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LECTURE NOTES

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CONTENT

CHAPTER-1

STONES

1. INTRODUCTION

Naturally occurring compact, solid and massive material in the earth's crust or on the surface are known as rocks. Rocks don't have definite shape and chemical composition. They are mixture of two or more minerals.Stones are derived from rocks and are used as construction material.

Minerals are naturally occurring inorganic substance having definite atomic structure and chemical composition. Minerals are divided into two types.

1. Rockformingminerals
2. Oreminerals

2. CLASSIFICATIONOFROCKS

Therocks fromwhich stonesarederivedarebroadlyclassified intothreetypes.They are:

1. Geologicalclassification
2. StructuralorPhysical classification
3. Chemicalclassification

Geological classification:

The classification of rock based on the mode of formation or the process of formation is known as geological classification. According to this classification rocks/ stones are are of three types.

1. Igneous rocks
2. Sedimentary rocks
3. Metamorphic rocks

Igneous rocks

Molten rock materials found below the earth's crust are known as magma. During volcanic eruption, this magma, under very temperature and pressure, and varieties of complex phenomena occurring below earth's crust beyond the comprehension of human being, comes out to the surface. The rocks formed due to cooling and consolidation of molten magma on the surface is known as igneous rock. Not all the magma during a volcanic eruption comesout to the surface of earth.

Dependingonthedepthofthesolidificationofmoltenmagma,igneousrocksaredividedinto three types.

1. Plutonic rocks
2. Volcanic rocks
3. Hypabyssal rocks

Plutonicrocks

The igneous rocks formed at a greater depth below the surface of earth are called plutonic rocks. These rocks are exposed on the surface due to erosion of overlying secondary rocks. These are coarsely crystallised. Examples of plutonic rocks are granite, syenite, gabbro.

Volcanicrocks

These are formed duetocoolingandsolidificationofmoltenmagma fromnumerousvolcanic eruptions on the surface of earth. Examples of such rocks are basalt, trap and rheolite.

Hypabyassalrocks

The rocks formed on account of cooling and solidification of molten magma at a shallower depth of about 2 to 3 km below the surface of earth. They show crystals that are partly coarse and partly fine.Examples of such rocks are aplites, dolerites, etc.

Igneousrocks arefurtherdividedintothreetypes dependinguponthesilicacontentinthem.

a. Acid rocks
b. Basic rocks
c. Ultrabasic rocks

Acid rocks: in acid rocks amount of silica content is more than 66%. Examples: granite, rhyolite.

Basicrocks:Amountofsilicacontentintheserocksisbetween45to55%. Ultra-

basicrocks:Amountofsilicacontentintheserocksislessthan45%.

Sedimentary rocks

The secondary rocks which are formed by chemical or mechanical activities of theweathering agents such as temperature, water, air, ice, etc. on the pre-existing rocks are knownassedimentary rocks.Weathering agents likewind, water, ice, atmospheric gases, etc. cause disintegration of the pre-existing rocks and thus sediments (particles) are formed.These sediments are transported and deposited by the agencies like river, seas, oceans, etc. The particles so deposited are gradually compressed and compacted under their own weight soastoformmassiverocks.Rocksthusformedareknownassedimentaryrocks.Theprocess of formation of sedimentary rocks takes place for millions of years.Sedimentary rocks are also known as secondary rocks as they are formed due to weathering and erosion of primary rocks. These are also called stratified rocks because these rocks are formed in layers. Limestone and sandstone belong to this category of rocks.

Like igneous rocks, sedimentary rocks are formed in different ways. On the basis of the formation, sedimentary rocks are divided into three different categories.

a. Clastic rocks
b. Chemicallyformedsedimentaryrocks
c. Organicallyformedsedimentaryrocks

Clasticrocks

The sedimentary rocks formed by deposition and consolidation of disintegrated sedimentsand fragments from previously formed rocks. These are formed in river basins, lake basins and sea basins. These types of stones are most widespread. They include sandstones, shales, breccias and conglomerates. Sandstones are very suitable as building stones.

Chemicallyformedsedimentaryrocks

Many sedimentary rocks are precipitated from river, lake and especially from sea water by evaporation. Some of the components of the previous rocks are taken in solution during the process of weathering and erosion. The waters may get saturated with these compounds with passage of time and precipitate them. The huge accumulation of these precipitates evaporates ultimately may form rock deposits of considerable importance. Limestones, gypsum, anahydrite and rock salts are few examples of chemically formed sedimentary rocks. These are not used as building stone.

Organicallyformedsedimentaryrocks

A great variety of life exists in the water bodies such as seas and oceans. Many sea animals have their hard parts made of bones which are a mixture of calcium and magnesium carbonates. After the death of these marine animals, the dead parts accumulate on the sea beds.Graduallyhugethicknessofsuchdepositsgetsformed andcompactedandconsolidated with passage of time. These are the organically formed sedimentary rocks. Limestone is an example of this rock.

Metamorphicrocks

Igneous rocks and sedimentary rocks undergo structural change under the influence of high temperature, pressure and chemical action and thus the original character of the parent rock are partly or wholly changes. Such process is known as metamorphosis and the rocks so formed are known as metamorphic rocks. Examples: marble, slate, gneiss, etc. Marble is formed from limestone ($CaCO_3$) by gradual heating over a very large period of time.

Chemical Classification

On the basis of dominant chemical composition, three main types of rock sare:

a. Silicious rocks

b. Calcareousrock

c. Argillaceousrocks

Silicious rocks

Silica is the predominant constituent of this rock and is more than 50% of the bulk compositionoftherock.Somesedimentaryandmetamorphicrocksareentirelymadeof

silica. These rocks are very strong and hence may be treated as good building stones. Examples of these rocks are granite, sandstone, gneiss.

Calcareousrocks

In these rocks carbonate is the dominant chemical component. These rocks generally belong to sedimentary and metamorphic rocks. Limestone, dolomite and marbles are entirely carbonate rocks and are very good building stones.

Argillaceousrocks

In these rocks clay (hydrous alumina silicate of K, Na, Ca and Mg) is the dominant component. These are mostly sedimentary and metamorphic rocks. These are very soft and hence not recommended as building stones. Examples of these rocks are slates and schists.

StructuralClassification

On the basis of physical characteristics of the rocks, the manner and arrangement of different particles rocks are classified into three categories. They are:

1. Stratified
2. Unstratified
3. Foliated

Unstratified Rocks

These rocks occur in huge masses without showing any layered structure in them. Igneous rocks and many metamorphic rocks are unstratified in nature. Some of the sedimentary rocks may be of unstratified in nature.

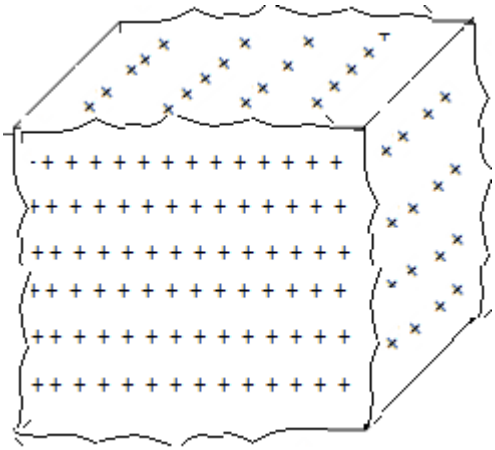
StratifiedRocks

These rocks occur in distinct layers of same or different colour and composition. Most of the sedimentaryrocksarestratifiedrocks.Thedifferentlayersarecalledbedsandseparatedby

planes, called bedding planes. These bedding planes arethe planes of weakness and thus play an important role in deciding the structural behaviour of the rocks as building material.

Foliated rocks

Some rocks have in them profuse development of well defined bands of different composition. Such rocks are known as foliated rocks. Examples of such rocks are schists and gneiss. Sometimes such layers are induced under pressure. These are not very good building stones.



Unstratified rock

3. USES OF STONES

Stones on account of numerous advantages they have in terms of their strengthcharacteristics, durability and bountiful availability as a natural resource have a wide spectrum of application including their use as very good and construction material for numerous civil engineering structures. Some of their uses are enlisted below.

a. Stoneisusedforgeneralbuildingwork, i.e.,walls,foundationsand superstructure.

b. It is also used for heavy engineering works such as docks, bridges, light houses andharbours.

c. Itisusedinindustrialconstructions.

d. Itisusedroadmetaland railwayballast.

e. Itisused asrawmaterialformanufactureoflime.

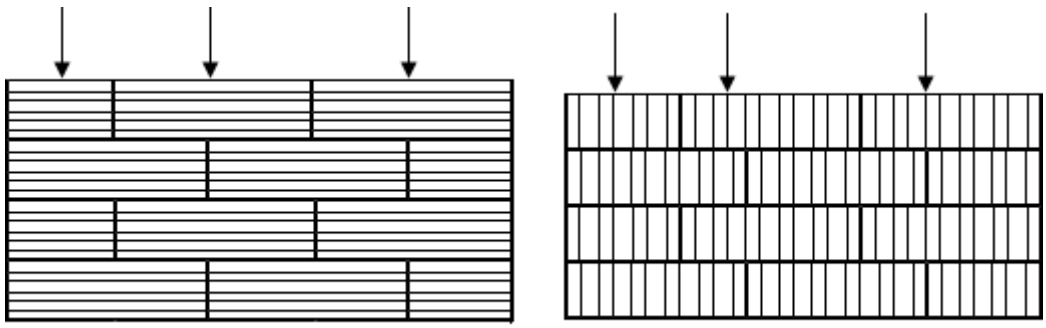
f. Itisalsousedasflux steelplant inthemanufactureof iron.

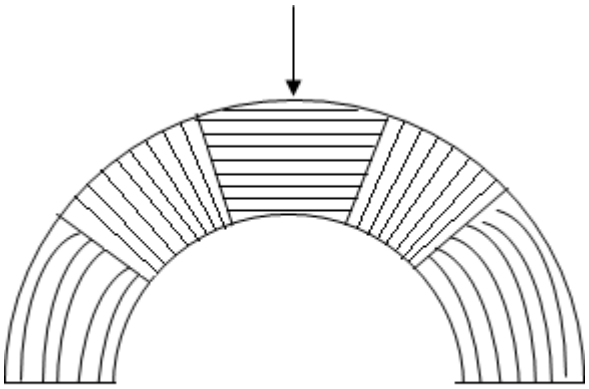
4. NATURALBEDOF STONE

The plane of contact (junction) of two layers of rocks in a stone obtained from stratified rock is known as the natural bed. It is also known as plane of cleavage or weakness.

The strength and durability of stratified stone depend on its position in a structure i.e., if the load is perpendicular or parallel to the bedding plane of the stone. The compressive strength of stone with the load acting perpendicular to the direction of 'natural bed of the stone' or plane of cleavage is always greater than that when the load acts parallel to the bedding plane.

In case of walls and columns where the load acts vertically downwards, the stones should be placed with natural bed horizontal so that thrusts act normal to the bedding plane. In arches where the load acts transverse, the stones are placed with natural bed vertical or inclined so that it is almost normal to the resultant forces.





(c)

Figure1.2Forceswithrespecttonaturalbed

5. QUALITIESOFGOODBUILDING STONE

Stones have wider applications in construction of heavy structures such as buildings, dams, harbours, weirs, bridges, etc. The qualities and suitability of good building stones shouldhave the following characteristics with the attributes given in each of them.

1. Appearance

   The stones should be of uniform and appealing colour. Lighter colours are preferredto darker ones as darker ones are less durable. For face work, the appearance of the stones very important.

2. Strength

   Stonesusedforbuilding constructionaresubjectedtocompressiveload. Sothestones should have high value of compressive strength to withstand the compression without getting crushed. closed grain and uniform textured stones are generally good in compressive strength.

3. Structure

A good stone if broken should not give dull appearance. Closed grain and crystalline structured stones are good building stones. Good building stone should have uniform texture. They should be free from cavities and cracks.

4. Hardness

   A good stone should be hard enough to resist the abrasion due to friction. Generally thestonesusedinfloors,pavementsandapronsof bridgeshouldhavegreatervalueof hardness. Hard stones should show no sign of scratching if scratched by knife.

5. Toughness

   Goodstonesshouldalsobetoughtowithstandthevibrationmachineriesandvibration due to moving loads over them. Stones used in construction of roads should be hard and tough.

6. Heaviness

   Specific gravity is the measure of heaviness of a substance. The specific gravity of a good building stone should be between 2.4 to 2,8.

7. Durability

   A good building stone should be long lasting. They should resist the action of weathering agents such as wind, rain, ice and temperature. Durability of stonesdepend upon their chemical composition and physical structure. A compact, homogeneous and free from chemicals susceptible to the action of hydrochloric acid and sulphuric acid.

8. Porosityandwater absorption

   Porosity is the percentage of void spaces available in a given volume of stone. Good building stone should have less water absorption. The water absorption of good building stone should be less than 5%.

9. Resistancetofire

   Stone when exposed to fire should be able to resist temperature. The stones should be freefrommineralssuchas$CaCO_3$andironoxidewhichlikelytodecomposeon

heating.Quartzexpands onlowtemperature.Hencestonesshouldnotbecomposedof minerals of different coefficient of thermal expansion.

10. Dressing

    Stonesshouldpossessgooddressingpropertiesforcarving.Marble isagoodexample of stone which has good dressing properties. However stones having good dressing qualities are weak in strength, less durable. Their hardness is also low.

11. Seasoning

    Stones after quarrying and dressing should be left for a period of 6 to 12 months for seasoningbeforeusedforconstruction.Awellseasonedstoneisfreefromquarrysap.

6. STONE QUARRYING

The process of extraction of suitable stones from their natural place of occurrence is called quarrying. Quarrying is also known as open cast mining for extraction of stones from natural rock. However, quarrying is different from mining in the way that in various operations are carried out for exploration and extraction of minerals such as coal, quartzite, etc., from amine under the earth.

There are different methods employed for quarrying of stones depending upon the geological structure of rock, amount of material required and their availability. They are:

a. Quarrying without blasting (Quarrying by hand tools such as crowbars, jumpers, pickaxe, feathers and wedges, channellizers, etc.

b. Quarryingby blasting

Quarryingbyhandtools

The rocks in the earth's crust are accompanied by the bedding planes, joints, fissures and cracks, etc. these offer least resistance for to splitting. In these methods light hand tools or even light channelling machines called channellizers are used for removal of block of rocks. In these methods no explosive material is used for breaking the stone. Some of the methodsof quarrying by hand tools are:

1. Digging

This method is used to quarry small pieces of stones. They are broken by pick-axe and taken out by crowbar. Laterite stones are quarried by digging.

2. Splitting

Splitting method is used for obtaining large blocks from hard and tough rock. Large blocks can be split by heating to get rectangular pieces. Wood, leaves or any other form of fuels is burnt on the surface of stone for few hours. Due to unequal expansion, stone splits and upper layer is separated. Separated stone pieces are taken out and given the desired shape for use.

3. Wedging

In this method a few holes are dug at selected places on the rock surface by using chisels and hammers or hammer drills. Steel wedges are inserted into each holes between two steel strips called feathers. The inserted wedges are struck simultaneously with hammers. As a result of hammer blows, cracks appear along the lines joining the holes. Then long iron bars are inserted into the holes and the cracks so caused help removing the block of rocks. Quarrying by wedging is shown in the Figure 1.3.

