UNIT - II

Basic Building materials

- Introduction: Importance – Objectives of study of building materials – Classification of construction materials – Properties of materials.
- Stones: Properties of building stones– Relation to their structural requirements – Classification of stones– Dressing of stones – Natural bed – Testing of stones.
- Bricks: Composition of good brick earth – Methods of manufacturing of bricks– comparison between clamp burning and kiln burning – Qualities of a good brick –Testing of bricks.
- Lime: Technical terms – Constituents of lime stone – Classification of lime – Manufacturing of lime.
- Cement: Properties of cement – types of cements – Testing of cements.
- Wood: Structure – Seasoning of timber – Defects in timber.

Objectives

- To develop knowledge of material science and behaviour of various building materials used in constructions
- Identify the construction materials required for the assigned work.
- Provide procedural knowledge of the simple testing method of cement, lime and concrete.

Classification of construction materials

Construction material or Building material is a material used for construction

Buildings can be categorized into five different types of construction:
fire-resistive, non-combustible, ordinary, heavy timber, and wood-framed.

Based on the construction type there are various materials used in the construction of buildings.

• Stone	Brick	Lime
• Cement	Metal	Timber
• Sand	Aggregates	mortar

Properties of materials

Physical properties

The characteristics of the building materials that can be observed and measured without changing its chemical identity

- Density
- Unit weight/Specific weight
- Specific gravity
- Porosity
- Water absorption
- Coefficient of softening
- Permeability
- Hygroscopicity
- Fire resistance
- Frost resistance
- Chemical resistance
- Heat conductivity
- Durability

Mechanical properties

The properties of building materials which opposes the deformation or breakdown of the material in presence of external force or load.

- Strength
- Elasticity
- Hardness
- Plasticity
- Brittleness
- Fatigue
- Impact strength
- Creep

Chemical properties

If a chemical change or reaction occur then, the observed characteristic is called chemical property.

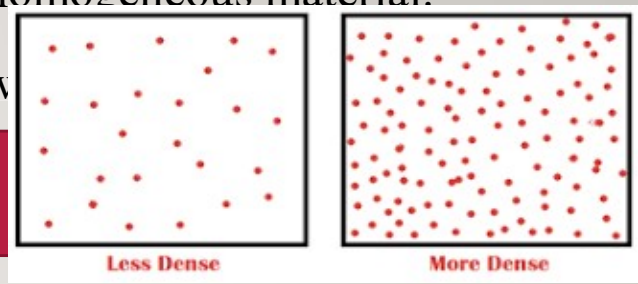
- Chemical composition
- Acidity
- Alkalinity
- Corrosion resistance
- Solubility

Physical properties:

- Density

Density of a material is defined as the mass of a unit volume of homogeneous material.

it is a measure of compactness of a substance (or) measure of how matter are packed.



Density=mass/volume $\rho=m/v$
SI units: kilogram/cubic meter

- Unit weight/Specific weight

"Weight per unit volume of a material is called its specific weight"

It is also Known as unit weight.

Specific weight=weight (of 1m3 vol)/vol.(1m3)
$\Upsilon=W/V$ units: N/m3

- Specific gravity

"specific gravity may be defined as the ratio of density of one material to the density of reference material (generally water at 4degree temp)"

Specific gravity=density of the material/density of reference material
$G= \rho_s/ \rho_r$ no units

Thesaurus.plus

- Porosity

"Porosity may be defined as percentage voids in total volume of a specimen"
It is denoted by symbol 'n'

Porosity=volume of voids/volume of material
n=Vv/V unitless

- Water absorption

"The ability of a material to absorb and retain water is known as water absorption".
It depends on the shape, size, volume, pores, etc. of the material.
It is denoted by 'w'

W=(M2-M1)/M1
M1=mass of ddry material , M2=mass of saturated material

- Coefficient of softening

" The ratio of compressive strength of material saturated with water to that in dry state is known as the coeff
The materials having coefficient of softening as equal to 0.8 or more are referred to as the *water resisting r*
For materials like clay the coefficient of softening is zero. For materials like glass and metal it is one.

Coefficient of softening=compressive strength of a material at saturated state / compressive strength of a material in dry state
unitless

- Permeability

"The capacity of material to allow water to penetrate under pressure is called permeability".

Materials like glass, steel and stones are impervious while earth, bricks are pervious

To measure permeability a pressure differential is applied across a porous material and the rate of flow is measured.

- Hygroscopicity

"The property of material to absorb water vapour from air is known as Hygroscopicity".

It depends on air temperature, humidity, relative humidity, pores, nature of substance involved, etc

The ideal way of measuring hygroscopicity would be to create a moisture sorption isotherm by looking at the change in water content V/s relative humidity at constant temperature.

- Fire resistance

"The ability of a material to resist the action of high temperature without losing its load-bearing capacity.

The material should be sufficiently fireproof to afford safety and stability in case of a fire.

- Frost resistance

"The ability of a water-saturated material to resist the repeated freezing and thawing without considerable decrease of mechanical strength or visible signs of failure".

- Chemical resistance

"The ability of material to withstand the action of acids, alkalies, gases and salt solutions".

- Heat conductivity

It is defined as the quantity of heat expressed in kcal, required to heat 1newton of material by 1°C

- Durability

The property of a material to resist the combined action of atmospheric and other factors is known as its durability.

Mechanical properties:

- Strength

The capacity of a material to resist failure caused by loads acting on it is called as strength. The load may be compressive, tensile or bending. It is determined by dividing the ultimate load taken by the material with its cross sectional area. Strength is an important property for any construction materials. So, to provide maximum safety in strength, factor of safety is provided for materials and it is selected depending on nature of work, quality of material, economic conditions etc.

- Elasticity

The capacity of a material to regain its initial shape and size after removal of load is known as elasticity and the material is called as elastic material. Ideally elastic materials obey Hooke's law in which stress is directly proportional to strain. Which gives modulus of elasticity as the ratio of unit stress to unit deformation. Higher the value of modulus of elasticity lower the deformations.

- Hardness

The property of a materials to resist scratching by a herder body. MOHS scale is used to determine the hardness of a materials. Hardness is most important to decide the usage of particular aggregate. It also influences the workability.

- Plasticity

When the load is applied on the material, if it will undergo permanent deformation without cracking and retain this shape after the removal of load then it is said to be plastic material and this property is called as plasticity. They give resistance against bending, impact etc. Examples: steel, hot bitumen etc.

- Brittleness

When the material is subjected to load, if it fails suddenly without causing any deformation then it is called brittle material and this property is called as brittleness. Examples: concrete, cast-iron etc.

- Fatigue

If a material is subjected to repeated loads, then the failure occurs at some point which is lower than the failure point caused by steady loads. This behavior is known as fatigue.

- Impact Strength

If a material is subjected to sudden loads and it will undergo some deformation without causing rupture is known as its impact strength. It designates the toughness of material.

- Abrasion Resistance

The loss of material due to rubbing of particles while working is called abrasion. The abrasion resistance for a material makes it durable and provided long life.

- Creep

Creep the deformation caused by constant loads for long periods. It is time dependent and occurs at very slow rate. It is almost negligible in normal conditions. But at high temperature conditions creep occur rapidly.

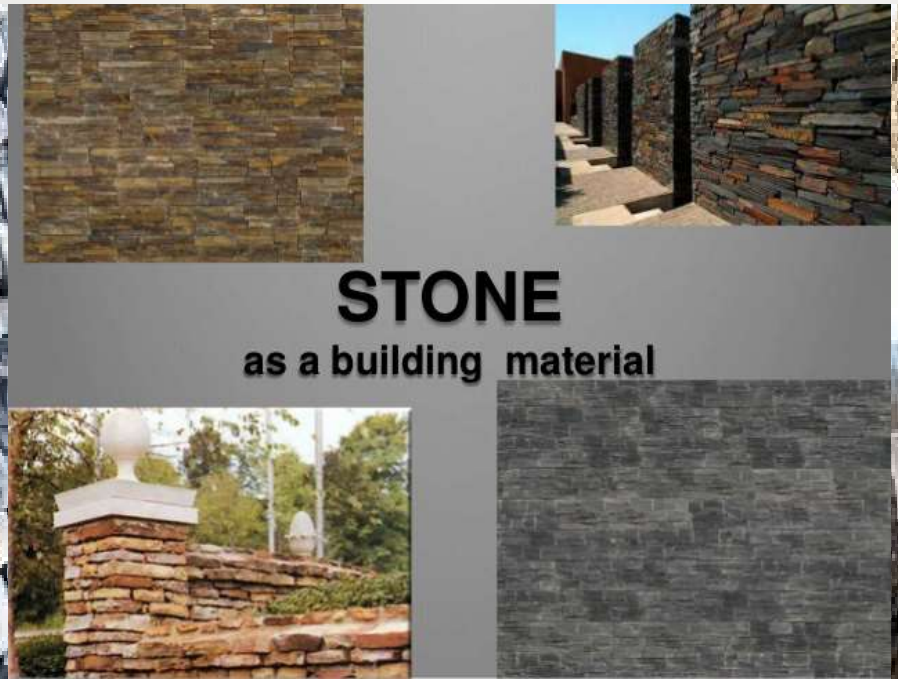
STONES: PROPERTIES OF BUILDING STONES– RELATION TO THEIR STRUCTURAL REQUIREMENTS – CLASSIFICATION OF STONES– DRESSING OF STONES – NATURAL BED – TESTING OF STONES.

STONES:

- The Stones are the fragmented parts of the rock, formed by weathering of sedimentary rock.

(or)

- The Stones are derived from rocks which form the earth's crust and have no definite shape or chemical composition but are mixtures of two or more minerals.



Properties of good building stone:

Different civil engineering construction use stone. It is necessary to find their suitability under different condition. The following properties of the stones should be looked into before selecting them for engineering works:

1. Appearance and colour:

stones must look good in appearance and be of uniform colour. such a quality is essential for stone to be used for decoration work.

Light coloured stones are preferred as they resist weathering action in a better way.

stones with iron oxide should not be used as the presence of iron oxide disfigures the stones and brings about disintegration.

2. Strength :

Stones are used as a compression member and should have sufficient compressive strength. In general, all stones possess a reasonable degree of strength.

The crushing strength of stone should be greater than 100N/mm^2.

Igneous rocks have a strength of around 100 N/mm^2 and some of the metamorphic rocks also possess these strengths. But sedimentary rocks have a lower sterngth.

3. Weight :

In general, good building stones should have a high weight to resist higher compressive forces.

Good building stones must have a specific gravity greater than 2.70 .

A heavy stone possess more compactness and less porosity.

4. Hardness and Toughness :

Stones must be hard and tough so that they can resist wear and tear. Hardness is assessed by scratching and toughness by hammering.

A good building stone should have a wearing resistance less than 3%, and if it is more than 3% it is not satisfactory.

Stones used for road work should be hard to resist wear and tear.

5. Porosity and Absorption :

All stones possess porosity. Stones that have a porosity over a certain percentage are unsuitable for building purposes.

The presence of a higher percentage of pores may absorb rain, which may deteriorate the stone.

A good stone should not absorb water more than 0.6% by weight. It must be capable of withstanding effects of atmosphere. If stones in a cold climate absorb water, they may freeze and even slt.

6. Compactness :

A good stone have a compact, fine, crystalline structure and must be strong. A compact stone is capable of withstanding the effect of external agencies effectively.

7. Fineness of grain :

Stones that are fine grained are suitable for moulding purposes. Such stones are easily carved and dressed. Non-crystalline structures stones are likely to disintegrate under the action of natural agencies

8. Resistance to fire :

Stones must be fire resistant, i.e., they must retain their shape when subjected to fire. Limestone resists fire up to about 800 degree C.

Sandstone can resist fire in a better way. Although argillaceous stones per poor in strength, they are highly fire resistant.

9. Durability :

Stones must be durable. Basically, stones that have their natural bed perpendicular to direction of pressure are durable.

Durable stones are those which are compact, homogeneous, acid resistant and have negligible water absorption.

10. Dressing :

dressing is the act of shaping a stone for decorative purpose or for other purposes.

For this, the stone should possess uniform texture and softness so that they may be easily dressed.

Hard stone can't be dressed

Qualities Of A Good Building Stone

Requirements of Good Building Stones

- Strength
- Durability
- Hardness
- Toughness
- Specific Gravity
- Porosity and Absorption
- Dressing
- Appearance
- Seasoning
- Cost

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

1. Crushing Strength:

For a good structural stone, the crushing strength should be greater than 100N/mm2. The approximate values of crushing strength of some of the stones are:

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

2. Durability:

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

For making stones durable, their natural bed should be carefully noted. The stones should be so arranged in a structure that the natural bed is perpendicular or nearly to the direction of pressure.

3. Hardness:

The stone used in floors and pavements should be able to resist abrasive forces caused by the movement of men and materials over them.

4. Toughness:

Building stones should be tough enough to sustain stresses developed due to vibrations. The vibrations may be due to the machinery mounted over them or due to the loads moving over them. The stone aggregates used in the road construction should be tough.

5. Specific gravity:

Heavier variety of stones should be used for the construction of dams, retaining walls, docks, and harbors. The specific gravity of good building stone is between 2.4 and 2.8.

6. Porosity and absorption:

Building stone should not be porous. If it is porous rainwater enters the pour and reacts with stone and crumbles it.

In higher altitudes, the freezing of water in pores takes place and it results in the disintegration of the stone.

7. Dressing:

Giving the required shape to the stone is called dressing. It should be easy to dress so that the cost of dressing is reduced.

However the care should be taken so that, this is not at the cost of the required strength and the durability.

8. Appearance:

The stones which are to be used for face work should be decent in appearance and they should be capable of preserving their colour uniformly for a long time.

A good building stone should be of uniform colour and free from clay holes, spots of other colour, bands, etc.

9. Seasoning:

Good stones should be free from the quarry sap. Laterite stones should not be used for 6 to 12 months after quarrying.

They are allowed to get rid of quarry sap by the action of nature. This process of removing quarry sap is called seasoning.

10. Cost:

Cost is an important consideration in selecting a building material. The proximity of the quarry to the building site brings down the cost of transportation and hence the cost of stones comes down.

Classification Of Rocks

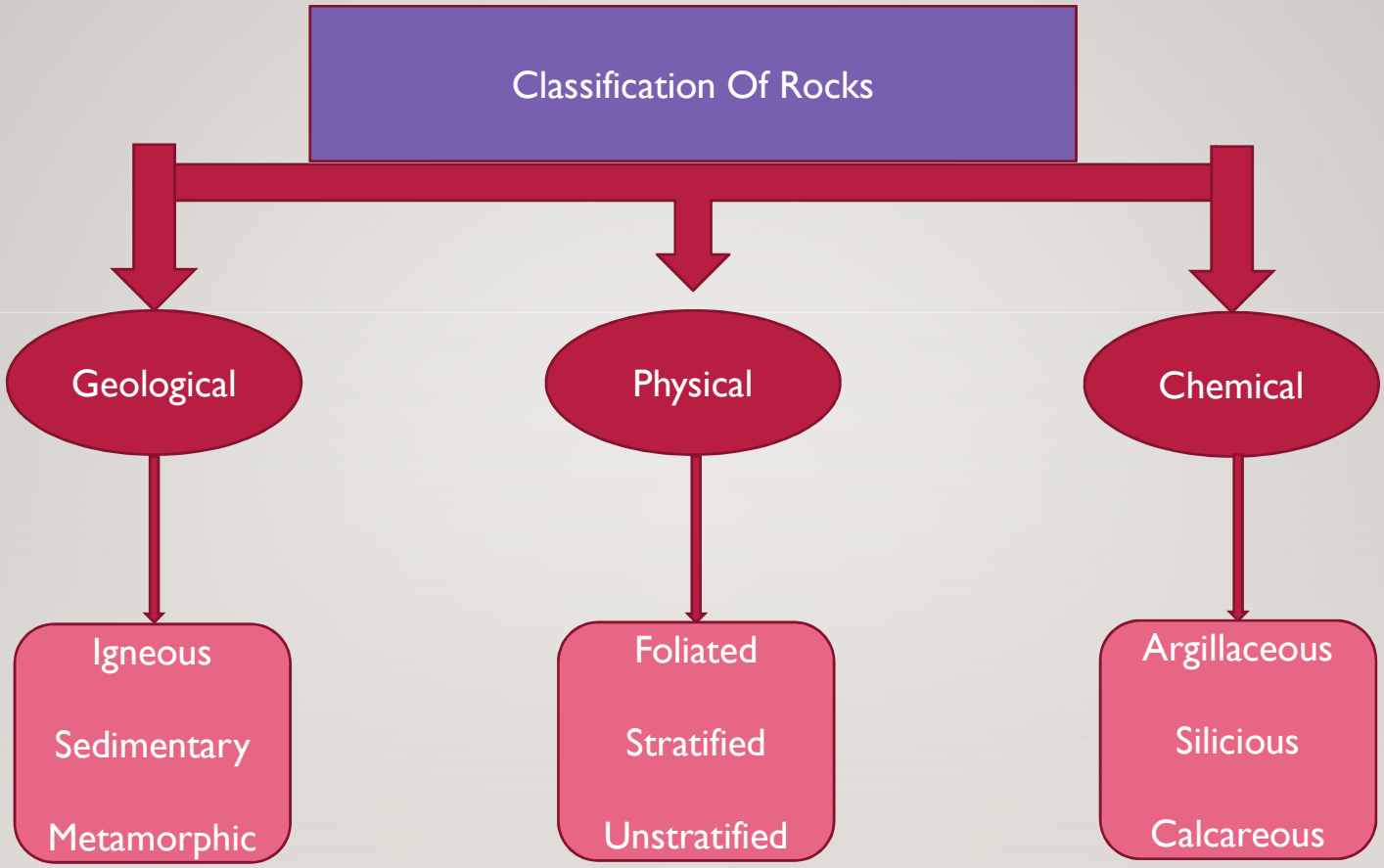
The origin and conditions of rock formation predetermine their chemical and mineralogical composition, crystalline structure and texture.

The three major classification are:

(1) Geological or genetic classification

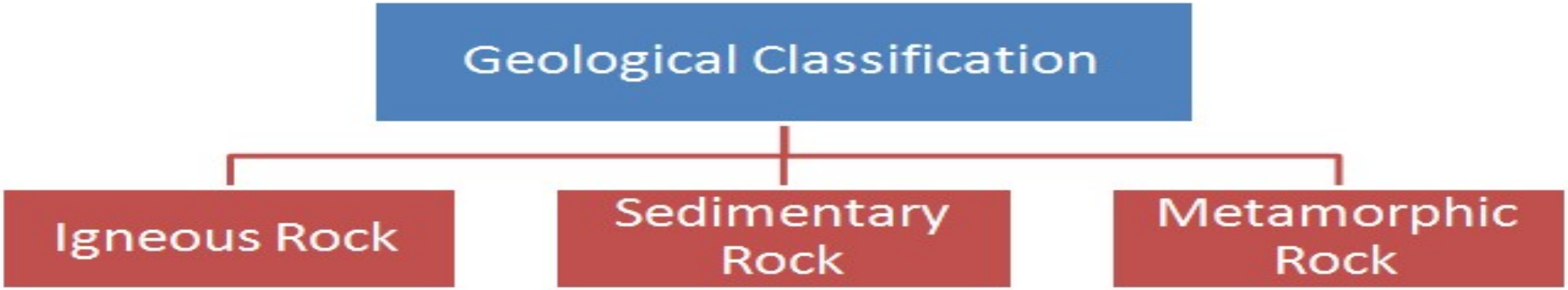
(2) Physical classification

(3) Chemical classification


Classification Of Rocks
Geological
Physical
Chemical
Igneous
Sedimentary
Metamorphic
Foliated
Stratified
Unstratified
Argillaceous
Silicious
Calcareous

Geological classification:

According to the geological classification, rocks are subdivided into three large groups, igneous rocks, sedimentary rocks, and metamorphic rocks.

