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RAILWAY RECRUITMENT BOARD

CIVIL ENGINEERING

BUILDING MATERIALS

SELF STUDY MATERIAL

CIVIL ENGINEERING FOR ALL

Building Materials

Introduction:

Any material which is used for construction purposes is known as building material. Many naturally occuring substances such as clay, rocks, sand and wood have been used since ages to construct buildings. Apart from naturally occuring materials,many man-made products are in use.

Now we will discuss these different types of building materials.

BUILDING STONES :

Stone is a naturally available building material which has been used from the early age of civilization. It is available in the form of rocks, which is cut to required size and shape and used as building block.

(1) **Classification of rocks:**

(i) Geological classification:Based on the origin of formation, stones are classified into three main group :- Igneous, sedimentary and metamorphic rock.

(a) **Igneous rocks:** The inside portion of the earth's surface has high temperature so as to cause fusion by heat at even ordinary pressures. The molten or pasty rocky material is known as the magma.This magma always tries to come out of the earth's surface through cracks or fissures. The rocks which are formed by the cooling of magma once on earth surface after volcanic eruption are known as the igneous rocks.

(b) **Sedimentary rocks:** These rocks are formed by regular deposition of products of weathering on the pre- existing rock. Craravel, sandstone, limestone, lignite, gypsum etc. are examples of sedimentary rocks.

(c) **Metamorphic rocks:** Previously formed igneous and sedimentary rocks undergo changes due to metamorphic action of pressure and internal heat for e.g:- due to metamorphic action granite becomes gneiss.

(ii) Physical classification: According to this classification, the rocks are of following types:-

(a) **Stratified rocks:** These rocks have layered structure or posess planes of stratification or cleavage. They can be easily split along these planes. E.g. Sand stone, lime stones, slate etc.

(b) **Unstratified rocks:** These rocks possess crystalline and compact grains. They can not be split along these planes. E.g. Granite, trap, marble etc.

(c) **Foliated rocks:** These rocks have a tendency to split along a definite direction only. The direction need not be parallel to each other as in the case of stratified rocks. This type of structure is very common in case of metamorphic rock.

(iii) Chemical classification : On the basis of their chemical composition, engineers prefer to classify rocks as :

(a) **Silicious rocks :** The main content of these rocks is silica. These are hard and durable. Eg. granite, trap etc.

(b) **Argillaceous rocks:** The main constituent of these rocks is argil i.e, clay. These rocks are hard and durable but brittle. Eg:- Slates, laterites.

(c) **Calcareous rocks:** The main constituent of these rocks is calcium carbonate. limestone is a calcareous rock of sedimentary origin while marble is a calcareous rock of metamorphic origin.

(2) **PROPERTIES OF STONES :** The following properties of the stone should be looked into before selecting them for engineering works:-

(i) **Structure:** The structure of the stone may be stratified or unstratified. Structured stone can easily be dressed hence, suitable for super structure. The unstratified stones are hard and difficult to dress. They are preferred for the foundation work.

(ii) **Texture:** Fine grained stones with homogeneous distribution look attractive and hence they are used for carving. such stones are usually strong and durable.

(iii) **Density:** Denser stones are stronger. Light weight stones are weak. Hence, stones with specific gravity less than 24 are considered unsuitable for building.

(iv) **Appearance:** A stone with uniform and attractive colour is durable.

(v) **Strength :** Strength is an important property to be looked into before selecting stone as building block. Indian Standard code recommends, a minimum crushing strength of 3.5 N/mm^2 for any building block.

Table 1.1: Crushing strength of common building stones.

Name of stone	Crushing strength in N/mm^2
Trap	300 to 350
Basalt	153 to 189
Granite	104 to 140
Slate	70 to 210
Marble	72
Sand Stone	65
Lime Stone	55
Laterite	1.8 to 3.2

(vi) **Hardness :** It is an important property to be considered when stone is used for flooring and pavement. Coefficient of hardness is to be found by conducting test on standard specimen in Dory's testing machine.

(vii) **Percentage wear :** It is measured by attrition test. It is an important property to be considered in selecting aggregate for road works and railway ballast. A good stone should not wear more than 2%.

(viii) **Seasoning :** The stone obtained from quarry contains moisture in pores. The strength of stone improves if this moisture is removed before using the stone.The process of removing moisture from pores is called seasoning. The best way of seasoning is to allow it to the action of natural heat and wind effect for 6 to 12 month. This is very much required in the case of laterite stones.

(3) **REQUIREMENTS OF STONES:-**

(i) **Structure:** The structure of stone may be stratified (layred) or unstratified structure. The selected stone should be easily dressed and suitable for super structure.

(ii) **Durability :** Stone selected should be capable of resisting adverse effects of natural forces like wind, rain and heat. These factors can promote their fast weathering.

(iii) **Hardness :** The stones used in floors and pavements should be able to resist abrasive forces caused by movement of man and material over them.

(iv) **Specific gravity :** Heavier variety of stone should be used for the construction of dams, retaining walls, docks and harbours. The specific gravity of building stone is between 2.4 and 2.8.

(v) **Porosity :** Building stone should not be porous. If it is porous then rain water enters into the pores and reacts with stone and crumbles it.

(4) **Tests on stones :** To as certain the required properties of stone, the following tests can be conducted:-

(i) **Crushing strength test :** For conducting this test, specimen of size 40 × 40 × 40 mm are prepared from parent stone. Then the sides are finely dressed and placed in water for 3 days.The saturated specimen is provided with a layer of Plaster of Paris on its top and bottom surfaced to get even surface so that load appiled is distributed uniformly. The uniform load distribution can be obtained satisfactorily by providing a pair of 5mm thick plywood instead of using plaster of paris layer also. The specimen so placed in the compression testing machine is loaded at the rate of $14N/mm^2$ per minute. The crushing load is recorded. The crushing strength is equal to the crushing load divided by the area over which the load is applied. At least three specimen should be tested and the average should be taken as crushing strength.

(ii) **Water Absorption test :** For this test, cube specimen weighing about 50 grams are prepared and the test is carried out in the steps given below:-

(a) Note the weight of dry specimen as W_1.

(b) Place the specimen in water for 24 hours.

(c) Take out the specimen, wipe out the surfaces with a piece of cloth and weigh the specimen. Let its weight be W_2.

(d) Suspend the specimen free in water and weigh it. Let its weight be W_3.

(e) Place the specimen in boiling water for 5 hours. Then take it out, Wipe the surfaces with cloth and weigh it.
Let this weight be W_4. Then,
Percentage absorption by weight

$$= \frac{W_2 - W_1}{W_1} \times 100 \quad \ldots (1)$$

Percentage absorption by volume

$$= \frac{W_2 - W_1}{W_2 - W_3} \times 100 \quad \ldots (2)$$

Percentage porosity by volume

$$= \frac{W_4 - W_1}{W_2 - W_3} \times 100 \quad \ldots (3)$$

$$\text{Density} = \frac{W_1}{W_2 - W_1} \quad \ldots (4)$$

$$\text{Specific gravity} = \frac{W_1}{W_2 - W_3} \quad \ldots (5)$$

$$\therefore \text{ Saturation coefficent } = \frac{\text{Water absorption}}{\text{Total Porosity}}$$

$$= \frac{W_2 - W_1}{W_4 - W_3}$$

(5) **STONE QUARRYING :** The process of digging stones from natural rock beds is known as quarrying. The term quarry is used to indicate the exposed surface of natural rocks.
The following are the three methods of quarrying:-
(i) Digging or excavating with hand tools.
(ii) Quarrying with channelling machine.
(iii) Quarrying by blasting.
Excavating, heating, wedging are the three different ways of quarrying stone by use of hand tools.In case of quarrying with channelling machine, Vertical to oblique grooves are made around the rock mass to be excavated, before drilling horizontal holes beneath the block and finally wedges are driven into the holes, and the blocks of stone are separated loose from its bed.
In method of quarrying by blasting, the explosives are used. The main purpose of quarrying stones by blasting is to loosen large masses of rocks and not to violently blow up the whole mass so as to convert it into very small piece of no practical use. This method is used for quarrying hard stones, having no fissures.

