BLACK DIAMOND SCHOOL OF ENGINEERING, JHARSUGUDA

STUDY MATERIAL

ON

BUILDING MATERIAL & CONSTRUCTION TEHNOLOGY (TH-3)

THIRD SEMESTER CIVIL ENGINEERING

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STONE

Classification of Rocks :-

→ Geological classification
→ Physical classification
→ chemical classification

∴ GEOLOGICAL CLASSIFICATION

→ Igneous rocks
→ Sedimentary rocks
→ Metamorphic rocks

Igneous rocks – The rocks which are formed by the cooling of magma or molten lava are known as the igneous rocks.

Type of igneous rocks :-

→ plutonic rocks
Such rocks are formed due to cooling of magma at depth from the earth's surface.
ex Granite

→ Hypabyssal rocks
Such rocks are formed due to cooling of magma at shallow or little depth from earth surface.

The rock possess finely grained crystalline structure.

ex dolerite

→ volcanic rocks

Such rocks are formed due to the cooling of magma at the earth's surface. These rocks are extremely fine grained in structure.

ex basalt

Sedimentary rocks

When weathering take place on igneous rocks and the small particle comes out and deposited in other place are called sedimentary rock.

Type of sedimentary rocks deposits occurs:-

→ Residual deposite
→ Sedimentary deposite
→ chemical deposite
→ organic deposite

Metamorphic rocks

These rocks are formed by the change in characters of the pre-existing rocks. The igneous as well as sedimentary rocks are changed in character when they are subject to great heat and pressure.

The process of change is known as the metamorphism.

Types of metamorphism occurs:-

→ Thermal metamorphism
→ cataclastic metamorphism
→ Dynamo-thermal metamorphism
→ plutonic metamorphism

∴ PHYSICAL CLASSIFICATION

→ Stratified rocks
→ unstratified rocks
→ foliated rocks

Stratified rocks:-

These rocks possess planes of stratification and such rocks can easily split up along these planes.

unstratified rocks:-

These rocks not occurs in definite layers and cannot be split up.

foliated rocks:-

These rocks have a tendency to be split up in a definite direction only. The foliated structure is most common in case of metamorphic rocks.

Qualities of good building stone :-

∴ CRUSHING STRENGTH

For a good structural stone the crushing strength should be greater than 100 N/mm². (~~annom square~~)

ROCK	STONE	CRUSHING STRENGTH MN/m
Igneous	Basalt	150 to 185
	Riolite	90 to 150
	Granite	~~15~~ to 127
	Syenite	90 to 150
	Trap	530 to 380
Sedimentary	Laterite	1.80 to 3.10
	Limestone	54
	Sand stone	64
	Shale	0.20 to 0.60

Metamorphic	Gneiss	206 to 370
	Slate	75 to 207

∴ APPEARANCE

The stone 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.

The colour of the stone for face work should be chosen by keeping in mind the general get up of the surrounding area.

∴ 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 and other influences, location in structures, etc.

∴ FACILITY OF DRESSING

The stones should be such that they can be easily carved, moulded, cut and dressed.

∴ FRACTURE

For a good building stone, its fracture should be sharp, even, bright and clear with grains well cemented together. A dull earthy and unevenly fracture of a stone indicates signs of early future decay.

∴ HARDNESS

The coefficient of hardness, as worked out in hardness test, should be greater than 17 for a stone to be used in road work.

If it is between 14 and 17, the stone is said to be of medium hardness.

If it is less than 14, the stone is said to be of poor hardness and such stone should not be used in road work.

∴ PERCENTAGE WEAR

In attrition test, if wear is more than 3 per cent, the stone is not satisfactory. If it is equal to 3 per cent, the stone is just tolerable. For a good building stone, the wear should be equal to or less than 3 per cent.

∴ RESISTANCE TO FIRE

The minerals composing stone should be such that shape of stone is preserved when a fire occurs.

∴ SEASONING

The stones should be well seasoned before putting into use. The stones obtained fresh from a quarry contain some moisture which is known as the quarry sap. The presence of this moisture makes the stone soft. Hence the stones quarried freshly are easy to work. It is therefore desirable to do dressing, carving, etc. when stones contain quarry sap.

The stones should be dried or seasoned before they are used in structural work.

A period of about 6 to 12 months is considered to be sufficient for proper seasoning.

∴ SPECIFIC GRAVITY

For a good building stone, its specific gravity should be greater than 2.7 or 50. The heavy stones are more compact and less porous and they can be used for various engineering applications such as dams, weirs, retaining walls, docks, harbours, etc.

∴ TEXTURE

A good building stones should have compact fine crystalline structure free from cavities, cracks or patches of soft or loose material. The stones with such texture are strong and durable.

∴ TOUGHNESS INDEX

In impact test, if the value of toughness index comes below 13, the stone is not tough. If it comes between 13 and 19, the stone is said to be moderately tough. If it exceeds 19, the toughness of stone is said to be high.

∴ WATER ABSORPTION

All the stones are more or less porous, but for a good stone, percentage absorption by weight after 24 hours should not exceed 0.60. The porous stone seriously affect the durability of stones. The porous stone should be recommended for places subjected to frost, rain or moisture.

∴ WEATHERING

A good building stone should possess better weathering qualities. It should be capable of withstanding adverse effects of various atmospheric and external agencies such as rain, frost, wind, etc.

STONE QUARRYING

The process of taking out stones from natural rock beds is known as the quarrying.

The term quarry is used to indicate the exposed surface of natural rocks.

USES OF STONE

The stones are used in the construction of building from the ancient time.

Following are the various uses to which stones are employed.

∴ STRUCTURE

The stone are used for foundation, walls, columns, lintels, arches, roofs, floors, damp proof course, etc.

∴ FACE WORK

The stone are cutted to give massive appearance to the structure. The walls are of bricks and facing is done in stones of desired shades.
This is known as composite masonry.

∴ PAVING (a surface made up flat stone laid in pattern)

The stones are used to cover floor of building of various type such as commercial, residential, industrial etc.

They are also adapted to form paving of roads, footpath, etc.

∴ BASIC MATERIAL

The stones are disintegrated (break up into small parts) and converted to form a basic material for cement concrete, manufacture of roads, calcareous cement, artificial stone, hollow blocks, etc.

∴ MISCELLANEOUS

In addition of above uses the stones are also used as ballast in railway, flux in blast furnace, block in the construction of bridge, retaining wall block, light house etc.

∴ NATURAL BEDS OF STONE

The building stones are obtain from rocks. The rocks have distinct plane of division along which stone can easily be split. This plane is known as natural bed of stone and it thus indicates the plane on bed on which sedimentary ~~stone~~ rocks are originally deposited.

→ Important

The stone miscellaneous general rule is to be observe is that the direction of natural bed of all sedimentary stone should be perpendicular or nearly so to the direction of pressure such arrangement give maximum strength to the stone work.

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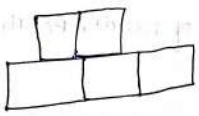


Horizontally → Vertical support
Vertically → Horizontal support

∴ DRESSING OF STONE :-

The stone after being quarried, are to be cut into suitable sizes and with suitable surface.

This process is known as dressing of stone and it carried out for the following purposes.

→ To get the desired appearance from stone work.

→ To make the transport from quarry easy and economical.

→ To suit to the requirements of stone masonary.

→ To take advantage of local man near quarry, who are trained for such type of work, etc.

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

∴ Axed finish –
The surface of hard stones such as granite are dressed by means of an axe. Such a finish is termed as an axed finish.

∴ Boasted or droved finish –
In this type of finish, the boaster is used to make non-continuous parallel marks on the stone surface. These marks may be horizontal, inclined or vertical. A boaster is a chisel having an edge of width about 80 mm.

∴ Chisel - draughted margins –
In order to obtain uniform joints for stone work, the margins are placed which may be either squared or pitched or chamfered.

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

∴ Dragged or combed finish –
In 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 as is obtained. This finish is suitable for soft stones only.

∴ 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 are formed in the projected portion. This finish is generally adopted to make the joints prominent.

∴ Moulded finish

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

∴ Hammer-dressed finish

In this type of finish, the stones are made roughly squares or rectangulars by means of a mallet'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 of the stone is made approximately smooth with a saw or with a chisel.

∴ polished finish

The surface of the stones such as marbles, granites, etc. can be polished either with hand or with machine.

∴ punched machine

On the stone surface, the depressions are made by using a punch. The surface of the stone takes the form of a series of hollows and ridges.

∴ Reticulated finish

This type of finish presents a net-like appearance. A margin, about 20 mm wide, is margin, about 20 mm wide, is marked on the edges of stone and irregular sinking are made on the enclosed space.

A margin, about 10 mm wide, is marked on the edge of stone and irregular sinking are made on the enclosed space.

A margin, about 10 mm wide, is provided around the irregularly shaped sinking, having a depth of a about 5 mm. A pointed tool is used to put the marks on the sunk surface so as to present a a pock-marked appearance.

∴ Rubbed finish

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

∴ Scabbling finish

In this type of finish, the irregular projections are removed with a scabbling hammer and in this way, the stones are roughly dressed.

∴ Tooled finish

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

∴ Self-faced or rock faced quarry faced finish

Some stones, as obtained from the quarry, possess smooth surface and they can be directly placed on the work.

∴ Sunk finish

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

∴ Vermiculated finish

The finish is just similar to rusticated type except that the sinking are more curved. This finish presents a worm-eaten appearance.

BRICKS

Bricks are structural unit of rectangular shape and convenient size are made of suitable clay by the process of moulding, drying and burning.

→ The factors why bricks is used are as follows %

1) Easy availability of clay.
2) construction method is known.
3) Ready to use size, shape, handling.
4) Cost effective.

→ COMPOSITION OF GOOD BRICKS EARTH %

1) Alumina (20% to 30%)
2) Silica (50% to 60%)
3) Lime (less than 5%)
4) oxide of iron (about 5% to 6%)
5) Magnesia

1) 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 excess than bricks shrink and warp during drying and burning & it become too hard when burnt

ii) SILICA
- A good brick should contain 50% to 60% of silica.
- The presence of this constituent prevent cracking, shrinking and warping of raw bricks.
- It imparts uniform shape to the bricks.
- The excess of silica destroys the cohesion between particles and the bricks become brittle.

iii) LIME
- A small quantity of lime not exceeding 5% is desirable in good brick earth.
- The lime prevents shrinkage of rock bricks.
- The excess of lime causes the brick to melt and hence its shape is lost.

iv) 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 imparts red colour to the bricks
- The excess of oxide of iron makes the bricks dark blue or blackish.

v) MAGNESIA
- A small quantity of magnesia in brick earth imparts yellow tint to the bricks and decreases shrinkage.
- But excess of magnesia leads to the decay of bricks.

