is used for massive structure such as dams, foundation, bridges abutments retaining walls etc. This cement should not be used in the reinforced concrete structure.

3.2.6 Portland Pozzolana cement

Portland pozzolana cement is produced by grinding an mixture of portland cement clinker and pozzolana. It takes longer time to gain strength.

It can be used for all types of mass concrete works and marine works.

3.2.7 Low heat cement

Low heat cement produces much less heat during cement hydration, and setting, compared to ordinary cement. Its initial setting and final setting time is almost the same as their of the ordinary cement but the rate of development of strength is lower than that common cement it is used in certain areas where heat generation is objectionable it is not suitable for use in ordinary structure.
3.2.8 High Alumina Cement

It is manufactured by melting a mixture of aluminium ore and lime and grinding the resulting clinker.

Its initial setting time is more than three and a half hours and final setting time five hours. It liberates more heat during setting, hence it cannot be used for massive structure such as dams, bridges, etc. However, it is costly type of cement the cement is very useful for emergency repair workers.

3.3 Grades of Cement

The various grades of cement are 33 grade - 43 grade and 53 grade.

The initial setting final setting times and properties of these cement are same as there of ordinary portland cement.

The ordinary portland cement of is 33 grade is 33 N/mm2 similarly the compressive strength of 43 grade is 43 N/mm2 and for 53 grade it is 53 N/mm2.

Higher grades of 43 and 53 generate greater heat of hydration and need proper curing.

3.4 Uses of Cement

Cement is commonly used binding material in the construction of Engineering structures.

These main uses are

- Preparation of mortar for all kinds of masonry plastering, pointing, ornament works etc.
- Preparation of plain cement concrete and reinforced of cement concrete.
- For construction of positing, beams, columns lintels etc.
- Construction of Engineering structure like, bridges, dams, docks, highways, flyover.
- Construction of retaining walls, water tanks, swimming pools, precast elements etc.
- In manufacture of hume pipes, Railway sleeper, water pipes electrical poles culverts etc.
- For preparation artificial bricks floor tiles, repair works etc.
3.5 Admixtures

Some times the ingredients other than cement fine aggregate and coarse aggregate are added in concrete to give it certain improve qualities or for changing different physical properties in its fresh and hardened stages. These ingredients are known as the admixtures.

The addition of an admixture may improve the concrete with respect to its strength.

Alum, aluminium sulphate, barium oxide, bitumen, calcium chloride, coal ash, common salt, iron oxide, potassium chloride etc. For instance when calcium chloride is added as admixture.

Advantages

• Adjusting the final setting times of concrete.
• Increasing durability of concrete
• Lesser water-cement ratios
• Reducing quality of cement
• Reduction in the permeability of concrete
• Higher early and ultimate strengths
• Higher slump and self-levelling concrete

3.6 Lime

Lime is a binding material like cement. Lime is not found in a free state in nature. Lime is obtained by burning of limestone or the calcareous materials. Lime stone seashells chalk and kankar are use raw material for lime.

3.6.1 Uses of Lime

• It is used in purification of water and sewage treatment
• It is used as a flux in metallurgy.
• It is used as a matrix for lime concrete used in building foundation and filling where early setting is not required.
• It is used as binding material for the preparation of mortar for brick and stone masonry.
• It is used as cementing material in plaster for covering walls and pointing joints.
• Crushed limestone is used as aggregate.
• It is used for white washing. It is also used to provide base coat for distempers.
• It is used in the preparation of sand lime bricks.

3.6.2 Classification of lime

Lime is generally classified into three categories, namely fat lime, Hydraulic lime and poor lime.

Fat lime: Fat lime is the lime with high calcium content. It is called as high calcium lime, pure lime, rich lime, white lime. The volume of fatline increases two to three times of its original volume after slaking. The process of addition of water to quicklime is called slaking

\[ \text{cao} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 \]

The process of heating of limestone at red heat known as calcination.

\[ \text{CaCO}_3 \rightarrow \text{cao} + \text{CO}_2 \]

Due to burning of limestone, carbon dioxide driven off as gas and calcium oxide (cao) is let is in the form of lumps. It is known as quick lime then it almost immediately cracks, swells and turns into powder with cracking sound. This powder produce is called slaked lime or Hydrated lime.

Properties of Fat lime

• It hardness of very slowly
• It is having the high degree of plasticity
• It slake is vigorously
• The colour is pure lime
• In the presence of air, it tends to set very slowly.

Uses of Fat Lime

• Fat lime is used in white washing, plastering walls. As lime mortar with sand for pointing is masonry works etc.

Hydraulic lime: It is obtained by burning of kankar or clay lime stones. The clay material imparts hydraulicity to the lime.

Properties: It slakes is very slowly with out producing appreciable heat or noise.
It is not perfectly white in colour

**Uses**: Hydraulic lime is suitable for works under water. It may also be used in powdered form for plaster work. It may be used for preparing mortar for brick work.

**Poor lime**: Poor lime is also called impure lime. It contains 10 to 40% excess clayed impurities.

**Properties**: Its forms a thin paste with mortar and does not dissolve in water. Its colour may not be white and it possesses inferior plasticity.

**Uses**: It is used for plaster and preparation of mortar for inferior works only.

**Summary**

- Cement is a binding material into made by grinding calcined limestone and clay to a fine powder.

**The chemical composition of cement as follow**

- **Lime (Cao)** 60-70%
- **Silica (SiO2)** 17-25%
- **Alumina or clay (Al2O3)** 3-8%
- **Ferrow oxide (Fe3O4)** 2-6%
- **Magnesium oxide (MgO)** 1-3%
- **Alkalies** 0.5 - 1%
- **Gypsum (CaSO4)** 3-5%
- **Sulphur trioxide (S03)** 1.2 - 75%

**Type of cement**

- Ordinary portland cement
- Quick setting cement
- Rapid hardening cement
- White cement
- Blast furnace slag cement
- Portland pozzolana cement
- Low heat cement
- High alumina cement

**Different Grades cement are 33,43 and 53 grades**

- Lime is obtained by burning of limestone or the Calcareous materials
- Classification of lime
- Fat lime, Hydraulic lime, and Poor lime

**Calcination**: The process of heating of limestone at red heat is known as calcination.

**Slaking**: The process of addition of water to quick lime is called slakeing.

- Lime is used in purification of water, used as flux.
- It is used for white washing and cementing material in plaster.

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**Short Answer Type Question**

1. What is chemical composition of cement?
2. What are the functions of various ingredients?
3. What are the different grades of cement?
4. Define calcination.
5. What are the Admixture?
6. What is Lime?

---

**Long Answer Type Question**

1. What is cement? Explain the function of ingredients.
2. What are the various types of cement? Explain.
3. State the classification of lime and their uses.
4. Differentiate between fat lime and Hydraulic lime.
4.1 Introduction

Sand is normally occurring granular material composed of finely divided rock and mineral particles. The most common constituents of sand is silica sand forms the important ingredient of mortar and concrete apart from to the uses. In consists of fine grains of silica (SiO₂). It is used in mortar and in concrete as fine aggregate.
4.1 Sources of Sand

Depending upon the source, sand can be broadly classified as

A) Natural Sand and B) Artificial Sand

4.1.1 Natural Sand

According to the source from which it is obtained, sand is of the following three different kinds:

- Pit sand
- River sand
- Sea sand

Pit sand

It is found as deposits in soil. It is obtained by making pits into soil. This Sand is usually composed of grains that are relatively angular; it often contains clay and organic matter which imparts colour to it. When washed and screened it is good sand for general purposes, i.e, for lime and cement mortars.

River sand

This sand is obtained from banks or river beds. River sand consists of fine rounded grains free from impurities. The colour of river sand is almost white and its particle size is smaller than pit sand. It is widely used for all purposes.

Sea sand

This sand is obtained from sea shores. Like river sand, sea sand contains small rounded grains. It is light brown in colour. Sea sand contains salts. These salts attract moisture from the atmosphere causes dampness and efflorescence and retards setting time of cement. Sea sand is generally avoided to be used for construction purposes. However, it should be thoroughly washed to remove the salts if it has to be used.

4.1.2 Artificial Sand or ROBO SAND

Natural sand is weathered and worn out particles of rocks and are of various grades or size depending on weathering. The main natural and cheapest resource of sand is river sand. Dams are constructed on every river hence these resources are erasing very fast. Now a days, good sand is not readily available. It should be transported from long distance. Those resources are also exhausting very rapidly due to rapid increase in the construction activity. So it is need of the time to find some substitute to natural river sand.
The artificial sand produced by **crushing stones** can be a better substitute to river sand. The process of manufacturing robo sand is totally different from ordinary stone crushers from which we get 40 mm, 20 mm, 10 mm size coarse aggregate. The byproduct obtained from stone crushing process is not called robo sand. It is a stone dust. The sand should be sharp, clean and course. The grains should be of durable material. The grain sizes must be such that it should give minimum voids. The presence of clay and silt retards the setting of the cement and makes the mortar weaker and the walls or the slab leaks and holds dampness. The sand in the mortar does not add any strength but it is used as an adulterant for economy. It prevents the shrinkage and cracking of mortar on setting. The sand must be of proper gradation (it should have particles from 150 microns to 4.75 mm in proper proportion). When fine particles are in proper proportion, the sand will have fewer voids. The cement required will be less when there are fewer voids in sand. Such sand will be more economical.

### 4.2 Characteristics of Good Sand

1. It should contain coarse, angular, sharp and durable particles of silica.
2. It should not contain harmful chemicals.
3. It should be chemically inert.
4. It should be clean and well graded. Grains should pass through 4.75 mm I.S. sieve and should retain entirely on 75 microns I.S sieve.
5. It should not contain salts which attract moisture from atmosphere.
6. Fineness modulus of sand should be between 2 and 3.
7. Sand should be free from any organic or vegetable matter.
8. Colour of sand should be uniform.

### Functions of Sand

1. Sand adds to the **bulk** of the mortar and makes it economical.
2. It helps **prevention of cracks** of mortar on drying.
3. Sand **prevents excessive shrinkage** of binding materials like cement, lime, etc.
4. By varying the proportion of sand, strength of mortar or concrete can be modified.
5. It **helps in setting of fat lime** effectively.
4.3 Grading of Sand

According to grain size, sand is classified as (a) Fine Sand, (b) Coarse Sand and (c) Gravelly Sand.

(a) Fine Sand: sand particles passing through sieve with clear openings of 1.587 mm size is known as fine sand. It is suitable for plastering work.

(b) Coarse sand: sand passing through sieve with clear openings of 3.175 mm size is known as coarse sand. This sand is suitable for masonry work.

(c) Gravelly Sand: sand passing through sieve with clear openings of 7.62 mm size is known as gravelly sand. This sand is suitable for concrete work.

4.4 Bulking of Sand

Sand has a phenomenal property of bulking. Bulking of sand means increase in its volume due to presence of surface moisture. The volume increases with increase in moisture content. The volume may increase up to 20 to 40% when moisture content is 5 to 10%. It is actually a thin film of water around the sand grains and interlocking of air in between the sand grains and film of water that makes the sand bulkier.

When moisture content is increased by adding more water, sand particles pack near each other and the amount of bulking of sand is decreased. This phenomenon starts when the moisture content is about 11 to 12% and then onwards this reversal continues. Near about 28 to 30%, bulking of sand is almost zero. Thus the dry sand and the sand completely flooded with water have practically the same volume.

Demonstration: Take some sand in a container and measure the height of it. Then add 1% of water by weight of sand. Then again pour the sand in the container and measure the height. You will observe an increase in its height. Keep repeating the same process. At certain point you will observe that the sand has regained its original height.

It means that fully dry sand and fully saturated sand occupy the same volume.

Allowance for bulking of sand has to be made while proportioning by volume for mortar or concrete. Otherwise, amount of sand taken will be less. This makes the concrete insufficiently workable.

Test

For finding the bulking of sand, a test is carried out with following procedure as shown in the fig.
Fig. 4.1 Bulking of Sand

i. A container is taken and it is filled two third with the sample of sand to be tested.

ii. The height is measured, say 20cm.

iii. Sand is taken out of container

iv. The container is filled with water

v. Sand is then slowly dropped in the container and it is thoroughly stirred by means of a rod.

vi. The height of sand is measured say 16cm, then bulking of sand =

\[
\frac{20 - 16}{16} = \frac{4}{16} \text{ or } 25\%
\]

Compensation for Bulkage

Ex) Calculate how much actual quantity of sand has to be added for 50cum of sand, if the bulkage is 25%?

Quantity of sand to be added

\[
= \text{actual quantity} + \text{compensation for bulkage}
\]

\[
= 50 + \left(\frac{25}{100}\right) 50
\]

\[
= 50 + 12.5
\]

\[
= 62.5 \text{ cu m.}
\]
Summary

1. Sand forms the important ingredient of mortar and concrete apart from other uses. It consists of fine grains of silica ($\text{SiO}_2$). It is used in mortar and concrete as fine aggregate.

2. The sources of sand are
   - Pit sand
   - River sand
   - Sea sand

3. The sand should be
   - Chemically inert
   - Clean and coarse
   - Sharp, angular and durable
   - Not contain salts
   - Well graded

4. According to the size of grains, sand is classified as fine, coarse and gravelly sand.

5. Sand prepared by crushing stones is known as Artificial sand

6. The presence of moisture in sand increases the volume of sand known as bulking of sand.

Short Answer Type Questions

1. What are sources of natural sand?
2. Write any four characteristics of good sand?
3. What is artificial sand?
4. What are different grades of sand?
5. What bulking of sand?
6. Write any four functions of sand?
Long Answer Type Questions

1. Explain the sources of sand.
2. Explain the characteristics of good sand.
3. Explain how sand is classified according to grain size.
4. Explain the importance of bulking of sand.
Structure

5.1 Definition
5.2 Classification of Mortar
5.3 Preparation of Cement Mortar

Learning Objectives

After completing this unit, the student will be able to understand

- Explain what is a mortar,
- Know how mortars are classified,
- Know different proportions of mortars for various construction works
- Explain different precautions in the use of mortars.

5.1 Definition

Mortar is a workable paste prepared by mixing water to the mixture of binding material like Cement or Lime and fine aggregate like Sand or Surkhi.

Mortar is used to bind construction blocks together and fill the gaps between them. The blocks may be stone, brick, fly ash blocks, etc. Mortar becomes hard when it sets, resulting in a rigid aggregate structure.

Traditionally mud is used to prepare mortar. Modern mortars are typically made from a mixture of sand, a binder such as cement or lime, and water.
Mortar can also be used to fix, or point, masonry when the original mortar has washed away.

The durability and strength of mortar will depend on the quality of ingredients of the mortar. The proper selection of mortar for masonry is very important. Choosing the right mortar type can lead to a durable masonry wall. Improper selection of mortar types for a particular masonry job can result in a leaky wall or deteriorating mortar. Mortar is the bonding agent that transforms the masonry unit and the mortar into a lasting masonry wall. It has to be durable, capable of keeping the masonry intact, and resist moisture penetration.

**Properties of good mortar:**

- It should develop **good bond** between the layers of bricks and stones.
- It should be **durable**.
- It should develop **impervious layer** for heat and rain water.
- It should be easily **workable**.
- It should be **cheap**.
- It should not adversely affect the durability of the other building materials.
- It should be capable of **developing desired stresses**.
- It should **harden** in reasonably **short period of time**.
- It should accept and maintain the colour of the paint or wash for a longer period of time.

**Uses of Mortar**

- It should **bind** bricks or stones in the masonry together into a solid mass.
- It is used to **join pipes**.
- It is used for **plastering** and **pointing** works.
- It is used to prepare all types of **concrete mixes**.
- It is used to **cover defects** of the building materials or unevenness due to improper workmanship in construction.
- It is used to provide **smooth and hard surface** to masonry walls and floors.
- It is used to form **even bedding** layer for placing the building units.
5.2 Classification of Mortars

Following are various types of mortar used in construction:

1. Lime Mortar
2. Cement Mortar
3. Surki Mortar

5.2.1 Lime Mortar

The uniform paste prepared by mixing water to sand and lime in suitable proportion is known as lime mortar.

Lime mortar is of two types. They are Hydraulic Lime Mortar and Fat Lime Mortar.

- Hydraulic Lime Mortar

Hydraulic lime is used as binding material in this mortar. The usual proportion of Lime:Sand of this mortar is 1:2 or 1:3. It possesses good strength and used in various works. It can be used in damp or wet conditions. It should be used within one hour after mixing.

- Fat Lime Mortar

Fat lime is used as binding material in this mortar. The usual proportion of Lime:Sand of this mortar is 1:1 or 1:2. The strength of this mortar is less than that of hydraulic lime mortar. It is used for inferior works. It cannot be used in damp or wet conditions.

5.2.2 Cement Mortar

In this type of mortar, cement is used as binding material. It is widely used for all important works due to its strength and other superior qualities.

A workable paste prepared by mixing water with cement and sand in suitable proportion is known as cement mortar.

General proportion of Cement : Sand of this mortar varies from 1:2 to 1:6 depending upon the strength requirements.

It should be consumed in the first 30 minutes after adding water to the mix, which is the initial setting time of cement.
This mortar is used in the construction of pipes, foundations, dams, bridges, canal lining, flooring, plastering, pointing, etc.

The following are the properties of cement mortar:

1. When water is added to intimate dry mixtures of cement and sand, hydration of cement starts and it binds sand particles and the surrounding surfaces of masonry and concrete.

2. The strength of mortar depends upon the proportion of cement and sand. Strengths obtained with various proportions of cement and sand are shown in table.

3. A mix richer than 1:3 proportion is prone to shrinkage.

4. Well proportioned mortar provides impervious surface.

5. A leaner mix is not capable of closing the voids in sand, and hence the plastered surface is pervious.

Table: Compressive strengths for various mix proportions:

<table>
<thead>
<tr>
<th>Sr.no.</th>
<th>Mix proportion (Cement: Sand)</th>
<th>Compressive strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1:3</td>
<td>10 N/mm²</td>
</tr>
<tr>
<td>2.</td>
<td>1:4</td>
<td>7.5 N/mm²</td>
</tr>
<tr>
<td>3.</td>
<td>1:5</td>
<td>5.0 N/mm²</td>
</tr>
<tr>
<td>4.</td>
<td>1:6</td>
<td>3.0 N/mm²</td>
</tr>
<tr>
<td>5.</td>
<td>1:8</td>
<td>0.7 N/mm</td>
</tr>
</tbody>
</table>

5.3 Preparation of Cement Mortar

Cement mortar may be prepared by manual mixing or by mechanical mixing. Mechanical mixing is preferred when mortar is required in large quantities to be used in continuous order.

(a) Mixing in Mechanical Mixer

In this case, cement and sand in desired proportion are fed in the mixer and mixed dry. Water is then added gradually and the wet mixing continued for at least one minute to obtain the mortar of desired consistency. It is necessary to
ensure that only the quantity of mortar which can be used within half an hour of its mixing should be prepared at a time. This is essential as after 30 minutes the mortar begins to set.