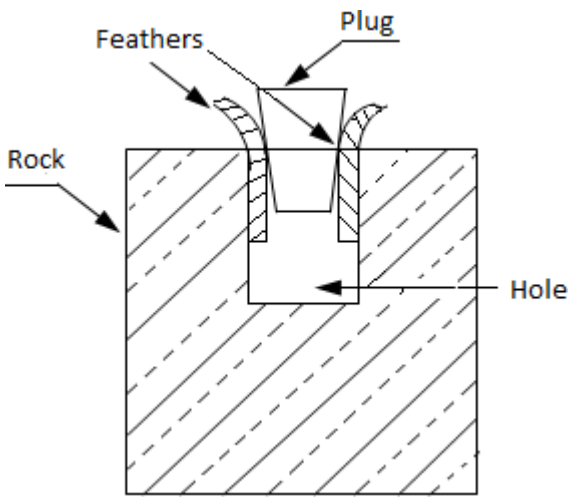


Figure1.3 PlugandFeathers

4. Channelling

In this method big machines called channellizers are used for quarrying. the machines are power driven. Channellizers are used for cutting large size single block of costly stones like marbles and lime stones. The channellizers can cut a groove up to 3 m depth, 3 m length and5 m width. Holes are then drilled horizontally from the free side to meet the groove at the backatitsbase.Wedgesandsteelbars areusedtoremove theblock(B)fromthe rock.Figure 1.4showsquarryingby channelling.

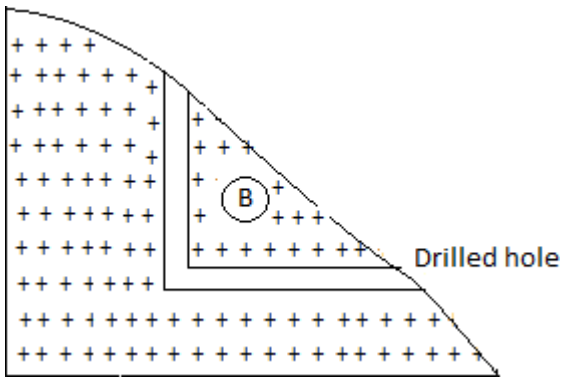


Figure1.4Quarryingbychannelling

7. DRESSING

The process of giving proper size, shape and finish to the stone obtained from the quarry is known as dressing. Dressing is done either by manually or mechanically or both.

Objectiveof Dressing

a. To reduce the size of the blocks to potable units: Dressing reduces the size of the block and hence the weight. Reduction of weight decreases the cost of transportation of stones from the quarry site.

b. To give proper shape to the stone: Different structural units require stones of different shape. Hence, stones are to be dressed before use as structural units.

c. To give appealing finish: Stones used in exposed face of the walls in temples and monuments should be dressed to give aesthetic appearance.

MethodsofDressing

Therearedifferentmethodsofdressing.Somemanualmethodsofdressingareasfollows.

Pitchedfacedressing

In this method, only the edges of a block of stone are made level with skilful use of hammer. Thesurfaceisleftinoriginalcut.Theminimumwidthofpitchedfacedressingroundthefour edges of the face shall be 2.5 cm.

Hammerdressing

In this dressing, the edges as well as faces are dressed to give an even regular surfaces. A hammer dressed stone is given rough tooling for a minimum width of 2.5 cm along the four edges of the face of the stone.

Chiseldrafting

In this method, straight grooves are made with the help of chisel at all the four edges. The superfluous stone at the centre is removed by chisels. The stones so dressed are used in plinths and corners of the buildings.

Roughtooling

In this method, a series of bands 4 to 5 cm wide with grooves in between are made all over thesurface.Eachbandhastoolmarksinthem.thesetoolmarksmaybehorizontal,verticalor at an angle of 45^0 etc. The edges and the corners are made square by using chisel andhammer.

Punched dressing

Punched dressing is done on the stones that have already been rough-tooled. In this method a seriesofparallelridges aremadebyusinghammerand chisel.Thesestonesareusedatplaces where even surfaces are required.

Closepicked finetooling

In this type of dressing, almost every type of irregular projection is removed from all the four sides of a stone. Its surface is given fine finish and appealing look.

Polishing

Polishingofstonesisdonebyrubbingwithsuitableabrasivematerial.Polishingofstonemay be done by holding them firmly on the top of a revolving table to which some abrasive material like sand or carborandum are fed.

8. CHARACTERISTICSOFDIFFERENTTYPES OFSTONESANDTHEIR USES

Granite: It is a coarse to medium grained igneous rock. It is essentially made up of felspar,quartz and mica.

Characteristics

a. Itsspecificgravityis2.64and waterabsorptionislessthan 1%.

b. Ithasmottled(spotted) appearance.

c. Most granites excellent building properties and are significantly strong and durable.Crushing strength varies from 110 to 140 MN/m^2.

d. Graniteshavepoor fireresistanceandcrackunderstrong fire.

e. Graniteshavethecapacity totakeveryfineandglassy polish.

f. Quantityoffelspardecidesthecolourofgranite.

Uses

a. Finegrainedgraniteissuitableforornamentalcolumn,plinth,etc.asittakesveryfine polish and exhibits glassy appearance.

b. High values of strength, hardness, specific gravity and durability make it suitable for construction of sea walls, light houses and bridge piers, etc.

c. Large pieces are used as building blocks for masonry structures, smaller ones as road metals or railway ballast and the chippings for manufacture of concrete.

Basalt: Itisavolcanictypeigneousrock.Themainconstituentsaresilica,aluminaand felspar.

Characteristics

a. Itsspecificgravityisabout 2.96.

b. Itisvery heavyandstrongandisheavierthan granite.

c. Itscrushingstrengthvariesfrom70to80MN/m^2.

d. Ithasgreenishgreytodarkgreycolour.

Uses

a. Basaltissuitableforpaving setsandasaroad metal.

b. Itisused asaggregateinconcrete.

c. Itisalsoused formanufactureof artificialstones.

Limestone: Limestone is a sedimentary rock of calcareous variety and of organic origin. Initsits purest form, it contains mainly $CaCO_3$, although some varieties may contain $MgCO_3$and small amount of silica and alumina.

Characteristics

a. Itsspecificgravityis2.6.

b. Itscrushing strengthis about52 MN/m^2.

c. The colour of limestone depends on its composition, especially the type of finely dispersed impurities present throughout the carbonate matrix. However, they are available in three main colours viz., brown, yellow and dark grey colours.

Uses

a. Limestonesarenotvery usefulasbuildingstonebecauseoftheirpoorstrengthvalues. However, dense, compact and massive varieties are used for stone masonry in walls.

b. Itisused asroadmetalwhenbettermaterialslike basaltandgranite arenotavailable.

c. Itisusedin blastfurnaces,bleaching, tanningand other industries.

Marble: It is metamorphic rock of calcareous variety. It is formed from the metamorphosisof limestone. Its main constituent is recrystallised hard and compact $CaCO_3$.

Characteristics

a. Itsspecificgravityisabout 2.72.

b. Crushingstrengthof marblevaries from50 to60 MN/m^2.

c. Itisvery hard andtakesafinepolish.

d. It is available in a variety of colours such as white, yellow, grey, green, red, blue and black colours.

e. Itiseasytoworkwithmarble.

Uses

a. Itisforcarving anddecorationwork.

b. Itisalsoused forsteps, walllinings,columns,electricalswitchboardsandtabletops.

Sandstone: Itisasedimentaryrockofsiliceousvariety.Itcontainssandorquartzcemented by lime, mica, magnesium, alumina, iron oxide.

Characteristics

a. Itsspecificgravityis2.25.

b. Itsstructureshowssandygrains.

c. Crushingstrength of sandstonevaries from 35to 40 MN/m2.

d. Sandstonesoccurinmanycoloursviz.,white,grey,pink,red,maroonanddark.

e. Fine grained sandstones with siliceous cementing material are strong and durable and are excellent building materials.

f. Sandstonesofdifferenthuesareavailable e.g.,white,grey,brown,pink,etc.

Slate: It is a metamorphic rock of argillaceous variety. It has a distinct foliated structure. It is composed of alumina mixed with sand or carbonate of lime.

Characteristics

a. Itsspecificgravityis2.8.

b. Agood slate is hard,tough and fine grained.

c. Crushingstrength ofslatevariesfrom 60to 70 MN/m^2.

d. Ithasgreyordarkblue colour.

e. Itcanbesplitintothin sheets.

f. Itisnon-absorbentanddurable.

g. Itproducesasharpmetallicsoundon hammering.

Uses

a. Thin-layeredslateshavinggoodcompressivestrengthareusedassillsandfor pavements inside and outside palatial building.

b. Slateispracticallyimperviousandhenceverysuitableforroofingstoneandurinal partitions.

Laterite: Itissedimentaryrockcomposedmostlyofoxidesofaluminiumwithvarying amounts of oxides of iron.

Characteristics

Itsspecificgravityvariesfrom2to2.2.

Ithasapoorcompressivestrength,whichvariesfrom20to30MN/m^2. It is

light to dark red in colour.

Ithas aporousandspongyorcellular structure.

Uses

a. Lateriteisusedasabuildingmaterial onlyinordinaryconstruction.

b. Itismostlyusedasroadmetals.

Gneiss: It isa metamorphic rock. It is formed by the metamorphosis of granite and has thesame constituents as granite. It is siliceous in composition and foliated in structure.

Characteristics

a. Gneissesarecoarsely crystallinerocks.

b. Itcanbe freelysplitintoslabs.

c. Gneissismoreeasytowork withthan granite.

d. Itisavailableindifferentcolours.

Uses

a. Coarsely crystalline and uniformly textured gneisses areas good building materials as granites.

b. Itisusedforornamentalanddecorative purpose.

Quartzite: Itiscomposedofsilica.Itisdense,hardandglassyinstructure. Somevarietiesof quartzite are very hard and strong and are considered to be very good as building stone. It is strong and durable and used as road metal or railway ballast. it is also used in concrete.

CHAPTER2

BRICKS

I. DEFINITION

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

Since long, bricks are believed to have been used by the people of ancient civilization. This has been established beyond doubt from the excavation of prehistoric sites like Indus Valley civilization at Mohen-jo-daro and Harrappa. Bricks are the most favoured structural units used for construction in the modern day world around the globe. This is on account of the following reasons in favour of bricks.

1. Easyavailabilityofclay
2. Knowhowofconstruction methods
3. Ready-to-usesize,shapeandhandling
4. Cost

All the above factors combined together go in favour of bricks to make them a very convenient building material.

II. COMPOSITIONANDSELECTIONOFBRICKEARTH

Earths of specific characteristics are used for manufacturing good bricks. A good brick earth should have the following components to give desired characteristics to the bricks manufacturedfromthem. A suitablebrickearthshouldhavethe following compositioninthe desired proportion.

Alumina

A good brick earth should have 20 to 30% of alumina. It gives required plasticity to the brick earth in the moulding stage (wet condition). Alumina content in brick earth should not be more than 30% because it makes the earth more plastic. Bricks made of such earth shrink on drying and cracks may appear on moulded bricks. However, if percentage of alumina is less than 20%, moulding of bricks to proper shape would become difficult.

Silica

The percentage of silica in good brick earth should be 50 to 60. Silica in brick earth may be present as a constituent of clay minerals or as free silica in the form of sand or quartz.Desired percentage of silica in clay imparts hardness and strength to the brick. Silica gives resistance against shrinkage and durability of brick to weather. However, if percentage of silica are higher in silica, moulding becomes difficult. Such bricks are found to be quitebrittle and porous.

Iron Oxide

A small amount of iron oxide (4 to 6%) reduces the softening temperature and makes the fusion of various constituents of clay possible at lower temperature. It also givescharacteristic red colourtothebricks. However, excessof ironoxide makesthe brick toosoft during burning which causes deformation of shape and size of the brick. The colour also becomes darker and hence not appealing.

Lime

Presence of lime makes burning and hardening quicker. Lime, if any, should be present in finely powdered form and thoroughly dispersed. Slaking ordisintegrationmay takeplacedue to presence of lime in the form of nodules or lumps.

Undesirableorharmful components

Thebrickearthshouldideallyfreefromthe followingharmful components.

1. Lime nodules
2. Organicmatterandvegetable roots
3. Sulphidesandsulphates
4. Alkalisalts
5. Pebblesofstoneand gravel

III. BRICKMAKING

Brickmakingorbrick manufacturinginvolvesthefollowing steps.

1. Preparationofbrickearth
2. Moulding of bricks
3. Dryingofbricks
4. Burning ofbricks

1. Preparationofbrickearth

Thesitewith soil suitableformanufactureofbricks is selected.Afterselection ofsite, thetop 15 to 20 cm layer overburden is removed to clear off harmful undesirable ingredients such as vegetation, pebbles and other organic matter. The earth below is then dug out and spread on the ground and exposed to the atmosphere for a period of about two weeks. Sometimes, additional amount of sand, lime etc. are also mixed with the dug soil depending upon the requirement if any. This process is known as **weathering**.

After weathering, the earth is then ground thoroughly to break the lumps if any present in it. The weathered earth is thoroughly mixed with the sand, lime added to it. The process is known as **blending**.

The blended earth is then spread out on a platform and desired amount of water is added to the mixture and the mixture is then **kneaded** thoroughly so as to form a homogeneous and plasticmix.Thisprocessisknownastempering.Generally25to30%of waterissufficient to make the mixture plastic enough for moulding. The amount of water added depends on the type of moulding.

For large scale manufacture of bricks, **pug mill** is used for kneading of clay. It consists of a conical upright steel cylinder covered at the top and with a hole at the bottom. Figure 2.1 shows a typical pug mill. It is 2 to 3 m in height, a part of which is buried under the ground. The top diameter is slightly more than the bottom diameter. A central rotating vertical shaft pivoted at the base, which can be rotated with the help of long arm driven mechanically or manually. The central shaft is attached with horizontal blades carrying knives.

Seasoned clay and water are added from the opening at the top. The rotation of the shaft and its churning effect on the clay-water mixture produce mud of required plasticity. The mud is then taken out from the hole at the base for moulding.

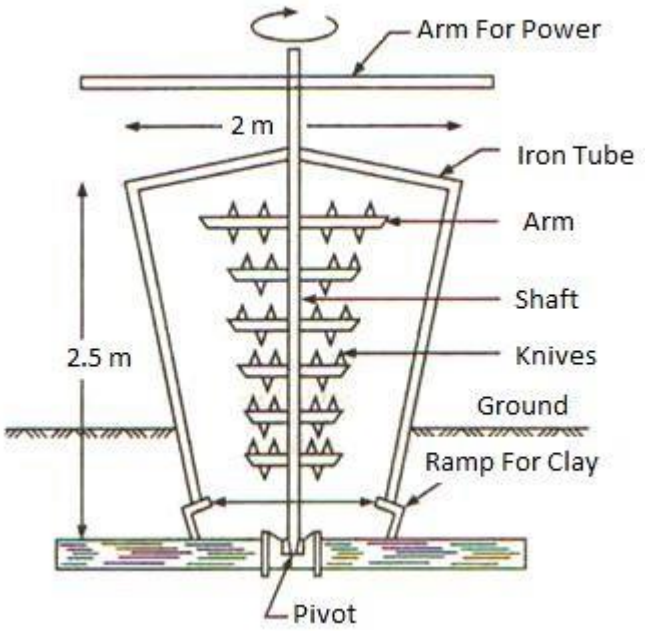


Figure2.1Pug Mill

2. Preparationofbrickearth

The process of making green bricks of proper shape and size from the tempered clay isknown as moulding. Moulding of brick is carried out with the help of a mould. A mould is made of either wood or steel. A wooden mould is fitted with iron plates at edges to make it strong. The inside dimensions of a mould are generally 8 to 10% larger than the size of the bricks. This is to allow shrinkage of bricks during drying.