→ Harmful ingredients in Brick Earth:-

→ LIME (excess of Lime)
→ IRON PYRITES (It is a composition of lime stone which is undesirable)
→ ALKALIES
→ PEBBLES (small stones)
→ VEGETATION AND ORGANIC MATTER

→ Manufacture of bricks

In the process of manufacturing the following four distinct operation are involve:-

→ preparation of clay
→ Moulding
→ Drying
→ Burning

→ Preparation of clay

The clay for bricks is prepared in the following order:-

i) unsoiling (upper part of soil is removed)
ii) Digging
iii) cleaning (pebble are clean)

iv) weathering (kept in atmosphere so that it will become dry)

v) Blending (Removing of the lumbs)

vi) Tempering (some temperature is provide to clay for completly dry)

* Unsoiling – The top layer of soil, about 200 mm in depth, is taken out and thrown away. It is because it contain lots of impurities.

* Digging – The clay is then dug out from the ground. It is spread on the ground leveled.

* cleaning – The clay, as obtained in the process of digging, should be cleaned of stones, pebbles, vegetable matter etc. If this particles are exces, the clay is to be washed and screened.

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

* Blending – The clay is made loose and any ingredient to be added to it, is spread out at its top. The blending makes clay fit for the next stage of tempering.

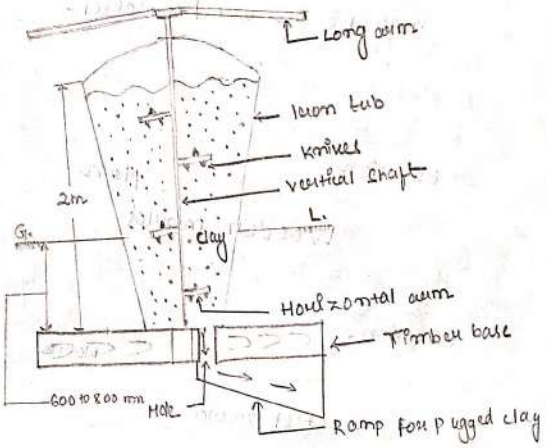
* Tempering – In the process of tempering, the clay is brought to a proper degree of hardness and it is made fit for the next operation of moulding. The tempering should not be done exhaustively to obtain homogeneous mass of clay of uniform character.

Pugging :-

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.

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



PUG MILL

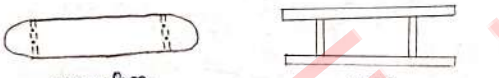
MOULDING :- The clay which is prepared as above is then sent for the next operation of moulding.

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 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.



Wooden mould

Steel mould

⇒ Type of Hand moulding

(a) Ground - moulded bricks
(b) Table - moulded bricks

→ 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 is dashed in the mould. The clay is pressed in the mould in such a way that it fills all the corners of the mould. The extra clay is removed with help of strick or wire. The mould is lifted up and raw bricks is left on ground.

→ Table - moulded bricks :-

The process of moulding these bricks is just similar as above. But in this case, the moulder stands near a table of size about 2m x 1m. The clay, mould, water pots, stock board, strickes and pasel 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 decrease gradually because of standing at the same place for long duration. The cost of brick moulding also increases when table moulding is adopted.

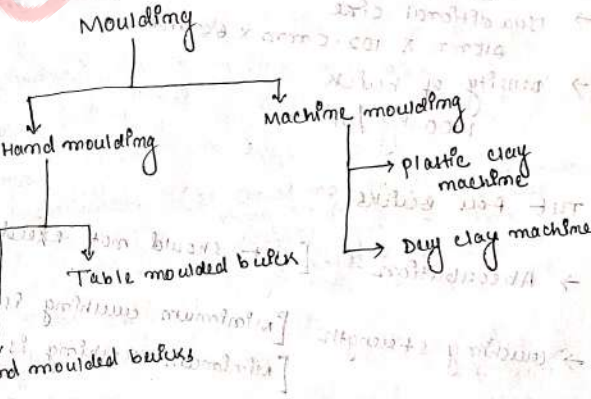
(ii) Machine moulding :- The moulding may also be achieved by machine, it proves to be economical when bricks in huge quantity are to be manufactured at the same spot in a short time.
It is also helpful for moulding hard and strong clay. These machines are broadly classified in two categories :-

(a) plastic clay machine
(b) Dry clay machine

→ plastic clay machine :-
Such machine 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 bricks are obtain. As the bricks are cut by wire, they are also known as the wire cut bricks.

→ 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 required 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 harder and stronger then ordinary hand - moulded bricks. They easily distinct from and exhibit uniform dense texture.



Hand moulding

motor – cement mixture

Important

→ In one meter cube 500 bricks are used.

→ Standard size of bricks (Nominal)
190 mm (l) x 90 mm (b) x 90 mm (h)

→ ~~Nominal~~ size (Actual size + motor)
200mm x 20 mm x 20mm

→ Modular size
215mm x 102.5mm x 65 mm

→ Density of brick
1800 kg/m³

Test for Bricks

→ Absorbation [It should not exceed 20%]

→ crushing strength [Minimum crushing is 3.50 N/mm²]
[Minimum crushing is 7 to 14 N/mm² graded as A]
[Minimum crushing is above 14 N/mm² grade AA]

→ Hardness

→ presence of soluble salts [It should not present]

→ shape and size

→ soundness → [It should not broken, it should give us clean ringing sound]

→ structure

• CLASSIFICATION OF BRICKS %

→ Unburnt or Sun dried bricks

→ Burnt Bricks

• Burnt Bricks

→ First class bricks

i) well burn

ii) 20% absorbation (It should not absorb water more than 20% of its own dry weight after 24 hour emerson in water)

→ Second class bricks

i) slightly over burn

ii) Rough surface

iii) 22% absorbation

→ Third class bricks

i) underburn, Dull sound, 23% absorbation.

→ Fourth class bricks

overburn, Irregular shape, Dark colour, It is called Jhama Bricks.

DRYING:- The damp bricks, if burnt, are likely to be cracked and deteriorated. 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 stack in alternate layers. All bricks are placed on edge. The bricks should be allowed to dry till they become leather hard or some-dry with moisture content of about 2 percent or so.

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

→ Artificial drying

→ Circulation of air

→ Drying yard

→ period for drying

→ sheers

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 overburnt, they will be brittle and hence break easily. If they are underburnt, they will be soft and hence cannot carry loads.

-: CEMENT :-

* Cement is a binding property which is used for construction purpose.

* Generally there are two types of cement that is
  → Natural cement
  → Artificial cement

- Natural cement :-
  Natural cement is obtain by burning and crushing the stone containing clay, carbonate of lime and some amount of carbonate of magnesium.

- Artificial cement :-
  The Artificial cement is obtain by burning at a very high temperature, a mixture of calcareous and argillaceous material.

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Varities of cement :-

- Ordinary portland cement (OPC)
- portland pozzoloma cement (PPC)
- portland blast furnace slag cement
- Rapid hardning portland cement
- white cement
- Blended cement

BULKING OF SAND :-

- ★ The presence of moisture in sand increases the volume of sand.
- ★ This is due to the fact that moisture causes film of water around sand particles and its results in the increase in volume of sand.
- ★ For a moisture content of about 5% to 8% this increases of volume may be as much as 20% to 40% depending upon the grading of sand.
- ★ The final the material the more will be increase in volume for a given moisture content.

WATER CEMENT RATIO :-

- ★ The water enters into chemical action with cement and this action causes setting and hardning of concrete.
- ★ The water lubricates the aggregate and it facilitated the passage of cement through the voids of aggregates. This means that water makes the concrete workable.
- ★ It is found theoretically that the water required for this two function is about 0.50 to 0.60 times the weight of cement. The ratio of amount of the water to the amount of cement by weight is termed as water cement ratio and the strength and the quality of concrete primely depends upto this ratio.

CEMENT CONCRETE :-

The cement concrete is a mixture of cement, sand pebbles or crushed rock and water which when placed in the skeleton of forms and allowed to cure, become hard like stone.

CURING

The concrete surface are kept wet for a certain period after placing of concrete so as to promote hardning of cement.

It consists of control of the temperature and of the moisture movement from and into the concrete.

PURPOSE OF CURING :-

The curing protects the concrete surface from the sun and the wind.

In presence of water is essential to cause chemical action which accompanies the setting of concrete. Normally there is an adiquit quantity of water at the time of mixing to cause hardning of concrete. But it is necessary to retain water until the concrete has fully harden.

The strength of concrete gradually increase with age if curing is efficient. The increase in strength in sudden and rapid in early stages and it continuous slowly for an indefined period.

By proper curing the durability and impermability of concrete are increased and shrinkage is reduced.

PERIOD OF CURING :-

Normally curing period is 7 days to 14 days If rapid hardning cement is used curing period can be considerable reduce.

WORKABILITY:-

The term workability is used to describe the easy or difficulty with which the concrete is handled, transported and placed between the forms with minimum loss of homogeneity.

Grading of aggregates:-

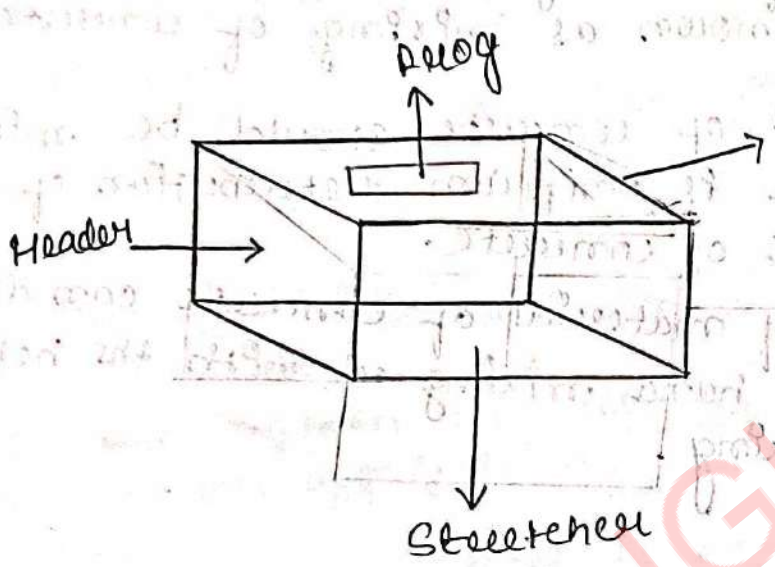
In order to ~~bot~~ obtain concrete of denser quantity the fine and coarse aggregate are properly graded.