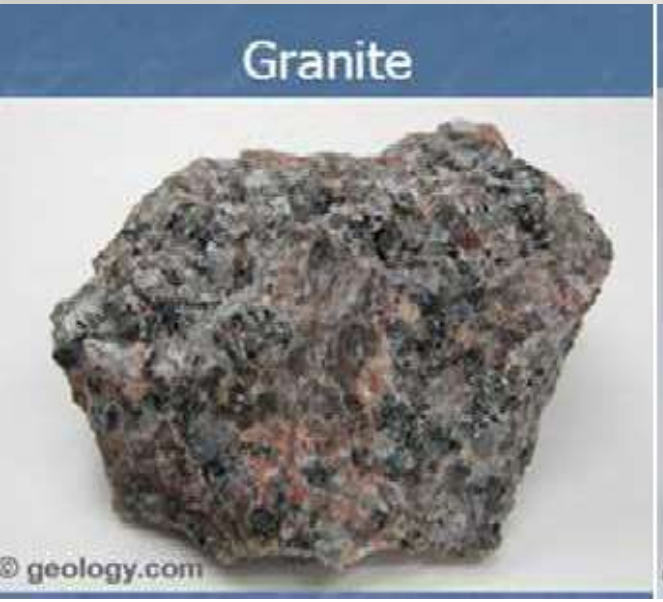


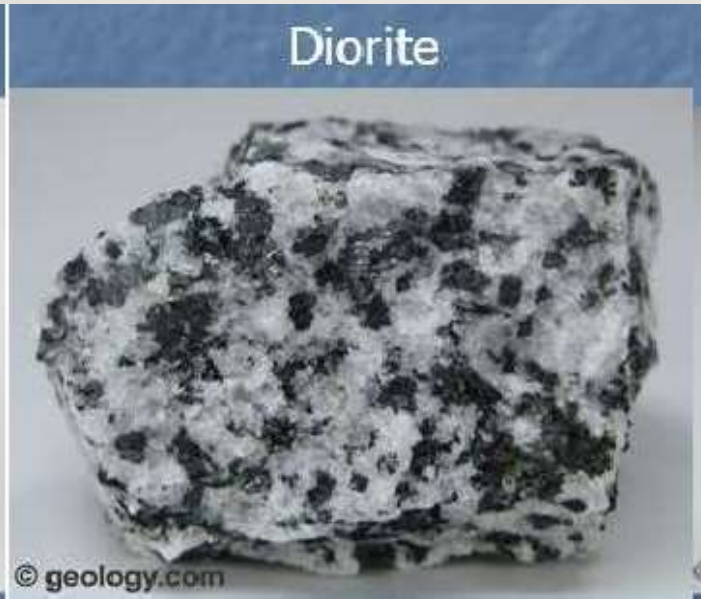
(1) Igneous rocks :

Cooling and hardening of molten magma result in the formation of igneous rocks. Depending on the rate of cooling the sizes of crystals are formed.

Granite, syenites, diorites and gabbros have large crystals, while basalts, rhyolites and andesites have small crystals.

Igneous rocks are generally very hard.





COLLECTION OF IGNEOUS ROCKS

Igneous rock forms through the cooling and solidification of magma or lava. Igneous rock may form with or without crystallization, either below the surface as intrusive (plutonic) rocks or on the surface as extrusive (volcanic) rocks.

1	2	3	4	5
				
ANDESITE	BASALT	DIORITE	DOLERITE	GABBRO
6	7	8	9	10
				
GRANITE BLACK	GRANITE PHORPHERY	GRANITE RED	GRANITE WHITE	KIMBERLITE
11	12	13	14	15
				
OBESIDIAN BLACK	OBESIDIAN GREEN	PEGMATITE	PUMICE	RHYOLITE

(2) Sedimentary rocks :

Transportation agents like wind, water and ice may move the loose weathered rock material and deposite them in the form of layers called sediments.

Such sediments when subjected to heavy pressure undergo compaction and cementation, resulting in the Sedimentary rocks.

Limestone, dolomite, shale, sandstone, etc., are sedimentary rocks.

COLLECTION OF SEDEMENTARY ROCKS

Sedimentary rocks are types of rock that are formed by the deposition of material at the Earth's surface and within bodies of water

1  BITUMENOUS COAL	2  CHALK LUMPS	3  CHERT	4  CONGLOMERATE	5  DIATOMITE
6  FLINT	7  LIME STONE BLACK	8  LIME STONE SILICIOUS	9  LIME STONE WHITE	10 MUD STONE
11  ROCK PHOSPHATE	12  ROCK SALT	13  SAND STONE RED	14  SAND STONE SILICIOUS	15  SHALE

(3) Metamorphic rocks :

Sedimentary rocks and to some extent igneous rocks when subjected to changes brought about by the combination of heat, pressure and plastic flow (called metamorphism) undergo changes in the structure,

Texture and mineral composition, and this results in the formation of metamorphic rocks. Gneiss, schist, slate, marble, etc. are metamorphic rocks.

Marble rock

Gneiss rock

Slate rock

Schist rock

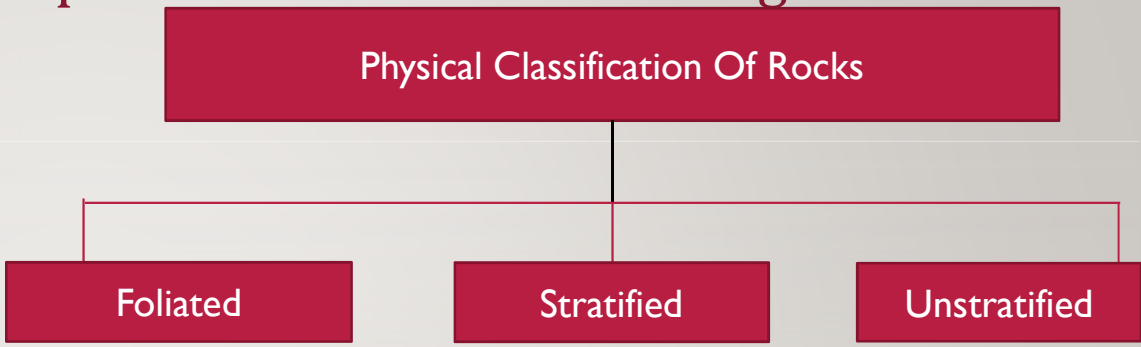
COLLECTION OF METAMORPHIC ROCKS

Metamorphic rocks arise from the transformation of existing rock types, in a process called metamorphism, which means "change in form".

1	2	3	4	5
ANTHRESITE	GNIESS	KHONDALITE	MARBLE BLACK	MARBLE GREEN
6	7	8	9	10
MARBLE PINK	MARBLE WHITE	PEGMATITE MICA	PHYLITE	QUARTIZITE GRAY
11	12	13	14	15
QUARTIZITE GREEN	QUARTIZITE WHITE	SERPENTINE	SLATE	TIGER EYE

Physical classification

The basis for such a classification is the physical properties of rocks, the manner and arrangement of different particles and mass forming a stone. They classified as follows:



(1) Foliated rocks
(2) stratified rocks
(3) Unstratified rocks

Foliated rocks :

These rocks shows definite paeallel arrangement of minerals showing a tendency to split in a specific direction.

Examples : metamorphic rock like gneiss, schist

Stratified rocks :

Stratified structure is formed due to the splitting of parallel layers of sedimentary rocks.

They exhibit distinct layers which can be separated. The plane of separation is called as a cleavage plane.

Examples : Limestone, slate, and sandstone

Unstratified rocks :

They are granular or crystalline structure and become solid and cooling.

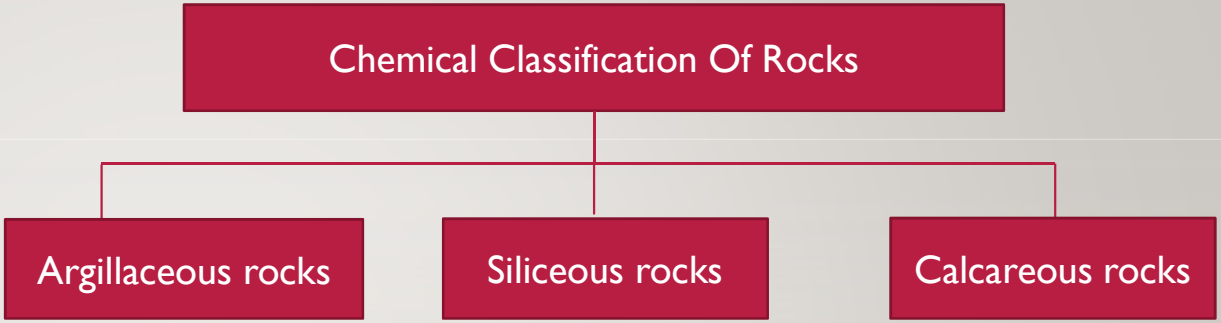
They do not show any sign of strata.

Examples : igneous rocks like granite, basalt, etc.

Chemical Classification Of Rocks

The presence of chemical constituents in the rocks is the basis for their type of classification, they are as follows :

(1) Argillaceous rocks
(2) Siliceous rocks
(3) Calcareous rocks



Argillaceous rocks :

In these rocks clay and alumina is the main constituents. Examples of the aegillaceous rocks are slate, laterite, etc.

Siliceous rocks:

In these silica is the main constituent. The presence of the silica in the free state is called sand, and in the combined state is silicate.

Rocks containing silica in the free state are harder, and those found in the combined form are likely to be disintegrated.

Examples of the silicate rocks are sandstone, quartzite, etc.

Calcareous rocks:

Calcium carbonate or lime is the main constituents in these rocks. They are readily acted upon by dilute HCL

Examples are limestone, marble, etc.

Dressing of stones

The stones after being quarried are to be cut into suitable sizes and with suitable surfaces. This process is known as the dressing of stones and it is carried out for the following purposes.

•to make the transport from quarry easy and economical,
•to gel the desired appearance from stone work,
•to suit to the requirements of stone masonry.

DRESSING OF STONES

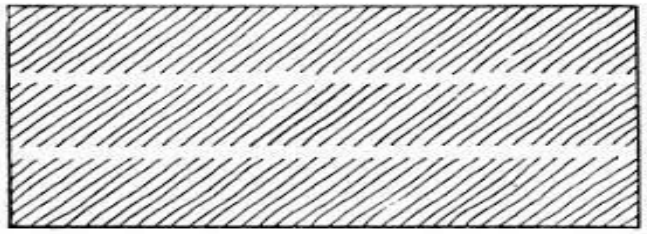
Following are the varieties of finishes obtained by the dressing of stones:

- Axed finish:

This type of finishing is used in hard stones like granites, where the dressing is done with the help of an axes. Such a finish is termed as an axed finish.

- Boasted or droved finish:

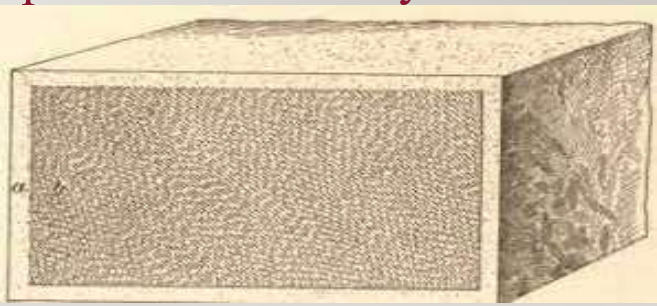
In this, the dressing is done with the help of a boaster and hammer, forming a series of 38 to 50 mm wide bands of more or less parallel tool marks, which cover the whole surface.



Boasted finish

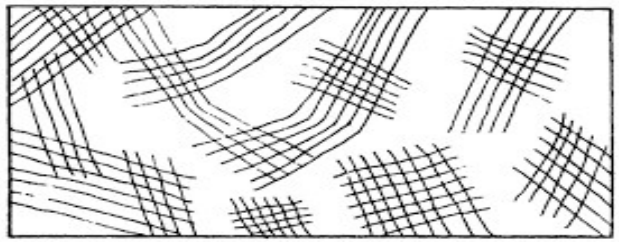
- Chisel-draughted margins:

In order to obtain uniform joints in stone work, the margins are placed which may be cither squared or pitched or chamfered.



- Dragged or combed finish:

This finish is used only in soft stones: This type of finish, a drag or a comb, which is a piece of steel with a number of teeth, is rubbed on the surface in all directions and surface.



Dragged finish

- Circular finish:

In this type of finish, the surface of stone is made round or circular as in case of a column.

- Furrowed finish:

In this type of finish a margin of about 20 mm width, is sunk on all the edges of stone and the central portion is made to project about 15 mm. A number of vertical or horizontal grooves about 10 mm wide arc formed in this projected portion. This finish is generally adopted to make the quoins prominent.

- Moulded finish:

The surface of stone can be moulded in any desired shape so as to improve the appearance of the work. The moulding can be made either by hand or machine.

- Scabbling Finish:

This type of rough dressing in which the irregular projections are removed by a scabbling hammer.

- Hammer-dressed finish:

In this type of finish, the stones are made roughly square or rectangular by means of a waller's hammer. The hammer-dressed stones have no sharp or irregular corners and have comparatively even surface so as to fit well in masonry.

- Plain finish:

In this type of finish, the surface ol the stone is made approximately smooth with a saw or with a chisel.

- Polished finish:

This type of finish is used in marbles, granite etc. These are polished either manually or with the help of machines. A glossy surface is obtained.

- Self-faced or rock-faced or quarry-faced finish:

Some stones, as obtained from the quarry posses smooth surface and they can be directly placed on the work. Such a stone surface is termed as the self-faced or lock-faced or quarry-faced finish.

- Reticulated finish:

This type of finish presents a net-like appearance. A margin, about 20 mm wide is marked on the edges of stone and irregular sinkings are made on the enclosed space. A margin, about 10 mm wide, is provided around the irregularly shaped sinking, having a depth of about 5 mm. A pointed tool is used to put the mark on the sunk surface so as to present a pock-marked appearances.

- Punched machine:

This is another form of rough dressing, usually used for lower portions of the buildings. The exposed face of the stone is dressed with the help of a punch, thus making depressions or punch holes at some regular distance apart. A 25 mm wide strip is made around the perimeter of the stone.

- Rubbed finish:

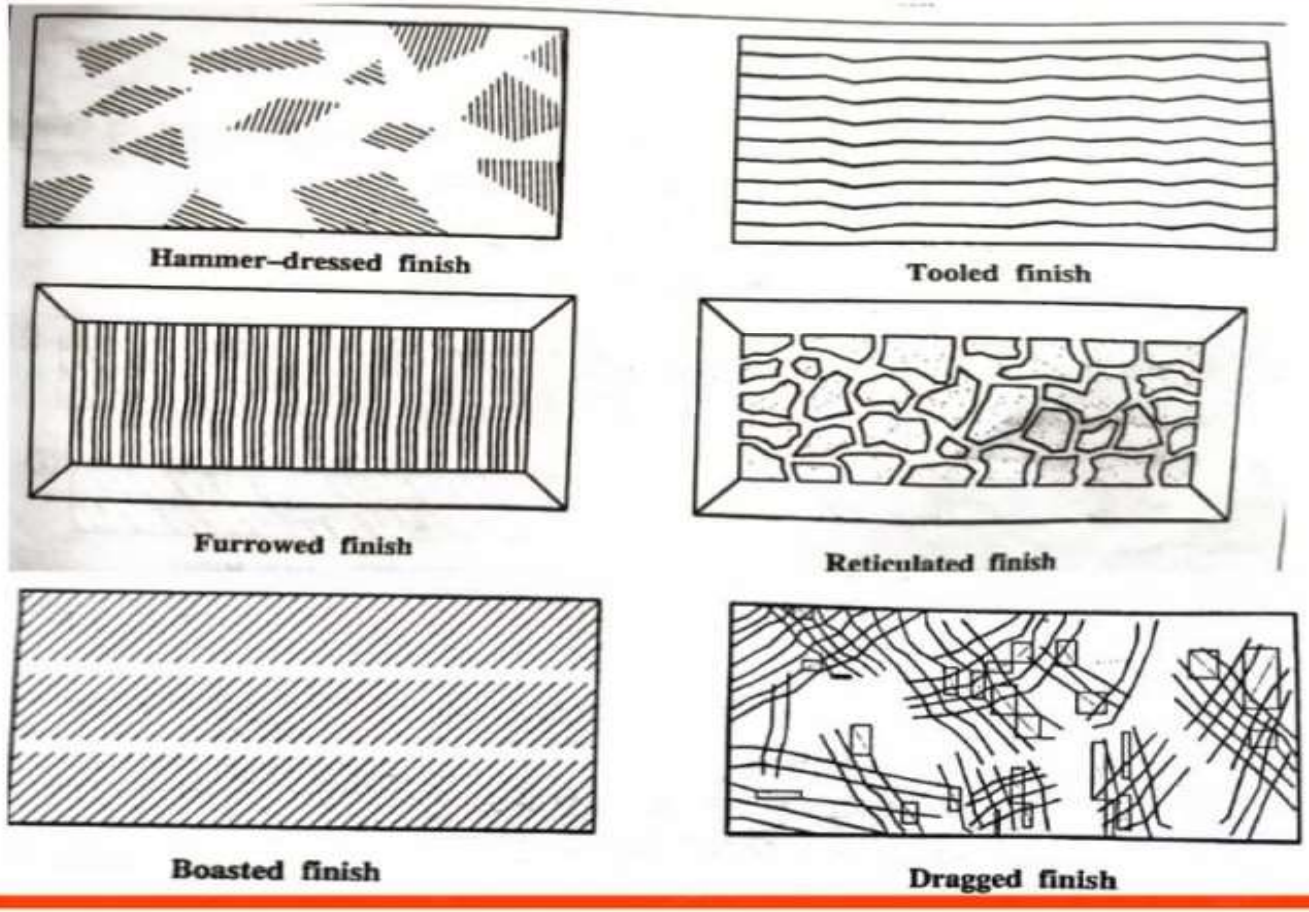
This type of finish is obtained by rubbing a piece of stone with the surface or by rubbing the surface with the help of a suitable machine. The water and sand are freely used to accelerate the process of rubbing.

- Tooled finish:

The stone surface is finished by means of a chisel and parallel continuous marks, either horizontal or inclined or vertical are left on the surface.

- Sunk finish:

This finish is obtained by sinking the surface below the original level in the form of wide grooves, chamfers, inclined surfaces, etc.



Stone surface finishing

Natural bed

Definition:

Building rocks arc obtained from rocks. These rocks have a distinct plane of division along which the rocks can be easily split. This plane is known as a natural bed of stone.

Importance of Natural bed of stones

-In stone masonry structures, generally, the rules observed are that the line or direction of the natural bed stones should be nearly so to the direction of pressure or perpendicular or Such an arrangement gives maximum strength to stonework.