(6) **USES OF STONE :**
Stones are used in following civil engineering construction:-

(i) Stone masonry is used for the construction of foundation walls, columns and arches.
(ii) Stones are used for flooring.
(iii) Stone slabs are used as damp proof courses, lintels and even as roofing materials.
(iv) Stones with good appereance are used for the face works of buildings. Polished marble and granite are commonly used for face work.
(v) Stones are used for paving of roads, footpaths and open spaces round the buildings.
(vi) Crushed stones with gravel are used to provide base course for roads. When mixed with tar, they form finishing coat.

(7) **COMMON BUILDING STONES :**

(i) **Basalt and trap :** The structure is medium to fine grained and compact. Their colour varies from dark gray to black. Fractures and joints are common. Their weight varies from 18KN/m^3 to 29KN/m^3. The compressive strength varies from 200 to 350 N/mm^2.

(ii) **Granite :** Granite are also igneous rocks. The colour varies from light gray to pink. The structure is crystalline, fine to coarse grained. They take polish well. and are hard durable. Specific gravity is from 2.6 to 2.7 and compressive strength is 100 to 250 N/mm^2.

(iii) **Sand Stone :** These are sedimentary rocks, and hence stratified. They consist of quartz and feldspar. They are found in various colour like white, grey, red, buff, brown, yellow and even dark grey.

(iv) **Slate :** These are metamorphic rocks. Composed of quartz,mica and clay mineral. The specific gravity is 2.6 to 2.7. Compressive strength varies from 100 to 200 N/mm^2.

(v) **Laterite :** It is metamorphic rock, having porous and spongy structure. Its specific gravity is 1.85 and compressive strength varies from 1.9 to 2.3 N/mm^2. It can be easily quarried in blocks.

(vi) **Marbles :** This is a metamorphic rock, that can take good polish. It is available in different pleasing colours-like white and pink. Its Specific gravity is 2.65 and compressive strength is 70-75 N/ mm^2 .

(vii) **Gneiss :** It is a metamorphic rock. It has fine to coarse grains. Alternative dark and white bands are common. They are used in minor construction. The specific gravity varies from 2.5 to 3.0 and crushing strength varies from 50 to 200 N /mm^2 .

BRICKS

At places where stones are not easily available but suitable clay for the manufacture of bricks is available, in plenty. The bricks are the only alternative material of construction. The term brick refers to small units of building material, often made from fired clay and secured with mortar, a bonding agent comprising of cement, sand and water. A brick retains heat, with-stands corrosion and resists fire.

(1) **COMPARISON OF BRICK AND STONE WORK :**

(i) At places where stone is not available, locally, brick work proves economical than stone work.
(ii) For brick work less skilled labour is required.
(iii) Bricks are more fire resistant than stones.
(iv) The brick work is less water proof than stone work.
(v) The brick work is weaker than the stone work.
(vi) The stone work proves cheaper at places where stones are easily available.

(2) **COMPOSITION OF GOOD BRICK EARTH**:-

Composition of Brick Earth

1. Alumina : 20-30%
2. Silica : 50-60%
3. Lime : 4-5%
4. Oxides of Iron : 5-6%
5. Magnesia : 1%

(1). Alumina (20-30%) : It imparts plasticity to the earth brick, so that it can be easily be molded in any desired shape.
If it is in excess, it causes shrinkage and warping during the drying of the bricks and makes the bricks too hard during burning process.
(Imparts brittleness to the brick)

Warping

(2). Silica (50-60%) : It prevents the cracking, shrinkage and warping of the bricks, thereby imparts uniform shape to it. If it is in excess, it destroys the cohesion in between the particles, hence, bricks become too brittle.

(3) Lime (4-5%) : It prevents the shrinkage of the bricks, if it is in excess, it causes the bricks to melt during the burning, thereby it results in loss in the shape of the bricks.
Note : During the burning of the bricks, calcium carbonate is converted into quicklime, that undergoes slacking process which in turn results in the cracking and disintegration of the bricks, due to increase in volume.

(4). Oxides of Iron (5-6%) : It helps Silica and lime to fuse with each other, hence leads to the development of strength in the brick.
It also imparts reddish brown in bricks.

(5). Magnesia (1%) : It also prevents the shrinkage in bricks.
It imparts yellow tint in the bricks.

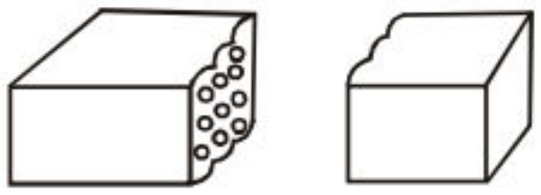
Harmful Ingredient Present in the Brick :

1. Lime → Slacking → in volume → cracking disintegration.
2. **Iron Pyrites :** Presence of Iron pyrite, leads to crystallisation and disintegration of bricks during the burning due to the oxidation of these pyrites.
3. **Alkalies :** It acts as a flux during the burning of bricks but if it is in excess, it causes the bricks to fuse with each other, thereby results in its twisting and warping.

Rotation of bricks along longitudinal axis in two different direction → twisting.

It also leads to efflorescence and staining in the bricks.

4. Stones/Pebbles :



Creating of voids (Brick is a compression member of non–homogeneous structure)
Presence of stones and pebbles in brick earth lead to the formation of weak and porous brick.
It's load carrying capacity is comparatively less.

5. Organic/Vegetative Matter :
Its presence helps in the burning of bricks but if these are left unburnt, it results in the formation of gases during their decomposition which when escapes through the body of the bricks, leads to the development of numerous voids. These voids results in decrease of load carrying capacity of the bricks.

(3) **HARMFUL INGREDIENTS IN BRICK EARTH:-**
Following are undesirable ingredients in brick earth:

(i) **Excess lime :** Bad effect of excess lime has already been stated.

(ii) **Iron Pyrites :** If iron pyrites are present in brick earth then the bricks get crystallized and disintegrated during burning because of the oxidation of the iron pyrites.

(iii) **Alkalies :** They are mainly in the form of soda and potash. The alkalies act as a flux in the kiln during burning and they cause bricks to fuse, twist and warp and loose shape.

(4) **MANUFACTURE OF BRICKS:-**
It is carried out in four distinct operations :

(1) Preparation of Clay :
Clay for the bricks is prepared in the following sequence:

(a) **Unsoiling :** It is the process in which top 200 mm of soil is thrown and is not used for manufacturing of bricks as it consists of majority of impurities in it.

(b) **Digging :** It is the process in which soil is dug out and spread over the level field to prepare it for next operation of cleaning.