The grading of fine aggregates is expressed in terms of BIS test. sieve nos 480, 240, 120, 60, 30, 15

The grading of fine aggregates has a mark effect on the uniformity, workablity and finishing quality of concrete.

BIS sieve	percentage by wt passing through sieve	
	natural or crushed grained sand	crushed stone sand
NO 480	95 to 100	90 to 100
NO 240	70 to 95	60 to 90
NO 120	45 to 85	40 to 18
NO 60	25 to 60	20 to 50
NO 30	5 to 30	5 to 30
NO 15	0 to 10	0 to 15

SIZE OF BRICKS :-



HEADER :-

This is a brick laid with its breadth on ~~with~~ width parallel to the face or front or direction of a wall. The course containing headers is called a header course.

Arrises :-

The edges formed by the intersection of plane surfaces of brick are called the arrises and they should be sharp, square and free from damage.

Bed :-

The lower surface of the brick when laid flat is known as the bed.

Stretcher :-

This is a brick laid with its length parallel to the face of the wall. The course containing stretcher is known as stretcher course.

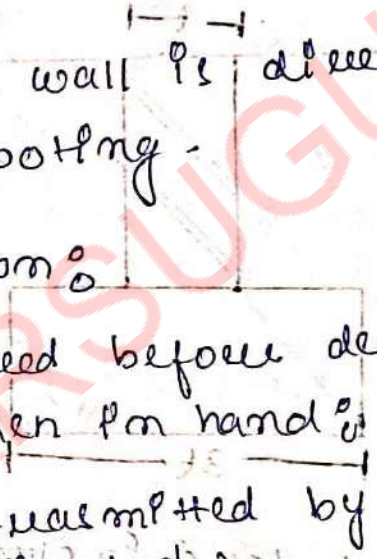
7) It provide structural safty against scouring.

Shallow foundation:

* In shallow foundation spread are provided under the base of the wall or column. this is known as footing and the foundation is known as spread foundation.

* The foundation which contain steps is known as stepped footing.

* In the foundation, if the wall is directly resting it is called simple footing.



Design of shallow foundation:

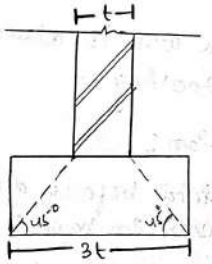
Following data are required before design of shallow foundation is taken on hand:

1. The total load to be transmitted by the wall or pier (column) to foundation bed.
2. The result of the trial pit of the strata and the corresponding bearing capacity of each strata of soil.
3. The design of shallow foundation involve two expest.
   * Width of foundation
   * Depth of foundation.

Width of foundation :-

The width of foundation is decided by adopting the following rules :-

1. If no footing are to be provided to the wall that is for simple footing the width of foundation should be equal to 3 times thickness of the wall.



2. The total load including dead load, live load and wind load coming on the wall per meter length or in case of a pier (column) at the centre of pier (column) is work out then the width of the foundation is obtain by the following relation.

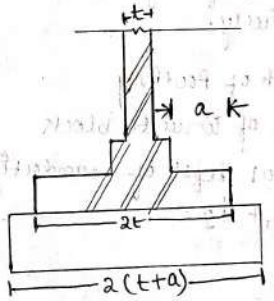
* For walls, width of foundation =

$$\frac{\text{total load per meter length}}{\text{allowable bearing capacity of soil}}$$

* For piers (column), width of foundation =

$$\left[\frac{\text{total load on the pier}}{\text{allowable bearing capacity of soil}}\right]^{1/2}$$

* Usually the walls and piers (column) are given footing such that the width and base become equal to twice the width of wall at the plinth level. By adding the width of upset of concrete the total width of foundation can be obtain for step footing.



* The greater result obtain from the rules brat (ii) and brat (iii) should be adopted.

* For loose soil Rankine's formula as given below can be used to find out minimum depth of foundation.

$$d = \frac{P}{w}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)^2$$

where

d = minimum depth of foundation in meter.

w = weight of soil in kg/m3 or KN/m3

ϕ = angle of repose.

P = load on soil in kg/m2 or KN/m2

Type of soil	Angle of repose (ϕ)
1) Loose earth	30 to 45
2) compact earth	50
3) Dry sand	25 to 35
4) Moist sand	30 to 45
5) wet sand	15 to 30
6) Clay	25 to 45
7) Gravel	30 to 40
8) Ashes	40
9) Gravel and sand	25 to 40

* For finding out of depth of concrete block the following formula can be used.

i) Depth of concrete block in cm $= \frac{1}{58}\sqrt{\frac{Pa^2}{m}}$

ii) Depth of concrete block in cm $= \frac{5}{6}t$.

where

P = total load on foundation bed in kg/m²

a = upset of concrete in cm.

m = safe modulus of rupture in kg/cm².

t = thickness of wall in cm above plinth level

Description	Modulus of rupture		
	kg/cm²	t/m²	kN/m²
1) Lime concrete	1.54	15.4	154
2) cement concrete 1:2:4	5.25	52.5	525
3) cement concrete 1:3:6	3.50	35.0	315
4) cement concrete 1:4:8	2.45	24.5	245

The depth of foundation should be found out by applying above mention rule and the greater value should be adopted.

1) End bearing pile :
The end bearing pile are used load through water or soft soil to a suitable bearing stream.

2) Friction pile :
Friction piles are used to transfer load to a depth of a friction load carrying material by means of skin friction along the length of the piles.

3) compaction pile :
compaction pile are used to compact loose granular soil thus increasing their bearing capacity. The compaction pile themselves doesn't carry any load. Hence they may be of bigger materials. Sometimes of sand only. The pile tube driven to compact the soil is gradually taken out and sand is filled in the place thus forming a sand pipe.

4) Tension pile or uplift piles :
uplift piles anchor down the structure subjected to uplift due to hydrostatic pressure.

5) Anchor pile :
Anchor pile provide encroauge against horizontal pull from sheet piling or other pooling force.

6) Fender pile :
Fender pile are used to protect water from structure against the impact from ship or other floating objects.

7) Sheet pile :
Sheet pile are commonly used to reduce seepage and uplift under hydraulic structure.

8) Batter pile :
The batter pile are used to resist large horizontal or large inclined forces.

b) classification based on material and composition :
1- concrete piles
(a) precast
(b) cast-in-situ
(i) Driven piles : cased or uncased.
(ii) Bored piles : pressure piles and under-reamed piles.
2- Timber pile
3- Steel pile
(a) H-piles (b) pipe pile (c) Sheet pile
4- composite piles.
a) concrete and timber.
b) concrete and steel.

CHAPTER-5

SAND GRAVEL,MORRUM AND FLYASH

Sand :-

-> Generally sand is formed by the decomposition of stone due to various effects of weather.

->The sand particles contains small grains of silica(SiO_2).

->There are 3 catagories of sand according to the natural sources from which it is obtained :

*Pit sand

*River sand

*see sand

PIT SAND

->These are obtained by forming pits.

->The pit is excavated from a depth of 1-2m from the ground.

->These pit sand consists of sharp , angular grains, which are free from salt.

-> these are excellent material for mortar of concrete work.

->These pit sand is rarely used now a days.

RIVER SAND

->This sand is obtained from river beds.

->This sand consists of fine rounded grains due to the action of water current.

-> The colour of river sand is white.

-> This sand is commonly used in cleaned condition, so it is used for all purposes.

SEE SAND

->This sand is obtained from see shores.

->These sand is also consist of fine rounded grains.

->The colour of this sand is light brown.

->This sand retards the setting action of cement.

CLASSIFICATION SAND ACCORDING TO THE SIZE OF GRAIN

According to the grain size of sand particles it is clasified to 3 type.

*Fine sand

*course sand

*Gravelly sand

=> The sand passing through a screen of opening of 1.5 mm is called as fine sand.These are mainly used in plastering purpose.

=> The sand passing through a screen of clear opening of 3.71 mm is called as course sand. It is mainly used for masonry work.

=> The sand passing through a c screen of clear opening of 7.61 mm is called Gravelly sand. These are commonly used for floorings, paving of road surfaces etc.

BULKING OF SAND :-

The presence of moisture in sand particles increases the volume of sand.It is due to the fact that the moisture causes a thin layerof water arround the particles which results increase in volume of sand.For a moisture content of about 5 to 8 percent , this increase in volume may be as much as 20 to 40 percent , depending upon the grading of sand. The finer the material, the more will be the increase in volume for a given moisture content . This phenomenon is known as the bulking of sand.

Qualities of sand for plaster & for Masonry work :-

- ⇨ The sand should be clean & coarse. It should be free from any organic or vegetable matter.
- ⇨ It should contain sharp, angular, coarse & durable grains.
- ⇨ It should not contain salts which attract moisture from atmosphere.
- ⇨ It should be well graded i.e, should contain particles of various sizes in suitable proportions. It should pass BIS No. 480 mesh sieve & should not pass BIS No. 15 sieve. The fineness modulus of sand should be between 2 & 3.

Grading of sand for plaster & for Masonry work :-

- ⇨ In order to obtained the concrete of good qualities , the sand should be properly graded.
- ⇨ For increasing the strength of concrete structure, the gradation should be required.
- ⇨ The grading of sand is expressed in terms of BIS test seive No. 480, 240, 120, 60, 30, 15.

⇨ The grading of sand has a marked effect bon the uniformity , workability & finishing qualities of concrete.

GRADING TABLE

BIS sieve No.	%age of wt passing through the sieve
No 480	95-100
No 240	70-95
No 120	45-85
No 60	25-60
No 30	5-30
No 15	0-10

USE OF GRAVEL :-

->There are 6 type of gravel

*1crushed gravels :- These are used in redimixed concrete.

*1round gravel :- These are used in roofing, decorating purposes etc.

*2 crushed gravel :- These are used for manufacturing of basement materials in drains .

*2round gravel :- These are used for roofing, decorating purposes .

*3crushed gravel :- These are used for basement material in roads .

*3round gravel :- These are used for decorating purposes in playgrounds.

USE OF MORRUM :-

->It is used as paving material in the construction of road.

->It is used as basement material in drains.

->It is used for filling underground tanks.

-> It is used for under laying surface of foundation.

-> It is used for flooring purposes in buildings.

USE OF FLY ASH

->It is used as an admixture in concrete.

->It also improves the strength of concrere.

-> It improves the water tightness of concrete.

