BUILDING MATERIALS & CONSTRUCTION TECHNOLOGY

LECTURE NOTE

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CHAPTER-01 STONE

- Stone is naturally available construction material. It is extracted from rock.

- The properties of stone depend on the mother rock from which it is extracted.

Rocks

- Rock is a naturally occurring solid aggregate of one or more minerals or mineraloids.

Classification of rocks

Geological classification

1. **Igneous rocks**

- Igneous rocks are rock formed when molten or partially molten material, called magma, cools and solidifies.

- Igneous rocks are classified according to the depth at which they formed in the earth's crust.

- Rocks formed within the earth are called intrusive or plutonic rocks because the magma from which they form often intrudes into the neighboring rock.

- Rocks formed at the surface of the earth are called extrusive rocks. In extrusive rocks, the magma has extruded, or erupted, through a volcano or fissure

  Example: Granite

2. **Sedimentary rocks**

- Sedimentary rocks are gradually deposited disintegrated rocks. These rocks take years to sediment in form of layers over layers.

- Surface of earth is subjected to various chemical agents which are brought by rain, frost and various other weather conditions.

- These agents break up the surface which is carried away by further rains to rivers and other water channels in which they continue to travel.

- As the velocity of the river decreases, matter starts depositing in form of debris and ultimately form the rock.

  Example: Sand stone, Lime stone

3. **Metamorphic rocks**

- When the pre-existing rocks (i.e., igneous and sedimentary rocks) are subject to great heat and pressure, they are changed in character and forms metamorphic rocks.

  Example: Granite changes to Gneisses, Lime stone to Marble and Shale to slate

  Physical classification

1. **Stratified rocks**

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

  Example: Sedimentary rocks.

2. **Unstratified rocks**

- These rocks do not exhibit any definite layers or strata. The structure of these rocks may be crystalline, granular or compact granular.
  Example: Igneous rocks

3. **Foliated Rocks**

- These rocks have a tendency to be split up in a definite direction only.
  Example: Metamorphic rocks.

Chemical classification

1. **Silicious rocks**
   Silica (sand) quartz is the chief constituents for this type of rocks.

   Example: Granite, sandstone.

2. **Calcareous rocks**

   • Calcium carbonate are the chief constituents in this type of rocks.

   Example: Limestone, dolomite, marble.

3. **Argillaceous rocks**

- In these rocks , clay is the main constituent
  Example: Slate , laterite

Uses of stone

Uses of building stones and their selection.

- Stones are used in the construction of foundation, walls, columns, lintels, arches, roofs etc.

- Stones are used to cover floor of buildings of various types such as residential, commercial, industrial etc. And also adopted for in paving of roads and foot paths.

- Stones are converted to form basic materials for concrete, murrum of roads, artificial stones, hollow blocks, etc.

- Stones are also used as ballast for railway track and also used as flux in blast furnace.

- Stone blocks are used in the construction of bridges, piers, abutments, retaining wall, dams etc.

- In modern days, polished stone panels are used as cladding for architectural purposes and also polished stone slabs are replacing the dining table tops in residential houses and restaurants.

- In the table below are given the important uses and the selection of stones for variety of work

Natural bed of stone

- It is the original bed, plane or position occupied by a stone during its formation in a sedimentary rock.

- In the case of metamorphic rocks, the plane of foliation or the plane of cleavage is assumed to be its natural bed.

- It is very difficult to trace the natural bed in the case of igneous rocks and the natural bed is not given due attention.

Qualities of good building stone

To find the suitability of stones under different conditions, the following characteristics should be considered

1. **Appearance and colour**

- The stones which are to be employed for decoration work should have uniform and appealing colour and should be free from flaws and clay holes.

- The use of stones which contain much iron should be discouraged as the formation of iron oxide disfigures them and brings about disintegration.

- The stones should also have the ability to receive good polish.

2. **Strength**

- Stones used in the structures are usually subjected to compression, so they should have sufficient strength to cope with the requirements.

- Generally all the stones possess a reasonable degree of strength as far as their use in building work is concerned, but for heavy structures only those stones are suitable which have high strength comparatively.

- In general, compressive strength should not be less than 100 N/mm^2.

3. **Specific gravity**

- If the specific gravity of stone is more, the stone is more heavier and stronger.

- The stone to be used on heavy engineering works docks, harbous, gravity dams etc. must have high specific gravity.

- In general, it varies from 2.4 to 2.8. For a good building stone specific gravity should be more than 2.7.

4. **Hardness and toughness**

- The stones must be adequately hard and tough so that they may resist wear and tear.
- Hardness may be tested by scratching with a pen knife.
- The stone used in floors, pavements and aprons of bridges, should be able to resist the abrasive forces caused due to wear and friction. For good stone wear should be equal or less than 3%. Interms of coefficient of hardness, it should be more than 14.
- Building stones should be tough enough to withstand stresses developed due to vibrations of machinery and moving loads over them. The stones used in the construction of roads should be hard as well as tough.

5. **Durability**

- A good building stone must be durable enough to resist the effect of weathering agencies e.g. rain, wind, temperature etc.
- A stone is more durable in case it is compact, homogeneous and free from any material

6. **Seasoning**

- Good stone must also be free from quarry sap.
- To ensure this, the stones after quarrying and dressing should be left for a period of 6 to 12 months for proper seasoning before using in construction work.

7. **Dressing**

- The art of dressing a stone is known as dressing.
- Stone should possess uniform texture and softness so that they may be easily dressed.
- If it is too hard, finish will be poor and dressing uneconomical.

8. **Cost**

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

9. **Porosity**

- Porosity exists in all the stones but if it is present in greater extent it makes the stones unsuitable for building construction because during rain, water seeping into pores contains acids and fumes which destroy the stone.
- When the climate is cold, water entering the pores may even freeze and split the stone.

10. **Absorption**

- Water absorption of stone is directly proportional to the porosity of rock. If a stone is more porous then it will absorb more water and cause more damage to stone.

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

- A good building stone should not absorbs water more than 5% of its original weight.

- Permissible limits of water absorption for some of the commonly used building stones are as follow:

Type of stone	Maximum limit of water absorption (%)
Sandstone	10
Limestone	10
Granite	1
Shale	10
Slate	1
Quartzite	3

11. Electrical resistance

- The electrical resistance of a stone decreases when it gets wet.

- Thus to have steady and high electrical resistance, the stone must be non absorbent like slate.

12. Resistance to fire

- Stones should be free from calcium carbonate, oxides of iron, and minerals having different coefficients of thermal expansion.

- Igneous rock show marked disintegration principally because of quartz which disintegrates into small particles at a temperature of about 575°C.

- Limestone, however, can withstand a little higher temperature; i.e. up to 800°C after which they disintegrate.

Dressing of stone

- The surfaces of stones obtained from quarry are rough. The blocks are angular i shape and non uniform in size. Hence their dressing is essential.

- The process of cutting the stones into suitable sizes and with suitable surfaces i known as dressing of stones. It is carried out for following purposes,

- To get desired appearance from stone work.
- To make the transport easy and economical.
- To suit the requirements of stone masonry.

Types of dressing of stones

Types of dressed or quarry faced surface

- This is the roughest form of surface finish.
- Stone as removed from the quarry has large projections which are knocked of with the quarry hammer and it is finally broken up into blocks of suitable size anc shape such as khandki, quoin, or rectangular blocks.
- The faces of the blocks are roughly planned and the stone is rendered suitable to be used in masonry.
- When used in a wall, the roughly finished surfaces are further modified by forming a 2 cm to 5 cm wide margin about the edges of the exposed face.

Rough tooled surface

- In this type of surface finish, the projection of the stone block are removed by means of chisels and the surface is nearly dressed true.
- The corners and the edges are made accurate, chisel draughted margins sunk anc the side and bed joints roughly treated to ensure proper bonding.

Tooled surface

- In this type of surface finish continuous parallel chisel marks are produced throughout the width of the stone.
- The parallel corrugations or chisel marks are made at closer intervals rendering the surface truly planned.
- Different types of tooled finishes are obtained by use of different chisel and marking patterns.

Cut stone surface

In this type of surface finish the surface is dressed by using a, sharp chisel so tha the chisel marks are practically imperceptible. It is considered superior to toolec surface.

Rubbed surface

This type of surface finish is obtained by grinding or rubbing a cut stone surface by hand or machine until it gets perfectly smooth.

Polished surface

- The rubbed surfaces of granite, marble of lime stones are polished to enhance thei texture.

- Polishing may be done by manual labour using sand and water, pumice stone etc or by rubbing machine.

Characteristics of different types of stone and their uses.

Granite

- Granite is a very hard and durable building stone and suitable for important work such as bridge abutments, piers, etc., where weight and durability are essential.

- It is not suitable for carving.

- It is mainly composed of quartz, feldspar and mica.

Limestone

- Limestone is a sedimentary rock and contains large proportion of calcium carbonate. It is easy to work.

- Limestone are used for flooring, paving and roofing. Limestone is also used for general building purposes and manufacture of lime.

Marble

- Marble is a metamorphic rock. It is very compact and durable stone.

- It is available in varieties of colours. It can easily be sawn and carved.

- It is extremely suitable for ornamental and superior type of building work. It is also suitable for flooring and veneer work.

Sandstone

- It is moderately stratified sedimentary rock consisting of grains of sand or quartz cemented together by silicates of alumins, lime and magnesium.

- It is easy to dressing work, and available in different colours.

- Extensively used in general building construction works and ornamental carving.

Slates

- These are metamorphic laminated clay rocks with planes of cleavage, along which they can be split into very thin slabs.

- Slates are used as a roofing and flooring material. Harder varieties of slates are used for dado work, damp proof materials and steps of stairs.

CHAPTER 3 : CEMENT, MORTAR,AND CONCRETE

Cement

- Cement is a fine, soft and powder type substance.
- Cement is most important material in building construction.

- The name cement refer to the material manufacture from lime stone, clay and made available in powder form, which mixed with water can set to hard durable mass even under water.
- The demand for cement is strongly correlated to the rate of economic development.
- In a general sense, cements are adhesive and cohesive materials which are capable of bonding particles together of solid matter.

- When cement is mixed with water, it can bind and sand aggregates into a hard solid mass called concrete.

Types of cement.

Types of cement and grades of cement

Ordinary Portland cement

- Ordinary Portland Cement (OPC) is by far the most important type of cement.
- The OPC was classified into three grades, namely 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031 - 1988.

- If the 28 days strength is not less than 33 N/mm², it is called 33 grade cement, if the strength is not less than 43 N/mm², it is called 43 grade cement, and if the strength is not less then 53 N/mm², it is called 53 grade cement.

Uses

- It is admirably suitable for use in general concrete construction when there is no exposure to sulphates in the soil or in ground water.

- It is used in small structures where heat of hydration will not cause any defect.

Rapid Hardening cement (IS;8041-1990)

- This cement is similar to ordinary portland cement.

- As the name indicates it develops strength rapidly and as such it may be more appropriate to call it as high early strength cement.

Rapid hardening cement develops at the age of three days, the same strength as that is expected of ordinary portland cement at seven days

- The rapid hardening cement has higher C3S and lower C□S content.

- A higher fineness of rapid hardening cement particles expose greater surface area for action of water and also higher proportion of C3S results in quicker hydration.

- Consequently, rapid hardening cement gives out much greater heat of hydration during the early period. Therefore, rapid hardening cement should not be used in mass concrete construction.

Uses

- The use of rapid heading cement is recommended in the following situations,
    - In prefabricated concrete construction
    - Where formwork is required to be removed early for re-use elsewhere
    - Road repair works
    - In cold weather concrete where the rapid rate of development of strength reduces the vulnerability of concrete to the frost damage.

Extra rapid Hardening cement

- Extra rapid hardening cement is obtained by intergrading calcium chloride with rapid hardening portland cement.

- The normal addition of calcium chloride should not exceed 2 per cent by weight of the rapid hardening cement.
- It is necessary that the concrete made by using extra rapid hardening cement should be transported, placed and compacted and finished within about 20 minutes.

- It is also necessary that this cement should not be stored for more than a month.

- It is not a common cement and hence it is not covered by Indian standard**.**

Uses

It is suitable for cold weather concreting, or when a very high early strength is required but when it is advisable to use aluminous cement.

Sulplate resisting cement (IS:12330+1988)

- Ordinary portland cement is susceptible to the attack of sulphates, in particular to the action of magnesium sulphate.

- Sulphates react both with the free calcium hydroxide in set cement to form calcium sulphate and with hydrate of calcium aluminate to form calcium sulphoaluminate, the volume of which is approximately 227% of the volume of the original aluminates.

- Sulphate attack is greatly accelerated if accompanied by alternate wetting and drying which normally takes place in marine structures in the zone of tidal variations.

- To remedy the sulphate attack, the use of cement with low C3A content is found to be effective. Such cement with low C3A and comparatively low C4AF content is known as Sulphate resisting cement.

Uses

The use of sulphate resisting cement is recommended under the following conditions,

- Concrete to be used in marine condition
- Concrete to be used in foundation and basement, where soil is infested with sulphates
- Concrete to be used in the construction of sewage treatment works

Portland slag cement (PSC)(IS:455-1089)

- This type of cement is made by intergrinding or blending Portland cement clinker with granulated inblast furnace slag which is a waste product in the manufacture of pig iron; thus, there is a lower energy consumption in the manufacture of cement.
- The resultant product is a cement which has physical properties similar to those of ordinary portland cement.
- In addition, it has low heat of hydration and is relatively better resistant to chlorides, soils and water containing excessive amount of sulphates or alkali metals, alumina and iron, as well as, to acidic waters, and therefore, this can be used for marine works with advantage.
- **Uses**: Portland slag cement is in common use in countries where slag is widely available and can be considered to be a cement for general use

Quick setting cement

- This cement as the name indicates sets very early. The early setting property is brought out by reducing the gypsum content at the time of clinker grinding.
- This cement is required to be mixed, placed and compacted very early.

Super Sulphated Cement (IS:6909-1990)

- Super sulphated cement is manufactured by grinding together a mixture of 80 - 85 percent granulated slag, 10 - 15 per cent hard burnt gypsum, and about 5 per cent Portland cement clinker.
- This cement is rather more sensitive to deterioration during storage than Portland cement.
- Super sulphated cement has a low heat of hydration of about 40 - 45 calories/gm at 7 days and 45-50 at 28 days.

- When we use super sulphated cement the water/cement ratio should not be less than 0.5.

Low heat cement (IS:12600-1989)

- Hydration of cement is an exothermic action which produces large quantity of heat during hydration.
- Formation of cracks in large body of concrete due to heat of hydration has focussed the attention of the concrete technologists to produce a kind of cement which produces less heat or the same amount of heat, at a low rate during the hydration process.
- A low heat evolution is achieved by reducing the contents of C3S and C3A which are the compounds evolving the maximum heat of hydration and increasing C2S.
- The feature of low heat cement is a slow rate of gain of strength. But the ultimate strength of low heat cement is the same as that of ordinary Portland cement.
- The 7 days strength of low heat at cement is not le in the case of ordinary Portland cement. is not less than 16 MPa in contrast to 22 MPa
- Other properties, such as setting time and soundness are same as that of ordinary portland cement.

