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[Unit-01]

Stone, aggregate and brick

★ Importance of Building Material :-

- ① Material Technology is a very wide subject which involves production of goods from raw material into a specific shape and form required for a particular application.
- ② Civil Engineering involves designed and constructed of infrastructure and buildings. So, it is important to know about materials and its properties so that it can be changed appropriately and use for construction work.
- ③ It is important to know which material are to be used in which an elements, How they were, its strength, suitability, its reaction with other materials when used in combination and other necessary details.
- ④ It is also required to study the failure pattern, failure types and mode of failure of the material. So that, the age of structure can be calculated.

⑤ Materials contribute in the advancements of technology so its knowledge is very important in Civil Engineering.

* Criteria for Selection of Construction Material :-

① Prescribed load : This quantifies resistance to compression, Tension and other type of loading on a given materials. Also the weight of material determines a significant part of structural load the building is required to support. So, while choosing a material the loads coming on it must be calculated and choice of material must be made accordingly.

② Serviceability : It is referred as a condition under which a structure is still considered useful. It includes factors such as stability, fire resistance, cracking and vibrations. So, while making choices of material all these factors are considered according to the requirements and designed in such a way that the construction survives or is serviceable for designed life-periods.

③ Aesthetics : Material should be selected in a way that they provide a pleasant appearance. It must be in accordance with the climate and culture of that region. It includes factors such as - Colour, Texture; material patterning, Size etc. All these factors when considered together while making choice of material its results in a aesthetically beautiful structure.

④ Economy : It is the most critical factor which is to be considered by selecting a construction material because it directly affects the overall cost of the Project. The choice of material must be in accordance with the budget of the customer. Increase in cost of Project will lead to various types of losses. So, always preferably used economical materials.

⑤ Environment : This is the last but most important factor to be considered while making choice of material in recent times. The material chosen should be such that it causes minimum damage to the environment in every possible way. Material available locally must be used to reduce transportation activities, they could be recycled or reused in different ways. All these efforts can lead to reduce environment impacts.

★ Basic physical properties of construction materials :-

- ① Bulk density: It is defined as the mass per unit Volume of a material in its natural state that is including pores and Voids, and is expressed as -

$$\rho_b = \frac{m}{V_b}$$

m = Mass of Sample in kg

V_b Volume of Sample in m^3

ρ_b = Bulk density in kg/m^3

ex:- The Bulk density of concrete is $2500 kg/m^3$.

- ② Porosity: It indicates the degree to which the Volume of material is occupied by pores. It is expressed as the Ratio of Volume of pores to the material Sample.

$$n = \frac{V_v}{V}$$

V_v = Volume of Voids

V = Volume of material Sample

n = Porosity

Note: Dense material which have porosity are used for construction requiring high strength. The Porous material have property to observe moisture. So, if we used such material in making concrete they will reduce its workability.

- ③ Water Absorption: It indicates the ability of material to absorb and retain water. It is expressed as percentage in weight of dry material.

$$W_w = \frac{M_1 - M}{M} \times 100$$

M_1 = Mass of Saturated Material

M = Mass of dry material

W_w = % Water Absorption

- ④ Specific Gravity: It is the ratio of weight of given Volume of Substance at a given temperature to the weight of equal Volume of distilled water at that temperature.

$$G_s = \frac{\rho_s}{\rho_w}$$

ρ_s = Density of Substance.

ρ_w = Density of Water

G_s = Specific Gravity.

⑤ Permeability: It is defined as the property of a porous material which permits the passage or seepage of water or any other fluid through its voids.

ex:- Gravels are highly permeable and clay is least permeable.

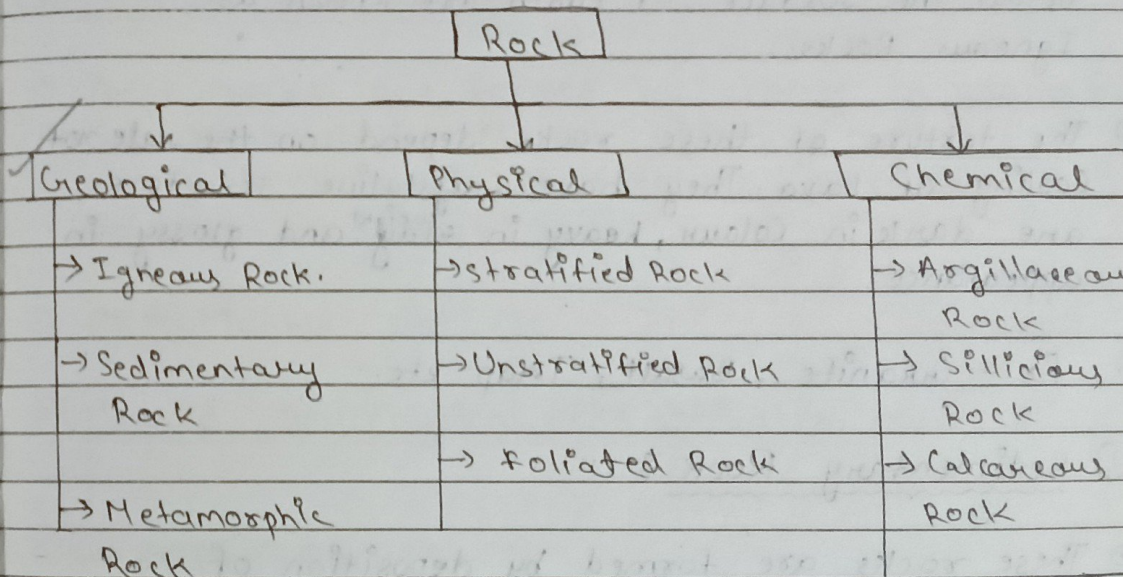
⑥ Durability: The property of material to resist the combined action of atmosphere and other factors is known as durability. The running or maintenance cost of any building will depend upon the durability of material used.

⑦ frost (stable) Resistance: The ability of water saturated material to resist repeated freezing and Thawing without much decrease in its mechanical strength or visible sign of failure is known as frost Resistance.

"Stone and aggregate"

* Rock: Rock is defined as the portion of earth crust which has no defined shape and structure they are made of heterogeneous material with no definite composition, consisting of minerals and organic materials.

* Classification of Rock:



Based on Geological classification :-

① Igneous Rock :-

- ① This Rock is of Volcanic origin.
- ② The Rocks which are formed by cooling and solidification of Molten lava or Magma above or below the surface of earth are known as Igneous Rocks.
- ③ The texture of these rocks depend on the rate of cooling of Lava. They have crystalline structure, are dark in colour, heavy in ^{weight} and glossy in appearance.
- ④ Ex - Granite, Basalt, Trap etc.

② Sedimentary Rock :-

- ① These rocks are formed by deposition of product of weathering on pre-existing rock surface are known as Sedimentary Rocks. These Rocks are stratified and show well-defined bedding-plan.

- ① They are soft and can be split along the bedding plan easily.

- ② The Various weathering agencies involve are wind, rain, running water etc.

- ③ Ex:- Sand stone, Lime stone etc.

③ Metamorphic Rock :-

- ① These rocks are formed by change in properties or characteristics of the existing rock as a result of change in Temperature, pressure, earth movement and heat.
- ② Ex:- Marble, slat etc.

Based on Physical Classification :-

① Stratified Rocks :-

They show Distinct layers along which the rock can be split.

ex:- Sandstone, Lime stone, slat etc.

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② Unstratified Rock:-

- ② They do not show any layers and cannot be broken into thin layers.

ex:- Granite, Basalt, Trap etc.

③ Foliated Rock:-

- ② They have the tendency to split-up only in a definite direction.

Based on chemical classification:-

① Argillaceous Rock:-

- ② The main constituent of these rocks is clay (Al_2O_3). They are hard and brittle.

ex:- Lathrite, slate etc.

② Siliceous Rock:-

- ② The main content of these rock is silica (SiO_2). that is also known as sand.

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- ② This Rocks are very hard and durable.

ex:- Granite, Basalt, Trap.

③ Calcareous Rock:-

The main content of these rock is lime (Ca).

ex:- Limestone, Marble, Dolomite etc.

Properties of good Building stone:-

- ① Strength - A good stone should be strong and durable to with stand the disintegrating action of various factors. Compressive strength of building stone rang between 60 to 200 N/mm^2

- ② Hardness - The stone should be hard enough to be stable. This property is important in the construction of bridges, floor, Basement etc.

- ③ Roughness - It is the ability of stone to with stand shock or impact. The stone should be able to resist many loads or vibration.

④ Specific Gravity - The specific gravity of most of the stone lies between 2.3 to 3.5.

⑤ Porosity & Water Absorption - The stone used for construction should not be very porous, because it will break easily when rain water enters the pores, freeze, expands and causes crack.

⑥ Fire resistance - The stone should be able to resist high temperature for which it should not contain calcium carbonate (CaCO_3), oxides of iron (Fe_2O_3), (FeO), limestone can withstand a little higher temperature.

⑦ Weight - It is the indication of density so it should be according to the requirement. For dams, retaining walls etc. heavy stones are required but for arches, domes etc. light weight stones are required.

⑧ Appearance - The appearance of stone is important from aesthetic point of view. It should have fine compact texture & light colour because dark colour fades with time.

⑨ Structure - The stones selected must have uniform structure free from creeds, cavities, loose grains etc. layers of the stone should not be visible.

⑩ Workability - The stone should be workable. Its cutting, dressing, transportation should be easy and economical.

* Quarrying of stones:-

Quarrying:- The process of extracting the stone from natural rock is known as quarrying of stone.

→ The site from which stone is extracted is known as Quarry.

Methods of Quarrying:- Following are the methods of quarrying:-

① Quarrying with hand tools.

② Quarrying with channelling machine.

③ Quarrying by blasting.

Quarrying with hand tools :-

→ This method is adopted for small-scale work and for soft stones like laterite, limestone, and sandstone.

→ Tool used: Pickaxes, hammers, chisels, and wedges.

→ stones are detached manually by cutting and splitting.

Quarrying with Channeling Machine :-

→ In this method, a channeling machine cuts continuous grooves or channels around the stone block.

→ The block is then separated by inserting wedges and gently tapping.

→ It is used for soft and medium stones like marble and limestone.