-> It permits the easier placing & finishing of concrete.

-> It is used for manufacturing the building bricks.

CHAPTER-6

MORTAR AND CONCRETE

6.1 Definition & Composition

Mortar is a mechanical mixture of cement and sand having different proportion prepared by adding required quantity of water. It is also known as binding material like cement or lime.

Mortar is used as a binding material for brick masonry and stone masonry, as a covering material to walls in the form of plaster to provide a smooth, hard and decorative.

6.2 **Properties of good building Mortar**

Following are the properties of good building mortar required

1. It should be easily workable.
2. It should develop adequate strength in tension, compression and bond for the work for which it is used.
3. It should set quickly so that the speed of construction is ensured.
4. It should be durable and not affect the durability of other materials.
5. It should bind the stone and brick to give a tight joint through which water cannot penetrate.
6. It should be capable of developing the designed stressed.
7. It should be cheap.

Uses of Mortar

The following are the uses of mortar

1. It is used to fill up the spaces between bricks and stones for making wall weather tight.
2. It is used to bind together the bricks in brick masonry.
3. It is used in concrete as a matrix.
4. It is used to form joints of pipes.
5. It is used to improve general appearance of structure.
6. It is used to hide open joints of a brickwork and stonework.
7. It is used to serve as a matrix or cavity to hold coarse aggregates.
8. It is used to bind the building units such as bricks, stones, etc. into a solid mass.
9. It is used to fill up cracks detected in the structure during maintenance process.

INGREDIENTS OF MORTAR

The ingredients of various mortars used for different engineering purpose are as follows

1. Binding materials (Cement, Lime)
2. Fine aggregates (Sand, Surkhi, Ashes, Cinder)

Binding materials

Cement mortar:

In this type of mortar, cement is used as a binding material. Depending upon the strength required and importance of work, the proportion of cement to sand by volume varies to different proportions. The surkhi and cinder cannot be used in cement mortar because they are not chemically inert substances.

Function: In cement mortar, cement performs the following functions:

- It makes the mortar impermeable by filling up the voids existing in the fine aggregate.
- It imparts strength to the mortar on setting and hardening.

Lime mortar:

It is also used as a binding material in preparing the mortars for various purposes but its strength is less than that of cement mortar. The surkhi is used as the fine aggregate in this case.

Fine Aggregates (SAND)

Sand is the most important fine aggregate which is used in cement mortar. The sand forms an important ingredient of mortar.

Classification of Sand:

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

1. The sand passing through a screen with clear openings of 1.5875mm is known as the fine sand. It is mainly used for plastering.
2. The sand passing through a screen with opening of 3.175mm is known as the coarse sand. It is generally used for masonry work.
3. The sand passing through a screen with opening of 7.62mm is known as the gravelly sand. It is used for concrete work.

Properties of good Sand

Following are the properties of good sand

1. It should be chemically inert.
2. It should be clean and coarse.
3. It should be free from any organic or vegetable matter.

4. Usually 3 to 4% clay is permitted.
5. It should contain sharp, angular, coarse and durable grains.
6. It should not contain salt.

Function of sand in Mortar:

The sand is used in mortar for following purposes:

1. **Bulk:** It does not increase the strength of mortar. But it acts as adulterant. Hence the volume of mortar is increased which results in reduction in cost.
2. **Setting:** If building material is fat lime, the carbon dioxide is absorbed through the voids of sand and setting of fat lime occurs effectively.
3. Strength: it helps in the adjustment of strength of mortar by variation of its proportion with cement or lime. It also increases the resistance of mortar.
4. **Surface area:** It subdivides the paste of the binding material in to a thin film and thus more surface area is offered for its spreading.
5. **Shrinkage:** It prevents excessive shrinkage of the mortar in the course of drying and hence the cracking of mortar during setting is avoided.

PERCAUTIONS IN USING MORTAR:

Following are the precautions are to be taken while making use of mortar:

1. **Consumption of mortar:** after preparation, the mortar should be as early as possible. The lime mortar should be consumed within 36 hours after its preparation and it should be kept wet or damp. The cement mortar should be consumed within 30 minutes.
2. **Frost action:** The setting action of mortar is affected by the presence of frost. It is therefore advisable to stop the work in frosty weather or to execute it with cement mortar.
3. **Workability:** The mortar should not contain excess water and it should be selected or recommended.

CONCRETE

Definition

The cement concrete is a mixture of cement, fine aggregate (sand), coarse aggregate (crushed rock) and water, which are well proportioned and mix properly. It become hard like a stone after proper curing.

CHARACTERISTICS OF GOOD CONCRETE

A good concrete should have following characteristics:

1. It should be high compressive strength. The compressive strength should not be less than 15.5 N/mm^2.
2. On hardening, it should exhibit minimum shrinkage.
3. It should be economical for the desired strength.
4. It should have minimum thermal expansion so as to provide good resistance to fire.
5. It must be adequately dense. The density of good concrete should be about 24kN/m^3.
6. It should sufficiently hard and provide enough resistance to abrasion.
7. This property is of paramount importance when concrete is to be used for making steps of stairs and road pavements.
8. It must be adequately durable to resist the effects of weathering agents.
9. It should have provided the required finish to the concrete structure.
10. It should minimum creep.
11. It is proved to be more economical than steel. This is due to the fact that sand and aggregates, forming the bulk of cement concrete, to the extent of about 80 to 90%.

ADVANTAGES OF CONCRETE:

Following are the advantages of concrete

1. It has high compressive strength.
2. As compared to other materials, concrete is economical in long run.
3. It is durable and fire resistant and requires very little maintenance.
4. The green concrete can be easily handled and moulded into any shape or size according to specifications.
5. The concrete can be pumped and hence it can be laid in the difficult positions also.
6. Concrete can even be sprayed on and filled into the cracks for repairs by the grading process.
7. Being stored in compression, it has unlimited structural applications in in combination with steel reinforcement.

DIS-ADVANTAGES OF CONCRETE:

Following are the disadvantages of concrete

1. Concrete is to be reinforced with steel bars or meshes since it has low tensile strength and hence cracks easily developed.
2. Provision for construction joints has to be made to avoid the development of cracks due to drying shrinkage and moisture movement in fresh concrete.
3. In order to avoid the formation of cracks due to thermal movement , expansion joints have to be provided.
4. Concrete is liable to disintegrate by alkali and sulphate attack.
5. Concrete as a material lacks in ductility and this factor provides disadvantageous with respect to earthquake resistance.

USES OF CONCRETE:

Following are uses of concrete

- Foundation
- Building
- Road
- Artificial
- Airfield
- Water retaining structures
- Dock and harbour
- Dams
- Bridges
- Bunkers

GRADING OF AGGREGATES:

In order to obtain concrete of denser quality, the fine and coarse aggregates are properly graded. The grading of fine aggregate is expressed in terms of BIS test sieves nos. 480, 240, 120, 60, 30 and 15.

GRADING LIMITS FOR FINE AGGREGATES

BIS sieve	Percentage by weight through seive	
	Natural or crushed gravel sand	Crushed stone sand
No. 480	95-100	90-100
No. 240	70-95	60-90
No. 120	45-85	40-80
No. 60	25-60	20-50
No. 30	5-30	5-30
No. 15	0-10	0-15

WATER-CEMENT RATIO:

1. It is the ratio of water to cement and is expressed as ratio of the weight or volume of water to the weight or volume of cement in concrete mixture.
2. Generally it is expressed as so many litres of water per cement bag (50kg).
3. It is found theoretically that water required for these two functions is about 0.50 to 0.60 times the weight of cement.
4. The quantity of water required in litres per bag of cement as 1 litre of water weighs 1 kg. For instance, if water required for 1 bag of cement is 30 litres, the water-cement ratio is equal to $\frac{30}{50}$ **= 0.60**

REINFORCED CEMENT CONCRETE (R.C.C.)

Concrete is good in resisting compression but is very weak in resisting tension. Hence reinforcement is provided in the concrete wherever tensile stress is expected. The best reinforcement is steel, since tensile strength of steel is quite high and the bond between steel and concrete is good. As the elastic modulus of steel is high, for the same extension the force resisted by steel is high compared to concrete. However in tensile zone, hair cracks in concrete are unavoidable. Reinforcements are usually in the form of

mild steel or ribbed steel bars of 6 mm to 32 mm diameter. A cage of reinforcements is prepared as per the design requirements, kept in a form work and then green concrete is poured. After the concrete hardens, the form work is removed. The composite material of steel and concrete now called R.C.C. acts as a structural member and can resist tensile as well as compressive stresses very well.

DEFINITION OF PRESTRESS:

Prestress is defined as a method of applying pre-compression to control the stresses resulting due to external loads below the neutral axis of the beam tension developed due to external load which is more than the permissible limits of the plain concrete. The pre-compression applied (may be axial or eccentric) will induce the compressive stress below the neutral axis or as a whole of the beam c/s. Resulting either no tension or compression.

Basic Concept

Prestressed concrete is basically concrete in which internal stresses of a suitable magnitude and distribution are introduced so that the stresses resulting from the external loads are counteracted to a desired degree.

CHAPTER-7

TIMBER

Definition:

The word timber is derived from an old English word timbrian which means to build. The timber denotes wood which is suitable for building or carpentry on various engineering purpose and it is applied to the trees measuring not less than 600mm in the circumference of the trunk.

Characteristics of good Timber:

Following are the characteristics of good timber

1. It should be heavy and uniform colour.
2. It should have regular annular rings.
3. A freshly cut surface should give a sweet smell.
4. It should have straight and close fiber.
5. It should be sonorous when struck.
6. It should be heavy in weight.
7. It should be free from shacks, flaws, dead, knots of any kind.
8. The cellular tissue of the medullary rays should be hard and compact.
9. When planed, its surface should present a firm bright appearance with a silky lustre.
10. A good timber should be strong for working as structural member such as joints, beams, rafters, etc. it should be capable of taking loads slowly or suddenly.

Advantages of Timber:

Following are the advantages of timber

1. It is light in weight yet strong.

2. It is easily available and can be quickly transported by simple means.
3. The floor joints in an average dwelling weighs less than rolled-steel beams of equal strength.
4. Boards may be cut rapidly by a saw and fastened firmly together with nails.
5. It is a good insulator of heat and sound.
6. When properly protected timber structures may be give good service for hundred of years.
7. It stands shocks and bumps, a good deal better than iron and concrete.
8. Repairs, additions and alterations to timber construction are easy.
9. On account of its light weight, timber is generally preferred for building works in earthquake region.
10. It is considered to be an ideal material of construction in sea water or marine works as it can resist corrosion.