Portland Pozzolana Cement (IS:1489-1991)

- Portland Pozzolana Cement (PPC) is manufactured by the intergrinding of OPC clinker with 10 to 25 per cent of pozzolanic material (as per the latest amendment, it is 15 to 35%).
- Pozzolana is a natural or artificial material containing silica and alumina in a reactive form.
- The most commonly used pozzolanic materials are volcanic ash, pumic, optaline, shales, cherts, burnt clay and fly ash etc.
- Portland pozzolana cement produces less heat of hydration and offers greater resistance to the attack of aggressive waters than ordinary portland cement.
- It is important to appreciate that the addition of pozzolana does not contribute to the strength at early ages.
- Strengths similar to those of ordinary portland cement.

Air entraining cement

- This cement is made by mixing a small amount of an air-entraining agent with ordinary Portland cement clinker at the time of grinding.

- Air entraining cement is not covered by Indian Standard so far.

- Air-entraining cement will produce at the time of mixing, tough, tiny, discrete non-coalesceing air bubbles in the body of the concrete which will modify the properties of plastic concrete with respect to workability, segregation and bleeding.

Coloured Cement (White Cement IS:8042 - 1989)

- For manufacturing various coloured cements either white cement or grey portland cement is used as a base.

- The use of white cement as a base is costly. With the use of grey cement only red or brown cement can be produced.

- Coloured cement consists of portland cement with 5-10 per cent of pigment.

- The pigment cannot be satisfactorily distributed throughout the cement by mixing, and hence, it is usual to grind the cement and pigment together

- The process of manufacture of white portland cement is nearly same as OPC.

Hydrophobic cement (IS:8043-1991)

- Hydrophobic cement is obtained by grinding ordinary portland cement clinker with water repellant film forming substance such as oleic acid, and stearic acid.

- The water repellant film formed around each grain of cement, reduces the rate of deterioration of the cement during long storage, transport, or under unfavorable conditions.

- The film is broken out when the cement and aggregate are mixed together at the mixer exposing the cement particles for normal hydration.

- The properties of hydrophobic cement is nearly the same as that ordinary portland cement except that it entrains a small quantity of air bubbles.

Masonry Cement (IS:3466 - 1988)

Ordinary cement mortar, though good when compared to lime mortar with respect to strength and setting properties, is inferior to lime mortar with respect to workability, water retentively, shrinkage property and extensibility.

Expansive cement

- It is produced by adding an expanding medium like sulpho aluminate and a stabilishing agent to the ordinary portland cement.

- This type of cement expands whereas other cements shrink, so that suffers no overall change in volume on drying.

High alumina cement (IS:6452-1989)

- High alumina cement is obtained by fusing or sintering a mixture, in suitable proportions of alumina and calcareous materials and grinding the resultant product to a fine powder.
- It is manufactured from bauxite and limestone in special reverberatory furnaces.
- It contains nearly 35 percent of alumina and the ratio of alumina to lime lies between 0.55 and 1.3.

Properties of cement

Physical Properties of Cement

Different blends of cement used in construction are characterized by their physical properties. Some key parameters control the quality of cement. The physical properties of good cement are based on:

Fineness of cement

- Soundness
- Consistency
- Strength
- Setting time
- Heat of hydration
- Loss of ignition
- Bulk density
- Specific gravity (Relative density)

Fineness of cement

The size of the particles of the cement is its fineness. The required fineness of good cement is achieved through grinding the clinker in the last step of cement production process. As hydration rate of cement is directly related to the cement particle size, fineness of cement is very important.

Consistency of Cement

- The ability of cement paste to flow is consistency.
- It is measured by Vicat Test.

- In Vicat Test Cement paste of normal consistency is taken in the Vicat Apparatus. The plunger of the apparatus is brought down to touch the top surface of the cement. The plunger will penetrate the cement up to a certain depth depending on the consistency. A cement is said to have a normal consistency when the plunger penetrates 10¡À1 mm.

Strength of Cement

- Three types of strength of cement are measured compressive, tensile and flexural. Various factors affect the strength such as water-cement ratio, cement-fine aggregate ratio, curing conditions, size and shape of a specimen, the manner of molding and mixing, loading conditions and age.

- **Compressive Strength**: It is the most common strength test. A test specimen (50mm) is taken and subjected to a compressive load until failure. The loading sequence must be within 20 seconds and 80 seconds.

- **Tensile strength**: Though this test used to be common during the early years of cement production, now it does not offer any useful information about the properties of cement.
- **Flexural strength**: This is actually a measure of tensile strength in bending. The test is performed in a 40 x40 x 160 mm cement mortar beam, which is loaded at its center point until failure.

Setting Time of Cement

- Cement sets and hardens when water is added. This setting time can vary depending on multiple factors, such as fineness of cement, cement-water ratio, chemical content, and admixtures. Cement used in construction should have an initial setting time that is not too low and a final setting time not too high. Hence, two setting times are measured:

- Initial set: When the paste begins to stiffen noticeably (typically occurs within 30- 45 minutes).

- Final set: When the cement hardens, being able to sustain some load (occurs below 10 hours).

Heat of Hydration

- When water is added to cement, the reaction that takes place is called hydration. Hydration generates heat, which can affect the quality of the cement and also be beneficial in maintaining curing temperature during cold weather.

- On the other hand, when heat generation is high, especially in large structures, it may cause undesired stress.

- The heat of hydration is affected most by C3S and C3A present in cement, and also by water-cement ratio, fineness and curing temperature.

- The heat of hydration of Portland cement is calculated by determining the difference between the dry and the partially hydrated cement (obtained by comparing these at 7th and 28th days).

Bulk density

When cement is mixed with water, the water replaces areas where there would normally be air. Because of that, the bulk density of cement is not very important. Cement has a varying range of density depending on the cement composition percentage. The density of cement may be anywhere from 62 to 78 pounds per cubic foot.

Specific gravity (relative density)

Specific gravity is generally used in mixture proportioning calculations. Portland cement has a specific gravity of 3.15, but other types of cement (for example, portland-blast-furnace-slag and portland-pozzolan cement) may have specific gravities of about 2.90.

Chemical properties of cement

The raw materials for cement production are limestone (calcium), sand or clay (silicon), bauxite (aluminum) and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate. Chemical analysis of cement raw materials provides insight into the chemical properties of cement.

Lime

- It is a major ingredient of cement and constitutes about two-third of cement.
- It's quantity should be maintained very carefully, as excess quantity and low of lime are both harmful to cement. If it is used in excess quantity, some of lime remains present unused or uncombined or as free lime.
- This free lime takes more time to hydrate which causes more expansion of hardened cement leading to cracks.
- If lime is low in quantity, the mix will be improper which will lead to low strength of cement as this cement will set quickly.

Silica

- It constitutes about one-fifth of cement. It's presence in proper quantity forms calcium silicates which give strength to cement.
- If silica is used in excess quantity, setting time of cement is increased and the strength is increased.

Alumina

- Alumina is about 6 - 7% of cement. If reacts with water very quickly and makes the cement to set quickly.

- If it is used in excess quantity it will weaken the cement as it acts as flux which lower the clining temperature.

- But since temperature is essential for proper cement, it should not be used in excess.

Iron oxide

- Iron oxide imparts colour and hardness to cement. It reacts with lime and silica during manufacture which reduces the calcination temperature.

- Its presence also imparts strength to the cement.

Magnesia

It is used in about 0.1 to 4%. Its main function is to impart hardness and colour to cement. Since it doesn't combine well with other oxides used in manufacture of cement, a high quantity of magnesia will make cement unsound.

Sulphur trioxide

This is used upto 3%. If it is used in excess it produces expansion of cement thus making it unsound and also excess of sulphur trioxide increases the setting time.

Alkalies

- These are used in form of soda and potash. Most of alkalies which are present in the raw material are driven away with the gases during burning.

- The quantity of alkali in cement is very less but they cause number of damages, mostly by reacting with the aggregates.

- If it is present in excess in cement they cause efflorescence and staining in concrete, brick work and masonry mortar.

Calcium sulphate

- It is about 3% of the cement and is added in the form of gypsum during the process of grinding of clinker. It is a retarder since it increases the initial setting time of cement.

- If gypsum is not added the cement will set at the moment water is added to it, without giving any time for mixing and placement.

Harmful constituents of cement

- Only alkali oxides and magnesium oxide adversely affects the quality of cement.

- If alkali oxides present in cement is more than 1% it renders cement unsound.

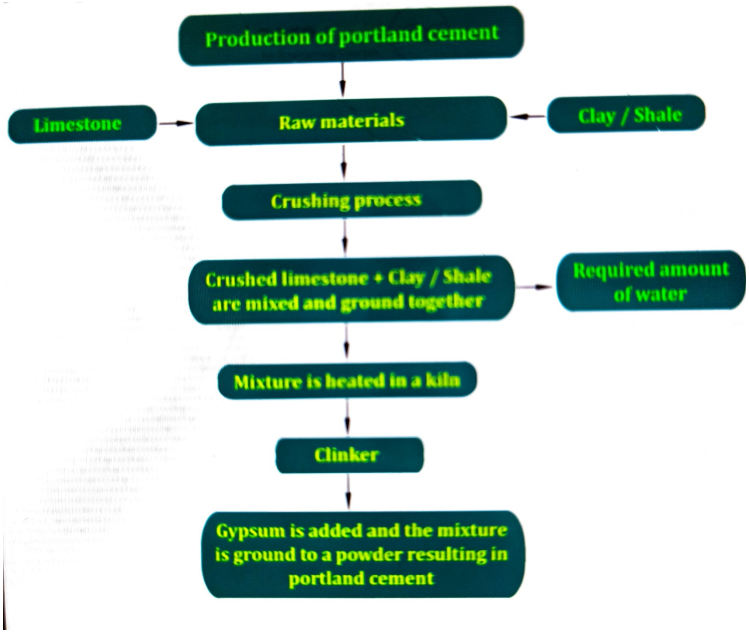
- Also if magnesium oxides present in cement exceeds 5%, it leads to crack after hardening of cement mortar or concrete, because magnesium oxide is burned at temperature of about 1500°C and it slakes slowly when mixed with water

Manufacturing of cement

There are two processes of manufacturing known as "wet" and "dry" processes depending upon whether the mixing and grinding of raw materials is done in wet or dry conditions.

The process of manufacture of cement consists of

- Crushing of raw materials
- Mixing
    - Wet process
    - Dry process
- Burning
- Grinding
- Storing



Crushing of raw materials

- Jaw crushers of various sizes are employed for the crushing purpose.
- Raw materials are crushed by crushers till the size of the raw material reduces to ¾ of an inch

Mixing of raw materials

Dry process

- Lime stone or chalk and clay are crushed into gyratory crusher to get 2-5 cm size pieces. Crushed material is ground to get fine particle into ball mill or tube mill.

- Each material after screening stored in a separate hopper. The powder is mixed in required proportions to get dry raw mix which is stored in silos (storage tank) and kept ready to be fed into the rotary kiln.

- A quantity of water about 12 percent by weight is added to make the blended meal into pellets.

- Raw materials are mixed in required proportions so that average composition of the final product is maintained properly.

Mixing of raw materials

Wet process

- In this process calcareous material such as limestone (calcium carbonate) are crushed, powdered and stored in bins. in bins.

- Argillaceous materials such as clay is mixed with water in wash mill and washed.

- By washing it removes any adhering organic impurities.

- Then it is stored in storage basins.

- Powdered limestone and washed argillaceous materials are mixed in wet grinding mills in proper proportions to get a slurry.

- Chemical composition of slurry is analysed and corrected if necessary by addition of the deficient materials.

- The slurry is then passed into storage tanks, where correct proportioning is done**.**
- The slurry contains 38-40% water stored in storage tank and kept ready for feeding to a kiln.

Burning

- Burning is carried out in rotary kiln which rotating at 1 - 2 rpm at its longitudinal axis.

- Kiln is a thick steel cylinder, 30 m to 200 m in length, 3 m to 8 m in diameter, lined by refractory bricks.

- It is inclined at gradient of 0.5-0.75 inch and can be rotated at the desired speed.

- Corrected slurry is then fed into rotary kiln for burning.

- The fuel is either powdered coal, oil or natural gas.

- The material at the lower end of kiln undergoes a series of chemical reaction at 1500°C.

- Lime, silica and alumina get recombined.
- The oxides in raw materials will be combined to form compounds into clinker.
- The fused mass turns into nodular form of size 3 mm to 20 mm is known as clinker.

Grinding

- The clinker drops into a rotary cooler where it is cooled under controlled conditions.
- The clinker is stored in silos or bins.
- The cooled clinker is then ground in a ball mill with the addition of 2 to 3% of gypsum in order to prevent flash-setting of the cement.
- A ball mill consists of several compartments charged with progressively smaller hardened steel balls.
- When the mill rotates, steel balls reduce clinker into fine powder.

Storage of ground materials

The particles crushed to the required fineness are separated by currents of air and taken to storage silos.

Packaging

- The ground powder is packed by automatic machines in a bag.
- This is then dispatched to the markets.

Importance and application of blended cement with fly ash and blast furnace slag.

Importance of blended cement.

- Blended cement are produced by inter-grinding Portland cement clinker together at temperatures of about 1400-1500°C) with supplementary cementitious materials (SCMs) or by blending Portland cement with SCMS such as fly ash from coal combustion in electricity-producing plants or blast furnace slag from iron- making plants.
- The production of blended cement involves interring one or more additives.
- The dominant materials used for blended cement are BFS, fly ash and silica fume. It offers several consumer and production-based benefits.
- From a final use phase perspective, It can help reduce required inventories for fly ash at ready mix locations as well as provide high quality and consistent product that offers early strengths and workability.

- ASTM C595 provides prescriptive-based specifications for specifically blended cement that consist of portland-cement clinker ground or blended with suitable proportions of granulated blast-furnace slag or natural or artificial pozzolans.

- These include portland blast-furnace slag cement, Portland pozzolana cement, and slag cement.

Technical importance

- Improves the workability of fresh concrete, making it easier to place and finish. Using less water also reduces shrinkage and permeability.

- Contribute to the long-term strength gain of concrete. Silica fumes can hasten strength development and reduce curing time.

- Lower heat of hydration and less risk of thermal cracking.

- Reduces heat of hydration and thermal stresses.

- Reduced overall concrete cost.

- The mineral supplements used to replace portland cement require significantly less processing and typically lower the cost of the concrete.

Environmental importance

- Lower water-cement ratios are used in construction, making it easier to work with and shape.

- Adding mineral admixtures such as slag, which is produced as a byproduct of other industrial processes, lowers the energy expenditure in producing overall quantities of OPC by around a megawatt per ton.

- The mineral admixture of blended concrete mix produces the waste products of steel plants and coal power plants, among others.

- By using this waste in cement, it lowers the demand on other components like limestone, silica and clay, helping to preserve these natural resources.