Therearetwo methods of moulding the bricks.

a. Hand moulding
b. Machine moulding

The tools essential in hand moulding process include brick mould, cutting edge or wire, wooden plates and stock board (Figure 2.2).

a. Handmoulding

In this method, moulding of bricks from tempered clay is done by using skilled manpower. Theclay is invariably kept soft so that it can be givendesired shape. Thewater content of the mudisgenerally18to25%thanthoseusedformachinemoulding.Thismethodisfurther

dividedintotwotypesdependingonthefactthatwhetherthemouldingisdoneontheground or on a specially designed table. They are

i. Groundmoulding
ii. Table moulding

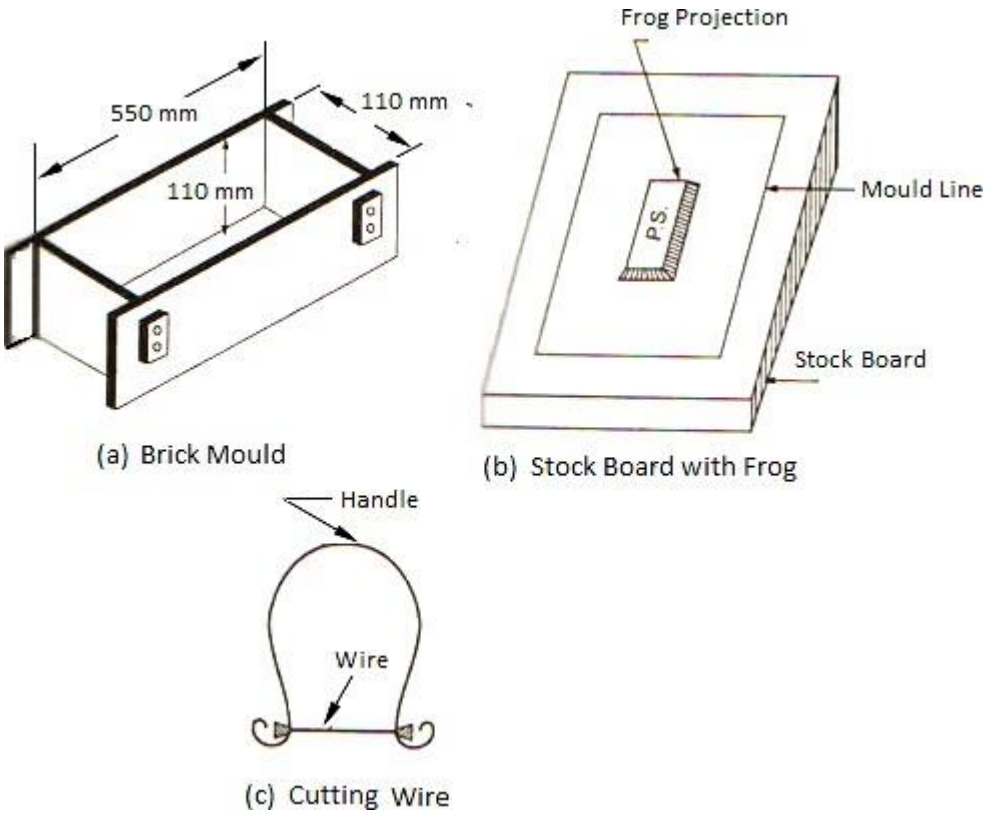


Figure2.2ToolsinHandMoulding

i. Groundmoulding

The process of moulding bricks on the ground by skilled manpower is known as ground moulding. In ground moulding, moulding is done on a levelled and rammed ground. Sand is sprinkled over the ground to avoid the sticking of moulded brick with the ground. The moulding process is started from one end of the ground and continued to the other end. The moulded bricks are laid on the levelled ground for drying.

Groundmouldingiscarriedoutinthefollowing steps.

The mould is dipped in water or sprinkled with sand in order to avoid sticking of the green mud to the inner side of the mould. A lump of is carefully dashed into the mould by hand. It should be ensured that the clay reaches to the sides and corners of the mould. Surplus mud if any is removed with the help of strike or cutting edge. The mould is then lifted with a sudden jerk leaving behind the moulded brick on the ground sprinkled with sand.

ii. **Table moulding**

In this process all the moulding operations are carried out by skilled worker on a specially designed table as shown in the Figure 2.3. The moulded bricks are transported to the drying place with the help of pallet boards. This process is similar to the pallet moulding on the ground. The mould is place over the stock board and some sand is sprinkled on the inside surface of the mould. A lump of mud is then carefully pushed into the mould, pressed thoroughly and skilfully such that the mud reaches to the sides and corners of the mould. The surplus mud is then cut away with the strike or cutting edge. A pallet is placed over the mould and the moulded brick is transferred to the pallet by turning the mould over it. The brick is transported to the drying yard.

Good quality bricks are produced in table moulding. However, the operation process is slow and hence the cost of production is slightly higher in table moulding. The table is large enough to accommodate all the accessories required for moulding.

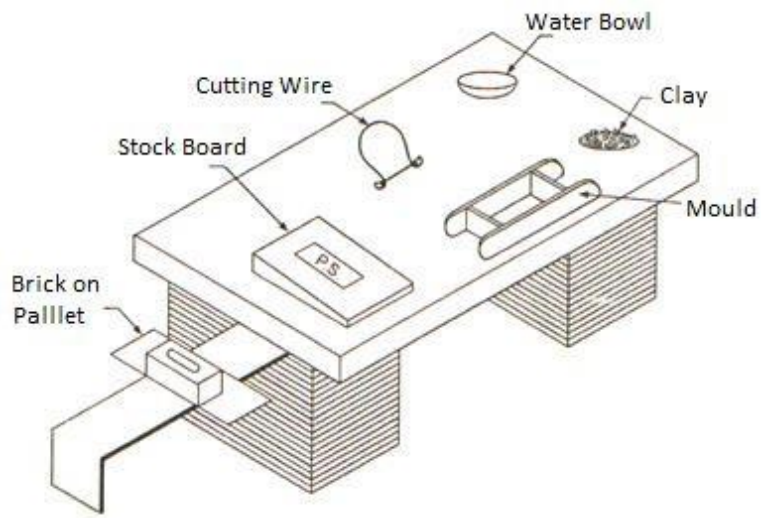


Figure2.3Table Moulding

b. Machine moulding

Machine moulding is useful for large scale manufacturing of bricks. About 2000 bricks can be moulded by a machine per day. It gives bricks of uniform quality and is cheaper in thelong run. Depending on the water content of clay, two methods of machine moulding are in use.

i. Stiffmud process
ii. Dry process

i. Stiffmud process

In this method, the very stiff or plastic clay is used for moulding. Only a small quantity i.e., about 8 to 12%of water is added during tempering in the pug mill. The clay is made to pass under pressure through a moulding machine. The pressed mud comes out through the orifice which gives the mud a continuous ribbon shape of given height and depth. This is cut into desired length by means of cutting wires. The cut bricks are then taken away for drying. A brief description of a typical worm gear type moulding machine as shown in Figure 2.4 is give below.

WormGearTypeMoulding Machine

Aworm geartypemouldingmachine comprisesofthefollowing parts

i. Feedingchamberprovidedwithwormgeartoapply pressure
ii. Hoppertoreceiveclaymix frompug mill
iii. Fixedorificeprovidedinthenarrow frontend
iv. Conveyorbeltonsetof rollers
v. Cutting wire device adjusted in front of the orifice to cut the moulded brick to give it third dimension

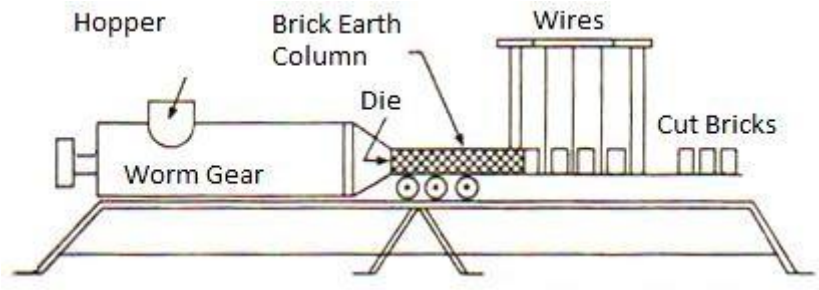


Figure2.5WormGearTypeMachine Moulding

ii. Dryprocess

In this type of moulding, very small quantity of water, a maximum of 10% of water is added during tempering so that the mix is almost dry. The clay is then fed through the hoppers into the mould and is compressed by a plunger with a pressure of about 50-150 kg/cm^2. Such a pressure is sufficient enough to convert the loose damp clay mass into a dense, very compact brick unit, which is then removed from the mould. The metal mould is heated during the moulding process to avoid sticking of clay. Bricks from such moulding machines can be directly taken for burning. The bricks, thus manufactured, have perfect shapes and sizes.

3. Drying

Mouldedbricks need to bedried beforeburning. Drying is essential due to following reasons.

i. tomakethegreen brickstrongenough sothattheycan behandledduring stacking
ii. to allow loss of moisture content at a slow rate because if the bricks are straight away burnt, they may disintegrate due to rapid loss of moisture
iii. thefuelrequirementissignificantlyreducedwithreductionofmoisturecontent

There are two methods of drying

a. Naturaldrying
b. Artificialdrying

a. Naturaldrying

In this method, bricks are dried in the sun in open after moulding.Bricks are laid flat side wise for 2to3daysfor drying.Whenthe bricksaredryenoughtobehandledsafely,theyare

carried to the specially prepared drying yards for stacking. Drying yards are situated at a higher elevation for draining off rain water. The bricks are stacked in the drying yards by keeping them at their edges. 8-10 bricks are kept in each row of a stack. Enough space is left betweentherowsandthe layersinastack forfree circulationofairaround eachbrick.Bricks are protected from direct exposure to sun. And sometimes roofs are also made over drying yard to protect them from heavy rains..

b. Artificialdrying

Artificial method of drying is used in mechanized brick manufacturing units where bricks in largescalearerequiredtobedriedataveryrapidrateandthroughoutthe yearindependentof weather conditions. Artificial drying is carried out in specially designed chambers or tunnels which receive heat from special furnaces built for the purpose.

4. Burning

Aftermouldinganddrying,bricksareburnteitherintheclamporinthekiln.Burningnot only imparts strength and hardness to the brick but also increases its density.

Clamps

Clamps or Pazwas are temporary working arrangements made for burning bricks. In this method dried bricks and locally available ordinary fuel are stacked together in alternative layers upto a desired height on a properly prepared ground to form a clamp. The clamp isthen plastered with mud from outside for its protection. It is ignited from the base andallowed to burn for about a month and then allowed to cool for another month.

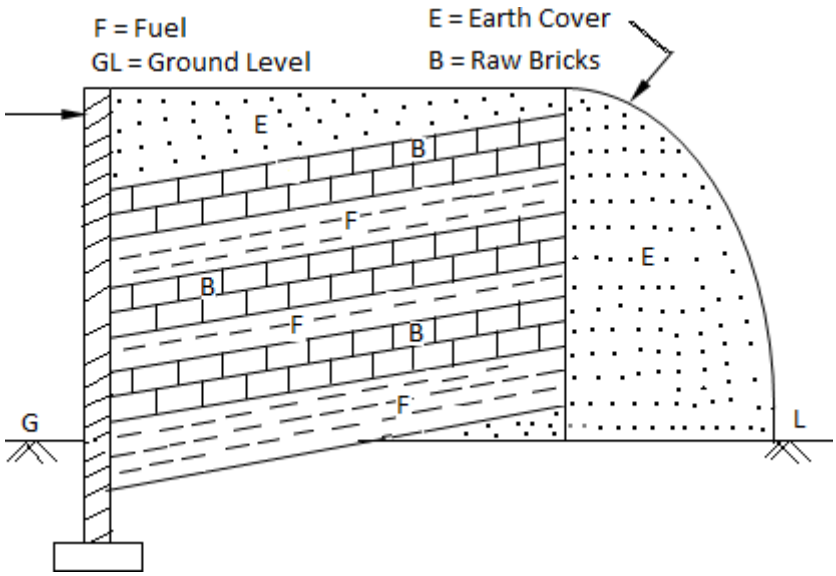


Figure2.6Clamp

A characteristic clamp is shown in the Figure 2.6. In this, a sloping ground of trapezoidal shapeand slopeangleofabout15^{0}isprepared. Thenarrowendofthetrapeziumisdugbelow the ground level and the wider end is raised by filling with the earth so dug. Over the ground soprepared,thefirstlayeroflocallyavailable fuel suchas straw,wood,leaves,branches,etc. is laid up to a height of about 1 m. Three to five layers of sun dried bricks are properly stacked over such fuel layer leaving sufficient open spaces between the brick layers. Over this, another layer of fuel of slightly smaller height is laid. The arrangement of alternatelayers of fuel and bricks is repeated till the required height is achieved. The clamp is then plastered with mud from outside and the clamp is ignited from the narrow end at the base. Itis allowed to burn for a month and then allowed to cool for a month.

Kilns

Unlike clamps, kilns are permanent structure used for burning bricks. Kilns are mainly divided into two broad categories based on their principle of their construction. They are: **intermittent kilns**, and the **continuous kiln**. An intermittent kiln is one, which produces bricks after a definite interval of time. On the other hand, a continuous kiln is the one, which producesbrickscontinuously.Continuouskilnconsistsofanumberofchambers.Burningin

a continuous kiln involves five stages of operations such as loading, burning, preheating, cooling and unloading. The operations in the chambers are so controlled that at a given time, different chambers perform different functions. For example, when one chamber is in the loading process, another chamber may be in the burning stage, the third chamber is in the preheating stage, the fourth chamber in the cooling stage and the fifth chamber in the unloadingorsupplystage.Theoperationsareshiftedfromchambertochamberinsuch away that at any time one chamber is available for unloading.

Intermittent kiln

Allahabad kiln is a common type of intermittent kiln and is widely used. It is generally rectangular in shape and has four permanent walls. It may be constructed totally underground or partly underground and partly over ground. The longer walls are raised perpendicular tothe directions of prevailing winds. The kilns are provided with a number of openings called flues, exactly opposite to each other with a view of charging fuels and controlling air. These openings are provided with dampers or door sheets, which can be raised or lowered.

The shorter walls are provided with doors for loading and unloading the bricks. The floors provided with narrow and deep grooves in the transverse direction running from one opening to the other in the long walls. The place between any two grooves makes a raised platform of about 1 m width. This is called rouse.

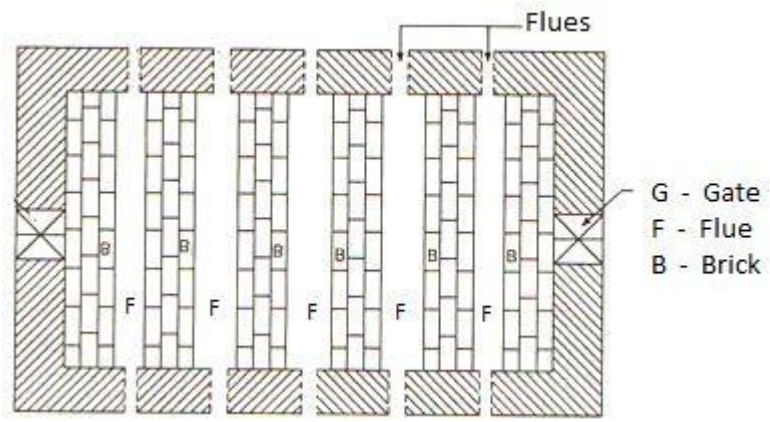


Figure2.7 Intermittentkiln(Allahabad Kiln)

IV. CLASSIFICATIONOFBRICKS

According to the IS: 1077 , 1971 of Bureau of Indian Standard bricks are classified into thefollowing classes.