Quarrying by blasting :-

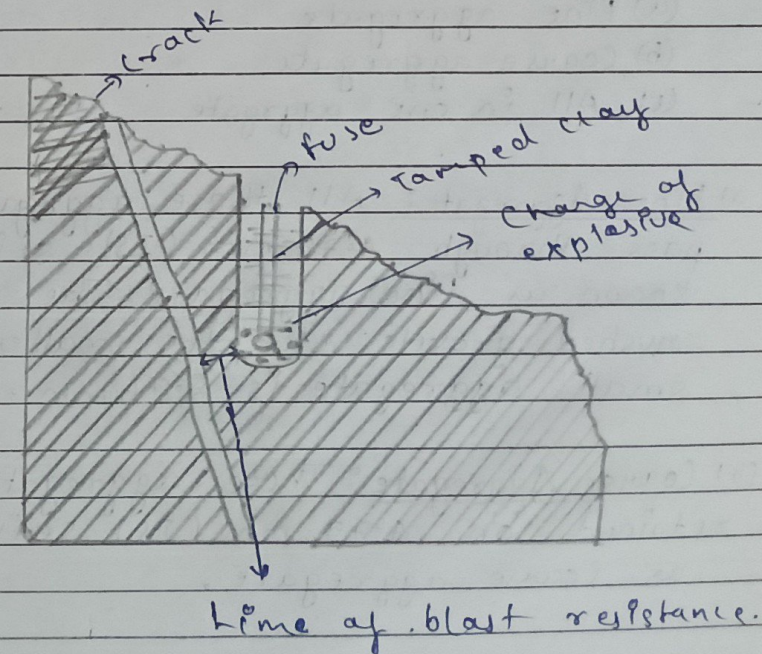
→ This method is employed for hard rocks such as granite, basalt, and trap.

→ Moles are drilled and filled with explosives (gun-powder or dynamite).

→ After firing, the rocks are broken into pieces and collected.

→ It is a fast and economical method for large-scale work.

Aggregates: These are inert or chemically inactive material which



Aggregate: These are inert or chemically inactive material which forms the bulk of cement concrete.

→ They are used as filler material and impart greater Volume, Stability and Durability to mortar / concrete.

Classification of Aggregates:

① On basis of Size:-

- (a) Fine aggregate
- (b) Coarse aggregate
- (c) All in one aggregate

(a) Fine Aggregate: All those aggregate that pass through 4.75 mm (IS) sieve, are known as fine aggregate. They may be sand, crushed gravels etc. the smallest size of small aggregate is 0.06 mm.

(b) Coarse Aggregate: Those aggregate that are retained on 4.75 mm (IS) sieve are known as coarse aggregate.

(c) All in one aggregate: All those aggregate sample which contain both coarse and fine aggregate in different percentages (%) are known as all in one aggregate.

② On basis of origin:-

- (a) Natural Aggregate.
- (b) Artificial Aggregate.

a) Natural Aggregate: These are obtained by crushing of naturally quarried stones. The most widely used aggregates are of Igneous origin. Aggregates obtained naturally are not clean enough so, they are washed and sieved before using.

b) Artificial aggregates: Artificial Aggregates are produced by thermal processing of materials such as clay, lime etc. They include broken bricks, blast furnace slag and synthetic aggregates.

③ On the basis of shape:-

- (a) Rounded Aggregate.
- (b) Irregular Aggregate.
- (c) Angular Aggregate.
- (d) Flakey Aggregate.
- (e) Elongated Aggregate.

(a) Round Aggregate: This aggregates are generally of sedimentary origin, that is formed by movement of air and water.

- They are spherical and rounded in shape. This aggregate have smooth surface and require minimum cement paste for bonding.
- They produce minimum voids (32%) in concrete which makes them unsuitable for high strength concrete.
- They form poor bonds due to poor interlocking.

(b) Irregular Aggregate: This aggregate have naturally irregular shape and known defined shape.

→ Such type of aggregate have about (36%) of voids and require more cement paste for bonding than rounded aggregates.

→ Because of irregularity in shape they develop good bond and are suitable for making ordinary concrete.

(c) Angular Aggregate: This type of aggregate are sharp, angular and rough in shape having maximum voids, about (40%)

→ Angular Aggregate are very good in bonding and show better interlocking between the particles.

→ They are suitable for high strength concrete and they require more cement paste.

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(d) flakey Aggregate: Those aggregates whose least lateral dimension thickness is less than (0.6 times) or (3/5 times) of its mean dimension are known as flakey aggregate.

(e) Elongated aggregate: Those aggregate whose greatest dimensions (length) is more than (1.8 times) or (9/5 times) of its mean dimension are known as elongated aggregate.

→ They are less durable and only (15%) of the shape sample is allowed.

★ Common Building stones of India:-

① Granite: It contains high percentage of Quartz.

→ It is a type of igneous rock.

→ It is hard, durable and available in different colours.

→ It has low porosity and high density.

→ It is an expensive stone.

Uses:- ① It is used exterior architectural and movement work and ornamental work.

② It is also used in flooring areas such as Kitchen & Bathroom and also in steps of staircase.

③ It is used as road metal & ballast.

② Syenite: It contains high percentage of Feldspar.

→ It is not easily available.

→ It is also igneous rock.

Uses:- It is used as road metal.

③ Gneiss: It is an igneous rock, called as stratified granite.

→ It is easy to work with it can split into thin layers.

Uses:- It is used in rough masonry work, street paving, good aggregate for concrete etc.

④ Limestone: It is a Sedimentary rock.

→ It's main context is lime and is of marine origin.

→ They are hard, rough and durable.

→ They have grainy texture and are light in colour.

Uses:- It is used in making tiles and slabs for flooring, roofing and paving.

→ It is used in making binding, material lime and cement.

⑤ Sandstone: They are of Sedimentary origin and mainly composed of Silica.

→ It is very hard and durable.

→ It allows percolation of water.

→ They are available in variety of colour.

Uses: Used in ashlar masonry, ashale & tiles for flooring, roofing and paving.

→ It is also used as aggregate for concrete, road metal and railway etc ballast.

⑥ Basalt: Basalt is formed by Volcanic activity.

→ It contains tapering pores naturally.

→ It is dark in colour and very tough.

→ It has good sound absorption and insulation. It is also acid and alkaline resistant.

Uses:- It is used in flooring tiles and wall cladding.

→ It is also used in rubble masonry and foundation construction.

⑦ Marble: It is a metamorphic rock formed by changes in limestone or dolomite.

→ They are easy to work and have fine grain.

→ They resist frost and moisture well.

Uses:- It is used for interior and exterior flooring work, ornamental work and sculpture carving.

Grading of Aggregates:-

- Grading refers to the determination of particles size distribution of the given aggregate sample.
- It should be done in such a way of that the smaller particles filled the voids between the larger particles.
- If ~~the~~ all the particles of sample are of same size then, the compacted mass will contain more voids. But, if aggregate comprising of particles of various sizes then the concrete will have a mass containing lesser voids.
- Therefore, it is important that the aggregates are well-graded to produce good quality concrete.
- The grading of aggregate is expressed in terms of percentage by weight retained or passing through the series sieves.

The Sieves that are taken for grading of aggregate or to find particle size distribution are given below:-

80 mm

63 mm

40 mm

20 mm

12.5 mm

10 mm

4.75 mm → Standard

2.36 mm

1.18 mm

600 Microns

300 Micron

150 Micron.

Coarse aggregate

Fine aggregate

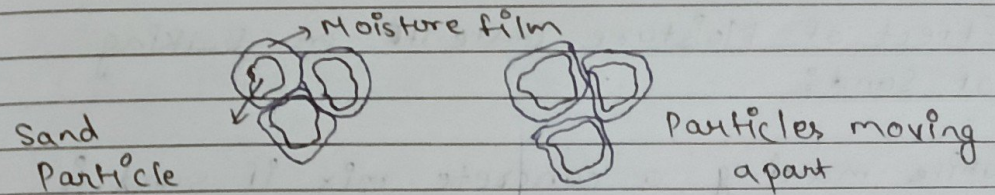
Fineness Modulus (FM):

- The fineness Modulus is a numerical index of fineness which gives some idea of the mean size of the particles in the given sample of aggregates.
- To determine the fineness Modulus of a given sample it is placed on the standard set of IS sieves (80 mm, 63 mm, 40 mm, 20 mm, 12.5 mm, 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 microns, 300 microns, 150 microns). and then it is vibrated.
- The material retained on each sieve after sieving is calculated by measuring its weight.
- The sum of cumulative percentages retained on each sieve when divided by 100 gives the value of its fineness modulus (F.M.).

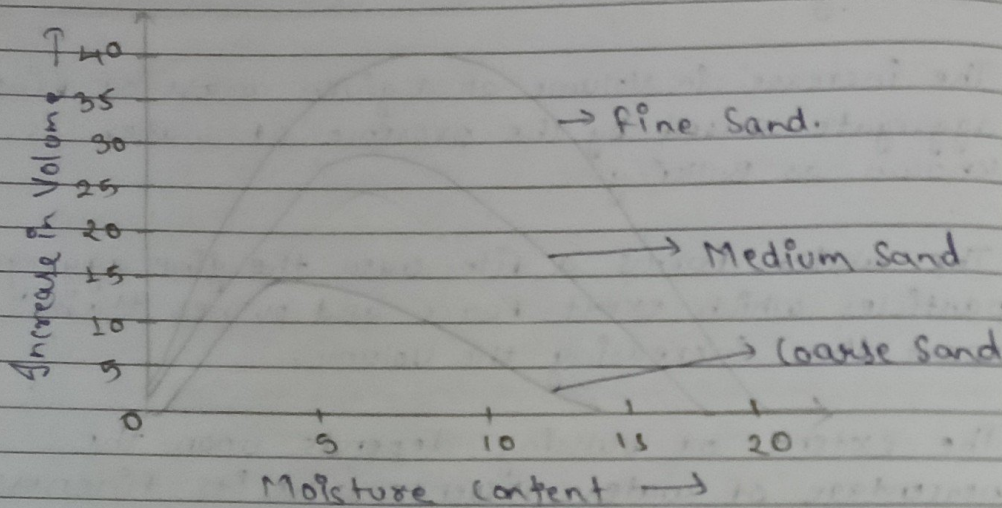
ex: An F.M. of 3 can be interpreted as the average size of particles in a given sample is of the third sieve size, that i.e. 600 microns.

Bulking of Sand :-

- The increase in volume of a given mass of fine aggregate caused by the presence of water is known as Bulking.
- The water forms a film over the fine aggregate particles which exert force and pushes them apart thus increasing the volume.
- The extent of bulking depends upon the percentage of water presence and its fineness.



- It increases with the moisture content upto a certain point (4-6% moisture content) reaches its maximum, and the film of moisture breaks, so it starts decreasing.
- With increase in a percentage of moisture, Volume increases from 15-30%.



Effect of Moisture Content on Bulking of Sand:

→ While making a concrete mix if sand is measured by volume and no provision is made for bulking then the moist sand will occupy more volume than the dry sand and hence the quantity of sand actually required will be reduced.