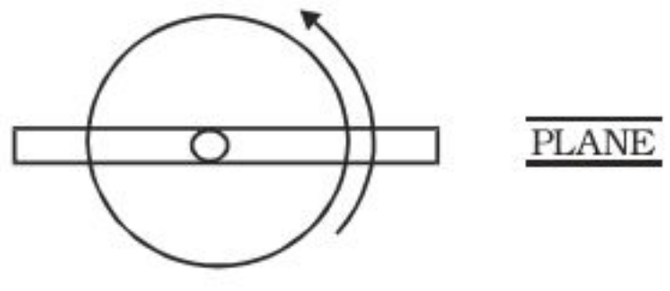
(c) **Cleaning :** It is the process in which impurities like stones pebbles, organic matter, vegetative matter is removed from clay.

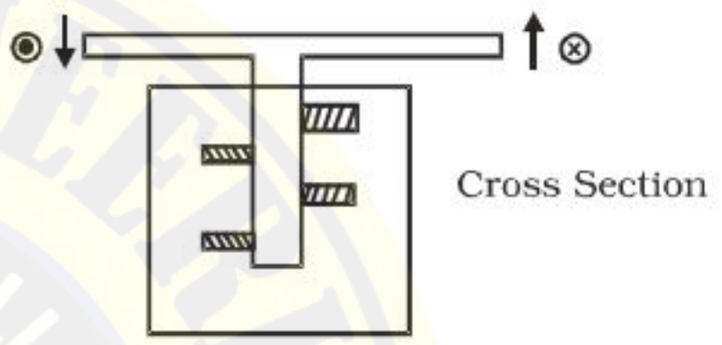
(d) **Weathering :** After cleaning the clay, it is exposed to the atmosphere for few weeks to few month for its softening/ripening/mellowing or weathering.

(e) **Blending :** It is the process in which different ingredients of the brick earth are spread over the weathered clay in definite proportion.

(f) **Tempering :** It is the process in which required degree of hardness is induced in the brick earth to make it suitable for the next operation of molding.

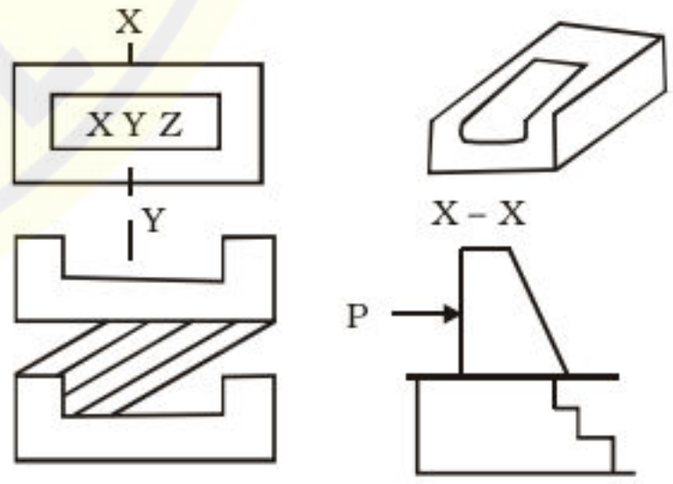
It is done in Pug mill.
Plasticity ↑ → Hardness ↓
Plasticity ↓ → Hardness ↑





(2) Moulding : The process of giving desired shape and size to the bricks is termed as moulding. During moulding a mark of depth (10-20 mm) is placed over the surface of the brick, that is termed as frog mark. It serves two purposes,

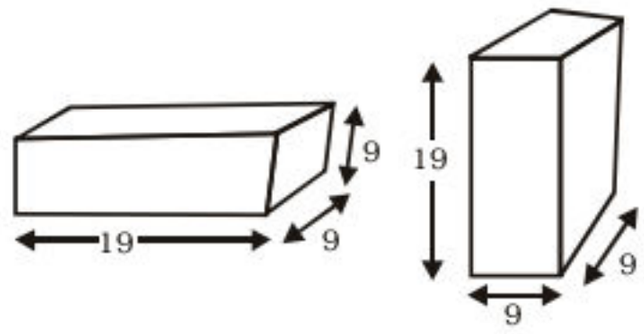
- Used to indicate the trade name of the manufacturer.
- It acts as a key for the mortar where another layer of brick is placed over it.



Quality of table moulded bricks is comparatively better than ground moulded bricks and its rate of moulding is also comparatively higher than ground moulded bricks.

(3) Drying : Moulded bricks if are directly burnt without drying are liable to get cracked due to excessive shrinkage, Hence, its drying is carried out before the burning operation in which the moisture content of the brick is reduced upto 2%.
Drying of the bricks is carried out either naturally or artificially.

During drying, bricks are always placed along their edges and never along its face, in order to speed upto process of drying.



19 × 9 at the 3 faces 19 × 9 at the 4 faces
9 × 9 at the 2 faces 9 × 9 at the 1 face
90 times more surface area expressed for drying.

(4) Burning : (The most important entire strength is developed here) because it imparts strength and hardness to the bricks. It makes them dense and durable.

It should be done properly. As if bricks are over burned, they become brittle. Hence, they can be easily broken and if bricks are under burned, they remain soft and are not able to carry the design load.

Burning of the bricks is carried out at 1100°C at which silica and lime fuse with each other thereby imparting strength to the bricks.

Burning of the bricks is carried out either in clamps or hills.

◆ **Quality of Good Bricks/Testing of Bricks :**

(1) The brick should be table moulded, well burnt and free from the cracks.

(2) The bricks should be of uniform shape and size.
Size of Standard Brick = 19 cm × 9 cm × 9 cm
Size of Conventional Brick
= 23 cm × 11.4 cm × 7.6 cm
Weight of $1m^3$ of bricks is approximately-1800 kg
Hence,the weight of single brick is approximately = (3.5–3.6 kg)
Volume = 20 × 10 × 10 = 2000 cm^3

$$= \frac{1.6}{2000} \quad \frac{1600}{2} = 800 \text{ bricks}$$

(3) The bricks should produce clear metallic ringing sound when struck with each other (Soundness test).

(4) The brick should possess uniform homogeneous structure along any section free from voids (break from any section and see.).

(5) Bricks when immersed in water for 24 hours should not absorb water by more than 20% in case of 1^{st} class bricks and not more than 22% in 2^{nd} class bricks. (Absorption test)

(6) The bricks should posses minimum compressive strength of 5.5 N/mm^2 (Crushing strength test).

(7) It should not break into pieces, when dropped over the level ground from the height of 1m (Toughness test).

(8) It should posses sufficient hardness and does not show any impression when scratched with finger nail over the surface (Hardness test).

(9) When immersed in water for 24 hours, it should not show any sign of staining or efflorescence (Alkali test).

(6) **IS CLASSIFICATION OF BRICKS :**

Is classification of brick has been given in table. It is based on Is : 1077-1957.

Table :- Classicfication based on IS : 1077-1957

Classification bricks	Compression St rength in N/mm^2	Water absorption in % in 24h	Efflore-scence
H_1	4.4	5	No
H_{11}	4.4	5	No
F_1	17.5	13	too small
F_{11}	17.5	12	little
I	7.0	70	to little
II	7.0	20	little
L_1	3.5	25	too little
L_2	3.5	25	little

H_1 and H_{11} bricks are first class bricks, F_1 and F_{11} are second class and L_1 and L_2 are equivalent to third class bricks.

(7) **TESTS FOR THE BRICKS :**

(i) **Absorption :** Brick is weighed dry and then kept immersed in water for a period of 16 hours. The brick is reweighed.The brick should not absorb water more than 20% of its dry weight.