Class of brick	Characteristics	Uses
First class	1. It is well burnt having smooth and even surface with perfectly rectangular shape and uniform reddish colour. 2. Its surface is smooth, clean and freefrom cracks. 3. When two bricks are stuck against each other a ringing sound is produced. 4. Its compressivestrength shall not beless than 140 kg/cm2. 5. It should not absorb more than 20% of water by weight when immersed inwater for 24 hours. 6. When scratched by finger nail, there should be no mark left on it. 7. When broken into two pieces, it should show uniform compact structure. 8. Show only slight efflorescence.	1. Excellent in all types of construction in exterior walls 2. UsedinR.B work 3. Used as ballast for R.C work 4. Used for flooring and walling purposes
Second Class	1. It is well burntorslightlyoverburnt,not perfectly rectangular shape, havingroughsurfaceanddoesnothaveuniform reddish colour. 2. Metallicringingsoundisproducedwhen two bricks are stuck against each other. 3. Compressive strength shall not be less than 70 kg/cm^2. 4. Itshouldnotabsorbmorethan20%of waterwhenimmersedinwaterfor24	1. These are used in internal walls not exposed to atmosphere. 2. Should be plastered, if used in facing work. 3. Thesearenotusedin R.B work. 4.Thesebricksmaybe laid in mud and lime mortar.

	hours. 5. Shows only slight efflorescence. 6. Itisnotfreefromlumpsand cracks.	
Third class	1. Thesebricksarenotburntinkilnandare slightly under or over burnt. 2. Thesearesoftandcanbe easilybroken. 3. They are light in colour with yellowish tinge. 4. When struck against each other, they do not produce ringing sound. 5. It should not absorb more than 25% of water by weight when immersed in water. 6. Efflorescenceismoderate. 7. Compressive strength is between 35 to 50 kg/cm2.	1. It is used in inferior construction work andatplacesoflessrainfall.
Jhama or over burnt brick	1. Due to over burning, these bricks loose shape and get twisted. 2. Theyaredarkin colour. 3. These are quite strong in compressive strength and have compressive strength more than150kg/cm^2. 4. Thesebrickshavelowporosityand waterabsorption.	1. These bricks are not used in building construction. 2. They may be used as road metals, and in foundation and floor soling.

V. QUALITIESOFGOODBUILDING BRICKS

1. Itshouldhaveperfectlyrectangularshape,regularsurfaceandredcolouredappearance.
2. Itshouldconfirm tothe specifiedsizei.e., 19x9 x 9cm formodular bricks.
3. It should be perfectly burnt. To confirm proper burning, two bricks are struck against each other. A metallic ringing sound confirms proper burning where as a dull thug indicates improper burning.

4. A good building brick should not absorb water more than 20% of its dry weight when immersed in water for 24 hours. In no case, it should be more than 25%.
5. Thecompressive strength ofabuilding brick in no casebeless 35 kg/cm2. Aroughtest for the strength of brick is to drop the brick from a height of 1 m on a hard surface. Upon falling, it should not break.
6. It should leave no mark when scratched by fingernail. This shows that the brick is hard enough for building construction.
7. A good brick has a uniform colour and structure throughout. To check this, a brick is taken from the lot and broken into two halves. The broken surfaces in both halves should have same appearance and structure.
8. Effloresceneshouldbe minimum.It showsthatthesalts ofalkalineare less.
9. A good brick should be able to resist the effects of weathering agents like temperature variation, rain, frost action, etc.
10. A good brick should have adequate resistance to fire. Ordinary bricks can resist temperature upto 12000 C.

VI. USESOFBRICKBATSANDSURKHIS

VII. USESOFHOLLOW BRICKS

Hollow bricks are also known as cavity bricks or cellular bricks. They have a few well defined sets of holes of specified dimensions made in their body. Hollow bricks are made of special type of brick earth having higher percentage of clay. Net weight o f a hollow brick is about one-third to one-half of the solid brick of same dimension. A hollow brick differs from a perforated one in the sense the body of the brick. Hollow bricks have following advantages in their favour. A typical hollow brick is depicted in the Figure 2.8.

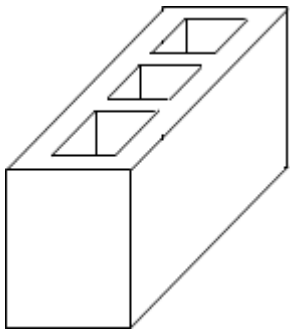


Figure2.8Hollow Bricks

Advantages

i. Itislightinweightandcanbemoreconvenientlyhandled.
ii. Itoffersbetterinsulationagainstheat,soundanddampnessofthe building.

Uses

They are used for construction of load bearing walls, partition walls or panel walls in multi-storeyed building. They are also used in building for better insulation against heat, sound and dampness.

CHAPTER-3

CLAYPRODUCTSANDREFRACTORYMATERIALS

=>Theproducts whicharepreparedfromclayareknownasclay product.

=>Theclaywhenmadewetwithwateritpossessplasticinnatureandthisplasticclaycan be moulded in any shape, then dried and burnt.

Theclayproductswhichareemployedintheconstructionofbuildingsaretile,terra cotta, porcelain, glazing etc.

TILE:-

-> Itmaybedefinedasthethin slabofbrickwhichareburntin kiln.

->Themanufacturing processof tileisjust similarto bricki.e

(i) Preparationof clay.

(ii) Moulding

(iii) Drying

(iv) Burning

->Thetilecan be classified astwo types

(i) Common tile

(ii) Encoustictile

COMMON TILE:-

->Thesetiles havedifferent shapeand sizeand mainlyused inpaving andflooring .

ENCOUSTICTILE

->Thesetiles areusedfordecorativepurpose,i.ein floors,walls,ceiling etc.

->Thesetilesaremanufacturedfromcarefullypreparedclay,colouringmaterialsandother ingredients.

=>The costof thesetiles aremorethan common tiles.

=>Thesetilesprovide uniform appearance.

TYPESOFCOMMONTILE

Dependingupon theusethereare3different typesof tile.

*Draintile

*Floortile

*Roof tile

DRAIN TILES

->Thetiles which areused fordrains purposes areknown as drain tiles.

->Generallytheseareusedinwaterloggedareas.

=>Thesetilesmaybecirculararsemicircularinshape.

=>ThesetilesarealsousedinIrrigationstructures.

FLOORTILES

->Thetileswhichareusedforflooringpurposesareknown as floortiles.

->Thesetiles maybeofsquareor hexagonal in shape.

->Thesetilesarehard.

=>thesetiles areavailable indifferentcolours.

=>Thesetilesdonotrequirepolishing &thefloorisreadytousefromthenextdayof laying.

ROOF TILES

->Thetiles which areused forroofing purposes areknown as Roof Tiles.

->Thesetiles areheat proof.

=>ThevarioustileswhichareavailableinthemarketareFlemishtiles,pottiles,corrugated tiles etc.

CHARACTERISTICSOF AGOOD TILE

Agood tileshould havethe following characteristics.

* Itshouldberegularinshapeandsize.

* Itshouldbehard.

* Itshouldwellburnt.

*Itshouldbefreefromanycracks.

TERRACOTTA:-

->Terracottameanbaked earth.

-> Itisatypeof clayproductwhichisglazedwithGalena.

=>Itisasoftmaterial.

=>Themanufacturing process of terracottaisalso similarto that of brick.

Properties

->It islightinweight.

->Itisfireproof.

->Itcanbeeasilyclean.

=>Itcanbeeasilymouldedindesiredshape.

=>Itcannotbeaffected byatmosphericagents.

USESOFTERRACOTTA:-

->Itisadoptedforalltypes ofornamentalwork.

->Itisusedasadecorativematerialinpillars,columns etc.

TYPESOFTERRA COTTA:-

Thereare2 typesofterracotta.

1. Porousterra cotta.
2. Polishterra cotta.

POROUSTERRA COTTA:-

->Toprepareporousterracottathesawdustareadded inclay beforethestageof moulding.

->Whenthearticlesfromsuchclayareburntinakiln,theorganicparticlesareburntandthey leave pores in the articles.

=>This terracottais fireproof.

=> Itis verylightin weight&structurally weak.

POLISHTERRA-COTA

->Thisisalsoknownasfineterra-cotta.

->Topreparethistypeofterra-cottathearticlesareburntinthekilnatatemperatureabout 650°c.

=>Thenthe articlesareremovedfrom thekiln&areallowedtocool down.

=>Theyarethencoatedwithglazingcompounds&burntagaininthekilnatatemperature about 1200°c.

=>Itisunaffectedbytheadverseatmosphericconditions.

EARTHENWIRE:-

->Theearthenwireisusetoindicatethearticlespreparedfromclaywhichisburnt atlow temperature & cooled down slowly.

->Thisclayis mixedwithrequiredquantity ofsand,crushedpotteryetc.

=>Theaddition ofsuchmaterials preventscrackingduring burning.

=>Theearthwireswithbasedmaterialbecomeimpervioustowater&theyarenotaffected by atmospheric action.

=>Theseareused forordinary drainpipes, partitionblocks etc.

STONE WIRE:-

->Thetermstonewireisusedtoindicatetothearticlespreparedfromclaywhicharemixed with stones and crushed pottery.

->This mixeris thenburnt ata hightemperature andcooled down slowly.

=>Thestonewiresarestrong,durable &fire resistant.

=>Theyareusedasjarstostorechemicals,washbasins etc.

PORCELAIN:-

Thetermporcelainisusedtoindicatetheearthenwirewhichiswhite,thinand semitransparent.

->Asthecolour ofporcelain is whiteit also knownas whitewire.

->Itishard andnon-porousmaterial.

=>Itis hard&nonporous.

->Theseareusedinvariouspurposeslikesanitary fittings,insulatingboards etc.

->Theseareoftwotypes

*Lowvoltageporcelain

*Highvoltageporcelain

Lowvoltageporcelain:-

- ⇨ Itisprepared bydryprocess &atlow voltage.
- ⇨ Ifsomelowquantityofaluminaisaddedthenitcanresisthightemperaturetoa certain extent.
- ⇨ Thesearemainly usedforswitch boards,insulatingtubes etc.

Highvoltageporcelain:-

- ⇨ Itispreparedbywetprocessathightemperature.
- ⇨ Itcanresist hightemp.&voltage.
- ⇨ Theseareusedin the construction ofatomic reactors,plugs etc.

GLAZING :

->Aglazeisaglassycoatthicknessabout0.1to0.2mmappliedonthesurfaceoftheclay products.

->Theglazing is donefor following purposes

*To improvethe appearance

*Tomakethearticlemore durable

*Toprotectthearticlesfromweatheringaction.

TYPESOF GLAZING

*Transparentglazing

*Opaqueglazing

TARNSPARANTGLAZING

->Whenaglazingmaterialfromtransparentcolourisprovidedinthesurfaceofclayproduct it is called as transparent glazing.

->Theappearanceofthis glazingislikeglass.

->Itgiveslessstrength.

=>Thisglazingisrarelyusedasitprovides lesssafetytothe articles.

OPAQUE GLAZING

->Thistypeofglazingisadoptedtogivebutterappearancethanthatgivenbytheburnt material.

->Theclayisfinelypowderanddried.Thenthesufficientquantityofwaterisaddedtoclay to make a plastic substance.

->Thearticleswhicharetobeglazedaredippedinthissubstancebeforeburningandthen heated.

=>Theburning ofarticles gives the flow ofclay particle & an opaqueglazeis formed.

=>Forobtainingcolouredglazes,aspecialcolourpigmentisaddedlikeironoxide,which gives red colour, copper oxide, which gives green colour etc.

REFRACTORY MATERIAL

->Thematerialswhichareable toresisthightemparatureareknownasrefractory material.

->Therefractorymaterialcanposessthefollowingpropaties.

*It'smeltingpointshouldbehigh.

* Itshouldbestrong anddurable.

* Itmustpossessresistancetoweatheringaction.

USES:-

->Theseareusedinblastfurnaces.

CLASIFICATIONOFREFLACTORYMATERIAL:-

->These areclassifiedinto followingtwo ways.

*Accordingtochemicalproperties

*Accordingtoresistancetotemparature.

ACCORDINGTOCHEMICALPROPERTIES:-

->Theseare3types.

*Acidicmaterial – e.gSilica,quartzaite.

*Basic–e.gmagnesiaDolamite.

*Neutralmaterial –e.gCarbon,chromite,boxite.

ACCORDINGTORESISTANCETO TEMPARAATURE

->These aredevidedinto2types

*Lowqualityrefractory material

*Highqualityrefractorymaterial

Lowqualityrefractory material:-

- ⇨ Thematerialwhosemeltingpointismorethan1580°cisknownaslowquality refractory material.
- ⇨ Thismaterialisusedfor manufacturingflyashbrick&alsousedforelectricboards.

Highqualityrefractorymaterial:-

- ⇨ Thematerialwhosemeltingpointisabout1600°cisknownashighqualityrefractory material.
- ⇨ Thesematerialsareusedforthe constructionofrockets, jetsetc.
- ⇨ Thistypeof materialis alsoused inthemanufacturingofvehicles.

CHAPTER-4

CEMENT

Compositionofcement:-

Thecementconsistsofthefollowing chemicals

°Lime-CaO- 62%

°Silica–SiO_2-22%

°Alumina-Al_2O_3-5%

°Calciumsulphate-$CaSo_4$-4%

°IronOxaide-Fe_2O_3-3%

°Magnesia-MgO-2%

°Sulphur-S-1%

°Alcalineandothermaterial-1%

Typesof cement:-

Accordingto thecreation ofthe cementit isclassified intotwo type.

* Naturalcement

* Artificalcement

NaturalCement:-

Thenaturalcementisobtainedbyburingandcrushingthestonescontainingclay carbonates of lime and some amount of carbonates of magnesia.

* Thequantityofclay innaturalcementis 20-40%.

*Thecolor ofthis cement is brown.

*Thiscementsets repidlywhen mixedwith water.

* Thecost ofthis typeofcementis very high.

* Thistypeof cementisrarely usedinIndia.

Artificialcement:-

->This typeof cementisprepared indifferent verities.

->Themanufacturing of this types ofcementincludes the following process.

* Mixingofraw materials.

* Burning.

* Crushing.

* Grinding.

Typesofartificialcement:-

:-Acidresistantcement.

:-Blastfornesscement.

:-Colouredcement.

:-Expandingcement.

:-High alumina cement.

:-Hydyophobiccement.

:-Lowhit cement.ral

:-Pozzuolanacement.

:-Quicksetting cement.

:-Rapidhardeningcement.

:-Sulphateresisting cement.

:-Whitecement.

Acidresisting cement:-

Anacid resisting cementis composed ofthefollowing ingradients.

i. Acidresistingaggregate.

ii. Additiveslikesodiumfluosilicate.

iii. Aquessolutionofsodiumsilicate.

Theadditionoffluosilicateacceleratesthehardeningprocessofsodiumsilicate&italso increases the resistance of cement to acid & water.

Blastfranace cement:-

->Forthis cementtheslag whichis obtainedfromblast furnaceis used.

->Theslag isa waste productinthe manufacturingprocessof iron.

=>The clinkerof cementis mixed with60–65 %ofslag.

=>Thestrengthof thiscement is less& itrequires longerquiring period .

Coloured cement:-

->Thecementofdesiredcolourisobtainedbymixingthemineralpigmentswithordinary cement.

->Theamount ofcolouringmaterial isbetween 5-10%.

=>Thecolouredcementiswidelyusedforfinishingoffloors,externalsurfacesetc.

=>Thechromiumoxidegivesgreencolour,cobaltgivesbluecolour&ironoxidegives brown red or yellow colour in different proportions.

Expandingcement:-

->Thistypeofcementisproducedbyaddingtheexpandingmaterialoringradientslikes sulpher alluminate to ordinary cement.

=>Thistypeofcementisusedfortheconstructionofwaterretainingstructures&for repairing the damaged concrete structures.

HydrophobicCement:-

- Thistypeofcementcontainstheadmixtureswhichdecreaseswettingabilityof cement grains.
- Usuallytheadmixturesareoxides,petroliumsetc.
- Thesesubstancesformathinlayerarroundcementgrains.
- Whenthiscementis used,thewaterresistanceof concreteis increased.

Highaluminacement:-

- Thiscementisproducedbygraindingtheclinkersfromedbycalciningbauxiteand lime.
- Thiscement israrely usedin India.

Low heat cement:-

- Inthiscementaconsiderableheatisproducedduringthesetting action.
- Itcontainshigher%ageofdicalciumsilicate&lower%ageoftricalcium aluminate.
- Thiscementpossessless compressivestrength.

Pozzuolona cement:-

- Itcanbeproducedbysurkhiwhichispreparedbyburningbricksmadefromordinary soils.
- Thiscement isused forconcrete workunder water.
- The%ageofpozzuolana material shouldbe between10 to 30.
- Itis cheap.