Determination of Bulking of Sand in Laboratory:

→ A container is taken and is filled $\frac{2}{3}$ rd with the sample of sand.

→ The height is measured (say 200 mm) or A.

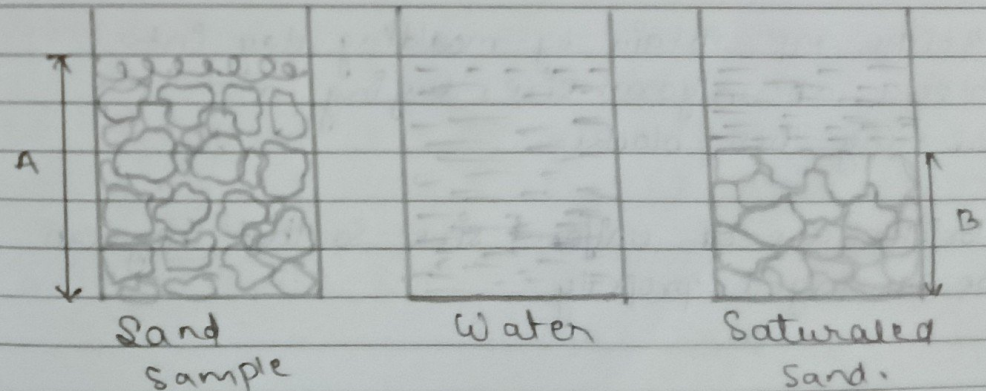
→ Now, the sand is taken out of the containers. It care should be taken that there is no loss of sand.

→ Now, the container is filled with water.

→ The sand is then, put again in the container and thoroughly stirred by a rod.

→ The height of sand is again measured (say 160 mm) or B.

$$\text{Bulking of Sand} = \frac{A - B}{B} \times 100$$



-! Here for example -

$$\text{Bulking of sand} = \frac{200-160}{160} \times 100$$

$$= \frac{40}{160} \times 100$$

$$= 25\%$$

★ Brick: It is like an artificial stone obtained by molding of clay into rectangular block of uniform size. It is a common building material as it is easily available and economical.

→ Bricks are one of the oldest building material.

→ They are so popular because they are cheap, durable and easy to handle.

→ Bricks are obtain by molding clay into blocks of uniform size, drying and then burning these blocks.

→ Bricks are of uniform size so that they can be arranged properly.

★ Properties of Bricks:-

① Size of brick - $(19 \times 9 \times 9)$ cm standard size.
 $u \times b \times h$

Nominal size with mortar = $20 \times 10 \times 10$ cm

② Size of frog - $(10 \times 4 \times 4)$ cm

The weight of brick is almost equals to 3 kg or 32 to 35 Newton.

Frog: A frog is a mark of depth about 2 cm on the surface of brick.

→ Size of frog - $(10 \text{ cm} \times 4 \text{ cm} \times 1 \text{ cm})$

The main purpose of providing frog in a brick are-

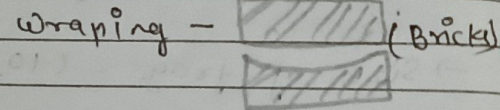
(a) It indicates the name of the manufacturer.

(b) In brickwork the bricks are layed with frog on the upper surface because it series as a key to the mortar when the next brick is placed over it.

★ Composition of Bricks :- (Ingredient of bricks)

S	-	Silica	-	50-60%	(to prevent warping)
A	-	Alumina	-	20-30%	(to give plasticity)
L	-	Lime	-	4-5%	(to prevent shrinkage)
I	-	Iron oxide	-	5-6%	(to give colour)
M	-	Magnesia	-	1%	(to give brownish colour)

(i) Silica (SiO_2) : It prevents the cracking, shrinkage and warping of bricks, hence give its a uniform shape. If it is an ~~excess~~ excess it destroy the cohesion between the particles present in the brick earth and finally leads to disintegration.



(ii) Alumina (Al_2O_3) : It imparts plasticity to the brick earth so, that it can be molded easily. If it is present excess it causes the shrinkage and warping of the brick during its drying and it becomes too hard when it is burnt.

(iii) Lime (CaO) : It also prevents the shrinkage of bricks. If it is in excess it causes the bricks to melt hence resulting in lost shape of the brick.

If the lumps of a lime are left in a brick, it slacks in the presence of moisture resulting in ~~crack~~ cracking and disintegration of the brick.

(iv) Iron oxide (Fe_2O_3) : It helps in fusing of Lime and Silica. It helps to impart red colour to the brick.

(v) Magnesia : It imparts yellow shed to the brick.

★ Harmful Ingredient in the Bricks :-

① Gravels, Grits, Pebbles - Bricks with pebbles and Gravels may crack while working. They do not allow the clay to be mixed thoroughly and spoil the appearance of the bricks.

② Iron Pyrites - Pyrites discolourise the bricks. They tend to oxides and decompose the brick during burning.

③ Organic Matter - On burning the bricks, with organic matter it gets charred and the leaves make tiny pores in the brick. This leads to increased water absorption and reduce strength.

④ Sulphur - It is found in clay as sulphate of calcium, magnesium or iron sulphide. It leads to the formation of spongy, swollen structure in the brick and will discolourise the bricks.

⑤ Alkalies - They are mainly present in the form of soda or potash. They make the brick clay unsuitable for making bricks as it melts the clay on burning making the brick unsymmetrical.

⑥ Carbonaceous material - They are present in the form bituminous matter forming black core in the brick.

✱ Test of Bricks:-

① Absorption - A brick is taken and its dry weight is measured.

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

→ After that its weight is measured again and the difference in weight indicates the amount of water absorbed by the brick.

→ It should not exceed 20% of dry brick weight.

② Crushing strength test - The crushing strength of brick is found by compression testing machine. It is passed till it breaks.

→ As per (IS) 1077 - 1970 the minimum crushing strength of brick is 3.50 N/mm^2 .

→ Class A - crushing strength 7 to 14 N/mm^2

→ Class AA - crushing strength above 14 N/mm^2

③ Hardness - In this test a scratch is made on brick surface with the help of finger nail.

→ If no impression is left on the surface the brick is treated as sufficiently hard.

④ Soundness - In this test two bricks are taken and they are struck with each other.

→ The brick should not break & make a clean ringing sound.

⑤ Presence of Soluble Salts - The Soluble Salts if present in bricks then, will cause efflorescence on the surface of brick.

→ For finding out its presence the brick is immersed in water for 24 hours.

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

→ The presence of grey or white, deposition on the surface indicates presence of soluble salts.

⑥ Shape and Size - In this test, the brick is closely inspected.

→ It should be of standard size ($19 \times 9 \times 9$ cm.), rectangular in shape with sharp edges.

→ For this test check at least 20 bricks for its dimensions.

⑦ Classification of Bricks -

The bricks can broadly be divided into two categories as follows:-

(i) Unburnt or Sun-dried brick.

(ii) burnt brick.

The unburnt or sun-dried brick are dried with the help of heat received from sun after the process of moulding. These bricks can only be used in the construction of temporary and cheap structures. Such bricks should not be used at places exposed to heavy rains.

The brick used in construction work are burnt bricks & they are classified into -

"Burnt brick"

First class
brick

Second class
brick

Third class
brick

Fourth class
brick

① First class bricks: These bricks are table-moulded and of standard shape and they are burnt in kilns. The surfaces and edges of the bricks are sharp, square smooth and straight.

→ They comply with all the qualities of good brick which are mentioned earlier.

→ These bricks are used for superior work of permanent nature. (water absorption 120% by weight)

② Second class brick: These bricks are ground-moulded and they are burnt in kilns. The surface of these bricks is somewhat rough and shape is also slightly irregular.

(water absorption 25%)

→ These bricks may have air cracks and their edges may not be sharp and uniform.

→ These bricks are commonly used at places where brick work is to be provided with a coat of plaster.

③ Third class bricks: These bricks are ground-moulded and they are burnt in clamps. These bricks are not hard and they have rough surface with irregular and distorted edges.

→ These bricks give dull ~~gro~~ sound when struck together. They are used for unimportant and temporary structures and at places where rainfall is not heavy.

④ Fourth class bricks: These are overburnt bricks with irregular shape and dark colour. These bricks are used as aggregate for concrete in foundations, floors, road etc.

→ because of the fact that the over burnt bricks have a compact structure and hence they are sometimes found to be stronger than even the first class bricks.

* fly Ash Bricks :-

→ fly ash bricks is a building material (masonry unit) containing class C or class F type fly ash and water.

→ The Main contains -

fly ash - 60 %

Sand/dust - 30 %

Portland Cement | Lime - 10 %

→ The strength of fly ash brick is 7.5 N/mm^2 .

→ They are lighter and stronger than clay brick.

Properties of fly ash bricks :-

① Fly ash bricks are light weight 2.6 kg and dimensions are $(23 \text{ cm} \times 11 \text{ cm} \times 7 \text{ cm})$. They reduce dead load on structure.

② The same number of bricks will cover a larger area than clay bricks.

① fly ash bricks provide high-fire resistance.

* Hollow Bricks :-

→ Hollow Bricks can be defined as the blocks with one or more than one hole or cavities passing through the block having 50-75% of solid material in total volume calculated from the over all dimensions of the Bricks.

→ They are made of a mixture consisting of cement, sand and minor amount of fly ash.

→ uses of Hollow bricks :-

① It is commonly used in compound wall.

② It is used for multi-story buildings, factories and residential building construction.

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- It is used for joining brick, stone, blocks --- etc.
- The mortar composition is designed by either ^{by} weight or volume in 1m^3 .

→ Characteristics of Good Mortar :-

- 1) It should be capable of developing good adhesion with building unit.

- 2) It should be capable of developing the designed stresses.
- 3) It should be capable of resisting penetration of rain water.
- 4) It must be cheap.
- 5) It should be durable & easily workable.
- 6) It should be chemically inert.
- 7) It should be well graded.
- 8) It should not contain salts that absorb moisture from the atmosphere.

→ Classification of Mortar

- 1) Cement mortar
- 2) Lime mortar
- 3) Sukhi mortar

1) Cement mortar - In this type of mortar cement is used as a binding material. Depending upon the strength required and importance of work. The proportion of cement to sand by volume varies from 1:2 to 1:6 or more.

- It should be noted that Sukhi or cinders should not be used in cement mortar as they are not inert.
- The cement mortar is used where high strength and water resisting properties are required in places such as underground construction, water saturated

soil... etc.

2) Lime mortar - In this type of mortar lime is used as the binding material. It may be fat lime or hydraulic lime.