(ii) **Crushing strength :** The crushing strength of brick is found out by pressing brick in a compression testing machine. As per BIS 1077-1957 the minimum crushing strength of bricks is 3.5N/mm^2. The brick with crushing strength of 7 to 14N/mm^2 are graded as 'A' and these having above 14 $N/mm^2$are graded as AA.

(iii) **Hardness :** If no impression could be made on the surface of the brick by finger nail, then the brick is treated to be sufficiently hard.

(iv) **Presence of soluble salts :** The soluble salts if present in bricks cause efflorescence on the surface of bricks. Immerse brick in water for 24 hours and allow it to dry in shade The absence of grey or white deposits on its surface indicates absence of soluble salts.

(v) **Soundness :** Two brick when struck with each other should emit metallic ringing sound.

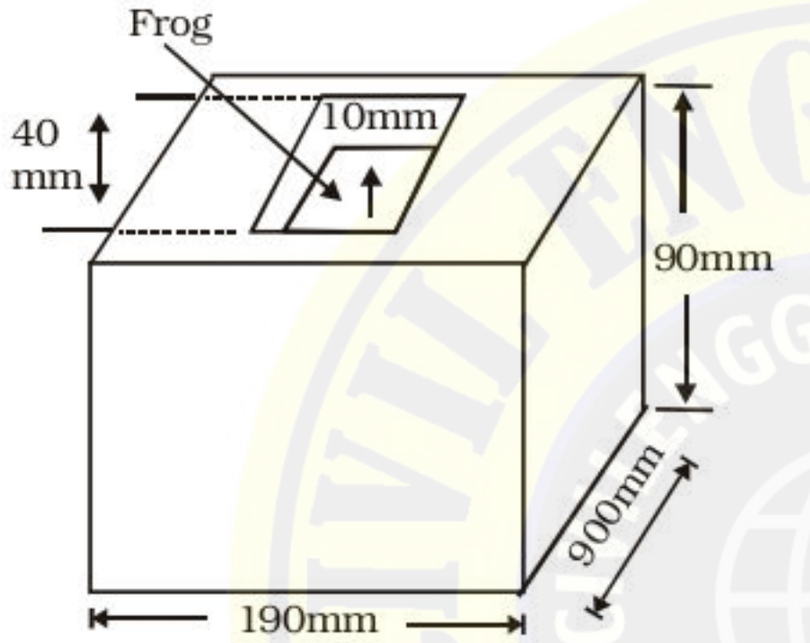
(vi) **Structure :** The fractured surface of the brick is examined. It should be homogeneous, compact and free from any defect .

(vii) **Shape and Size :** For this test 20 bricks of standard size (190 × 90 × 90 mm) are sorted at random and they are stacked lengthwise along the width and along the height. The resulting stack of 20 bricks should be within following limits.

Length	3680 mm	to	3920 mm
Width	1740 mm	to	1860 mm
Height	1740 mm	to	1860 mm.

The brick should be truly rectangular with sharp edges and smooth surfaces.

(8) **SIZE AND WEIGHT OF BRICKS :**BIS has recommended the standard size of the bricks as 190mm × 90mm × 90mm with mortar thickness the size of such brick becomes 200mm × 100mm × 100mm which is also known as the nominal size of the modular brick. The bricks of large size are difficult to burn properly and they become too heavy to be placed with a single hand. On the other hand if bricks are small, more quantity of mortar is required.



Nominal size of modular Brick.

(9) BRICK MASONRY:-

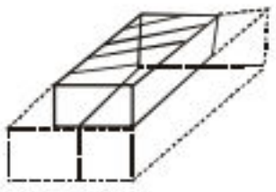
Brick Masonry :

1. **Stretcher :** The long face of the brick is termed as stretcher.
2. **Header** is the short face of the brick.
3. **Closer** is the portion of the brick cut along its length.

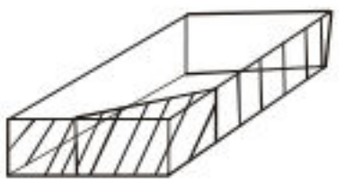
Types of Closer ;

(a) Queen closer Half :

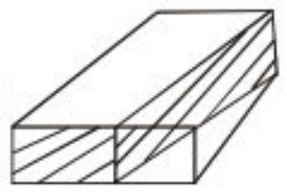
(b) Queen Closer Quarterly :



(c) King closer :

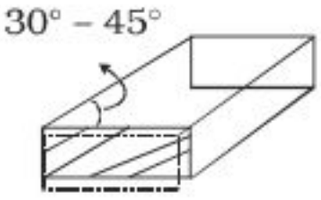


(d) Bevelled closer :



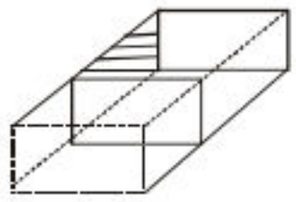
$\theta = 30° - 45°$

(e) Mittered closer :

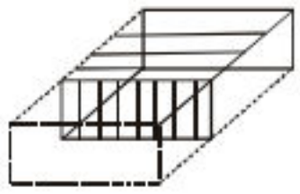


4. **BAT** is the portion of brick cut along its width.

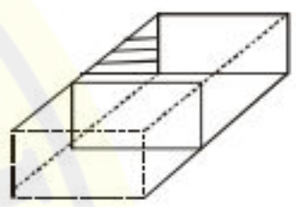
(a) Half Bat :



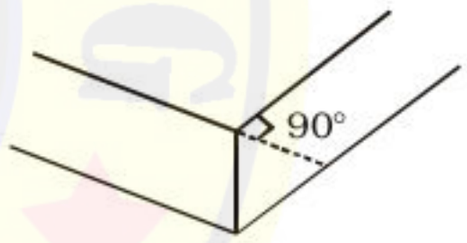
(b) Three Quarter Bat :



(c) Bevelled Bat :



5. **QUOIN** is the exterior angle along the face of the wall.



It can be more than 90° also (≥ 90°).

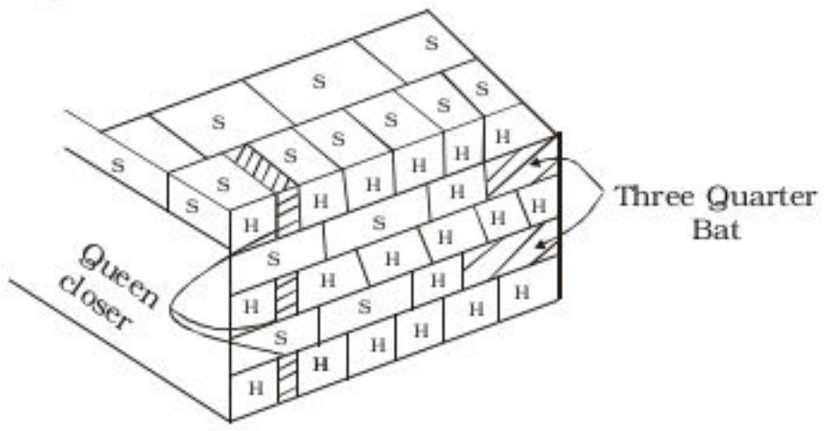
(10) TYPES OF BONDING IN BRICK MASONRY:-

1. English Bonding is the arrangement of Bonding that consists of alternate layer of header and stretcher laid over each other.

   In order to break the alignment of vertical joints to be in straight line in alternate coarses, queen closer is placed next to Quoin header, in each alternate course.

   Brick wall having thickness in the multiples of odd number of half bricks like 1.5 brick wall, 2.5 brick wall have header on one face and stretcher on other face in each course.