Quick setting cement:-

- Thiscementisproducedbyaddingsmallpercentageofaluminiumsulphateandby finely grinding the cement.
- Thewsettingactionofthis cementstartswithin5 minutes.
- Thiscement isused tolay concreteunder static water&running water.

Rapidhardening cement:-

- Itisjustsimilartoordinarycement butisgivesmorestrengththanordinary cement.
- Itisnotdamagedeasily.
- ItcontainshighpercentagesoftricalcIiumsilicate .
- Thestructureswithheavyload areconstructedwiththis cement.
- Thiscementiscostlierthanordinarycement&isverylight.

Sulphateregistingcement:-

- Theordinary cementis mixedwithcalsiumhydroxideandfinallygrinded.
- Thecementisusedforthestructrewhicharetobedamagedbyalkalineconditions such as canal linings, culverts , siphons etc.
- Thecement is usedin marine construction.

White cement:-

- Thiscementispreparedfromtherawmaterialswhicharepracticallyfreefrom colouring oxides of iron,manganese or chromium.
- Itisusedforplasteringwork,floorfinishingetc.
- Itisalsocostlythanordinarycement.

Propertiesof cement:-

Followingarethe propertiesof cement.

1. Itiseasilyworkable.
2. Itgivesstrengthtothemasonarywork.
3. Itisan excellentbindingmaterial.
4. Itoffersgood resistancetothe moisture.
5. Itpossessgoodplasticity.

6. Itstiffensorhardensearly.

Testingofqualityofcement:-Fortestingthequalityofacement,thefollowingtestsare carried out in the laboratory :-

(i) Fineness
(ii) Consistency
(iii) Compressive strength
(iv)Settingtimes(Initial&Final)
(v)Soundness

CHAPTER-5

SANDGRAVEL,MORRUMANDFLYASH

Sand :-

->Generallysand isformedby thedecomposition ofstoneduetovariouseffectsof weather.

->Thesandparticles containssmallgrainsofsilica(SiO_2).

->Thereare3catagoriesofsandaccording tothe naturalsources fromwhichitisobtained :

*Pit sand

*Riversand

*seesand

PIT SAND

->Theseareobtainedbyformingpits.

->Thepit is excavated froma depthof1-2m fromthe ground.

->Thesepitsandconsistsofsharp,angulargrains,whicharefreefromsalt.

->theseareexcellentmaterialformortarofconcrete work.

->Thesepitsandisrarely usednowa days.

RIVERSAND

->Thissandisobtained fromriver beds.

->Thissandconsistsoffineroundedgrainsduetotheactionofwater current.

->The colour ofriver sand is white.

->This sandiscommonly usedin cleanedcondition,so itisused forall purposes.

SEE SAND

->Thissandisobtainedfromseeshores.

->Thesesandisalsoconsistoffinerounded grains.

->Thecolour ofthis sand is light brown.

->Thissandretardsthesettingactionofcement.

CLASSIFICATIONSANDACCORDINGTOTHESIZEOFGRAIN

Accordingtothegrainsizeof sandparticles itisclasified to3 type.

*Finesand

*coursesand

*Gravellysand

=>Thesandpassingthroughascreenofopeningof1.5mmiscalledasfinesand.Theseare mainly used in plastering purpose.

=>Thesandpassingthroughascreenofclearopeningof3.71mmiscalledascoursesand.It is mainly used for masonry work.

=>Thesandpassingthroughacscreenofclearopeningof7.61mmiscalledGravellysand. These are commonly used for floorings, paving of road surfaces etc.

BULKINGOF SAND :-

The presence of moisture in sand particles increases thevolume of sand.It is due to the fact that the moisture causes a thin layerof water arround the particles which results increase in volumeofsand.Foramoisturecontentofabout5 to8percent,thisincreaseinvolumemay 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.

Qualitiesofsandforplaster& forMasonrywork :-

- ⇨ Thesandshouldbeclean&coarse.Itshouldbefreefromanyorganicorvegetable matter.
- ⇨ Itshouldcontainsharp, angular,coarse&durablegrains.
- ⇨ Itshouldnotcontainsalts whichattractmoisturefrom atmosphere.
- ⇨ It should be well graded i.e, should contain particles of various sizes in suitable proportions.ItshouldpassBISNo.480meshsieve&shouldnotpassBISNo.15 sieve. The fineness modulus of sand should be between 2 & 3.

Gradingofsand forplaster&forMasonrywork :-

- ⇨ Inordertoobtainedtheconcreteofgoodqualities,thesandshouldbeproperly graded.
- ⇨ Forincreasingthestrengthofconcretestructure,thegradationshouldberequired.
- ⇨ ThegradingofsandisexpressedintermsofBIStestseiveNo.480,240,120,60,30, 15.

- ⇨ Thegradingofsandhasamarkedeffectbontheuniformity,workability&finishing qualities of concrete.

GRADINGTABLE

BISsieveNo.	%ageof wt passing through thesieve
No 480	95-100
No 240	70-95
No 120	45-85
No 60	25-60
No 30	5-30
No 15	0-10

USEOF GRAVEL :-

->Therearе6type of gravel

*1crushedgravels :-Theseareusedin redimixed concrete.

*1roundgravel :-Theseareused in roofing,decorating purposes etc.

*2crushedgravel :-Theseareused formanufacturing ofbasement materials indrains.

*2roundgravel:-Theseareusedfor roofing,decoratingpurposes .

*3crushedgravel:-Theseareusedforbasement materialinroads .

*3roundgravel :-Theseareused fordecorating purposes in playgrounds.

USEOFMORRUM:-

->Itisusedaspavingmaterialintheconstructionofroad.

->Itisusedasbasementmaterialindrains.

->Itisusedfor fillingundergroundtanks.

->Itisusedforunderlayingsurfaceoffoundation.

->Itisusedforflooringpurposesinbuildings.

USE OF FLY ASH

->Itisusedasanadmixtureinconcrete.

->Italsoimprovesthestrengthofconcrere.

-> Itimprovesthewatertightnessof concrete.

-> Itpermitstheeasierplacing&finishingofconcrete.

->Itisusedformanufacturingthebuildingbricks.

CHAPTER-6

MORTARANDCONCRETE

Definition& Composition

Mortar is a mechanical mixture of cement and sand having different proportionpreparedbyaddingrequiredquantityofwater.Itisalsoknownasbinding material like cement or lime.

Mortarisusedasabindingmaterialforbrickmasonryandstonemasonry,asacovering material to walls in the form of plaster to provide a smooth, hard and decorative.

PropertiesofgoodbuildingMortar

Followingarethe properties ofgood building mortar required

1. Itshouldbeeasilyworkable.
2. Itshoulddevelopadequatestrengthintension,compressionandbondfortheworkfor which it is used.
3. Itshouldset quicklysothat thespeedofconstructionis ensured.
4. Itshouldbedurableandnotaffectthedurabilityofothermaterials.
5. Itshouldbindthestoneandbricktogiveatightjointthroughwhichwatercannot penetrate.
6. Itshouldbecapableofdevelopingthedesignedstressed.
7. Itshouldbe cheap.

UsesofMortar

Thefollowing aretheuses ofmortar

1. Itisusedtofillupthespacesbetweenbricksandstonesformakingwallweather tight.
2. Itisusedtobind togetherthebricksinbrick masonry.
3. Itisusedin concreteasamatrix.
4. Itis usedto formjoints of pipes.
5. Itis usedto improvegeneralappearanceof structure.
6. Itisusedto hideopenjointsof abrickworkand stonework.
7. Itisused toserveasamatrix orcavityto holdcoarse aggregates.
8. Itisused tobind thebuilding unitssuchas bricks,stones, etc.into asolid mass.
9. Itisusedtofillupcracksdetectedinthestructureduringmaintenance process.

INGREDIENTS OF MORTAR

Theingredientsofvariousmortarsusedfordifferentengineeringpurposeareas follows

1. Bindingmaterials(Cement,Lime)
2. Fineaggregates(Sand,Surkhi,Ashes,Cinder)

Bindingmaterials

Cement mortar:

In this type of mortar, cement is used as a binding material. Depending upon the strengthrequiredandimportanceofwork,theproportionofcementtosandbyvolumevaries todifferentproportions.Thesurkhiandcindercannotbeusedincementmortarbecausethey are not chemically inert substances.

Function:Incementmortar,cementperformsthefollowingfunctions:

- Itmakes themortar impermeableby filling upthevoidsexisting inthefine aggregate.
- Itimpartsstrengthtothemortaronsettingandhardening.

Limemortar:

Itisalsoused asabindingmaterialinpreparingthemortarsforvariouspurposesbut itsstrengthislessthanthatofcementmortar.Thesurkhiisusedasthefineaggregateinthis case.

FineAggregates(SAND)

Sandisthemostimportantfineaggregatewhichisusedincementmortar.Thesand forms an important ingredient of mortar.

ClassificationofSand:

Accordingto thesizeof grains, thesand isclassified asfineandcoarseand gravelly.

1. Thesandpassingthroughascreenwithclearopeningsof1.5875mmisknownasthe fine sand. It is mainly used for plastering.
2. Thesandpassingthroughascreenwithopeningof3.175mmisknownasthecoarse sand. It is generally used for masonry work.
3. Thesandpassingthroughascreenwithopeningof7.62mmisknownasthegravelly sand. It is used for concrete work.

PropertiesofgoodSand

Followingaretheproperties ofgood sand

1. Itshouldbechemicallyinert.
2. Itshouldbe clean andcoarse.
3. Itshouldbe freefromanyorganicorvegetablematter.

4. Usually3to 4%clayis permitted.
5. Itshouldcontain sharp,angular,coarseanddurablegrains.
6. Itshouldnotcontainsalt.

Functionofsand in Mortar:

Thesandisused inmortarfor following purposes:

1. **Bulk:**Itdoesnotincreasethestrengthofmortar.Butitactsasadulterant.Hencethe volume of mortar is increased which results in reduction in cost.
2. **Setting:**Ifbuildingmaterialisfatlime,thecarbondioxideisabsorbedthroughthe voids of sand and setting of fat lime occurs effectively.
3. Strength:ithelpsintheadjustmentofstrengthofmortarbyvariationofitsproportion with cement or lime. It also increases the resistance of mortar.
4. **Surfacearea:**Itsubdividesthepasteofthebindingmaterialintoathinfilmandthus more surface area is offered for its spreading.
5. **Shrinkage:**Itpreventsexcessiveshrinkageofthemortarinthecourseofdryingand hence the cracking of mortar during setting is avoided.

PERCAUTIONSIN USING MORTAR:

Followingaretheprecautions areto betakenwhilemaking useof mortar:

1. **Consumptionofmortar:**afterpreparation,themortarshouldbeasearlyaspossible. 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. **Frostaction:**Thesettingactionofmortarisaffectedbythepresenceoffrost.Itis thereforeadvisableto stop the work in frosty weather orto execute it with cement mortar.
3. **Workability:**Themortarshouldnotcontainexcesswateranditshouldbeselected or recommended.

CONCRETE

Definition

Thecementconcreteisa mixtureofcement,fineaggregate (sand),coarse aggregate(crushedrock)andwater,whicharewellproportionedandmixproperly.Itbecome hard like a stone after proper curing.

CHARACTERISTICSOF GOOD CONCRETE

Agoodconcrete shouldhavefollowing characteristics:

1. Itshouldbehighcompressivestrength.Thecompressivestrengthshouldnotbeless than 15.5 N/mm^2.
2. Onhardening,itshouldexhibitminimum shrinkage.
3. Itshouldbe economicalforthedesiredstrength.
4. Itshouldhaveminimumthermalexpansionso astoprovidegoodresistanceto fire.
5. Itmustbeadequatelydense.Thedensity ofgoodconcreteshouldbeabout24kN/m^3.
6. Itshouldsufficientlyhardandprovideenoughresistancetoabrasion.
7. Thispropertyisofparamountimportancewhenconcreteistobeusedformaking steps of stairs and road pavements.
8. Itmustbeadequatelydurabletoresisttheeffectsofweatheringagents.
9. Itshouldhaveprovided therequiredfinish totheconcretestructure.
10. Itshouldminimumcreep.
11. It is proved to be more economical than steel. This is due to the fact that sand and aggregates,formingthebulkofcementconcrete,totheextentofabout80to90%.

ADVANTAGESOFCONCRETE:

Followingarethe advantagesofconcrete

1. Ithashigh compressive strength.
2. Ascomparedtoothermaterials, concreteiseconomicalinlong run.
3. Itisdurableandfireresistantandrequiresverylittlemaintenance.
4. Thegreenconcretecanbeeasilyhandledandmouldedintoanyshapeorsize according to specifications.
5. Theconcretecanbepumped andhenceitcan belaidinthedifficult positions also.
6. Concretecanevenbesprayedonandfilledintothecracksforrepairsbythegrading process.
7. Beingstoredincompression,ithasunlimitedstructuralapplicationsinincombination with steel reinforcement.

DIS-ADVANTAGESOFCONCRETE:

Followingarethe disadvantagesofconcrete

1. Concreteistobereinforcedwithsteelbarsormeshessinceithaslowtensilestrength and hence cracks easily developed.
2. Provisionforconstructionjointshastobemadetoavoidthedevelopment ofcracks due to drying shrinkage and moisture movement in fresh concrete.
3. Inordertoavoidtheformationofcracksduetothermalmovement,expansionjoints have to be provided.
4. Concreteisliabletodisintegratebyalkaliandsulphateattack.
5. Concreteasamateriallacksinductilityandthisfactorprovidesdisadvantageouswith respect to earthquake resistance.

USES OF CONCRETE:

Followingareusesof concrete

- Foundation
- Building
- Road
- Artificial
- Airfield
- Waterretaining structures
- Dockandharbour
- Dams
- Bridges
- Bunkers

GRADINGOF AGGREGATES:

In order to obtain concrete of denser quality, the fine and coarse aggregates are properlygraded.Thegradingoffineaggregateisexpressedintermsof BIStestsievesnos. 480, 240, 120, 60, 30 and 15.

GRADINGLIMITSFORFINE AGGREGATES

BISsieve	Percentagebyweightthroughseive	
	Naturalorcrushedgravel sand	Crushedstonesand
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-CEMENTRATIO:

1. Itistheratioofwatertocementandisexpressedasratiooftheweightorvolumeof water to the weight or volume of cement in concrete mixture.
2. Generallyitisexpressed assomanylitresofwaterpercementbag(50kg).
3. Itisfoundtheoreticallythatwaterrequiredforthesetwofunctionsisabout0.50 to 0.60times theweight of cement.
4. Thequantityofwaterrequiredinlitresperbagofcementas1litreofwaterweighs1 kg. For instance, if water required for 1 bag of cement is 30 litres, the water-cement ratioisequalto $\frac{30}{50}$ **= 0.60**

REINFORCEDCEMENTCONCRETE(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,haircracksinconcreteareunavoidable.Reinforcementsareusuallyintheformof

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 ofthe beam c/s. Resulting eitherno 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:

Thewordtimberisderivedfromanold English wordtimbrianwhichmeansto 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.

CharacteristicsofgoodTimber:

Followingarethe characteristicsofgoodtimber

1. Itshouldbeheavyanduniform colour.
2. Itshouldhaveregularannular rings.
3. Afreshlycut surfaceshouldgiveasweet smell.
4. Itshould havestraight andclose fiber.
5. Itshouldbesonorouswhenstruck.
6. Itshouldbeheavyinweight.
7. Itshouldbe freefromshacks,flaws,dead,knotsofanykind.
8. Thecellulartissue ofthe medullary raysshouldbehardand compact.
9. Whenplaned,itssurfaceshouldpresentafirmbrightappearancewithasilky lustre.
10. Agoodtimbershouldbestrongforworkingasstructuralmembersuchasjoints, beams, rafters, etc. it should be capable of taking loads slowly or suddenly.