(b) Manual Mixing

In this case, specified quantity of sand is spread and leveled on clean dry masonry platform. Required quantity of cement bags are emptied over the sand layer. The ingredients are then mixed thoroughly by turning them over the sand layer. The ingredients are then mixed thoroughly by turning them over and over. Backward and forward several times with the help of spade. Dry mixing is continued till the mix have attains a uniform colour. A batch of dry mix is then put in the shallow masonry tank and just sufficient quantity of water is added to bring the mortar to the consistency of a paste. The quantity of dry mix taken in each batch should be such the mortar formed each time is consumed within half an hour.

Summary

1. Mortar: Mortar may be defined as a plastic mixture of a binding material, fine aggregate and water in appropriate proportions.

2. The mortar is used for
   - Binding Bricks
   - Plastering
   - Forming Joints

   To form a matrix to hold the pieces of aggregate together, thus leading to formation of a solid mass of concrete.

3. Types of mortar
   - Lime mortar, cement mortar, composite mortar, gypsum mortar.

4. The preparation of cement mortar by
   - a. Manual mixing for small works
   - b. Mechanical mixing

Short Answer Type Questions

1. Define Mortar.

2. What are the properties of mortar?
3. Name the types of Mortar.

4. Write any four important uses of mortar.

**Long Answer Type Questions**

1. Explain the properties of mortar.

2. Explain the methods of preparation of cement mortar.

3. Write the uses of mortar.
## Structure

6.1 Introduction  
6.2 Uses of Concrete  
6.3 Mixing of Concrete  
6.4 Compaction of Concrete  
6.5 Curing of Concrete  
6.6 Ready-mixed Concrete

## Learning Objectives

After completing this unit, the student will be able to understand:

- Know what concrete is and the purpose of using it
- Know the different uses of concrete
- Know the different types of concrete properties
- Understand the grades of concrete
- Explain the water cement ratio
- Understand the preparation of cement concrete
- Know the different methods of concrete
- Know the curing of concrete and methods
6.1 Introduction

Concrete is a product obtained by mixing a binding material (such as cement, lime) sand and crushed metal and water in required proportion.

Constituent concrete: The following are the main constituents of concrete.

Cement: The various type of cement are used as binding, material. It imparts of strength after setting and hardening. It binds the aggregates into solid mass by virtue of a setting and hardening properties, when mixed with water. It fills the voids in fine aggregate and makes the concrete impermeable.

Fine aggregate: Sand consist of small angular and free from dust and should not contain organic. It should be chemically inert.

Coarse aggregate: Coarse aggregate obtained by crushing granite, trap crushed granite chips are community used in RCC items. It will fill the requirement of size, shape, strength, durability etc.

Water: Water should be fresh and clean should free from organic impurities harmful, salts, greasy and oil sustenances.

6.2 Uses of Concrete

Concrete is extensively being used for all types of construction works.

- Plain concrete is mainly used in foundations, floors, mass concrete work for heavy walls.
- Reinforced concrete is commonly used normal RCC works slabs, columns, beams, walls, small span arches, stairs, lintels etc.
- Precast concrete used in the piles fence post, electrical poles, Pipes, Gardens Chairs.
- Concrete in the construction of water retaining tanks, reservoirs, construction of roads.
- Concrete used in the cement concrete blocks, culverts, retaining walls, massive reinforced members.

Type of Concrete

The following type of concrete are commonly used in different constructional.

- Cement concrete
• Lime concrete
• Surkhi concrete
• Reinforced cement concrete
• Precast concrete
• Pre-stressed concrete etc.

6.2.1 Cement concrete

Cement concrete is a mixture of cement, sand, gravel, water in appropriate proportion. Cement concrete is a very important structure material and is extensively used on a variety of construction works. It is strong in compression and weak in tension. Generally coarse aggregate having up to 40 mm diameter are used in concrete works. Where as aggregate having 25 mm diameter are used for walls and floor.

**Grades of concrete**

<table>
<thead>
<tr>
<th>Designation</th>
<th>Characteristic Strength at 28 days</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>M5</td>
<td>5N/mm²</td>
<td>1:5:10</td>
</tr>
<tr>
<td>M7.5</td>
<td>7.5/mm²</td>
<td>1: 4: 8</td>
</tr>
<tr>
<td>M10</td>
<td>10N/mm²</td>
<td>1: 3: 6</td>
</tr>
<tr>
<td>M15</td>
<td>15N/mm²</td>
<td>1: 2 :4</td>
</tr>
<tr>
<td>M320</td>
<td>20N/mm²</td>
<td>1:1 1/2 :3</td>
</tr>
<tr>
<td>M25</td>
<td>25N/mm²</td>
<td>1 : 1 :2</td>
</tr>
</tbody>
</table>

6.2.2 Lime Concrete

It is a mixture of slaked lime, fine aggregate, coarse aggregate, and water. Lime concrete is extensively used as a levelling course for foundation of buildings as base concrete under floor. Lime concrete is cheaper than cement concrete. Generally 1-2:4 is the common proportion used for different purposes.

6.2.3 Surkhi Concrete

Surkhi concrete is prepared by mixing slaked lime, sand, surkhi, coarse aggregate, and water in required proportion.
6.2.4 Reinforced cement concrete (RCC)

The concrete is which reinforced steel bars have embedded to enable it to take up tension safely, known as reinforced cement concrete. It possesses high tensile strength.

Advantages

The structure are strong enough. The combination of concrete and steel provides much rigidity of structure.

- The RCC constructions are not affected by termites.
- RCC structure are be almost impervious.
- RCC structured can be constructed of desired shape.
- RCC sections has much less weight than that of plain cement concrete.
- The life of RCC structure increased as with the introduction of moisture.
- The combination of concrete and steel is economical because compressive forces are borne by concrete and tensile forces by steel.

Uses of RCC

RCC is extensively used in all sorts of construction works like buildings, bridges, arch as tanks etc.

6.2.5 Precast concrete

Concrete may be classified as precast and cast-in-site concrete. Cement concrete which is prepared at the site of use of is called cast-in-site. Precast concrete is also ordinary cement concrete but it is prepared in a factory where precast unit of cement concrete are produced on a large scale. Precast cement concrete units are widely used in various works.

6.2.6 Pre-stressed Concrete

Pre stressed concrete is also reinforced cement concrete but reinforcing materials are pre stressed before embedding in concrete pre-stressed concrete is manufactured in a factory with high grade controlled concrete. The strength of this concrete is more than three to four times of concrete normally used in RCC.

Items such as pre stressed beams, girders, railway sleeper, fencing posts etc are extensively used.
Water-Cement Ratio

The ratio of volume of water in litres to that of the weight of cement in a concrete mix is known as water-cement ratio.

Water has to perform two functions:

• Water enters into chemical action with cement and causes setting and hardening of cement.
• Water lubricates the aggregate making the concrete workable.

Minimum quantity of water should be used to have reasonable degree of workability. If excess water is added the strength of the concrete is considerably reduced. Water cement ratio is 0.45 to 0.55 for structures subjected to regular wetting and drying. Water cement ratio is 0.55 to 0.65 for thin sections and mass concrete continuously under water.

Workability: Workability may be defined as the ease or difficulty with which the concrete is mixed, transported and placed in position, with minimum loss of homogeneity.

If the concrete mixture is too wet, coarse aggregates settle at the bottom of concrete mass and the resulting concrete becomes of non-uniform composition. On the other hand, if the concrete mixture is too dry, it will be difficult to handle and place in position.

If more water is added to attain the required degree of workmanship, it results into concrete of low strength and poor durability.

If the strength of concrete is not to be affected, the degree of workability can be obtained by slightly changing the proportions of fine and coarse aggregates, in case the concrete mixture is too wet. By adding a small quantity of water cement paste in the proportion of original mix, in case the concrete mixture is too dry.

6.3 Mixing of Concrete

The process of mixing various constituents of concrete in specified proportions is known as mixing. The mixing of the constituents should be continued till the concrete attains uniform color and consistency. The various materials are mixed carefully to obtain good quality of concrete.

Methods of Mixing: The following two methods are generally used for mixing purposes. Hand mixing and machine mixing.
Hand Mixing: The process of mixing the ingredients of concrete by manual labour is called hand mixing. The concrete prepared by this method is known as hand mixed concrete. It is generally used for small works and in special cases where noise is to be avoided.

The following operations are adopted in hand mixing.

- A platform is constructed with bricks or lean cement concrete.
- The required quantity of cement is spread uniformly over sand and both are mixed together in dry state with the help of kassies or shovel.
- After this the above mixture is spread uniformly over a stack of coarse aggregates and whole mass is mixed in dry state in order to have uniform color.
- After obtaining a uniform coloured mix by mixing the ingredients in dry state, a hollow is made in the centre of the mixed material. After this 75% of the required quantity of water based on the water cement ratio is added and the material is turned towards the middle with the help of shovels. The mixture is mixed thoroughly to obtain uniform color and consistency. The remaining amount of water is added with continuation of mixing process.

Machine Mixing

The process of mixing the ingredients of concrete by a machine is called machine mixing. It is adopted by big projects where large quantity of concrete is required continuously. Machine mixing requires less quantity of cement than hand mixing. The concrete is produced at a much faster rate. The concrete produced by this process is known as machine mixed concrete.
The machine used for this purpose is known as a concrete mixer. The concrete mixers are classified as Batch mixer and Continuous mixer. In the batch mixers, materials are charged in batches whereas the materials are fed continuously in continuous mixers. Batch mixers are further classified as Non-tilting type and tilting type. Continuous mixes are further classified as Gravity type and forced type.

**Operation of Mixers:** Concrete should be mixed for at least 1 minute and preferably for 3 minutes. Under normal conditions, 10% of the mixing water should be placed in the drum before adding dry materials. Water should be then added uniformly with dry materials leaving 10% to be added after all the other materials are placed in the drum. The mixers should not be loaded above their rated capacity. The speed of the mixer is generally 15 revolutions per minute.

**General principles in the use of concrete mixers:**

- Water should be added to the mixer at the same time and over the same period as other constituents.
- Mixing should be continued until the concrete is of uniform color and consistency.
- The mixer should not be loaded beyond its designed capacity.
- The mixer should be set accurately.
- Adherence of cement should be reduced by rubbing grease or oil over the mixer after cleaning.
- Extra 10% of cement should be added for the first batch.
- Badly worn and bent blades should be replaced.
- The speed of the mixer should be uniform and it should be checked up at regular intervals.

**6.4 Compaction of Concrete**

The process of eliminating the air voids in the concrete to increase the density of concrete is known as compaction. About 5% of air voids reduce the strength of the concrete by 30% compaction is to be done to increase the strength of the concrete.
Methods of Compaction

Compaction can be done by hand ramming or by mechanical compaction by vibrators.

Hand ramming: For unimportant works compaction can be carried out by hand methods like ramming, tamping, spading and slicing with suitable tools. Hand methods require use of a fairly wet concrete.

Vibrators: The mechanical devices which are used for compaction of concrete in the formwork are known as vibrators.

6.4.1 Types of Vibrators

Depending on the depth of the concrete, and the importance of the work different types of vibrators are used.

Internal vibrators: These types of vibrators are used for structures such as beams having sufficient depth. These vibrators consist of a metal rod which is inserted in fresh concrete. The rod vibrates while it is being inserted, vibrates the concrete and removes the air. Internal vibrators should be inserted and withdrawn slowly and they should be operated continuously while they are being withdrawn. These vibrators are more efficient than other types of vibrators. These are also known as needle vibrators.

Surface vibrators: These vibrators are mounted on platforms or screeds. They are used for finishing concrete surfaces such as bridge floors, road slabs, station platform and where the thickness of the structure is less.

Form vibrators: These vibrators are attached to the formwork and the vibrating action is conveyed to concrete through the formwork during vibrations. These are used for structures which are too thin for the use of needle vibrators.

Vibrating Tables: These are in the form of a table and concrete is placed on the table. The vibration of the table increases the compaction of the concrete. These vibrators are widely used for making pre-cast products.

6.5 Curing of Concrete

Concrete structures are kept wet for a certain period after placing of concrete. This process is known as curing of concrete. In curing, water enters into chemical action with cement causing the setting of cement concrete. As the strength of concrete gradually increases with age, curing is necessary to produce durable and impermeable concrete.
Methods of Curing

As per the conditions at the site and depending upon the size, shape and position of the member, different methods of curing are adopted.

Ponding of water over the concrete surface after it has set: This is the most common method of curing the concrete slab or pavements. It consists of storing the water to a depth of 50 mm on the surface by constructing small puddle clay bunds all around. Ponding may lead to efflorescence by leaching.

Covering the concrete with wet straw or damp earth: In this method the damp earth or sand in layers of 50 mm are placed over the surface of concrete pavements. The material is kept moist by sprinkling water periodically.

Covering the concrete with wet burlap: The concrete is covered with burlap (coarse jute or hemp) as soon as possible after placing. The material kept moist continuously for the curing period. The covering material can be reused considerably.

Sprinkling of water: This is a useful method for curing vertical and inclined surfaces of concrete. This method is not effective as it is difficult to ensure that all the parts of concrete are wet all time. Water can be sprinkled by spraying or flogging. Spraying produces fine sprays whereas flogging produces mist like effect.

Covering the surface with waterproof paper: Waterproof paper prevents loss of water from concrete and protects the surface from damage. This method is used for concrete slabs and pavements. A good quality paper can be often reused.

Membrane curing of concrete: The process of employing a membrane forming compound on concrete surface is termed membrane curing. The curing membrane serves as a physical barrier to prevent loss of moisture from the concrete to be cured. The different sealing compounds used as membranes are bituminous and asphaltic, rubber latex emulsions, emulsions of resins and emulsions of paraffin.

6.6 Readymade Cement

Ready-mix concrete is a type of concrete that is manufactured in a factory or batching plant, according to a set proportion, and then delivered to a work site, by truck mounted transit mixers. This results in a precise mixture, allowing specialty concrete mixtures to be developed and implemented on construction sites.
Building Construction and Maintenance Technician

Fig. 6.2 Ready Mix Concrete

Ready – mixed concrete is particularly useful on congested sites or in road construction where little space for a mixing plant and for extensive aggregate stockpiles is available. The greatest advantage of this ready-mixed concrete is that it is made under better conditions of control than are normally possible. Since the central mixing plant operates under near factory conditions, a close control of all operations of fresh concrete is possible.

Proper care during transportation of concrete is also ensured by the use of agitator trucks. The responsibility of placing and compacting of concrete lies with the personnel at the site. The use of ready-mixed concrete is useful when only small quantities of concrete is required or when concrete is to be placed at intervals.

There are two types of ready mixed concrete. In the first case, mixing is done at a central plant and the mixed concrete is transported, usually in an agitator truck which revolves slowly so as to prevent segregation and undue stiffening of the mix. Such a concrete is known as centrally mixed concrete. The second category is the transit mixed or truck mixed concrete. Here the materials are batched at a central plant but are mixed in a mixer truck either in transit to site or immediately prior to the concrete being discharged.
Summary

1. Concrete is mixture of binding materials, sand, crushed stone and water.

2. Concrete used for heavy loaded RCC Columns, arches, water tanks, bridges, floor beds, pre cast members etc.

3. The ratio of volume of water in litre to the weight cement on a concrete mix to known as water cement ratio.

4. The concrete in which reinforcing steel bars have embedded to enable it to take-up tension safely known as reinforced concrete.

5. The mixing of concrete may be
   - By hand mixing
   - Machine mixing

Proportion of Ingredients of cement concrete for different items of work

<table>
<thead>
<tr>
<th>Nature of Work</th>
<th>Mix Proportion</th>
<th>Maximum size of coarse aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very heavily stressed members of structures.</td>
<td>1:1:2</td>
<td>12.7mm</td>
</tr>
<tr>
<td>R.C.C tanks, pipes other water retaining structures &amp; thin engineering structures.</td>
<td>1:11/2:3</td>
<td>12.7mm</td>
</tr>
<tr>
<td>Flooring, DPC &amp; general RCC works such as slabs, beams, columns, lintels etc., for ordinary buildings.</td>
<td>1:2:4</td>
<td>20mm</td>
</tr>
<tr>
<td>Massive works, dams retaining walls for each fill.</td>
<td>1:3:6</td>
<td>Specified combination of 20 &amp; 40mm</td>
</tr>
<tr>
<td>Mass concrete foundation (depends on the type of structure) under flooring etc.</td>
<td>1:4:8 or 1:5:10</td>
<td>40mm</td>
</tr>
</tbody>
</table>
6. Machine mixing may be carried are commonly by
   (i) Continuous mixers
   (ii) Batch mixers
7. The compaction may be defined as to expel the air bubbles in the mass and make it impermeable in addition to the securing desired depth.
8. Compaction may be done by Hand ramming and vibrator
9. Mechanical compaction may be done by
   (i) Internal vibrator
   (ii) External vibrator
   (iii) Surface vibrator
10. Curing is the process of keep the set concrete damp for some days in order to enable the concrete gain more strength.

**Short Answer Type Questions**

1. Define cement concrete.
2. State the uses of cement concrete.
3. What are the ingredients of cements concrete?
4. Define water cement ratio.
5. What are the ingredients of RCC?
6. Define curing.
7. Mention different methods of curing.
8. What is pre-cast concrete.
9. What is meant by ready mix concrete?
10. What are the advantages of RCC?

**Long Answer Type Questions**

1. What are the advantages of concrete?
2. Explain the mixing cement concrete.
3. Explain the importance of water -cement ratio in a concrete mix.
4. Explain the methods of compactions.
5. Explain the methods of curing.
7.0 Introduction

Wood can be considered the best natural building material. Wood is a hard, fibrous tissue found in many trees. It has been used for hundreds of thousands of years for both fuel and as a construction material. It is probably the first construction material used by man.
Timber is that sort of wood which is proper for buildings or for tools, utensils, furniture, etc. Technically the wood of growing trees which can support loads and suitable for construction purposes is known as timber.

Timber is used for making doors, windows, ventilators, shelves, rafters, reapers, floors, etc. During construction, it is also used for formwork, centering, etc.

Timber is also widely used to manufacture products like plywood, eco-board, hard board, particle board, veneers, etc. Wood and wood products which are free from defects are widely used in the construction industry due to their versatility.

**Structure of Timber**

7.1 **Defects in timber**

Defects are structural faults within the timber which may impair its strength, resilience or durability and should not be confused with surface blemishes. Features of some timbers such as knots may be termed Natural defect while others such as short grain are termed artificial defects, because they could have been reduced with more careful conversion (sawing of the log into useful sizes) or seasoning (the reduction of the moisture content in the timber.)

**The main defects caused in timber are**

- Defects due to natural forces
• Defects due to conversion
• Defects due to fungi
• Defects due to insects
• Defects due to seasoning

Defects due to natural forces

These are caused basically due to abnormal growth and rapture of tissues. Following are the defects caused by these forces.