   Minimum lap available to stretcher is 1/4 the length of brick in each course.



Queen closer should never be placed either at the starting or end of any course, as it is liable to get displace.

(11) **THE CLAY PRODUCTS :** The clay occurs plenty in nature and production of clay in nature is mainly due to orthoclass felspar. The clay when made wet possesses a high degree of tenacity and plasticity. Such plastic clay can be moulded in desired shapes. The clay products which are employed in building industry are tiles, terracotta, earthen wares, stone wares, and bricks.

(i) **Tiles :** The tiles are the thin slab thinner than bricks. Tiles can be classified into two groups:-

(a) **Common Tiles :** These tiles have different shape and sizes. These are mainly used for paving, flooring and roofing.

(b) **Encaustic tiles:** These tiles are used for decorative purpose in floors, walls,ceiling and roofs.

(ii) **Terra-Cotta:** Terra means earth and cotta means baked. Hence, terra cota means baked earth. Thus it is a type of earthen ware or porous pottery made from local clays and glazed with glazes containing galena. The dried articles are filled in muffle furnance and temprature is raised to 1200°C. This temperature is maintained for about four days and the burnt product are then allowed to cool for 5 days.

Terra-cotta articles may be porous and polished. To prepare porous terra cotta, the saw dust or ground cork is added in clay before the stage of moulding, when articles are burnt in a kiln, the organic particles are burnt and they leave pores in the article. The porous terracotta is a fire proof and sound proof material.

(iii) **Earthenware:** The earthenware indicates wares prepared from clay when burnt at low temperature.

(iv) **Stoneware:** These are wares prepared from refractory clays which are mixed with stone and crushed pottery. The mixture is than burnt at high temperature and cooled down slowly. The stone ware is more compact and dense than earthenware.

(v) **Glazing:** The surface of clay products are sometimes glazed. A glaze is a glassy coat of thickness about 0.1 to 0.2 mm applied on the surface of an item and then fused into place by burning at high temperature.

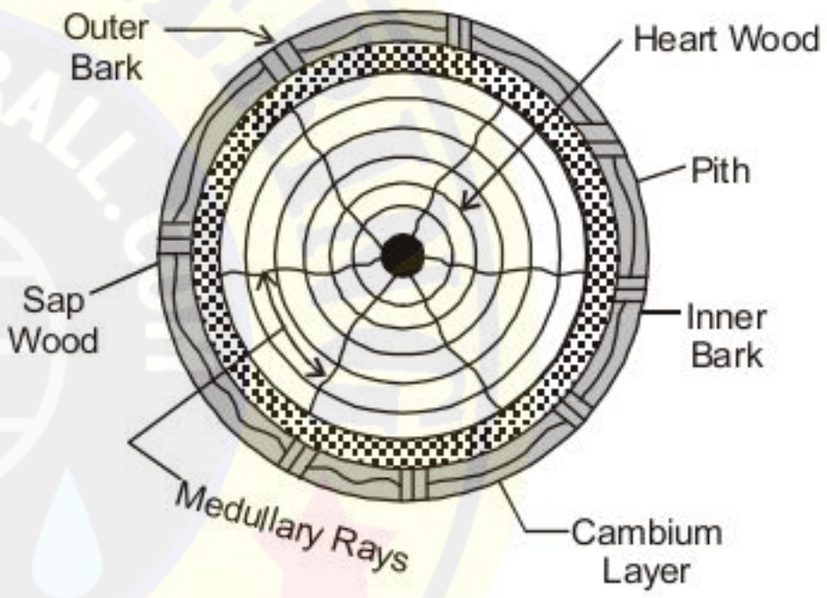
(vi) **Opaque glazing :** Superior clay is turned into plastic cream like substance by adding water. This plastic substance is known as slip.The articles to be glazed are dipped in the slip before burning and subsequently heated.

(vii) **Refractories :** The term refractories is used to indicate substances that are able to resist high temperatures but still maintain their shapes,strength and durability.

(viii) **Porcelain :** The term is used to indicate fine earthenware which is white and semi- transparent. Being white in colour, it is also reffered as the white ware. It is hard, brittle and non-porous. It is prepared from clay, felspar, quartz and minerals. The porcelains are of two types namely low voltage porcelains and high voltage porcelains. carbon and graphite, cordierite porcelain, steatic porcelain, zircon porcelain are the examples of high voltage porcelains.

TIMBER : Timber is the term which denotes wood, suitable for building or carpentry or other engineering purposes. It is applied to the trees measuring not less than 0.6m in girth or circumference of the trunk of the tree.

Part of the timber :



Cross-section of a timber

Heart Wood : The inner annual rings surrounding the pith is known as heart wood. It is usually dark in colour.

It does not take active part in the growth of tree. But it imparts rigidity to tree and hence, it provides strong and durable timber for various engineering purposes.

Pith : The innermost central portion or core of the tree is called the pith or medulla.

Sap Wood : The outer annual rings between heart wood and cambium layer is known as sap wood. It is usually light in colour and weight. It indicates recent growth and it contains sap.

It takes active part in the growth of tree and sap moves in an upward direction through it. Sap wood is also known as alburnum.

Combium Layer : The thin layer of sap between sap wood and inner bark is known as cambium layer. It indicates sap which has yet not been converted into sap wood.

Inner Bark : It gives protection of cambium layer from any Injury.

Outer Bark : It consist of cells of wood fibre and is also known as cortex.

Medullary Rays : The thin radial fibres extending from pith to cambium layer are known as medullary rays. The function of these rays is to hold together the annual rings of heart wood and sap wood.

(1) Defects in Timber :

(A) Defect due to Conversion :

(i) Chip Mark : Marks or Signs placed by chips on the finished surface of timber.

(ii) Diagonal grain : This defect is formed due to improper sawing of timber.

(B) Defects Due to Fungi :

(i) Blue Stain : Sap of wood is stained to bluish colour by the action of certain type of fungi.

(ii) Brown Rot : The term rot is used to indicate decay or disease of timber. Certain types of fungi remove cellulose compounds from wood and hence, wood assumes the brown colour due to removal of cellulose.

(iii) Dry Rot : Dry rot occurs at places where there is no free circulation of air such as improperly ventilated basements, rooms etc.

Unseasoned soft woods and sap wood are easily attacked by dry rot.

Dry rot is also caused by charring, painting and tarring the unseasoned timber.

(iv) Heart Rot : This is formed when a branch has come out of a tree.

The tree becomes weak and it gives out hollow sound when struck with a hammer.

(v) Sap Stain : Certain types of fungi do not bring about the complete decay of timber. But they feed on cell contents of sap wood. In doing so, sap wood loses it colour.

It generally occurs when moisture content goes beyond 25% or so.

(vi) Wet Rot : Fungi cause chemical decomposition of wood of the timber and in doing so, they convert timber into a greyish brown powder.

The important facts to be remembered in connection with wet rot are :

Alternate dry and wet conditions favour the development of wet rot.

If unseasoned or improperly seasoned timbers are exposed to rain and wind. They become easily liable for the attack of wet rot.

(vii) White Rot : In this case, certain types of fungi attack lignin of wood and wood assumes the appearance of a white mass consisting of cellulose compounds.

(C) Defect causing Insects :

(i) Beetles : They form Pin-holes of size about 2 mm diameter in wood. They attack the sap wood of all species of hard wood.

The timber is converted into fine flour like powder.

(ii) Marine Borers : They are generally found in salty water. They make holes or bore tunnels in wood for shelter.