Advantagesof Timber:

Followingaretheadvantagesoftimber

1. Itislightinweightyetstrong.

2. Itiseasilyavailableandcanbequicklytransportedbysimplemeans.
3. The floor joints in an average dwelling weighs less than rolled-steel beams of equalstrength.
4. Boardsmaybecut rapidlybyasaw andfastened firmlytogetherwith nails.
5. Itisagoodinsulatorof heatand sound.
6. When properly protected timber structures may be give good service for hundred ofyears.
7. Itstandsshocksandbumps, agooddeal betterthan ironand concrete.
8. Repairs,additionsandalterationstotimberconstructionare easy.
9. Onaccountofitslightweight,timberisgenerallypreferredforbuildingworksin earthquake region.
10. It is considered to bean ideal material ofconstruction in seawaterormarineworks as it can resist corrosion.

Dis-AdvantagesofTimber:

Followingarethe dis-advantagesof timber

1. Thegreatestdisadvantageisitsreadycombustibility,whichcanbediminishedbutnot eliminated even by expensive treatment.
2. Framebuildingsbuiltcloselytogetherpresentaseriousconflagration hazard.
3. Timberswellsand undergoesshrinkagewith changingatmospheric humidity.

UsesofTimber:

Followingarethe usesoftimber

1. Itisgenerallyusedintheformofpiles,posts,beams,lintels,door-windowframes, and leaves, roof members, etc.
2. Itisemployedforflooring,ceiling,paneling,and constructionofpartitionwalls.

3. Itisusedforformworkforconcrete,forthetimberingtrenches,centeringforarch work, scaffolding, transmission poles and fencing.
4. Itisusedin wagonsandcoach building,marineinstallations bridges.

CLASSIFICATIONANDSTRUCTUREOFTIMBER :

Fortheengineeringpurposes,thetreesareclassifiedinto**two** categories.

i.e-1.EexogenusTree 2.EndogenousTree

ExogenousTree:

1. Thesetreesaregrowoutwardsandincreaseinbulkbytheformationofsuccessive annular rings on the outside under the bark.
2. Inthesetrees,eachannualringrepresentslayerofwood,depositedevery year.
3. Example:-Deodar,Chir, Sal,Kail,Shishum,Teak.
4. TheExogenous trees maybefurther classifiedinto two categories:
    1. ConifersTree 2.Deciduousorbroad-leafstrees

EndogenousTree:

1. Thesetreesaregrowsinwardsor endwards.
2. Thesteamsofthesetreesaretooflexibleandthustheyarenotmuchsuitablefor engineering works.

StructureofTree:

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

Fromthevisibilityaspect,thestructurefatreecanbedividedintotwocategories:

I. Macrostructure

II. Microstructure

Macrostructure:

Followingarethedifferent 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 cellulartissues 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. **Cambiumlayer:**-Thethinlayerofsapbetweensapwoodandinnerbarkisknownas 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 theannual rings of heart wood and sap wood. These rays are sometimes broken.

Microstructure:

Thestructureofwoodapparentonlyatgreatmagnificationiscalledthemicrostructure. It is studied under a micro scope in which living and dead cells are present.

Aliving cellconsists of thefollowing 4 parts:

I. Membrane

II. Protoplasm

III. Sap

IV. Core

Thedeadcellconsists of following3 parts:

I. Conductivecell

II. Mechanicalcell

III. Storagecell

DefectsinTimber:

Thedefects occurs intimberaregrouped into following five categories

1. Defectsduetoconversion
2. Defectsduetofungi
3. Defectsduetoinsects
4. Defectsduetonaturalforces
5. Defectsduetoseasoning

(1) Defectsduetoconversion: Inthiscase,thefollowingdefectsmayoccurs:

I. Chipmark

II. Diagonal grain

III. Torngrain

IV. Wane

(2) Defectsduetofungi: Thefungiareminutemicroscopicplantorganism.Theyattack timber only when the following two conditions are satisfied.

I. Themoisturecontent f timberis above20%.

II. Therearepresences of airand warmthforthe growthoffungi.

Followingdefects areoccurs in thetimber by fungi:

I. Blue stain
II. Brownrot
III. Dryrot
IV. Heartrot
V. Saprot
VI. Wetrot
VII. Whiterot

(3) Defectsduetoinsects: Followingaretheinsectswhichareusuallyresponsibleforthe decay in timber;

I. Beetles
II. Marineborers
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. ChemicalStain
IV. CoarseGrain
V. DeadWood
VI. Druxiness

VII. Foxiness

VIII. Knots

IX. Rind Galls

X. Shakes

XI. Twisted Fiber

XII. Upsets

XIII. WaterStain

XIV. WindCrack

(5) Defectsduetoseasoning: Followingarethedefects occursdueto seasoning:

I. Bow

II. Case-hardening

III. Check

IV. Collapse

V. Cup

VI. Honey-combing

VII. RadialShakes

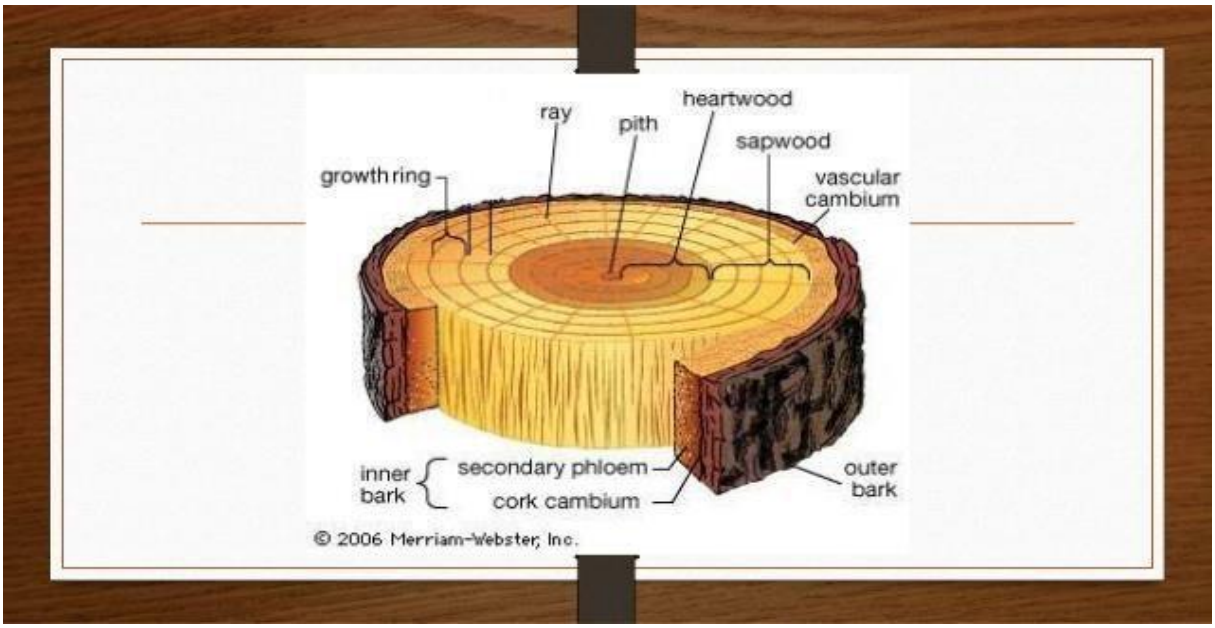
VIII. Twist

IX. Warp

Rind gall:

Adefectintimbercausedbyabruiseinthebarkwhichproducesacalluson thewood over which later layers grow without consolidating. Or

Adefectintimbercausedbyabruiseinthebarkwhichproducesacallusuponthe woodoverwhichthelaterlayersgrowwithoutconsolidating.Laslett,TimberandTimber Trees.

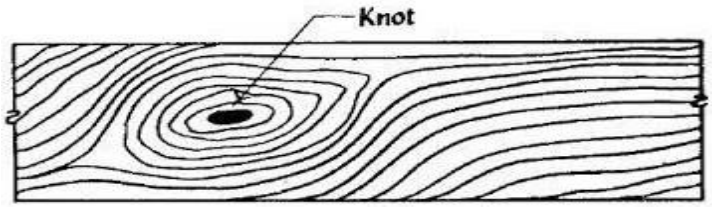


Knots

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 trunkofthetreeitself.Inmostcasesknotsarecausedbythe natural growth of the tree, though the specific circumstances under which they form determines how they will appear. Someknotsareformedbyfungalinfections,however,and

canspreadtoothertreesonyourproperty as well.



Quality ofgoodTimber:

Ingeneral,thequalityof god timberdependsuponthefollowing factors

1. Environmentalcondition ofthelocality.
2. Maturityof thetree.
3. Methodof seasoning.
4. Natureofsoil.
5. Processofpreservation.
6. Timeoffelling.

Decayof Timber:

Thetimberissaidtobedecayedwhenitissodeterioratedthatitlossesits value as an engineering material.

Followingarethe variouscauseswhichfavored theearlydecay ofthe timber:

1. Alternatedry andwet condition.
2. Badstorageor stackingof timber.
3. Improperseasoning.
4. Keepingtimberincontactwith dampness.
5. Useoftimber withouttaking sapwood fromits structure.
6. Usingunseasonedtimberwithoutapplyingsuitablepreservativeonitssurface.

PreservationofTimber:

Thepreservationoftimberiscarriedouttoachievethefollowingthree objectives:

1. To increasethe lifeof timber structures.
2. Tomakethetimberstructures durable.
3. Toprotectthetimberstructuresfromthe attackof destroyingagents.

RequirementsofagoodPreservation;

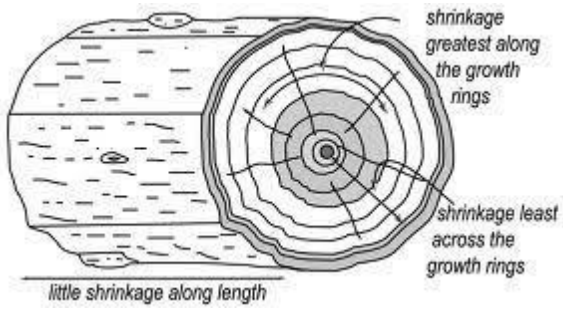
Followingarethe requirements ofagood preservation:

1. Itshouldbecapableofcovering alargeareawithsmall quantity.
2. Itshouldbefreefromunpleasantsmell.
3. Itshouldbenon-inflammable.

4. Itshouldbequitefficientinkillingfungi,insects etc.
5. Itshouldnotaffectthestrengthcharacteristicoftimber.

Seasoning of timber:

1. Seasoningoftimberistheprocessofdryingtimberorremovingmoistureorsap, 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.



Objectivesof seasoning

Followingarethe objectives of seasoning

1. Tominimizethe tendencyof timber to shrink.
2. Toincreasethe strength.
3. Tomakethe timbersafeagainst fungiand insects.
4. Tomakethetimbereasilyworkableinany shape.
5. Tomakethe timbersuitable for gluing.

No.	Typeof timber	Thicknessinmm			
		12	25	38	50
1	Non-refractory	6 Days	8 Days	12 Days	17 Days
2	Moderatelyrefractory	7 Days	10 Days	14 Days	18 Days

3	Highly refractory	9 Days	12 Days	17 Days	22 Days

DiseasesofTimber:

Thecommondiseasesof thetimber are

I. Dryrot

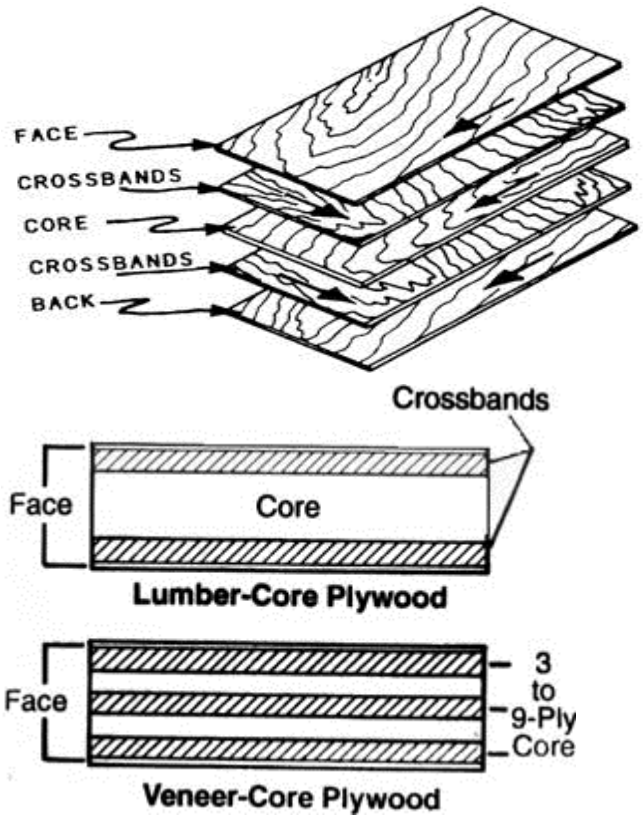
II. Wetrot

Timbersaresuitable forvarious uses:

Sl.No.	Application/Uses	Timber
1	Sportsgoodsandbaskets. Match	Ash,Oak,Mulberry. Pine,
2	industry.	Simul.
3	Bulk carts.	Babul.
4	Musicalinstruments.	Jack.
5	Railway sleepers.	Deodar,Kail,Sal,Ash.
6	Wellcurbs.	Mango, Jack, Simul.
7	DoorsandWindows.	Sal, Deodar.
8	Scaffolding	Bamboo,Sal.
9	Agricultural tools	Babu,Ash, Mulberry.
10	Highclassjourneyandfurniture	Teak,Shishum,Walnut.

Plywood:

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



Theadvantages of plywood are

1. Better appearance.
2. Easilyworkableandcapableofbeingsharedtonumerousdesign.
3. Uniformtensilestrengthinall direction.
4. Lightinweightandgreater strength.

CHAPTER-8

PAINTS,VARNISHESANDDISTEMPERS

The paints are coatingsoffluid materials and the are applied over the surfacesof timberand metals. The varnishes are transparent ornearly transparent solutions ofresinous materials and they are applied over the painted surfaces. The distempers areappliedoverthe plastered Surface.

PurposeofPaintingasurface:

Following arethe objectsofpainting asurface:

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

(ii) Itprevents decay ofwood and corrosion inmetal.

(iii) Itis used to give good appearance to the surface. The decorative effects Maybe created by painting and the surface becomes hygienicallygood clean, colourful and attractive.

(iv) Itprovides asmooth surface foreasy cleaning.

CHARACTERISTICS OFANIDEALPAINT

Followingare the characteristics ofanideal paint:

(i) It should possess agood spreading power i.e. maximum area Ofthesurface should be covered byminimum quantity ofthe paint.

(ii) The paint should befairly cheapand economical.

(iii) The paint should besuchthatitcanbe easily andfreely applied onthe surface.

(iv) The paint should besuch that itdries inreasonable time and not too rapidly.

(v) The paint should besuch that itscolour ismaintained foralong time.

(vi) The paint should form ahard and durable surface.

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

(viii) The paint should not be affected byweathering actions ofthe atmosphere.

(ix) The paint shouldpossess attractive andpleasing appearance.

(x) Thesurface coated withpaint should notshowcrackswhen thepaint dries.

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

INGREDIENTSOF ANideal PAINT

AnOilpaint essentially consists ofthe following ingredients:

(1) abase,
(2) avehicle orcarrier,
(3) adrier,
(4) acoloring pigment, and
(5) asolvent.

(1) Bases: A baseis asolid substance in afinestateofdivision and itforms thebulk of a paint. Itdetermines the character of the paint and imparts durability to the surface which ispainted. It reduces shrinkage cracks formed ondrying anditalsoformsanopaquelayerto obscurethesurfaceofmaterial tobepainted

BASES FORPAINTS

1. White lead
   i. This isacarbonate oflead and itforms the baseoflead paints. It possesses good bulk and isthemost widelyused base.
2. Red lead
   i. Thisisanoxide ofleadanditforms thebaseoflead paints.
   ii. It isquite suitable forpainting iron surfaces andfor providing apriming coat tothewood surfaces.
3. Oxide ofzincorzincwhite
   i. This isanoxide ofzincand itforms thebase ofallzinc paints.
   ii. Itissmooth, transparentandnonpoisonous.
4. Oxide ofiron
   i. This isanoxideofiron and itforms thebase ofall ironpaints.
5. Titanium white
   i. This material possesses intense opacity
6. Antimony white
   i. This isnearly similar to thetitaniumwhite.
7. Aluminium powder
   i. This forms thebulk ofaluminium paints.