• Burrs
• Callus
• Chemical stain
• Coarse grain
• Dead wood
• Druxiness
• Foxiness (Having reddish brown color)
• Knots
• Rind galls
• Shakes: These are splits along the length of the plank where the cells or fibres have separated.
  • Cup shakes
  • Heart shakes
  • Ring shakes
  • Star shakes
  • Radial shakes
  • Fibers
  • Upsets
  • Water strains
  • Wind cracks
Burls

These are formed when a tree has received injury or shock in its young age. Due to such injury, the growth of tree gets completely upset and irregular projections appear on the body of the timber.

Chemical Stain

Due to chemical action by some external agency, wood is sometimes discoloured. This is known as chemical stain.

Coarse Grain

If a tree grows rapidly, annual rings are widened. It is known as coarse grained timber and such timber possesses less strength.

Dead Wood

Timber which is obtained from dead standing trees contains dead wood. It is indicated by light weight and reddish colour.

Knots

Knots are the remains of outgrowing branches of a tree. Their grain runs at an angle to that of the main timber and where the knots are large and numerous the fibres are distorted and the strength of the timber much reduced.

Defects due to Conversion

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

- **Chip mark**: This defect is indicated by the marks or signs placed by chips on the finished surface of timber
- **Diagonal grain**: Improper sawing of timber
- **Torn grain**: When a small depression is made on the finished surface due to falling of some tool
- **Wane**: Presence of original rounded surface on the finished surface

Defects due to Fungi

Fungi attacks timber when these conditions are all present

1. The timber moisture content is above 25%
2. The environment is warm enough
3. There is lots of air
Wood with less than 25% moisture remains free of fungi for centuries. Similarly, wood submerged in water will not be attacked by fungi because of absence of air.

- Blue strained
- Brown rot
- Dry rot
- Heart rot
- Wet rot
- White rot
- Sap strained

**Defects due to Insects**

Timber may be attacked in certain circumstances by various wood-boring insects, which differ in their choice of species and condition of the wood - from standing trees to woodwork which has been in service for many years.

**Insects responsible for the decay of timber**

**Beetles**

These are small insects. They form pin holes and form tunnels in all directions. They convert timber into fine powder.

**Marine borers**

These are found in marine water. They do not feed on wood. They dig holes or form tunnels for shelter and the wood looses colour and strength.

**Termites**

Popularly known as white ants, these insects are found in tropical and sub-tropical countries. They feed on wood inside out, form tunnels and live in colonies. They usually do not disturb out shell. Good timbers like teak, sal, etc are not attacked by termites.

**Defects due to Seasoning**

- **Bow**: Bending of timber along its length.
- **Case hardening**: Due to quick drying of exposed surface, internal tension develop irregular cracks known as case hardening.
• **Check:** Check A check is a crack along the length of a board which may be very small and therefore not a serious weakness.

• **Collapse:** Flattening of wood on drying due to uneven shrinkage.

• **Cup:** Bending of wood or formation of curvature in the transverse direction.

• **Honey combining:** Development of internal cracks due to drying

• **Radial shakes:** These are radial cracks.

• **Split:** These are checks over the entire length of timber.

• **Twist:** It is a spiral distortion along its length.

• **Warp:** Twisting of timber in a small portion.

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**Fig. 7.2 Defects due to Seasoning and Insects.**
Fig. 7.3 Defects of Timber due to natural forces

Cross-Crack or Split

Cup & Star Shakes  Rind Gall and Knot  Ring Shakes

Hear Shakes  Wind Crakes  Radial Shakes

Twisted Fibres

Paper - II Building Materials and Maintenance
### Common varieties of timber found in Andhra pradesh

<table>
<thead>
<tr>
<th>Sl.no.</th>
<th>Timber Name</th>
<th>Colour</th>
<th>Brief Description</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Babul</td>
<td>Whitish red</td>
<td>Close grained, heavy &amp; and it takes up a good polish. Density: 835 kg/m³</td>
<td>Bodies and wheels of bullock cart, agricultural instruments, tool handles, scaffolding, roofing, etc.</td>
</tr>
<tr>
<td>2.</td>
<td>Bamboo</td>
<td>Flexible, very strong and durable</td>
<td></td>
<td>Scaffolding, thatched roofs, rafters, temporary bridges, etc.</td>
</tr>
<tr>
<td>5.</td>
<td>Yack</td>
<td>Yellow, darkens with age</td>
<td>Even grained, compact, hard and smooth.</td>
<td>Houses, boats, oars, well curbs, door panels.</td>
</tr>
<tr>
<td>6.</td>
<td>Gumar</td>
<td>Pale Yellow</td>
<td>Strong and durable especially under water; easily worked. Density: 580 kg/m³</td>
<td>Planks for door panels, furniture, carriages, well curbs &amp; yokes.</td>
</tr>
<tr>
<td>7.</td>
<td>Mango</td>
<td>Deep gray</td>
<td>It is easy to work, moderately strong, maintains its shape well. Density: 560-720 kg/m³</td>
<td>Cheap furniture, toys, packing boxes, cabinet work, panels for doors and for windows</td>
</tr>
</tbody>
</table>
Decay of Timber

Following are the causes for the early decay of timber

(i) Alternate dry and wet conditions.

(ii) Bad storage or stacking of timber.

(iii) Fungi which are responsible for developing diseases in timber such as blue stain, brown rot, dry rot, heart rot, sap stain, wet and white rot.

(iv) Improper seasoning.

(v) Insects such as beetles, marine borers, termites, etc.

(vi) Keeping timber in contact with damp wall, damp earth, etc.

(vii) Shocks or impacts received during young age from natural forces such as fast blowing wind, etc.

(viii) Use of timber without taking out sap wood from its structure.

<table>
<thead>
<tr>
<th>No.</th>
<th>Stain Wood</th>
<th>Color</th>
<th>Characteristics</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.</td>
<td></td>
<td></td>
<td>It is hard, fibrous and close-grained. It does not take up a good polish. It</td>
<td>It is used for house building, railway</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>requires slow and careful seasoning. It is durable under ground and water.</td>
<td>sleepers, shipbuilding, and bridges.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Density: 880-1050 kg/m³</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Stain Wood</td>
<td>Yellow</td>
<td>It is close grained, very hard and durable. Density: 960 kg/m³</td>
<td>It is used for furniture and other</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ornamental works.</td>
</tr>
<tr>
<td>10.</td>
<td>Tamarind</td>
<td>Dark Brown</td>
<td>It is knotty and durable. Density: 1280 kg/m³</td>
<td>It is used for agricultural instruments,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>well curbs, sugar mills, carts and brick</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>burning.</td>
</tr>
</tbody>
</table>
(ix) Using seasoned timber without applying suitably preservative on its surface.

(x) Using unseasoned wood with the application of protective coat of paint or tar.

### 7.2 Wood Products

Following are the few products of wood which are widely used for furniture, partitions, etc.

1. Veneer
2. Plywood
3. Particle board
4. Laminated wood
5. Straw board
6. Ecoboard

#### 1. Veneer

Veneer refers to thin slices of wood, usually thinner than 3 mm (1/8 inch), that typically are glued onto core panels (typically, wood, particle board or medium-density fiberboard) to produce flat panels such as doors, tops and panels for cabinets, parquet floors (the inside lower horizontal surface) and parts of furniture.

![Fig. 7.4 Veneers](image)

Plywood consists of three or more layers of veneer, each glued with its grain at right angles to adjacent layers for strength. Veneer beading is a thin layer of decorative edging placed around objects, such as jewelry boxes. Veneer is also a type of manufactured board.
Veneer is obtained either by "peeling" the trunk of a tree or by slicing large rectangular blocks of wood. The appearance of the grain and figure in wood comes from slicing through the growth rings of a tree and depends upon the angle at which the wood is sliced.

Walnut is a very suitable wood for veneering. Other species like teak, sisoo, elm padwick, oak, rosewood, etc., are commonly used.

Depending on the process of cutting, veneers may be classified as:


2. Plywood

Plywood is a manufactured wood panel made from thin sheets of wood veneer. It is one of the most widely used wood products. It is flexible, inexpensive, workable, re-usable, and can be locally manufactured. Plywood is used instead of plain wood because of its resistance to cracking, shrinkage, splitting, and twisting/warping, and its general high degree of strength.

Plywood layers (called veneers) are glued together with adjacent plies having their grain at right angles to each other.

Cross-graining has several important benefits: it reduces the tendency of wood to split when nailed at the edges, it reduces expansion and shrinkage equating to improved dimensional stability, and makes the strength of the panel consistent across both directions. There are usually an odd number of plies so that the sheet is balanced—this reduces warping. Because of the way plywood is bonded (with grains running against one another and with an odd number of composite parts) it is very hard to bend it perpendicular to the grain direction.

Plywood is commercially available in thickness ranging from 4mm 25mm.

Advantages of Plywood

- It is light in weight, and has good strength depending upon thickness.
- It is available in bigger dimensions than natural wood. Hence joints can be avoided.
- No seasoning is required.
- It can be cut, nailed and glued easily in making furniture.
- It has high resistance to cracking, splitting and warping.
- It has less tendency to shrink and swell as it is cross-grained.
3. Particle Board

Particleboard is a composite product of wood manufactured from wood particles, such as wood chips, sawmill shavings, or even saw dust, and a synthetic resin or other suitable binder. The moisture content of wooden chips is first reduced to about 15% and then pressed in the presence of heat and moisture to form long sheets of particleboard.

The wood pieces used to make particleboard may be hardwoods or softwoods.

Particleboard is cheaper and denser than solid wood, and is often used for indoor products in which appearance and durability are not key requirements. Surfaces that will be visible are often painted or covered with wood veneers for better appearance.

A major disadvantage of particleboard is that it is very much prone to expansion and discoloration due to moisture, particularly when it is not covered with paint or another sealer. Therefore, it is rarely used outdoors or places that have high levels of moisture.

4. Laminated Board

Laminated wood is an engineered wood product composed of thin layers of wood, or veneers, that are glued together to make a stronger wood product. The inner core consists of wooden strips of thickness not exceeding 7mm. The layers are laid and glued with all wood grains parallel. They are strong and durable and do not split easily.

It is also made similar to the plywood. Plywood is a stronger form of laminated wood, where the wood grains of each layer are laid perpendicular to each other.
Laminated woods are used in building applications, such as partitions, packing cases, floor coverings, furniture and wall panels.

5. Straw Board

The environmentally friendly, economical, and recyclable solid panels are made of all natural fibrous raw materials.

These rigid building panels are designed to replace labor intensive drywall construction for interior partition walls. The durable panels feature thermal and acoustic insulation as well as fire and termite resistance and are available for a variety of applications to speed up the construction processes. Other applications for strawboard panels include load and non-bearing ceilings, roofing, doors, flooring, and prefabricated buildings.
Strawboard panels are made of solid core, compressed wheat or rice straw. High pressure and temperatures (240°C) forces the straw to release a natural resin that binds the fibers together. The compressed panels are then covered with paper liners and adhered to both sides with water based non-toxic glue. The panel’s high density and low oxygen content does not support combustion. These straw boards are made in various thicknesses ranging from 25mm to 75mm.

The product’s workability is similar to wood as it can be sawn, drilled, routed, nailed, screwed, and glued. Lightweight wall attachments such as shelf brackets, picture frames, mirrors, and towel bars can be attached directly to the panel.

6. Ecoboard

Ecoboards are 100% environment friendly. However, these are not made from wood. It is manufactured from sugarcane waste (known as ‘bagasse’) obtained from sugar factories. Bagasse is broken into small size particles and fed into hammer mills to obtain good quality fibre, which is then dried to reduce the moisture content to below 2%.

The dried and sized material is mixed with glue binders. The glued bagasse is formed in 3 layers, coarse in the middle, fines in top and bottom side and then subjected to high pressure with high temperature. These bagasse boards are made at different thicknesses. The boards are allowed to cure for a day or two and then subjected to sanding to obtain smooth surface and to relieve loose material in the surface and to have uniform thickness of the board.

Some are pressed with base paper to make the bagasse boards water resistant and to ensure durability.
Properties of plain Ecoboard

100% wood free smooth surface and excellent bonding strength, High durability, Easy maintenance, Excellent machinability, Dimensional stability, More economical, saves time and labor, No deformation, Moisture resistance, Fire retardant, High resistance to abrasion, Termite resistance, Excellent screw holding capacity. It is relatively cheaper.

Uses of Ecoboard:

It is used for partitions, vanity flooring, decorative railings, doors, windows, false ceiling, wall paneling, all types of furniture, etc.

7.3 Characteristics of a good timber

Following are the characteristics or qualities of a good timber:

1. It should be free from sap and be from heart of a sound tree.
2. It should have straight and close fibres.
3. It should give a clear ringing sound when struck. Dull heavy sound is a sign of internal decay.
4. It should be of uniform dark colour. Light colour usually indicates timber with low strength.
5. It should have regular annual rings.
6. Timbers with narrow annual rings are generally the strongest.
7. Freshly cut surface should give sweet smell.
8. It should have bright and smooth surface when planed. Dull appearance is a sign of defective timber.
9. Teeth of saw should not get clogged while sawing.
10. Out of same variety of timber, darker and heavier pieces are stronger.
11. It should be free from dead knots, from too many knots, shakes or other defects.
12. It should have firm adhesion of fibers and compact medullary rays.
13. A good timber should be durable. It should be capable of resisting the actions of fungi, insects, chemicals etc.
14. A good timber should be capable of retaining its shape during conversion or seasoning. It should not bow or warp or split.
15. A good timber should be capable of offering resistance to shocks due to vibrations.

7.4 Seasoning

The process of drying of timber is known as the seasoning of timber

**Objects of seasoning of timber**

The seasoning of timber is carried out to achieve the following objects.

1. To reduce “movement” in timber.
2. To reduce the tendency to split, wrap and shrink.
3. To impart hardness, stiffness and strength.
4. To increase the resisting power of timber.
5. To reduce the weight and to minimize cost of transportation and easily handling.
6. To make timber safe from attack of fungi and insects.
7. To maintain the shape and size of component of timber articles which are expected to remain unchanged.
8. To make the timber burn readily, if used as fuel.
9. To make timber easily workable and facilitate operations during conversion.
10. To make timber fit for receiving treatment of paints, preservatives, varnishes etc.

**Methods of seasoning of timber**

The methods of seasoning of timber can be broadly divided into the following two categories


1. **Natural or air seasoning**: Is a slow process and the reduction in moisture content to the desired level may not be attainable, by air seasoning alone.

2. **Artificial or kiln seasoning**: Is thus adopted for faster drying and to attain the low level of moisture content required. The stacking space required is reduced if this seasoning is adopted.
Natural or air seasoning

In this method, the seasoning of timber is carried over by the natural air and hence it is also called as air seasoning. The following procedure in the air seasoning:

1. The timber in a form of log is not usually fit for this process of seasoning. Hence, it is cut and sawn into suitable sizes of planks and scantlings.

2. The timber sizes can either be stacked horizontally OR vertically, the stacking in horizontal is common as shown in fig(7.1)

3. The ground, where stack is to be constructed is cleared and leveled for good drainage.

4. The platform of stack in made slightly higher above 30 cms above ground level. (for this purpose. Rows of brick OR concrete pillers OR with pillers of wood coated with Tar are construction).

5. The timber pieces are sorted out according to lengths and thickness. They are arranged in layers one over the other. (Care should be taken that all members of in the particular layer are of same thickness to avoid wastage, and occurring of cracks).

6. Each layer is separated by spacers of sound dry wood. The usual dimension of spacer vary from 35x25 mm, to 50x35mm. larger dimension being width.

7. The distance of spacers depends upon the sizes of timber members to be seasoned.

8. The length of stack is equal to length of timber piece. The width and height of stack are restricted to about 150 cms x 300cms respectively.

9. The stack should preferably covered by a roof of suitable material to protect from wind, rain, sun heat etc.

10. The distance between the adjacent stacks should be at least 60 cms.
Advantages

1. Air seasoning is simple and economical method.
2. It does not require much skill and attention.
3. The chances of seasoning defects in the timber is less, as it is slow process.

Disadvantages

1. As it depends on natural air, it sometimes difficult to control.
2. Moisture content cannot be reduced less than 15 to 18 %
3. The drying of different surfaces may not be uniform.
4. Can be easily attacked by insects and fungi due to long period of seasoning.
5. Very slow; time taken for seasoning is more according the capital cost will be blocked for long time.
6. Large space is required for stacking.
Artificial seasoning

Artificial seasoning is preferable instead of natural seasoning due to the following reasons.

1. The defects such as shrinkage, cracking and warping are minimized in artificial seasoning.
2. There are practically no chances for attack of fungi and insects.
3. The drying in different surfaces is even and uniform.
4. The period of seasoning considerably reduces.
5. Better control of circulation of air and temperature.
6. The wood is more suitable for finishing and preserving items like painting etc.
7. The desired moisture contents can be obtained.

Methods of Artificial seasoning

(i) Boiling

(ii) Chemical Seasoning

(iii) Electrical seasoning

(iv) Kiln seasoning

(v) Eater seasoning

(a) Boiling: In this method, the timber is immersed in water and then boiled. Thus the timber has to be boiled ‘3’ to ‘4’ hours and then it is dried slowly under shed.

In this process, the time of seasoning and shrinkage of timber is reduced, but affects the elasticity and strength of timber. In it timber may be exposed to the action of hot stream. It is proves to be costly.

(b) Chemical Seasoning (Salt Seasoning): In this method the timber is immersed in solution of suitable salt. It is then taken out and seasoned in ordinary way. The interior surface of timber dries in advance of exterior one and chances of forming external cracks are reduced.

(c) Electrical Seasoning: In this method, use is made of high frequency alternating current. The resistance of electricity increases, the timber dries internally which also result in the production of heat. It is most rapid method of seasoning. This method is costly and uneconomical to season timber for commercial purpose.
(d) Kiln seasoning: In this method, the drying of timber is carried out inside an airtight chamber OR even.

The process is as follows

1. The timber is arranged inside the chamber, such that spaces are left for free circulation of air.

2. The air saturated with moisture are heated to a temperature of about 35°C and 38°C, is then forced into the chamber by suitable arrangements.

3. This forced air is allowed to circulate round the timber pieces. As air is fully saturated with moisture, the evaporation from the surfaces of timber pieces is prevented. The heat gradually reaches inside timber pieces.

4. The relative humidity is now gradually reduced.

5. Then the temperature is raised and maintained till the desired degree of moisture content is attained.

Depending upon mode of construction and operation, the kilns are of two types. They are

1. Stationary kilns and

2. Progressive kilns.

1. Stationary Kiln: It is also known as a compartment kiln. In it the process of seasoning is carried out in single compartment only. In it the drying operations are adjusted as drying proceeds. This kiln is adopted for seasoning of timber which requires a close control of humidity and temperature. It gives better results.

2. Progressive Kiln: In it the carriage with timber sections travels slowly from one end to other end of kiln. In doing so, it gets seasoned. The hot air is supplied from the discharging end, so that the temperature is less at the charging end and it increases towards the discharging end. It is used for seasoning timber on a large scale. If it is not properly attended, the drying in the kiln prove to be unsatisfactory.