-Natural beds of stones can be examined by pouring water and examining the directions of layers. A magnifying glass may also be used for this purpose.

-An experienced worker can easily locate and check the direction of the natural bed of stones from the resistance offered to the chisel.

-Stones break easily along these natural beds. With respect to natural bed, stones are placed in different situations as follows:

1) Arches:

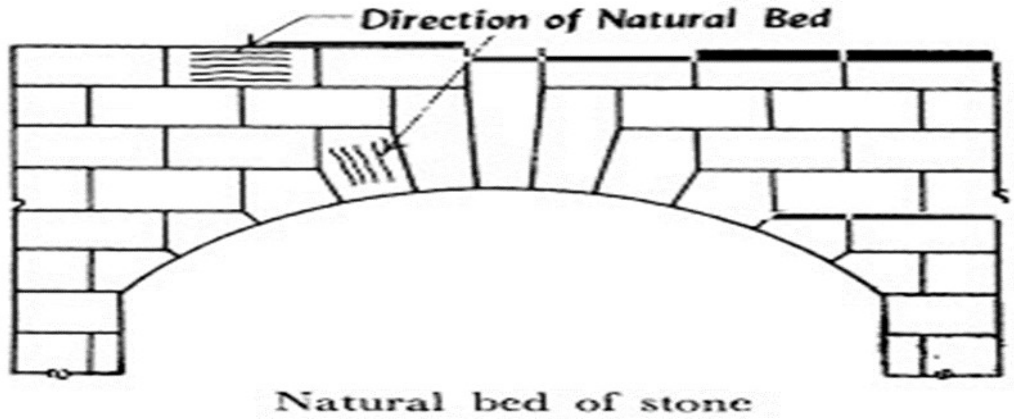
In this type of stone arches, the stones are placed with their natural beds radial as shown in fig. With such an arrangement, the thrust or the force of the arch weight above acts normal or perpendicular to the direction of the natural bed stone arch.

2) Cornices, string courses, etc.:

In the case of cornices, stones are partially unsupported, string courses, etc. Hence they should be placed with the direction of natural beds as vertical. This principle will not hold good for cornerstones. It would be desirable, in such cases, to adopt stones without natural beds.

3) Walls:

Stones should be placed in walls with the direction of their natural beds horizontal as shown in fig.



Testing of stones

The building stones are to be tested for their different properties. Following are such tests for the stones:

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

❑ Acid Test:

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

❑ Attrition test:

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

The following procedure is adopted:

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

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

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

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

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

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

7.Percentage wear worked out as : **Percentage wear = (Loss in Weight/Initial Weight) x 100**

❑ Crushing test:

-Samples of stone is cut into cubes of size 40 x 40 x 40 mm sizes of cubes are finely dressed and finished.
-Maximum number of specimen to be tested is three. Such specimen should be placed in water for about 72 hours prior to test and therefore tested in saturated condition.
-Load bearing surface is then covered with plaster of Paris of about 5mm thick plywood.
-Load is applied axially on the cube in a crushing test machine. Rate of loading is 140 kg/sq.cm per minute.
-Crushing strength of the stone per unit area is the maximum load at which the sample crushes or fails divided by the area of the bearing face of the specimen.

❑ Crystallisation test:

-At least four cubes of stone with side as 40mm are taken. They are dried for 72 hrs and weighed. They are then immersed in 14% solution of Na_2SO_4 for 2 hours.
-They are dried at 100 degree C and weighed. Difference in weight is noted.
-This procedure of drying, weighing, immersion and reweighing is repeated at least 5 times.
-Each time, change in weight is noted and it is expressed as a percentage of original weight.
-Crystallization of $CaSO_4$ in pores of stone causes decay of stone due to weathering. But as $CaSO_4$ has low solubility in water, it is not adopted in this test.

❑ Freezing and thawing:

-Stone specimen is kept immersed in water for 24 hours. It is then placed in a freezing machine at -12 degC for 24 hours.

-Then it is thawed or warmed at atmospheric temperature. This should be done in shade to prevent any effect due to wind, sun rays, rain etc. this procedure is repeated several times and the behavior of stone is carefully observed.

❑ Hardness test:

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

1. A cylinder of diameter 25mm and height 25mm is taken out from the sample of stone.
2. It is weighed.
3. The sample is placed in Dorry's testing machine and it is subjected to a pressure of 1250 gm.
4. Annular steel disc machine is then rotated at a speed of 28 rpm.
5. During the rotation of the disc, coarse sand of standard specification is sprinkled on the top of disc.
6. After 1000 revolutions, specimen is taken out and weighed.
7. The coefficient of hardness is found out from the following equation:

Coefficient of hardness = 20 - (Loss of weight in gm/3)

❑ Impact Test

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

1. A cylinder of diameter 25mm and height 25mm is taken out from the sample of stones.
2. It is then placed on cast iron anvil of machine.
3. A steel hammer of weight 2 kg is allowed to fall axially in a vertical direction over the specimen.
4. Height of first blow is 1 cm, that of second blow is 2 cm, that of third blow is 3 cm and so on.
5. Blow at which specimen breaks is noted. If it is nth blow, ‘n’ represents the toughness index of stone.

❑ Microscopic test:

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

1.Average grain size
2.Existence of pores, fissures, veins and shakes
3.Mineral constituents
4.Nature of cementing material
5.Presence of any harmful substance
6.Texture of stones etc.

❑ Smith's Test

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

❑ Water Absorption Test

The test is carried out as follows:

1. From the sample of stone, a cube weighing about 50gm is prepared. Its actual weight is recorded as W1 gm.
2. Cube is then immersed in distilled water for a period of 24 hrs.
3. Cube is taken out of water and surface water is wiped off with a damp cloth.
4. It is weighed again. Let the weight be W2 gm.
5. Cube is suspended freely in water and its weight is recorded. Let this be W3 gm.
6. Water is boiled and cube is kept in boiling water for 5 hours.
7. Cube is removed and surface water is wiped off with a damp cloth. Its weight is recorded. Let it be W4 gm.

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

Percentage absorption by weight after 24 hours =(W2 - W1) x 100 / W1

Percentage absorption by volume after 24 hours = (W2 - W1) x 100 / (W2 - W3)

Volume of displaced water = W2 - W3

Percentage porosity by volume = (W4 - W1) x 100 / (W2 - W3)

Density =W1 / (W2 - W3) kg/m3, Specific Gravity = W1 / (W2 - W3)

Saturation Coefficient = (Water Absorption/Total Porosity) = (W2 - W1) / (W4 - W1)

BRICKS

- Contents:

❖Bricks

❖Composition of good brick earth

❖Methods of manufacturing of bricks

❖comparison between clamp burning and kiln burning

❖Qualities of a good brick

❖Testing of bricks.

INTRODUCTION TO BRICKS:

A brick is building material used to make walls, pavements and other elements in masonry construction. Traditionally, the term brick referred to a unit composed of clay, but it is now used to denote any rectangular units laid in mortar.

- The bricks are obtained by moulding clay in rectangular blocks of uniform size and then by drying and burning these blocks.

- The artificial material of construction in the form of clay bricks of uniform size of shape are known as bricks.

- Size of brick

1) Traditional brick:- 23cm X11.4 cm X 7.6 cm

2)Modular Brick :- 19 cm X 9 cm X 9 cm

USES OF BRICKS:

Bricks are used in following civil works

1.As building blocks for constructing walls and partitions.

2.As pavers for footpaths.

3.For bridge piers & industrial foundations.

4.For lining sewer lines.

5.For protecting steel columns from fire.

6.For lining ovens,furnances & chimneys.

COMPOSITION OF GOOD BRICK EARTH

Following are the constituents of good brick earth:

- Alumina
- Silica
- Lime
- Oxides of iron
- Magnesia

✓**Alumina:**

-It is the chief constituent of every kind of clay. A good brick earth should contain about 20% to 30% of alumina.

-This constituent imparts plasticity to the earth so that it can be moulded.

-If alumina is present in excess, with inadequate quantity of sand, the raw bricks shrink and wrap during drying and burning and become too hard when burnt.

✓**Silica:**

-It exists in clay either as free or combined.

-As free sand, it is mechanically mixed with clay and in combined form, it exists in chemical composition with alumina.

-A good brick earth should contain about 50% to 60% of silica.

-The presence of this constituent prevents cracking, shrinking and warping of raw bricks. It thus imparts uniform shape to the bricks.

-The durability of bricks depends on the proper proportion of silica to the brick earth.

-The excess of silica destroys the cohesion between particles and the bricks become brittle.

✓Lime:

-A small quantity of lime not exceeding 5%is desirable in good brick earth.

-It should be present in a very finely powdered state because even small particles of the size of a pin-head cause flaking of the bricks.

-The lime prevents shrinkage of raw bricks.

-The sand alone is infusible. But it slightly fuses at kiln temperature in presence of lime. Such fused sand works as a hard cementing material for brick particles.

-The excess of lime causes the brick to melt and hence its shape is lost.

-The lumps of lime are converted into quick lime after burning and this quick lime slakes and expands in presence of moisture. Such an action results in splitting of bricks into pieces.

✓**Oxide of iron:**

-A small quantity of oxide of iron to the extent of about 5 to 6% is desirable in good brick earth.

-It helps as lime to fuse sand. It also imparts red colour to the bricks.

-The excess of oxide of iron makes the bricks dark blue or blackish.

-If the quantity of iron oxide is comparatively less, the bricks will be yellowish in colour.

✓**Magnesia:**

-A small quantity of magnesia in brick earth imparts yellow tint to the bricks and decreases shrinkage.

-Excess of magnesia leads to the decay of bricks.

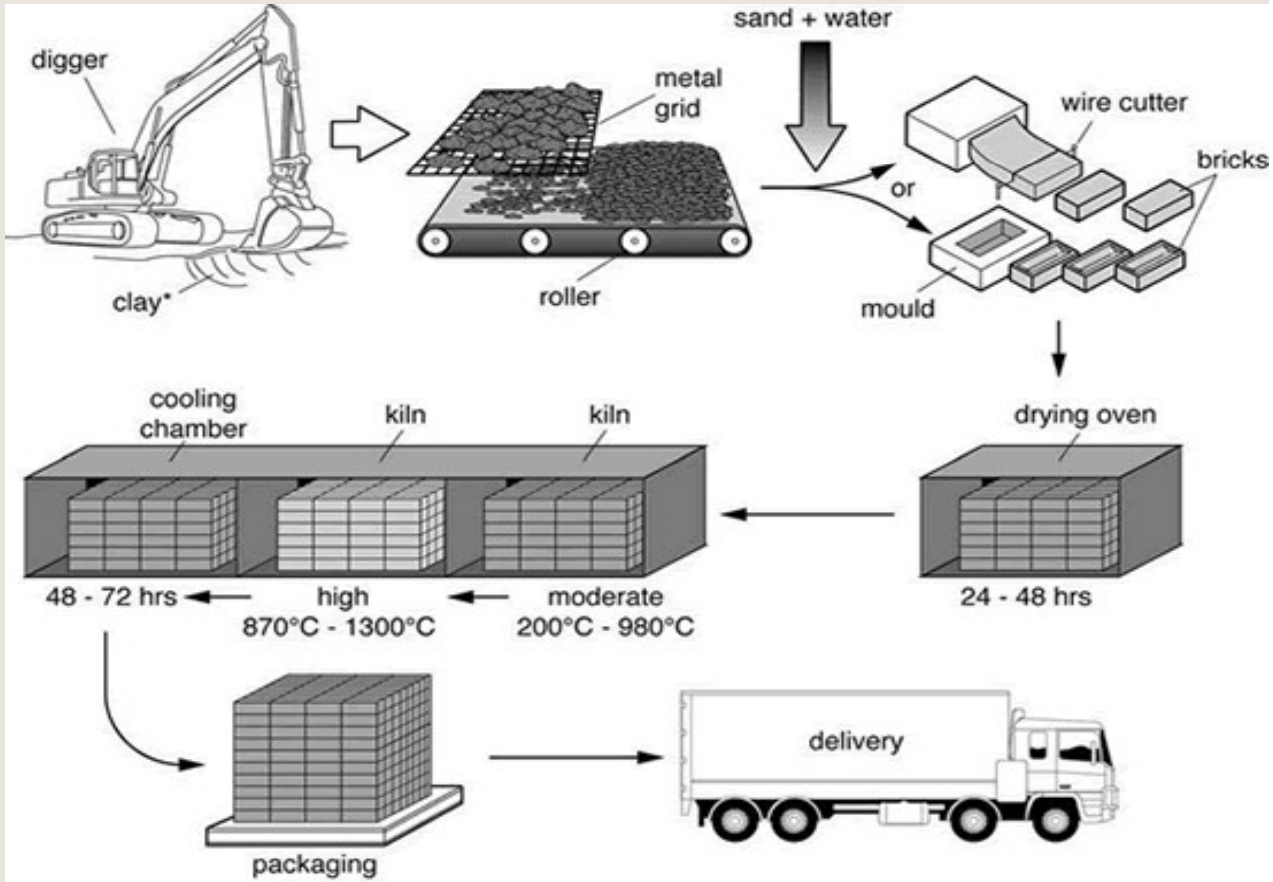
HARMFUL INGREDIENTS IN BRICK EARTH

- Lime
- Iron pyrites
- Alkalies
- Pebbles
- Vegetation and organic matter

METHODS OF MANUFACTURING OF BRICKS

In the process of manufacturing bricks, the following four distinct operations are involved:

- Preparation of clay
- Moulding
- Drying
- Burning



Each of these operations of manufacturing bricks will now be studied at length.

(1)Preparation of Clay:

The clay for bricks is prepared in the following order:

(i) Un-soiling
(ii) Digging
(iii) Cleaning
(iv) Weathering
(v) Blending
(vi) Tempering

(i) Un-Soiling:

-The top layer of soil, about 200 mm in depth, is taken out and thrown away.

-The clay in top soil is full of impurities and hence it is to be rejected for the purpose of preparing bricks.

(ii) Digging:

-The clay is then dug out from the ground. It is spread on the levelled ground, just a little deeper than the general level of ground.

-The height of heaps of clay is about 600 mm to 1200 mm.

(iii) Cleaning:

-The clay, as obtained in the process of digging, should be cleaned of stones, pebbles, vegetable matter, etc.

-If these particles are in excess, the clay is to be washed and screened. Such a process naturally will prove to be troublesome and expensive.

-The lumps of clay should be converted into powder form in the earth crushing roller.

iv) Weathering:

-The clay is then exposed to atmosphere for softening or mellowing. The period of exposure varies from few weeks to full season.

- For a large project, the clay is dug out just before the monsoon and it is allowed to weather throughout the monsoon.

(v) Blending:

-The clay is made loose and any ingredient to be added to it is spread out at its top.

-The blending indicates intimate or harmonious mixing. It is carried out by taking small portion of clay every time and by turning it up and down in vertical direction.

-The blending makes clay fit for the next stage of tempering.

(vi) Tempering:

-In the process of tempering, the clay is brought to a proper degree of hardness and it is made fit for the next operation of moulding.

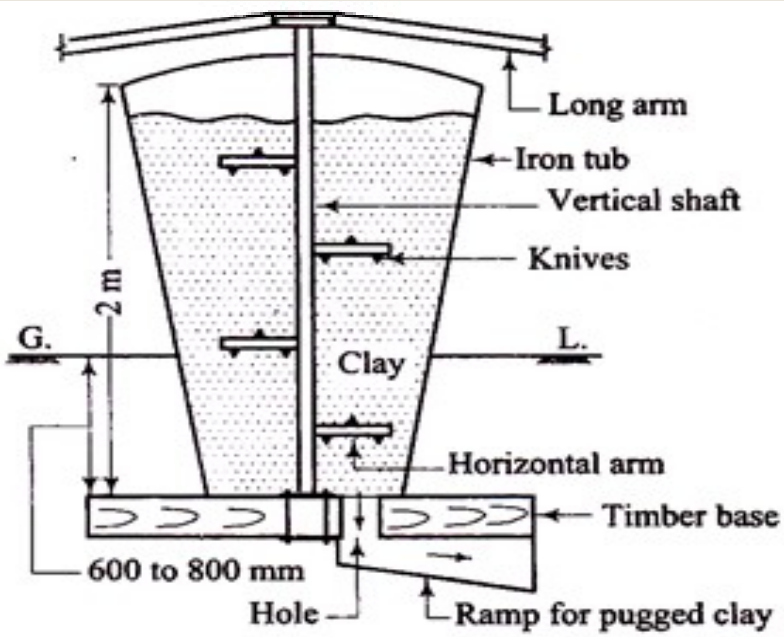
-The water in required quantity is added to clay and the whole mass is kneaded or pressed under the feet of men or cattle.

-The tempering should be done exhaustively to obtain homogeneous mass of clay of uniform character.

For manufacturing good bricks on a large scale, the tempering is usually done in a pug mill.

- A typical pug mill capable of tempering sufficient earth for a daily output of about 15000 to 20000 bricks is shown in fig.

- The process of grinding clay with water and making it plastic is known as the pugging.



Pug mill
FIG. 4-1

- A pug mill consists of a conical iron tub with cover at its top. It is fixed on a timber base which is made by fixing two wooden planks at right angles to each other.

- The bottom of tub is covered except for the hole to take out pugged earth. The diameter of pug mill at bottom is about 800 mm and that at top is about one meter.

- The provision is made in top cover to place clay inside the pug mill.
- A vertical shaft with horizontal arms is provided at the center of iron tub. The small wedge-shaped knives of steel are fixed on horizontal arms.

- The long arms are fixed at the top of vertical shaft to attach a pair of bullocks. The ramp is provided to collect the pugged clay. The height of pug mill is about 2 m. Its depth below ground is about 600 mm to 800 mm to lessen the rise of the barrow run and to throw out the tempered clay conveniently.

- In the beginning, the hole for pugged clay is closed and clay with water is placed in pug mill from the top. When the vertical shaft is rotated or turned by a pair of bullocks, the clay is thoroughly mixed up by the actions of horizontal arms and knives and a homogeneous mass is formed.

- The rotation of vertical shaft can also be achieved by using steam, diesel or electric power. When clay has been sufficiently pugged, the hole at the bottom of tub is opened out and the pugged earth is taken out from ramp by barrow i.e., a small cart with two wheels for the next operation of moulding. The pug mill is then kept moving and feeding of clay from top and taking out of pugged clay from bottom are done simultaneously.

- If tempering is properly carried out, the good brick earth can then be rolled without breaking in small threads of 3 mm diameter.

(2) Moulding:

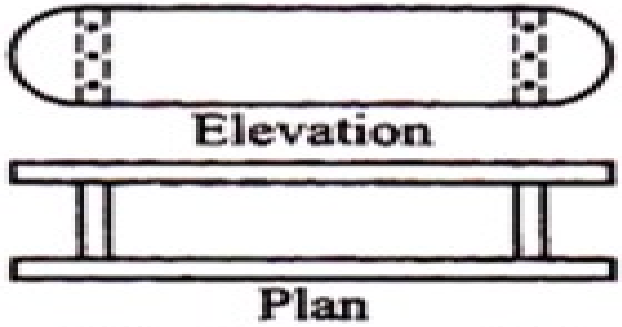
The clay which is prepared as above is then sent for the next operation of moulding.