- Using additives to reduce cement production also reduces pollution

Application of blended cement

- Major engineering projects

- Domestic construction

- Precast concrete
- Stabilisation including pavement recycling for road construction
- Mining applications
- Specialist formulations such as adhesives, renders, mortars and grouts

Mortar: Definitions and types of mortar

Introduction to mortar

- The workable paste prepared by mixing a binding material, fine aggregate and water in suitable proportion is called mortar.
- The ingredients of various mortars used for different engineering purposes are,
    - Binding or cementing material such as cement and lime.
    - Fine aggregates such as sand, surkhi, ashes, cinder, etc.
    - Water
- Proportion of mortar is expressed as (1: n) where
    - 1 is expressed the unit quantity of binding material (cement or lime).
    - N is expressed the unit quantity of fine aggregate.
- Mortars is used as a binding material in stone or brick masonry or concrete, as a covering material to walls in the form of plaster to provide, a smooth, hard and decorative surface.

Types of mortar

Mortars are classified in several ways, i.e based on the binding agent, properties of binding agent and aggregates etc.

- Cement mortar
- Lime mortar
- Lime cement mortar
- Special mortars
    - Mud mortar

- Cement clay mortar
- Light and heavy mortars
- Decorative mortars
- Air entrained mortar
- Gypsum mortar
- Fire resistant mortar
- Packing mortar
- Sound absorbing mortar
- X-ray shielding mortar

Sources and classification of sand ,bulking of sand

Introduction to fine aggregates

- Fine aggregate is the aggregate whose particles pass through 4.75 mm mesh sieve but are retained on 0.15 mm mesh sieve completely.
- Sand, crushed stones, ashes, cinder, etc., are the examples of the fine aggregate.
- Sand is generally called as fine aggregate.
- Sand is formed by disintegration of rocks by weathering agencies such as wind, rain, heat etc.
- Sand may be obtained from pits, river, lake or sea shore.
- When obtained from pits, it should be washed to free it from clean and silt.
- According to source fine aggregate may be described as:
- **Natural Sand**: It is the aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies.
- **Crushed Stone Sand:** It is the fine aggregate produced by crushing hard stone.
- **Crushed Gravel Sand:** It is the fine aggregate produced by crushing natural gravel.

Requirements

- Fine aggregate should consist of coarse angular sharp and hard grains.
- It must be free from coatings of clay and silt.

- It should not contain any organic matter.
- It should be free from hygroscopic salt.
- It should be strong and durable and chemical inert.
- The size of sand grains should pass through 4.75 mm IS sieve and should be entirely retained on 75 micron IS sieve.

Uses

- Fine aggregate is used to make mortars and concrete of desired grade.
- Fine aggregate also used as filling material.

Classification of sand

- Based on the grain size of the particle, sand is classified as Fine Sand (0.075 to 0.425mm), Medium Sand (0.425 to 2mm), and Coarse Sand (2.0 mm to 4.75mm).
- Based on origin, sand is classified as Pit sand, River sand, Sea sand, and manufactured sand.

Bulking of sand

- The free moisture content in fine aggregate results in bulking of volume.
- Free moisture forms a film around each particle. This film of moisture exerts what is known as surface tension which keeps the neighbouring particles away from it. Similarly, the force exerted by surface tension keeps every particle away from each other.
- Therefore, no point contact is possible between the particles. This causes bulking of the volume.
- It is interesting to note that the bulking increases with the increase in moisture content upto a certain limit and beyond that the further increase in the moisture content results in the decrease in the volume and at a moisture content representing saturation point, the fine aggregate shows no bulking.
- The extent of surface tension and consequently how far the adjacent particles are kept away will depend upon the percentage of moisture content and the particle size of the fine aggregate.
- From this it follows that the coarse aggregate also bulks but the bulking is so little that it is always neglected.

- Extremely fine sand and particularly the manufactured fine aggregate bulks as much as about 40 per cent. for Engineering Courses

- Therefore, it is absolutely necessary that consideration must be given to the effect of bulking in proportioning the concrete by volume

Sieve size	Sieve sizePercentage of passing for			
	Grading Zone - I	Grading Zone - II	Grading Zone - III	Grading Zone - IV
10 mm	100	100	100	100
4.75 mm	90 - 100	90 - 100	90 - 100	95 - 100
2.36 mm	60 - 95	75 - 100	85 - 100	95 - 100
1.18 mm	30 - 70	55 - 90	75 - 100	95 - 1000
600 micron	15 - 34	35 - 59	60 - 79	80 - 100
300 micron	5 - 20	8 - 30	12 - 40	15 - 50
150 micron	0 - 10	0 - 10	0 - 10	0 - 15

Use of gravel,morrum, and fly ash as different building material

Gravel

- For formation of sub base of internal roads in the residential layouts.

- For reclamation of low lying areas.

- For backing of revetment.

- Filler material in water bound macadam roads.

Morrum

- Morrum is also type of soil mostly used for construction purpose.

- Morrum is used in road pavements, plinth filling, backfilling in trenches, footing pits etc.
- It is suitable type of soil in the construction field since it does not contain organic matters and can be compacted easily forming hard surfaces.

Fly ash

- The utilization of fly ash in the construction industry is not a new technology but it is a growing technology in improving the construction quality as well as the environment quality. Adding fly ash in concrete give benefits in term of economical, ecological and technical.

- Currently, fly ash used by cement industries as a pozzolanic material for manufacturing of Portland Pozzolana Cement since the Si02 and Al2SiO3 content is very similar to Portland Cement.

- In the presence of moisture and at room temperature, it reacts chemically with calcium hydroxide to derive compounds possessing cementitious properties.

- Technically, the use of fly ash together with Portland cement contributes to the consumption of Ca(OH)2 which is formed during the hydration of cement and leads to the formation of cementitious products.

- The glassy phase of fly ash and calcium hydroxide generated leads to the formation of additional C+S+H gel and results in higher density and strength. The compressive strength increased at later ages compared to the early ages.

- This green technology enhances the durability and service life of concrete structures.

- Normally fly ash was used in blended cement to product insitu concrete mix however fly ash also can be used in high strength precast and prestressed concrete.

- Having slow strength development at early age, the use of fly ash in high strength precast and prestressed concrete has been limited.

- Somehow, current studies have validated that superplasticized fly ash concrete with low water-to-cement ratio can be proportioned to meet the very early age strength as well as other requirements for precast or prestressed concrete products.

- Significant research about an artificial lightweight aggregate has been carried out using fly ash to replace normal aggregates.

- Fly ash can be used in manufacturing of light-weight aggregates.

- This aggregates are light due to the presence of air voids and used in structural lightweight concrete to reduce the dead load of a concrete structure and leads to the economic savings in terms of structural design.

Concrete

Introduction to concrete

- Concrete is mixture of cement, sand, brick or stone ballast and water which when placed in forms and allowed to cure becomes hard like stone.

- The hardening is caused by the chemical reaction between the cement and water.

- The cement and water form a paste which upon hardening, binds the aggregates to a permanent mass.

- Cement is called the binding material. The stone or brick ballast is called the coarse aggregates as distinguished from the fine aggregates which is sand.

Characteristics of good concrete

- Concrete should have high compressive strength.
- On hardening, it should exhibit minimum shrinkage.
- It must be adequately dense. The density of a good concrete should be about 24 kN/m³.
- It should be economical for desired strength.
- It should sufficiently hard and provide enough resistance to abrasion. This property is of paramount importance when concrete is to be used for making steps of stairs and road pavements.
- It must be adequately durable is resist the effects of weathering agencies. (Example rain, frost action, variations in temperatures, etc.,).
- It should have minimum thermal expansion so as to provide good resistance to fire.
- It should provide the required finish to the concrete structures.
- It should have sufficient impermeability or water tightness
- It should have minimum creep.

Concrete composition

The ingredients of concrete are,

- Cement
- Aggregate
    - Coarse aggregate
    - Fine aggregate
- Water
- Admixture

Cement

Cement is binding material in the cement concrete.

Aggregates

In the cement concrete, to provide good quality of concrete aggregate is used in two size groups.

- Fine aggregate (sand) particle size less than 4.75 mm.

- Coarse aggregate particle size more than 4.75 mm

Fine aggregate

- Sand consists of small angular or rounded grains of silica.

- Sand is commonly used as the fine aggregate in cement concrete. Both natural and artificial sands are used for this purpose.

Coarse aggregate
Coarse aggregates strongly influence the strength of concrete, mix proportions.

Water

- The water is used in concrete plays an important part in the mixing, laying compaction setting and hardening of concrete.

- The strength of concrete directly depends on the quantity and quality of water is used in the mix.

Admixture
These are additional fine materials added to plain concrete to improve its properties.

- It improves workability.

- It reduces segregation of concrete.

- It accelerates setting and hardening of concrete.

Ex: Fly ash, calcium chloride etc.,

- Concrete admixtures are used to improve the behavior of concrete under a variety of conditions and are of two main types:

1. Chemical admixtures reduce the cost of construction, modify properties of hardened concrete, ensure quality of concrete during mixing/transporting/placing/curing, and overcome certain emergencies during concrete operation.
2. Mineral admixtures

Mineral admixtures make mixtures more economical, reduce permeability, increase strength, and influence other concrete properties. Mineral admixtures affect the nature of the hardened concrete through hydraulic or pozzolana activity.

Water cement ratio

- The water-cement ratio is the ratio of the weight of water to the weight of cement used in a concrete mix.

- A lower ratio leads to higher strength and durability, but may make the mix difficult to work with and form.

- Workability can be resolved with the use of plasticizers or super-plasticizers.

Properties of fresh concrete

Properties of concrete in its fresh state are very important because the influence the quality of the hardened concrete.

The fresh concrete has the following properties:

- Workability

- Bleeding

- Segregation

Workability

- Workability is defined as the ease with which concrete is handled, transported and placed in forms with minimum loss of homogeneity.

- The amount of compaction decides the workability of concrete.

- Hundred percent compaction of concrete is an important parameter for contributing to the maximum strength and workability of concrete.

- The lack of compaction will result in air voids whose damaging effect on strength and durability.

- To enable the concrete to be fully compacted with appreciable effort, the maximum water/cement ratio is considered.

- The function of water is to lubricate the concrete, so that the concrete can be compacted with specified efforts forthcoming at the site of work. LearnEna

- The workable concrete should have sufficient amount of water required for handling concrete without segregation, for placing without loss of homogeneity, for compacting with the amount of efforts forth coming and to finish it sufficiently easy.

- The presence of such quantity of water is of vital importance for the term "workability of concrete".

Segregation

- Segregation can be defined as the separation of the constituent materials of concrete.

- A good concrete is one in which all the ingredients are properly distributed to make homogeneous mixture.

- Segregation may of three types:
    - The coarse aggregate separating out or settling down from the rest of the matrix.
    - The paste or matrix separating away from coarse aggregate.
    - Water separating out from the rest of the material being a material of lowest specific gravity (bleeding).
- Segregation is difficult to measure quantitatively, but it can be easily observed at the time of concreting operation.

Bleeding

- Bleeding is a form of segregation where some of the water in the concrete tends to use to the surface of the freshly placed material.
- Bleeding is predominantly observed in a highly wet mix, badly proportioned and insufficiently mixed concrete.
- In thin members like roof slab or road slabs and when concrete is placed in sunny weather show excessive bleeding.
- Sometimes, along with this water; certain quantity of cement also comes to the surface.
- When the surface is worked up with the trowel and floats, the aggregate goes down and the cement and water come up to the top surface.
- The formation of cement paste at the surface is known as laitance. Due to this, the top surface of slabs and pavements will not have good wearing quality

Grading of aggregate

- The way of particles of aggregates fit together in the mix, as influenced by gradation, shape and surface texture.
- The particle size distribution of aggregates is called grading.
- To obtain a grading curve for aggregate, sieve analysis has to be conducted

Coarse sieve analysis

- The aggregates used for making concrete are normally of the maximum size 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 600 micron, 300 micron and 150 micron.
- The aggregate fraction from 80 mm to 4.75 mm are termed as coarse aggregate and those fraction from 4.75 mm to 150 micron are termed as fine aggregate.

Apparatus required

- Weighing balance

- IS sieve of size 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 , lower than micron, 300 micron, 150 micron, 1 than 150 micron.

- Oven

Procedure

- Using a riffler, take a representative sample of aggregate from field and dry in the oven.

- Weight the required quantity of dried sample, keep it in tray.

- Arrange the sieve by size. The largest aperture sieve being kept at the top and the smallest aperture sieve at the bottom. A receiver is kept at the bottom and a cover is kept at the top of the whole assembly.

- The sample is put on the top sieve, and the whole assembly is fitted on a sieve shaking machine.

- The amount of shaking depends upon the shape and the number of particles. Atleast 10 minutes of shaking is desirable.
- The portion of sample retained on each sieve is weighted.

- The percentage of aggregate retained on each sieve is calculated on the basis of the total mass of sample taken and from these results, percentage passing through each sieve is calculated.
- The result of sieve analysis are plotted to get a particle distribution curve with percentage finger as the ordinate and particle diameter as the abscissa, the diameter being plotted on a logarithmic scale.

Types of aggregate based on curve shape

- Based on the shape of curve, the aggregate can be classified as

    - Uniformly graded or poorly graded

    - Well graded

    - Gap graded

Uniformly graded or poorly graded

- For uniformly graded aggregate, only a few sizes dominate the bulk material.

- With this grading, the aggregates are not effectively packed, and the resulting concrete will be more porous, unless a lot of paste is employed.

Well graded

- One of the most important factors for producing workable concrete is good gradation of aggregates.

- Good grading implies that a sample of aggregates contains all standard fractions of aggregate in required proportion such that the sample contains minimum voids.
- A sample of the well graded aggregate containing minimum voids will require minimum paste to fill up the voids in the aggregates.

- Minimum paste will mean less quantity of cement and less quantity of water, which will further mean increased economy, higher strength, lower-shrinkage and greater durability.

Gap graded

- Gap grading is a kind of grading which lacks one or more intermediate size.

- Gap graded aggregates can make good concrete when the required workability is relatively low.

- Advantages of gap grading are more economical concrete, use of less cement and lower w/c ratios.

- When they are used in high workability mixes, segregation may become a problem.

- The resulting concrete is very stiff and has low workability. An extreme case is no- fines concrete. This concrete is difficult to handle and compact; developing low strength and high permeability.
- Sometimes aggregates available at sites may not be of specified or desirable grading.

- In such cases two or more aggregates from different sources may be combined to get the desired grading.

Grading of fine aggregates

- The way of particles of aggregates fit together in the mix, as influenced by gradation, shape and surface texture.

- The particle size distribution of aggregates is called grading.

- The grading determine the paste requirement for a workable concrete since the amount of void requires needs to be filled by the same amount of cement paste in a concrete mixture.

- To obtain a grading curve for aggregate, sieve analysis has to be conducted.

Apparatus required

- Weighing balance

IS sieve of 10 mm, 4.75 mm, 2.36 mm, 600 micron, 300 and 150 micron in size.