(a) Water Seasoning: In this method, the following procedure is adopted.

1. The timber is cut into pieces of suitable sizes.
2. These pieces are immersed totally in water, preferably in running water of stream. The time has to be increased fully to obtain good results.

3. The thicket OR large end of timber is kept pointing upstream side of stream.

4. The timber is kept like that for a period of ‘2’ to ‘4’ weeks. During the period the sap contained in timber is washed away in water.

5. The timber is then taken out of water and allowed to dry under the shed having free circulation of air. The water that has replaced sap from the timber dries out and the timber is seasoned.

It is quick method and it renders timber which is less liable to shrink OR warp. It removes the organic materials contained in sap of timber. It however weakens the timber and makes it brittle.

**Summary**

In this unit, you have gained adequate knowledge of Timber as one of the important construction materials. Wood is used as structural elements in buildings for various purposes. The timber used for engineering purposes should be free from defects as far as possible. Defects free timber is possible only when tree has been felled at proper time and with adequate precautions. It is also necessary that timber should be properly seasoned and necessary preservatives are used before it is used for engineering purposes.

**Synopysis**

- Timber is building material used for the construction of doors, windows, roofs, partitions, beams, cupboards etc.
- The defects occurring in a timber are classified into
- Defects due to conversion chip mark, diagonal grain, torn gain, wane
- Defects due to fungi, blue shain, brown rot, dry rot, heart rot, sap stain, wet rot, white rot etc
- Defects due to insects beetles, marine borers, termites etc
- Defects due to natural forces burls, callus, chemical stain, coarse grain, dead wood, druxiness, knots, shakes etc
- The wood based products are
- Veneers
Building Material and Maintenance Technician

- Plywood
- Fibre boards
- Impreg timbers
- Compreg timbers

A good timber should have

i. Shinning appearance
ii. Dark colour
iii. Free from defects
iv. Durable to action of fungi, insects, chemicals etc
v. Fire resistance
vi. Should hard
vii. Mechanical wear
viii. Sweet smell
ix. Should give char ringing sound
x. Structure should be uniform
xi. Should have low water permeability

Short Answer Type Questions

1. Name common varieties of Timber found in Andhra Pradesh.
2. Name any four defects in timber.
3. Name any four wood based products.
4. What is ply wood?
5. What is veneer?
6. What is meant by seasoning?

Long Answer Type Questions

1. Explain different defects in timber briefly.
2. What are the important qualities of good timber?
3. List out the wood based products and explain briefly.
4. Explain the seasoning of timber.
Structure

8.1 Types of metals
8.2 Plastics
8.3 Asbestos
8.4 Adhesives
8.5 Glass
8.6 Thermocol
8.7 Plaster of Paris (POP)
8.8 Wall Paper
8.9 P.V.C Pipes
8.10 Bitumen and Tar

Learning Objectives

After studying this unit the student will able to

• Know the different types of metals
• Know the properties uses of cast iron
• Know the properties, uses of mild steel
• Know the commonly used structural steel sections
• Know the Aluminium, copper, uses and properties
• Know the uses of plastics and properties
• Know about the glass and types of glass uses
• Know about the Thermocole, plaster of Paris, Wall paper, PVC and Their uses
• Know about the Bitumen and Tar
• Know about the Fal-G concrete

Introduction

Metals and their alloys are integral part of construction industry. They are employed for various purposes such as structural members, roofing materials, doors, windows, tanks, pipes, etc.

8.1 Types of Metals

Metals can be grouped under the following two categories:

• Ferrous metals &
• Non-Ferrous metals

Ferrous Metals

In a more general sense, ferrous metals are metals or metal alloys that mainly contain iron. Carbon steel and Stainless steel are examples of ferrous metals. They are both alloys (mixture of different metals) that contain a fair amount of iron and therefore known as Ferrous metals.

Three important ferrous metals are Cast-Iron, wrought-Iron and Steel.

Non-Ferrous metals

These are metals that contain no iron but also include some alloys that contain appreciably very small amounts of iron.

These are generally more expensive than ferrous metals, non-ferrous metals are used because of desirable properties such as low weight (e.g., aluminum), higher conductivity (e.g., copper), non-magnetic property or resistance to corrosion (e.g., zinc). Some non-ferrous materials are also used in the iron and steel industries.

8.1.2 Cast Iron

Chemical Composition
Cast iron is formed by remelting Pig Iron, and is useful for a variety of engineering purposes. (Pig Iron is a crude impure iron extracted from iron ores.)

Cast iron is an alloy, a blend of the elements iron, carbon and silicon. The carbon content in cast iron is 3% to 4.5% by weight. It contains 95% iron with other impurities. Silicon and small amounts of Manganese, Sulfur, and Phosphorus are also present in it. It is popular because of its low cost and ability to make complex structures.

The products of cast iron exhibit reasonable resistance against corrosion. The cast iron is neither malleable nor ductile, and it cannot be hardened like steel. It melts at about 1200°C, and has either a crystalline or a granular fracture. The mechanical properties of cast iron are very much dependent on the carbon content.

**Following are some of the properties of cast iron**

1. It has granular crystalline structure.
2. It is hard but brittle also.
3. It has a low melting point. It melts at 1200°C.
4. Its specific gravity is 7.5.
5. It cannot absorb impact loads as it is not ductile.
6. It has weak tensile strength (150 N/mm²). Addition of vanadium can increase the strength of cast iron.
7. It has high compressive strength (600 N/mm²)
8. It has good resistance to oxidation. It does not rust easily.
9. Cast iron structures show resistance to deformation and provide a rigid frame.
10. It cannot be magnetized.
11. It cannot be welded.
12. It becomes soft in salt water.

**Uses of cast iron**

Cast irons have a wide range of applications, including machine and car parts like cylinder heads, blocks, and gearbox cases; cookware; water, gas and sewer pipes; ornamental castings like lamp posts, gates; compression members like columns, column bases; agriculture implements; rail chairs etc. It is used in the manufacture of wrought iron and steel.
8.2.3 Steel

Steel is an alloy of iron, consisting of carbon (usually 0.1-1.7%), as a hardening agent. Besides carbon, there are many metal elements that are part of steel alloys.

The elements other than iron and carbon, used in steel are chromium, manganese, tungsten and vanadium. All these elements along with carbon, act as hardening agents. They prevent dislocations from

**Types and Uses**

Steel is often classified by its carbon content:

- **Mild (low carbon) steel**
  
  Carbon content: 0.05% to 0.26%

  They are the most common form of steel as they come at a relatively low cost and provide material properties that are acceptable for many applications. They are neither brittle nor ductile, but are malleable. The surface hardness can be increased through carburizing.

- **Medium Carbon Steel**

  Carbon content: 0.29% to 0.54%

  They balance ductility and strength and have good wear resistance. They are used in forging and for large industrial and automotive components

- **High carbon Steel**

  Carbon content: 0.55% to 0.95%

  They are very strong and are used for springs and high-strength wires.

- **Very high carbon steel:**

  Carbon content: 0.96% to 2.1%

  These steels can be tempered to great hardness and are used for specialized products such as knives, axles, or punches. Steels above a carbon content of 1.2% are generally formed through powder metallurgy. Steels with carbon content above 2% are considered to be cast iron.

  High-carbon steel is serviceable for dies and cutting tools because of its great hardness and brittleness.

  Low- or medium-carbon steel is used for sheeting and structural forms because of its amenability to welding and tooling.
Alloy steels, now most widely used, contain one or more other elements to give them specific qualities.

Alloy steels contain varying amounts of different metals and materials to specialize their properties.

- Aluminum steel is smooth and has a high tensile strength.
- Chromium steel finds wide use in automobile and airplane parts on account of its hardness, strength, and elasticity, as does the chromium-vanadium variety. Stainless steel, which was developed in England, has a high tensile strength and resists abrasion and corrosion because of its high chromium content.
- Nickel steel is the most widely used of the alloys; it is nonmagnetic and has the tensile properties of high-carbon steel without the brittleness.
- Nickel-chromium steel possesses a shock resistant quality that makes it suitable for armor plate.
- Wolfram (tungsten), molybdenum, and high-manganese steel are other alloys.

**Mild Steel**

**Composition:**

- **Iron** 99%
- **Carbon** 0.1 to 0.25%
- **Sulphur** 0.06%
- **Phosphorous** 0.06%

**Properties of Mild Steel**

Mild Steel is one of the most common of all metals and one of the least expensive steels used. It is to be found in almost every product created from metal.

1. It has fibrous structure.
2. Being a softer metal it is easily welded.
3. It is very durable (although it rusts).
4. It is relatively hard and is easily annealed.
5. It has poor resistance to corrosion. It must be protected by painting as it rusts readily.
6. It is malleable and ductile.
7. It can be permanently magnetized.
8. Its Modulus of Elasticity is 210 KN / mm$^2$
9. Ultimate compressive strength is 475 N/mm$^2$
10. Ultimate tensile strength is 600 N/mm$^2$
11. Its specific gravity is 7.85
12. Its melts at about 1400$^\circ$ C

**Uses of Mild Steel**

- Having less than 2% carbon it will magnetize well and being relatively inexpensive can be used in most projects requiring a lot of steel.
- Most everyday items made of steel have some milder steel content. Anything from cookware, motorcycle frames through to motor car chassis, use this metal in their construction.
- Used for making reinforcing steel to be used in RCC works.
- Used for making power transmission towers, refrigerators, etc.

**Different types of steel reinforcement bars used as reinforcement in concrete structures**

Mild steel bars conforming to IS: 432 (Part I) and Cold-worked steel high strength deformed bars conforming to IS: 1786 (grade Fe 415 and grade Fe 500, where 415 and 500 indicate yield stresses 415 N/mm$^2$ and 500 N/mm$^2$ respectively) are commonly used.

Grade Fe 415 is being used most commonly nowadays. This has limited the use of plain mild steel bars because of higher yield stress and bond strength resulting in saving of steel quantity.

**TMT Bars**

- TMT bar means thermo mechanically treated bar i.e. hot rolled steel wire is passed through cold water to make their surface harder as well as to keep the core softer.
- It serves two purposes corrosion resistance and weldability. Bars range in diameter from 6 to 50 mm. Cold-worked steel high strength deformed bars start from 8 mm diameter. For general house constructions, bars of diameter 6 to 20 mm are used.
TOR Steel

- Popular name of HYSsD bars is tor steel, i.e., High Yield Strength Deformed bar. As the name implies it has comparatively high strength than Mild Steel. They are graded as Fe415, Fe500 i.e. Yield stress of 415 N/sq mm and 500 N/sq mm respectively. The HYSsD bars may be hot/cold worked.

- As tor or HYSsD steel is stronger, it saves cost. Strength of an 8 mm diameter tor steel bar is almost equal to 10 mm diameter plain steel bar. Similarly, a 10 mm dia tor steel bar has almost same strength as 12 mm plain steel bar. In actual, tor is a trade name belonging to Tata steel company.

- These bars can be used as a general purpose concrete reinforcement in all types of reinforced concrete construction (RCC).

**Advantages**

- Savings in Steel: minimum 25% compared to TMT bars of Grade Fe415
- Higher breaking load
- Higher bond strength due to scientific rib design
- Savings in construction Cost

**Weights of steel bars of various diameters per meter**

<table>
<thead>
<tr>
<th>Nominal Diameter(mm)</th>
<th>Weight/unit Length(kg/m)</th>
<th>Cross-Sectional Area (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0.222</td>
<td>28.3</td>
</tr>
<tr>
<td>8</td>
<td>0.395</td>
<td>50.3</td>
</tr>
<tr>
<td>10</td>
<td>0.617</td>
<td>78.5</td>
</tr>
<tr>
<td>12</td>
<td>0.888</td>
<td>113</td>
</tr>
<tr>
<td>14</td>
<td>1.21</td>
<td>154</td>
</tr>
<tr>
<td>16</td>
<td>1.579</td>
<td>201</td>
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<tr>
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<td>314</td>
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<tr>
<td>25</td>
<td>3.855</td>
<td>491</td>
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<tr>
<td>28</td>
<td>4.83</td>
<td>616</td>
</tr>
<tr>
<td>32</td>
<td>6.316</td>
<td>804</td>
</tr>
</tbody>
</table>
The malleability of mild steel also allows it to be rolled or beaten into thin sheets.

### 11.5 Commonly Used Structural Steel Sections

1. **Angle Sections**: they may have equal or unequal legs. Widely used in the construction of steel roof trusses.

2. **T-Sections**: used as structural members in the steel roof trusses and also in the buildup sections.

3. **Channel Sections**: They consist of one web and two flanges. Used as structural members in steel framed structures.

4. **I-Sections**: popularly known as beams or rolled steel joists, these are used for floor beams, columns, lintels, etc.

5. **Expanded Metal**: Used for reinforcing concrete in foundations, roads, bridges, etc. It is also used for partitions.

6. **Square Bars**: Used in the grill work for gates, windows, etc. Commonly used cross-sections vary from 5mm to 25mm.

7. **Round Bars**: Widely used as reinforcement in concrete structures, grill works, etc.

8. **Flat Bars**: Used in the grill work for gates, windows, etc.

9. **Plates**: Used to connect steel beams, roof trusses tension members, built-up sections, etc.

10. **Ribbed Bars**: Used as reinforcement in concrete structures.
8.1.5 Reinforcing Steel

HYSD Bars (High Yield Strength Deformed Bars):

These bars have projections or ribs on their surface. They are made up of high strength steel and are much stronger than plain bars. They are produced by controlled cold twisting of hot rolled bars. Each bar is twisted individually and tested. These bars are available in sizes varying from 6mm to 50mm. These bars are used for almost all concrete works.

Advantages of HYSD bars over Plain Bars:

- Due to high yield strength HYSD bars are used for saving steel. On account of increase in bond stress such bars normally do not need end hook. Transport, storage bending and fixing charges are less than 35% cost of mild steel bar.
- They have better structural qualities.
- These rods can be bent through 180° without any cracks formation on the outer surface.
- Some types of Ribbed HYSD bars can be welded.
- These bars have 40% more bond strength with concrete. Therefore, end hooks are not required.

8.1.6 Galvanized Iron

Aluminium: Aluminium is extracted from Bauxite or by various process
Properties

- It is a very good conductor of heat and electricity.
- It is silver white metal with bluish single.
- It is a non magnetic substance.
- It is highly resistant by nitric and organic acid.
- It is light in weight, malleable, and ductile.
- It is very soft.
- It melts at 600°C.
- It possesses high toughness and tensile strength.

Uses: Aluminium is used for making frames of doors and windows, corrugated sheets for roofing, piping, railings, posts, and panels in building construction.

- It is used for making aluminium alloys.
- It is used in the manufacture of electrical conductors.
- It is used in the manufacture of paints in powder form.
- It is used for making parts of aeroplane, cooking utensils, furniture etc.

Copper: Copper is one of the most widely used metal. Copper is obtained from copper pyrite ores.

Properties: It has popular reddish brown colour.

- It is a light, tough, strong and malleable and ductile metal.
- It has high thermal and electrical conductivity.
- It is forging and rolling is possible.
- It is workable in hot and cold condition and can be drawn into wire.
- It cannot be welded.
- It melt at 1083°C.

Uses: It is extensively uses for making electrical cables, alloys, household utensils,

- It is used for electro plating and electrotyping.
• The market form of copper are ingots, sheets, tubes and wires.

• It is mainly used in the manufacture alloys of which brass and bronze.

Alloys: An alloy is a mixture of two or more metals.

1. Brass: Brass is an alloy of copper and zinc having about 60 to 70 percent copper and 30 to 40 percent zinc it can be rolled in to sheets, turned into tubes, drawn into wires or cast into moulds. The colour of fresh brass is bright yellow.

   Uses: Brass is used for various purposes such as doors, and window fittings, stop cocks and valves in water works, households utensils, perfective sheets.

2. Bronze: Bronze is an alloy of copper line and contains about 80% copper. They are stronger and superior to brasses for corrosion resisting properties.

   Uses: Bronze such as door used in building industry for various purposes such as door, windows ash, frames, grills, balconies, screens, and for many decorative purposes.

8.1.7 Uses of different types of metals

Lead: Lead is obtained from the ore known as Galena. Leads is used as a base paint. It is used for gutters, Flashings, cistern linings, water service pipes, gas pipes, sheets of rooting. It is used for making bullet shots.

Tin: Tin is extracted from oxide ores. Tin is used to provide protective coatings to iron and steels sheets and copper wires cables. It is used in the form of foil for wrapping cheese, fruits, and other food materials.

Zinc: Zinc is obtained from calamine ores zinc is used in various forms for roof sheets, gutters, flashings, kitchen tops, zinc oxide is used in different types of high grade paints.

8.2 Plastics

Plastics is an organic substance and it is made from resin with or without fillers, plastic is and pigments the resin may be natural or synthetic. Plastic is such a substance that can be moulded into any desired shape under heat and pressure.

Classification of Plastics: The plastic are classified into the following two groups base on the behaviors with respect to heating.

(a) Thermo plastic
(b) Thermo setting plastic

(a) **Thermo plastic**: It is softens by heat and hardness when cooled down. These variety of plastic can be used by remoulding as many times as required.

**Ex**: Cellulose and shellac.

(b) **Themos setting plastic**: It requires, a great pressure and momentary heat during moulding takes place in this process cannot reversed.

**Ex**: Bakoltz.

**Advantages**

- Plastic are very light weight
- These can be moulded into any desired shape
- These can be made any colour and transparent in appearance
- These can be use a permanent decorative materials
- These have low thermal conductivity
- It can be sawn, drilled and punched like wood and can be welded like steel
- These are rush proof
- These are cheep due to their high weight and low maintenance.

**Uses of Plastic**

- In bath and sink units.
- Ciston ball floats.
- Corrugaed and plain roofing sheets.
- Electrical conducts, bends, junction boxes etc
- Electrical insulator.
- Floor tiles, wall tiles, roof light, safety glass etc.
- Paints, vanished, water resistant adhesive.
- Plastic used for making sets squares, side rubes, dolls, toys, fountain
• In the manufacture lenses

• Glass reinforced polished are used for making load bearing structure, fencing walls and roof etc.

Disadvantages of Plastics

Most of the plastic possess low heat resistance, the plastic are not very hard. The plastic disintegrates gradually and because of the effects, of light, air and temperature they loose strength, becomes soft and get dull as time passes.

8.3 Asbestos

Asbestos is the name given to a group of fibrous, naturally occurring silicate minerals. It is composed of hydrous silicates of calcium and magnesium. They generally exist in nature in metamorphic or igneous rocks.

Asbestos is resistant to heat and most chemicals (most forms are chemically inert). The fibers do not evaporate into air or dissolve in water. They have no odor or smell and do not migrate through soil. At least 5,000 different products have been manufactured from asbestos.

Long exposure to high concentrations of asbestos fibers will cause health problems.

Properties of Asbestos

• It has tremendous resistance to heat and electricity.

• It is chemically inert.