Following are the two ways of moulding:

- (i) Hand moulding
- (ii) Machine moulding.

(i) Hand Moulding:

-In hand moulding, the bricks are moulded by hand i.e., manually.
-It is adopted where manpower is cheap and is readily available for the manufacturing process of bricks on a small scale.
-The moulds are rectangular boxes which are open at top and bottom. They may be of wood or steel.
-A typical wooden mould is shown in fig. It should be prepared from well-seasoned wood.
-The longer sides are kept slightly projecting to serve as handles.
-The strips of brass or steel are sometimes fixed on the edges of wooden moulds to make them more durable.

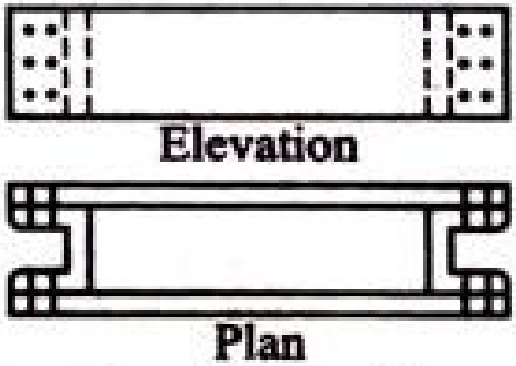


Wooden mould
FIG. 4-2

-A typical steel mould is shown in fig.
-It is prepared from the combination of steel plates and channels.
-It may even be prepared from steel angles and plates.
-The thickness of steel mould is generally 6 mm.
-They are used for manufacturing bricks on a large scale.
-The steel moulds are more durable than wooden moulds and they turn out bricks of uniform size.
-The bricks shrink during drying and burning.

Hence the moulds are to be made larger than the size of Steel mould fully burnt bricks.

-The moulds are therefore made longer by about 8 to 12 per cent in all directions.
-The exact percentage of increase in dimensions of mould is determined by actual experiment on clay to be used for preparing bricks.



Steel mould
FIG. 4-3

The bricks prepared by hand moulding are of two types:

(a) Ground-moulded bricks

(b) Table-moulded bricks.

(a) Ground-Moulded Bricks:

- The ground is first made level and fine sand is sprinkled over it. The mould is dipped in water and placed over the ground. The lump of tempered clay is taken and it is dashed in the mould. The clay is pressed or forced in the mould in such a way that it fills all the corners of mould.
- The extra or surplus clay is removed either by wooden strike or metal strike or frame with wire. A strike is a piece of wood or metal with a sharp edge. It is to be dipped in water every time.
- The mould is then lifted up and raw brick is left on the ground. The mould is dipped in water and it is placed just near the previous brick to prepare another brick. The process is repeated till the ground is covered with raw bricks.
- A brick moulder can mould about 750 bricks per day with working period of 8 hours. When such bricks become sufficiently dry, they are carried and placed in the drying sheds.

- The bricks prepared by dipping mould in water every time are known as the slop-moulded bricks. The fine sand or ash may be sprinkled on the inside surface of mould instead of dipping mould in water. Such bricks are known as the sand-moulded bricks and they have sharp and straight edges.
- The lower faces of ground moulded bricks are rough and it is not possible to place frog on such bricks. A frog is a mark of depth about 10 mm to 20 mm which is placed on raw brick during moulding.
- **Frog--It serves two purposes:**

(1) It indicates the trade name of the manufacturer.

(2) In brickwork, the bricks are laid with frog uppermost. It thus affords a key for mortar when the next brick is placed over it.

- The mould is placed to fit in the projection of wooden block and clay is then dashed inside the mould. A pallet is placed on the top and the whole thing is then turned upside down. The mould is taken out and another pallet is placed over the raw brick and it is conveyed to the drying sheds.
- The bricks are placed to stand on their longer sides in drying sheds and pallet boards are brought back for using them again. As the bricks are laid on edge, they occupy less space and they dry quicker and better.

(b) Table-Moulded Bricks:

- The process of moulding these bricks is just similar as above. But here the moulder stands near a table of size about 2 m x 1 m. The clay, mould, water pots, stock board, strikes and pallet boards are placed on this table. The bricks are moulded on the table and sent for the further process of drying.
- However the efficiency of moulder decreases gradually because of standing at the same place for long duration. The cost of brick moulding also increases when table moulding is adopted.

(ii) Machine Moulding:

- The moulding may also be achieved by machines It proves to be economical when bricks in huge quantity are to be manufactured at the same spot in a short time. It is also helpful for moulding hard and strong clay.

These machines are broadly classified in two categories:

(a) Plastic clay machines

(b) Dry clay machines.

(a) Plastic Clay Machines:

- Such machines contain a rectangular opening of size equal to length and width of a brick.
- The 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.
- The arrangement is made in such a way that strips of thickness equal to that of the brick are obtained. As the bricks are cut by wire, they are also known as the wire cut bricks.

(b) Dry Clay Machines:

- In these machines, the strong clay is first converted into powder form.
- A small quantity of water is then 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 known as the pressed bricks and they do not practically require drying. They can be sent directly for the process of burning.
- The wire cut and pressed bricks have regular shape, sharp edges and corners.
- They have smooth external surfaces. They are heavier and stronger than ordinary hand-moulded bricks. They carry distinct frogs and exhibit uniform dense texture.

(3) Drying:

- The damp bricks, if burnt, are likely to be cracked and distorted. Hence the moulded bricks are dried before they are taken for the next operation of burning. For drying, the bricks are laid longitudinally in stacks of width equal to two bricks. A stack consists of eight or ten tiers.
- The bricks are laid along and across the stock in alternate layers. All bricks are placed on edge. The bricks should be allowed to dry till they become leather hard or bone-dry with moisture content of about 2 per cent or so.

The important facts to be remembered in connection with the drying of bricks are as follows:

(i) Artificial Drying:

- The bricks are generally dried by natural process. But when bricks are to be rapidly dried on a large scale, the artificial drying may be adopted. In such a case, the moulded bricks are allowed to pass through special dryers which are in the form of tunnels or hot channels or floors. Such dryers are heated with the help of special furnaces or by hot flue gases. The tunnel dryers are more economical than hot floor dryers and they may be either periodic or continuous.

- In the former case, the bricks are filled, dried and emptied in rotation. In the latter case, the loading of bricks is done at one end and they are taken out at the other end. The temperature is usually less than 120°C and the process of drying of bricks takes about 1 to 3 days depending upon the temperature maintained in the dryer, quality of clay product, etc.

(ii) Circulation of Air:

- The bricks in stacks should be arranged in such a way that sufficient air space is left between them for free circulation of air.

(iii) Drying Yard:

- For the drying purpose, special drying yards should be prepared. It should be slightly on a higher level and it is desirable to cover it with sand. Such an arrangement would prevent the accumulation of rain water.

(iv) Period for Drying:

- The time required by moulded bricks to dry depends on prevailing weather conditions. Usually it takes about 3 to 10 days for bricks to become dry.

(v) Screens:

- It is to be seen that bricks are not directly exposed to the wind or sun for drying. Suitable screens, if necessary, may be provided to avoid such situations.

(4) Burning:

- This is a very important operation in the manufacture of bricks. It imparts hardness and strength to the bricks and makes them dense and durable. The bricks should be burnt properly. If bricks are over-burnt, they will be brittle and hence break easily. If they are under-burnt, they will be soft and hence cannot carry loads.

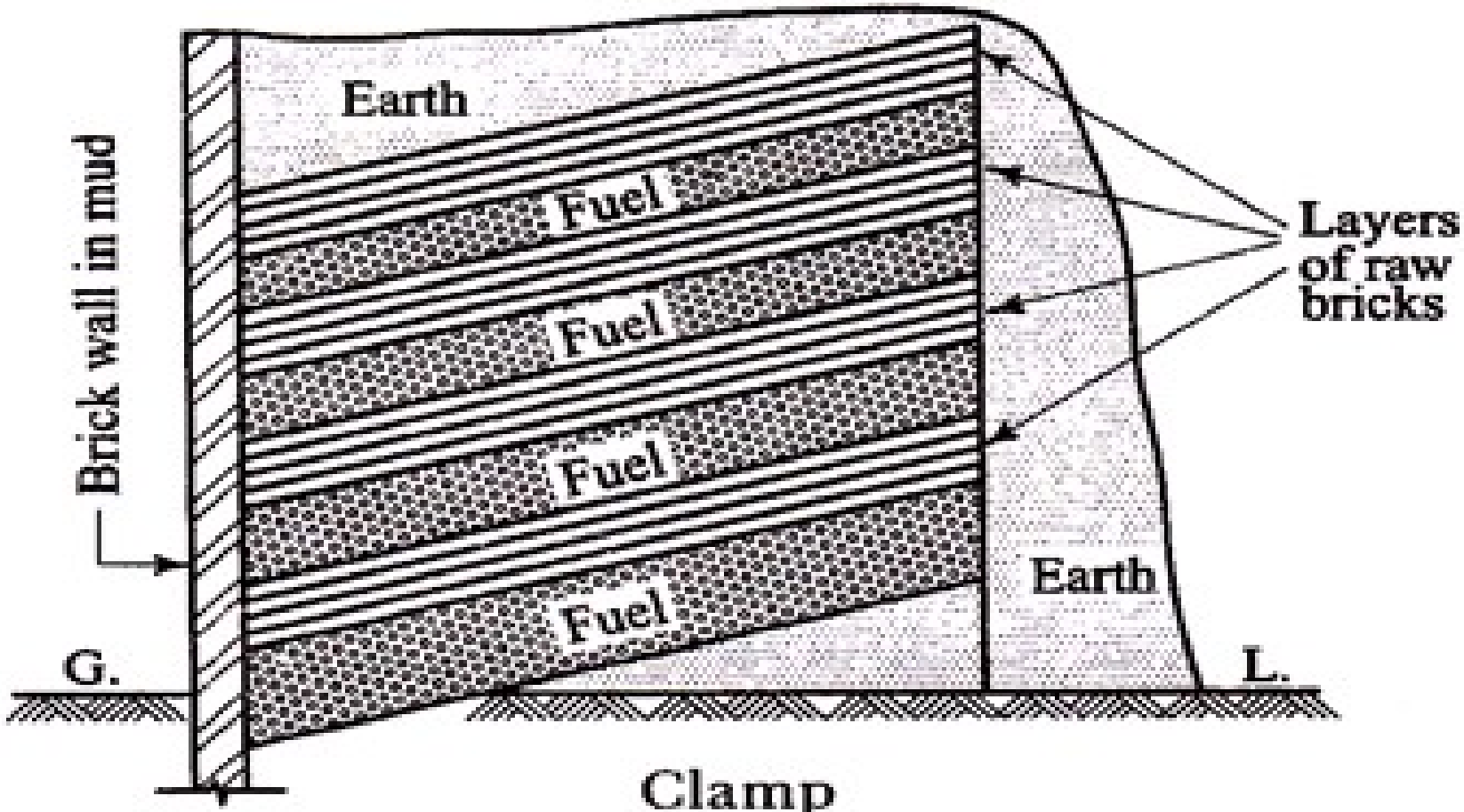
- When the temperature of dull red heat, about 650°C, is attained, the organic matter contained in the brick is oxidized and also the water of crystallization is driven away.

- The burning of bricks is done either in clamps or in kilns. The clamps are temporary structures and they are adopted to manufacture bricks on a small scale to serve a local demand or a specific purpose. The kilns are permanent structures and they are adopted to manufacture bricks on a large scale.

➢**Clamps:**

Procedure:

A typical clamp is shown in fig.



Clamp
FIG. 4-4

Following procedure is adopted in construction of clamp:

- (i) A piece of ground is selected. Its shape in plan is generally trapezoidal. The floor of clamp is prepared in such a way that short end is slightly in the excavation and wider end is raised at an angle of about 15° from ground level.

- (ii) The brick wall in mud is constructed on the short end and a layer of fuel is laid on the prepared floor. The fuel may consist of grass, cow dung, litter, husks of rice or ground nuts, etc. The thickness of this layer is about 700 mm to 800 mm. The wood or coal dust may also be used as fuel.

- (iii) A layer, consisting of 4 or 5 courses of raw bricks, is then put up. The bricks are laid on edges with small spaces between them for the circulation of air.

- (iv) A second layer of fuel is then placed and over it, another layer of raw bricks is put up. Thus alternate layers of fuel and raw bricks are formed. The thickness of fuel layer gradually decreases as the height of clamp increases.
- (v) The total height of a clamp is about 3 m to 4 m. When nearly one-third height is reached, the lower portion of the clamp is ignited. The object for such an action is to burn the bricks in lower part when the construction of upper part of clamp is in progress.

- (vi) When clamp is completely constructed, it is plastered with mud on sides and top and filled with earth to prevent the escape of heat. If there is any sudden and violent outburst of fire, it is put down by throwing earth or ashes.
- (vii) The clamp is allowed to burn for a period of about one to two months.
- (viii) It is then allowed to cool for more or less the same period as burning.
- (ix) The burnt bricks are then taken out from the clamp.

Advantages of Clamp Burning:

Following are the advantages of clamp burning:

-(i) The burning and cooling of bricks are gradual in clamps. Hence the bricks produced are tough and strong.

-(ii) The burning of bricks by clamps proves to be cheap and economical.

-(iii) No skilled labour and supervision are required for the construction and working of clamps.

-(iv) The clamp is not liable to injury from high wind or rain.

-(v) There is considerable saving of fuel.

Disadvantages of Clamp Burning:

Following are the disadvantages of clamp burning:

-(i) The bricks are not of regular shape. This may be due to the settlement of bricks when fuel near bottom is burnt and turned to ashes.

-(ii) It is a very slow process.

-(iii) It is not possible to regulate fire in a clamp once it starts burning and the bricks are liable to uneven burning.

-(iv) The quality of bricks is not uniform. The bricks near the bottom are over-burnt and those near sides and top are under-burnt.

➢Kilns:

A kiln is a large oven which is used to burn bricks.

The kilns which are used in the manufacture of bricks are of the following two types:

- (1) Intermittent kilns
- (2) Continuous kilns.

(1) Intermittent Kilns:

- These kilns are intermittent in operation which means that they are loaded, fired, cooled and unloaded. Such kilns may be either rectangular or circular in plan. They may be over-ground or underground.

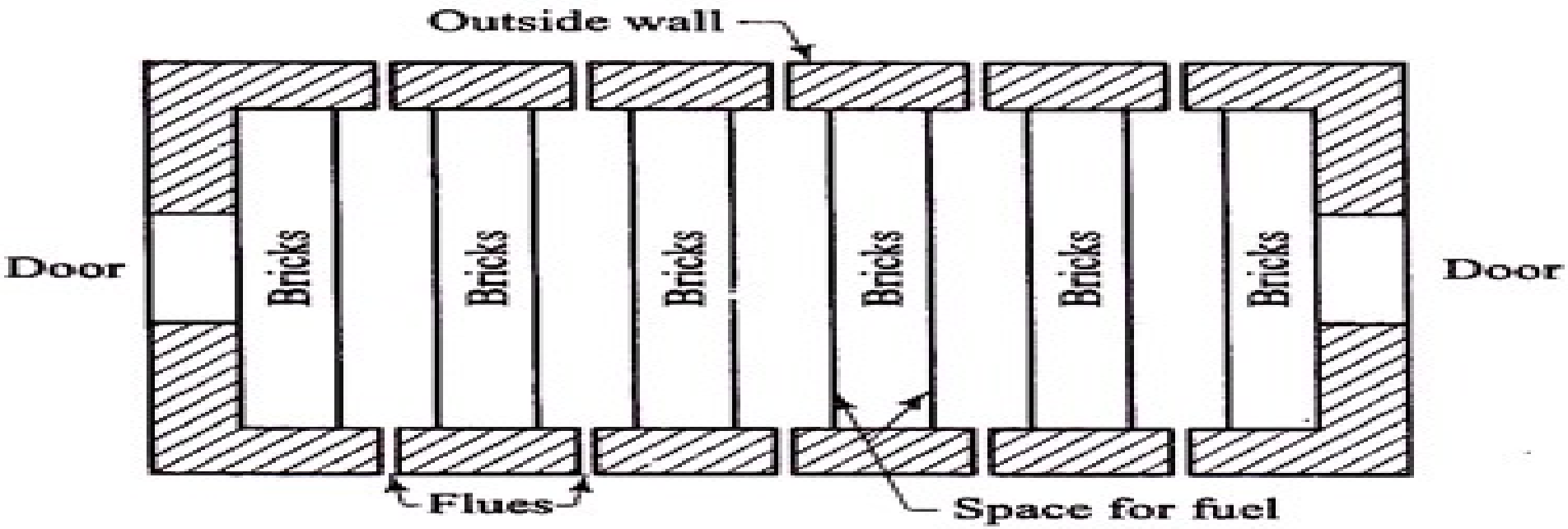
They are classified in two ways:

(i) Intermittent up-draught kilns

(ii) Intermittent down-draught kilns.

(i) Intermittent Up-Draught Kilns:

- These kilns are in the form of rectangular structures with thick outside walls. The wide doors are provided at each end for loading and unloading of kilns. The flues are channels or passages which are provided to carry flames or hot gases through the body of kiln. A temporary roof may be installed of any light material. Such roof gives protection to the raw bricks from rain while they are being placed in position. This roof is to be removed when the kiln is fired.
- Fig. shows the plan of a typical intermittent up-draught kiln.



Intermittent kiln
FIG. 4-5

(ii) Intermittent Down-Draught Kilns:

- These kilns are rectangular or circular in shape. They are provided with permanent walls and closed tight roof. The floor of the kiln has openings which are connected to a common chimney stack through flues. The working of this kiln is more or less similar to the up-draught kiln.
- But it is so arranged in this kiln that hot gases are carried through vertical flues up to the level of roof and they are then released. These hot gases move downward by the chimney draught and in doing so, they burn the bricks.

(2) Continuous Kilns:

- These kilns are continuous in operation. This means that loading, firing, cooling and unloading are carried out simultaneously in these kilns. There are various types of the continuous kilns.