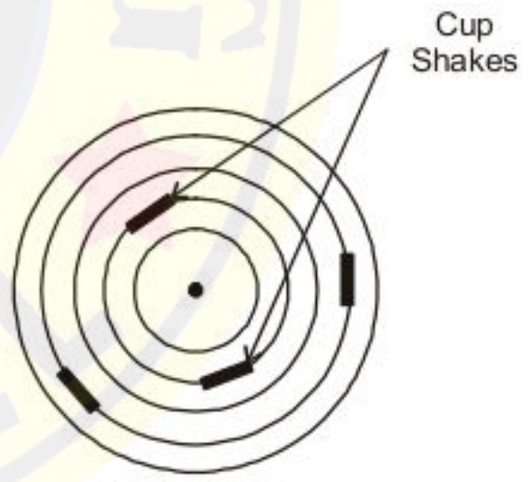
(iii) Termites : These are popularly known as white ants and are found in abundance in tropical and sub-tropical countries. They make tunnels inside the timber in different directions. However, they usually do not disturb the outer shell or cover of very few good timbers such as teak, sal etc. which can resist the attack of white ants.

(D) Defects due to Natural Forces :

Burls : These are particularly formed when a tree has received shock or injury in its young age.

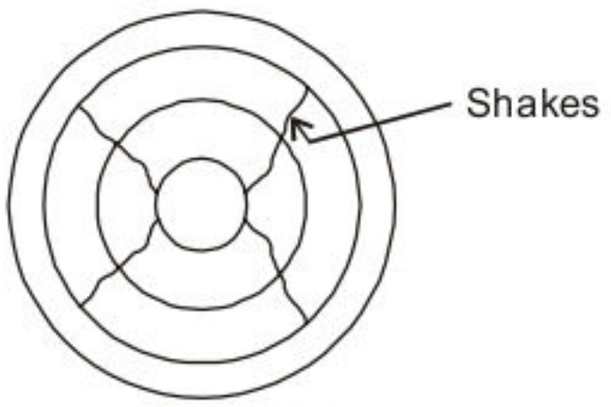
Shakes : These are cracks which partly or completely separate the fibres of wood. Following are the different varieties of shakes.

(a) Cup Shakes : They are caused by the rupture of tissue in a circular direction. It is a curved crack that separates partly one annual ring from the other. It develops due to non-uniform growth.



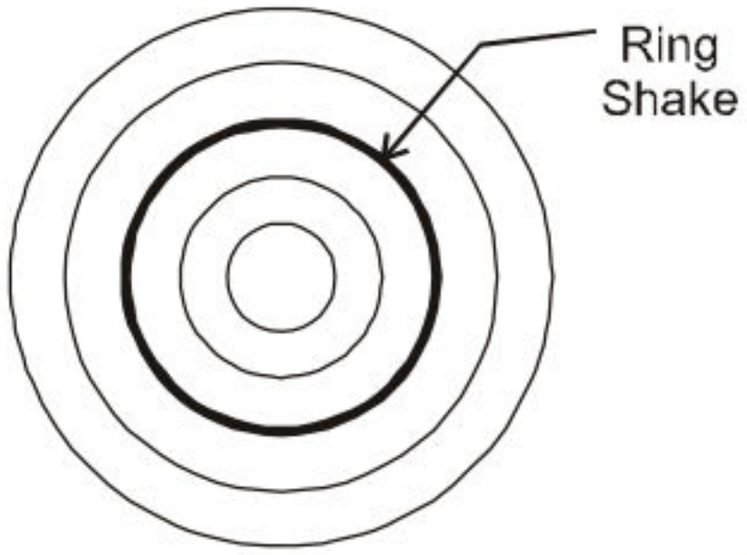
Cup Shakes

(b) Heart Shakes : These cracks occur in the centre of cross-section of tree extending from pith to sap wood in the direction of medullary rays. These cracks occur due to shrinkage of interior part of tree which is approaching maturity. Heart Shakes divides the free cross-section into two to four parts.



Heart Shakes

(c) Ring Shakes : When Cup Shakes cover the entire ring, they are known as ring shakes.



Ring Shake

(d) Star Shakes : These are cracks which extend from bark towards the sap wood. They are usually confined upto the plane of sap wood. They are usually formed due to extreme heat or frost.

(2) **MARKET FORMS OF TIMBER**

(i) **Battern :** It is roughly squared timber and is obtained by removing bark and sap wood, One of the cross-sectional dimension exceeds 50mm while the other exceeds 200mm.

(ii) **Board :** It is a plank having paralled sides. Its thickness is less then 50mm and width exceeds 150mm.

(iii) **Planks :** It is just like board. Its thickness is less then 50mm and width exceeds 50mm.

(iv) **Pole :** It is known as spar. It is a square long log whose diameter does not exceeds 200mm.

(v) **Log :** It is the trunk of tree obtained after removal of branches.

(vi) **Scantling :** This is a timber piece whose breadth and thickness exceeds 50 mm but are less than 200mm in length.

(vii) **Quartering :** It is square piece of timber,the length of side being 50mm to 150mm.

(3) **QUALITIES OF GOOD TIMBER :**

(i) **Appearance :** Freshly cut surface of timber should exhibit hard and shining appearance.

(ii) **Colour :** Light colour indicates timber of low strength. Hence, colour of the timber should be dark.

(iii) **Defects :** Timber should be free from defects like knots, flaws, shakes etc.

(iv) **Fibres :** The timber should have straight fibres.

(v) Timber should be hard, easily workable and fire resistant.

GLASS :

Glass in an amorphous (non-crystalline) solid which is often transparent and has widespread practical, the chrnological and decorative purpose usages in things like Window panes, tableware and optodectronics.

The most familiar and historically the oldest, type of glass are based on the chemical compound Silica (sillicon dioxide) the primary constituent of sand.

Brief History :

(i) As a result of oil crisis in the late 1970s the glass architecture at that time was subject to increase criticism uncoated flot glass was considered a waste of energy.

(ii) Interpance was one of the first company to succefully market neutral heat protection coating, one example is "iplus neutral". It is considered to be the first colour-neutral thermal insulating glass in glass history.

(iii) The key to sucess was a special silver coating. This technology is now the basis for the manufacturing of high quality thermal insulating glass.

Main type of glass :

(i) Annealed glass.
(ii) Toughened glass.
(iii) Laminated glass.
(iv) Coaked glass.
(v) Mirrored glass.
(vi) Patterened glass.

Annealed glass : It is the basic flot glass product. This is first result in the float process. It is common glass that tends to break into lare, jagged shards. It is used in some end products and often in double gazzed windows. It is also the starting material used to produce more advanced product through further processing such as laminating, toughening, coating etc.

Toughened glass : Toughened glass is made from annealed glass treated with a thermal tempering process.

(i) Toughened glass is treated for more resistant to breakage than simple annealed glass due to counteracting stresses and to break in a more predictable way when it does break, thus providing a major safety advantage in almost all of its applications.

(ii) Car windshields and Windows, glass portions of building facades, glass sliding doors and portions in houses and offices, glass furniture such as table tops and many other products typically use toughened glass.

LAMINATED GLASS :

(i) This glass is made up of two or more layers of glass with one or more interlayers of polymeric maperiol bounded between the glass layer.

(ii) Rather than shattering on impact, laminated glass are held together by the interlayers giving more saftey as well as to some degree, reducing the security risks associated with cary penetation.

COATED GLASS :

(i) Surface coating can be applied to glass to modify its appearance and give it many of the advanced characterisitcs and function available in to adays flat glass products.