• It has no odor or smell and does not dissolve in water.

• Its tensile strength is better than that of steel.

• It is non-flammable.

• It binds very well with cement and other insulating materials which makes it an excellent building material.

• It is available in a range of shades, viz. blue, green and grey depending upon the composition.

• It is easily workable. It can be cut, drilled and screws can be fitted easily.

• It is flexible, smooth and non-porous.
Uses of Asbestos

Following are the uses of asbestos:

- The most popular use is asbestos-cement roofing sheets. They are prepared by mixing cement and asbestos fibers and moulded into corrugated or flat sheets. Corrugated sheets are used as roofing material, whereas, flat sheets are used for door and window shutter panels, false ceiling, thermal insulation and for fire exits.

- Other important applications in construction include:

  - Asbestos cement sewage pipes,
• Insulating cement, insulating block, pipe covering,
• Acoustical panels/plaster,
• Floor tile, ceiling tile,
• Insulation for Heating, Ventilation and Air Conditioning (HVAC) systems,
• Insulated electrical wire and panels,
• Fire bricks, fireproofing spray, fire door interiors, refractory and boiler insulation materials.

8.4 Adhesives

An adhesive is a substance used for sticking objects or materials together. It is usually in the form of liquid or semi-liquid state. Examples are Fevicol, Feviquick, Araldite, etc.

The types of materials that can be bonded are vast but they are especially useful for bonding thin materials. Adhesives cure (harden) by either evaporating a solvent or by chemical reactions that occur between two or more constituents.

Adhesives are advantageous for joining thin or dissimilar materials, minimizing weight. The main disadvantage of most adhesives is that they do not form an instantaneous joint because the adhesive needs time to cure.

Advantages

Following are the advantages of Adhesives over the conventional methods of Bolting, Riveting and Welding:

• Vast variety of materials can be bonded.
• Weight can be minimized by bonding either similar or dissimilar materials.
• It produces sufficient strength.
• Their application is easy, economical and quick.
• Corrosion between different metals joined can be prevented.
• Impermeable joints can be made.
• It creates a massive effect.

Disadvantages

• They are not stable at high temperature and pressure.
• Sometimes they fail to attain desired strength.
One single adhesive for all materials is not available. Suitable adhesive has to be selected for different materials.

8.5 Glass

Glass is usually a transparent or translucent material that has no crystalline structure, yet behaves like a solid. Common glass is generally made of a silicate (such as silicon oxide, or quartz) combined with other substances and melting the minerals at temperatures around 1700 degrees Celsius. Other materials that can be added to produce different colours or properties include minerals like cobalt or sulphur, etc.

Glass used in windows and windshields, called soda glass, is made by melting a silicate with sodium carbonate (soda) and calcium oxide (lime).

Other types of glass are made by adding other chemical compounds. Adding boron oxide results in a tougher glass that remains solid at high temperatures, used for cooking utensils and scientific apparatus. Glass used for decorative purposes often has iron in it to alter its optical properties.

While it is still molten (a hot liquid), glass can be manipulated by glass blowers to form bottles and other decorative articles. They blow air into the liquid glass through a long pipe.

General Properties

1. It is a good heat, sound, and electric insulator.
2. It has no definite crystalline structure.
3. It is extremely brittle.
4. It can take up high polish.
5. It reflects, absorbs and transmits light.
6. It has no sharp melting point. It varies between $1400^\circ - 1500^\circ$ C.
7. It is resistant to most of the chemicals.
8. It can be welded but difficult to be cast into large pieces.
9. It is available in beautiful colours.
10. It can be reinforced with steel wires.
11. With modern technology, it can be made lighter than cork, softer than cotton and stronger than steel. It can be made bullet-proof.
12. It can be moulded into articles of desired shapes.

13. It is not usually affected by air or water.

**Fig. 8.3 Glass Blocks used in Bathrooms**

**Uses of different types of Glass**

1. **Soda Glass**

   It is the cheapest & most common glass. It is prepared by fusing soda ash, sand, and limestone. It is also called soft glass. It fuses at comparatively low temperatures. The major disadvantage of using this glass is that it is brittle & breaks easily. It cracks when subjected to sudden changes of temperature.

   Soda glass is used for the manufacture of window glass, mirrors, common glassware etc. It is easily attacked by chemicals.

2. **Hard Glass**

   It is obtained by fusing potassium carbonate & limestone. It is used for making hard glass apparatus. It is more resistant to the action of acids.

3. **Lead Crystal Glass**

   It is made from potassium carbonate, lead oxide & sand. Lead glass has high refractive index. It, therefore, sparkles & is used for making expensive glass ware. The surface of lead glass objects is often cut into decorative patterns to reflect light. Cut glass show extraordinary sparkle.

4. **Pyrex Glass**

   It is made by fusing a mixture of sand, lime, borax (Na₂B₄O₇·10H₂O) & alkali carbonates. It is used to make good chemical laboratory apparatus, ampoules, pharmaceutical containers, et. In home, it is familiar with oven ware.
5. **Optical Glass**

It is specially made so as to be free of strains & defects. It is used for making lenses for spectacles, microscopes, cameras, telescopes & other optical instruments.

6. **Photochromic Glass**

It is a special variety of glass that temporarily darkens when exposed to bright light. It is, therefore, very useful as a sun-shield. This automatic darkling property of photochromic glass is because of the presence of silver bromide.

7. **Safety Glass**

It is prepared by placing a layer of transparent plastic between the two layers of glass by means of suitable adhesive. The 3 layers are joined together by the action of heat & pressure. The glass does not break easily under ordinary impact, & that is why it is known as safety glass. It is used in making wind screens of aero planes, automobiles, bulletproof glass etc.

8. **Glass Fibres**

It is in the form of fibres. It has varied applications in most of the industries. Glass wool is a bundle of loose glass fibres, which is an excellent heat insulator. It is used as insulating material in refrigerators, ovens etc. Another important class of glass fibre is optical fibres which are extensively used in telecommunication, surgical operation etc.

9. **Coloured Glass**

These are obtained by adding certain colouring material, such as metallic oxides, to the molten mass. Different additions may produce different coloured glasses.

8.6 **Thermocol**

Thermocol contains a thermoplastic compound, called polystyrene. It is commercially manufactured from petroleum.

It is manufactured through a simple process. Thermoplastic granules are expanded through application of steam and air. Expanded granules become much larger in size but remain very light.

Thermocol is a good resister of cold and heat but since it is a petroleum product it dissolves in any solvent of petroleum.
Properties of Thermocol:

- It contains 3-6 million discreet cells per liter giving it excellent insulating properties.
- It can be cut easily with simple tools like knife or a saw.
- It can be painted with Plastic Emulsion paints or water bound distemper.
- It has a high insulating efficiency, resistance to moisture, adequate structural strength and dimensional stability makes it easy to use.
- Thermocol insulation is permanent and lifelong.
- It is not environment friendly and proper care should be taken while disposing off.

All these attributes explain the outstanding insulation properties and remarkable resistance to moisture vapor penetration, making it the ideal low temperature insulation material with the best combination of desirable properties.

Availability in the Market:

The thermocol is available in the form of rectangular slabs, semi-circular pipe sections etc.

Uses of Thermocol

Thermocol Products work against heat, cold, sound and humidity. Thermocol is widely used as packaging material, roof & wall insulation material and for various industrial applications.
**Insulation**

In *Refrigeration*, it is used in industrial refrigeration, cold storage, cooled rooms, refrigerated trucks, domestic refrigerator and air-conditioning ducts.

**In Building Construction:**

In building construction, it is used for heat insulation for ceilings, false ceilings, roofs, walls, floors, floating floors, doors, partitions and cemented water tanks.

**Acoustic Insulation:**

It is used for sound insulation in cinema halls, factories, offices and residential buildings.

**For Packaging:**

It is used for packing fragile products and delicate equipments such as electronic goods, glassware (molded and hand cuts) and similar products.

It can also be used as a source of *display* in exhibitions and for multiple types of *decorations*.

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**8.7: Plaster of Paris (POP)**

Plaster of Paris is basically a building material that consists of a fine, white-colored powder, known as calcium sulfate hemihydrate.

It is made by heating the mineral *gypsum*. Large deposits were originally found outside of Paris in France hence its name.

Unlike mortar and cement, plaster remains quite soft after setting, and can be easily manipulated with metal tools or even sandpaper. These characteristics make plaster suitable for a finishing, rather than a load-bearing material.

![Fig. 8.5 Plaster of Paris](image)
(i) When gypsum is heated to about 150°C, it losses water and produces the powdery white substance called plaster of Paris.

Gypsum + heat => Plaster of Paris + steam

\[ 2\text{CaSO}_4 \cdot 2\text{H}_2\text{O} + \text{heat} \Rightarrow 2\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O} + 3\text{H}_2\text{O} \]

(Two molecules of Calcium Sulphate together hold one water molecule. So no. of water molecules per molecule of Calcium Sulphate is said to be 1/2. So the formula is often written as \( \text{CaSO}_4 \cdot 1/2\text{H}_2\text{O} \).)

(ii) The process of making plaster of Paris is reversible; meaning that if the dry plaster powder is mixed with water, it re-forms into gypsum.

When water is added to the plaster of Paris powder it rehydrates (absorbs water) and quickly hardens.

\[ \text{Plaster of Paris} + \text{water} \Rightarrow \text{Gypsum} \]

\[ 2\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O} + 3\text{H}_2\text{O} \Rightarrow 2\text{CaSO}_4 \cdot 2\text{H}_2\text{O} + \text{heat} \]

The chemical formula for plaster of Paris is \( \text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O} \) which means that there is one molecule of water around two molecules of \( \text{CaSO}_4 \) group.

**Properties and Uses**

It is used for construction purposes, either by mixing with other substances or as a finishing material. However, plaster of Paris is widely used in home decors; various designs can be made in the walls and ceilings. For many modern sculptors, it is a favorite sculpting material, mainly because of its easy occurrence and speed of setting. In addition to arts and architecture, plaster of Paris is also used in orthopedics to make smooth casts for broken limbs. In forensic science, molds of footprints and other important markings are made by using plaster of Paris for further investigation.

- It is resistant to fire and heat. It is used as an insulation to protect wood or metal columns and beams from high temperatures.

- It is light in weight. Sometimes, fillers such as saw dust, granules of cork, etc, are added to make it still lighter and to improve its sound and heat insulation qualities.

- It is practically unaffected by bacteria.

- It cannot be used for wet surfaces as it is slightly soluble in water.

- It sets in 5 to 10 minutes. That is why; small quantities should only be mixed. To prolong its setting time fillers are added to it. It should not be handled with bare hands. Rubber gloves and goggles should be used.
- It shows negligible shrinkage upon drying. So moulds of actual dimensions can be used for castings.

- It seals thin cracks in the plastered surfaces.

- It is used in the ornamental plastering works. Gypsum boards are used for false ceiling, partition walls and internal linings. They are easy to use, repair, light in weight, and fire proof.

- Plaster of Paris (POP) is used in artwork, pottery, dentistry, and in orthopedics to make smooth casts for fractured bones.

### 8.8 Wall Paper

Wall papers are used to beautify the interior walls of the building. They are prepared exclusively with paper or in combination with other materials. They are either printed, coated or embossed and available in different colours.

Before pasting the wall paper, the surface has to be made free from loose matter and cracks. The surface should be leveled and dried. Wall putty is used to fill the cracks and level the surface. The wall paper is then pasted carefully using suitable paste.
The surface of the wall paper may be varnished for better appearance and to protect its surface. Washable and metal coated wall papers are also available in the market.

### 8.9 PVC Pipes

Polyvinyl chloride (PVC) is a versatile building material. Its popularity is increasing day by day. Pure polyvinyl chloride without any plasticizer is a white, brittle solid.

![Fig. 8.7 PVC Pipes](image)

It is insoluble in alcohol, but slightly soluble in **tetrahydrofuran** (A colorless liquid (C₄H₈O) used chiefly as a **solvent for plastics**). It can be made softer and more flexible by the addition of plasticizers.

Its properties can be modified according to the strength requirements by adding other substances called additives.

It is used for door and window shutters and pipes in the building construction. The other applications of PVC include bottles, cables, bags, tubes, floor coverings, furniture, etc.

### PVC Pipes

A polyvinyl chloride (PVC) pipe is made from a plastic and vinyl combination material. The pipes are durable, hard to damage, cheap and easily worked. A PVC pipe does not rust, rot, or wear over time. For that reason, PVC piping is most commonly used in water systems, underground wiring, and sewer lines.

Due to the ability of PVC pipe to withstand extreme movement and bending, it is also increasingly used in earthquake prone areas; it can withstand the rigorous shaking of the earth without experiencing any damage. The smooth surface of
the PVC pipe is also resistant to bacterial contamination, such as E. coli. Therefore, water can be kept free of contamination.

**Advantages PVC Pipes**

- **Corrosion Resistance**: PVC pipes are non-conductors of electricity and immune to electrochemical reactions caused by acids, bases, and salts that cause corrosion in metals.

- **Chemical Resistance**: PVC pipes exhibit resistance to a wide range of chemical reagents in temperatures up to 140 °F and are resistant to chemicals normally found or used in homes.

- **Light Weight**: A person can easily carry two 20-foot lengths of 4-inch PVC pipe, but could carry less than 5 feet of 4-inch iron pipe with the same effort.

- **Flexibility**: While PVC pipes are made from rigid (unplasticized) PVC compound, the pipe itself has the ability to yield under loading without fracturing.

- **Long-Term Tensile Strength**: The long-term hydrostatic design basis (HDB) for PVC is two or more times greater than that for other common thermoplastic pipe materials.

- **Abrasion/Wear Resistance**: PVC pipes exhibit outstanding resistance to wear and abrasion.

- **Impact Strength**: Under normal conditions, PVC pipes possess relatively high resistance to impact damage when compared to pipes made from clay, concrete, and most other conventional materials.

- **Coefficient of Friction**: PVC pipes provide smoother wall surfaces that reduce fluid friction and resistance to flow.

- **Water Quality**: PVC pressure pipes do not adversely alter water quality. There are no corrosion by-products with PVC pipe.

**Disadvantages of PVC Pipes**

- They cannot be used at high temperatures and pressures.

- They are liable to creep.

- Their strength is not comparable to Cast-Iron or Galvanized-Iron Pipes.

- They tend to expand more than C.I or G.I pipes.
PVC DOORS

Advantages of PVC Doors

- **Water Proof**: They are waterproof and do not expand, contract or warp when they come in contact with water.
- **Termite Proof**: Termites or other insects cannot harm them.
- **Maintenance Free**: Because of its smooth surface, it is easy to clean.
- **Easy to Install**: It is very quick & easy to install them.
- **Economical**: Their price is low.
- **Durability**: PVC Doors last around 12 years.
- They are resistant to fungal and bacterial growth.
- **Resistance to Weathering**: Weather has no effect on PVC building materials. Problems like rotting, rust, etc. do not occur. They are suitable to coastal areas also.
- **Thermal Insulation**: They have low thermal conductivity. Thermal conductivity is the measurement of the speed at which heat travels through a material.
- **Availability in Different Sizes**: They are available in different sizes and colour in the market.
- They are bendable and bondable.
8.10 Bitumen and Tar

Bitumen

Bitumen is an oil based substance. It is a semi-solid hydrocarbon produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process. The process is known as fractional distillation of petroleum. It is black or brownish black in colour. It is solid or semi-solid in state.

Bitumen is also commonly known as “asphalt cement” or “asphalt”. Asphalt is the term used for a mixture of sand, filler and bitumen, which is used as a road paving material. The asphalt mixture contains approximately 5% bitumen. At ordinary temperatures bitumen is a stable, semi-solid substance.

![Fig. 8.9 Bitumen](image)

Uses of Bitumen

- It is used in the construction of roads and pavements.
- It is used as a waterproofing material for roofs, swimming pool, canal lining, dam construction and river bank protection.
- It is used to protect the wooden and metal surfaces which are below the ground level.
- It is used as a damp proof course.
- It is used in the manufacture of bitumen paints.

Tar

Tar is a dark black liquid with high viscosity. It is obtained by destructive distillation of carbonatious matter.
Tar may be classified into the following three categories depending upon its source:

1. Coal tar
2. Mineral tar
3. Wood tar.

1. **Coal tar:** Coal tar is a brown or black liquid of extremely high viscosity. Coal tar is among the by-products when coal is carbonized to make coke or gasified to make coal gas. It is used for road pavement construction and wood preservation.

2. **Mineral Tar:** it is obtained by distillation of bituminous shale. It is also called maltha.

3. **Wood Tar:** a dark viscous product obtained from wood by distillation or by slow burning without flame. It is used in its natural state to preserve timber, rope, etc. it is obtained by the distillation of pines and similar resinous wood.

**Summary**

- **Ferrous Material:** Ferrous metal are those which contains iron as base metal.
  
  *Ex*: Cash iron, wrought iron steel.

- **Non Ferrous metals:** Metal which do not contain iron as their main constituent are called non ferrous metals.

  *Ex*: Aluminium, copper etc.

- Cast iron contains 1.7 to 1.5 percent carbon together with other impurities like sulphur, phosphorus, silicon and manganese.

- Steel is an intermediate for between coast iron wrought iron. The maximum carbon content in steel is limited to 1.5 percent.

  Aluminium is extracted from bauxite ore by various process.

- Copper si one of the most widely used metal, it is obtained from copper pyrite ores.

- Plastic is an organic substance and it is made from resin with or without fillers, plasticizers and pigments.

- Asbestos is the name given to a groups of fibrous, naturally occurring silicate materials.
It is composed of hydra silicates of calcium an magnesium.

- Adhesive is a substance used for sticking objects or materials together.
  Ex: Fevicol, Fevi quick, Araldite etc.

- Glass is a mixture of metallic silicates used for gas tubes, windows glass, electrical bulbs, lenses etc.

- Different types of glass are soda glass, Hard glass, pyrex glass, optical glass, safety glass, bullet proof jackets coloured glass etc.

- Thermocol contains a thermo plastic compounds called polystrene.

- Plaster of Paris: Is a building material that of a fine white coloured powder, known as calcium sulfate hydrate. It is made by heating the mineral gypsum.

  Gypsum of heat - plaster of Paris esteem.

- Wallpaper: Are used to identify the interior walls of the buildings.

- PVC (Polyvinyl chloride): Is made from a plastic and vinyl combinational materials.

- Bitumen is an oil based substance: It is a semi-solid hydro carbon produced by removing the lighter fractional heavy crude oil during the refining process.

- Tar: Is a dark-black liquid. It may be obtained from distillation of coal.

**Short Answer Type Question**

1. Define Ferrow metals.
2. Define Non-Ferrow metals.
3. What are the uses of coat iron?
4. What are the uses of steel in building industry?
5. What are the different types of steel reinforcement bar used a reinforced in concrete structure?
6. State the uses of Aluminium.
7. State the uses of copper.
8. What are the properties of plastics?
9. Name any four uses of plastics.
10. What are the uses of glass?
11. Name any four uses of Adhesive.
12. What is Thermacole?
13. Write the uses of Bitumen and Tar?
14. State the uses of PVC.