Following three varieties of continuous kilns will be discussed:

(i) Bull's trench kiln

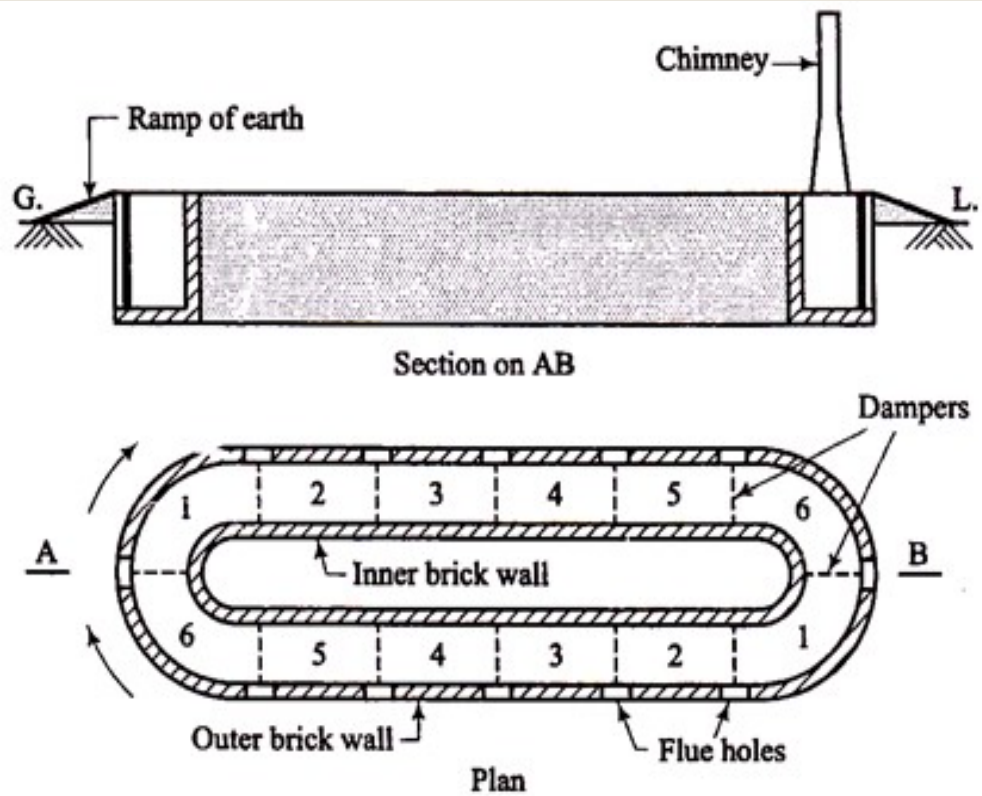
(ii) Hoffman's kiln

(iii) Tunnel kiln.

(i) Bull's Trench Kiln:

- This kiln may be of rectangular, circular or oval shape in plan.

Fig. shows a typical Bull's kiln of oval shape in plan.



Bull's trench kiln
FIG. 4-6

- As the name suggests, the kiln is constructed in a trench excavated in ground. It may be fully underground or partly projecting above ground.

- In latter case, the ramps of earth should be provided on outside walls. The outer and inner walls are to be constructed of bricks. The openings are generally provided in the outer walls to act as flue holes. The dampers are in the form of iron plates and they are used to divide the kilns in suitable sections as shown in fig. 4-6. This is the most widely used kiln in India and it gives continuous supply of bricks.

- The bricks are arranged in sections. They are arranged in such a way that flues are formed. The fuel is placed in flues and it is ignited through flue holes after covering top surface with earth and ashes to prevent the escape of heat. The flue holes are provided in sufficient number on top to insert fuel when burning is in progress.

- Usually the two movable iron chimneys are employed to form draught. These chimneys are placed in advance of section being fired. Hence the hot gases leaving the chimneys warm up the bricks in next section. Each section requires about one day to burn.

- When a section has been burnt, the flue holes are closed and it is allowed to cool down gradually. The fire is advanced to the next section and the chimneys are moved forward as shown by arrows in fig. 4-6. The Bull's trench kiln is working continuously as all the operations — loading, burning, cooling and unloading are carried out simultaneously.
- Fig. 4-6 shows Bull's kiln with two sets of sections. The two pairs of chimneys and two gangs of workers will be required to operate this kiln. A tentative arrangement for different sections may be as shown in table 4-1.

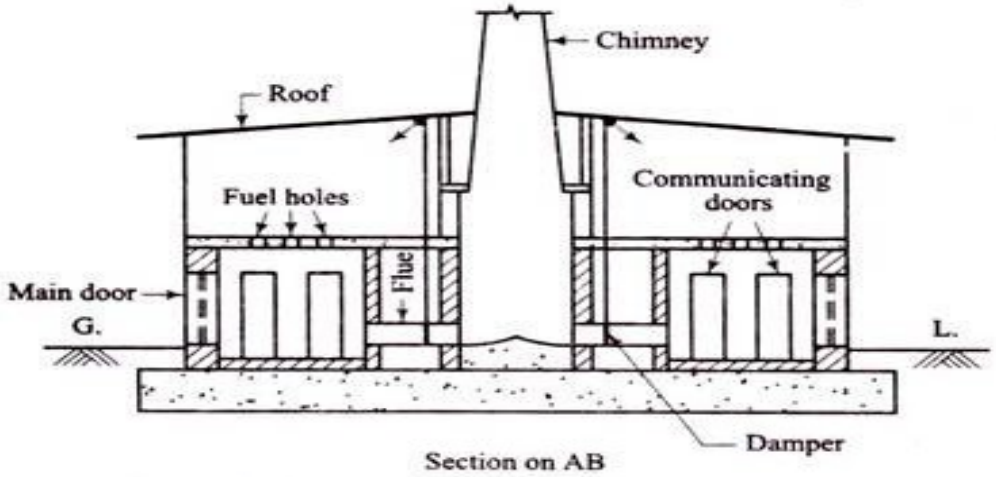
TABLE 4-1

Section	Arrangement
1	Loading
2	Empty
3	Unloading
4	Cooling
5	Burning
6	Heating

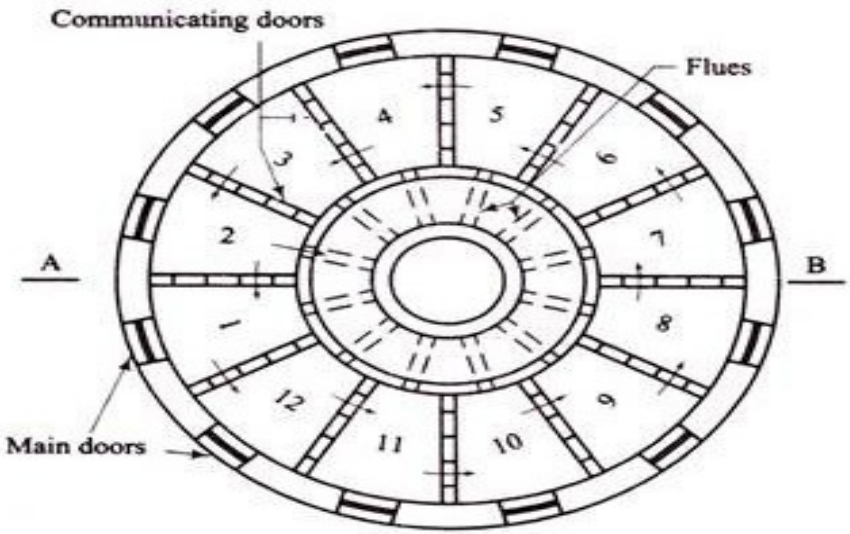
(ii) Hoffman's Kiln:

- This kiln is constructed over-ground and hence it is sometimes known as the flame kiln. Its shape is circular in plan and it is divided into a number of compartments or chambers. As a permanent roof is provided, the kiln can even function during rainy season.

Fig. shows plan and section of the Hoffman's kiln with 12 chambers.



Section on AB



Plan

Hoffman's kiln

FIG. 4-7

Each chamber is provided with the following:

- (a) A main door for loading and unloading of bricks,
- (b) Communicating doors which would act as flues in open condition,
- (c) A radial flue connected with a central chimney, and
- (d) Fuel holes with covers to drop fuel, which may be in the form of powdered coal, into burning chambers.
- The main doors are closed by dry bricks and covered with mud, when required. For communicating doors and radial flues, the dampers are provided to shut or open them. In the normal condition, only one radial flue is connected to the chimney to establish a draught.
- In this type of kiln, each chamber performs various functions in succession, namely, loading, drying, burning, cooling and unloading.

As an illustration, 12 chambers shown in fig. 4-7, may be functioning as follows:

- Chamber 1 — Loading
- Chambers 2 to 5 — Drying and pre-heating
- Chambers 6 and 7 — Burning
- Chambers 8 to 11 — Cooling
- Chamber 12 — Unloading

COMPARISON BETWEEN CLAMP BURNING AND KILN BURNING

In order to bring out points of difference between similar items of clamp burning and kiln-burning of bricks, the below chart is prepared.

No.	item	Clamp-burning	Kiln-burning
1.	capacity	About 20000 to 100000 bricks can be prepared at a time.	Average 25000 bricks can be prepared per day
2.	Cost of fuel	Low as grass, cow dung, litter, etc. may be used.	Generally high as coal dust is to be used.
3.	Initial cost	Very low as no structures are to be built.	More as permanent structures are to be constructed.
4.	Quality of bricks	The percentage of good quality bricks is small about 60% or so.	The percentage of good quality bricks is more about 90% or so.
5.	Regulation of fire	It is not possible to control or regulate fire during the process of burning.	The fire is under control throughout the process of burning.
6.	Skilled supervision	Not necessary throughout the process of burning.	The continuous skilled supervision is necessary.

No.	item	Clamp-burning	Kiln-burning
7.	structure	Temporary structure.	Permanent structure.
8.	suitability	Suitable when bricks are to be manufactured on a small scale and when the demand of bricks is not continuous.	Suitable when bricks are to be manufactured on a large scale and when there is continuous demand of bricks.
9.	Time of burning and cooling	It requires about 2 to 6 months for burning and cooling of bricks.	Actual time for burning of one chamber is about 24 hours and only about 12days are required for cooling of bricks.
10.	Wastage of heat	There is considerable wastage of heat from top and sides and hot flue gas is not properly utilized.	The hot flue gas is used to dry and pre-heat raw bricks. Hence the wastage of heat is the least.

QUALITIES OF A GOOD BRICK

The good bricks which are to be used for the construction of important structures should possess the following qualities:

i. The bricks should be table-moulded, well-burnt in kilns, copper-coloured, free from cracks and with sharp and square edges. The colour should be uniform and bright.

ii. The bricks should be uniform in shape and should be of standard size.

iii. The bricks should give a clear metallic ringing sound when struck with each other.

iv. The bricks when broken or fractured should show a bright homogeneous and uniform compact structure free from voids.

v. The brick should not absorb water more than 20% by weight for first class bricks and 22% by weight for second class bricks, when soaked in cold water for a period of 24 hours.

vi. The bricks should be sufficiently hard. No impression should be left on brick surface, when it is scratched with finger nail.

vii. The bricks should not break into pieces when dropped flat on hard ground from a height of about one metre.

viii. The bricks should have low thermal conductivity and they should be sound-proof.

ix. The bricks, when soaked in water for 24 hours, should not show deposits of white salts when allowed to dry in shade.

x. No brick should have the crushing strength below 5.50N/mm^2.

TESTING OF BRICKS

A brick is generally subjected to the following tests to find out its suitability for the construction work:

- Absorption
- Crushing strength
- Hardness
- Presence of soluble salts
- Shape and size
- Soundness
- structure

❑Absorption:

-A brick is taken and it is weighed dry

-It is then immersed in water for a period of 16 hours.

-It is weighed again and the difference in weight indicates the amount of water absorbed by the brick.

-It should not, in any case, exceed 20% of weight of dry brick.

❑Crushing strength:

-The crushing strength of a brick is found out by placing it in a compression testing machine.

-It is pressed till it breaks.

-As per BIS: 1077-1957, the minimum crushing or compressive strength of bricks is 3.50N/mm^2.

-The bricks with crushing strength of 7 to 14N/mm^2 are graded as A and those having above 14N/mm^2 are graded as AA.


absorption


Crushing strength


hardness
Nail Impression on Brick


Presence of soluble salts

❑Hardness:

-In this test, a scratch is made on brick surface with the help of a finger nail.

-If no impression is left on the surface, the brick is treated to be sufficiently hard.

❑Presence of soluble salts :

-the soluble salts, if present in bricks, will cause efflorescence on the surface of bricks.

-For finding out the presence of soluble salts in a brick, it is immersed in water for 24 hours.

-It is then taken out and allowed to dry in shade.

-The absence of grey or white deposits on its surface indicates absence of soluble salts.

-If the white deposits cover about 10%surface, the efflorescence is said to be slight and it is considered as moderate, when the white deposits cover about 50% of surface.

-If grey or white deposits are found on more than 50% of surface, the efflorescence becomes heavy and it is treated as serious, when such deposits are converted into powdery mass.

❑Shape and size:

- In this test, a brick is closely inspected.
- It should be of standard size and its shape should be truly rectangular with sharp edges.
- For this purpose, 20 bricks of standard size (190mm x 90mm x 90mm) are selected at random and they are stacked lengthwise, along the width and along the height.
- For good quality bricks, the results should be within the following permissible limits:

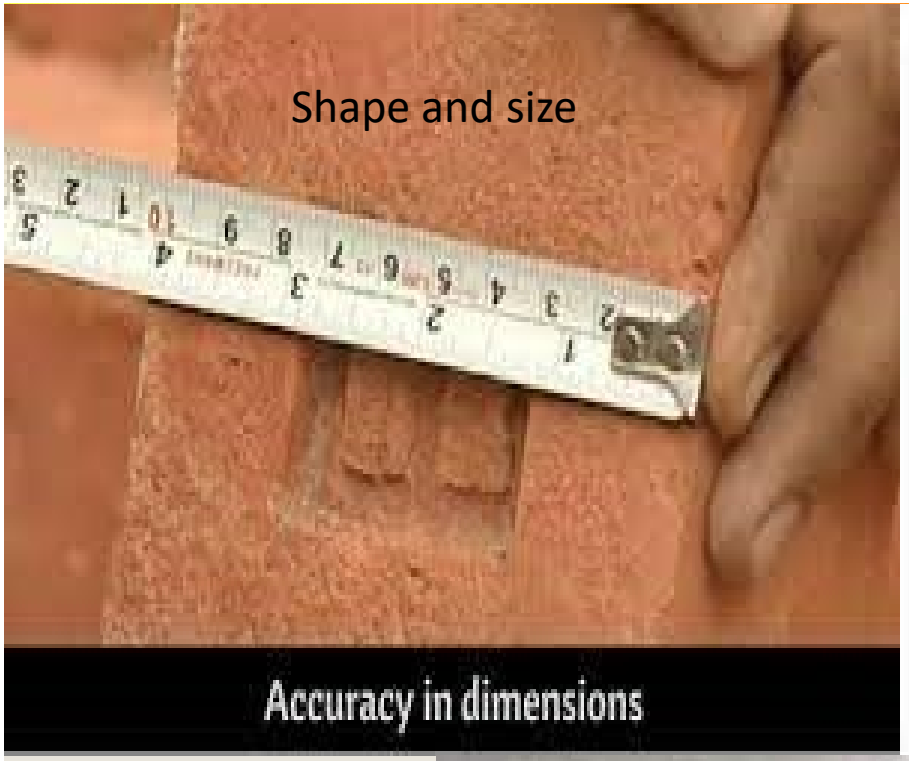
Length :	3680 mm to 3920 mm
Width :	1740 mm to 1860 mm
Height :	1740 mm to 1860 mm

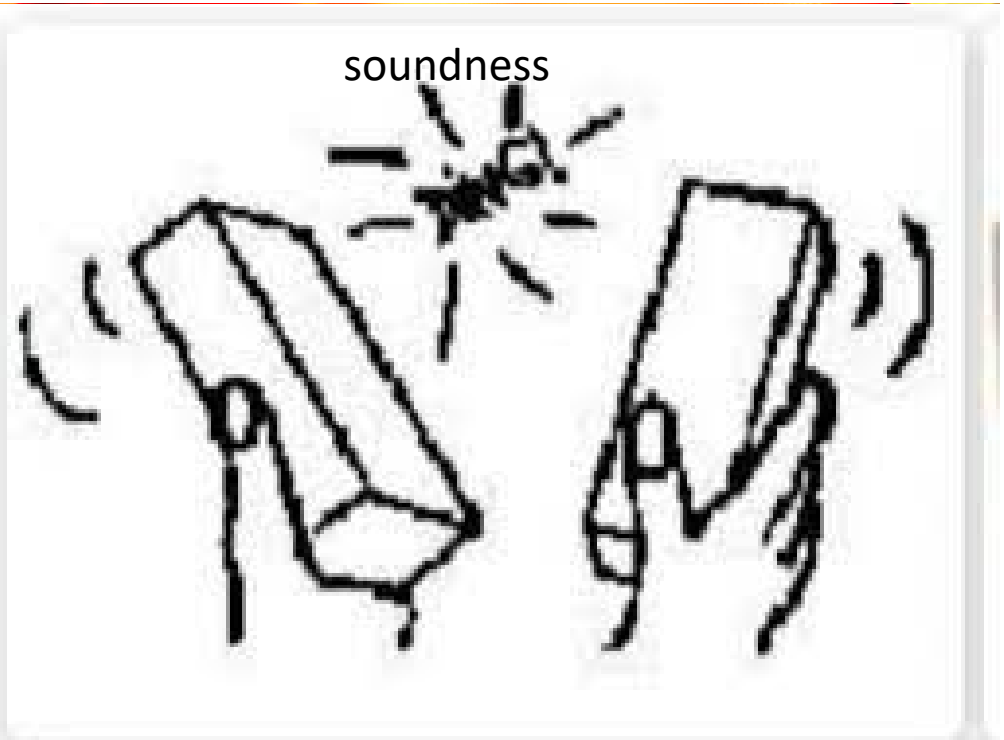
❑Soundness:

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

❑Structure:

- A brick is broken and its structure is examined.
- It should be homogeneous, compact and free from any defects such as holes, lumps, etc.


Shape and size
Accuracy in dimensions


soundness


structure

TYPES OF BRICKS:

The following types of bricks are available in market:

1. *Building bricks.*
2. *Heavy duty building bricks.*
3. *Perforated building bricks.*
4. *Hollow bricks.*
5. *Facing bricks.*
6. *Paving bricks.*
7. *Sewer bricks.*
8. *Specially shaped bricks.*
9. *Fire clay bricks.*
10. *Fly ash bricks.*

Constituents of Cement

Lime (CaO)	• 62-65%
Silica (SiO_2)	• 17-25%
Alumina (Al_2O_3)	• 3-8%
Gypsum ($CaSO_4$)	• 3-4 %
Iron Oxide (Fe_2O_3)	• 3-4%
Magnesia (MgO)	• 1-3%
Sulphur (S)	• 1-3%
Alkalies (K_2O, N_2O)	• 0.2-1

Functions of Different Constituents of Cement

1. Lime (62-65%)
   - Imparts strength and Soundness (volume)
   - Excess- makes cement unsound, causes it to expand & disintegrate
   - Deficiency- reduces strength of cement, causes it to set quickly
2. Silica(17-25%)
   - Imparts Strength to cement
   - Excess- increases strength of cement BUT increases setting time of cement
3. Alumina (3-8%)
   - Imparts quick setting property
   - Reduces clinkering temperature, if it is in excess weakens the cement

Functions of Different Constituents of Cement

4. Gypsum (3-4%)
   - Present in form of calcium sulphate
   - **Used to increase initial setting time of cement**

5. Iron Oxide (3-4%)
   - Imparts Colour, Strength and hardness to cement
   - It induces reddish brown tint to the cement

6. Magnesia (1-3%)
   - Imparts Strength and colour to cement (yellowish tint)
   - Excess- makes cement unsound

Functions of Different Constituents of Cement

7. Sulphur (1-3%)
   - It is also responsible for imparting soundness

   Note: Soundness due to lime and Magnesia can be measured directly but *no test is available to measure soundness due to sulphur*

8. Alkalies (0.2-1%)
   - Presence of alkalies causes **efflorescence** and staining of structure
   - Alkalies react with water and white grey spots are formed

Bougues Compounds

Water reacts with ingredients of Cement chemically, resulting in formation of Complex Chemical Compounds termed as Bogues Compounds, *which are not formed simultaneously*

1. TriCalcium Aluminate
2. TetraCalcium Alumino Ferrate
3. TriCalcium Silicate
4. DiCalcium Silicate

Bougues Compounds

1. TriCalcium Aluminate (C_3A or $3CaO.Al_2O_3$)
   - 4-14% by weight
   - Formed within 24 hours of addition of water in cement
   - **Responsible for maximum amount of heat of hydration**
2. TetraCalcium Alumino Ferrate (C_4AF or $4CaO.Al_2O_3.Fe_2O_3$)
   - 10-18% by weight
   - It is also formed within 24 hours of addition of water to cement
   - Amount of heat of hydration evolved during formation of this compound **initially** is comparatively more which goes on decreasing with time

Bougues Compounds

3. TriCalcium Silicate(C_3S or $3CaO.SiO_2$)
   - 45-85% by weight
   - Formed within **a week** of addition of water in cement
   - **Responsible for development of early strength of cement in initial stages**
4. DiCalcium Silicate(C_2S or $2CaO.\ SiO_2$)
   - 15-35% by weight
   - It is formed very slowly after addition of water in cement and **may require a year of so for its formation**
   - It is responsible for **progressive strength** of cement in **later stages**

Note:

✓ If **early** strength is required- increase **C_3S** (emergency road work, prefabricated construction work, etc.)