Procedure

- Arrange the sieve by size. The largest aperture sieve being kept at the top and the smallest aperture sieve at the bottom. A receiver is kept at the bottom and a cover is kept at the top of the whole assembly.

- The fine aggregate sample is put on the top sieve, and the whole assembly is fitted on a sieve shaking machine.

- The amount of shaking depends upon the shape and the number of particles. At least 10 minutes of shaking is desirable for soils with small particles.

- The portion of sample retained on each sieve is weighted.
- The percentage of soil retained on each sieve is calculated on the basis of the total mass of sample taken and from these results, percentage passing through each sieve is calculated.
  From the sieve analysis the particle size distribution in a sample of aggregate is found out.

- In this connection a term known as "Fineness Modulus" (F.M.) is being used.

- Fineness modulus is an empirical factor obtained by adding the cumulative percentages of aggregate retained on each of the standard sieves ranging from 80 mm to 150 micron and dividing this sum by an arbitrary number 100.

- Many a time, fine aggregates are designated as coarse sand, medium sand and fine sand.
- A sand having a fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete.

Sieve size	Sieve sizePercentage of passing for			
	Grading Zone - I	Grading Zone - II	Grading Zone - III	Grading Zone - IV
10 mm	100	100	100	100
4.75 mm	90 - 100	90 - 100	90 - 100	95 - 100
2.36 mm	60 - 95	75 - 100	85 - 100	95 - 100
1.18 mm	30 - 70	55 - 90	75 - 100	95 - 1000
600 micron	15 - 34	35 - 59	60 - 79	80 - 100
300 micron	5 - 20	8 - 30	12 - 40	15 - 50
150 micron	0 - 10	0 - 10	0 - 10	0 - 15

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- Where concrete of high strength and good durability is required, fine aggregate conforming to any one of the four grading zones may be used, but the concrete mix should be properly designed.

- It is recommended that fine aggregate conforming to Grading Zone IV should not be used in reinforced concrete. for Engineering Co

- It must be remembered that the grading of fine aggregates has much greater effect on workability of concrete than does the grading of coarse aggregate.

- Experience has shown that usually very coarse sand or very fine sand is unsatisfactory for concrete making.

- The coarse sand results in harshness bleeding and segregation, and the fine sand requires a comparatively greater amount of water to produce the necessary fluidity.

Mixing

- Thorough mixing of the materials is essential for the production of uniform concrete.

- The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency.

- There are two methods adopted for mixing concrete:

    - Hand mixing

    - Machine mixing

Hand mixing

- Hand mixing is practised for small scale unimportant concrete works.

- As the mixing cannot be thorough and efficient, it is desirable to add 10 per cent more cement to cater for the inferior concrete produced by this method.
- Hand mixing should be done over an impervious concrete or brick floor of sufficiently large size to take one bag of cement.

- Spread out the measured quantity of coarse aggregate and fine aggregate in alternate layers.

- Pour the cement on the top of it, and mix them dry by shovel, turning the mixture over and over again until uniformity of colour is achieved.

- Water is sprinkled over the mixture and simultaneously turned over.

- This operation is continued till a good uniform, homogeneous concrete is obtained.

Machine mixing

- Mixing of concrete is almost invariably carried out by machine, for reinforced concrete work and for medium or large scale mass concrete work.
- Machine mixing is not only efficient, but also economical, when the quantity of concrete to be produced is large.

- Batch mixers
    - Batch mixers produce concrete, batch by batch with time interval, whereas continuous mixers produce concrete continuously without stoppage till such time the plant is working.
    - In normal concrete work, it is the batch mixers that are used.
    - Batch mixer may be of pan type or drum type.
    - The drum type may be further classified as tilting, non-tilting, reversing or forced action type.

Continuous mixer

- The continuous mixer machine gives a stream of mixed concrete based on volumetric proportioning.
- Material is fed into one end from two or more aggregate conveyors, cement in screw feeder and flow metered water.
- The powerful twin-shaft mixing action transforms the raw materials into a continuous stream of mixed concrete suitable for roller compacted concrete, flow able fill and other less critical high-volume applications.

Transporting

- Concrete can be transported by a variety of methods and equipments.
- The precaution to be taken while transporting concrete is that the homogeneity obtained at the time of mixing should be maintained while being transported to the final place of deposition.

<u>Mortar pan</u>

- Use of mortar pan for transportation of concrete is one of the common methods adopted.
- In this case, concrete is carried in small quantities.
- While this method nullifies the segregation to some extent, particularly in thick members.

- Disadvantage of this method, exposes greater surface area of concrete for drying conditions. This results in greater loss of water, particularly, in hot weather concreting.

Wheel barrow

- Wheel barrows are normally used for transporting concrete to be placed at ground level.

- This method is employed for hauling concrete for comparatively longer distance as in the case of concrete road construction.
- If concrete is conveyed by wheel barrow over a long distance, on rough ground, it is likely that the concrete gets segregated due to vibration.

Crane, bucket and rope way

- A crane and bucket is one of the right equipment for transporting concrete above ground level.

- Crane can handle concrete in high rise construction projects and are becoming a familiar sites in big cities. LearnEngg

- Cranes are fast and versatile to move concrete horizontally as well as vertically along the boom and allows the placement of concrete at the exact point.

- Cranes carry skips or buckets containing concrete. Skips have discharge door at the bottom, whereas buckets are tilted for emptying.

- For a medium scale job the bucket capacity may be 0.5 m^3.

Truck mixer and dumpsters

- For large concrete works particularly for concrete to be placed at ground level, trucks and dumpers or ordinary open steel body tipping lorries can be used.

- As they can travel to any part of the work, they have much advantage over the jubilee wagons, which require rail tracks.

- Dumpers are of usually 2 to 3 cubic metre capacity, whereas the capacity of truck may be 4 cubic metre or more.

Belt conveyors

- Belt conveyors have very limited applications in concrete construction.

- The principal objection is the tendency of the concrete to segregate on steep inclines, at transfer points or change of direction, and at the points where the belt passes over the rollers.
- Conveyors can place large volumes of concrete quickly where access is limited.

Chute

- Chutes are generally provided for transporting concrete from ground level to a lower level.

- The sections of chute should be made with metal and all runs shall have approximately the same slope, not flatter than 1 vertical to 2.5 horizontal.

- The layout is made in such a way that the concrete will slide evenly in a compact mass without any separation or segregation.

Skip and hoist

- This is one of the widely adopted methods for transporting concrete vertically up for multistorey building construction.

- At the ground level, mixer directly feeds the skip and the skip travels up over rails upto the level where concrete is required.

- At that point, the skip discharges the concrete automatically or on operation.

Transit mixer

- Transit mixer is one of the most popular equipments for transporting concrete over a long distance particularly in Ready Mixed Concrete plant (RMC).

- In transit mixer, the mixed concrete is transported to the site by keeping it agitated all along at a speed varying between 2 to 6 revolutions per minute.

- In some plants, the concrete is batched at the central batching plant and mixing is done in the truck mixer either in transit or immediately prior to discharging the concrete at site.

Pumps and pipeline

- Pumping of concrete is universally accepted as one of the main methods of concrete transportation and placing.

- The pump was powered by a diesel engine.

- In this concrete placed in a collecting hopper is fed by rotating blades into a flexible pipe connected to the pumping chamber.
- A concrete which can be pushed through a pipeline is called a pumpable concrete.

Placing of concrete

- Placing of concrete is the process of depositing the concrete in its required position.

- Concrete should be placed in position in a proper manner as easily as possible within the initial setting time of the cement.

Precautions

- Concrete should not be thrown from a height to avoid segregation.

- The layers of concrete should be horizontal so as to prevent water running off and carrying some mortar with it.

- Layers should follow one another so that each is laid before the previous one had a time to set otherwise the surface of previous one is to be roughened by cross lines when green so as to ensure a key being formed between the layers.

- All Laitance (Squeezed out mortar) collecting at the top which becomes soft and chalky when hardened, must be removed before placing new concrete.

- The concrete should be thoroughly worked around the reinforcement and tapped in such a way that no honeycombed surface appears on removal of the framework.
- In case placing of concrete is to be suspended for sometimes, grooves must be made in the finished work, for joining future work, before initial setting time of cement.

- The placing of concrete should be carried out uninterrupted between predetermined construction of joints.

- During placing, it should be seen that all edges and corners of concrete surface remain unbroken, sharp and straight in line.

Compacting and curing of concrete

Compaction

- Compaction of concrete is the process adopted for expelling the entrapped air from the concrete after placing it in position.
- In the process of mixing, transporting and placing of concrete air is likely to get entrapped in the concrete.

- In other words, stiff concrete mix has high percentage of entrapped air and, therefore, would need higher compacting efforts than high workable mixes.

- In order to achieve full compaction and maximum density, with reasonable compacting efforts available at site, it is necessary to use a mix with adequate workability. Cour

Methods of compaction

The following methods are adopted for compacting the concrete:

- Hand compaction
    - Rodding
    - Ramming
    - Tamping

Compaction by vibration

- Internal vibrator
- Formwork vibrator
- Table vibrator
- Platform vibrator
- Surface vibrator
- Vibratory roller

- Compaction by pressure and jolting
- Compaction by spinning

Hand compaction

- Hand compaction of concrete is adopted in case of unimportant concrete work of small magnitude.
- Rodding is done continuously over the complete area to effectively pack the concrete and drive away entrapped air.
- Light ramming can be permitted in unreinforced foundation concrete or in ground floor construction.
- Tamping is one of the usual methods adopted in compacting roof or floor slab or road pavements where the thickness of concrete is comparatively less and the surface to be finished smooth and level.
- Tamping consists of beating the top surface by wooden cross beam.

Compaction by vibration

- Where high strength is required, it is necessary that stiff concrete, with low water/cement ratio be used.
- To compact such concrete, mechanically operated vibratory equipment, must be used.
- A concrete with about 4 cm slump can be placed and compacted fully in a closely spaced reinforced concrete work, whereas, for hand compaction, much higher consistency say about 12 cm slump may be required.
- The action of vibration is to set the particles of fresh concrete in motion, reducing the friction between them and affecting a temporary liquefaction of concrete which enables easy settlement.

Internal vibrator

- Of all the vibrators, the internal vibrator is most commonly used.
- This is also called, needle vibrator or poker vibrator.
- This essentially consists of a power unit, a flexible shaft and a needle.

Formwork vibrator (external vibrator)

- Formwork vibrators are used for concreting columns, thin walls or in the casting of precast units.
- The machine is clamped on to the external wall surface of the formwork.
- The vibration is given to the formwork, so that the concrete in the vicinity of the shutter gets vibrated.

Table vibrator

- This is the special case of formwork vibrator, where the vibrator is clamped to the table.
- They are commonly used for vibrating concrete cubes.

Platform vibrator

- Platform vibrator is nothing but a table vibrator, but it is larger in size.
- This is used in the manufacture of large prefabricated concrete elements such as electric poles, railway sleepers, prefabricated roofing elements etc.

Surface vibrator

- Surface vibrators are sometimes knows as, screed board vibrators.
- A small vibrator placed on the screed board gives an effective method of compacting and leveling of thin concrete members, such as floor slabs, roof slabs and road surface.

Vibratory roller

- One of the recent developments of compacting very dry and lean concrete is the use of vibratory roller. Such concrete is known as Roller Compacted Concrete.
- Heavy roller which vibrates while rolling is used for the compaction of dry lean concrete.

Compaction by pressure and joining

- Compaction by pressure and jolting is one of the effective methods of compacting dry concrete.
- This method is often used for compacting hollow blocks, cavity blocks and solid concrete blocks.

- The stiff concrete is vibrated, pressed and also given jolts.
- With the combined action of the jolts vibrations and pressure, the stiff concrete gets compacted to a dense form to give good strength and volume stability.
- By employing great pressure, a concrete of very low water cement ratio can be compacted to yield high strength.

Compaction of spinning

- Spinning is one of the recent methods of compaction of concrete.
- This method of compaction is adopted for the fabrication of concrete pipes.
- The plastic concrete when spun at a very high speed, gets well compacted by centrifugal force.

Curing

- Concrete derives its strength by the hydration of cement particles.
- The hydration of cement is not a momentary action but a process continuing for long time.
- The quantity of the product of hydration and consequently the amount of gel formed depends upon the extent of hydration.
- Cement requires a water/cement ratio about 0.23 for hydration and a water/cement ratio of 0.15 for filling the voids in the gel pores.
- It can be also stated as "A water/cement ratio of about 0.38 would be required to hydrate all the particles of cement and also to occupy the space in the gel pores".
- Curing is the process of controlling the rate and extent of moisture loss from concrete during cement hydration.
- Curing methods may be divided broadly into four categories:
    - Water curing
    - Membrane curing
    - Application of heat
    - Miscellaneous

Water curing

The best method of curing as it satisfies all the requirements of curing, namely, promotion of hydration, elimination of shrinkage and absorption of the heat of hydration.

- Immersion
- Ponding
- Spraying or fogging
- Wet covering

Water curing is done by covering the concrete with a layer of water for a period of time and the evaporation of moisture is from the surface of the water.

Membrane curing

- Concrete works are carried out in places where there is acute shortage of water.
- The quantity of water, normally mixed for making concrete is more than sufficient to hydrate the cement, provided this water is not allowed to go out from the body of concrete.
- Concrete could be covered with membrane which will effectively seal off the evaporation of water from concrete.
- Curing compounds are liquids which are usually sprayed directly onto concrete surfaces and which then dry to form a relatively impermeable membrane that retards the loss of moisture from the concrete.

Application of heat

- When concrete is subjected to higher temperature it accelerates the hydration process resulting in faster development of strength.
- Therefore, subjecting the concrete to higher temperature and maintaining the required wetness can be achieved by subjecting the concrete to steam curing.
- The exposure of concrete to higher temperature is done in the following manner:
    - Steam curing at ordinary pressure
    - Steam curing at high pressure
    - Curing by Infra-red radiation
    - Electrical curing

- A faster attainment of strength will contribute to many other advantages mentioned below:

    - Concrete is vulnerable to damage only for short time.
      Concrete member can be handled very quickly.

    - A smaller curing tank will be sufficient.

    - The work can be put on to service at a much early time.

    - Prestressing bed can be released early for further casting.

    - A fewer number of formwork will be sufficient or alternatively with the given number of formwork more outturn will be achieved.

Steam curing at ordinary pressure

- This method of curing is often adopted for prefabricated concrete elements.

- Application of steam curing to in-situ construction will be difficult task.

- However, at some places it has been tried for in situ construction by forming a steam jacket with the help of tarpaulin or thick polyethylene sheets.

High pressure steam curing

- The high pressure steam curing is something different from ordinary steam curing, in that the curing is carried out in a closed chamber.

- High pressure steam cured concrete develops in one day, or less the strength as much as the 28 days strength of normally cured concrete. The strength developed does not show retrogression.

- High pressure steam cured concrete exhibits higher resistance to sulphate attack, freezing and thawing action and chemical action. It also shows less efflorescence.