- Fat lime shrinks to a great extent and so requires two to three times volume of sand. The lime should be slaked before using it. This mortar is unsuitable for damp construction or water logged area.
- For hydraulic lime the ratio of lime to sand is 1:2 or so. This mortar should be consumed within one hour after mixing. It has more strength and can be used in damp situation.
- Lime mortar has high plasticity and can be placed easily. It has good binding property and shrink -s very little. It is sufficiently durable and used in lightly loaded parts of building.

3) Sukhi mortar - This type of mortar is prepared using Sukhi as adulterant.

- The powder of Sukhi used must pass through BPS sieve no. 9 with residue not more than 10% by weight.
- Sukhi mortar is used for ordinary masonry work but it cannot be used for plastering.

→ Selection of Mortars :-

Nature of work	Type of mortar
1) Construction work in water logged areas and exposed position.	Cement or lime mortar prop. 1:3, lime being eminently hydraulic lime.
2) Damp - proof courses and cement concrete roads.	Cement mortar prop. 1:2
3) General R.C.C. work such as lintels, pillars, slabs, stairs - - etc.	Cement mortar prop. 1:3, the concrete mix being 1:2:4.
4) Internal walls and surface of less importance.	Lime cinder mortar prop. being 1:3 sand is replaced by ashes or cinders.
5) Mortar for laying of fire-bricks.	Fire resisting mortar consisting of 1 part of aluminous cement to 2 part of finely crushed powder of fire bricks.
6) Partition wall and parapet wall.	Cement mortar prop. 1:3 or lime mortar proportion 1:1 lime should be moderately hydraulic lime.

7) Plaster work	Cement mortar prop. 1:3 to 1:4 or lime mortar prop. 1:2
8) Pointing work	Cement mortar prop. 1:1 to 1:2
9) Reinforced brick work	Cement mortar prop. 1:3.
10) Stone masonry with best varieties of stone.	Lime mortar prop. 1:2, lime being eminently hydraulic lime.
11) Stone masonry with ordinary stone brickwork foundation - - etc.	Lime mortar prop. 1:2 or cement mortar proportion 1:6 lime should be eminently hydraulic lime or moderately hydraulic lime.
12) Thin joints in brick-work.	Lime mortar prop. 1:3, lime being fat lime.

Cement :- Cement used in construction industry is a binding material which is capable of bonding to gether particle of solid matter into a compact durable mass. It has adhesive & co-hesive properties. It is the most important building material used in the field of construction.

• It was invented by Joseph Aspdin in 1824.

• It is composed a two type of Component :-

- 1) Argillaceous compound (clay)
- 2) Calcareous compound (calcium)

→ Composition of Cement :-

Constituents	Range	Perm Composition
L : Lime	62-67%	62%
S : Silica	17-25%	20%
A : Alumina	3-8%	5%
C : Calcium Sulphate (gypsum)	3-4%	3%
I : Iron oxide	3-4%	3%
M : Magnesia	1-2%	1%
S : Sulphur	1-2%	1%
A : Alkalies	0.1-1%	1%

Notes:- Soundness - Resistance to change in volume.

Function of each ingredient of Cement :-

1) Lime (L) :- It imparts strength and Soundness to Cement. If it is an excess it makes the Cement unsound, and if it is deficient the strength of the Cement decreases & also its setting time reduce.

2) Silica (S) :- It imparts strength to cement. Excess of silica causes slow setting of cement.

3) Alumina (A) :- It imparts quick setting property to the Cement. It also lowers the clinkering temperature. If it is an excess it reduces the strength of Cement.

4) Calcium Sulphate (gypsum) :- (CaSO_4) Gypsum helps in increasing the initial setting time of cement.

5) Iron oxide :- It imparts colour to the cement. It also gives strength & hardness to cement. It also help in fusion of different ingredient of cement.

6) Magnesia :- (MgO) It imparts soundness to cement and also add colour to it. If it is an less quantity

-ly it makes the cement hard and if it is in excess it causes cracks in mortar & concrete & makes it un-sound.

7) Sulphur :- A very small amount of sulphur is useful in making sound cement. If it is in excess it makes the cement unsound.

8) Alkalies :- Alkalies are present in the raw material of cement in very small quantities in the form of residue. If it is in excess it causes efflorescence and cracking.

Hydration of Cement :-

Anhydrous cement doesn't bind fine & coarse aggregate together, it acquires adhesive properties only when mixed with water. The chemical reaction that takes place between cement and water is known as hydration of cement.

- The chemistry of concrete is essentially the chemistry of the reaction between cement and water and the amount of hydration depends upon the presence of water. The products of hydration are important because they have the required cementing or adhesive properties.

- The quality, quantity and rate of formation of these products are important for the concrete to gain the required strength.

→ Chemistry of Setting & Hardening :-

When water is added to cement the ingredients of cement react chemically with water and form various chemical compounds. They are known as Bouges compounds.

The formation of this compound is not simultaneous. The order of their formation is-

- 1) C_3A - Tri calcium Aluminate ($3CaO \cdot Al_2O_3$)
- 2) C_4AF - Tetra calcium Aluminoferrate ($4CaO \cdot Al_2O_3 \cdot Fe_2O_3$)
- 3) C_3S - Tri calcium Silicate ($3CaO \cdot SiO_2$)
- 4) C_2S - Di calcium Silicate ($2CaO \cdot SiO_2$)
- 1) Tri calcium Aluminate - C_3A ($3CaO \cdot Al_2O_3$) :-

- It is formed within 24h of the addition of water to cement.
- It is 4-14% by weight.

- Maximum amount of heat is liberated during the formation of this compound. This is known as heat of hydration (Cal/gm). Upto 3 days maximum amount of heat liberated is 210°Cal/gm .

2) C_4AF - Tetra Calcium Aluminoferrate ($4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$) :-

It is also form within 24h of addition of water into cement but after the formation of C_3A . It is 10-18% by weight.

- The heat of hydration of C_4AF is one third of the amount of C_3A . upto 3 days heat realised equal to 70°Cal/gm .

3) C_3S - Tri Calcium Silicate ($3\text{CaO} \cdot \text{SiO}_2$) :-

It is formed within a week of addition of water into cement. Since it include lime & silica both, this compound impart strength.

- Heat of hydration of C_3S is approximately equal to Heat of hydration of C_4AF .
- The Heat of hydration of C_4AF is 60°Cal/gm .
- It is 45 - 65% by weight.

4) C_2S - Dicalcium Silicate ($2\text{CaO} \cdot \text{SiO}_2$) :-

It is formed within one year of

addition of water into cement. Hence, it is responsible for progressive strength of cement. If the strength of cement is required at later stages the proportion of C_2S must be increased.

- Heat of hydration equal to 10°Cal/gm .

Note :- If high strength of cement is required at early stages the proportion of C_3S must be increased.

→ Heat of hydration of cement :-

The reaction of cement with water is exothermic reaction, heat considerable amount of heat is realised during this process. This liberation of heat is known as heat of hydration. The study and control of heat of hydration. Become important in the construction of bridges, dams... etc.

- where mass concreting is to be done.
- On mixing of cement with water a rapid heat revolution, lasting for few minute occurs.
- This heat evolution is due to the reaction of aluminates. This initial heat evolution stops quickly when the solubility of aluminate is depressed by gypsum.

- Next heat evolution is due to formation of C_4AF .
- Different compound hydrate at different rate and liberate different quantities of heat.
- The main heat of hydration is due to C_3S .
- Fineness of cement is also responsible for the rate of development of heat.
- The hydration process is not instantaneous the reaction is faster in early period & continues indefinitely at a decreasing rate.

* Heat of hydration of cement is given by the following relation:-

$$H = aA + bB + cC + dD \text{ in cal/gm.}$$

where,

a, b, c, d = % of heat released by each Bouge's compound.

A, B, C, D = Amount of heat of hydration released by each Bouge's compound.

Note:- for Ordinary portland cement (OPC) after 7 days

heat of hydration = $89-90^\circ \text{ Cal/gm.}$

after 21 days = $90-100^\circ \text{ Cal/gm.}$

→ Water Requirement of Cement:-

C_3S Requires 24% of water by weight for its complete hydration.

• C_2S Requires 21% of water by weight for its complete hydration.

• Cement as a whole require 23% of water by weight for its complete hydration.

• 15% of water is required to fill the voids in cement.

$$\text{Total} = 23\% + 15\%$$

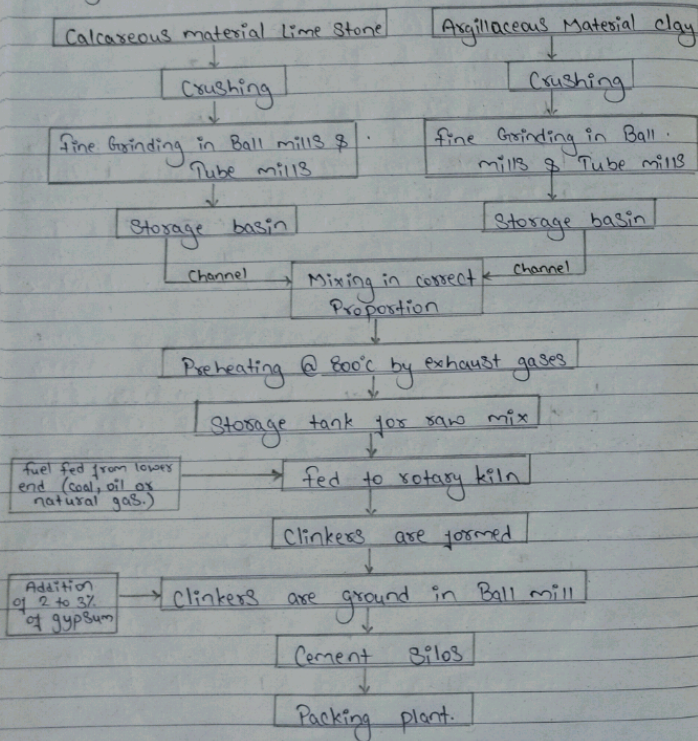
$$= 38\% \approx (40\%)$$

• Effectively water required for complete hydration of cement is 38% or 40%.