(2) Vehicles

Thevehiclesaretheliquidsubstances whichholdtheingredientsofapaintin liquidsuspension.Theyarerequired mainlyfortworeasons:

(i) tomakeitpossible tospread thepaint evenly anduniformly onthe surfacein theformofathinlayer;and

(ii) toprovideabinderfortheingredientsofapaintsothattheymaystickor adheretothesurface

VEHICLES FOR PAINTS

1 Linseed oil

(i) This isthemost common material used asvehicle ofa paint. Itisextracted from flax seeds. The linseed oil prepared from fine full-grown ripe seeds is clear transparent, pale , sweet tothe taste and practically odourless. Itisused invarious grades.

2 nut oil

(i) This oilisextracted from ordinarywalnuts.It isnearly colourlessanddriesrapidly Itdoesnotprovide adurable finish and isused forordinary work asit ischeap.

(3) Driers:

Thesesubstancesacceleratetheprocessofdrying.Adrierabsorbsoxygenfromtheairand transfers ittothe linseed oil , which in turn, gets hardended .

Thevariouspatented driers are available inthe market. They maybeeitherin the form of soluble driers orpastedriers.The former driersarecompoundsofmetals such as cobalt,lead,manganese, etc.dissolvedinlinseedoilorsomeothervolatileliquid.The latterdriers arecompoundsofthe samemetal.

Thelitharge, red lead and sulphateofmanganesecan also be used as driers. The litharge is the most commonlyused drier , the proportion being1.25 N to 5 litres of oil . the red lead is lesseffective than lithargeanditistobeusedwhenitsadditiondoesnotinterferewith the tintofthe paint. The sulphateofmanganeseisusedwithzincpaintssoastoeliminate the risk of discolouration of a lead drier.

(4) Colouringpigments:

whenitisdesiredtohaveadifferentcolourthanthebaseofapaint,acolouring pigment istobeadded.Thepigmentsareavailable in the form of fine powders in variouscoloursandqualities.

(5) Solvents:

Thefunctionofasolventistomakethepaintthinsothaticanbeeasilyapplied onthe surface. It alsohelps thepaintinpenetratingthroughtheporoussurfaces. The mostcommonly usedsolvent is the spirit of turpentine.

Theturpentine isinflammable, evaporates rapidly anddriestheoil consequently. Theuseofathinner inpaint reducestheprotectivevalueofthe coating, flattens Coloursand lessens theglossofthelinseedoilasthespirits evaporateleavingan excessofcolournot mixedwith the oil.

THEPROCESSOFPAINTING

Brushes: Itisnecessary tohave good brushesforpainting.Thebrushesshouldbe composed ofbristlesandnotofhorsehairs.Thebristlebrushesareelasticandpossess goodpaint-holding capacity. Thebristlesare splits atendsand in thisrespectthey can be distinguishedfrom horse hairs.

Paints: ThereadymixedPaints 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. Thereadypaintsarenormallyexpensiveandtheyaretobeusedsoonafteropeningthesealed 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: Theterm knotting isused toindicate thecovering orkillingofall knots inwoodwork with asubstance throughwhichtheresin cannotexudeor come out . There are three methods ofknottingasmentioned below:

(i) Ordinaryor size knotting:Thisisappliedintwo coats. Forthefirstcoat, theredlead ground inwater andmixed withStrongglue size is usedin hot condition. Thiscoat dries inabout tenminutes andthen second coat is applied.The second coat consists ofredleadgroundinoilanditisthinnedby boiledoilandturpentine.

(ii) Patent knotting: Thisisapplied intwocoats.Forboththecoats,thevarnishprepared bydissolving shellacinmethylated spirits ofwine isused.

(iii) Limeknotting:The knot is covered by hot lime and itisleft for 24 hours. The surfacethenscrappedoffand then ordinary knottingiscarriedout.

Stopping: Thetermstoppingisusedtoindicatetherubbingdownofthe surface afterthe firstcoatofpaintis applied.Therubbingisdonebymeansof pumice-stoneor glass-paperorboth. Beforerubbingiscommenced, theholes, cracks, etc.onthe surface arefilled with ordinaryputtymadefromwhitingand linseedoil.The puttybecomeshardwhenitdries.

Thetermhardstoppingisusedwheninsteadofordinaryputty,anadmixture of one-third white lead and two-thirdordinary putty,is filled inholes,cracks, etc.Itis adoptedforsuperiorwork .

Coats: Thepaintisusuallyappliedinthreeorfourcoats.The first coatknownastile primingcoat, the secondoneasunder coatandtheremaining asfinishingcoats. Theprimingcoatcreatesalayerorfilmwhich provides adhesionofthepaint with thesurface.Italso protectsthesurfacefromweathering actions.Thesuitable materialforpriming-coatshouldbeused,dependingonthenatureofsurfaceto bepainted.The undercoatservestoprovidefoundationorsupporttothefinishing coat.

Thesurfaceismadeevenandallirregularitiesofthesurfaceareremovedby thiscoat. ,

The finishing coat orcoats arethenappliedasperrequirement .

VERNISHING:Thetermvarnishisusedtoindicatethesolutionofresinsorresinous substances preparedeitherinalcohol,oilorturpentine.

Followingarethemainobjects ofapplyingvarnishonawoodensurface:

(i) Itbrightens the appearance ofthegrain inwood.

(ii) It renders brilliancy tothepainted surface.

(iii) Itprotectsthepaintedsurfacefromatmosphericactions.

(iv) Itprotectstheunpainted woodensurfaces ofdoors,windows,rooftrusses, floors, etc., from theactionsofatmosphericagencies .

CHARACTERISTICSOFANIDEALVARNISH:

Followingarethecharacteristics ofanideal varnish:

(i) Itshould render the surface glossy .

(ii) Itshoulddryrapidlyandpresent afinishedsurfacewhichisuniforminnature andpleasinginappearance.

(iii) Thecolourofvarnishshouldnotfadeawaywhenthesurfaceisexposedto theatmosphericactions.

(iv) Theprotectingfilmdevelopedbyvarnishshouldbetough,hardanddurable.

(v) Itshouldnotshrinkorshowcracksafterdrying .

INGREDIENTSOF A VARNISH:

Following are the ingredients ofavarnish:

(1) Resins orresinous substances

(2) Driers

(3) Solvents.

(1) **Resins or resinous substances:**The commonly used resins arecopal, lac or shellac androsin. Thecopal isahard substance andisavailablefrom theearth atplaceswhere pinetreesexistedinpast.Itisavailableinvarietyof forms. Thelacorshellacisobtainedbyexudationofsometypes ofinsectsin India. Therosin isobtainedfrompinetrees.Otherresins areamber,mastic, gum dammar, etc.

(2) **Driers:**Thefunctionofadrierinvarnishistoacceleratetheprocessofdrying. Thecommondriersusedinvarnishesarelitharge, whitecopperandleadacetate .

(3) **Solvents:**Dependinguponthenature ofresin,thetypeofsolventis decided.

SOLVENTS FOR RESINS

No.	Solvent	Resins
1.	Boiled linseed oil	Amber, Copal
2.	Methylated spirits ofwine	Lacorshellac
3.	Turpentine	Mastic, Gum dammar, Rosin
4.	Wood naphtha	Cheap varieties ofresins

PROCESSOFVARNISHING:

Theapplicationofvarnishonthewoodworkiscarriedoutinthefollowingway:

(1) **Preparation ofsurface:**The woodworkisthoroughlyrubbeddownbymeansof sandpaper orpumicestone.Thesurfaceisthenmadesmoothandclean.

(2) **Knotting:**Theprocessofknottingisthencarriedoutasincaseofpainting.

(3) **Stopping:** Thesurfaceofwoodworkisthenstopped.This isdoneby meansof hotweak gluesize. Itwillfilluptheporesonthesurface.OneNof gluewill formaboutonelitreofgluesize.Alternatively,theboiledlinseedoilcanbeappliedintwocoats. Whenthesurface becomesdry,itshouldbeonceagain rubbeddown withsandpaper.

(4) **Coats ofvarnish:**Thevarnish isthenappliedonthesurfaceinthincoats. The next coatisappliedafterthepreviousonehasthoroughlydriedup. The varnishing should not be done withordinary paint brushes. But fine haired varnishing brushes should be used .

DISTEMPERING:

PURPOSEOFDISTEMPERING:

Themainobjectofapplyingdistempertotheplasteredsurfacesistocreatea smoothsurface.Thedistempersareavailableinthemarketunderdifferenttrade names. Theyarecheaperthanpaintsandvarnishesandtheypresenta neat appearance. they areavailableinavarietyofcolours.

PROPERTIESOFDISTEMPERS :

Followingarethepropertiesofdistempers:

(i) Ondrying,thefilmofdistemper shrinks.Henceitleadstocrackingandflaking, ifthe surface toreceivedistemperisweak.

(ii) The coatingsofdistemperareusuallythickandtheyaremorebrittlethanothertypesofwater paints.

(iii) Thefilmdevelopedbydistemperisporousincharacteranditallowswater vapourtopassthroughit. Henceitpermitsnewwallstodry outwithoutdamaging thedistemperfilm.

(iv) Theyaregenerallylight incolourandtheyprovideagoodreflectivecoating .

(v) They arelessdurablethanoilpaints.

(vi) Theyaretreated aswater paints andtheyareeasytoapply.

(vii) Theycanbeapplied onbrickwork,cement plasteredsurface,limeplastered surface, insulatingboards,etc.

(viii) Theyexhibitpoorworkability.

(ix) Theyprovetobeunsatisfactoryindamplocationssuchaskitchen,bathroom, etc .

INGREDIENTSOF ADISTEMPER :

Adistemper iscomposed ofbase, carrier,colouring pigmentsandsize.For base,thewhitingorchalkisusedandforcarrier,thewaterisused. Thusitismore or lessapaint inwhich whiting orchalk isused asbase instead of white leadand thewaterisused ascarrierinsteadoflinseed oil.

The distempersare availableinpowderformorpasteform.Theyareto bemixedwithhotwaterbeforeuse.Theoil-bounddistempersareavarietyofanoilpaintinwhichthe dryingoilissotreatedthatitmixeswithwater.The emulsifyingagentwhich iscommonlyusedisglueorcasein. Asthewater dries, theoilmakesahardsurfacewhichiswashable.

Itshouldberemembered thatmostofthemanufacturersofreadymadedistemper supply completedirectionsforuseoftheir products.Thesedirectionsareto be strictly followedtoachievegood results.

PROCESSOFDISTEMPER:

Theapplication ofdistemper iscarried out inthe following way:

(1) **Preparationofsurface:**Thesurfacetoreceivethedistemperisthoroughlyrubbedand cleaned. Theimportantfactstobekeptinmindare:

(i) Thenewplasteredsurfacesshouldbekeptexposedforaperiodoftwo monthsor sotodryoutbefore distemperisappliedonthem.The presence of dampnessonthesurface resultsinfailureofdistempercoating.

(ii) The surfacetoreceive distempershouldbefreefromany efflorescencepatches. These aretobewipedoutbycleancloth.

(iii) Theirregularitiessuchascracks,holes,etc.ofthesurfacearetobefill bylime putty orgypsumandallowedtobecomehardbefore distemperis appliedonthesurface.

(iv) Ifdistemperistobeappliedontheexistingdistemperedsurfaces,the old distempershouldberemovedby profuse watering.

(2) **Primingcoat:**Afterpreparing thesurface toreceive thecoatsofdistemper aprimingcoatisappliedanditisallowedtobecomedry.Forreadymade distempers, theprimingcoatshouldbecomposed of materials as recommendedbythe makersofdistempers. Forlocalmadedistempers, themilk is usedfor priming coat. Onelitreofmilkwillcoverabout $10m^2$ofthesurface.

(3) **Coatsofdistemper:**Thefirstcoatofdistemperisthenappliedonthesurface. It should beofalight tintandappliedwithgreatcare. Thesecondcoat of distemperisappliedafter thefirstcoathasdriedandbecomehard. Following factsare tobe remembered:

(i) Thedistempering should bedoneindryweathertoachievebetter results.

(ii) Theoil-bound distemper orwashabledistemperadhereswelltooil-painted walls, wood,corrugated iron,etc.Butaprimingcoatofpuremilkshould beappliedbefore distemperingisdoneonsuchsurfaces.

(iii) The applicationofdistemper byaspraying pistolissuperiortothat by brushes. The sprayingaffordssmoothanddurablefilmofdistemper.

APPLICATIONOFWHITEWASHING :

The fresh lime isslaked atsiteofwork and mixed thoroughlywith sufficientquantity ofwaterinatub.Itisthenscreenedthroughacleancloth. Theclean gum dissolvedinhot water isthen addedattherateof20N$perm^3$ oflime. The rice maybeusedin placeofgum.

The surface tobewhitewashed shouldbecleanedbeforetheworkisstarted. Forwhitewashing wallswhicharewhitewashed before,theoldloosewhitewash is to befirstremovedandrepairingtotheplasteriscarriedout, ifnecessary.

The whitewashisappliedwithjutebrushandthebrushis soworkedthata surfacewithuniformcolourisobtained.Thethreecoatsaregenerallyapplied,each afterthepreviouscoat hascompletelydried.

Thelimeistoxicforgerms. Itreflectslightandthusitincreasesthebrightnessofthe surface. The white washing therefore is extensively used forinterior wall surface.

Theprocessofwhitewashingissometimesusedforexteriorwallsurfaces also.Asatisfactoryworkgivesanopaquesmoothsurfacewithuniformwhite colourand doesnotreadilycome offonthehand, whenrubbed.

APPLICATIONOF COLOURWASHING:

This isprepared byaddingthecolouringpigmenttothescreenedwhitewash.Itshould beseenthatthecolouringpigmentis notaffectedbythepresenceof lime.
Ordinarily, theyellow earthispopularforcolour washing.Generally, the wallsare colour washedandceilingsarewhitewashed.The mixtureistobekeptconstantly stirredduringuse.

Thecolourwash isapplied inthesamefashion asthewhitewash. Asatisfactoryworkdoesnotgiveoutpowderwhen thefinished surfaceis rubbedwiththefingers.

The process ofcolourwashingimpartscleanlinessandpleasantappearanceofthesurfaces whicharetreated .

REPAINTINGOF OLDSURFACE :

Repaintingoldwoodwork:Ifthepaint ontheoldwoodwork hascrackedorhas developed blisters,itistoberemoved.Ifthe surfacehasbecomegreasy.it shouldbecleanedbyrubbingdownsand-paperorfinepumicestone.Theold paintcanalsoberemovedbyapplyinganyoneofthefollowingthree paint solvents .
(i) A solutioncontaining2 N of causticsodatoalitreofwateris prepared and usedtowashthesurface. Thepaintdissolvesandthesurfacebecomes clean.
(ii) Amixtureconsisting ofone part ofsoftsoap and twopartsofpotashis preparedandone part ofquicklimeisthenaddedafterwards. Thismixtureis appliedonthesurfacein a hot stateandallowedtostay forabout24hours. Thesurfaceisthen washedwith hotwater.
(iii) Amixtureconsistingofequalpartsofwashingsodaandquicklimeis broughttoa paste form by addingrequiredquantityofwater.Itis applied on thesurfaceand keptforaboutanhour.The surface isthenwashedwithwater.
After removing old paint from the surface, the woodwork ispainted asin
case ofpainting onnew woodwork.