- High pressure steam cured concrete exhibits lower drying shrinkage, and moisture movement.

- In high pressure steam curing, concrete is subjected to a maximum temperature of about 175°C which corresponds to a steam pressure of about 8.5 kg/sq.cm.

Curing by infra-red radiation

- Curing of concrete by infra-red radiation has been practised in very cold climatic regions in Russia.

- It is claimed that much more rapid gain of strength can be obtained than with steam curing and that rapid initial temperature does not cause a decrease in the ultimate strength as in the case of steam curing at ordinary pressure.

- The system is very often adopted for the curing of hollow concrete products. The normal operative temperature is kept at about 90°C.

Electrical curing

- Concrete can be cured electrically by passing an alternating current through the concrete itself between two electrodes either buried in or applied to the surface of the concrete.

- Care must be taken to prevent the moisture from going out leaving the concrete completely dry.

Miscellaneous methods of curing

- Calcium chloride is used either as a surface coating or as an admixture, since it has been used satisfactorily as a curing medium.

- Both these methods are based on the fact that calcium chloride being a salt, shows affinity for moisture.

- Formwork prevents escaping of moisture from the concrete, particularly, in the case of beams and columns.

- Keeping the formwork intact and sealing the joint with wax or any other sealing compound prevents the evaporation of moisture from the concrete.
- This procedure of promoting hydration, can be considered as one of the miscellaneous methods of curing.

4. Other construction materials

Timber : classification and structure of timber.

Classification of timber

- Exogenous Trees
    - These trees grow outward and have distinct consecutive annular rings in their horizontal section. They can be further divided into two types:

    - Soft wood - Chir, Deodar, fir, koil, pine, spruce, etc.

    - Hard Wood - Babul, Mahogany, oak, sat, teak, etc.

    - Lumber mostly used for engineering purposes comes from Exogenous Trees.
- Endogenous Trees
    - These trees grow inwards and fibrous mass can be seen in the longitudinal sections.

    - Eg: Bamboo, Cane, Palm etc. These trees have limited engineering applications.

Structure of timber

- The cross-section of a tree has several layers which differ from one tree to other.

- The layers include pith or medulla, heartwood, sapwood, cambium layer, medullary rays, and the bark.

- The different elements constituting the structure of a tree are explained briefly below:
    - **Pith or medulla**
      The innermost central portion that contains entire cellular tissue is called pith or medulla.
    - **Heart wood**
      The annual rings that surround the pith are called as heartwood. This portion is dark in color and it does not take part in the growth of a tree. This part forms the strongest and durable art of a tree.
    - **Sapwood**
      The few outer annual rings are called sapwood. This part of the tree is active in growth
    - **Cambium layer**
      The thin layer between the bark and sapwood is termed as cambium layer. This layer contains sap which is yet to be converted into the sapwood.
    - **Medullary Rays**
      These are vertical layers of cellular tissues and are thin radial lines from plinth to the cambium layer.
    - **Bark**
        - Bark or cortex is the outermost cover or skin of the tree. It is further divided into the inner bark and outer bark.

            - The layer covering the cambium layer is called inner bark.

            - The outer skin which is the protective layer of the tree is called bark or cortex.

Seasoning of timber - importance

- To decrease the volume and weight of timber and thereby to lower the cost of transport and handling.

- To improve strength, hardness and stiffness and better electrical resistance of timber.

- To allow the timber to burn readily, if used as fuel.

- To increase the resisting power of timber so that it is less liable to attack by insects and fungus.
- To maintain the size and shape of the components of the timber particles.
- To make the timber fit for receiving treatment of paints, preservatives, varnishes etc.
- To make timber easily workable.
- To make the timber suitable for gluing i.e. effectively joining two members of timber with the aid of glue.
- To reduce the tendency of timber to crack, shrink and warp.

Characteristics of good timber

Strength

- The timber should be strong enough to withstand the loads whether being applied slowly or suddenly.
- It should possess enough strength in direct compression and transverse direction.

Durability

- A good timber should be capable of resisting the various actions due to fungi, insects, chemicals, physical and mechanical agencies.
- According to durability, timber is classified into three categories.
    - Class I - Timbers having average life of 120 months and over.
    - Class II - Timbers having average life of 60 to119 months.
    - Class III - Timbers having average life of 59 months and below.

Weather resistance

- A good timber should possess adequate resistance against weathering effects such as alternate drying and wetting, alternate heating and cooling because of temperature variations, wind effects, etc.

Fire resistance

The timber should offer sufficient resistance against fire, so that it should not easily ignite. It helps in fire protection of buildings.

Elasticity

- The timber should be capable of regaining its original shape when load causing deformation is removed.

- The property is important when timber is to be used for bows, carriage shafts, sport goods, wooden beams, wooden floors, etc.

Workability

- The timber should be easily workable and should not clog the teeth of saw.

- It should also be capable of being easily planed or made smooth.

Toughness and Abrasion

A good timber should be capable of offering resistance to shocks due to vibrations and should not deteriorate due to mechanical wear.

Other properties of a good timber

- Timber should have sufficient weight. A timber with heavy weight is considered to be sound and strong.

- The structure of timber should be uniform, hard and compact. It should not show wood lines at a freshly cut surface.

- A timber should have sufficient hardness. It should have resistance against penetration.

- A timber should have favourable physical characteristics such as straight fibres, shining appearance, free from defects, sweet smell, good sound when struck, etc.

- A good timber should have dark colour in appearance, it represents the sign of hard timber. Light colour in timber indicates less strength.

- It should be free from defects such as dead knots, flaws, cracks, shakes etc.

- It should not get warped or split during seasoning.

- In resinous timber, that with the least resins in its pores is strongest and most durable. In non resinous timbers that with least sap is best.

- It should be harmless to human being.

Clay products and refractory materials - Definition and Classification

Introduction to clay products

Introduction to clay products

- Clay is a fine-grained natural rock or soil material that combines one or more clay minerals with traces of metal oxides and organic matter.

- Clays are plastic due to their water content and become hard, brittle and non-plastic upon drying or firing.

- The materials like brick, tiles which are made by clay and are called clay products. Most commonly used clay product in construction industry are:

    - Bricks
    - Tiles
    - Refractory bricks
    - Earthenware
    - Stoneware
    - Porcelain
    - Terra cotta

Tiles

Introduction

- Tiles is one the major building material used for finishing purposes. It gives aesthetical appearance to the building.

- Tiles are thin slabs of brick earth or clay. It is usually burnt in kiln.

- These are thinner than bricks and have a greater tendency to crack and warp in drying and burning than ordinary bricks and are more liable to breakage.

- Therefore, a great care is needed in their manufacture. They should be dried in the shade, burnt and cooled gradually in specially made kilns.

Earthenware

- The clay products which is manufactured from ordinary clay mixed with sand, crushed pottery etc., by burning at low temperature is known as earthen ware.

- The earthenware are generally soft and porous. They are liable to damage by atmospheric action.

- They should not absorb water more than 18% by weight.

- When glazed, the earthenware become impervious to the water and they are not affected by acids or atmospheric agencies

Stoneware

- It is the clay product which is manufactured from refractory clay mixed with crushed pottery, powered stone, etc., by burning at high temperature.

- They clay is prepared carefully and moulding is done accurately to the required shape.

- It is then dried and the material burnt in a kiln, raising the heat gradually to a high temperature and maintaining this for one to three days depending upon the size of kiln and the articles in it. The burnt stoneware is allowed to cool down gradually.

- It is impervious to moisture, hard, closed grained and durable.

- The stoneware is more compact and dense than earthenware.

- The stoneware's can be kept clean easily.
- When glazed, the stoneware's becomes impervious to the water and they are not affected by acids or atmospheric agencies.

Terra cotta

- Terra cotta is a kind of high quality earthenware which is used as a substitute for stone for ornamentation of building.

- It is made from a finely ground mixture of refractory brick clay and shale or refractory clay and impure clay which is mixed with ground brick or other burnt clay product to reduce shrinkage.

Uses

- Used for all sorts of ornamental work.

- Used as building material in the form of shaped blocks.

Porcelain

O The term porcelain is used to indicate fine earthenware which is white, thin and semi transparent, it is sometimes referred to as white ware.

Porcelain

- The term porcelain is used to indicate fine earthenware which is white, thin and semi transparent, it is sometimes referred to as white ware.
- It is prepared from clay, felspar, quartz and minerals. The constituents are finely ground and then are thoroughly mixed in liquid state.

- The mixture is given the desired shape and is burnt at high temperature.
- The various types of porcelains available are used for various uses such as sanitary wares electric insulators, crucibles, reactor chambers, etc.
- Low voltage porcelain is prepared by dry process and is mainly used for lamp sockets, switch blocks, etc., High voltage porcelain is prepared by wet process.

Properties and uses of refractory materials

Properties of refractories

A good refractory material should have the following properties:

- It should be able to withstand high temperatures generated in the furnace.
- It should be able to withstand sudden alternating, heating and cooling, ie thermal shocks.
- It should be able to withstand abrasion and rough usage.
- Its contraction and expansion due to the inevitable temperature variation should be minimum possible.
- It should be able to withstand fluxing action of the slags and the corrosive action of glass.
- It should have good heat insulating properties.
- It should be chemically inactive at elevated temperatures.
- It should be impermeable to gases and liquids as far as possible.
- If used in electric furnaces, it must have low electrical conductivity.

Iron and steel : Uses of cast iron , wrought iron , mild steel and tor iron

Uses of cast iron

- Cast-iron is used for making cisterns, water pipes, gas pipes and sewers, manhole covers and sanitary fittings.
- For making ornamental casting, such as brackets, gates, lamp posts, spiral staircases etc.
- For making parts of machinery which are not subject to heavy shocks.
- For manufacturing compression members like columns in buildings, bases of columns, etc.

- For preparing agricultural implements. For preparing rail chairs, carriage wheels, etc.

Uses of wrought iron

- It is used for pipe making due to its superior corrosion and fatigue resistance and better welding and threading qualities.
- It is used for making bars for stay bolts, engine bolts and rivets etc. because properties demanded in these applications are corrosion and fatigue resistance.
- For making plates.
- For making special chains and crane hooks due to its good weldability and high impact strength.
- It is also used extensively for general forging applications.

Uses of mild iron

- Building and Construction. The building and construction industry is one of the biggest consumers and supporters of steel fabrication. ...
- Water Pipes. Most underground water pipes are made of stainless steel. ...
- Furniture and Appliances. ...
- Packaging.

Uses of tor iron

- Ribbed tor steel bars can be bent through 1800 without formation of any crack or fracture on their outside surface.
- Welding is possible in these types of bars. It can be welded by electric flash butt welding or arc welding.
- Use of these bars reduces the cost of reinforcement up to 30 to 40%, hence economical.
- These bars are easily identified as they have got peculiar shape.
- The structural properties of these bars are better than that of ordinary plain round bars.
- These bars possess excellent bonding properties and hence the end hooks are not required.
- They can be used for all major types of reinforced concrete structure.

- Bending, fixing and handling of these bars are very simple. This result in to less labour charge

5 Surface protective materials.

Composition of paint

- Paint is a liquid that will spread over a solid surface, dry and harden forming an adherent, coherent film acting as a surface protective material

- Paint is a fluid paste prepared by dissolving a base in a vehicle along with the colouring pigments.

The six important constituents of paints are

- Base
- Inert filler or adulterant

- Vehicle or carrier

- Drier

- Solvent

- Pigment

Base

- Base is the body of the paint

- It is either metallic or mineral.

- It forms the bulk of a paint

- A base is usually opaque and it possesses covering power i.e., a thin layer when applied on a surface completely covers and hides the material

- It gives durability to the surface

- It makes the paint as resistant against abrasion and prevents formation of shrinkage cracks in the film

- White lead, red lead, zinc lead, iron-oxide,titanium white,antimony white, aluminium powder, etc., are the most commonly used bases

Inert filters

- These are used to dilute the base of a paint

- Inert fillers increase the durability and lessens the cost of paint

- They should not be used in excess amount as otherwise the paint may lose its original character and may become weak

- Barium sulphate (Baryte) silica, litho phone, whiting, charcoal, gypsum, silicate of magnesia or alumina etc., are the usual inert fillers.

Vehicle or carrier

- Vehicle is a liquid substance used in a paint for dissolving and holding the base and pigment in suspension

- Vehicle enables the paint to spread over the surface in a thin and uniform layer when applied

- The vehicle helps the base and pigment to enter into the pores, cracks and fissures if any on the surface

- It hardens and by absorbing oxygen from the atmosphere forms a resinous semi elastic coat which gives a durable and impervious skin

- Refined linseed oil is the most commonly used vehicle in paints O Beside linseed oil, tug oil, poppy oil, nut oil may also be used as vehicle.

Drier

- Driers are used to accelerate the process of drying and hardening

- Driers in a paint are required to thicken the vehicle

- It improves durability and prevents shrinkage cracks

- It reduces the cost of paint and also modify the weight of paint

- Litharge, manganese dioxide, lead acetate and cobalt are the usual driers.

Solvent or thinner

- Thinner is required to reduce the consistency of the paint

- It evaporates after the paint has been applied to the surface

- It also helps the paint to penetrate into the surface to be painted

- It makes the paint to be applied

- It increases the workability of paint

- Turpentine oil is the most commonly used solvent

- Petroleum spirits and naphtha are also very good solvents.

Colouring pigments

- Pigment is the colouring agent mixed with the base to produce the desired colour of the paint
- The pigment in a paint should have the property of readily amalgamating with
    - The vehicle opacity
    - Chemical inertness
    - No crystalline structure
    - Fine state of division
    - Insolubility
- Indigo, cobalt blue, burnt amber, graphite, copper sulphate, zinc chromate, carmine are some of the examples for colour pigments

Composition of enamels

- Enamel is a paint having white lead or zinc white, ground in a small quantity of oil and mixed with petroleum sprit and resinous matter
- It is available in different colours
- They dry quickly and furnish a hard glossy surface
- They can be used for internal as well as external works and are generally recommended for application on wood work
- These are acid resistant and water proof
- They can not be affected by alkalis, gases and steam etc
- It is not affected by hot and cold water
- These are very good quality paints.

Composition of varnishes

- A transparent or semi-transparent solution of a resinous substance either linseed oil, turpentine or alcohol is called varnish
- Varnishes provide a protective coating and gloss to the surface
- Ingredients of a varnish are
    - Resin
    - Solvent
    - Drier
- Resin
    - A natural or synthetic organic substance which is soluble in some organic solvent
    - Ex: Amber, copal, gum anime
- Solvent
    - It acts as vehicle of the varnish and helps in spreading the resin
    - Ex: Boiled linseed oil
- Drier
    - It helps in quick drying of the varnish
    - Ex: Litharge, white copper, lead acetate
- The type of solvent depends upon the resin used.