Manufacturing of Cement :-

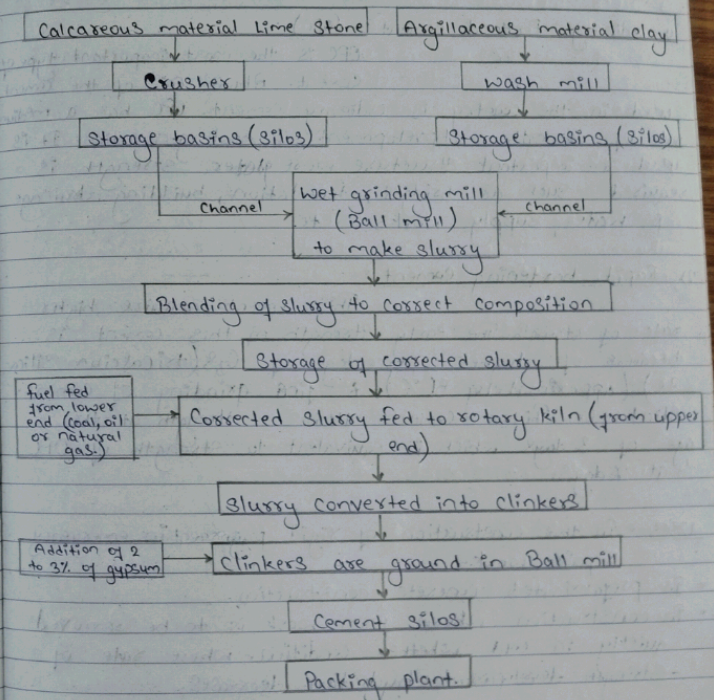
- 1) Dry Process..
- 2) Wet Process..

1) Dry process:-



(flow dig. - dry process)

2) Wet process:-



(flow dig. - wet process)



Types of cement :-

1) Ordinary Portland Cement :- (OPC)

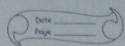
OPC is the most important type of cement. About 60% of the cement used in the country is ordinary cement. OPC has a medium rate of strength development & heat generation. It is used in important structures where greater strength is required such as bridges, foundation, building drainage & water supply works...etc.

2) Rapid hardening Cement :-

This cement acquires higher rate of strength. The early strength of this cement is because of higher percentage of C_3S (tricalcium silicate) (approximately 56%) & fine grinding of cement clinkers. This cement attains strength at the age of 3 days which is equivalent to strength of OPC at 7 days.

Uses :- In the construction of rigid pavement in emergency repair work.

- In precast concrete construction.
- In construction where form work is to be removed quickly in cold weather condition, where rate of strength development by hydration decreases.



3) Extra Rapid Hardening Cement :-

It is manufactured by intergrinding cement clinkers with calcium chloride ($CaCl_2$) not more than 2% by weight of cement.

- This cement must be mixed, transported, placed & finished within 20 minutes of its formation.
- This cement acquires 25% more strength than rapid hardening cement and 10-20% more strength in 7 days and at the end of 90 days its strength is similar to that of OPC.

4) Sulphate Resisting cement :-

OPC is prone to the attack of sulphate specially $MgSO_4$ which reacts with calcium hydroxide ($Ca(OH)_2$) to form calcium sulphate ($CaSO_4$) & calcium aluminate ($CaSO_4 \cdot Al_2$) which has 22% more volume than its original form. This cement is produced by reducing the proportion of C_3A (tricalcium aluminate) & C_4AF . the expansion of $CaSO_4$ & $CaSO_4 \cdot Al_2$ result in crack & subsequent disruption.

Uses :-

- Marine structure.
- Sewage treatment works.
- Foundation & basements in soil having higher % of sulphate.
- Piles which are to be constructed in marshy areas.

5) Super Sulphated Cement :-

It is manufactured by intergrinding of 80-85% of granulated slag, 10-15% of gypsum & 5% of cement clinkers. This cement is more resist to attack of Sulphate.

6) Quick Setting Cement :-

In this type of cement, the quantity of gypsum is reduced & small percentage of aluminium sulphate is added. It is ground more finer than OPC. Its initial setting is 5 min. & final setting time is 30 min.

Uses :-

- It is used when concrete is to be laid under water or in running water.

7) High alumina cement :-

It is manufactured by fusing 40% bauxite, 40% lime, 15% Iron oxide with a little ferric oxide & silica, magnesia. At a very high temperature

- Alumina content should not be less than 32%
- Cement ingredient is monocalcium aluminate. (Ca)

Properties :- It is not quick setting (Initial setting time = 30 min. (Final setting time should not exceed 60 min.))

- It attains strength in 24 h. and has high early strength, high heat of hydration & resistant to chemical attack.
- The cement should not have expansion more than 5mm.

Uses :-

- It is resistant to the action of fire, sea water, acidic water and sulphate.
- It should not be used in places where temp. exceed 18°C .

8) Portland Slag cement :-

It is manufactured either by intergrinding a mixture of portland cement clinker & granulated cement with addition of gypsum or calcium sulphate.

- Slag is a non-metallic product consisting essentially of glass containing silicate & alumina silicate of lime. Granulated slag is obtained by further processing the molten slag by rapid chilling or quenching it with water, steel or with air.

Properties :- Specific surface of slag cement should not be less than $2250 \text{ cm}^2/\text{g}$.

- The expansion of cement should not be more than 10mm and point 0.8% when tested by Lechatelier method & autoclave test.

- The initial & final setting time & compressive strength requirement are same as ordinary portland cement for grade 33.

Uses :-

- Used for mass concreting.
- eg - dam, foundation etc.
- Used in all places where OPC is used.

9) Low heat Portland Cement :-

To limit the heat of hydration of low heat portland cement the tri calcium aluminate component in cement is minimized and high % of dicalcium Silicate & tetra calcium Alumino ferrite is added.

Properties :- The expansion should not be more than 10mm and 0.8 % by Lechatellier method & autoclave test.

- The minimum initial setting time should not be less than 60min. and final setting should not be more than 600min.

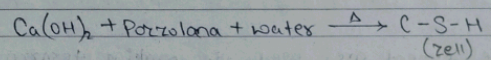
Uses :-

- Most suitable for large mass concrete work such as dam, foundation

10) Portland Pozzolana Cement :-

It is manufactured by grinding portland cement clinker and pozzolana or by intimately and uniformly blending portland cement & fine pozzolana.

- A Pozzolanic material itself possesses known cementitious property but in the presence of water it reacts with calcium hydroxide & product produce cementitious property.



Properties :-

- This have lower rate of development of strength but ultimate strength is comparable with OPC.
- The initial & final setting time are 30min. & 600min.

Uses -

- Used in the places of mass concrete such as dam and in place of high temp.

n) white & coloured portland cement :-

It is manufactured

from pure white chalk & clay free from Iron oxide.

- Greasyish colour of cement is due to Iron oxide.
- So the Iron oxide is reduced and limited below 1%.
- Coloured cement are made by 5-10% colouring pigment before grinding.
- These cement have same properties as that of OPC.

Uses:-

- These cement are used for making terrazzo flooring, face plaster of wall, Ornamental work and casting stone.

Test of Cement :-

(1) Physical test :-

a) Consistency test :- This is a test to estimate quantity of mixing water to form a paste of normal consistency defined as that % water requirement of cement paste.

- The water requirement for various test of cement depends of the normal consistency of the cement which it self depends upon the compound composition & fineness of the cement.

→ fig Exp. no. - 6

(b) Determination of Initial & final setting time :- When water is added to cement the resulting paste start to stiffen and gain strength & lose the consistency simultaneously.

- weekend apparatus used for the purpose of Initial & final setting time.
- The initial setting time may be defined as the time taken by the paste to stiffen to such an extent that the Vicat needle is not permitted to move down through the paste to within 5 ± 0.5 mm measured from the bottom of the mold.

- The final setting time is the time after which the paste become so hard that the angular attachment to the needle under standard weight fails to leave any marks on the hardened concrete.

③ Soundness test:- It is essential that the cement concrete doesn't undergo large change in volume after setting.

- This is ensured by limiting the quantities of free lime & magnesia which causing change in volume of cement.
- Soundness of cement may be tested by Lechatelier method or by autoclave method.
- For OPC, BHC, LHC and PPP It is limited to 10mm where as HAC and SPC It should not exceed 5mm.

→ Lechatelier's method:- The mould is placed on glass sheet and is filled with neat cement paste formed by gauging 100gm cement with 0.76 time water required to give paste of standard consistency.

- Mould is covered with glass sheet and a small weight is placed on the covering glass sheet.
- Mould is then submerged in water at temperature of $27 \pm 32^\circ\text{C}$. After 24 hour mould is taken out and distance separating is measured.

- The mould is again submerged in water & boiled for 3 hours. Mould is removed from water and is cooled down. distance betn the indicator point is measured again.

→ Autoclave method:-

④ Determination of strength:-

① Compressive strength:-

Compressive strength is the basic data required for mix design by these test the quality & quantity of concrete can be controlled and the degree of adulteration can be checked.

- The test specimen are 70.6mm cubes having face area of about 5000mm².
- A mixture of cement and standard sand in the proportion 1:3 by weight is mixed dry and then water until mixture is of uniform colour.
- The quantities of cement, standard sand and water are 185 gm, 555 gm & $\left(\frac{P}{4} + 3.5\right)$.
- Mould is filled completely with cement paste and is placed on the vibration table.
- The cube are then removed from the mould and submerged in clean fresh water.
- Compressive strength is taken to be the average of the result of the 3 cube.
- The load is applied starting from zero at rate of 35N per square mm per min.

(*) Tensile strength :-

The tensile strength may be determined by briquette test method or split tensile strength test.

(*) Briquette method :-

- A mixture of cement & sand is prepared in the proportion of 1:3 by weight.
- The % of water to be used is calculated from $\left(\frac{P + 2.5}{5}\right)$.

- The temp. of water and the test room should be $27 \pm 2^\circ\text{C}$.
- Mixed is filled in the mould and additional heap of mix is placed on the mole and is pushed down with the standard spectula. until the mixture is levelled with the top of the mould. Do other side also.
- They are then kept for 24 hours at a temp. of $27 \pm 2^\circ\text{C}$ and in an atmosphere having 90% humidity.
- The Briquette are then kept in clean fresh water and are taken out before testing.
- Six Briquette are tested and the average tensile strength is calculated.



Cement Admixture:- Cement Admixture is a material added to concrete or mortar during mixing or before to improve its property such as strength, workability, setting time, durability or resistance to chemical.

Types of Admixtures:-

① Plasticizer:- (water reducing the Admixture)

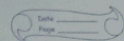
Purpose:- It improve workability without increasing water.
• used in slab, beam, column, improve concrete flow & increase strength by reducing water cement ratio.
eg:- lignosulphonates

② Superplasticizer:- (High range water reduces).
It highly strength workability or (increase) strength.

• It use in high rise building, pump concrete, highly reinforced section, high strength concrete.
eg:- Sulphonated naphthalene, Poly carboxylate ether.

③ Excellator & It speed up setting & early strength gain.