(ii) Coating is usually applied by controlled exposure of the glass surface to vapours, which lind the glass forming a pernmanent coating.

MIRRORED GLASS :

(i) To produce mirrored glass, a metal coating is applied on the glass. The coating is generally made of Silane, aluminium, gold or chrome.

PATTERNED GLASS :

(i) Patterned glass is a flat glass whose surface displays a regular pattern.

(ii) The most common method for producing patterned glass is to pass heated glass (usually just after it exit the furance where it is made) between rollers whose surface contain the negative relief of the desired pattern(s).

Different uses of glass :

(i) Supply of natural day light (ii) protection from rain, window and cold (iii) Transparency or translucency (iv) means of communication (v) Heat protection (vi) Sound protection (vii) Object and personal protection (viii) Fire protections (ix) use of solar energy (x) Means of design (xi) Electromagnetic dampening.

Structural Glass System :

Structural glass facades are most easily categorized by the structure types that support them :

(i) Strongback System :

(a) The structural systems are the simplest form of structural support for a glass wall, but are only useful in relatively short spans of two to six meters usually.

(b) These systems can include both vertical and horizontal structural components.

(c) Sometimesverticalsareusedwithnohorizontals.

(d) They can be comprised of simple steel or aluminium open or closed sections with provisions for the attachment of the glazing system usually of spider type.

(ii) **Truss System :**

(a) Truss system empolyes a planar truss design, often in a hierarchial system that may be combine with other element types including tension components.

(b) Truss design vary widely with an emphasis on fine detailing and craftmanship.

(c) Rod or cable elements may be incorporated into the truss design and lateral tensile system are often used to stabilize the facade structure.

Glass for Green Building :

(i) Reflective glass come with reflective coating that filters heat and let optimum light into the buildings.

(ii) Reduce the heat gain inside the building and thus reduces electricity and cooling costs.

(iii) slow optimum light (natural day lighting) inside thebuildingand thusreducethecostforartificial lighting.

Polymers : Chain of H-C molecules. Each repeat unit of H-C is a monomor. eg. ethyence (C_2H_4), polyethyrene ($-Ch_z - Ch_z$).

Polymers : Thermosets soften when heated and harden on coeling. It is totally reversible. Thermoplast is a material which do not soften on heating.

Plastics : It can be moldable into many shape and have sufficient structural rigidity. Are one of the most commonly used class of materials.

Plastics are used in clothing, housing, automobiles aircraft, Packaging, electronics, signs recreation items and medical implants.

Natural plastics : Hellac, rubber, as phalt and cellulase.

CHARACTERISTICS AND APPLICATIONS OF SOME COMMON THERMOPLASTICS

Material	Characteristics	Applications
Polyethylene polymaide (Nylon)	Chemically resistant, tough, low friction coeff., low strength. Good strength and toughness abrassion resistant, liquied absorber, low friction coeff.	Flexible bottles, toys, battery parts, ice trays, film wrapping. Bearing gears-cams, bushing and jacketing for wires and cables.
Fluorocarbon (Teflon)	Chemically inert, excellent electrical properties, relatively weak.	Anticorrosive seals, chemical pipes and valves, bearing, antiadhesive coating.

Vinyl	Low cost general purpose material, rigid, can be made flexible.	Floor coverings, pipe, electrial wire insulation, garden wose phonograph records.
Polystyrene	Excellent electrical Prop and optical clarity, good thermal and dimensional stability.	Wall tile, battery cores, toys, lighting pannals, housing appliances.

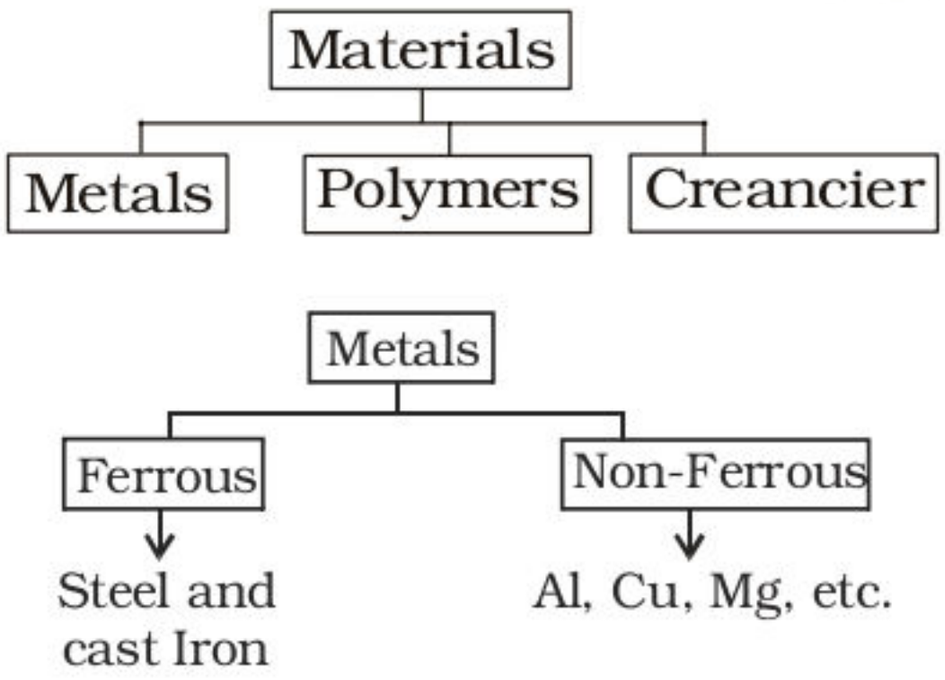
CHARACTERISTICS AND APPLICATIONS OF SOME COMMON : THERMOSETTING POLYMERS

Material	**Characteristics**	**Applications**
Epoxy (Araldite)	Excellent mechanical properties and corrosion resistance, good electrical properties ; Good adhesion and demensional stability.	Electrical molding, sints, adhesives, protective coatings, fiber reinforced plastic (FRP), laminates
Phenalic (Bakelite)	Excellent thermal stability (>150° C) inexpensive, can be compounded with resins.	Motor housings, telephones, auto distributions, electrical fixtures.
Polyster (Aropol)	Excellent electrical properties, low cost, can be formulated for room or high temperature often fiber reinforced.	Helmets, fiberglass boats, auto body components, chair fans.

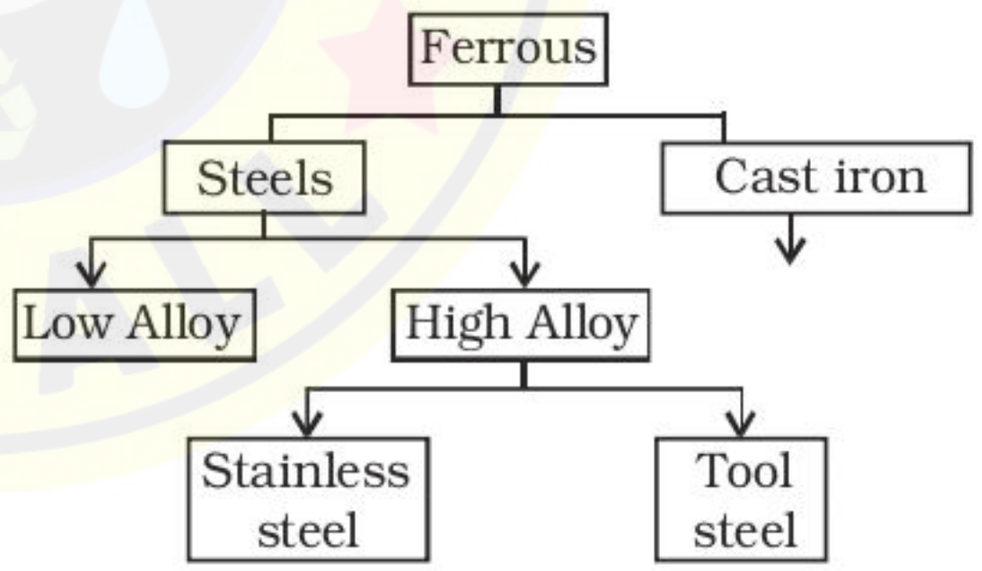
Elastomers : A polymer with rubber like elasticity is known as elastomers. Each of the monomers that link to form the polymer is usually made of carbon, hydrogen, oxygen or silicon. Cross linking of monomers provide flexibility.