Dis-Advantages of Timber:

Following are the dis-advantages of timber

1. The greatest disadvantage is its ready combustibility, which can be diminished but not eliminated even by expensive treatment.
2. Frame buildings built closely together present a serious conflagration hazard.
3. Timber swells and undergoes shrinkage with changing atmospheric humidity.

Uses of Timber:

Following are the uses of timber

1. It is generally used in the form of piles, posts, beams, lintels, door-window frames, and leaves, roof members, etc.
2. It is employed for flooring, ceiling, paneling, and construction of partition walls.

3. It is used for formwork for concrete, for the timbering trenches, centering for arch work, scaffolding, transmission poles and fencing.
4. It is used in wagons and coach building, marine installations bridges.

CLASSIFICATION AND STRUCTURE OF TIMBER :

For the engineering purposes, the trees are classified in to **two** categories.

i.e- 1.Eexogenus Tree 2. Endogenous Tree

Exogenous Tree:

1. These trees are grow outwards and increase in bulk by the formation of successive annular rings on the outside under the bark.
2. In these trees, each annual ring represents layer of wood, deposited every year.
3. Example:- Deodar, Chir, Sal, Kail, Shishum, Teak.
4. The Exogenous trees may be further classified into two categories:
    1. Conifers Tree 2. Deciduous or broad-leafs trees

Endogenous Tree:

1. These trees are grows inwards or endwards.
2. The steams of these trees are too flexible and thus they are not much suitable for engineering works.

Structure of Tree:

A tree basically consists of three parts namely :- trunk, crown, and roots.

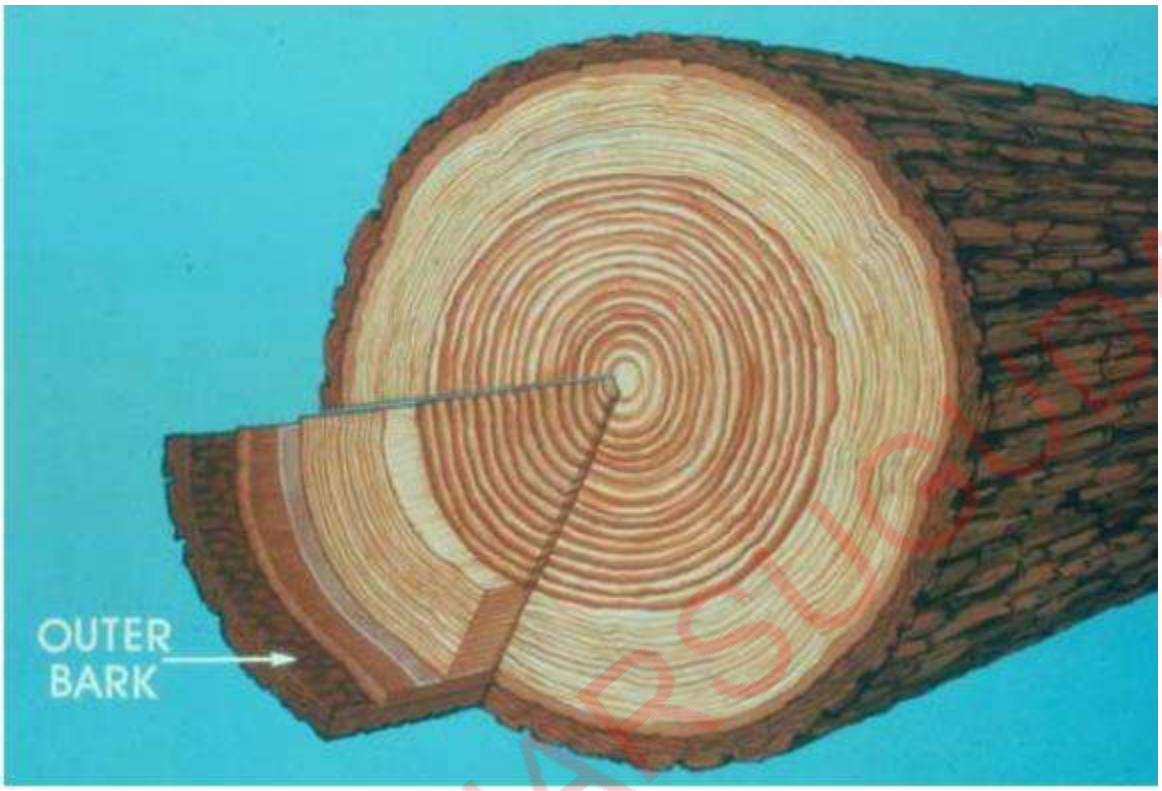
From the visibility aspect, the structure f a tree can be divided into two categories:

I. Macrostructure

II. Microstructure

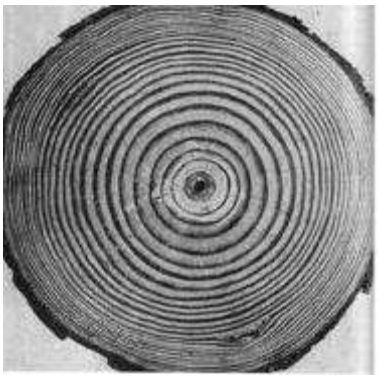
Macrostructure:

Following are the different components



1. **Pith:-** The innermost center person or core of the tree is called the pith or medullar. It varies in size and shape for different types of trees, it consist entirely of cellular tissues and it nourishes the plant in its young age when the plant becomes old the pith dies up.

2. **Heart wood:-** The inner annual rings surrounding the pith constitute the heart wood. It is usually dark in colour it indicate dead portion f tree. But it provides strong and durable timber for various engineering purpose.



3. **Sap wood:-** The outer annual rings between heart wood and cambium layer is known as the sap wood. It is usually light in colour and weight. It indicates recent growth of sap woods are less sharply defined then those of heart wood.

4. **Cambium layer:-** The thin layer of sap between sap wood and inner bark is known as cambium layer. If the bark is removed for any reason the cambium layer gets exposed and the cells are cease to be active resulting in the death of tree.

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

6. **Outer bark:-** The outer skin or cover of the tree is known as the outer bark. It is the outer most protective layer and it sometimes contains cracks. It is also known as the Cortex.

7. **Medullary ray:-** The thin radial fibers extending from pith to cambium layer are known as the medullar rays. The functions of these rays are to hold together the annual rings of heart wood and sap wood. These rays are sometimes broken.

Micro structure:

The structure of wood apparent only at great magnification is called the microstructure. It is studied under a micro scope in which living and dead cells are present.

A living cell consists of the following 4 parts:

I. Membrane

II. Protoplasm

III. Sap

IV. Core

The dead cell consists of following 3 parts:

I. Conductive cell

II. Mechanical cell

III. Storage cell

7.2 Defects in Timber:

The defects occurs in timber are grouped in to following five categories

1. Defects due to conversion
2. Defects due to fungi
3. Defects due to insects
4. Defects due to natural forces
5. Defects due to seasoning

(1) Defects due to conversion: In this case, the following defects may occurs:

I. Chip mark

II. Diagonal grain

III. Torn grain

IV. Wane

(2) Defects due to fungi: The fungi are minute microscopic plant organism. They attack timber only when the following two conditions are satisfied.

I. The moisture content f timber is above 20%.

II. There are presences of air and warmth for the growth of fungi.

Following defects are occurs in the timber by fungi:

I. Blue stain
II. Brown rot
III. Dry rot
IV. Heart rot
V. Sap rot
VI. Wet rot
VII. White rot

(3) Defects due to insects: Following are the insects which are usually responsible for the decay in timber;

I. Beetles
II. Marine borers
III. Termites

(4) Defects due to natural forces: The main natural forces responsible for causing defects in timber. Following are the defects are caused by these forces:

I. Burls
II. Callus
III. Chemical Stain
IV. Coarse Grain
V. Dead Wood
VI. Druxiness

VII. Foxiness

VIII. Knots

IX. Rind Galls

X. Shakes

XI. Twisted Fiber

XII. Upsets

XIII. Water Stain

XIV. Wind Crack

(5) Defects due to seasoning: Following are the defects occurs due to seasoning:

I. Bow

II. Case-hardening

III. Check

IV. Collapse

V. Cup

VI. Honey-combing

VII. Radial Shakes

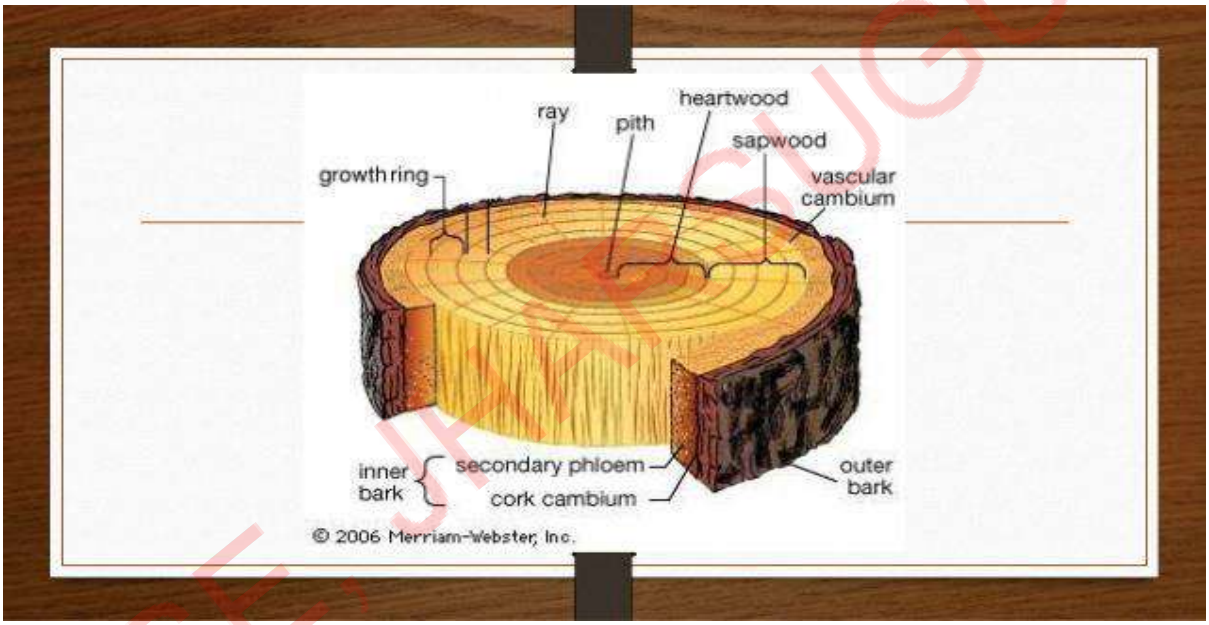
VIII. Twist

IX. Warp

Rind gall:

A defect in timber caused by a bruise in the bark which produces a callus on the wood over which later layers grow without consolidating. Or

A defect in timber caused by a bruise in the bark which produces a callus upon the wood over which the later layers grow without consolidating. Laslett, Timber and Timber Trees.