• used in cold weather concreting, road repair work & precast concrete element.
eg:- Calcium chloride, non-chloride excellators.



④ Retarder:- It delay in setting time.
• used in hot weather concreting, mass concreting & long distance concrete transport.
eg:- Sugar based, gypsum based admix.

⑤ Air & trapping Admixture:-

It create tiny air bubble to improve durability.

• used in freeze thaw resistant concrete, Pavement in cold region & improves workability.
eg:- Resin, fatty Acid.

⑥ water proofing Admixture:-

It reduce permeability.
• used in water tank, basement, Roof slab & toilet & bathroom.
eg:- calcium Seacrate, silicates.

⑦ Mineral Admixture:- (Supplementary cementitious material)

Type	Purpose	Application
1) Fly ash	improve workability & durability.	mass concrete, foundation.
2) Ground granulated blast slag	Reduce heat of hydration.	Damp, soft foundation.

3) Silica fume	Increase strength & Impermeability.	high strength concrete.
4) Metakolin.	Improved durability.	maxine structure

UNIT - 04

Timber, Glass, Steel, Aluminium & Plastic

Wood is the hard, fibers material that makes a up the tree under the bark where as timber may be defined as a wood which retain its natural physical structure and chemical composition. & is suitable for various engineering work.

* Characteristics of good timbers :-

- ① Uniform texture.
- ② narrow annual ring, closer the ring greater is the strength.
- ③ Dark Colour - wood is darker then the sap wood and timber from hard wood is stronger.
- ④ Sweet smell and a shiny fresh cut surface it is indicative of sound wood.
- ⑤ free from the defect in timber the defect weaken the timber and affect workability.
- ⑥ Heavy weight it is an indication that the wood is from heart wood.
- ⑦ No, wettiness at fresh at surface.
- ⑧ when struck Sonorous sound is produced.

③ Compact medullary rays they greatly influence shrinkage & there by influence mechanical properties it offer more resistive to shrinkage.

* Seasoning of Timber :-

① Seasoning is the process of reducing the moisture content of timber in order to prevent the timber from possible formantation and making it suitable for use.

② It can also be defined as the process of drying the wood to a moisture content approximately equal to the average humidity of the surroundings, where it is permanently fixed.

③ Some of the object of seasoning wood are as follow:

- (a) Reduce the shrinkage & warping after replacing in structure.
- (b) Increase strength, durability & workability.
- (c) Reduce its tendency to split & decay.
- (d) Make it suitable for painting.

1e) Reduce its weight.

Maximum moisture content of timber as per (IS) is 28% for standard element such as beam, rafter & post are as follows →

Zone		%
Zone (1)	Dry Zone	12%
Zone (2)	Moderate Dry Zone	14%
Zone (3)	moist zone	17%
Zone (4)	moist zone	20%

Method of Seasoning:-

- (1) Natural Seasoning
- (2) Artificial Seasoning

Natural Seasoning: The log of wood is sawn into plank of convenient size and stacked under a cover shape in cross-wire direction in alternate layer so as to permit free circulation of air.

→ The duration for drying depends upon the type of wood and size of plank.

→ Air seasoning or natural seasoning reduces the moisture content of wood 12-15%.

Artificial Seasoning: - Type of artificial seasoning are -

- ① Boiling Seasoning.
- ② Chemical Seasoning.
- ③ Electrical Seasoning.
- ④ Kiln Seasoning.
- ⑤ Water seasoning.

① Boiling Seasoning: In this method, the timber is immersed in water for 1-2 days and then water is boiled for 3-4 hours. It is then dried slowly under a shed. This method takes less time.

② Chemical Seasoning: It is a method in which chemicals are used which increase the rate of vapourisation. In this method, timber is immersed in a soluble salt solution and then taken out of it. It is then allowed to dry in a shed.

③ Electrical Seasoning: The logs are placed in such a way that their two ends touch the electrodes. Current is passed through the setup. Being a bad conductor, wood resists the flow of current, generating

heat in the process which resist result in its drying.

- ④ Kilan Seasoning - In this method, wooden logs is placed in side the air tight chamber of the kilan in which saturated air is pumped for evaporation in water.

The simple is then, moved in another chamber in which the relative humidity of air is decreased gradually to ensure uniform section of log.

- ⑤ Water Seasoning - In this method, timber pieces are placed in running stream of water for about 2-4 week during which the shape is washed away by water.

Timber is then taken to water and allow to dry under a shed having free circulation of air.

This is a unique method and it prevent shrinkage, eye or warping.

Defects in timbers -

Defects can occurs in timber at various stage principally during the growing period and during the conversion and seasoning process.

① Defect due to conversion:-

- (i) Diagonal grain.
- (ii) wane
- (iii) Check mark
- (iv) Torn grain

② Defect due to fungi:-

- (i) Blue stain
- (ii) heart rot
- (iii) White rot
- (iv) Brown rot
- (v) Sap stain
- (vi) Dry rot
- (vii) Wet rot

③ Defects due to insects:-

- (i) Beetles.
- (ii) termite.

④ Defects due to Natural force :-

- (i) knots
- (ii) Shakes
- (iii) wind crack
- (iv) twisted fiber
- (v) water strom

⑤ Defects due to Seasoning :-

- (i) Twist
- (ii) Warp
- (iii) honey combing
- (iv) Red rot shak
- (v) Cup shak

Qualities of good timber -

① appearance - A freshly cut surface of timber should exhibit hard and shiny appearance.

② colour - The colour of timber should preferably dark. The light colour usually indicate timber with low strength.

③ Durability - A good timber should be durable it should be capable of resisting the action of fungi, insects, chemical, physical agencies and Mechanical agencies.

→ If wood is exposed to the action of acid and alkalis for a prolong period it is seriously damage.

④ Elasticity - This the property by which timber return to its original shape when load causing it deformation is removed.

→ This property of timber would be essential when it is to be used for sports goods, carriage shaft etc.

⑤ fire resistance - The timber is a bad conductor of heat. A dense wood offer good resistance to the fire and it required sufficient heat to cause a flame.

→ The heat conductivity of wood is low and its depend on various factor such as moisture content, surrounding temp., orientation of fiber and bulk density etc.

Industrial Timber -

The Timber which is prepared scientifically in a factory is termed as the Industrial timber and such timber passes desired shape, appearance, strength etc.

Followings are the fine variety of Industrial timber:-

- ① Veneers
- ② plywood
- ③ Fiber board
- ④ Impreg timber.
- ⑤ Compreg timber
- ⑥ Block board & lamin board
- ⑦ Gulam timber
- ⑧ flush door shutter
- ⑨ Particle board or chip board
- ⑩ hard board.

(1) Veneers - This are thin sheet or slice of wood of superior quality.

→ The thickness of veneers varies from 0.4 mm to 0.6 mm or more.

→ They are obtained by rotating a log of wood against a sharp knife of rotatory cutter or saw saw.

→ The Veneers after being removed are dried in kiln to remove moisture.

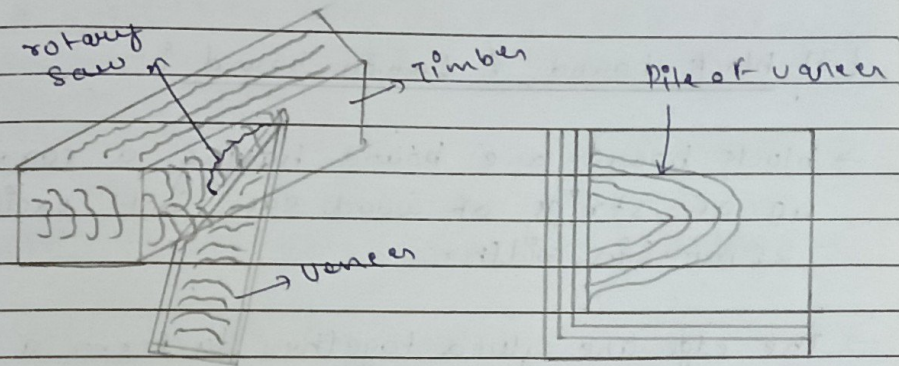


Fig → Veneers.

(2) Fiber board - This are rigid board and they are also known as pressed wood or re-constructed wood.

→ The thickness varies from 3 mm to 12 mm.

→ They are available in length vary from 3-4.5 meter & in width vary from 1.2 m - 1.8 m

→ The weight of fiber board depends on the pressure applied during manufacture.

→ The maximum and minimum limit of weight are respectively 9600 N/m^3 & $500 - 600 \text{ N/m}^3$.

(3) block board & Lamin board :-

→ block board are board having a core made up of strips of wood each not exceeding 25 mm in width.

→ The edge are glued together to form a solid sheet which is then finished with one or two cross bonded veneers on each face.

→ The wooden strips may be obtained from small round wooden logs left over from timber conversion or pillar causes remaining veneers production.

→ This board are extensively used for railway carriage, bus bodies, motor and craft for furniture partition paneling for pre-fabricated houses etc.

→ when the thickness of core strip does not exceed 2 mm such board are known as lamin board.

* Uses of Timber :-

① It is used for door and windows frames shutter of door and windows, roofing material etc.

② It is used for form work of cement concrete, centre of an arch, scaffolding.

③ It is used for making furniture agricultural industrial sport goods, musical instruments etc.

④ It is used for making railway coach wagon.

⑤ It is used for railway sleeper, packing cases etc.

⑥ It is used for temporary bridges and board construction.

⑦ It is used for making toys engineering work etc.

★ Aluminium: Aluminium occurs in abundance on the surface of earth.

→ It is available in various form such as oxides, Sulphate, Silicate, phosphate etc. but it is commercially produced mainly from Bauxite ($Al_2O_3 \cdot 2H_2O$) which is hydrated oxides of Aluminium.

* Properties of Aluminium -

- ① It is very good conductor of heat and electricity.
- ② It is silver white metal with bright metallic luster on freshly broken surface.
- ③ It is non-magnetic substance.
- ④ It is nearly attacked by nitric acid, organic or water it is highly resistance to corrosion.
- ⑤ It is light in weight, malleable and ductile.
- ⑥ It is very soft.

⑦ It melts at $600^\circ C$ and its boiling point is $2026^\circ C$.

⑧ It possesses great toughness and tensile strength.

⑨ It readily dissolves in HCl acid.

⑩ Its specific gravity is about 2.70.

* Forms of Aluminium :-

① Casting based -

- ① Baluster head
- ② hardware & fittings.
- ③ Security and decorative grills.

② foil and Powder Based -

- ① Paints
- ② water-proofing sheet.
- ③ Insulative foil
- ④ Laminate Product.

③ Sheet Based -

- ① Cable tray.