Repaintingoldironworkand steelwork:The oldsurfaceshouldbe thoroughly cleaned bythe applicationofsoap-waterandifgreaseispresent,it shouldbe removedbywashing thesurfacewithlimeandwater. If itisnecessarytoremoveoldpaint, thesurfaceshouldbeburnt, usuallybya blowlampandthen oldpaint shouldbescrapedoffordissolvedand removedbyusinganypaint solvent,After thesurface isthus prepared,thepaintingiscarriedoutasincaseofnewironworkorsteelwork.

CHAPTER-9

CASTIRON:

Thecastironismanufacturedbyre-meltingpig-ironwithcokeandlimestone.Thisre- melting is done in a furnace known as the cupola furnace .

USESOF CASTIRON:

Followingaretheimportantuses ofcast-iron:

(i) Formakingcisterns,waterpipes,gaspipesandsewers,manholecoversandsanitary fittings .
(ii) For makingornamentalcastingssuchasbrackets,gates,lampposts,spiral staircases, etc.
(iii) Formakingparts ofmachinerywhicharenotsubjecttoheavyshocks.
(iv) For manufacturingcompressionmemberslikecolumnsinbuildings,basesof columns, etc.
(v) Forpreparing agricultural implements.
(vi) Forpreparingrailchairs, carriagewheels,etc.

WROUGHTIRON:
Thewroughtironisalmostpureironandithardlycontainscarbonmorethan0.15percentor so . But the process of its manufacture is laborious and tedious .

USEOFWROUGHT-IRON:

The wrought-ironisreplacedatpresenttoaverygreatextentbymildsteel. It istherefore producedtoavery smallextent atpresent.Itisusedwhereatough material isrequired .

The wrought-iron,atpresent, isusedforrivets, chains, ornamentaliron work, railwaycouplings, waterandsteam pipes,raw material formanufacturingsteel, bolts and nuts, horseshoebars,handrails,strapsfortimber roof trusses,boiler tubes, roofing sheets, armatures,electro-magnets , etc .

STEEL:

Depending upon thecarbon content,thesteelisdesignatedasthemildsteelormediumcarbon steel or highcarbon steel.Thevarioususesofsteelaregovernedby theamountof carboncontainedinit.
Thecarboncontentofmildsteelisabout0.10to0.25percent.Whencarbon contentislessthan0.10per cent, itisknownasthedeadsteelorverylow carbon steel.
The carboncontentofmediumcarbonsteel isabout0.25 to0.60percent. Thehigh carbonsteelisalsoknown asthe hardsteelanditscarboncontent variesfrom 0.60 to 1.10percent orso.

USES OF STEEL:

Nameof steel	**Carbon content**	**Uses**
Mild steel	Up to0.10%	Motorbody,Sheetmetal,tin plate, etc.
Medium carbon Steel	Up to 0.25%	Boilerplates,structuralsteel,etc.
	Up to 0.45%	Rails,tyres, etc.
	Up to 0.60%	Hammers,largestamping and pressingdiesetc.
High carbon steel	Up to 0.75%	Sledgeshammers,springs, stamping dies ,etc.
Orhard steel	Up to 0.90%	Miner'sdrills,smith'stools,stone mason'stoolsetc.
	Up to 1.00%	Chisels,hammers,saws,wood working tools,etc.
	Up to 1.10%	Axes,Cutlery,drills,knives,picks,punches,etc.

Itisobserved that the steel isrequired forthe existence ofthe heavy a lightengineering industries,forshipbuilding, railways androlling stock, automobiles sheet metal industries, power generation and electrical industries, etc. Itshouldalsobenoted thattheentire range ofelectrical engineering industry depends upontheproperty ofmagnetism ofsteel.

PROPERTIESOFMILDSTEEL

Followingarethepropertiesofmildsteel:
(i) Itcanbemagnetisedpermanently.
(ii) Itcanbereadilyforgedandwelded.
(iii) Itcannotbeeasilyhardened andtempered.
(iv) Ithasfibrousstructure.
(v) Itismalleable andductile.
(vi) Itisnoteasilyattacked bysaltwater.
(vii) Itistougher andmoreelasticthanwrought-iron.
(viii) Itisusedforalltypesofstructural work.
(ix) Itrustseasilyandrapidly.
(x) Itsmelting pointisabout 1400°C.

(xi) Itsspecificgravity is7.80.
(xii) Itsultimate compressivestrength isabout80to120kNpercm^2
(xiii) Itsultimate tensileandshearstrengths areabout60to'80kNpercm^2

PROPERTIESOFWROUGHTSTEEL

Following aretheproperties ofhardsteel:
(i) Itcanbeeasilyhardened andtempered.
(ii) Itcanbemagnetisedpermanently.
(iii) Itcannotbereadilyforgedandwelded.
(iv) Ithasgranular structure.

CAST IRON:

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USESOF CASTIRON:

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(i) Formakingcisterns,waterpipes,gaspipesandsewers,manholecoversandsanitary fittings .
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WROUGHTIRON:
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CHAPTER-

10BITUMINOUSMATERIA

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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.

TYPESOFBITUMINOUS MATERIALS

Normallythreetypesofbituminousmaterialsareextensivelyusedincivilengineering works. They are as follows.

Bitumen → It is the heavy end (i.e. higher molecular weight) residue from the fractionationof 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 isobtained 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.

Tarisnolongerusedforhighway constructionasit isconsideredto beahealth hazard

COMPARISONBETWEENBITUMEN,TAR&ASPHALT

Sl No	Property	Bitumen	Tar	Asphalt
1	Colour	Darkwithslight reddish tinge	DeepDark	Blackish brown
2	Carbon Content	Moderate	High	Low
3	State	Solid	ViscousLiquid	Solid or Semi-solid
4	Effecton Heating	Melts	Becomesmore fluid	Burnswithasmoke flame & becomes plastic

5	SettingTime	Less	More	Less
6	Adhesive Power	More	More	Less
7	Resistanceto	More	Less	More

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

TYPESOF TARAND THEIR USE

Birch tar or birch pitchis 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 forconstruction 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

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

Mastic asphaltbeing thermoplastic substance is widely used in the building industry for waterproofingflatroofsandtankingunderground.Masticasphaltisheatedtoatemperature

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 depthand asphalt emulsions are also blended into recycled hot-mix asphalt to create low-cost pavements.

Otherusesof Asphalt

Asphalt/bitumen is used to make Japan black, a lacquerknown 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.

CHAPTER-11

PLASTICS,HEATPROOFINGANDACOUSTICMATERIALS

Plastic is the generic name for a family of synthetic materials derived from petrochemicals. It is often product of two or more components.

There are many families of plastics and polymers being used in construction industry. Examples of plastics used in building are: Acrylic, Composites, Expanded Polystyrene, Polycarbonate,Polyethylene,Polypropylene,Polyvinyl Chloride

UsesofPlasticasBuilding Materials

Someoftheexamples belowareProducts ofPlastics intheConstruction industry:

- Pipes :ElectricalConduits,RainWater&Sewagepipes,Plumbing,Gas Distributions.
- Cables:PVCInsulation oncables,InsulationTapes.
- Floorings: Flooringtiles &Rolls .
- Domes/skylights : Opaqueaswellas transparent.
- Roofing:Coloured orDoubleskinnedfor insulation.
- Windows&doors:Extrudedsections forDoorand windowsand panels.
- Storagetanks:Storagetanks.
- Hardwareaccessories: Washers,Nutbolts,Sleeves,Anchoringwires.
- Temporarystructures:Guardcabins, tents
- Insulationmaterials:PVCsheets,insulatingmembranes.

Fireproofing or Heat proofing is rendering something (structures, materials, etc.) proof against fire, or incombustible; or material for use in making anything fire-proof. It is apassive fire protectionmeasure.

CharacteristicsofFire Fighting/Resistant Materials

- Thematerialusedinbuildingshouldbeofsuchnaturethatitdoesnotdisintegrate under the effect of heat produced during fire.
- Thematerialshouldnotexpandduetoheatalsoandshouldensurestabilityof structure.
- Thenatureofmaterialusedinbuildingshouldhaveminimumcontractiondueto sudden cooling with water after the material is heated at high temperature.
- Thenatureofmaterialusedinthebuildingshouldbesuchthatitdoesnotcatchfire easily.

FireResistantPropertiesofBuilding Materials

Stone:
It is a bad conductor of heat. Sand stone with fine grains can moderate fire successfully without having serious cracks. Granite is disintegrated when it receives heat from fire. Lime stone is easily crumbled by ordinary fire. Most of stones are disintegrated into small pieces when heated during fire and cooled afterwards.

Brick:
Bricks are bad conductor of heat. They have no serious effect of heat until the temperature during fire rises above 1200 degrees to 1300 degrees. At the time of construction if good quality mortar is used and brick work constructed by skilled mason, brick masonry offers good resistance to fire.

Clayorshale tile:

HollowclayorshaletileshallbelaidinTypeM, S,N,Oorgypsummortar.Clayorshaletile used in nonbearingpartitions and forfireresistanceshall meet therequirements ofcode. Clay or shale tile used in exterior walls and in all load bearing walls shall comply with the requirements of code.

Gypsum:
Pouredgypsumusedforfireresistanceandfloorandroof constructionshallcontainnotmore than12 1/2percentofwoodchips,shavingsorfiber,measuredinadrycondition,asa percentage by weight of the dry mix. Gypsum mortar shall be composed of one part gypsum and not more than three parts clean, sharp, well-graded sand, by weight. Fibered plaster may be used where unsanded or neat gypsum plaster is prescribed.

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Acoustics (also known as room acousticsand **building acoustics**) is the science and engineering of achieving a good sound within a building and is a branch of acousticalengineering. Architectural acoustics can be about achieving good speech intelligibility in a theatre, restaurant or railway station, enhancing the quality of music in a concert hall or recording studio, or suppressing noise to make offices and homes more productive and pleasant places to work and live in. Architectural acoustic design is usually done by acoustic consultants

TheAcousticNatureofMaterials

Concrete, stone, and other masonry materials:

Masonry materials are great for sound isolation, especially when used in floors and walls where the masonry material is quite thick. A solid concrete wall 1 ft. thick will rarely cause clients to complain about sound isolation, for two reasons. One is the material's *rigidity*, meaningthatitwillnotflexandcreatesoundwavesonthequietsideofthewall.The otheris concrete's*mass*.Nothingstopssoundwavesquitelikemassivematerials,andtheyare

especially capable of stopping the critical low frequencies that are so hard to stop with less massive materials. Stone and brick are very similar to concrete in mass, and concretemasonry units, although they are lighter, can do a very good job when they are fully filled with concrete, instead of just filling the cells that contain the rebar.

Concrete slabs also do a good job of isolating sound between floors – something that is very difficult to do any other way.

Wood, and wood products:

Woodismuchlessdense thanmasonry,andprovidesmuchlessintheway ofsoundisolation for that reason. Wood products like MDF, on the other hand, are somewhat more massive, and are sometimes used in interior walls to add mass. OSB is less dense than MDF, but canbe useful as well, as part of an integrated system. Plywood comes in varying densities, and again can contribute something to the equation in a multi-layer wall.

Wood's real beauty lies in its ability to reflect sound in a pleasing way, meaning that it is a useful material for sound treatment. Since wood resonates easily, it has a way of absorbing some of the sound energy as it vibrates, letting some of the sound pass through to the other side, and reflecting some of the sound back from whence it came. This genteel quality of wood is one reason it is widely used in the making of musical instruments, and wood has a major role to play as an interior finish material in good sounding rooms.

Steel:

Steel is a quite dense material, but because of its expense it is rarely used as a sound isolation material. Steel's density actually becomes a liability in structural uses where its dense nature causes it to carry sound vibrations for long distances. If you strike an I-beam with a hammer and place your ear to the other end –let's say 24 ft. away, you'll see that the sound carries quite well through the steel. This type of sound transfer is called *structure-borne vibration*, where sound is carried through some material other than air for a time. The other main typeof sound transfer is *air-borne vibration.*

Steel studs can actually transmit less structure-borne vibration than wood, even though steelis more prone to this problem simply because flimsy steel studs have much less cross- sectional area to carry the vibrations between the two wall surfaces.

Drywalland plaster:

Drywall is the poor man's masonry, and for interior walls can provide a lot of mass for the money. But one ½" layer doesn't do all that much. Multiple layers are used in sound studios and broadcast facilities where high mass walls are needed.

Roofing:

Asphalt shingles are fairly massive, as you know if you hauled them up to the roof, but they arealsothin. Installationwitha largeoverlap, heavyfelt, andevendouble layersheathing can

help quiteabit. Ceramic and claytilesaremoremassivethanwoodshakes by far,and can do a reasonable job in residential applications. Metal roofing has mass but is thin, and requires that the underlying structure be fairly massive.

Glassandothertransparentmaterials:

Glass is quite massive – about three times as massive as drywall. So in a sound wall with three 5/8" layers of drywall on one side, one layer of 5/8" glass maybe inserted to create a window *on that side*, provided that it is properly sealed. A corresponding piece of glasswould be required on the other side of the wall, at the appropriate thickness.

A relatively recent development is the invention of absorptive glass-like products that offer pretty good transparency while absorbing enough sound to reduce the harsh reflectivity usually associated with glass. These products are made from Plexiglas or thin transparent foils, perforated with tiny holes. Their use is mainly confined to professional sound studios.

Insulatingmaterials(fiberglass,foam,rockwool,etc.):

Insulating materials have little mass, so they have limited uses for sound isolation. However, fiberglass has good sound *absorption* characteristics, and is very useful as a sound treatment material for sound room interiors. Fiberglass and rock wool, which has similar acoustic properties, absorbsound byslowingthe *velocity* ofthe airparticles carryingthewave. Wood, on the other hand, absorbs sound best when in the *pressure zone* of a sound wave. Sound waves are at highest pressure when at lowest velocity, so care must be taken to place materials appropriately. Waves are generally at highest pressure at room boundaries, particularly multiple boundaries like dihedral and trihedral corners.

PlasticsandRubber(vinyl,neoprene):

Plastics are sometimes used in the manufacture of low-cost acoustical devices, but have limitedusefulness.Rubber,particularlyneoprenerubberisverygoodasa mechanicalisolator
-- for floating glass and preventing the diaphragmatic vibrations of the glass fromtransmitting into the wall, for instance.

Mass loaded vinyl can be used inside wall cavities to increase sound isolation, and is hung in a limp, as opposed to stretched, fashion.

Mechanicalandplumbingmaterials(ductwork,metalandplasticpipes):

Metal and plastic pipes are often transmitters of structure borne vibration, and can be isolated or deadened with rubber materials. Refrigerant lines are especially bad for transmitting high-pitched whining noises through buildings, so you want to locate them carefully, and de-couple them from the structure.

Ductwork should be heavy sheet metal, lined with at least 1" of acoustic liner. Flex duct is virtually acoustically transparent, and should be avoided when you are picky about crosstalk between the ducts in attics and other mechanical spaces.

Fabricsandothersoft materials:

Fabrics, carpets, and other soft materials can be useful for sound treatment. Heavy stage type curtains are much more effective than thin fabrics. Carpets, although sometimes better than nothing, can soak up too much mid and high frequency sound while leaving boomy lower frequencies untreated. As part of an overall plan, carpet can be put to good use, but area rugs are much more versatile and adjustable.

Specialtyacoustical products:

Specialtyproductsgenerallyfallintotwocategories:thoseusedforsoundisolation,andthose used for acoustical treatment. Those used for sound isolation include various shock absorbers used to isolate air handlers and ductwork, and even to float concrete slabs, as well asneoprene isolators used for floating drywall off of studs (in conjunction with metal furring channel). Specialized door seals also utilize neoprene, and the best onesare adjustable, sothat the installer can tweak any gaps between the door and the neoprene. Neoprene is also used under floor plates to isolate walls from floors. When specifying neoprene, care must be taken to get the proper *durometer*, or firmness, of neoprene, so that it doesn't bottom out and cease to work as a shock absorber. Sound deadening board can be used between layers of drywall, or between the drywall and the studs, to reduce structure borne vibration while also deadening resonances.