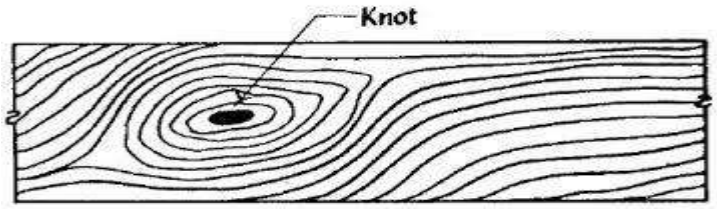


Knots

Knots are cut or broken off limbs or sprout branches, green or dead, protruding, flush, or depressed, but with exposed sound or rotten wood. If the exposed wood is sound, the knot is "sound"; if rotten, it is "unsound".

Knots are common blemishes in trees, often causing lumps or holes within the trunk of the tree itself. In most cases knots are caused by the natural growth of the tree, though the specific circumstances under which they form determines how they will appear. Some knots are formed by fungal infections, however, and

can spread to other trees on your property as well.



Quality of good Timber:

In general, the quality of god timber depends upon the following factors

1. Environmental condition of the locality.
2. Maturity of the tree.
3. Method of seasoning.
4. Nature of soil.
5. Process of preservation.
6. Time of felling.

7.3 Decay of Timber:

The timber is said to be decayed when it is so deteriorated that it losses its value as an engineering material.

Following are the various causes which favored the early decay of the timber:

1. Alternate dry and wet condition.
2. Bad storage or stacking of timber.
3. Improper seasoning.
4. Keeping timber in contact with dampness.
5. Use of timber without taking sap wood from its structure.
6. Using unseasoned timber without applying suitable preservative on its surface.

Preservation of Timber:

The preservation of timber is carried out to achieve the following three objectives:

1. To increase the life of timber structures.
2. To make the timber structures durable.
3. To protect the timber structures from the attack of destroying agents.

Requirements of a good Preservation;

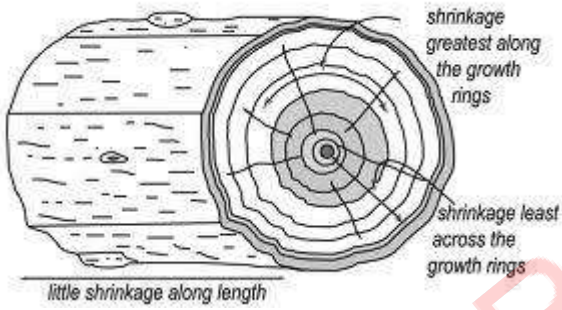
Following are the requirements of a good preservation:

1. It should be capable of covering a large area with small quantity.
2. It should be free from unpleasant smell.
3. It should be non-inflammable.

4. It should be quit efficient in killing fungi, insects etc.
5. It should not affect the strength characteristic of timber.

7.4 Seasoning of timber:

1. Seasoning of timber is the process of drying timber or removing moisture or sap, present in a freshly felled timber, under more or less controlled conditions.
2. Freshly felled timber contains a large quantity of moisture roughly from 100 to 200% based on dry weight of timber.



Objectives of seasoning

Following are the objectives of seasoning

1. To minimize the tendency of timber to shrink.
2. To increase the strength.
3. To make the timber safe against fungi and insects.
4. To make the timber easily workable in any shape.
5. To make the timber suitable for gluing.

No.	Type of timber	Thickness in mm			
		12	25	38	50
1	Non-refractory	6 Days	8 Days	12 Days	17 Days
2	Moderately refractory	7 Days	10 Days	14 Days	18 Days

3	Highly refractory	9 Days	12 Days	17 Days	22 Days

Diseases of Timber:

The common diseases of the timber are

I. Dry rot

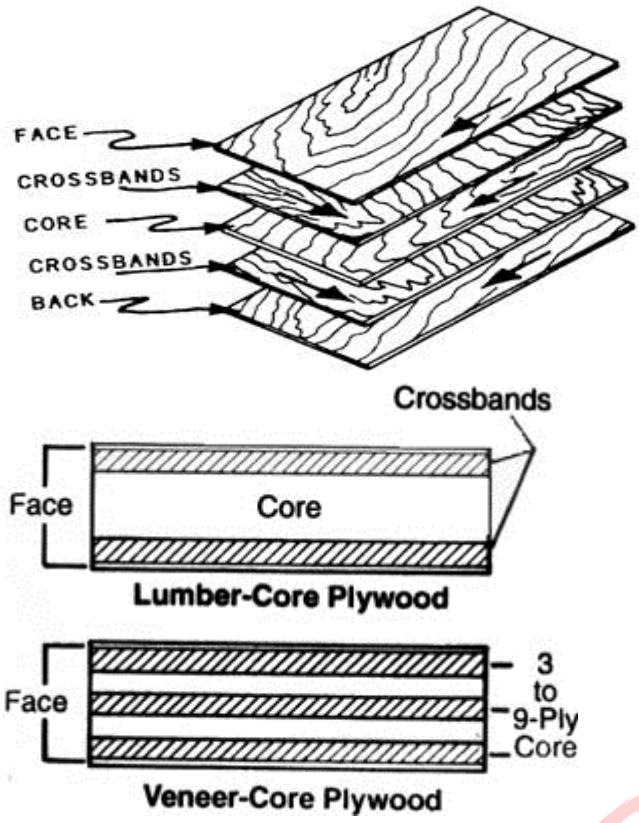
II. Wet rot

Timbers are suitable for various uses:

Sl.No.	Application/Uses	Timber
1	Sports goods and baskets.	Ash, Oak, Mulberry.
2	Match industry.	Pine, Simul.
3	Bulk carts.	Babul.
4	Musical instruments.	Jack.
5	Railway sleepers.	Deodar, Kail, Sal, Ash.
6	Well curbs.	Mango, Jack, Simul.
7	Doors and Windows.	Sal, Deodar.
8	Scaffolding	Bamboo, Sal.
9	Agricultural tools	Babu, Ash, Mulberry.
10	High class journey and furniture	Teak, Shishum, Walnut.

7.5 Plywood:

Plywood is made by cementing together several layers of wood which may be thin veneers or thicker boards.



The advantages of plywood are

1. Better appearance.
2. Easily workable and capable of being shared to numerous design.
3. Uniform tensile strength in all direction.
4. Light in weight and greater strength.

CHAPTER-8

PAINTS, VARNISHES AND DISTEMPERS

The paints are coatings of fluid materials and the are applied over the surfaces of timber and metals. The varnishes are transparent or nearly transparent solutions of resinous materials and they are applied over the painted surfaces. The distempers are applied over the plastered Surface.

Purpose of Painting a surface :

Following are the objects of painting a surface:

(i) It protects the surface from weathering effects of the atmosphere and actions by other liquids, fumes and gases.

(ii) It prevents decay of wood and corrosion in metal.

(iii) It is used to give good appearance to the surface. The decorative effects May be created by painting and the surface becomes hygienically good clean, colourful and attractive.

(iv) It provides a smooth surface for easy cleaning.

CHARACTERISTICS OF AN IDEAL PAINT

Following are the characteristics of an ideal paint:

(i) It should possess a good spreading power i.e. maximum area Of the surface should be covered by minimum quantity of the paint.

(ii) The paint should be fairly cheap and economical.

(iii) The paint should be such that it can be easily and freely applied on the surface.

(iv) The paint should be such that it dries in reasonable time and not too rapidly.

(v) The paint should be such that its colour is maintained for a long time.

(vi) The paint should form a hard and durable surface.

(vii) The paint should not affect health of workers during its application.

(viii) The paint should not be affected by weathering actions of the atmosphere.

(ix) The paint should possess attractive and pleasing appearance.

(x) The surface coated with paint should not show cracks when the paint dries.

(xi) When applied on the surface, the paint should form a thin film of uniform nature.

INGREDIENTS OF AN ideal PAINT

An Oil paint essentially consists of the following ingredients:

(1) a base,
(2) a vehicle or carrier,
(3) a drier,
(4) a coloring pigment, and
(5) a solvent.

(1) Bases: A base is a solid substance in a fine state of division and it forms the bulk of a paint. It determines the character of the paint and imparts durability to the surface which is painted. It reduces shrinkage cracks formed on drying and it also forms an opaque layer to obscure the surface of material to be painted

BASES FOR PAINTS

1. White lead
   i. This is a carbonate of lead and it forms the base of lead paints. It possesses good bulk and is the most widely used base.
2. Red lead
   i. This is an oxide of lead and it forms the base of lead paints.
   ii. It is quite suitable for painting iron surfaces and for providing a priming coat to the wood surfaces.
3. Oxide of zinc or zinc white
   i. This is an oxide of zinc and it forms the base of all zinc paints.
   ii. It is smooth, transparent and non poisonous.
4. Oxide of iron
   i. This is an oxide of iron and it forms the base of all iron paints .
5. Titanium white
   i. This material possesses intense opacity
6. Antimony white
   i. This is nearly similar to the titanium white.
7. Aluminium powder
   i. This forms the bulk of aluminium paints.

(2) Vehicles

The vehicles are the liquid substances which hold the ingredients of a paint in liquid suspension. They are required mainly for two reasons:

(i) to make it possible to spread the paint evenly and uniformly on the surface in the form of a thin layer; and

(ii) to provide a binder for the ingredients of a paint so that they may stick or adhere to the surface

VEHICLES FOR PAINTS

1 Linseed oil

(i) This is the most common material used as vehicle of a paint. It is extracted from flax seeds. The linseed oil prepared from fine full-grown ripe seeds is clear transparent, pale , sweet to the taste and practically odourless. It is used in various grades.

2 nut oil

(i) This oil is extracted from ordinary walnuts. It is nearly colourless and dries rapidly It does not provide a durable finish and is used for ordinary work as it is cheap.

(3) Driers:

These substances accelerate the process of drying. A drier absorbs oxygen from the air and transfers it to the linseed oil , which in turn, gets hardended .
The various patented driers are available in the market. They may be either in the form of soluble driers or paste driers.The former driers are compounds of metals such as cobalt,lead,manganese, etc. dissolved in linseed oil or some other volatile liquid. The latter driers are compounds of the same metal.