- ② flat type fall ceiling.
- ③ Prefabricated houses.
- ④ Rain water Artilicals.
- ⑤ Roof & Slidings.

④

- ① Door and window frames.
- ② green house and roof top garden.
- ③ Hardware and fittings.
- ④ fascia panel and curtain wall
- ⑤ north light glazing frames
- ⑥ Partition and space distributions.
- ⑦ Space grid and geodesic domes.

Uses of Aluminium:-

- ① It is used as a reducing agent in the manufacturing of steel.
- ② It is used making aluminium alloys, auto-mobiles bodies, and surgical instruments.
- ③ It is used in casting of steel.
- ④ It is used in the manufacturing of electrical.

③ It is used in manufacturing of paint in powder form.

★ Steel :-

→ Steel is an alloy of iron and carbon but contain other element as well as impurities or alloying element.

→ Depending upon the Carbon content the steel designated that mild steel, medium, high Carbon steel.

→ The Various use of steel are according to the percentage (%) of Carbon on it.

Type of Steel	Carbon Content	Uses.
① Mild steel	0.15 - 0.2%	motor body, metal teen plate.
② Medium steel	0.3 - 0.8%	Structural steel rails, hammer.
③ High Carbon steel	0.8 - 1.5%	Making tools, mason tools etc.

Properties of Mild steel -

- ① It can be magnetised permanently.
- ② It can be readily forged and welded.
- ③ It can not be easily hardened and tempered.
- ④ It has fibrous structure.
- ⑤ It is malleable and ductile.
- ⑥ It is not easily attacked by salt water.
- ⑦ It is tougher and more elastic than wrought iron.
- ⑧ It is used for all type of structural work.
- ⑨ It rusts easily and rapidly.
- ⑩ Its melting point is about 1400°C .
- ⑪ Its specific gravity is 7.8.
- ⑫ Its ultimate compressive strength is about $80 - 120 \text{ KN/cm}^2$.

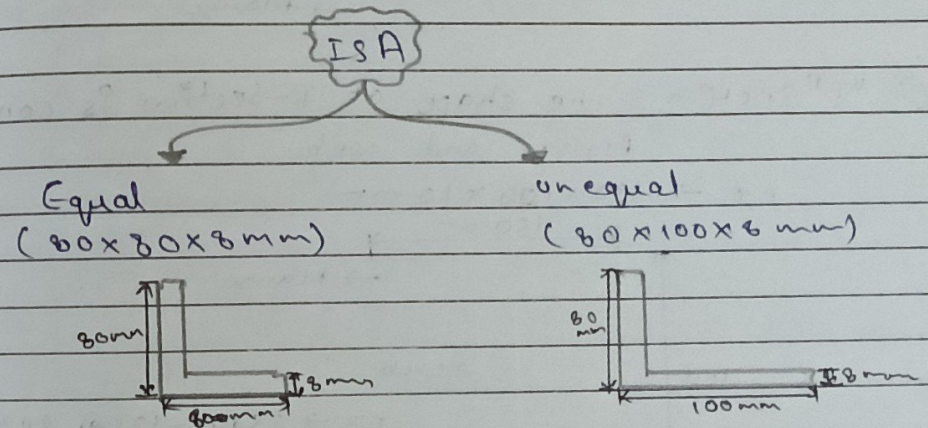
- ⑬ Its ultimate tensile strength is of the order of 200 N/mm^2 and minimum elongation of 10%.

forms of steel -

- ① Angle Section or "L-Section" - The Angle Section may be equal legs and unequal.

→ The angle section used in the construction of steel roof.

(ISA) - Indian Standard Angle Section



- ② "I Section" or beam section - These are also known as roller steel joist or rolled steel beam.

→ It consist of two flanges and a connected by a web

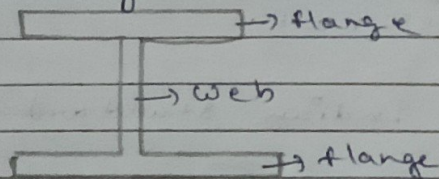
→ It is designated by depth and weight.

Ex → ISLB: 500 @ 730.7 N/m

↑ Depth

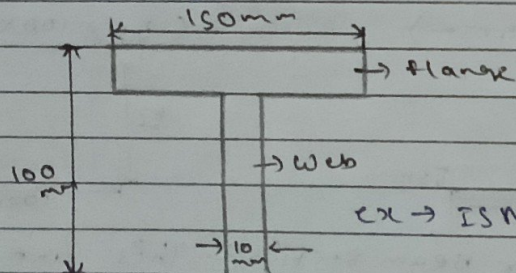
↑ weight

→ They are used in the construction of beam, girders, railway track etc.



③ "T" Section - The shape of T-Section is consist flange and web.

ex → 150 x 100 x 10 mm.

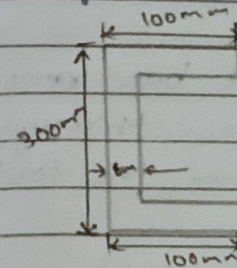


ex → ISNT-125 @ 288.8 N/m

→ T-section is designated by its depth and weight.

④ C-Section or Channel section - The channel section consist of a web with equal flanges

→ It is designated by height of web & width of flange. ex (100 x 300 x 8 mm)



⑤ HYSD Bars or Ribbed Bar - This bar are form high in yield strength of steel

⑤ HYSD (High Yield Strength deform) - It is bars have logs, ribs or deformation on the surface which in habbit longitudinal movement of the bar relative to surrounding concrete.

→ The deformed surface ensure better bond between reinforcement and concrete.

→ They are available in various sizes from 6 mm to 50 mm dia with moulding weight perimeter length as 2.22 N to 154.10 N.

⑥ TMT (Thermo mechanically treated Bars):-

→ This bars are extra high strength reinforcing bar which eliminate any form of Cold twisting

→ In this process the steel bar receives short intensive cooling as they pass through a water cooling system after the last rolling mill stand.

→ TMT bars are also rolled with ribs to increasing bond.

→ They are produced in three grades Fe415, Fe500, Fe550.

* Fe - strength for ferrous material

* No - Indicate yield strength.

⑦ Plastic:-

→ Plastic are made from resin with or without fillers, plasticizers and pigment however, now a days the term resin and plastic are considered synonymous.

→ Plastic are replacing glass, ceramics and other building material due to low temp. range in which they can be brought to the plastic state and the consequent is of forming and fabrication and also for there low cost and easy availability

→ These are organic materials of high molecular weight which can be moulded to any desired form when subjected to heat and pressure in the presence of catalyst.

→ Plastic are classified as:-

(i) Thermoplastic (ii) Thermosetting

(i) Thermoplastic :-

→ Thermoplastic or heat non-convertable group is the general term applied to plastic which become soft when heated and hard on cool down.

→ The process of softening and hardening may be repeated for an indefinite time provided the temperature during heat is not so high as to cause chemical decomposition.

→ It is thus possible to give one shape and re-shape this plastic by means of heat and pressure.

→ One important advantage of these variety of plastic is that the scrap obtained from old and worn-out article can be effectively used again.

ex - drainage pipe, electric equipments, refrigerator part, food container, impulsion paint etc.

(ii) Thermosetting:-

→ Thermosetting plastic cannot be reused.

→ They require great pressure and momentary heat during moulding and finally get hardened on cooling.

→ The chemical reaction in these process cannot be reversed. Once solidified they cannot be softened.

→ These type of plastic passes originally through thermoplastic stage when they are heated in temp. range of 127°C to 177°C , they set

permanently and further application of heat does not alter their form or soften that but a temp. of about 343°C . the charring occurs.

→ The thermosetting plastic are also soluble in alcohols and certain organic solvents.

ex:- Door furniture, reinforced plastic, electrical fittings, table wares, glass fiber reinforced plastic, adhesives

* Properties of plastic :-

① Appearance - Some plastic are completely transparent in appearance with the addition of suitable pigment the plastic can be made to have appearance of variety of attractive, opaque, stable and translucent colour.

② Chemical resistance - The plastic offer great resistance to moisture, chemicals and solvent.

→ The degree of chemical resistant depends on the chemical composition of plastic.

→ Many plastic are found to possess excellent corrosion resistance. They are used to convey chemicals.

③ Dimensional stability:- This property of plastic quite satisfactory with that of other common engineering material.

④ Ductility:- Plastic lacks ductility hence, its member may fail without warning.

⑤ Durability:- The plastic are quite durable if they possess sufficient surface hardness. The plastic specially thermoplastic variety are likely to be attacked by termites and rodents but the danger of such an attack is not very serious due to the fact that the plastic have nutritional value.

⑥ Electric insulation:- The plastic possess excellent electric insulated property.

⑦ Finishing:- Any surface treatment may be given to the plastic it is also easy to have technical control during its manufacture.

⑧ Fire-resistance:- The plastic are organic in nature and hence all plastics are combustible but depending upon the nature structure, the resistance to high temperature and fire varies considerably among various variety of plastic.

→ The cellulose acetate plastic burns slowly.
→ The polyvinyl-chloride plastic are ~~not~~ non-inflammable.

⑨ Glass:-

→ Glass is an amorphous substances having homogeneous texture it is a hard, brittle, transparent or translucent material.

→ It is most common material glazed into frames for doors, window and curtain walls because, of demand for more natural day light in office, commercial complex, industries, educational institutional and residential building.

* Constituents of glass:-

→ The raw material used in manufacturing glass are:-

- ① Silica
- ② Lime
- ③ Soda
- ④ Potash
- ⑤ ~~Lead~~ lead oxide.
- ⑥ Collets, (Broken glasses).

* Commercial forms of glasses :-

① Sheet Glass - It is used for glazing doors, windows and partition and is obtained by blowing the molten glass into the shape of cylinder.

→ The ends of cylinder so produced are cut a way and the cylinder is flattened over the plain tray.

→ Available in thickness 2, 2.5, 3, 4, 5, 5.5, 6.5 mm

→ The permissible tolerance on length and width of sheet glass are ± 1.5 mm and ± 2 mm.

② Plate Glass - It is used for all engineering purpose and is superior to sheet glass.

→ It is produced pouring the molten glass on casting table and leveling it to an uniform thickness.

→ Both the glass surface are then ground, smoothen and polished.

Type	Uses
① Ground glass quality	Showcases, Cabinets, counter etc.
② Selected glazing quality	making mirrors
③ Special selected quality	High class work, wind-screen of vehicle

③ Laminated Glass - It is made by sandwiching a layer of poly-vinyl butyral between two or more layer of plate or sheet glass.

→ It is also known safety glass.

→ The examples are heat-proof glass, sound-proof glass and bullet-proof glass.