✓ Strength in required to be increased in **later** stages- increase **C_2S**

Hydration of Cement

- Heat of hydration of Ordinary Portland Cement during 7 days is about 89-90cal/gm and during 28 days is about 90-100gm
- Water- About 23% of by weight of cement is required to carry out the complete hydration
- About 15% of water is used up in filling voids of the cement particles, hence effectively 38% of water (by wt of cement) is required to carry out complete hydration

$$\underline{Rate\ of\ Hydration\ C_4AF > C_3A > C_3S > C_2S}$$

Que: Explain the manufacturing process of cement by wet process.

[SSC 2011 – 15 Marks]

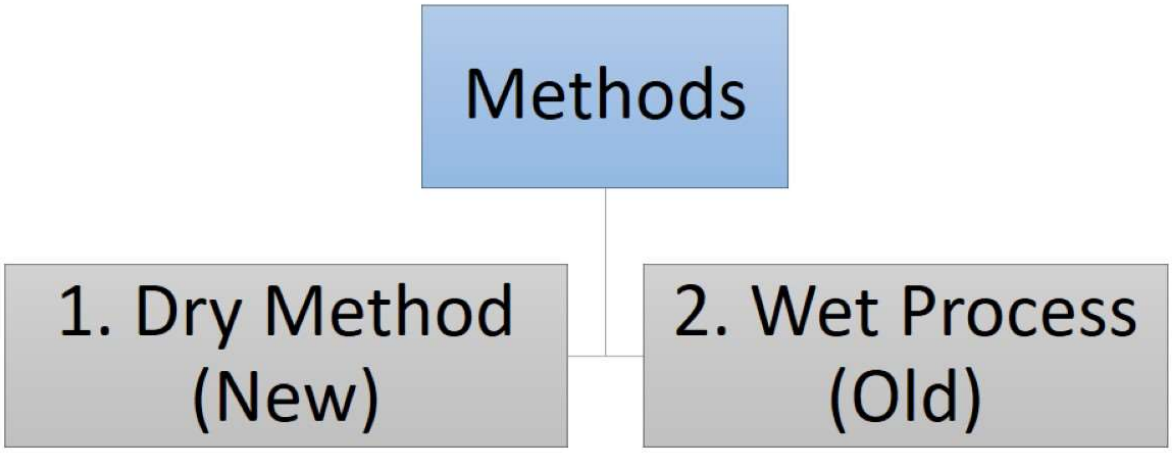
Que. Discuss the manufacture of Cement

[SSC 2010 – 10 Marks]

Manufacturing of Cement

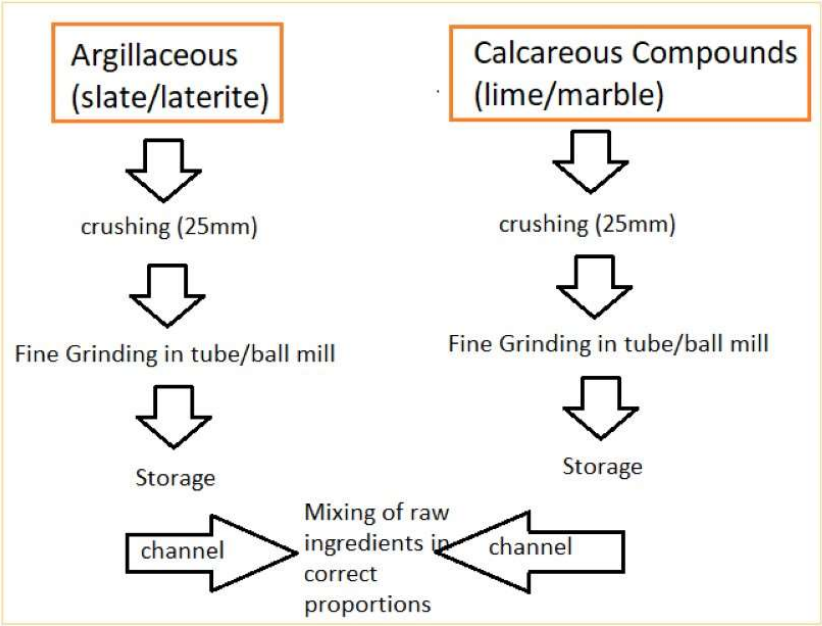
Manufacturing of cement includes three basic operations:

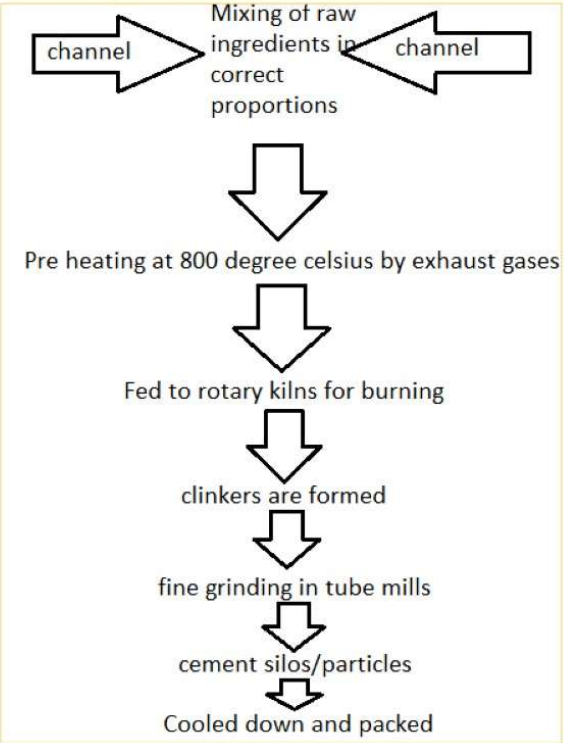
Methods of Manufacturing of Cement



Methods of Manufacturing of Cement

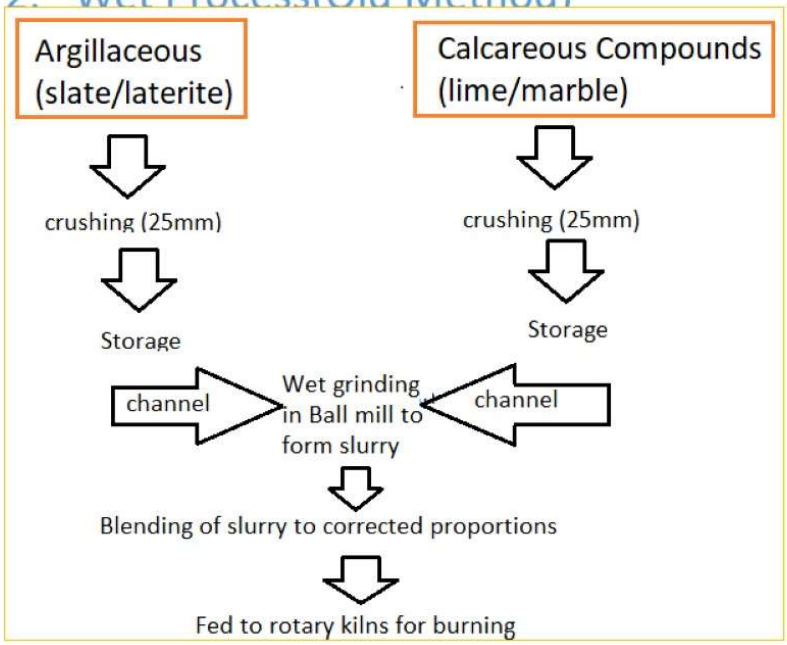
1. Dry Process(New Method)

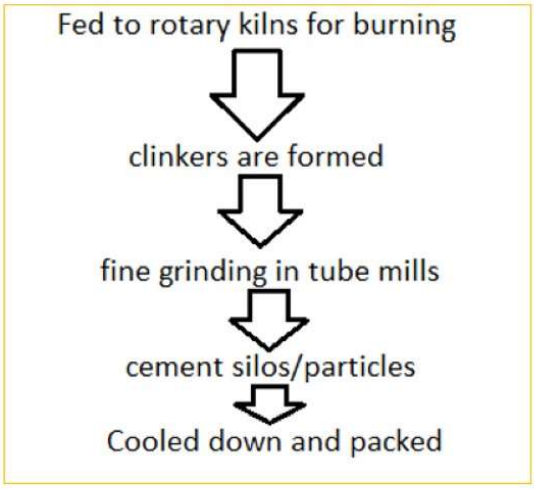




Methods of Manufacturing of Cement

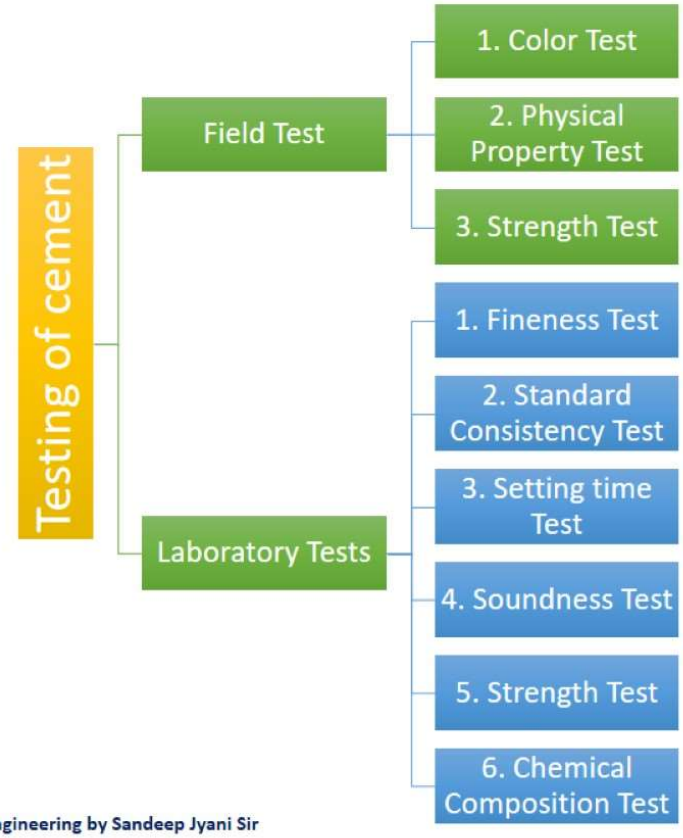
2. Wet Process(Old Method)





Testing of Cement

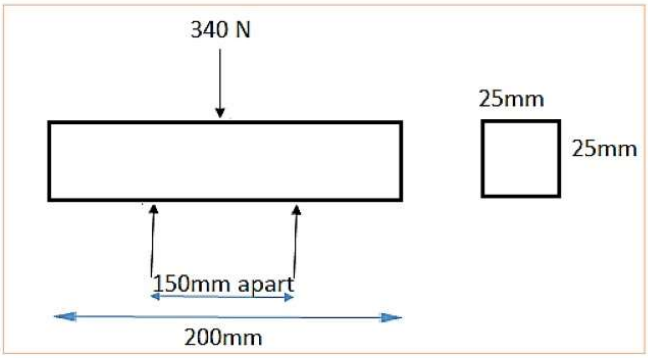
Testing of cement is carried out to analyze the presence of desirable properties in it.



Testing of Cement

I. Field Test

1. **Colour test**: Cement should possess uniform grey colour
2. **Physical Property Test**:
   - Should feel smooth when rubbed in between fingers
   - Cement should sink in water and should not float over the surface
   - Sample should be free from presence of any lumps which are formed due to absorption of moisture
3. **Strength Test**
   - Prepare a block of cement to be tested of size 25x25x200 cubic mm
   - Immerse in water for 7 days
   - Now remove the mould and subject it to point load of 340N by placing it over supports 150mm apart
   - Sample should show no sign of failure under the application of this load



Testing of Cement

II. Lab Test

1. **Fineness Test**: used to check proper grinding which has direct impact on rate of hydration, rate of gain of strength and evolution of heat

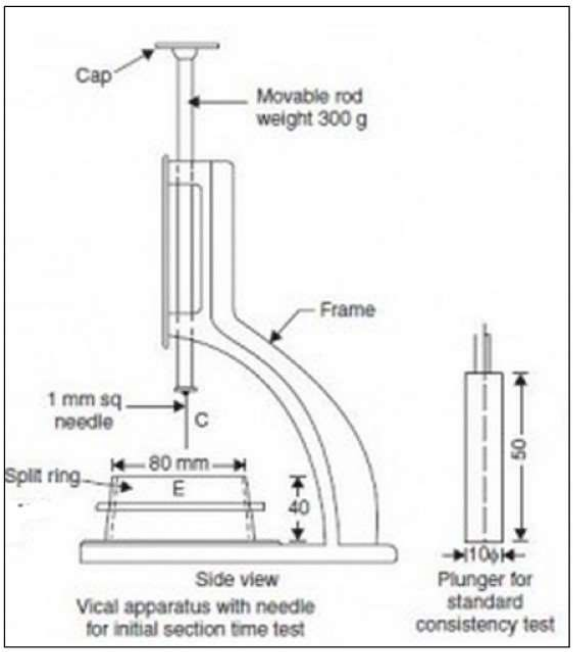
   A. Sieve Test:
   - Take 100gm of cement and place it on IS Sieve no. 9 (90 micron)
   - Perform sieving for 15mins
   - Weight of residue should not exceed 10% of original weight for OPC

   B. Air Permeability Test: represented in terms of specific surface area (cm^2/gm)
   - Blaines air permeability apparatus is used
   - Based on relationship between flow of air through cement bed and surface area of cement particles forming the bed
   - For OPC, SSA should not be less than $2250 cm^2/gm$

Testing of Cement

2. Standard Consistency Test:

- Standard Consistency should be known before we know about Setting time, soundness
- Standard Consistency-permits penetration of **vicat plunger of size 10mm dia and 50 mm height** upto a depth of **33-35mm** from top into the mould
- We find the water content at which the cement consistency is produced
- Take 500gm of cement and add 23% of water by weight of cement in first trial
- Lower the plunger gently upto surface of mould and release quickly
- The moisture content at which this cement paste of standard Consistency is produced is termed as **"P"**.



Testing of Cement

3. **Setting time Test:** carried out to know whether cement is deteriorated due to storage. Two times are associated with setting of cement:
   A. **Initial Setting Time**
   B. **Final Setting time**

A. Initial Setting time: time which is being measured from the instant water is added to cement upto the time cement **starts** loosing its plasticity.

- Take 500gm cement and gauge it with **0.85P**
- Lower the square needle gently and release it quickly
- Note time required by needle to penetrate 33-35mm from top
- This time is called Initial Setting time

✓ ***For OPC, initial setting time is 30 mins***

Testing of Cement

B. Final Setting time: time which is being measured from the instant water is added to cement up to the time cement **completely** looses its plasticity and attains sufficient firmness.

- Take 500gm cement and gauge it with **0.85P**
- Lower the annular collar with needle gently and release it quickly
- Final setting time is the time when annular collar fails to make an impression over the mould but needle does show

✓ ***For OPC, final setting time is 10 hours***

Testing of Cement

4. Soundness Test:

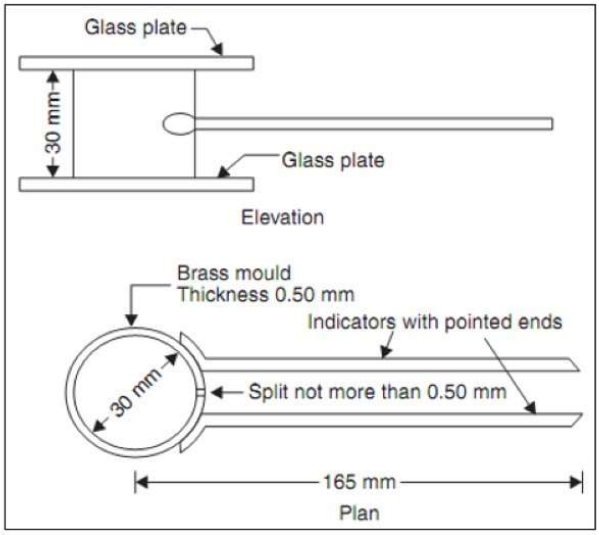
It is important that cement after setting does not show any appreciable change in volume as it seriously affects the durability of the structure

- Soundness of Cement is due to LIME, MAGNESIA and SULPHUR

A. Soundness due to Lime

- Gauge the cement with **0.78P** and fill the paste in mould
- Cover top and bottom with glass plates and immerse entire assembly in water having temperature 27-32°c for 24hours
- Remove mould and note the displacement of split with help of indicator arms
- Then again we immerse entire assembly, increase temperature in 25-30 mins upto boiling point, and maintain it for next three hours
- Note the displacement of split with the help of indicator arms

✓ **The difference in reading in both the parts of test should not exceed 10mm for OPC**



Testing of Cement

4. Soundness Test:

B. Soundness due to Lime and Magnesia

- This test is sensitive to both Lime and Magnesia
- Prepare a mould of lean cement of size 25mm(cube)
- Place in autoclave in which steam pressure is increased upto 21kg/cm^2 and is maintained for next three hours
- The mould is removed, percentage expansion of the mould is noted in each direction **which should not exceed 0.8% for OPC**

Autoclave Apparatus

Testing of Cement

5. Strength Test:

Compressive strength Test

- Cement : annure sand = 1:3
- Wt of sand 550gm and water cement ratio 0.4
- Mortar is filled in size of 70.5mm or 75mm mould and immersed in water for 7 days curing period
- Compressive strength of cement is tested in Universal Testing Machine (UTM)

✓ **At 28 days = 33N/mm^2**
✓ **At 7 days = 2/3(Strength at 28 days)**
✓ **At 3 days = 50%(Strength at 28 days)**

UTM- Universal Testing Machine

Testing of Cement

6. Chemical Composition Test:

- The ratio of alumina to iron oxide should not be less than 0.66
- The ratio of lime to silica, Alumina and iron oxide should not be greater than 1.02 and should not be less than 0.66. This ratio is termed as **Lime Saturation Factor**

$$0.66 < \frac{CaO - 0.7\ SO_3}{2.8\ SiO_2 + 1.2\ Al_2O_3 + 0.65\ Fe_2O_3} < 1.02$$

Some Important Points

- Total weight of Magnesia should not be greater than 5%
- Total loss on ignition should not be greater than 4%
- Total sulphur content should not be greater than 2.75%
- Weight of insoluble residue should not be greater than 1.5%

Types of Cement

1. Rapid Hardening Cement

- Higher rate of development of strength
- Must not be confused with quick setting cement
- Strength of RHC at the age of 3 days is same as that of OPC at 7 days
- After 90 days, strength of RHC and OPC is almost same
- Produced by fine grinding of clinkers, increasing proportion of C_3S and reducing C_2S
- Used in Pre fabricated construction work, cold weather concreting where framework is used for speedy construction

Types of Cement

2. Extra Rapid Hardening Cement

- Produced with intergrinding rapid hardening cement clinkers with **$CaCl_2$, proportion of which should not be greater than 2% of weight of cement**
- This cement should be mixed, transported, compacted and finished within 20 minutes of its formation
- This cement has approx. 20-25% higher strength than rapid hardening cement at the age of one or two days and 10-15% higher strength at the age of 7 days
- After 90 days, strength is almost same as that of OPC
- Application- same as Rapid hardening cement

Types of Cement

3. Sulphate Resisting Cement

- OPC is highly susceptible to attack of sulphates
- Its manufactured by reducing proportion of C_3A and C_4AF such that C_3A is not greater than 5% and $2\ C_3A + C_4AF$ should not be greater than 25%
- Used in foundation work, sewage treatment work, marine structures and construction of pipes in marshy areas

Types of Cement

4. Super Sulphated Cement

- Produced by intergrinding granulated blast furnace slag and 10-15% hard burned Gypsum and 5% cement clinkers
- Application – same as sulphate resisting cement

5. Portland Slag Cement

- Granulated Blast Furnace slag+ Gypsum + cement clinkers
- Offer high resistance against attack of chlorides and sulphates
- Higher water tightness property due to less permeability

6. Quick Setting Cement

- Produced by adding small quantity of Aluminum Sulphate, fine grinding the cement clinkers and reducing proportion of Gypsum
- Used in grouting operations and under water concreting

Types of Cement

7. Low Heat Cement

- Produced by reducing proportion of C_3A (about 5%) and increasing the proportion of C_2S (about 46%)
- This cement shows slow rate of development of strength
- Used where bulk concreting is required

Lime

- Lime is produced from the calcination of its ore i.e. **limestone**
- Calcination is the process in which limestone is heated up to redness, leading to the loss of carbon dioxide and moisture from it and resulting in the formation of lime

$$\boxed{(Limestone)CaCO_3 \xrightarrow{\textbf{Calcination}} CaO(Lime) + CO_2}$$

- Lime which is produced from relatively pure lime stone (% purity 90 to 95%) is termed as **Quick Lime/Caustic Lime**.