The litharge, red lead and sulphate of manganese can also be used as driers. The litharge is the most commonly used drier , the proportion being 1.25 N to 5 litres of oil . the red lead is less effective than litharge and it is to be used when its addition does not interfere with the tint of the paint. The sulphate of manganese is used with zinc paints so as to eliminate the risk of discolouration of a lead drier.

(4) Colouring pigments:

when it is desired to have a different colour than the base of a paint, a colouring pigment is to be added. The pigments are available in the form of fine powders in various colours and qualities.

(5) Solvents:

The function of a solvent is to make the paint thin so that i can be easily applied on the surface. It also helps the paint in penetrating through the porous surfaces. The most commonly used solvent is the spirit of turpentine.
The turpentine is inflammable, evaporates rapidly and dries the oil consequently. The use of a thinner in paint reduces the protective value of the coating, flattens Colours and lessens the gloss of the linseed oil as the spirits evaporate leaving an excess of colour not mixed with the oil.

THE PROCESS OF PAINTING

Brushes: It is necessary to have good brushes for painting. The brushes should be composed of bristles and not of horse hairs. The bristle brushes are elastic and possess good paint-holding capacity. The bristles are splits at ends and in this respect they can be distinguished from horse hairs.

Paints: The readymixed Paints of different make and various brand are available in the market. They are available in different tints and can be applied in the same form as received. The ready paints are normally expensive and they are to be used soon after opening the sealed container because of the fat that volatisation of the vehicle and solvent will take place when exposed to the atmospheric oxygen . If the ready mix paint is kept expose to air for a long duration, the solidification of the base and the pigment occurs.

Knotting: The term knotting is used to indicate the covering or killing of all knots in woodwork with a substance through which the resin cannot exude or come out . There are three methods of knotting as mentioned below:

(i) Ordinary or size knotting: This is applied in two coats. For the first coat, the red lead ground in water and mixed with Strong glue size is used in hot condition. This coat dries in about ten minutes and then second coat is applied. The second coat consists of red lead ground in oil and it is thinned by boiled oil and turpentine.

(ii) Patent knotting: This is applied in two coats. For both the coats, the varnish prepared by dissolving shellac in methylated spirits of wine is used.

(iii) Lime knotting: The knot is covered by hot lime and it is left for 24 hours. The surface then scrapped off and then ordinary knotting is carried out.

Stopping: The term stopping is used to indicate the rubbing down of the surface after the
first coat of paint is applied. The rubbing is done by means of pumice-stone or glass-paper or both. Before rubbing is commenced, the holes, cracks, etc. on the surface are filled with ordinary putty made from whiting and linseed oil. The putty becomes hard when it dries.

The term hard stopping is used when instead of ordinary putty, an admixture of one-third white lead and two-third ordinary putty, is filled in holes, cracks, etc. It is adopted for superior work .

Coats: The paint is usually applied in three or four coats. The first coat known as tile priming coat, the second one as under coat and the remaining as finishing coats. The priming coat creates a layer or film which provides adhesion of the paint with the surface. It also protects the surface from weathering actions. The suitable material for priming-coat should be used, depending on the nature of surface to be painted. The under coat serves to provide foundation or support to the finishing coat. The surface is made even and all irregularities of the surface are removed by this coat. ,

The finishing coat or coats are then applied as per requirement .

VERNISHING : The term varnish is used to indicate the solution of resins or resinous substances
prepared either in alcohol, oil or turpentine.

Following are the main objects of applying varnish on a wooden surface:

(i) It brightens the appearance of the grain in wood.

(ii) It renders brilliancy to the painted surface.

(iii) It protects the painted surface from atmospheric actions.

(iv) It protects the unpainted wooden surfaces of doors, windows, roof trusses, floors, etc., from the actions of atmospheric agencies .

CHARACTERISTICS OF AN IDEAL VARNISH :

Following are the characteristics of an ideal varnish:

(i) It should render the surface glossy .

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

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

(iv) The protecting film developed by varnish should be tough, hard and durable.

(v) It should not shrink or show cracks after drying .

INGREDIENTS OF A VARNISH:

Following are the ingredients of a varnish:

(1) Resins or resinous substances

(2) Driers

(3) Solvents.

(1) **Resins or resinous substances:** The commonly used resins are copal, lac or shellac and rosin. The copal is a hard substance and is available from the earth at places where pine trees existed in past. It is available in variety of forms. The lac or shellac is obtained by exudation of some types of insects in India. The rosin is obtained from pine trees. Other resins are amber, mastic, gum dammar, etc.

(2) **Driers:** The function of a drier in varnish is to accelerate the process of drying. The common driers used in varnishes are litharge, white copper and lead acetate .

(3) **Solvents:** Depending upon the nature of resin, the type of solvent is decided.

SOLVENTS FOR RESINS

No.	Solvent	Resins
1.	Boiled linseed oil	Amber, Copal
2.	Methylated spirits of wine	Lac or shellac
3.	Turpentine	Mastic, Gum dammar, Rosin
4.	Wood naphtha	Cheap varieties of resins

PROCESS OF VARNISHING :

The application of varnish on the woodwork is carried out in the following way:

(1)**Preparation of surface:** The woodwork is thoroughly rubbed down by means of sand paper or pumice stone. The surface is then made smooth and clean.

(2) **Knotting:** The process of knotting is then carried out as in case of painting.

(3) **Stopping:** The surface of woodwork is then stopped. This is done by means of hot weak glue size. It will fill up the pores on the surface. One N of glue will form about one litre of glue size. Alternatively, the boiled linseed oil can be applied in two coats. When the surface becomes dry, it should be once again rubbed down with sandpaper.

(4) **Coats of varnish:** The varnish is then applied on the surface in thin coats. The next coat is applied after the previous one has thoroughly dried up. The varnishing should not be done with ordinary paint brushes . But fine haired varnishing brushes should be used .

DISTEMPERING :

PURPOSE OF DISTEMPERING :

The main object of applying distemper to the plastered surfaces is to create a smooth surface. The distempers are available in the market under different trade names. They are cheaper than paints and varnishes and they present a neat appearance.

they are available in a variety of colours.

PROPERTIES OF DISTEMPERS :

Following are the properties of distempers:

(i) On drying, the film of distemper shrinks. Hence it leads to cracking and flaking, if the surface to receive distemper is weak.

(ii) The coatings of distemper are usually thick and they are more brittle than other types of water paints.

(iii) The film developed by distemper is porous in character and it allows water vapour to pass through it. Hence it permits new walls to dry out without damaging the distemper film.

(iv) They are generally light in colour and they provide a good reflective coating .

(v) They are less durable than oil paints.

(vi) They are treated as water paints and they are easy to apply.

(vii) They can be applied on brickwork, cement plastered surface, lime plastered surface, insulating boards, etc.

(viii) They exhibit poor workability.

(ix) They prove to be unsatisfactory in damp locations such as kitchen, bathroom, etc .

INGREDIENTS OF A DISTEMPER :

A distemper is composed of base, carrier, colouring pigments and size. For base, the whiting or chalk is used and for carrier, the water is used. Thus it is more or less a paint in which whiting or chalk is used as base instead of white lead and the water is used as carrier instead of linseed oil.

The distempers are available in powder form or paste form. They are to be mixed with hot water before use. The oil-bound distempers are a variety of an oil paint in which the drying oil is so treated that it mixes with water. The emulsifying agent which is commonly used is glue or casein. As the water dries, the oil makes a hard surface which is washable.

It should be remembered that most of the manufacturers of ready made distemper supply complete directions for use of their products. These directions are to be strictly followed to achieve good results.

PROCESS OF DISTEMPER :

The application of distemper is carried out in the following way:

(1) **Preparation of surface:** The surface to receive the distemper is thoroughly rubbed and cleaned. The important facts to be kept in mind are:

(i) The new plastered surfaces should be kept exposed for a period of two months or so to dry out before distemper is applied on them. The presence of dampness on the surface results in failure of distemper coating.

(ii) The surface to receive distemper should be free from any efflorescence patches. These are to be wiped out by clean cloth.

(iii) The irregularities such as cracks, holes, etc. of the surface are to be fill by lime putty or gypsum and allowed to become hard before distemper is applied on the surface.

(iv) If distemper is to be applied on the existing distempered surfaces , the old distemper should be removed by profuse watering.

(2) **Priming coat:** After preparing the surface to receive the coats of distemper a priming coat is applied and it is allowed to become dry. For ready made distempers, the priming coat should be composed of materials as recommended by the makers of distempers. For local made distempers, the milk is used for priming coat. One litre of milk will cover about $10m^2$ of the surface.

(3) **Coats of distemper:** The first coat of distemper is then applied on the surface. It should be of a light tint and applied with great care. The second coat of distemper is applied after the first coat has dried and become hard. Following facts are to be remembered:

(i) The distempering should be done in dry weather to achieve better results.

(ii) The oil-bound distemper or washable distemper adheres well to oil-painted walls, wood, corrugated iron, etc. But a priming coat of pure milk should be applied before distempering is done on such surfaces.

(iii) The application of distemper by a spraying pistol is superior to that by brushes. The spraying affords smooth and durable film of distemper.

APPLICATION OF WHITEWASHING :

The fresh lime is slaked at site of work and mixed thoroughly with sufficient quantity of water in a tub. It is then screened through a clean cloth. The clean gum dissolved in hot water is then added at the rate of 20 N per m^3 of lime. The rice may be used in place of gum.

The surface to be whitewashed should be cleaned before the work is started. For whitewashing walls which are whitewashed before, the old loose whitewash is to be first removed and repairing to the plaster is carried out, if necessary.

The whitewash is applied with jute brush and the brush is so worked that a surface with uniform colour is obtained. The three coats are generally applied, each after the previous coat has completely dried.

The lime is toxic for germs. It reflects light and thus it increases the brightness of the surface . The white washing therefore is extensively used for interior wall surface.

The process of whitewashing is sometimes used for exterior wall surfaces also. A satisfactory work gives an opaque smooth surface with uniform white colour and does not readily come off on the hand, when rubbed.

APPLICATION OF COLOURWASHING:

This is prepared by adding the colouring pigment to the screened whitewash. It should be seen that the colouring pigment is not affected by the presence of lime. Ordinarily, the yellow earth is popular for colour washing. Generally, the walls are colour washed and ceilings are whitewashed. The mixture is to be kept constantly stirred during use.