Types and uses of surface protective materials like paints, enamels, varnishes, distemper, emulsion, french polish and wax polish

Types and uses of paints

The following are the types of paint

1. Aluminium paints
2. Bituminous paints
3. Anti-corrosive paints
4. Bronze paints

5. Plastic paints

6. Silicate paint

7. Asbestos paint

8. Cellulose paint

9. Colloidal paints

10. Enamel paints

11. In borderers paints

12. Synthetic rubber paints

for Engineering Courtes

14. Graphite paints

15. Casein paints

Aluminium paint

- This paint is manufactured using finely ground aluminum powder suspended in quick drying oil or spirit varnish
- This paint is not affected by high temperature, salt water and moist weather
- It retains its original colour and luster for a long period and permits washing with soap and water
- It offers good protection against rusting and corrosion
- It is widely used for painting hot water pipes, gas tanks, marine piers, oil storage tanks, radiators etc.

Bituminous paint

- This paint is made of asphalt, bitumen or pitches dissolved in any type of oil or petroleum or white spirit
- The paint is always black in colour
- They are alkali resistant and are used to paint exterior brick work, concrete and plastered surfaces

- This paint is used on surfaces which are immersed in water for Engine
- They deteriorate very fast when exposed to sunlight

Anti-corrosive paints

- These paints essentially consists of the linseed oil as vehicle
- They have red lead, zinc oxide, iron oxide, zinc dust, zinc chromate, etc, as their base
- These paints should have quick drying and hardening properties These paints are cheap, durable and are usually black in colour
- These paints are used mainly to protect the surface of metallic structural steel work

Paints on metals

Powder coated paints

- Powder coating is a type of coating that is applied as a free-flowing, dry powder.
- The most common way of applying the powder coating to metal objects is to spray the powder using an electrostatic gun.
- Powder coatings produce less hazardous waste than conventional liquid coating.
- Powder which does not adhere to the part, called overspray, can be recycled and reused (no wastage).
- The applied powder is then heated (cured) to its melting point, after which it flows to form a smooth film.
- This is durable finish very resistant to scratches, cracking, peeling, UV rays and rust.

Types and uses of special paints

The following are the special types of paints

1. Bronze paint
2. Plastic paint
3. Silicate paint

Bronze paint

- These paints are prepared by dissolving aluminium bronze or copper bronze in cellulose lacquer as vehicle
- These paints give a very reflective type of surface and hence are very useful for being applied on radiators
- These paints are also used for painting interior or exterior metallic surfaces.

Plastic emulsion paint

- Plastic emulsion paint is water based wall paint
- It is based on acrylic and provide a smooth matt finish to the walls
- These paints are also washable and easy to maintain just as premium emulsions
- It is extremely durable but is not suitable for application on external surfaces, wood and iron surfaces
- According to Indian standard it should confirm to the specification given by IS: 5411
- It should be of approved brand and manufacturer

Silicate paints

- A silicate paint is prepared by adding calcium and finely ground silica with resinous materials
- Silicate dispersion paint is also known as inorganic mineral paint
- It forms a very hard and durable coating on the painted surface
- It is possible to apply directly on brick, concrete or plastered surface, but only after wetting them
- The paint does not require any priming coat
- This paint is not applied on hot surfaces
- Silicate paint does not form a film and it bonds by penetrating into the surface
- It also protects the walls from the microorganisms
- Silica paint is environment friendly
- It has non-toxic applications
- It is highly durable especially on masonry products, and lightfast

- It is acid rain resistant and has antifungal properties
- It reduces carbonization of cement based materials

Mineral paints

- Mineral paints are a variety of silicate paints
- Mineral based coatings formulated with potassium silicate or sodium silicate, also known as water glass as the binder and combined with inorganic, alkaline- resistant pigments
- They are fully inorganic (containing no organic solvents)
- They are more of a stain, that becomes integral to the substrate, rather than a coating
- They are alkaline and therefore inhibit micro biotic growth
- It reduces carbonization of cementitious materials
- The majority of non-toxic concrete stains and limestone restoration products are silicate based
- Mineral paints are also used as a non-toxic wood preservative

Types and uses of enamel paints

- An enamel paint is obtained by adding white lead or zinc white (base) to varnish (vehicle)
- To obtain the required colour, colouring agents may also be added
- This paint dries slowly after application and forms a hard, durable, smooth, glossy, solid thin film
- The painted surfaces are not affected by atmospheric effects
- Enamel paints can be used both for interior as well as exterior painting
- Enamel is also used on wood to make it resistant against water and rot.

Enamel paints are classified as

- Oil-based enamels
- Water-based enamels

- Alkyd-based enamels

Oil-based enamels

- It has a strong solvent odour

- Oil-based enamel reaches optimum hardness in 8 to 24 hours depe drying conditions
- Oil-based enamels dry from the inside to outside so when we feel completely dry to their touch, they are fully cured

- Paint thinner or mineral spirits are used to clean up the surface

Water based enamels

- These are also called latex or acrylic paints

- Water-based enamel takes up to a month to cure and hence care must be taken with washing and handling

- Water-based enamels dry from outside to inside. A skin forms on the surface of the paint, so it feels dry to the touch within an hour

- The underlying paint film dries very slowly

- In humid or cool conditions, it can take several weeks to fully harden

- This type is easier to use

- It has a fairly low odour

- These are heat resistant

Floor enamel

It may be used for concrete, stairs, basements, porches and patios

Fast dry enamel

• It can dry within 10-15 minutes of application.

• This is ideal for refrigerators, counters, and other industrial finishes

High-temp enamel

It may be used for engines, brakes, exhausts, etc.

Types and uses of varnishes

- Varnish is a transparent, hard, protective finish or film, primarily used in wood finishing but also for other materials

- Varnish is traditionally a combination of a drying oil, a resin, and a thinner or solvent

The following are the types of varnishes

- Oil varnishes
- Spar varnishes
- Flat varnishes
- Spirit varnishes
- Asphalt varnishes

Oil varnishes

- Oil varnish uses linseed oil as solvent and takes about 24 hours to dry
- It is suitable both for interior and external works

Spar varnishes

- Spar varnish derives its name from its use on spars and other parts of ships
- It gives sticky effect in warm weather
- It is not used indoors

Flat varnishes

Materials such as wax, metallic soap or finely divided silica when added to varnish, produce a dull appearance on drying known as flat varnish

Spirit varnishes

- Spirit varnish is a resin dissolved in spirit. French polish, lacquer and shellac varnish are some examples of spirit varnish
- These are mostly used for furniture and on unpainted wood surfaces
- It dries very quickly

Asphalt varnishes

- Asphalt varnish is made by dissolving melted hard asphalt in linseed oil. Turpentine or petroleum spirit is as a thinner
- It is used over shop fabricated steel works

Water varnishes

- The varnish in which hot water is used as solvent is known as water varnish

- Resins like shellac are dissolved in hot water by adding, ammonia, borax etc.
- These varnishes are used for maps, pictures, etc.

Varnishes for wood

Polyurethane

- Polyurethane is widely used as one of the most durable protective wood finishes.
- Polyurethanes are now available in both oil-based and water-based.
- Polyurethane is harder and more resistant to abrasion than its naturally-derived counterparts.
- It is also cheap, easy to use, and available in a range of different finishes from glossy to matte

Melamine coatings

- Melamine wood coating provides excellent appearance with fast drying properties.
- It has good chemical and weather resistance.

Touch wood

- Touch wood can be applied on wood quickly.
- It is mainly used for touch up jobs on woods.
- Touch wood dose not require a separate sealer coat to be applied.
- The same material can be applied as undercoat and top coat.
- Touch wood interior provided better hardness and protection.

Types and uses of distemper

- A distemper is a paint with white chalk as base and water as thinner,
- Some colouring pigments and glue are also added to get the required colour
- These are also called as water paints
- They are available in powder and paste forms and

- They are substantially cheaper than other paints
- They are most suitable for plastered surfaces and white washed surfaces of interior walls
- The coatings formed by distemper are thick and more brittle compared to paints
- They are workable easily in application but less durable
- The film can be applied on even newly plastered surfaces

There are four types of distemper

1. Oil Bound Distemper (OBD)

2. Washable oil free distemper

3. Non washable distemper

4. Emulsion paints

Oil Bound Distemper

- These are the distempers in the form of paste
- These are made thin by adding water before use
- When distemper is applied to the surface, the water evaporates and resulting into a formation of thin film over the surface.
- The thin film is colourful and decorative.

Emulsion paints

- An emulsion paint is a water-based paint
- Emulsion paints are also known as latex paints
- The polymer formed in emulsion paints is through an emulsion polymerization in which the monomers were emulsified in a water continuous phase
- The polymer is not soluble in water and hence the paint is water resistant, after it has dried
- Emulsion paints consist of polyvinyl acetate and synthetic resins as binding materials

- It is easy to apply and it dries quickly in about 1.5 to 2 hours
- It is mainly used for painting steel and wood work

Oil paint

- Oil paintings often possess an unsurpassed richness, depth and luminosity that lends itself well for capturing highly realistic objects and scenes.
- Oil paint made of pigment ground in oil, usually linseed oil.
- When oil oxidizes, it forms a solid film that binds the pigments, allowing oil paintings to be enjoyed for hundreds of years.
- Oil paints are mostly used on wood materials like doors and windows.

Wax polish

- Wax polish is a decorative finish
- It consists of bees' wax dissolved in turpentine
- Wax, linseed oil, turpentine and varnish are mixed in the ratio 2: 1.5: 1: 0.5, by weight
- It is used for highlighting the grain over wooden surfaces
- It is also used over marble with 1 part of wax dissolved in 4 parts of hot turpentine
- It is a non abrasive coating
- It protects the paint finish
- It microscopically fills in the dents and dimples in the paint to shine

PART: B (CONSTRUCTION TECHNOLOGY)

Chapter 1 - Introduction

Buildings and classification of buildings based on occupancy

Main parts of building.

Definition of building as per NBC

National Building Code of India (SP: 7-1970) defines the building as any structure for whatsoever purpose and of whatsoever materials constructed and every part thereof whether used as human habitation or not and includes foundations, plinth, walls, floors, roofs, chimneys, plumbing and building services, fixed platforms, verandah, balcony cornice or projection, part of a building or any thing affixed thereto or any wall enclosing or intended to enclose any land or space and signs and outdoor display structures.

Main parts of building

A building has two basic parts

- Substructure or foundation
- Superstructure

Substructure

- Substructure or Foundation is the lower portion of the building, usually located below the ground level, which transmits the loads of the superstructure to the supporting soil.

- A foundation is therefore that part of the structure which is in direct contact with the ground to which the loads are transmitted.

Superstructure

- Superstructure is that part of the structure which is above ground level, and which serves the purpose of its intended use. A part of the superstructure, located between the ground level and the floor level is known as plinth.

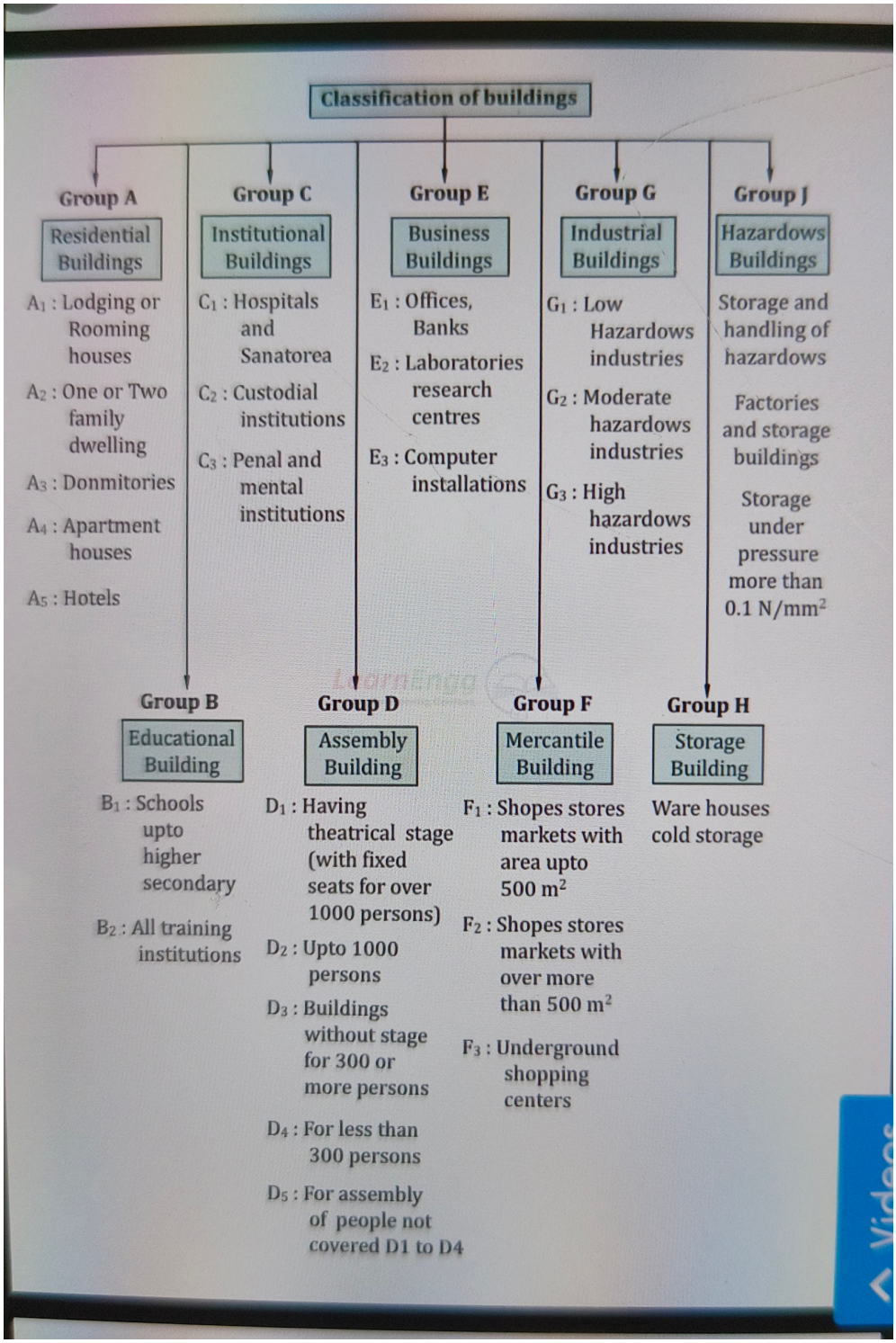
- Plinth is therefore defined as the portion of the structure between the surface of the surrounding ground and surface of the floor, immediately above the ground.

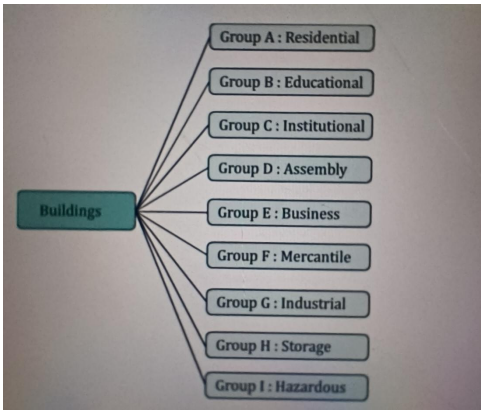
- The level of the floor is usually known as the plinth level.