**Long Answer Type Question**

1. Write the composition and properties of coat iron.
2. Write the composition and properties of steel.
3. What are plastic and mention type of plastics?
4. What are the general properties of glass?
5. What are the advantages and disadvantages of adhesives?
6. What are the properties and uses of Asbestos?
7. What are the properties and uses of Thermocole?
8. What are the properties and uses of Aluminium?
9. Write a short note on Bitumen and Tar.
9.1 Introduction

Buildings is defined as any structure for the whatever purpose and whatever material used for construction and every part there of whatever use as human habitation.

9.2 Classification of buildings as per NBC

According National Buildings Code of India 1970, the buildings on the base of occupancy are classified into following groups.

9.2.1 Residential buildings

All the buildings is which sleeping accommodation is provided for residing with or without cooking ording are known as Residential Buildings.
For example Apartments, Flats, Private Houses, Hotels, Hostels, Cottages, other houses motels etc.

9.2.2 Education buildings

All those buildings which constructed for education from a nursery to the university. For example: School, Colleges, Universities etc. These buildings provide facilities like class rooms, staff rooms, Drawing rooms, Laboration, Administrative blocks, Library etc.

9.2.3 Institutional buildings

These buildings are used for purpose such as Medical Health recovering health for after illness etc. These buildings provide sleeping accommodations for the occupants.

9.2.4 Assembly buildings

All those buildings or part of buildings where group of people assemble for amusement, social, religious or similar purpose, for example Theaters, Assembly halls, Auditora, Museums, Restaurants, Places of Workship. (Temple, Church, Gurdwara etc). Bus stations, etc.

9.2.5 Business buildings

Are those which are used for purpose such as transaction of Business banks, City halls, Court Houses, Libraries etc.

9.2.6 Mercantile buildings

These group includes any building or part buildings which is used as shops, stores, market, for sale and display of product or wholesale or retail.

9.2.7 Industrial buildings

This group includes any buildings or part a buildings in which product of different kinds of properties, assembled or processed for example Laboratories, Assembly Plants, Power Plants, refineries, daries etc.

9.2.8 Storage buildings

Are those structure which are primarily used for the storage for example warehouses, cold storages, garages etc.

9.2.9 Hazardous buildings

This group includes those buildings structures which are used for the storage, handling, manufacture or materials, which are liable, to burn with extreme rapidity and provide hazardous health.
9.3 Component of parts of buildings

A building is made of the following structural components:

9.3.1 Foundation

It is the lowest part of structure below the surface of the ground, which is indirect contact with sub-strata and transmits all the loads to the subsoil.

**Plinth**: It is the middle part of the structure above the surface the ground up to the surface of the floor, immediately above the ground.

9.3.2 Walls and piers in super structure

The primary function of wall is to enclose or divide the space. These wall may be built of different materials such as brick or stones etc.

9.3.3 Ground, upper floor

The main function of a floor is to provide support for occupants, furniture and equipment of a building.

9.3.4 Doors and window

The main function of doors in a building is to serve as a connecting link between internal parts of buildings allow the free movement outside the buildings. Window are provides for the proper ventilation and lighting of a buildings.

9.3.5 Sills, lintels and widths shades

Window sills are provided. A structural element has constructed above the opening enough to support the weight of the wall above the openings. Weather shades are combined with lintels of window to protect them from weather elements such as sun, rain, frost etc.

9.3.6 Roof

A roof is a upper most part of a building whose main function is to enclose the space and to protect the same from the effects of weather elements such as sun, rain wind, heat, snow etc.

9.3.7 Steps and stairs

Steps consist of a tread and riser of number of steps leading from one floor to another.

9.3.8 Finishes for walls

Finishes such as pointing are applied in the walls.
9.3.9 Utility fixtures

The common built-in fixture are cupboards shelves, smokeless chulas etc.

Summary

Buildings is defined as structure for the whatever purpose and if whatever material used for construction and every part there of weather used as human habitation or not.

- Classification of Buildings as per NBC
- Residential Buildings
- Educational Buildings
- Institutional Buildings
- Assembly Buildings
- Mercantile Buildings
- Industrial Buildings
- Storage Buildings
- Hazardous Buildings

Short Answer Type Questions

1. Define Buildings.

2. What are Residential Buildings?

3. State the classification of buildings and NBC.

4. List the components part of a buildings.

Long Answer Type Questions

1. State the classification of Buildings explain briefly.

2. List the components parts of buildings and explain briefly.
## Structure

10.1 Introduction  
10.2 Definition  
10.3 Classification of Soil  
10.4 Types of Foundations  
10.5 Bearing capacity of soil  
10.6 Requirement of good foundation  
10.7 Causes of failures of foundations and remedial measures

## Learning Objectives

After learnings this unit, student able to understand

- The definition of foundation  
- Know about the soil and classification of soil  
- Know the types of foundations  
- Know the shallow foundation  
- Know about the deep foundation  
- Know the bearing capacity of soil  
- Know the requirements of good foundation
• Know the causes of failures of foundation

• Know the remedial measures

10.1 Introduction

A foundation is that part of the structure which is in direct contact with the ground. The selection of material and type of foundational depends upon the types of structure and the nature of underlying soil.

10.2 Definition

A foundation is that part of the structure which is indirect contact with ground. It transfers the load of the structure to the soil below so as to avoid over loading of the soil beneath.

10.2.1 Function of foundation

The following are the main functions of foundation:

- To transmit and distribute the total loads of the structure to a larger area of underlying support.
- To prevent the differential settlement of a structural.
- To provide stability to the structure.
- To prevent cracks due to movement at moisture in case of weak or poor soils.
- To prepare a level and hard surface for concreting and masonry work.
- To support the structure.

10.3 Classification of soil

To an engineer, soil is the unaggregated or uncemented deposit of minerals or organic particles or fragment covering large portion of earth crush.

Classification of Soil

Soils are classified into three divisions:

1. Coarse grained soils: In these soils, more than half the material by weight is larger than 75 micron I.S sieve size.

   Ex: Gravels, Sands

2. Fine grained soils: In these soils, more than half the material by weight is smaller than 75 micron I.S sieve size.
Ex: Inorganic silts and very fine sands
Inorganic clays gravelly clays
Organic silts and clays

3. Highly organic and other miscellaneous: These soils contain large percentage of fibrous organic matter, such as peat and the particles of discomposed vegetation.

10.4 Types of Foundations

Foundation may be broadly divided into two groups

1. Shallow foundation
2. Deep foundation

1. Shallow foundation: The foundation whose depth is not more than its width is called a shallow foundation.

The various types of shallow foundation are

Wall footings: These footings can be simple or stepped. The base course of these footing can be concrete. The width of concrete base should be at least equal to twice the width of wall.

Fig 10.1(a) Simple Wall Footing
Fig 10.1(b) Two-brick thick stepped wall footing
**Isolated or Column footings**: They are used to support individual columns. They can be either of stepped type or have projection in the concrete base. Generally 15 cm offset is provided on all side of concrete bed. For heavy loaded columns, steel reinforcement is provided in both the direction concrete bed.

![Fig 10.2 Types of Columns footings](image)

**Combined footing**: A combined footing support two or more columns in a row. The combined footing can be or in trapezoidal in shape.

![Fig 10.3 Combined footings](image)
**Inverted Arch Footings**: This type of construction is used on soft soils to reduce the depth of foundation loads above an opening are transmitted from supporting walls through inverted arches to the soil.

![Inverted Arch Footings](image1)

**Continuous footings**: In this type of footing a single continuous R.C slab is provided as foundation of two or three or more columns in a row. This type of footings is suitable at earth quake zone and also prevents differential settlement in the structure.

![Continuous Footings](image2)

**Cantilever footings**: Cantilever footings consist of two or more individual footings connected by a beams called strap. This type of footing may be used where the distance between the columns is so great that a combined trapezoidal footings becomes quite narrow with high bending moments.
**Grillage footing**: This type of footing is used to transmit heavy loads from steel columns to the soils having low bearing capacity.
This footing is made up of rolled steel joists as grillage beams provided in single double tiers. In double tier arrangement the top tier is laid perpendicular to the bottom one. The total footing is embedded in cement concrete.

**Raft foundation**: A raft or mat is a combined footing that covers the entire area beneath a structure and supports all the columns. A raft foundation is also used to reduce settlement above highly compressible soils by making the weight of structure and raft equal to the weight of soil excavated. A raft may undergo large settlement without causing harmful differential settlement.

![Fig 10.8 Raft Foundation](image)
**Deep Foundation**: A foundation is deep if the depth is equal or greater than the width. These foundations carry loads from a structure through weak compressible soils of fills on the stronger and less compressible soils. These foundations are in general used on piles.

**Pile Foundation**: The pile foundation is a construction support on piles. A pile is an element of construction of timber, concrete or steel or combination of them. Pile may be defined as a column support type of foundation which may be contain side or precash.

Pile made classified on following criteria

1. Classification based on the function

**Bearings files**: These piles penetrate through the soft soil and their bottom rest on hard striatum.

![Fig 10.9 Bearing Pile](image)

**Friction piles**: When loose soil extends to a great depth the piles are driven up such a depth that frictional resistance developed the sides of the piles equal to the load coming on the piles.

![Fig 10.10 Friction of Pile](image)
**Screw Piles**: A screw pile consist of a hollow cast iron cylinder with one or more blades at the bottom. The blades are made of cast iron.

![Fig 10.11 Screw Pile](image)

**Compaction Pile**: They are used to compact loose granular soils in order to increase their bearing capacity.

![Fig 10.12 Compaction soils](image)

2. Classification Based on material and composition

**Cement concrete piles**: These piles possess gods compressive strength.

(a) **Precast concrete piles**: These piles are manufactured in factory. They may tapered or parallel sides and may be square, octogonal or round shape. The piles used for a maximum load for soft ones. They may be reinforced to with stand handling stresses.
(b) **Cast-in-situ concrete piles**: A bore is dug into the ground by inserting casing. This bore is filled with cement concrete after placing reinforcement.

![Cast-in-situ Pile](image)

**Fig 10.13 Cast-in-situ Pile**

### 10.5 Bearing capacity of soil

The load or pressure developed under the foundation without introducing any damaging movement in the foundation and in the supported structure is called bearing capacity of the soil.

**Safe bearing capacity**: The maximum pressure which the soil can carry safely without any risk of shear failure irrespective of any settlement is known as safe bearing capacity of soil.

**Ultimate bearing capacity soil**: The ultimate bearing capacity of soil may be defined as the gross pressure intensity at the base of the foundation at which the soil fails inshear.
10.6 Requirement of good foundation

Following are the basic requirement to be fulfilled by a foundation to be satisfactory.

Location: The foundation should be located that it is able to resist any unexpected future influence with may be adversely affect its performance.

Stability: The foundation structure should be stable against any possible failure. The foundation base should be rigid enough to bring down the differential settlement to a minimum when the super imposed loads are unevenly distributed.

Settlement: The foundation should not settle to such an extent so as to impair use fullness.

10.7 Cause of failures of foundation and remedial measures

1. The main causes of failure of foundation and measure are as follow

(i) Unequal settlement of the subsoil: This occurs due to unequal distribution of load on the foundation, varying bearing capacity soil.

Due to unequal settlement of the subsoil the cracks are formed in the buildings.

Measures: The foundation should rest on the rock or hard soil.

(ii) The allowable bearing pressure on the soil is not exceeded even under the worst condition.

(iii) The design of foundation should be appropriate to the nature of sub soil.

2. Unequal settlement the masonry

Binding material in masonry construction shrinks and gets compressed when loaded excessively before it has fully set.

Measures: The mortar to be used should be stiff and in line with desired work ability.

• The masonry work should be raised evenly

• The height of wall to be raised per day should be one meter.

(i) The curing should be done at least 10 days.
3. With drawal of moisture from the subsoil

When the water table falls, the soil particles lose cohesion and hence, there is shrinkage of soil resulting in the cracks to the buildings.

Measures: The precaution to be taken to avoid such failure would be drive files up to the hard rock.

4. Horizontal moment of the earth

Very soft soil is liable to give way under the action of load.

Measures: It is desirable to construction the retaining walls.

5. Lateral pressure on the super structure

The time of a sloped roof or action of wind on the superstructure causes wall to be over turn.

Measures: To prevent this failure would be to provide a sufficient wide base and design the foundation for the worst condition.

6. Transpiration of trees and shrubs

The roof of trees planted near a building may extend up to the foundation level and may absorb the moisture it may lead to cracks in the buildings.

Measures

(i) The foundations should be taken sufficient deep.

(ii) Trees should not be planted near the building with a minimum distance of sun.

7. Atmospheric action

The heavy rains or a variation in temperature or frost action may damage the foundation.

Measure

(i) The foundation should be taken beyond the depth up to which rain water can reach.

(ii) Suitable under ground drains should be provided.

(iii) The sides trenches should be filled with earth and well consolidated.
**Summary**

1. A foundation is that part of the structure where indirect contract with ground. It transfers the load of the structure to the soil below so as to avoid over-loading of the soil beneath.

2. Classification of soil
   - Coarse grained soils
   - Fine grained soils
   - Highly organic soils and other miscellaneous soil

3. Types of foundation
   - Shallow foundation
   - Deep foundation

4. The foundation whose depth is not more than its width is called shallow foundation.

5. Types of shallow foundation
   - Wall footing
   - Isolating or column footings
   - Combined footing
   - Inverted Arch footing
   - Continuous footing
   - Contilever footing
   - Grillage footing
   - Raft foundation

6. A foundation is deep, the depth is equal to or greater than width.

7. Pile may be defined as a column support type of foundation which may be cast-in-situ or pre cast.

8. The bearing capacity of soil is defined as maximum load per uit area which the soil will restore safely without displacement.

   - Unequal settlement of the sub soil
• Unequal settlement of the masonry
• Withdrawal of moisture from the sub soil
• Horizontal moment of the earth
• Lateral pressure on the super structure
• Transpiration of trees and shrubs.
• Atmospheric actions

Short Answer Type Questions

1. What is shallow foundation?
2. What is deep foundation?
3. Define foundation.
5. State the classification of shallow foundation.
6. Define bearing capacity in soil.

Long Answer Type Questions

1. Define foundation and their functions.
2. Explain the following
   (a) Wall footing
   (b) Continuous footing
   (c) Combined footing
   (d) Column footing
3. What are the causes of failures? What measures are to be taken to prevent sun failure.
4. What are the requirements good foundation?
5. State the classification of piles and explain briefly.
UNIT 11

Masonry

Structure

11.1 Stone masonry

11.2 Brick Masonry

Learning Objectives

After studying this unit, the student will be able to

• Understand about different types of masonry
• Learn about materials used for stone masonry and brick masonry
• Know about tools used by masonry
• Know the construction of brick masonry

11.1 Stone Masonry

The art of building structures in stones, is called stone masonry. Where stones are available in abundance in nature, on cutting and dressing to the proper shapes, they provide an economical material for the construction of various building components such as walls, columns, footings, etc.

11.1.1 Materials required for stone masonry

The following are the material used in the construction of stone masonry are

Stone: Granite, basalt, marble, sand stone, quartzite etc.
Binding materials: Cement, lime
Fine aggregate: Sand

11.1.2 Tools required for stone masonry

Trowel: This used to lift and spread mortar.

Square: This is made of flat steel having each arm about 0.5 m long. This is used to set up to right angles.

Plumb rule and bob: This is used to check the vertically of walls.

Spirit level: This is used to check the horizontally of the surface.

Line and pins: This is used to maintain the alignment of the work-in-progress.

Chaisels: They are used to dress the stones.

Spall Hammer: This is a heavy hammer used for rough dressing stone.

11.1.3 Types of stone masonry

The stone masonry can be classified broadly following two categories.

Rubble Masonry: The stone masonry in which roughly dressed or undressed stones are laid in a suitable mortar is called rubble masonry.

Rubble masonry may be divided into

(i) Uncoursed random rubble masonry

(ii) Coursed random rubble masonry

(iii) Dry rubbel masonry

(i) Uncourse random rubble masonry

The masonry in which stones blocks not properly dressed are used as obtained from the quarry, is called uncoursed random rubble masonry in this type vertical joints are not constructed in plumb.

(ii) Coursed random rubble masonry

The masonry in which 5 to 20 cm sized stones of equal height are used in every course, is called random rubble masonry the joints are about 1.5 cm thick. Stones used between the header should not be small than 5 cm in thickness.
Fig. 11.1 Uncoursed Random Rubble Masonry

Fig. 11.2 Coursed Random Rubble Masonry
(iii) **Dry Rubble Masonry**

The structure made with stones laid in different courses, without any mortar is called Dry rubble masonry. The stones used in this type of construction should have maximum bedding area.

**Ashlar masonry**: The stone masonry in which properly cut in uniform size and dressed with fine finish stones are laid with a mortar of uniform thickness, is called ashlar masonry.

**Ashlar masonry is further classified**

(i) Ashlar fine

(ii) Ashlar rock and quarry fuel

(ii) Ashlar chamfered

(iv) Ashlar facing

(i) **Ashlar fine**

In this type of stone masonry the stone blocks are finely chisel dressed and then faces are made perfectly the in shape and joints are kept less than 3 mm. The face stones are normally laid as headers and stretcher in alternate courses. The height of stones used in masonry should never be less their breadth.

Fig 11.3 Ashlar Fine Masonry
(ii) Ashlar rock

In this type of stone masonry the exposed faces of facing stones, are obtained from the quarry. If the stone projection is more than 8 cm, it is hammered to provide a rough surface.

![Fig. 11.4 Ashlar rock](image1)

(iii) Ashlar chamfered

It is similar to the quarry faced masonry with difference that edged round the exposed faces of each stone, are levelled at an angle of 45° from a depth of 2.5 cm.

![Fig. 11.5 Ashlar chamfered](image2)

(iv) Ashlar facing

In this type the exposed face is constructed with stone masonry and
backing is constructed in brick masonry, rubble masonry. The backing and fac-
ing are constructed simultaneously the composite construction reduces, the expenditure to a great extent.

![Ashlar facing](image)

**Fig. 11.6 Ashlar facing**

### 11.2 Brick Masonry

Brick masonry is unifined mass obtained by systemic arrangement of laying bricks and bonding them together with mortar.

#### 11.2.1 Principle of Brick masonry

1. A good brick masonry should utilize bricks which are sound, hard, well burnt, uniform colour, shape and size.

2. The bricks should be compact, hougenous free from cracks holes, the bricks should be soaked water at least two hour before use.

3. The bricks should be laid on their beds with the frogs pointing up wards.

4. Course should be laid truly horizontal and truly vertical joints.

5. Minimize the use of brick -bats.

6. The height of brick masonry in a day should be less than 1.5 m.

7. The walls should be stopped with a toothed end.

8. Finished brick work in cement mortar should be cured 1 to 2 weeks.
Bonding

Bonding is a process of arranging bricks with mortar to tie together in a mass of brick work.