- This quick lime has very high affinity for water hence reacts rigorously with it resulting in the formation of **Hydrated or Slaked lime.**

(Quick Lime) $\mathbf{CaO + H_2O \longrightarrow Ca(OH)_2}$ (slaked lime or hydrated Lime)

- The slaked lime should be used as fresh as possible as it has very high affinity for carbon dioxide, hence reacts with it and results in the formation of precipitate of calcium carbonate.

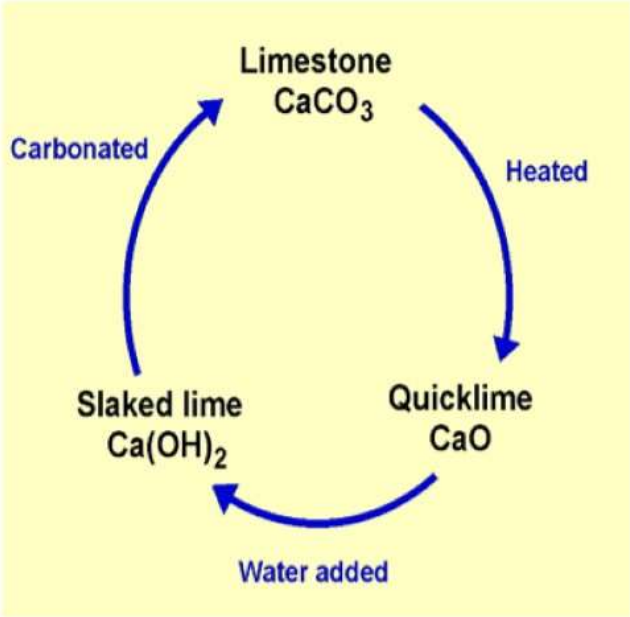
(slaked Lime) $\mathbf{Ca(OH)_2 + CO_2 \longrightarrow CaCO_3}$ (Lime stone)

Lime Cycle

$$(Limestone)CaCO_3 \xrightarrow{\text{Calcination}} CaO(Lime) + CO_2$$

$$(Quick\ Lime)CaO + H_2O \longrightarrow Ca(OH)_2\ Slaked\ lime/hydrated\ lime$$

$$(Slaked\ lime)\ Ca(OH)_2 + CO_2 \longrightarrow CaCO_3\ (Limestone)$$



Constituents of Lime

- Clay
- Soluble Silicates
- Magnesium Carbonate
- Sulphates

Constituents of Lime

1. Clay:
   - Presence of clay in lime impacts ***hydraulicity*** to it and makes it insoluble in water.
   - It should be in the range of 8 to 30%

Note: **Hydraulicity**: It is a property of lime by virtue of which it can set underwater and in damp conditions when there is no free circulation of air.

2. Soluble Silicates:
   - Silicates in the form of calcium, magnesium and aluminium also impacts Hydraulicity in lime.

Constituents of Lime

3. Magnesium Carbonate:
   - Presence of Magnesium carbonate in Lime allows it to slake and set slowly.

4. Sulphates:
   - Presence of sulphates in small quantity retards the process of slaking and increases the setting process of lime.

Types of Lime

On the basis of percentage purity of the Lime, it is generally classified into following

1. Fat/ Rich/ Pure/ High calcium/ white lime
2. Hydraulic Lime/ water Lime
3. Poor Lime/ Impure Lime/ Lean Lime

Types of Lime

1. Fat/ Rich/ Pure/ High calcium/ white lime:

- The lime which is produced from relatively pure lime stone (having percentage purity 90-95% and clay content 5 to 10%) is termed as **Pure lime/Rich Lime/ High calcium Lime**.
- This lime slakes vigorously and its volume is in increased nearly 2-2.5 times that the original volume so called **Fat Lime**
- This lime posses high plasticity and sets slowly, hence is generally used in the work where strength is not required
- This lime possess pure white color, hence is generally used for finishing work like plastering and white washing.

Types of Lime

2. Hydraulic Lime/ water Lime:

- It is the type of lime that is produced from relatively impure Lime stone (having percentage purity 70-90% and clay content 10-30%).
- This lime is capable of setting underwater on in damp condition where there is no free circulation of air, hence is being treated as Hydraulic Lime or Water Lime
- This Lime does not show slaking and sets comparatively quickly, hence is generally used for those works strength is required i.e. masonry works.
- The colour of this lime is not perfectly white hence it is not used for finishing work.

Types of Lime

3. Poor Lime/ Impure Lime/ Lean Lime:

- It is the lime which is produced from relatively impure lime stone having high percentage of impurities in it (clay content is greater than 30%)
- This lime does not slake, sets or hardens very slowly, posses poor binding property , hence is generally used for inferior works like brick walls.
- This lime possess muddy white colour

Function or Uses Of Lime

1. It is used for finishing activities like plastering or white washing.
2. It is used for masonary works.
3. It is used for stabilization of soil.
4. It is used for manufacturing of glass for reducing the temperature.
5. It acts as a flux in metallurgical operations.

What is Wood?

- Wood is a hard and fibrous substance which forms a major part of the trunk and branches of a tree.
- It can also be defined as a natural polymeric material which practically does not age.

Timber

"Wood prepared for use in building and carpentry"

Timber is used for Engineering Activities is derived from **Trees** that are generally of two types:

1. Exogenous Trees
   A. Conifer Trees (Soft wood Trees) {Chir, deodar, Pine spruce}
   B. Deciduous Trees(Hard Wood Trees) {Sal, teak, oak, babul}
2. Endogenous Trees (Bamboo, Cane, Palm)

Classification on the basis of Durability

Test specimens of size 600 × 50 × 50 mm are buried in the ground to half their lengths and their condition is noted form time to time

1. High durability: If the average life is more than 10 years.
2. Moderate durability: If the average life is 5-10 years.
3. Low durability: If the average life is less than 5 years.

Classification on the basis of Modulus of Elasticity

- **Group A**: Modulus of elasticity in bending above $12.5\ kN/mm^2$
- **Group B**: Modulus of elasticity in bending above $9.8\ kN/mm^2$ and below $12.5\ kN/mm^2$
- **Group C:** Modulus of elasticity in bending above $5.6\ kN/mm^2$ and below $9.8\ kN/mm^2$

Classification on the basis of Availability

X

- X—Most common, $1415\ m^3$ or more per year

Y

- Y—Common, $355\ m^3$ to $1415\ m^3$ per year

Z

- Z—Less common, below $355\ m^3$ per year

*Based upon the figures given by the forest departments.

Classification on the basis of Position

1. Standing Timber
   -A living tree.

2. Rough Timber:
   -It is a part of felled tree

3. Converted Timber or Lumber:
   -Logs of timber sawn into planks, posts, etc

Trees

1. Exogenous Trees
   a) These are the trees that grow in bulk by increasing in outward direction
   b) These trees never shed their leaves until new ones are grown- EVERGREEN TREES (Conifer Trees)
   c) These trees bear Coned shaped fruits hence this class of trees is known as Conifer Trees
   d) These Trees consist of Circular rings along their horizontal section that is added up each year hence is termed as Annular Rings, which is helpful in finding age of tree

Trees

1. Exogenous Trees

- The wood used for engineering purposes is mostly derived from these trees only
- These are further divided into two types:

A. Conifer trees (Soft Wood Trees)

- These trees possess distinct annular ring and indistinct medullary rays
- Light in weight, color hence soft wood
- Example- Chir, Deodar, Pine, Spruce

1. Exogenous Trees

B. Deciduous Trees (Hard Wood Trees)

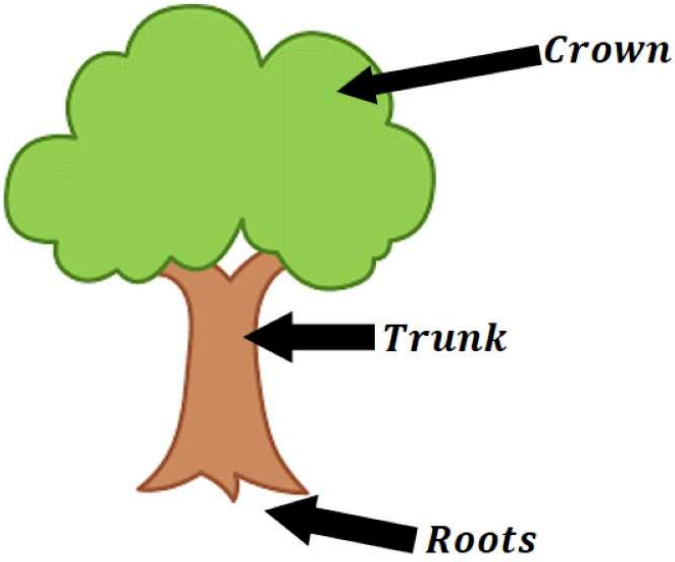
- These are also known as BROAD LEAVED TREES
- They shed their leaves in autumn which again grown back in springs
- Wood obtained for these trees is Hard, strong, non resinous and dark in color
- These possess indistinct annular rings and distinct medullary rays
- EXP: Sal, teak, Oak, Babul

Trees

2. Endogenous Trees

- These are the trees which grow in Bulk in inward direction and consist of Fibrous marks throughout their longitudinal section
- Wood obtained from these trees have limited Engineering applications
- Example: Bamboo cane, palm tree

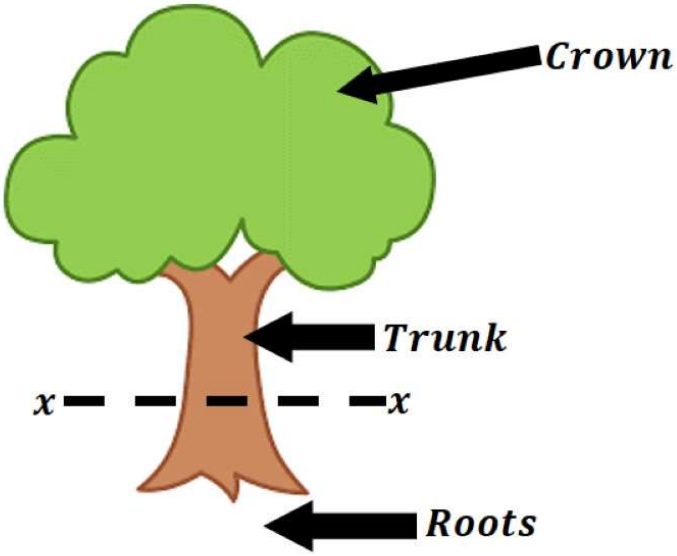
Structure of Tree

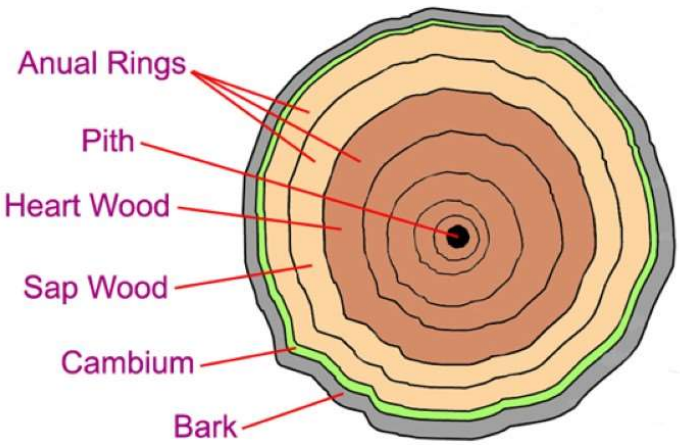


Crown **: (Branches and Leaves)**

Trunk**: Trunk consists of 80% of the bulk of wood**

Structure of Tree

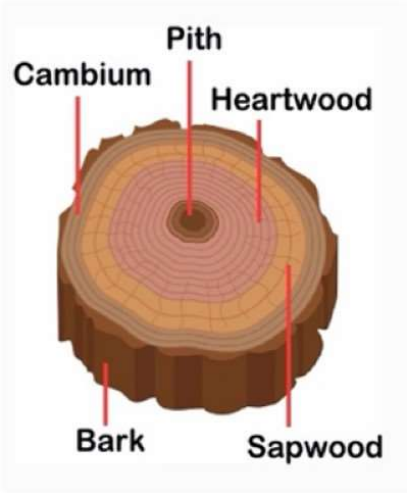




Pith-> Heart Wood -> Sap Wood->Cambium Layer->Inner bark-> Outer bark

Structure of Tree

1. Pith/Medulla:
   a) Inner most portion
   b) Entirely consists of **cellulose** (which is used for nourishment of plant in its **young age**)
   c) As **Plant** grows into **Tree**, it decays and does not take any active part in growth of the tree



2. Heartwood
   a) Inner annular ring surrounding the pith constitutes heartwood
   b) It has dark color that represents dead portion of the tree
   c) Does not participate in growth of tree but imparts **strength and rigidity** to it
   d) Wood used for engineering purposes majorly

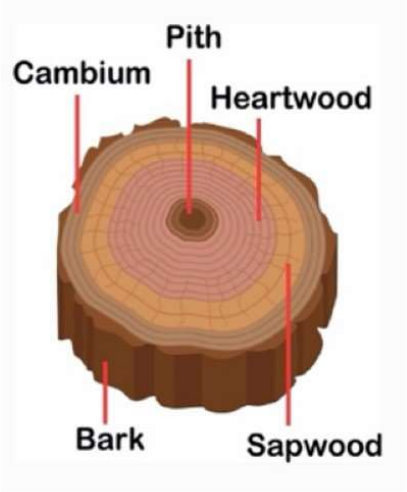
Structure of Tree

3. Sap Wood (Alburnum):

a) Outer annual rings between Heartwood and Cambium layer

b) It has light color

c) It plays active role in growth of the tree



4. Cambium Layer

a) It is the Sap being converted to Sapwood, i.e future growth of the tree is dependent upon this Cambium Layer only

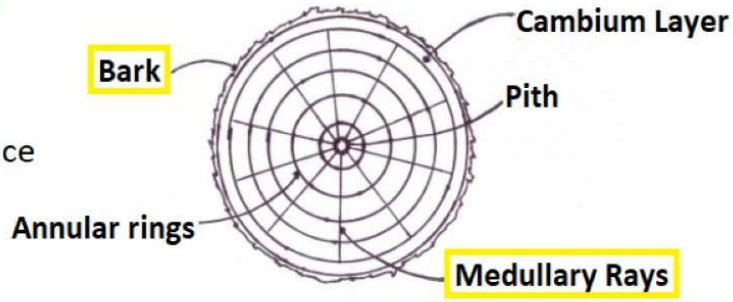
b) If due to any reason, bark of the tree is removed exposing the Cambium layer, it can lead to *Scissor of Cells* of wood in Cambium layer, which can finally lead to death of tree

Structure of Tree

5. Medullary Rays:

a) Radial Fibers extending from Pith to Cambium layer holding the annual rings of sapwood and heartwood together is termed as Medullary rays

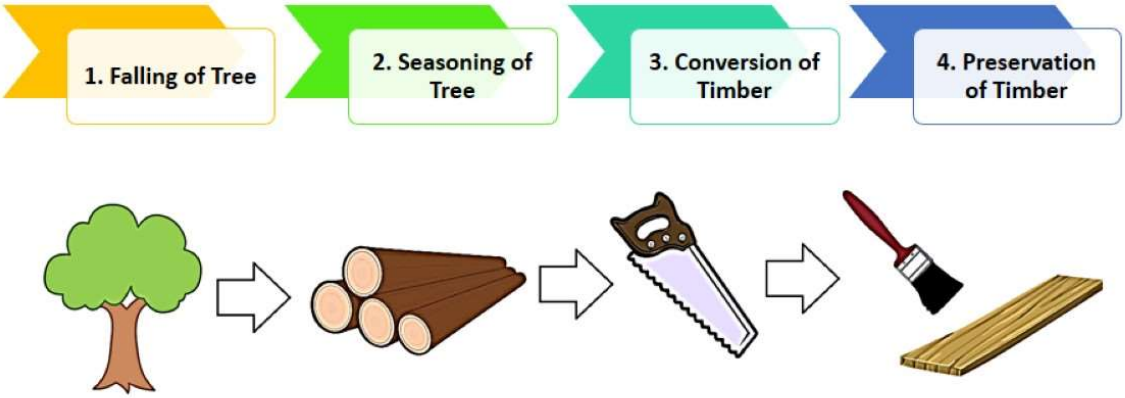
b) Strength of timber in Transverse direction is dependent on presence of Medullary rays



6. Bark

a) It is protected covering over the Cambium layer to safeguard the future growth of the tree