- The built-up covered area measured at the floor level is known as plinth area.

Classification of building

According to the national building code of India, buildings are classified based on occupancy, as follows


Classification of buildings
Group A
Residential Buildings
A1 : Lodging or Rooming houses
A2 : One or Two family dwelling
A3 : Donmitories
A4 : Apartment houses
A5 : Hotels
Group C
Institutional Buildings
C1 : Hospitals and Sanatorea
C2 : Custodial institutions
C3 : Penal and mental institutions
Group E
Business Buildings
E1 : Offices, Banks
E2 : Laboratories research centres
E3 : Computer installations
Group G
Industrial Buildings
G1 : Low Hazardows industries
G2 : Moderate hazardows industries
G3 : High hazardows industries
Group J
Hazardows Buildings
Storage and handling of hazardows
Factories and storage buildings
Storage under pressure more than 0.1 N/mm2
Group B
Educational Building
B1 : Schools upto higher secondary
B2 : All training institutions
Group D
Assembly Building
D1 : Having theatrical stage (with fixed seats for over 1000 persons)
D2 : Upto 1000 persons
D3 : Buildings without stage for 300 or more persons
D4 : For less than 300 persons
D5 : For assembly of people not covered D1 to D4
Group F
Mercantile Building
F1 : Shopes stores markets with area upto 500 m2
F2 : Shopes stores markets with over more than 500 m2
F3 : Underground shopping centers
Group H
Storage Building
Ware houses cold storage



Group A and B building

Group A : Residencial buildings

- These are those buildings in which sleeping accommodation is provided for normal residential purposes, with or without cooking or dining or both facilities.

- Buildings of group A are further sub divided as follows.

Sub-division A-1: Lodging or Rooming Houses

These include any building or group of buildings under the same management, in which separate sleeping accommodation for a total of not more than 15 persons, in either transient or permanent basis with or without dining facilities, but without cooking facilities for individuals, is provided.

Sub-division A-2: One or two Family Private Dwellings

- These include any private dwelling which is occupied by members of a single family and has a total sleeping accommodation for not more than 20 persons.

- If rooms in a private dwelling are rented to outsiders, these should be for accommodating not more than 3 persons.

Sub-division A-3: Dormitories

These include any building in which group sleeping accommodation is provided, with or without dining facilities, for persons who are not members of the same family.

Example: Hostels

Sub-division A-4: Apartment Houses (Flats)

These include any building or structure in which living quarters are provided for three or more families living independently of each other and with independent cooking facilities.

Example: Apartment houses, mansions and chawls.

Sub-division A-5: Hotels

These include any building or group of buildings under single management in which sleeping accommodation, with or without dining facilities, is provided for hire to more than 15 persons who are primarily transient, for example hotels, inns, clubs and motels.

Example: Hotels, inns, clubs and motels.

Group B: Educational buildings

These include any building used for school, college, or day-care purposes for more than 8 hours per week involving assembly for instruction, education or recreation and which is not covered by Group D.

Group C and D building

Group C; Institutional Buildings

- These include any building or part thereof, which is used for purposes such a medical or other treatment or care of persons suffering from physical or mental illness, disease or infirmity, or aged persons and for penal or correctional detension in which the liberty of inmates is restricted.

- Institutional buildings ordinarily provide sleeping accommodation for the occupants.

Sub-division C-1: Hospitals and Sanitaria

This sub-division includes any building or group of buildings under single management, which is used for housing persons suffering from physical limitations because of health or age.

Example: Hospitals, infirmaries, sanitaria and clinics.

Sub-division C-2: Custodial Institutions

This sub-division includes any building or group of buildings under single management, which is used for the custody and care of persons such as children, convalescents and the aged.

Example: Homes for the aged and infirm, convalescent homes and orphanages.

Sub-division C-3: Penal Institutions

This sub-division includes any building or a group of buildings under single management, which is used for housing persons under restraint, or who are detained for penal or corrective purposes, in which the liberty of the inmates is restricted.

Example: Jails, prisons, mental hospitals, mental sanitaria and reformatories.

Group D : Assembly Buildings

- These include any building or part of a building, where group of people congregate or gather for amusement, recreation, social, religious, patriotic, civil, travel and similar purpose.

- Example: Theatres, motion picture houses, assembly halls, auditoria, exhibition halls, museums, skating rinks, gymnasiums, restaurants, places of worship, dance halls, club rooms, passenger stations and terminals of air, surface and marine public transportation service, recreation piers and stadia.

- Buildings under group D are further sub divided as follows.

Sub-division D-1

This sub-division includes any building primarily meant for theatrical or operatic performances and exhibitions and which has a raised stage, proscenium curtain, fixed or portable scenery or scenery loft, lights, motion picture booth, mechanical appliances or other theatrical accessories and equipment and which is provided with fixed seats over 1000 persons.

Sub division D-2

This sub-division includes any building primarily meant for use as described for sub-division D-1 but with fixed seats for less than 1000 persons.

Sub division D-3

This sub-division includes any building, its lobbies, rooms and other spaces connected thereto, primarily intended for assembly of people, but which has no theatrical stage or theatrical and/or cinematographic accessories and has accommodation for more than 300 persons.

Example: Dance halls, night dubs, halls for incidential picture shows, dramatic, theatrical or educational presentation; lectures or other similar purposes, having no theatrical stage except a raised platform and used without permanent seating arrangement; art galleries; museums; lecture halls; libraries; passenger terminals and buildings used for educational purposes for less than 8 hours per week.

Sub-division D-4

This sub-division includes any building primarily intended for use as described in sub-division D-3 but with accommodation for less than 300 persons.

Sub-division D-5

This sub-division includes any building meant for outdoor assembly of people not covered by sub-division D-1 to D-4,

Example: Grand stands, stadia, amusement park structures, reviewing stands and circus tents.

Other group of building

Group E: Business buildings

These include any building or part of building which is used for the transaction of business, for the keeping of accounts and records and similar purposes, doctors and dentists (unless these are covered by the provisions of group C), service facilities such as new stands, lunch counters serving less than 100 persons, barber shops and beauty parlours.

Sub division E-1

Offices, banks , professional establishment

Sub division E-2

Computer installations

Group F : Mercantile buildings

- These include any building or part of a building, which is used as shops, stores, markets, for display and sale of merchandise, either wholesale or retail.

- Office, storage and service facilities incidental to the sale of merchandise and located in the same building should be included under this group.

- Minor merchandising operations in buildings primarily meant for other uses should be covered by group under which the predominant occupancy is classified.

Group G : Industrial buildings

These include any building or part of a building, or structure in which products or materials of all kinds and properties are fabricated, assembled or processed.

Example: Assembly plants, laboratories, dry cleaning plants, power plants, pumping stations, smoke houses, gas plants, refineries, dairies and saw mills.

Group H : Storage buildings

These include any building or part of a building, used primarily for the storage or sheltering (including servicing, processing or repairs incidental to storage) of goods, wares or merchandise (except those that involve highly combustible or explosive products or materials), vehicles or animals.

Example: Warehouses, cold storages, freight depots, transit sheds, store houses, truck and marine terminals garages, hangers (other than aircraft repair hangars), grain elevators, barns and stables.

Group J : Hazardous buildings

- These include any building or part of a building which is used for the storage, handling, manufacture or processing of highly combustible or explosive materials or products which are liable to burn with extreme rapidity and/or which produce poisonous fumes or explosions.

- For storage, handling, manufacturing or processing which involve highly corrosive, toxic or noxious alkalies, acids or other liquids or chemicals producing flame, fumes and explosive, poisonous, irritant or corrosive gases; and for the storage, handling or processing of any material producing explosive mixtures of dust or which result in division of matter into fine particles subject to spontaneous ignition.

- Examples of buildings in this class are those buildings which are used for,

- Storage under pressure of more than 0.1 N/mm³ and in quantities exceeding 70 m³ of acetylene, hydrogen, illuminating and natural gases, ammonia, chlorine, phosgene, sulphur dioxide, carbon dioxide, methyl oxide and all gases subject to explosion, fume or toxic hazard.

- Storage and handling of hazardous and highly flammable liquids.

- Storage and handling of hazardous and highly flammable or explosive materials other than liquids.

- Manufacture of artificial flowers, synthetic leather, ammunition, explosive and fireworks.

Different components of a building

Components of building

A building has the following components

- Foundation

- Plinth

- Masonry units - walls and column

- Floor structures

- Roof structures

- Doors, windows, and other openings

- Vertical transportation such as stairs, lifts, ramps, etc

- Building finishes

Foundation

It is the lowest part of the building below the surface of the surrounding ground, which is in direct contact with sub-soil and transmits all loads on to it.

Functions of foundations

- The basic function of the foundation is to transmit all the loads (dead loads, super-imposed loads, wind & earth quake loads etc.,) acting on the super structure to the soil on which the building rests.

- To distribute the loads uniformly to the soil, to prevent unequal settlements of foundation.

- To provide a level and hard surface for superstructure.

- To increase the stability of the structure against sliding and over turning

Plinth

- Plinth is defined as the portion of the structure between the surface of the surrounding ground and floor level of the building.

- The minimum height of plinth should not be less than 450 mm.

Functions of plinth

- To protect the building from dampness or moisture penetration into it. This increase the stability and durability of the structure.

- To transmit the load of super structure to the foundation.

- To act as a retaining wall so as to keep the filling in position below the floor of the building.

- To improve the elevation of the building.

Masonry units

Masonry may be defined as the construction of building units bonded together with mortar.

Wall

- Walls are the most essential components of a building.
- Walls are mainly meant for enclosing or dividing the space.
- Basically, load bearing wall is an essential component of the building.
- In case of framed structures, the columns take entire load and the walls are meant for enclosing the space.

Functions of wall

- To provide required privacy for various room in a building.
- To transfer the loads from the floors to the foundation.
- The external walls will provide the required safety against theft.
- To protect the interior of the building against natural agencies like rain, sun, snow, wind etc.

Columns

A columns is an isolated vertical load bearing member, the width of which is neither less than its thickness nor more than four times its thickness.

Functions of column

These are the vertical members meant for carrying loads from beam and floor slabs and transferring the same to foundations.

Floor structure

- Floors are the horizontal elements which divide the building into different levels for the purpose of creating more accommodation within a restricted space one above the other and provide support for the occupants, furniture and equipment of a building.
- The floor of a building immediately above the ground is known as ground floor.
- All other floors which are above the ground floor are known as the upper floors.

Roof structures

- A roof is the upper most part of a building.
- It is a covering provided on the top of the building with a view to keep out rain, snow, sun and wind and to protect the building from their adverse effects.

Doors , windows and other opening

Doors

- A door is a movable barrier provided in the opening of a wall, to provide access to various spaces of a building.

- A door is a frame work of wood, steel etc., secured in the wall opening for the purpose of providing access to the users of the building.

Window

- Similarly, a window may be defined as an opening made in the wall for the purpose of providing day light, vision and ventilation

- Since doors and windows are provided in the openings in the walls, a discontinuity is formed in the wall, in the vertical direction.

Lintels

Lintels are therefore essential. A lintel is a horizontal structural member provided over the doors, windows or other openings, to span the gap, so as to support the super-imposed load carried by the wall above the opening.

Sill

Window sills are provided between the bottom of window frame and wall below it, to protect the top of wall from wear and tear.

Sunshade

Sunshades are generally combined with lintel, that are provided on doors and windows of exterior walls.

Vertical transportation structures

- These consists of stairs, ramps, ladders, lifts and escalators etc., to afford access between various floors.

- Out of these, stairs are the most common.

- A stair may be defined as series of steps suitably arranged for the purpose of connecting different floors of a building.

- Location of stairs should be provide easy approach in any building.

Building finishes

Finishes are several types such as pointing, plastering, painting, distempering, decorative colour washing, etc.

Functions of finishes

- To protect the structure, especially the exposed surface from the effect of rain, sun, wind action etc.
- To increase the life of the structure.
- Theses finishing's cover up some extent, the defective or poor workman ship.
- To provide a true, even and smooth finished surface. This also improves the aesthetic appearance of the structure as a whole.

Site investigation - objectives, site reconnaissance and explorations.

Objectives of site investigation

- To know the type of soil and thickness of different strata existing below ground level.
- To know the physical and shear properties of different strata of soil under lying below the ground level.
- To assign the suitable safe bearing capacity of the underlying soil based on field and laboratory testing.
- To determine the depth of foundation.
- To know the depth of under ground water table and its fluctuations.
- To select safe and most economical type of foundation.

Depth of soil exploration

- In general, should be carried out to a depth at which the increase in pressure due to structural loading is likely to cause perceptible settlement or shear failure of foundations. Such a depth, known as significant depth.
- Depth of soil exploration depends upon the type of structure, its weight, size, shape and disposition of the loaded areas, and the soil profile and its properties.
- The significant depth may be assumed to be equal to one-and-a-half to two times the width (smaller of the lateral dimension) of the loaded area.

Stages in site investigation

Site investigation or sub-soil exploration is carried out stage-wise as given below.

- Site Reconnaissance

- Preliminary site exploration
- Detailed exploration
- Preparation of soil investigation report

Site reconnaissance

- Site reconnaissance is the first stage of site investigation. In this stage, visual inspection of the site is done and information about topographical and geological features of the site are collected. The general observations made in site reconnaissance are as follows:
- Presence of drainage ditches and dumping yards etc.
- Location of groundwater table by observing well in that site.
- Presence of springs, swamps, etc. LearnEngg
- High flood level marks on the bridges, high rise buildings, etc. are observed.
- Presence of vegetation and nature of the soil.
- Past records of landslides, floods, shrinkage cracks, etc. of that region.
- Study of aerial photographs of the site, blueprints of present buildings, geological maps, etc.
- Observation of deep cuts to know about the stratification of soils

Preliminary site exploration

- Preliminary site exploration is carried out for small projects, light structures, highways, airfields, etc.
- The main objective of preliminary exploration is to obtain an approximate picture of sub-soil conditions at low cost. It is also called general site exploration.
- The soil sample is collected from experimental borings and shallow test pits and simple laboratory tests such as moisture content test, density, unconfined compressive strength test, etc. are conducted.
- Simple field tests such as penetration methods, sounding methods, geophysical methods are performed to get the relative density of soils, strength properties, etc.
- The data collected about subsoil should be sufficient enough to design and build light structures. Following are some of the general information obtained through primary site exploration.

- Approximates values of soil's compressive strength.
- Position of the groundwater table.
- Depth and extent of soil strata.
- Soil composition.
- Depth of hard stratum from ground level.
- Engineering properties of soil (disturbed sample)

Detailed site exploration

- Detailed exploration is preferred for complex projects, major engineering works, heavy structures like dams, bridges, high rise buildings, etc.
- A huge amount of capital is required for a detailed site exploration hence, it is not recommended for minor engineering works where the budget is limited. For such type of works, data collected through preliminary site exploration is enough.
- In this stage, numerous field tests such as in-situ vane shear test, plate load test, etc. and laboratory tests such as permeability tests, compressive strength test on undistracted soil samples are conducted to get exact values of soil properties.