Types of bonds
The bond can be classified as follow

1. Stretcher bond
2. Header bond
3. English bond
4. Flemish bond

English bond: In this type of bond, alternate of headers and stretcher are laid. It is necessary to place queen closer after the first header in the heading course for breaking the joints vertically.

The following points to be kept in view

1. A queen closer must be provided after the queen header.
2. A header course never start with a queen closer.
3. Each alternate header should be centrally placed over a stretcher.
4. Continuous vertical joints should not be allowed.
5. The wall thickness equivalent to an even number of half bricks, the wall shall present the similar appearance on both the faces.
6. The wall thickness equivalent to an add number of half bricks the same course stretcher on one face and header on the other.
7. The joints on the header course should be made thinner than those in the structure course.

Flemish Bond: The bond in which header and stretcher are laid alternately in the same course is called single Flemish bond. In this bond the facing of the wall consist of Flemish bond and the filling as well as backing consist of English bond in each course.

Double Flemish Bond: In this type of bond, both the facing and backing of the structure consists of Flemish bonds, and the fillings consist of either stretcher or headers. The queen closer is placed next to the queen header in alternate course in order to break the continuity of the vertical joints.
11.7 One brick wall English bond

11.8 One and a half brick wall English bond

11.9 One brick wall double flemish
Brick Masonry: Brick masonry is unified mass obtained by systematic arrangement of laying bricks and bonding them together with mortar.

Bonding: Bonding is a process of arranging bricks with mortar to tie them together in a mass of brick work;

Types of bond

- Stretcher Bond
- Header Bond
- English bond
- Flemish Bond.

English Bond: The bond which contain alternate course of stretcher and header is called English bond.

Single Flemish Bond: The bond in which headers and stretcher are laid alternately in the same course is called Single Flemish Bond.

Double Flemish Bond: The bond in which both the facing and backing of the structure consists of flemish bonds and the fillings consist of either stretcher or headers.
Short Answer Type Questions

1. What do you understand by dressing of stones?
2. List out the material used in stone masonry.
3. Name the tools required of masonry construction.
4. Enumerate the classes of stone masonry.
5. Name the various types of Ashlar masonry.
6. List different type of Brick bonds.
7. Define Brick Bond.

Long Answer Type Questions

1. Explain the construction of Rubble masonry with neat stretcher.
2. Explain the construction of Ashlar masonry with neat stretchers.
3. State the principles of Bricks masonry.
4. Explain the construction of brick way in English Bond.
5. English bond and flemish bond in brick masonry constructions.
Structure

12.0 Introduction
12.1 Damp Proofing
12.2 Treatment with standards water proofing chemicals
12.3 Cracks in Walls
12.5 Floors
12.5 Leakages RCC Roofs

Learning Objectives

After studying this unit, student will be able to

• Know the objectives of maintenance
• Understand the annual and special repairs
• Know the dampness in buildings and causes
• Understand the cracks in walls, causes and prevention of cracks
• Student know the types of floor and their maintenance
• Know the repair of floor
• Know the removed of stains
12.0 Introduction

The works that are required to keep a building in order, either to rectify the damages or to prevent before the damages surface out and the works are required to improve the appearance or preserve its like are called maintenance.

Objectives of Maintenance are

• To protect the buildings and its engineering services
• To restore the buildings to original specification
• To provide further facilities and improving function
• To increase the utilization of the buildings
• To ensure safety requirements which are many times mandatory
• To preserve the good working condition of the buildings so as to serve the purpose for which it was designed.

Annual Maintenance

Annual maintenance or routine such as white washing painting whose life is minimal as compared to whole life of the buildings is done by the fund provided annually for the purpose which is normally $1/2$\% of the cost construction. Example of annual maintenance are white washing, colour washing paintings.

Special Maintenance

May be done for strengthening and updating of the building to meet the new condition of usage or to increase its service ability to rectify heavy damage. Special maintenance may include part of complete the work occupying as longer internal such as renewal floors, roofs, replacements of doors etc.

12.1 Damp proofing

The treatment given to the walls, floors and basements to keep the in dry condition is called “Damp Proofing”.

12.1.1 Dampness in Buildings

The buildings which is constructed to protect the human beings, their assets from weathering agents rain, wind sun light has to encounter these
weathering agencies. The rain water enters the buildings through its various components such as basements, floors, walls, openings, doors and windows in lintels, roofs, parapet walls etc. Moisture in solids, liquid, or vapour form can be regarded as the principal agent causing deterioration. Moisture enters the buildings from various weak points, junctions. This moisture is dangerous to the building material in reducing their life period and sometimes causes the damage of the building; its collapse even.

**Causes of Dampness:** The dampness in buildings are various locations in caused due to the following

- Faculty design of structure making the components porous.
- Use of substandard material in building constructions.
- Bad workmanship causes improper water proofing.
- Condensation of the moisture present in the atmosphere on the building components.
- Absorption of moisture by building materials, when exposed to water, ice.
- Improper rain water pipe connection and defective junction between roof slab and parapet walls.
- Leakages in wet areas of buildings, kitchen, bathroom, water closet etc.
- Leakage due to sub standards plumbing.

### 12.1.2 Effects of Dampers

- Softening and crumbling of plaster and resultings peeling of walls and ceilings.
- Dampness in building causes of efflorescences and results in the disintegration of building material which may causes failure building.
- Warping, buckling and roffing of timber
- Growth of fermites and results in damage of doors, windows and cupboards etc.
- The corrosion of metals and reinforcement resulting into loss of strength of components.
- Deperiorate Electrical fittings short circuits and their by causing fire hazards
• Dampeners in buildings increase mosquito breeding, causing, unhealthy living conditions.

• Alternate conditions of dampeners and dryer causes cracking.

### 12.2 Treatment with standard waterproofing chemicals

CICO Non-shrink polymers waterproof grouting compound is a free flooring powder for addition to near cement milk. It plasticizes the mix allowing for substantial reduction in water content with ensuing effecting the fluidity, thus improving the strength and impermeability of the grout. CICP non-shrink polymeric waterproof grouting compound is used as an admixture for injection grouting to effectively waterproof and stop leaks in underground structures, basements, funnels, lift walls. It is also used for grouting pre-stressed members.

### Integral Water Proofing Compounds

Cetex and WPSP are integral waterproofing compounds. It makes concrete and pre-segregation. It acts both as highly efficient plasticizer and waterproofing compounds when liquid is added to wet concrete or mortar.

### Water Proof (EPOXY) Coatings, UV resins PU Bases

This is a two components, polyurethane polymer based waterproofing coatings. It cures to form impervious tough and abrasion resistant, water proof and weather durable coatings. It remains unaffected by salt water.

### Dr. Fixin super Last

These are preferred for enhancing strength of a repair mortar and provides durability. Dr. Fixin super later is the perfect solution to control leakages.

### EPDM Membrane used an Terrace Application

EPDM waterproofing membrane is a popular product in the market, as there as reliable effective, extremely long lasting EPDM membrane coating and bonding agent are very effective for construction and renovation purposes.

### Nano Technology Base Concrete Penetrating Sealer

Polysilic is an inorganic formulation specially designed for concrete in Indian climatic condition and makes it water tight almost permanently.

### Tuff Plast Mortar Plasticizer

This is a mortar plasticizer and is highly workable water proofs plaster additive for mortar in liquid form. It fills natural pores within the mix to reduce
porosity and improve water tightness giving smooth finish plaster reducing drying shrinkage cracks.

12.3 Cracks in walls

Cracks in buildings are of common occurrence some cracks are inevitable. Some cracks will be an indication of instability for the structure, but many others look very serious may have little or no effect on the stability of structure. In the building the crack may be in

1. Brick masonry
2. Stone Masonry
3. Concrete
4. Plastering

If cracks left uncured, they cause further deterioration by exposing the inner part of masonry components to the atmospheric agencies. This further deterioration leads to

1. Instability of the structure and
2. Psychological discomfort to inmates.

Thus the cracks need to be tended immediately.

Cracks are broadly classified as,


1. Structural cracks are mainly due to incorrect design faulty construction and overloading of the structure. Example Cracking of an R.C.C beam.

2. Non-Structural cracks are mostly due to internally induced stresses. These do not result in structural weakening directly. In the course of time, penetration of moisture through cracks, result in corrosion of reinforcement and thus may render the structural unsafe. It requires maintenance. These do not endanger the safety of a building. These create feeling of faulty work and instability of structure. It leads to dimensional change. These induces internal stresses causing cracks. Internal stresses could be tensile, compressive or shear in nature. Example

(a) Vertical cracks in long compared wall due to shrinkage of thermal movements.

(b) Tension crack in masonry wall.
(c) Shear crack in masonry wall.

Occurrence of closely spaced fine cracks at surface are called ‘Crazing’.

Modern buildings are prone to crack because these comprise of tall and slender, thin walls, designed for higher stresses and built at faster rate.

Old buildings are lesser prone to cracks because these are consist of short, thick walls designed for low stresses and built at slow rate. Wider cracks are aesthetically objectionable and closely spaced and greater in number cracks may have lesser damage to the structure.

**Causes of Cracks**

A building components develops cracks whenever stress in the component exceeds its strength. Stress in the structural component could be

(a) Due to externally applied forces or

(b) Due to internally induced forces.

**There external applied forces are**

1. Dead load
2. Live load
3. Wind load
4. Seismic load or
5. Due to foundation settlement.

The internal induced forces are due to

1. Thermal movements
2. Moisture changes
3. Chemical action

**Causes of Cracks (IS SP-25-1984)**

IS SP-25-1984 has listed the which following major cause of non structural cracks are discussed in detail in unit 2.

1. Moisture changes
2. Thermal variations
3. Elastic deformation
4. Creep  
5. Chemical reaction  
6. Foundation movements and settlements of soils  
7. Vegetation  

Sooner or later after the completion of construction cracks appear in most of the buildings. Some of them are superficial and can easily be repaired while some are dangerous and can even lead to collapse. It is therefore necessary to know and understand the cause of cracking so that if effect can be understood.

**Principal Causes of Cracking**

**The Principal causes of cracking are again listed as follows**

1. Temperature variations, both expansion and contraction of the building can cause cracking. The cracking may also be due to different co-efficient of expansion of material used in the construction.

2. **Moisture content changes**

   Drying results in shrinkage and wetting results in expansion. Changes in moisture content cause various components to change their sizes.

3. **Loading**

   The structure where dead load and live load are within design limits, there could be some cracking which is not significant. Where the structure is overloaded there would be extensive cracking.

   4. Ground movements including unequal settlements earthquake, land side, creep. The cracks form or appear because apart of building has become displaced from the rest without any change in actual change in material.

   *E.x.* Mining subsidence, Earthquakes.

   5. Vibration from traffic, machinery etc. Vibration from some machine traffic, causes cracks only if the amplitude of vibration is considerable. Classification of cracks based on its width. Cracks may appreciably vary in width from very thin hairy cracks to visible to naked eye. Width about 0.01 mm to 5 mm or more. Cracks may be uniform width through out or may be narrow at one end gradually widening at the other end.

    6. Due to corrosion of steel in reinforced concrete works.

    7. Construction process such as construction joints in RCC etc.
8. Due to buildings and buckling.

9. Tree growth in the surrounding area of building.

10. The effect of gases. Liquids and solids

The only gas likely to leach crack is carbon dioxide. This gas causes carbonation of porous Portland cement products leading to an overall shrinkage. The effect of water is physical. This is due to change in water content or chemical changes leading to cracks. Solids like sulphates may have their origin in the material itself, or transferred from other material or from the soil. Soluble sulphate cause expansion in structural elements leading to cracks in Portland cement products.

**Classification of Cracks as per SP : 25 : 1984.**

Depending on thickness of crack they are divided into thin, medium and wide cracks as per IS SP 25 : 1984.

- **Thin crack**: $< 1$ mm in width
- **Medium crack**: 1 to 2 mm in width
- **Wide crack**: $> 2$ mm width.

**Crack Nature**

- Cracks may be straight, toothed, stepped map pattern or random.
- Crack may be vertical horizontal or in diagonal.
- Crack may be at surface or may extend to more than one layer of material.

**Prevention of Cracks**

To prevent the cracks first they have to be investigated for the probable cause and suitable action is proposed. The cracks can be prevented to some extent, by taking some precautions measure during planning, designing and execution and maintenance works.

**Investigation of Cracks in Walls**

All cracks have a similar appearance though the cause is different.

It is not possible to reconnect the masonry in a permanent manner as in the case of welding of metal.
Reoccurrence of the crack after some period is also common. Every crack is an indication that the building is becoming unsafe and needs caring. Sufficient notice time is usually available.

Investigation of Cracks include the following information is so as to diagnosis the cause of cracks.

**Direction of cracks**

The crack may be vertical diagonal, coupled with whether the crack is straight, toothed, variable and irregular. The direction and material through which the crack passes should be recorded.

**Extension of Crack**

The starting and ending point of crack should be noted. It should be noted whether the cracks extends across openings. It should be observed whether cracks passes through DPC or touches ground.

**Width of Crack**

Width of the crack should be observed. It is tapers off, mark the end of cracks and note the direction of the taper.

**Depth of Crack**

The depth of cracks should be observed as to how many of the material comprising the wall been cracked. The crack in a painted plastered wall may be confined to the paint film, may pass into the plaster, may pass on into the wall or may pass right though it. A piece of wire can be useful for probing the depth of crack.

**Alignment of Crack**

Crack should be investigated for its alignment. Alignment will indicate whether cracks have been produced by a straight pull as with tensile force or by a diagonal pull as with a shear action.

**Sharpness of Edges**

Investigation of edges of the cracks reveal useful information. Most cracks have sharp edges. Some edges are roughened or rounded indicate due to compressive forces or vibrations Badly broken edges will often be indicative of initial compressive forces.

**Cleanliness**

Cracks should be examined with magnifying glasses. Examine for brightness of crack or presence of dirt of presence decorative material inside. This investigation helps to identify the age of the crack whether it is fresh or old.
Other Information

Crack should be observed over period of time. The crack may be static or may be active/developing. Cracks in buildings on clayey sub soils are likely to vary its width more or less continuous. These cracks should not be filled with rigid material and any temporary filling should be carried out with a flexible material. Remedial measure should not be carried out immediately. After investigation in detail is completed then remedy can be planned.

Following items to be Inspected in Brick Masonry

1. **Condition of pointing**: Pointings give good appearance and protection of joint from weathering agents. Joint is weak point in masonry subjected to decay. The condition of pointing should be observed whether joints are exposed or in proper conditions.

2. **Dampness**: Absorption of moisture by the material is the major cause of dampness. In material structure is of granular moisture movements take place by capillary action.

3. **Growth of Vegetation**: Growth of vegetation takes place over masonry and at masonry joints. This growth of harmful as they cause cracks due to penetration of roots.

4. **Structural Failures**: Brick work of the building should be observed for structural failures due to settlements, due to cracks or due to duality construction.

Most of the buildings material having pores in their structure in the form of inter molecular space. Material expand on absorbing moisture and shrink on drying. These movements are reversible. The extent of movements depends on molecular structure and porosity of material. Apart from reversible movement, some material under go irreversible movement due to initial moisture changes after their manufacture. Ex. Shrinkage of cement and lime based material and initial drying.

Remedial Measures for Cracks in walls

For vertical cracks in external walls

1. No permanent work should be done until the upward movements has virtually ceased. This can be determined from the tell tales.

2. Wide cracks should be filled using compressible material or a cover a strip technique.
3. Fine cracks can be left unless they allow water to penetrate.
4. If water penetrates wall must be made water tight.
5. Foundation of building must always be taken below the level moisture penetration in clays.

**For Vertical cracks in external wall near corner building**
1. In buildings having relatively long elevations movement joints should be placed.
2. Bricks of low moisture expansion should be used.

**For Diagonal Cracks in External Walls across the corner of two walls**
1. It is necessary to underpin the foundation before repairing the walls.
2. A weak mortar or a sealant backed with foamed plastics will usually be suitable.
3. Roots of large fast growing trees near the building should be pruned.
4. If building are to be founded on shrinkage clay slab soil, the foundation should be strip type not less than 1.4m deep.

**For Diagonal Cracks (Boundary Wall)**
1. If the mortar joints are damaged by sulphate attack or by frost, it may be necessary to rebuild the wall.
2. Otherwise crack can be filled with weak mortar.
3. The boundary walls should be provided with vertical movements joints at 8 to 10 m apart in case of calcium silicate and concrete blocks.
4. In case of clay bricks, the above distance must be doubled.
5. If bricks are known to contain excessive amount of soluble sulphates, the mortar should be based on cement having higher resistance to sulphates.

For Cracks due to settlement, concentrated loads and expansion and contraction

**1. Use of C.M:** The cracked surface should be thoroughly cleaned and wetted properly. Rich mix of content sand 1:3 is filled in the crack.
2. Use of bitumen compound

3. Use of expansive cement

Fig 12.1 Cracks in Walls

This reinforcement be covered by mortar to give further strengths as well as protection to the reinforcement. In areas of very severe damage, replacement of the member or portion of member can be carried out as discussed later.

In the case of damage wall and floor diaphragms, steels mesh could be provided on outside of the surface and nailed or bolted to the wall. Then it may covered with plaster or micro-concrete.
12.5 Floors

Definition: Floors are horizontal elements of a building structure which divide the building into different levels for the purpose of creating more accommodation and provide support for the occupants' furniture and equipment of a building.

12.5.1 Maintenance of Floors

Settlement of Floors

The floors consist of bed over desired level of sand or murram filling and finishing coat to give smooth and pleasant appearance. The maintenance problems hence include, apart from entry of moisture, settlement of filled up murram, failure or subsidence of soil, stains in finish due to usage wear and tear of flooring etc. In case of ground floors this defect would be there if the plinth fillings etc. The upper floors are subjected to entirely different problems compared to ground floors. Major problems is due to deflection of RCC slab below the slab. A cushion layer of lime concrete of 40-50 mm thick is advised to be laid on RCC slab over which flooring can be laid, to avoid the above problem. The soil used for filling of basements is inferior quality or sub soil itself may undergo settlement. This problem is the case of buildings in clayey soils which undergo swelling and shrinkage on account of moisture changes. Along walls or when deep fillings exist the floor may exhibit cracks. To avoid deep fillings, it is advised to go for cellar floor wherever possible. Where the sinking is unsightly or to be repaired, the flooring has to be broken refilling is done and flooring relaid.

With everyday cleaning and mopping it might be possible to keep floors reasonably clean, yet under constant use stains scratches would start showing and mar the appearance.

Usual flooring material are as follows

1. Concrete
2. Terrazzo
3. Marble
4. Kota/Shahabad and similar flooring stones.
5. PVC, Rubber Linoleum, floors.

Maintenance of Concrete Floors

- Problems connected with concrete floors are
• Roughness

• Poor finish with cement droppings

• Weak strength

Concrete floor defects as above can not be removed by regrinding like terrazzo floor. Only way to out is to cover it up by PVC flooring etc, it by paintings.