The colourwash is applied in the same fashion as the whitewash. A satisfactory work does not give out powder when the finished surface is rubbed with the fingers.

The process of colour washing imparts cleanliness and pleasant appearance of the surfaces which are treated .

REPAINTING OF OLD SURFACE :

Repainting old woodwork: If the paint on the old woodwork has cracked or has developed blisters, it is to be removed. If the surface has become greasy. it should be cleaned by rubbing down sand-paper or fine pumice stone. The old paint can also be removed by applying anyone of the following three paint solvents .

(i) A solution containing 2 N of caustic soda to a litre of water is prepared and used to wash the surface. The paint dissolves and the surface becomes clean.

(ii) A mixture consisting of one part of soft soap and two parts of potash is prepared and one part of quicklime is then added afterwards. This mixture is applied on the surface in a hot state and allowed to stay for about 24 hours. The surface is then washed with hot water.

(iii) A mixture consisting of equal parts of washing soda and quicklime is brought to a paste form by adding required quantity of water. It is applied on the surface and kept for about an hour. The surface is then washed with water. After removing old paint from the surface, the woodwork is painted as in
case of painting on new woodwork.

Repainting old ironwork and steelwork: The old surface should be thoroughly cleaned by the application of soap-water and if grease is present, it should be removed by washing the surface with lime and water. If it is necessary to remove old paint, the surface should be burnt, usually by a blow lamp and then old paint should be scraped off or dissolved and removed by using any paint solvent, After the surface is thus prepared, the painting is carried out as in case of new ironwork or steelwork.

CHAPTER-9

CAST IRON :

The cast iron is manufactured by re-melting pig-iron with coke and lime stone . This re-melting is done in a furnace known as the cupola furnace .

USES OF CAST IRON :

Following are the important uses of cast-iron:

(i)For making cisterns, water pipes, gas pipes and sewers, manhole covers and sanitary fittings .
(ii) For making ornamental castings such as brackets, gates, lamp posts, spiral staircases, etc.
(iii) For making parts of machinery which are not subject to heavy shocks.
(iv) For manufacturing compression members like columns in buildings, bases of columns, etc.
(v) For preparing agricultural implements.
(vi) For preparing rail chairs, carriage wheels, etc.

WROUGHT IRON :
The wrought iron is almost pure iron and it hardly contains carbon more than 0.15 percent or so . But the process of its manufacture is laborious and tedious .

USE OF WROUGHT-IRON :

The wrought-iron is replaced at present to a very great extent by mild steel. It is therefore produced to a very small extent at present. It is used where a tough material is required .

The wrought-iron, at present, is used for rivets, chains, ornamental iron work, railway couplings, water and steam pipes, raw material for manufacturing steel, bolts and nuts, horse shoe bars, handrails, straps for timber roof trusses, boiler tubes, roofing sheets, armatures, electro-magnets , etc .

STEEL:

Depending upon the carbon content, the steel is designated as the mild steel or medium carbon steel or high carbon steel. The various uses of steel are governed by the amount of carbon contained in it.
The carbon content of mild steel is about 0.10 to 0.25 per cent. When carbon content is less than 0.10 per cent, it is known as the dead steel or very low carbon steel.
The carbon content of medium carbon steel is about 0.25 to 0.60 per cent. The high carbon steel is also known as the hard steel and its carbon content varies from 0.60 to 1.10 per cent or so.

USES OF STEEL:

Name of steel	**Carbon content**	**Uses**
Mild steel	Up to 0.10%	Motor body ,Sheet metal ,tin plate, etc.
Medium carbon Steel	Up to 0.25%	Boiler plates , structural steel , etc.
	Up to 0.45%	Rails , tyres , etc.
	Up to 0.60%	Hammers ,large stamping and pressing dies etc.
High carbon steel Or hard steel	Up to 0.75%	Sledges hammers ,springs , stamping dies ,etc.
	Up to 0.90%	Miner's drills,smith's tools,stone mason's tools etc.
	Up to 1.00%	Chisels ,hammers ,saws,wood working tools,etc.
	Up to 1.10%	Axes,Cutlery,drills,knives,picks,punches,etc.

It is observed that the steel is required for the existence of the heavy a light engineering industries, for ship building, railways and rolling stock, automobiles sheet metal industries, power generation and electrical industries, etc. It should also be noted that the entire range of electrical engineering industry depends upon the property of magnetism of steel.

PROPERTIES OF MILD STEEL

Following are the properties of mild steel:
(i) It can be magnetised permanently.
(ii) It can be readily forged and welded.
(iii) It cannot be easily hardened and tempered.
(iv) It has fibrous structure.
(v) It is malleable and ductile.
(vi) It is not easily attacked by salt water.
(vii) It is tougher and more elastic than wrought-iron.
(viii) It is used for all types of structural work.
(ix) It rusts easily and rapidly.
(x) Its melting point is about 1400°C.

(xi) Its specific gravity is 7.80.
(xii) Its ultimate compressive strength is about 80 to 120 kN per cm^2
(xiii) Its ultimate tensile and shear strengths are about 60 to' 80 kN per cm^2

PROPERTIES OF WROUGHT STEEL

Following are the properties of hard steel:
(i) It can be easily hardened and tempered.
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High carbon steel stamping dies ,etc. Or hard steel	Up to 0.75%	Sledges hammers ,springs ,
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CHAPTER-10

BITUMINOUS MATERIALS

INTRODUCTION

Bituminous materials or asphalts are extensively used for roadway construction, primarily because of their excellent binding characteristics and water proofing properties and relatively low cost. Bituminous materials consists of bitumen which is a black or dark coloured solid or viscous cementitious substances consists chief high molecular weight hydrocarbons derived from distillation of petroleum or natural asphalt, has adhesive properties, and is soluble in carbon disulphide. Tars are residues from the destructive distillation of organic substances such as coal, wood, or petroleum and are temperature sensitive than bitumen. Bitumen will be dissolved in petroleum oils where unlike tar.

TYPES OF BITUMINOUS MATERIALS

Normally three types of bituminous materials are extensively used in civil engineering works. They are as follows.

Bitumen → It is the heavy end (i.e. higher molecular weight) residue from the fractionation of crude oil. It is a thick sticky black liquid obtained after extraction of things like fuels, fuel oils, lubricating oils and waxes from the crude oil.

Tar → It is similar to bitumen but is not extracted from crude oil. It is obtained from destructive distillation of organic materials like coal, wood etc.

Asphalt → It is a mixture of bitumen and aggregates (inorganic heavy fillers, sands, grit, stones) of various kinds used for construction of road surfaces.

Tar is no longer used for highway construction as it is considered to be a health hazard

COMPARISON BETWEEN BITUMEN, TAR & ASPHALT

Sl No	Property	Bitumen	Tar	Asphalt
1	Colour	Dark with slight reddish tinge	Deep Dark	Blackish brown
2	Carbon Content	Moderate	High	Low
3	State	Solid	Viscous Liquid	Solid or Semi-solid
4	Effect on Heating	Melts	Becomes more fluid	Burns with a smoke flame & becomes plastic
5	Setting Time	Less	More	Less
6	Adhesive Power	More	More	Less
7	Resistance to	More	Less	More

	Acid			
8	Uses	As Damp Proof Course & Roofing felt	For preserving Timber	As damp proof course, for paints, as roofing felt & for road works

TYPES OF TAR AND THEIR USE

Birch tar or birch pitch is a substance (liquid when heated) derived from the dry distillation of the bark of the birch tree.
Birch tar was used widely as an adhesive as early as the late Paleolithic or early Mesolithic era. It has also been used as a disinfectant, in leather dressing, and in medicine.

Coal tar is a brown or black liquid of extremely high viscosity. Coal tar is among the by-products when coal is carbonized to make coke or gasified to make coal gas. Coal tars are complex and variable mixtures of phenols, polycyclic aromatic hydrocarbons (PAHs), and heterocyclic compounds.
Coal tar is sometimes used for heating or to fire boilers as it is flammable. Coal tar was a component of the first sealed roads. Coal tar is also used to manufacture paints, synthetic dyes, and photographic materials.

Pine tar is a sticky material produced by the high temperature carbonization of pine wood in anoxic conditions (dry distillation or destructive distillation). The wood is rapidly decomposed by applying heat and pressure in a closed container; the primary resulting products are charcoal and pine tar.
Pine tar is now mainly used as a softening solvent in the rubber industry, and for construction material and special paints. Pine tar can be used for preserving wooden boats (and other wood which will be exposed to the elements) by using a mixture of pine tar, gum turpentine and boiled linseed oil

TYPES OF ASPHALT AND THEIR USE

Asphalt concrete pavement material is commonly composed of 5% asphalt/bitumen cement and 95% aggregates (stone, sand, and gravel). Due to its highly viscous nature, asphalt/bitumen cement must be heated so it can be mixed with the aggregates at the asphalt mixing plant.

Asphalt concrete paving is widely used in airports around the world. Due to the sturdiness and ability to be repaired quickly, it is widely used for runways dedicated to aircraft landing and taking off.

Mastic asphalt is a type of asphalt which differs from dense graded asphalt (asphalt concrete) in that it has a higher asphalt/bitumen (binder) content, usually around 7–10% of the whole aggregate mix, as opposed to rolled asphalt concrete, which has only around 5% added asphalt/bitumen.

Mastic asphalt being thermoplastic substance is widely used in the building industry for waterproofing flat roofs and tanking underground. Mastic asphalt is heated to a temperature

of 210 °C (410 °F) and is spread in layers to form an impervious barrier about 20 millimeters (0.79 inches) thick.

Asphalt emulsion contain up to 70% asphalt/bitumen and typically less than 1.5% chemical additives. There are two main types of emulsions with different affinity for aggregates, cationic and anionic.

Asphalt emulsions are used in a wide variety of applications. Chipseal involves spraying the road surface with asphalt emulsion followed by a layer of crushed rock, gravel or crushed slag. Slurry seal involves the creation of a mixture of asphalt emulsion and fine crushed aggregate that is spread on the surface of a road. Cold-mixed asphalt can also be made from asphalt emulsion to create pavements similar to hot-mixed asphalt, several inches in depth and asphalt emulsions are also blended into recycled hot-mix asphalt to create low-cost pavements.

Other uses of Asphalt

Asphalt/bitumen is used to make Japan black, a lacquer known especially for its use on iron and steel. Asphalt/bitumen also is used in paint and marker inks by some graffiti supply companies (primarily Molotow) to increase the weather resistance and permanence of the paint and/or ink, and to make the color much darker. Asphalt/bitumen is also used to seal some alkaline batteries during the manufacturing process.