Processing of Timber



Processing of Timber

1. Falling of Trees

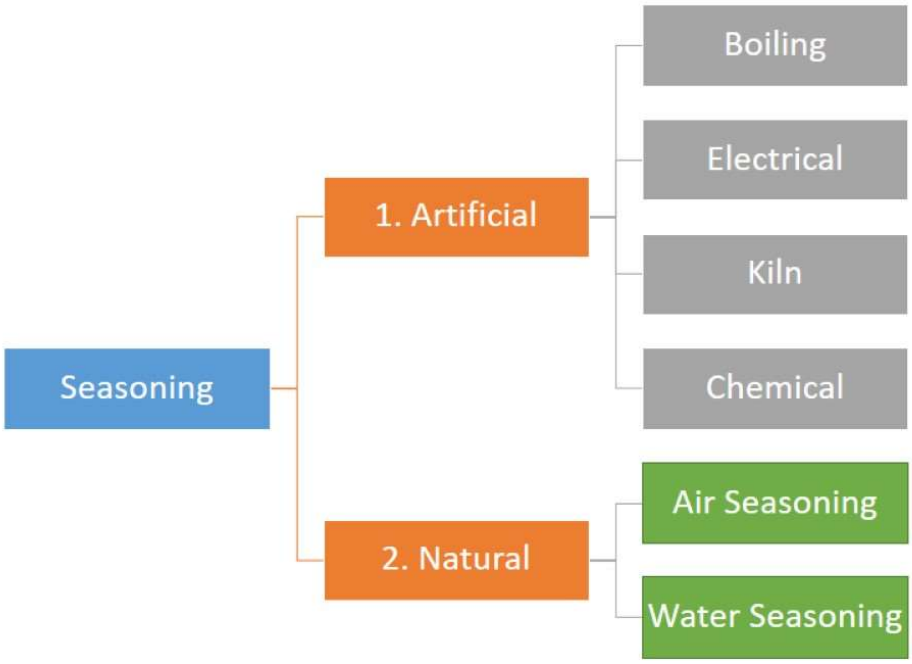
- Should be done at suitable age (optimum age 50-100yrs)
  - ❖Over Mature: Decayed wood is obtained
  - ❖Under mature: Sap wood is obtained
- Trees should be cut in such a way that maximum wood is obtained from it. Sawing is done at section just above the ground
- Sawing should be done in season when movement of Sap is minimum, hence **avoided in Autumn and Spring** when Sap movement is maximum through the section of tree
- In **hilly areas**, cutting should be done in **mid summers** as in winter- rain fall occurs
- In **Plain areas**, cutting should be done in **winters** as excessive loss of moisture may take place in summers

Processing of Timber

2. Seasoning of Trees

Newly fallen trees contain moisture up to 50%, which needs to be removed before using for any Engineering activity, this process of drying the timber to make it fit for Engineering use is called Seasoning

- Water is present in form of **Moisture and Sap**
- During seasoning, free water is removed from tree and point at which it is completely removed is termed as Fiber Saturation Point
- Seasoning is done upto moisture content of **10-12%**
- Practical limit of moisture content achieved is **15%**


Seasoning
1. Artificial
2. Natural
Boiling
Electrical
Kiln
Chemical
Air Seasoning
Water Seasoning

2. Seasoning of Timber

I. Artificial Seasoning

A. Boiling

- Logs of timber are placed in water, temperature of which is raised upto boiling point and is maintained for 3-4 hours, then dried naturally
- Increase in temperature->Quick Evaporation->Duration of seasoning decreases
- **Quickest method** of seasoning but costly

B. Electrical Seasoning

- Timber is subjected AC(Alternative Currents), as wood is bad conductor of electricity, produces heat, which is utilized in seasoning of timber

2. Seasoning of Timber

I. Artificial Seasoning

C. Kiln seasoning

- Logs of timber are placed in air tight chamber
- Fully saturated air is forced into it at temperature of 35-40°C
- Then temperature is increased gradually and does not result in evaporation, relative humidity is not reduced, hence uniformly drying the timber

D. Chemical seasoning

- Logs are immersed in Solution of salts that increase rate of evaporation and helps bring down the duration of seasoning

2. Seasoning of Timber

II. Natural Seasoning

A. Air Seasoning

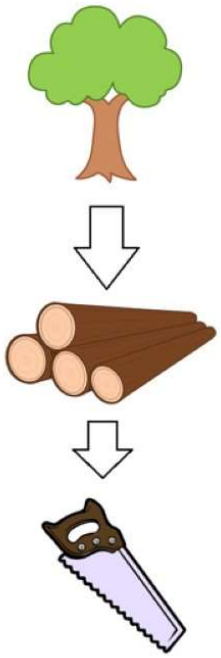
- In a shed with a platform of height 300 mm timber is stacked.
- Care is taken to see that air can circulate around each timber balk. Moisture content decreases over a period of time.

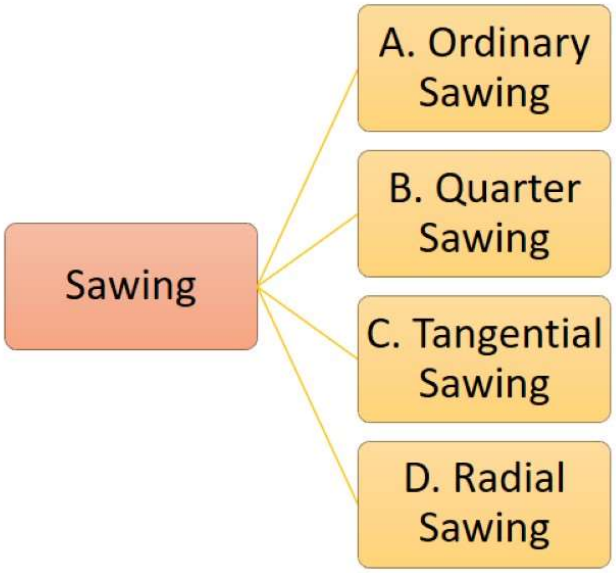
B. Water Seasoning

- Logs of Timber are immersed in water stream such that larger portion is placed upstream direction of flow
- The sap is replaced by flowing water, flowing water can be removed in shorter time

3. Conversion of Timber

Process of sawing the timber into sections of suitable shape and size is termed as Conversion of Timber

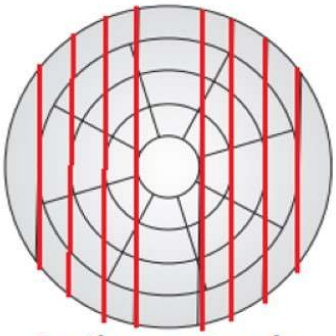




3. Conversion of Timber

A. Ordinary Sawing

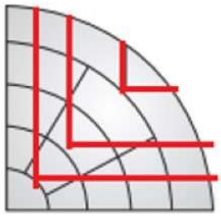
- ✓Wastage is minimum
- ✓**Most Economical**
- ✓Cuts are made tangential to Annular Rings
- Sections are liable to shrink



Ordinary Sawing

B. Quarter Sawing

- Cuts are made at right angles to each other
- ✓Used when **annual rings are indistinct**
- Sections are liable to bend in transverse direction



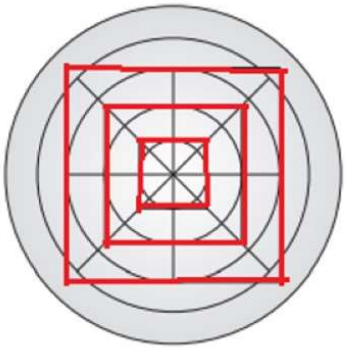
Quarter Sawing

3. Conversion of Timber

C. Tangential Sawing

- Cuts are made tangential to the annual rings that meet each other at right angle

❖**Strength obtained in this section is minimum** as medullary rays are also cut that are used for holding the annual rings in position



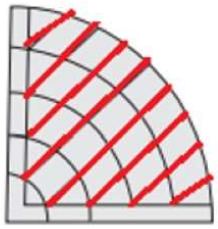
Tangential Sawing

D. Radial Sawing

- Cuts are made parallel to the medullary rays/ radial directions
- Decorative effect

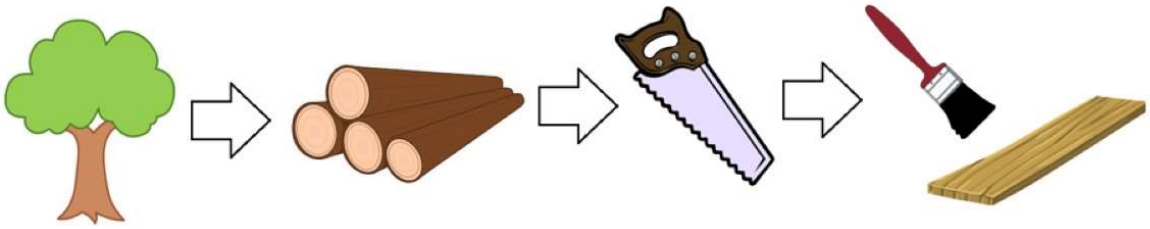
✓**Strongest Section** is obtained

❖Wastage is also maximum



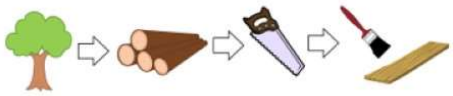
Radial Sawing

4. Preservation of Timber



- Preservation is carried out in order to increase the life of timber structure to make it more durable and increase its resistance against attack of fungi, insects, termites, etc.

4. Preservation of Timber



A. AsCu Arsenic Copper Treatment:

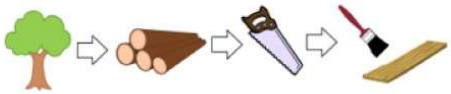
- Timber is coated with solution of Arsenic pentoxide, Copper sulphate and Potassium Dichromate

✓This treatment increases resistance against attack of white ants.

B. Chemical Salts:

- Copper sulphate, Zinc Chloride, mercury chloride, Sodium Fluoride increase the durability of Structure

4. Preservation of Timber



C. Preservation with Coal Tar:

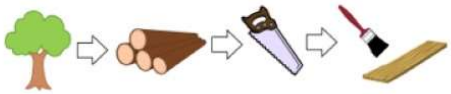
- Hot tar is applied over the surface

✓ **It increases resistance against fire**.

D. Creosote Oil :

- Produced by distillation of tar
- Application of creosote oil almost doubles life of timber
- Process of application is called Creosotic in which oil at temperature of 50°C, pressure 0.7-1 N/mm^2 is applied uniformly over the timber

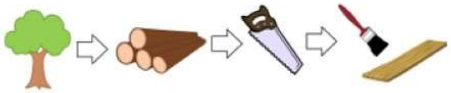
4. Preservation of Timber



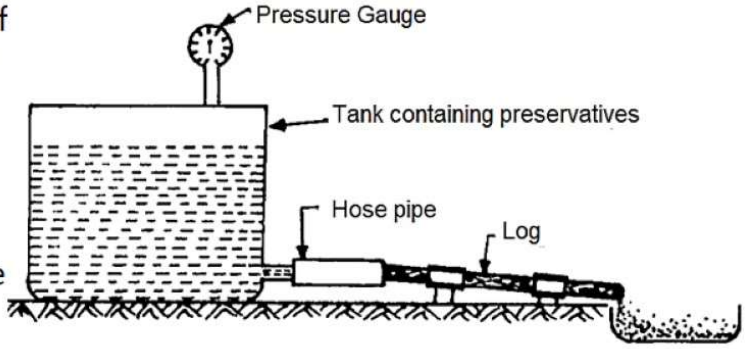
E. Oil Paints/Solignum Paints:

- Oil and solignum paints increase the resistance to water

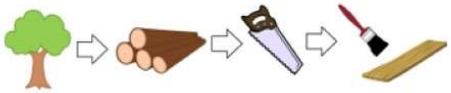
4. Preservation of Timber



- **Boucherie Process:**
- Sapwood of almost all green timbers with the bark on and of bamboos in green condition, soon after felling, can be treated using any of the inorganic water soluble preservatives by this process.
- The log of wood attached to the hose pipe and connected to the reservoir containing preservative at an air pressure of 0.1–0.2 N/mm2 on its surface
- Due to hydrostatic pressure, the preservative displaces the sap in the wood.
- The treatment is stopped when the concentration of preservative at the lower end of the log is the same as that in the reservoir



4. Preservation of Timber



- **Fuel Cell or Bethel Process:**

Defects in Timber

- Defects can occur due to:

Seasoning

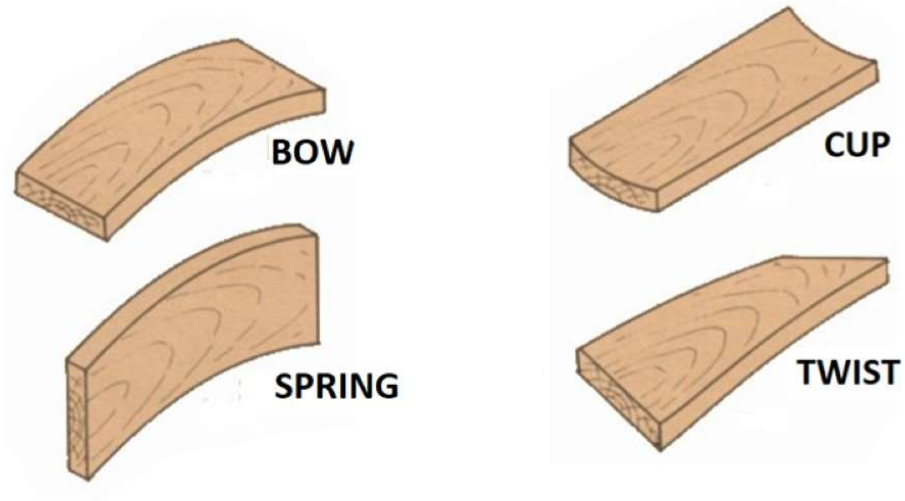
Natural Resources

Conversion of Timber

Fungi

Defects in Timber

1. Defect due to Seasoning



Defects in Timber

2. Defect due to Natural Resources

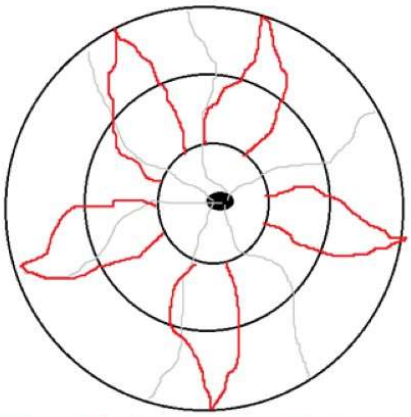
- **Checks** is a longitudinal crack which is usually normal to the annual rings. These adversly affect the durability of timber because they readily admit moisture and air.
- **Shakes** are longitudinal separations in the wood between the annual rings. These lengthwise separations reduce the allowable shear strength without much effect on compressive and tensile values. The separations make the wood undesirable when appearance is important. Boths the shakes and checks if present near the neutral plane of a beam they may materially weaken its resistance to horizontal shear.

- **Heart Shake** occurs due to shrinkage of heart wood, when tree is overmatured. Cracks start from pith and run towards sap wood. These are wider at centre and diminish outwards.
- **Cup Shake** appears as curved split which partly or wholly separates annual rings from one another. It is caused due to excessive frost action on the sap present in the tree, especially when the tree is young

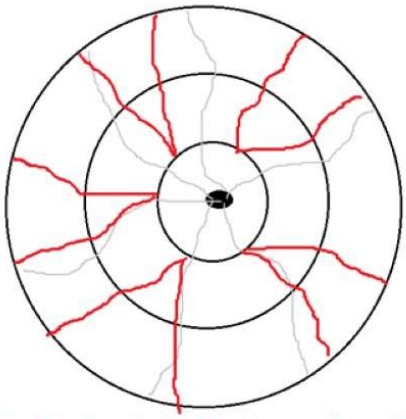
Defects in Timber

2. Defect due to Natural Resources

- Heartshakes and StarShakes: a defect in timber consisting of shrinkage and separation of tissues across the annual rings usually along the rays



Heart Shakes-Pointing Outwards

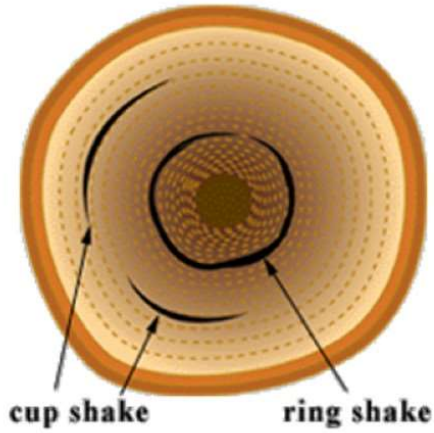


Star Shakes (pointing towards center)

Defects in Timber

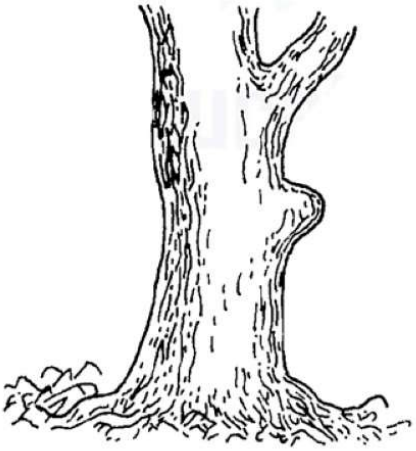
2. Defect due to Natural Resources/Abnormal Growth

- Cupshakes and Ring shake: defect in timber consisting of shrinkage and **separation of the annual rings**



Defects in Timber

2. Defect due to Natural Resources/Abnormal Growth



- **Rind Galls:** is formed by swelling caused by the growth of layers of sapwood over wounds after the branch has been cut off in an irregular manner

- **Knots:** are bases of twigs or branches buried by cambial activity of the mother branch. The root of the branch is embedded in the stem, with the formation of annual rings at right angles to those of the stem

Defects in Timber

3. Defect due to Conversion of Timber

A. Chipmark
- Formed due to marks of plaining tools

B. Torn Grain
- Depression over timber due to falling of tools

C. Diagonal Grain
- Due to improper cutting

D. Wane
- Due to presence of originally rounded surface on finished timber section

4. Defects in Timber due to Fungi

A. Blue stain: fungi carries decomposition of sap and leaving blue color spot over it
B. Brown Rot: caused due to removal of cellulose by fungi resulting in reddish color
C. White Rot: formed due to removal of Lignin(important in the formation of cell walls) leading to development of white spots
D. Dry rot: formed where there is no free circulation of air, fungi converts it to dry powdered form

4. Defects in Timber due to Fungi

E. Wet Rot: formed due to alternate wetting and drying of timber structure

Wood Products

1. What is Veneer?

Veneering is the process of manufacture of wood based products in which thin sheets of woods are produced which are known as Veneers

- The thickness of veneers varies from 0.4 to 0.6 mm.
- In no case it should exceed 1 mm.
- *Most preferable wood for veneers is Walnut*

Wood Products

2. Plywood

- A wood panel glued under pressure from an odd number (usually 3 to 13) of layers/piles of veneers is known as ***Plywood***

Faces "Faces" are outermost veneer sheets

Core "Core or Centre" are plies that have grain direction parallel to that of Faces

Cross Bands Plies which have grain directions perpendicular to that in the face are termed as "Cross Bands".