Before laying PVC floor the cement floor should be ground to level and the PVC tiles laid. Uneven concrete subbase will show through the PVC floor.

Cement concrete floors are more porous when compared to a terrazzo flooring and it if stains the stains are difficult to remove.

Fig. 12.2 Cement concrete floor

Fig. 12.3 Mosaic flooring
12.5.2 Types of Floors

- Mud flooring and murram flooring
- Stone flooring
- Cement concrete flooring
- Mosaic flooring
- Terrazzo flooring
- Tiled flooring
- Rubber flooring
- Marble flooring
- Plastic or PV.C. Flooring etc

12.5.3 Construction of Cement concrete floor

This type of flooring is most commonly used these days in residential, commercial and all types of public buildings. The concrete flooring consist of two components a base course and a wearing course.

The thickness of concrete layer is about 40 mm and it is carried out in profession of 1:2:4 cement concrete. The size of course aggregates varieties form 20mm to 6mm. The square or diagonal lines are marked on the concrete surfaces when it is still wet.

At places where hard wearing surface is required the granolithic finish is carried out above the layer of cement concrete. The finish is composed of cement sand and specially selected aggregates. The granolithic concrete should be laid before the base concrete has set and its thickness varies form 10mm to 20mm. After laying the concrete the surface is required is tamped and floated with wooden floats. The surface is then finally smoothened by means of steel trowel.

After the flooring is completed the whole surface is covered with wet bags or with 5 cm of wet sand and kept wet for atleast 10 days by sprinkling water at suitable intervals.

12.5.3 Terrazo Floor: This is a special type of concrete flooring in which marble chips are used as aggregates and which, when polished with carbo random stone, presents a smooth surface. Any desired colour is obtained by using marbles chips of different shades and sizes and also using different colour cement.
The proportion of terrazzo mix depends on the size of marble chips. Proportion generally 1:2 to 1:3 i.e. one part of cement to two or three parts of marble chips by volume. The cement and marble chips are mix in dry condition and the required quantity it water is added so as to obtain a plaster mixture. This mixed is laid on sound and rough base.

The base is made of cement mortar 1:3. The base is kept wet watered for at least 7 days. The polishing is carried out after 3 days of laying of terrazzo mix. The first coat polishing is done by means of coarse carborandum stone, second coat is done by means of finely grained carborandum stone and wax is applied as a finer coat of polishing to get glossy surface. The total thickness of the terrazzo floorings about 20 mm. The flooring is used residential buildings, bathrooms, hotels, temples, theaters etc.

12.5.4 Mosaic flooring

This flooring which consist of tiles available in variety of pattern and colour is commonly used in operation theaters, temples, bathrooms and superior type of buildings floors.

For construction of mosaic flooring first of hard concrete base is laid over this concrete base, while it is still wet, a 2cm layer of cement mortar, 1:2 is laid. Upon the bed of the cement motor, small pieces of broken tiles are arranged in definite patterns. After this cement or colour cement is sprinkled at the top and surface is rolled by light roller till the even surface is attained. This surface is left for 24 hour to dry and then it is rubbed with pumice stone to get a smooth and polished surface. The polished surface is finally allowed to dry for about two week before use.

12.5.5 Marble flooring

This flooring is used for superior work and especially where extraordinary clean lines is required as in case of operation theaters in hospitals, temples, bathrooms, kitchens etc.

The construction of this flooring is exactly same as that of mosaic floorings, except that the use of marble pieces instead of mosaic files is made.

Maintenance of Terrazzo Floor

In good terrazzo floor the top surface should have at least 70% marble. Terrazzo floor can be in situ or by tiles. Cast in situ terrazzo is very similar to concrete floor except that aggregable is marble.

Pressed tiles on the other hand are denser and more wear resistant. Higher surface layer density makes scratching difficult but it is also makes initial
polishing of floor difficult. Tiles floor once polished properly retain shine for a long time.

Correct way to polish terrazzo is by 60, 80 and 120 grade carborundum stones along with fillings in the pores by same coloured cement paste and final polish by 320 grade stone.

There is tendency on the part of workman and contractor to stop grinding at 80 to 120 grade. This leaves a scratchy surface which can at best take temporary shine given buy heavy layer of wax. It course of time dust and grease into the scratches and makes floor dirty. Forced with such problem only way is to regrind the surface with carborandum stones of proper grade. Cleanliness and shine is therefore in built in the proper construction process.

Soaps, scrubbing powder, soda, inorganic salts and crystalling salts should never be used in cleaning a dirty terrazzo floor.

Terrazzo is maintained by daily dusting mopping, cleaning with neutrally detergents and very occasional waxing and buffing.

Polishing with tin oxide can give a very fine mirror like finish for a terrazzo floor.

**Maintenance of Marble floor**

Marble floor or surface in marble can be well maintained with very little efforts with good sweeping and amp mopping marbles are not to be given wax polish.

Abrasive cleaning powder should never be used on marble. Soapy cleaners or soaps should never be utilized for cleaning of marble as these give a due lifeless appearance to marble. An acidic cleaning agent will leave the surface dull and an alkali cleaners destroy marble. Only a neutrals detergent can be used. Marble should be washed and rinsed thoroughly to remove all traces of detergent.

Tin oxide polishing gives beautiful finish.

**Maintenance of Kota/Shahabad Flooring**

These are very durable. If care is taken to get a scratch free surface it can stand for a long time. Acidic cleaner, abrasives powder will spoil the surface.

This is one of the hard stones available which can take good polish. Should iron studded shores are used it would get spoilt under traffic.
Maintenance of PVC, Rubber, Linoleum, Floors

These floorings are available in tile or roll form. The floors are not water resistant. Vacuuming and slight damp mop would remove all dust. The life of these floor is about 10 year. The surface may get scratched rather easily. Mentioned above are the problem of floors which are non-structural. The structural problems are discussed below.

Curling up of floor

Curling up of floor occurs at corners and there is a diagonal crack at corner. This defect is seen when the thickness of floors is less and it bonding with the base is lost.

Settlement of Floors

In case of ground floors this defect would be there if the plinth filling etc., has not been done properly. Along walls or where deep filling exist the floor may exhibit sinking cracks. The malady is deep rooted and it is constructed defect. Where the sinking is unsightly or to be repaired, the flooring has to be broken, proper refilling is done and the flooring relaid.

Crazy cracking may occur in concrete and terrazzo flooring in upper floors. This is because the RCC slab on which the floorings is laid is undergoing deflection according to the loads. Whereas the RCC slab because it is reinforced can withstand these changes the flooring cannot. Hence it develops deep crazy cracks. This is rather head to avoid success can be hard with a cushion layer of lime concrete etc., which may be 40-50 mm cushion layer the floors does not crack. However the problem of curling at edges will have to be tackled by appropriate thickness of flooring.

Wearing

The concrete terrazzo or any other flooring wears under. This will have to be checked by pouring water, which stay in form of channels or poodles if it is other than concrete like terrazzo. The only course remedy is to regrind the floor.

Temperature and contraction

The cement when sets, it release lot of heat. Thus contraction floor panels after it is cast is normal phenomenon. The floor panels if they are laid of large dimensions or of odd dimensions may have more cracking. To avoid cracking to large extent normally floor panel should be squarish and length to breadth ratio should not exceed 1.5 in any case. Where the contraction joints in
the floor border or skirting does not coincide with the floor panels, the smaller of the two will exhibit sympathetic cracking.

Repairs to Flooring

- Repairing to floor would be needed an account of pitting cracking spelling at joints and may be due to normal wear and tear or accident etc. The treatment would be dependent on the type of floor.

- Problem in repair of floor specially concrete floor and terrazzo floor is that it is difficult to rectify the damage not repair does not stick. Replacing entire panel makes problems matching the colour very difficult.

- Dustily concrete or terrazzo floor with a lot crocodile cracking on surface is not repairable.

- Pitting consist of small holes on the surface resulting from aggregate becoming loose. Dents caused by accidents etc.

- Repairs to pitting can be done epoxy resin mixed with matching colour and cements. The cavity is cleaned.

Removal of Stains form floors

Stains result from abuse of flooring or accidental spill of standing material. Stains should be removed as soon as possible. If delayed stain removal become difficult. An old stain takes longer period of sustained effort for removal and even then the results may not be very satisfactory. Weeks acids such as acetic, oxalic acid may damage surface of flooring it left for long time on the surface.

For Stain Removal Basically Following Guidelines Operate

Water based stain: Use water to remove.
Alcoholic stain: Use alcohol to remove.
Stain due to acid: Use alkali to neutralize
Stain due to grease: Use liquid neutral detergent
(Stain with albumin: Use cold water (Hot water absolutely not to be used)

Suggested Methods for Removal Of Common Stains - Rust

Dissolve one part of sodium citrate to six parts of water and mix it with equal volume of glycerin. Now mix this liquid with whiting to form a tiff paste.
Apply with a trowel or blade. After paste has dried it should be removed and check the rust is also removed. If needed the treatment may have to be repeated several times. To completely remove the rust aluminum citrate can be used to get better. It may be damage the flooring. For deep stains sodium hydrosulphite may be used.

**Second Method for Removal of Deep stain on horizontal surface**

The surface should first be soaked with a solution of sodium citrate in six part of water. Dip white cloth in solution and apply over the stain for 10 to 15 minutes. Remove cloth to sprinkle over this layer, sodium hydrosulphite crystals, moisten with water. Now cover with a paste made of whiting and water and applied by trowel or by blade. Keep it for an hour and remove and rinse thoroughly with water, to get cleaned surface.

**Method for Removal of Deep Stains - Vertical Surface**

On vertical surface similar treatment is to be done but as crystals cannot be placed directly a paste of whiting and water is taken on trowel and crystals are put over this paste and applied on the vertical surface. Thus the crystals will be in contact with stain and rest of the procedure is same.

**Removal of Stains Due to Paints and Varnish**

While paints is wet take it out by soaking it with cloth. Do not rub in the pain. Small residue of paint can be removed fresh by carbon tetrachloride, amyl acetate. For old stains strong paint removers should be used. This may results in certain amount of salt formation which initially gives unsightly appearance but will disappear with normal cleaning in few days. Emulsion paints are soluble water and can be removed by first softening paint by water and lifting it out gently.

**Remove of stain due to Asphalt**

Stains due to asphalt can be removed by applying warm kerosene. Final removal can be done by carbon tetrachloride.

**Removal of stain due to Oil, Grease etc**

The industrial floor may get coating of oil and grease and it will make floor slippery. Oil when spilled should be immediately mopped up. Quickly hydrated lime, cement or whiting. Sponging with petrol or benzene will also remove oil stain. When oil has penetrated deep into concrete, sponging with solvent will not be useful as it removed only from surface. Thoroughly and the resin mix is used a pasted of fill. Traffic should not be allowed till epoxy sets property.
Cracking can be repaired be expansive grout or by epoxy

Spelling near joints be problem. Concert near the joint almost always is a weak mortar. Where depth of spall is less than 25mm, the repairs can be done by epoxy resins. Where large chunks are involved, the spalling area should be cut in a regular way and recombined with a binder like araldite, epoxy etc., applied at the junction of old and new work to joint effectively the old and new surface.

PVC tiles which get damaged etc., have to be cut out by a sharp knife, the old adhesive thoroughly scraped and new tiles placed with adhesive. When scuff marks on PVC floors are to be removed then firm grade steel wool could be used to rub off the scuff marks. When stone following is used the damaged piece could be removed and new place with matching veins added.

Removal of other stains

Coffee stains can be removed by one part of glycerin. In four parts of water and wiped by cloth. Urine stains can be removed by 10% solution of citric acid and washed with plenty of hot water. INK stains can be removed by applying ammonia water on cotton. Sodium perborate be mixed in hot water and mix whiting at a thick paste, apply and allow to dry 10% solution of oxalic acid or ammonium oxalate or citric acid or hydrogen peroxide.

12.6 Leakage of R.C.C Roof

12.6.1 Definition

A roof is defined as the upmost part of buildings which is constructed to give protection to the buildings against rain, heat snow, wind etc.

Types of Roofs: The roof are classified into the following three groups

(i) Pitched or sloping roof
(ii) Flat or terraced roof
(iii) Curved roofs

(i) Pitched or sloping roofs

A sloping roof is known as pitched roof. The technical term used in connection with pitched roof are

(a) Barge board: These are the wooden planks which are fixed on the gable end of a roof.
(b) **Battens**: These are the thin strips of woods which are fixed on the rafter. They support the roof ceiling.

(c) **Cleats**: These are small blocks of wood which are fixed on the trusses to preventive sliding to purlins.

(d) **Eaves**: The lower Edens of roof which are resting upon the supporting walls known as the eaves.

(e) **Gable**: The triangular upper part of wall formed at the end of pitched roof as known as gable.

(f) **Hip**: The angle formed the intersection of two roof slopes is known as the Hip.

(g) **Purlins**: The wooden pieces which are placed horizontally on principal rafters to carry the common rafter are known as purlins.

(i) **Rafters**: These are the piece of the which extend form the eaves to the which are common rafters, hip rafter jack rafter, and principal rafters.

(j) **Ridge**: A wooden piece provided at the ridge live of slopping roof is known as the ride.

(k) **Span**: The horizontal distance between internal face of wall is known as span. The horizontal distance between the centres of walls is known as effective span.

(l) **Tubs**: The frame work, usually of triangles and designed to support the roof coverings is known as tubs.

(m) **Wall-plates**: These are the long wooden members which are embedded on top to receive the common rafters. They actually connect the wall of the roof.

**The pitched roofs are classified into three categories**

(i) Single roofs

(ii) Double roofs or purlin roofs

(iii) Trussed roofs

**Flat roof or Terrace roofs**

A roof of which is nearly flat is known as flat roof. The flat roof are normally laid at a slope of in 2 to 6, slopping in one or more direction form centre, to drain of the rain water efficiently and smoothly.
Advantages of Flat roofs

- The flat roofs can be utilized for several purpose, such as for roof Gardens, celebrating function etc.

- The construction and maintenance of flat roofs is simpler than other types of roofs.
In care of flat roofs the construction of upper floors care of flat roof, can be readily taken up when desired.

The flat roof is considered to be best choice for multi stored public buildings and apartments.

Disadvantages of Flat Roof

- Flat roof cannot be used for long spans without the use of intermediate columns are beams.
- The flat roofs are not suitable at places at heavy rainfall and snow fall.
- The self weight of flat roofs is heavier and initial cost is more than pitched roof.
- The speed of construction is slower than pitched roof.
- Construction of RCC Slab floor: R.C.C. Slabs are becoming very popular in the construction floors for modern buildings. R.C.C. is a combination of two material, cement concrete and steel.
  - A well designed centering either of steel to timber, is erected to support its own weight the super imposed load.
  - After centering the reinforcement is placed on the interior surface which has been finish first with thin coat of oil and then with a thin layer of cement concrete.
  - The cement concrete is then poured around the reinforcement and for the required thickness of slab, and well consolidated by means of reamer.
  - The concrete is now cured for about 2 weeks to attain its full strength.
  - After the concrete has sufficiently hardened the framework is removed and the rapper and under surface are treated as desired.

Leakages of RCC Roofs

Commonly used roofs are RCC for buildings. Improper roofs about serve the purpose, for which it is intended. If it allows any moisture, drops of water, considerable quantities of water during rain season call or as leakage in roof.

Causes of Leakages

- Voids in concrete due to poorly designed.
• Poor placement compaction of concrete
• Excess of fine aggregates consisting of fine and
• Improper curing
• Thermal expansion
• Early removal of farm work
• Formation of cracks due to defective design
• Improper slope provided for draining of rain water
• Improper weathering course over RCC roofs

**Repairs flat roofs**: In case of flat roofs the rain water enter either through the defective parapet wall or cracked roofing tiles etc. The water proofing treatment given to flat roofs as follow namely.

**Causes of Corrosion**: The following are the factors responsible for causing corrosion of reinforcement

• Congested reinforcement in small concrete sections
• Excessive water cement ratio
• Improper construction methods
• In competent supervising staff
• Initially reinforcement before placing concrete
• Insufficient cover steel. Reinforcement before placing concrete
• Poor workmanship
• Preserve of salts

**Repair**: The spalled area should be scarified by hand chipping or by compressed air chipper to a depth of at least 20mm. The area should be wetted and kept moist for at least 14 hour. Free water should be removed if it collects in the low spots. Slabs requiring major strengthening should be provided with a mat of reinforcing bars. Studs 4mm or 6mm thick should be shot into the scarified slab but left projecting a distance that permits the mat to be held in exact position. The supporting bars should be welded to the top of studs, and the top layer of the mat should be fastened to the supporting bars. For this type of mat, the covering of concrete must be at least 50 mm thick.
Lime Concrete Terracing

(i) The process consists of laying the lime concrete to the appropriate shape, application of hot prime war over dried lime concrete and finally, laying sheet and lime over the primed surface.

(ii) The process of laying consists of various operations. First of laying D.P.C of hot bitumen 1.70 kg/m² roof surface spreading over the hot bitumen layer laying lime concrete at proper slope in average thickness of 10 cm and finally laying two courses of flat tiles in cement mortar. The joint of the top course of tile being filled with mortar and 5% of crude oil, based on the weight of cement.

12.6.2 Spalling of Concrete

Removed of concrete cover from bottom of the reinforcement cement concrete member such as roof slab, beam is called spalling. Spalling causes the reinforcement in that member exposed. Exposure of reinforcement at the bottom of the RCC slab leads to corrosion of reinforcement in the presence of air and moisture. Thermal expansion or sudden changes in temperature are also the causes of spalling.

12.6.3 Corrosion of Reinforce Cement

The process of gradual wearing away of a vary of metal due to chemical or electrochemical reaction by its surroundings such that the metal is converted into oxide salt or some other compounds.

Remedial measures for roof leakages

- The essential condition for the protection of the steel in reinforcement concrete against corrosion is cover over the bars.
- Local weak spots take place at construction joints at the end of days work.
- Shrinkage of the concrete must be controlled by suitably designed reinforcement.
- The bars are painted with any of the anti-corrosive paint, available in the market.
- Grouting with micro concrete can be done as remedial measure, if the RCC roof is suspected of any leakage in the very first rainy season.
- The concrete with coarse aggregate of screenings less than 10 mm size is used as cover the bottom of the slab.
Short Answer Type Question

1. Define maintenance of buildings.
2. What is annual maintenance?
3. Define damp proofing course.
4. List types of floors.
5. List type of roofs.
6. Define corrosion.

Long Answer Type Question

1. State the objectives of maintenance.
2. List causes for dampness.
3. What are the effects of dampness?
4. Explain the treatment with standard waterproofing chemicals.
5. Explain the causes of cracks in walls.
6. Explain the remedial measure for cracks.
7. Explain the construction of cement concrete floor.
8. Explain the construction of mosaic floor.
9. Explain the settlement of floors.
10. Explain the methods of removal of stains.
11. Explain the remedial measures for roof leakages.
12. Explain the spalling of concrete.