Glass transition temperature Tg, is the temperature at which transmission from rubbery to rigid state takes place in polymers.

Elastomers are amorphous polymers existing above their tg. Hence, considerable segmental motion exists in them. Their primary uses are in seals, adhesives and molded flexible parts.



Ferrous Materials :



Steels : It is alloys of iron-carbon. May contain other alloying elements.

Several grades are available

(i) Low alloy (< 10 wt%)

- Low carbon (< 0.25 to 0.60 wt%)
- Medium carbon (0.25 to 0.60 wt%)
- High carbon (0.6 to 1.4 wt%)

(ii) **High alloy :**

- Stainless steel (> 11 wt% cr)
- Tool steel

- **Low carbon steel :**

(i) **Plain carbon steel :** very low content of alloying elements and small amounts of Mn.

(ii) Most abundant grade of steel is low carbon steel-greatest quantity produced; least expansive.

(iii) Not responsive to heat treatment; cold working needed to improve the strengh.

(iv) Good Weldability and machinability.

(v) High strength low Alloy (HSLA) steels : Alloying elements (like Cu, V, Ni and Mo) up to 10 wt%, have higher strength and may be heat treated.

- **Medium Carbon steel :**

(i) Carbon content in the range of 0.3 – 0.6%

(ii) Can be treated-austenitizing, quenching and then tampering.

(iii) Most often used in tampered condition – tempered mastensite.

(iv) Medium carbon steel have low hardenability.

(v) Addition of Cr, Ni, Mo improves the heat treating capacity.

(vi) Typical applications : Railway wheels and tracks, gears, crankshafts.

- **High Carbon steel :**

(i) Carbon content 0.6 – 1.4%

(ii) High 'C' content high hardness and strength.

(iii) Used in hardened and tempered condition.

(iv) Strong carbide formers like Cr, V, W are added as alloying elements to form corbide of there metals.

- **Stainless steel :** A group of steel that contain at least 11% cr. Exhibits extraordinary corrosion resistance due to formation of a very thin layer of Cr_2O_3 on the surface.

- **Aluminium steel :** Most of the steel produced today are made by either BOS (Basic oxygen steelmaking) or in an Arc Furance but in both the processes the impurities (C, Mn, P, Ti etc.) are oxidised by the method of oxygen blowing.

That oxygen dissolves in the liquid steel. In order to remove this dissolved oxygen, deoxidizers like Al, Si, CaC_2 are used in order to remove the dissolved oxygen. This is called killing of steel. If steel is not killed, there oxygen bubbles segregate together during the casting producing blow holes. This is know as Aluminium steel. So the main purpose of Aluminium in steel are :

(i) Aluminium is used as a deoxider.

(ii) Aluminium is used to produce a fine austenitic grain size.

(iii) Aluminium is also used as an alloying addition.

IRON : The iron is the most popular metal for engineering purposes. It has been used in the Construction activity since pre-historic times. It is available in abundance and is estimated that it constitutes about 4.5% of the crust of the earth.

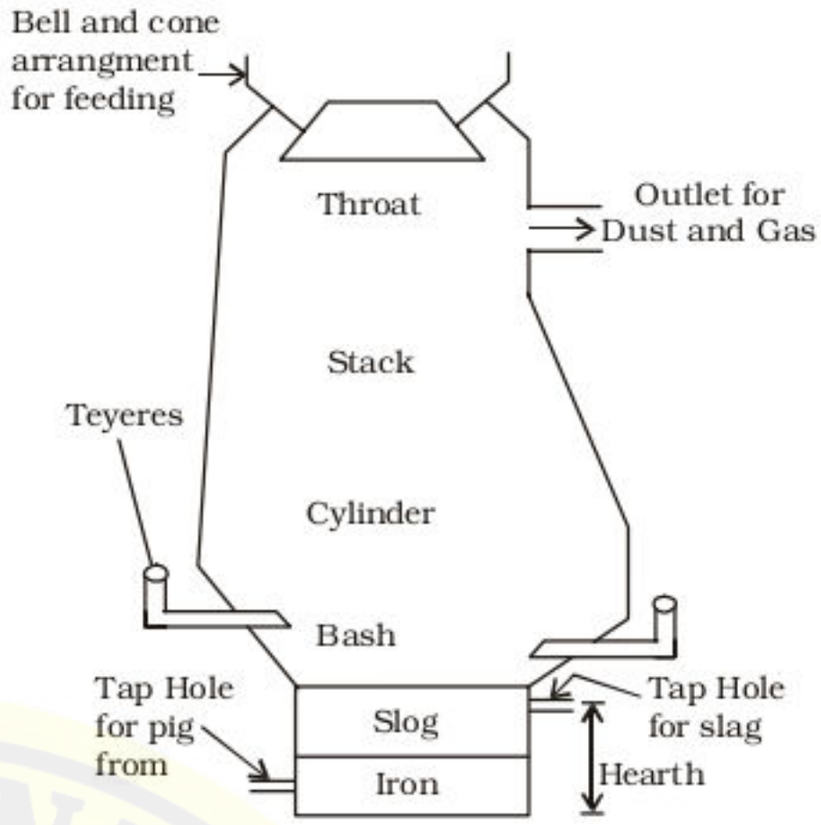


Figure : Blast Furnace

BITUMEN : Bitumen is a primary engineering material,due to its low cost as compared to other binding materials. It is used in relatively thick films to provide protective film against corrosive influences and weather. Bitumen is a dense viscous material, dark, black or brown in colour, used as a binding and waterproofing material.

(1) **USES OF BITUMEN**

(i) For paving road.

(ii) For manufacturing of roofing belt and also points.

(iii) For moisture proof and laminated packing material.

(iv) For coating on roofs, walls and floors.

(2) **MEMBERS OF BITUMEN FAMILY :**

(i) ASPHALT : When bitumen contains some inert mineral or material.

(ii) LAKE ASPHALT**:** It is found in well defined surface deposits it contains.

(iii) Binder → 54%

(iv) Mineral matter →36%

(v) Organic matter →10%

(3) **CUTBACK BITUMEN :**

(i) Cutback is defined as the bitumen in which the viscosity has been reduced by a volatile diluent for surface dressing, bitumen macadam and soil bitumen stablization.

(ii) Rapid curing:- naphtha and gasoline.

(iii) Medium curing :- kerosene.

(iv) Slow curing → light oils.

Traditionally bitumen is regarded as colloidal system which consists of higher molecular weight asphaltence micelles that are dissolved in lower molecular weight oil medium called as matteres. ❑❑❑