Heat proof glass:

Sound proof glass:

④ Tempered glass - It is made from plate glass by re-heating it in its finished shape at 650°C .

→ By cooling rapidly both sides of glass are given a permanent compressive stress without stressing the interior of the glass which is still in fluid state and is 3-5 times stronger than plate glass.

→ It is used extensively in sport arena, sliding doors and curtain walls.

⑤ Coloured glass - It is produced by adding oxides of metals to molten glass.

Type	Metallic oxide
① Ruby - red glass	lead glass, 1% of cupric oxide and 1% of magnetic oxide of iron.
② Ruby - rose glass	Gold chloride is used as colouring agent.
③ Blue - glass	0.1% of Cobalt in ordinary ordinary glass

④ Yellow-glass (greenish)
(i) Uranium glass

2-3% of alkaline uranate

(ii) Selenium glass (orange)

Selenite and reducing agent or ferrous oxide and HNO_2 .

⑤ Green glass

oxide of ~~uran~~ chromium

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[UNIT - 05]

- Miscellaneous Building materials.

Paint: Paint is a liquid or semi-liquid coating material applied on surface to protect them from weathering, corrosion, moisture, and to give a smoother & decorative finish.

Ingredients of paint :-

① Pigment: Prime pigments to impart colour and opacity.

→ It provides colour, coverage and durability.

eg:- Titanium oxide for white, iron oxide for red.

② Binder (resin): A binder, is an adhesive that holds the pigment particles together and to a surface.

→ It provides durability, toughness and water resistance.

eg: linseed oil, walnut oil etc.

③ Extender: Larger pigment particles added to improve strength, adhesion, the film and save costs.

→ It reduces cost, improves durability, hardness, controls gloss.

eg: Calcium carbonate.

④ Solvent: Sometimes called as a thinner - either the organic solvent or water is used to reduce the viscosity of the paint for better application.

eg:- alcohols, mineral spirits etc.

⑤ Additives: It is used to modify the properties of the liquid paint such as dry film, durability.

Enamel Paint: Enamel paint is a glossy, hard and durable paint made by mixing pigment with varnish (or synthetic resin). After drying it forms a smooth shiny, and waterproof coating. It is used on wood, metal, doors, windows and furniture where a strong protective finish is required.

Types of Enamel Paint -

→ Oil-Based Enamel - It is made with drying
→ It is a very durable, glossy and water-resistant.

2) Water-Based Enamel: It is used water as a solvent.

→ quick drying, low odour & Environment friendly.

3) Synthetic Enamel: It made with Synthetic resins.

→ Provides a hard, smooth and long-lasting finish.

4) Acrylic Enamel: Contains acrylic Resins.

→ It is a fast drying, provides good colour retention.

* Varnish: Varnish is a transparent or clear protective coating applied to wood, metals and painted surfaces. It is hard, glossy, film after drying. Varnish is traditionally combined with drying oil, resin and thinner as solvent.

→ Varnish protect the surface from moisture, sunlight, scratches & enhances the natural appearance of the material.

Types of Varnish:

① Oil-Varnish - It is generally made from drying oil and resins.

→ It is used on wood furniture and floors.

② Spirit Varnish - It prepared by using alcohols and resin.

→ It is used for light interior work.

③ Water Varnish - It prepared by water.

→ It is used water as a solvent and interior wood work.

④ Synthetic Varnish - It is made from Synthetic resins like polyurethane.

→ Suitable for both interior and exterior.

⑤ Asphalt Varnish - It is made from asphalt/bitumen.

→ It's a black coating after the drying.

→ Used for iron/metal protection.

Composition of oil paint - Oil paint is made up of following main ingredients are:-

- ① Pigment - Provides body and opacity of the paint.
- ② Binder - A drying oil that hold the pigment particles together and bind them to the surface.
- ③ Solvent - A Volatile liquid added to the paint to thin it out for easier application.
eg:- Turpentine.
- ④ Drier - A substance that increases the rate at which the paint dries by acting as catalyst.
- ⑤ fillers (extenders) - Inert substance added to improve the paint properties and reduce the cost.

Characteristics of Ideal Paint -

- ① Good Adhesion - The paint should stick firmly to the surface without peeling.
- ② Durability - It must last long and resist weather and ageing.
- ③ Smooth finish - It should produce a uniform pleasing.
- ④ Weather Resistance - It should with stand sunlight, resin, heat and moisture.
- ⑤ Economical - Ideal paint cost should be reasonable and affordable.
- ⑥ Non-Toxic - Paint should not release harmful or strong odours.
- ⑦ Washability - The surface should be easy to clean without losing shine.

④ Distemper: Distemper is a low-cost paint used for interior wall finishing. It gives a matte (non-shiny) finish and is commonly used in houses.

→ It is a traditionally, budget-friendly and water-based paints.

→ It has easy to apply and Available in many colours.

→ The Ingredients of ^{Distemper} ~~Paint~~ paint are as follows -

(i) Base - Chalk

(ii) Binder - glue or casein

(iii) Solvent - water

(iv) Pigments - colouring agents.

→ It can be applied directly to the surface like - houses, wooden, etc.

→ It has poor durability and low washability.

Distemper

"Dry distemper"

"oil-bound distemper"

⑤ Primer: A Primer is a base coating applied before paint to create a surface smooth, uniform base and improve the top coat adhesion and longevity.

→ To stops moisture or rust marks from coming through paints.

→ It used on wood to stop absorption and improve finish.

→ Used on metal surfaces to prevent rust.

→ It also used in new plaster for sealing the porous surface.

⑥ Fire-proofing Material: Fire-proofing materials are materials used to protect structural elements from the effects of fire by resisting high temperatures, reduce heat transmission, and prevent rapid spread of flames.

Common fire-proofing Materials -

① Concrete: A strong and highly fire-resistant material, used in reinforced structures.

eg:- furnaces, chimney, boiler etc

- ② Gypsum: Often found in dry wall, gypsum contains water molecules that turn to steam when heated, which slows the spread of fire.
eg:- walls, ceiling etc.
- ③ Mineral wool: A type of insulation made from natural minerals, it is used in plasters and boards for fire resistance.
- ④ Intumescent coating (Fire Paint): These are paints that expand, forming an insulating layer to protect the underlying material
ex- steel beam, columns etc.
- ⑤ Vermiculite: An insulating material used in fire-resistant plasters and door-cores.
- ⑥ Fire bricks: fire bricks are made from refractory materials like fire-clay that provided resistance to high-temperature.
- ★ Water-Proofing Materials: Water-Proofing material are substances or coating used to make a surface impermeable to water.
They prevent the penetration of moisture, protect the structure from dampness and increase the durability of walls, roofs, basements and floors.

Common Water-Proofing Material:-

- ① Asphalt (Bitumen): Asphalt waterproofing material is a durable, waterproof material derived from petroleum, used in construction to protect structure from water.
- ② Cementitious: Cementitious waterproofing uses a cement-based liquid or slurry to create water resistant barrier on concrete and masonry surfaces like - foundation, roofs, and basements.
- ③ Membrane Waterproofing: Membrane water-proofing involves applying a waterproof layer to a surface to prevent water from seeping through. It protects the structure of building from water.
- ④ Liquid-applied waterproofing: Liquid-applied water proofing is a liquid coating that is applied to a surface to make it resistant to water. It often used in roofs, balconies, foundation, wet areas like Bathrooms.
- ⑤ Water-repellent chemical: Water-repellent chemical waterproofing is a method that applies chemical to the surface to make it hydrophobic, causing water to bead up and roll off. It often used in brick, stone, or concrete.

★ Acoustic Materials: Acoustic material is a special material to used in building for control, absorb, or manipulate sound waves to reduce noise and improve sound quality in a space.

→ It generally used in auditoriums, theatres and cinemas, conference rooms, libraries, offices etc.

Common Acoustic Materials:-

① Glass wool: Glass wool is a porous, flexible insulation material made from molten glass fibers that absorb sound by trapping sound waves, converting their energy into heat.

② Acoustic Panels: Acoustic panel are soft panels that can be placed within rooms to improve sound quality by absorbing reflected sound or echoes.

③ Wood Wool Boards: It is an acoustic material made from wood fibers mixed with a binder like cement and is effectively absorbs sound, converting sound energy into heat to reduce echoes.

★ Heat Insulating Material: Heat - Insulating material are those which offer high resistance to heat flow and are used to maintain desired temperature conditions in building and industrial structures

→ Low thermal conductivity.

→ Light in weight

→ Non-combustible

→ Common type of Heat Insulating material are glass wool, foamed plastic, light weight concrete etc.

→ It is used in walls, roofs of a building or used in cold-storage and refrigerators.

★ Adhesive Materials: An adhesive is a substance that can bind two or more surfaces together, resisting their separation.

→ They are used in building works where material like wood, tiles, plastic, metals, flooring need to be fixed firmly.

→ Strong bonding strength.

→ Quick setting or curing

→ Durable

→ Workable and easy to apply

→ Non-corrosion and stable

→ Adhesive Material: Natural glue, casein adhesive etc.

★ Termite Proofing Material: Termite-proofing material create a barrier or a hostile environment to prevent termites from damaging structure.

→ Common types of termite proofing materials are treated wood, boric acid, or soil insecticides (chemical barriers), steel, mesh or concrete etc. (physical barriers). etc.

Paint Commonly used in building

① Emulsion Paint - This is a water-base paint and one of the most widely used type for interior.

② Acrylic Paint - A type of water-based paint known for its durability and flexibility.

③ Enamel paint - create a hard, durable and often glossy coating that is easy or easy to clean. (doors, traffic area).

④ Oil-base paint - offers a durable finish that is very resistant to wear and tear.

factors affect selection of paint

① Surface type - (wood, metal, plastic etc)

② Durability Requirement - (High traffic, low traffic area)

③ Cost & budget.

④ Drying time.

⑤ Health and safety.

⑥ Brand & Quality.

⑦ finish - matte, satin, gloss.

SHORT NOTES:-

① Bitumen - Bitumen is a black, sticky, semi-solid petroleum product.

→ It is obtained during the distillation of crude oil.

uses:-

① Road construction.

② Water-proofing roofs & Basements.

③ Damp-proof courses.

② Tar:- Tar is a dark, viscous liquid obtained from the destructive distillation of coal or wood.

→ It contains harmful chemical & produces more fumes.

Uses:-

① Road Construction.

② Water-proofing and sealing work.

③ Asphalt:- Asphalt is mixture of bitumen and mineral aggregates (Sand, gravel, stone).

→ Bitumen act as a binder in their mixture.

Uses:-

① Construction of highways, airports & parking.

② Repair & maintenance.

③ Industrial flooring.

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