CHAPTER 2 FOUNDATION

Concept of foundation and its purpose

Introduction to foundation

Foundation is lower part of the structure which is provided to distribute the loads to the soil thus providing base for the superstructure.

Purpose of foundation

- To distribute the load of the structure over a larger area to avoid overloading of subsoil below it.
- To prevent unequal settlement.
- To prevent over turning by taking the foundation deep into ground and increasing its stability.
- To provide level surface for erecting building/structure.
- The foundation is laid below ground level due to the following reasons,
- To secure adequate bearing capacity.

- In case of clay soils, there is a shrinkage and swelling in the soil upto some depth below the G.L. to seasonal weather changes.

- Foundations in fine sand and silt are laid below the zone of frost penetration.

Types of foundations- shallow and deep

Types of shallow foundation

- Foundation is said to be shallow when the depth of foundation is equal to or less than its width.

- A shallow foundation is also known as an open foundation, since such a foundation is constructed by open excavation.

- A shallow foundation is placed immediately below lowest part of the super structure supported by it.

Types of shallow foundation

- Spread footing
    - Strip footing
    - Pad footing
- Combined footing
- Strap footing
- Mat or raft foundation

Types of deep foundation

- When the foundation has to carry heavy structural loads and if the bearing capacity of soil is low at shallow depths, the foundations are to be taken to deeper depths until a hard stratum is reached. Such foundations are called as deep foundations.

- Deep foundations may be of the following types
    - Deep strip, rectangular or square footings
    - Pile foundation
    - Pier foundation
    - Well foundation or caissons
- The usual strip, rectangular or square footings come under the category of deep foundations, when the depth of the foundation is more than the width of the footing.

Shallow foundation

Design of foundation of thumb rule

- Foundation depth not less than 1 meter.
- Foundation width not less than 1 meter.
- Foundation length not less than 1 meter.
- 50mm cover block used in foundation.
- Minimum 10mm bar used in foundation.
- Foundation concrete used not less than M20 grade.
- Foundation will be cost after PCC work.
- Foundation footing thickness minimum 400mm.
- OPCC ratio M10 used in foundation.
- If soil bearing capacity is less then 24kn/m³ than provide pile foundation

Spread footing for walls

- Spread footings are those which spread the super imposed load of wall or column over a larger area.
- Spread footings support either a column or wall. Spread footings may be of the following types.
    - Single footing for a column (isolated footing)
        - Single footing for a column, in which the loaded area (b x b) of the column has been spread to the size B x B through a single spread.
        - Stepped footing for a column
            - Stepped footing for a heavily loaded column, which requires greater spread. The base of column is made of concrete.

Width of shallow foundation

A shallow foundation may be no less than 800 mm and no more than 3m in depth. In areas where the earth is strong and can readily support the weight of the building, shallow foundations may be employed.

Thickness of concrete block

Minimum Thickness of Concrete Footing

Type of Footing	Minimum Thickness
Masonry	**250 mm**; twice the maximum projection from the face of the wall
Plain concrete	200 mm, or twice the maximum offset in a stepped footing
Reinforced concrete (depth above bottom reinforcement)	150mm 300mm

Deep foundations: Pile foundations - their suitability, classification of piles based on materials functions and methods of installation

Pile foundation

Pile foundation is the one type of deep foundation in which the loads are taken to a low level by means of vertical members is called as pile, which may be of timber, concrete or steel.

Situation demand for pile foundation

- Where the live load and dead load coming from the structure is considerably large.
- Where the construction of grillage or raft foundation is not economical.
- When the loads are to be taken to depth in a weak soil, by virtue of skin friction developed along the length of pile.
- When sandy soils are to be compacted to increase the bearing capacity by means of compaction piles.
- When the foundations are to be protected from the danger of erosion in case the foundations are taken below the depth of scour.
- When the anchorage against horizontal pull is to be provided.
- When the structures are to be protected against uplift pressure or overturning moment.
- In case, where large inclined forces are to be resisted.

Types of Piles Based on Materials

1. Timber Piles
    - Untreated
    - Treated with Preservative
2. Concrete Piles

    - Pre-cast Piles
    - Cast-in-place Piles
3. Steel Piles
    - I-Section Piles
    - Hollow Piles
4. Composite Piles

Timber

- Timber piles are the types of piled foundations that are placed under the water level. They last for approximately about 30 years. They can be rectangular or circular in shape. Their diameter or size can vary from 12 to 16 inches. The length of the pile is usually 20 times the top width.

- They are usually designed for 15 to 20 tons. Additional strength can be obtained by bolting fish plates to the side of the piles.

Concrete piles

Pre-cast Concrete Pile

The precast concrete pile foundation is cast in a pile bed in horizontal form if they are rectangular in shape. Usually, circular piles are cast in vertical forms. Precast piles are usually reinforced with steel to prevent breakage during their mobilization from the casting bed to the location of the foundation. After the piles are cast, curing has to be performed as per specification. Generally curing period for pre-cast piles is 21 to 28 days.

Cast-in-Place Concrete Piles

This type of pile footing is constructed by boring soil up to the desired depth and then, depositing freshly mixed concrete in that place and letting it cure there. cast in situ concrete pile foundation is constructed either by driving a metallic shell to the ground and filling it with concrete and leaving the shell with the concrete or the shell is pulled out while concrete is poured. Usually, round piles are used in cast-in situ piling.

Steel Piles

Steel piles may be of I-section or hollow pipe. They are filled with concrete. The size may vary from 10 inches to 24 inches in diameter and the thickness is usually ¾ inches. Because of the small sectional area, the piles are easy to drive. They are mostly used as end-bearing piles.

Classification of pile foundation based on function

- **End bearing pile**
  End bearing piles are used to transfer load through water or soft soil to a suitable bearing stratum. Such piles are used to carry heavy loads safely to hard strata. Multi storeyed buildings are invariably founded on end bearing piles. So that the settlements are minimized.

- **Friction pile**
  Friction piles are used to transfer loads to a depth of a frictionload carrying material by means of skin friction along the length of the pile. Such piles are generally used in granular soil where the depth of hard stratum is very great.

- **Combined end bearing and friction pile**
  A pile which transfers the super imposed load both through side friction as well as end bearing. Such piles are more common, specially when the end bearing piles pass through granular soil.

- **Compaction piles**
  - Compaction piles are used to compact loose granular soils, thus increasing their bearing capacity.

  - The compaction piles themselves do not carry a load. Hence they may be of weaker material (such as timber, bamboo sticks etc.,) sometimes of sand only.

  - The pile tube, driven to compact the soil, is gradually taken out and sand is filled in its place thus forming a sand pile.

Classification of piles based on method of installation

There are a four main types of pile foundation, each with its own method of construction:

1. Driven piles
2. Bored piles
3. Driven and cast-in-situ piles
4. Aggregate piles

Chapter 3 Walls and masonry works

Purpose of walls

- Wall is one of the most essential components of a building.

- The primary function of a wall is to enclose or divide space of the building to make it more functional and useful.

- Walls provide privacy, afford security and give protection against heat, cold, sun and rain.

- Walls provide support to floors and roofs.

- Walls should therefore be so designed as to have provision of adequate

  - Strength and stability

  - Weather resistance

- Durability
- Fire resistance
- Thermal insulation
- Sound insulation

Classification of walls - load bearing,non-load bearing walls, retaining walls.

Walls may be basically divided into two types

- Load bearing
- Non load bearing

- Each type may further be divided into external walls and internal or divide wall.
- Load bearing walls are those which are designed to carry super imposed loads in addition to their own weight.
- Non load bearing walls carry their own load only.
- Walls are further classified as follows

Partition wall

- A partition wall is a thin internal wall which is constructed to divide the space with the building into rooms or areas.
- It may either be non load bearing or load bearing. A load bearing partition wall is called an internal wall.

Party wall

A party wall is a wall separating adjoining buildings belonging to different owners or occupied by different persons. It may or may not be load bearing

Separating wall

- A separating wall is a wall separating different occupancies within the same building

Curtain wall

A curtain wall is a self supporting wall carrying no other vertical loads but subject to lateral loads

Load bearing wall

- It can be exterior wall or interior wall. It brace from the roof to the floor.

- As the height of the building increased, required thickness of wall and resulting stress on foundation will also increase and cause it to be uneconomical.

- The thickness of load bearing walls is based on the quantity of load from roof it has to bear. For example a load bearing wall with just a ground floor can have its outer walls of 230mm, while with one or more floors above it, based on occupancy type, its thickness may be increased.

- The load bearing walls can be reinforced or unreinforced masonry walls.

Load bearing walls may further divided into the following types

- Solid masonry wall
- Cavity wall
- Faced wall
- Veneered wall

Solid masonry wall

- Solid masonry walls are the one most commonly used.
- These walls are built of individual blocks of internal, such as bricks, clay or concrete blocks or stones, usually in horizontal courses, cemented together with suitable mortar.
- A solid wall is constructed of the same type of building units throughout its thickness. However it may have openings for doors, windows, etc.

Cavity wall

- A cavity wall is wall comprising two leaves, each leaf being built of structural units and separated by a cavity and tied together with metal ties or bonding units to ensure that the two leaves act as one structural unit.
- The space between the leaves is either left as a continuous cavity or is filled with non load bearing insulating and water proofing material.

Faced wall

A faced wall is a wall in which the facing and backing are of two different materials which are bonded together to ensure common action under load.

Veneered wall

- A veneered wall is a wall in which the facing is attached to the backing but so bonded as to a result in a common action under load.

Non load bearing wall

- Non load bearing walls carry their own load only.
- They generally serve as divide walls or partition walls. The external non load bearing wall, commonly related to framed structures is termed as panel wall.

Retaining walls

- A retaining wall is a wall designed to retain soil or water on one side.
- Design of a retaining wall Retaining walls have a primary function of retaining soils or water at an angle in excess of the soil's nature angle of repose.
- Walls within the design height range are designed to provide the necessary resistance by either their own mass or by the principles of leverage.

Types of retaining walls

- Mass retaining walls
- Cantilever walls
- Counterfort retaining walls
- Precast concrete retaining walls
- Precast concrete crib-retaining walls

Classification of walls as per materials of construction

Load bearing wall

- As the name suggests, the construction of the entire building rests on the walls instead of the pillars.
- Generally, the load from the slab is transferred onto the beam, from the beam to the column, and then to the foundation.
- In simple terms, whether its external or internal walls, the wall that carries the entire weight of the structure including the self-weight of the structural elements, is called a load-bearing wall.
- Strip foundations are adopted for the load-bearing walls.

Non load bearing wall or Drop wall

- This non-load-bearing wall does not support the ground or roof load above them which implies it does not bear any of the construction load.
- The most effective examples are partition walls inside the building, where they are constructed to divide rooms and these walls should not be with their structural integrity.
- These types of walls might be eliminated or shortened without affecting the structure of the building.
- The thickness of a non-load bearing wall is usually between 100 mm to 125 mm.

Shear wall

- A shear wall is a wall that is built around a lift pit, water pump or ladder to retain soil.
- There are two pressures on shear wall, either it can be air pressure, soil pressure or water pressure.
- The shear wall is adapted to resist lateral forces exerted on the structure due to wind, earthquake or any other lateral load.
- To explain, let us take an example of overhead water tank.
- The overhead tank is exposed to air because it is built at heights that includes the wind pressure over it.
- The water tank contains water which creates water pressure inside the tank, shear wall resists these forces without any deflection.

Retaining wall

- The wall that is constructed to maintain an uneven level of the floor on its two faces known as a retaining wall.
- The wall that is built around the plot below the floor to retain soil at one end and land sliding after the earthwork on site are known as retaining wall.

Brick masonry wall

- The wall that is built with the help of bricks is called a brick masonry wall, while masonry is used to join bricks to the wall, the thickness of the brick wall can be 20 cm or 10 cm.
- The 20 cm wall is adopted for exterior walls.
- The 10 cm wall is adopted for interior walls.

- Remember, the length of a brick wall in a single section should not exceed 4 meters, if it exceeds, a column must be constructed with RCC.

Course rubble stone masonry walls

- The wall, which is regularly constructed with the shape of stones that are well finished & dressed is called the course rabble stone masonry wall.

- This types of walls are usually adopted for the abutments of bridges, composite walls or boundary walls.

Random rubble stone masonry wall

The wall that is constructed with irregular shapes of stones is called a random rubble wall, which has more masonry than the courted debris stone wall.

Core wall

- The core wall has been constructed from the foundation which has grown to the height of the building.

- In these types of walls, the wall itself acts as a column, while the core wall is constructed to hold the lateral force exerted on the structure due to wind, earthquake or another lateral load.

- These walls are a combination of shear walls, they organized and arranged like a core and installed on the geometric center of the building to minimize the torsional effect.

Precast walls

- As the name itself proves it is a finished wall, where this wall is cast into the factory and bought on site to be installed.

- These walls are preferred, where space for working is limited and labor is less likely.

- The most effective part of precast walls is companies providing skilled labor to install walls in your site.

Parapet wall

The wall is built on the top floor of the building to prevent something from falling off the roof, while the height of the parapet wall is 3 feet.

Curtain walls

A wall made with glass, aluminum, or steel frame is called a curtain wall that is commonly adopted in offices, hospitals, and other public buildings.

Boundary wall or Compound walls

The wall that is constructed across the building to indicate the boundary of the plot is known as boundary wall.

Partition Walls

Requirements of partition walls

- The partition wall should be strong enough to carry its own load.
- The partition wall should be strong enough to resist impact to which the occupation of the building is likely to subject them.
- The partition wall should have the capacity to support suitable decorative surface.
- A partition wall should be stable and strong enough to support some wall fixtures, wash basins etc.
- A partition wall should be as light as possible.
- A partition wall should be as thin as possible.
- A partition wall should act as a sound barrier, specially when it divides two rooms.
- A partition wall should be fire resistant.

Brick partition

Brick partitions are quite common since they are the cheapest. Brick partitions are of three types:

- Plain brick partitions
- Reinforced brick partitions.
- Brick nogging partitions.

Plain brick partitions

- Plain brick partitions are usually half brick thick. i.e., stretchers bond.
- These walls are plastered on both the sides. This walls is considerably strong and fire resistant.

Reinforced brick partitions

- These are stronger than the ordinary brick partitions and are used when better longitudinal bond is required or when the partition wall has to carry other super imposed loads.

- The thickness of the wall is kept equal to half brick (10 cm). The reinforcement consists of steel meshed strips, called exmet made from thin rolled steel plates which are cut and stretched (or expanded) by a machine to a diamond network.

- Such a strip is known as expanded metal and is provided at every third course.

Brick nogging partitions

- Brick nogging partition wall consists of brick work (half brick thickness) with the frame work of wooden members. The timber frame work consists of,

    - Sill
    - Head
    - Vertical members, called studs, and

    - Horizontal members called nogging pieces

- The vertical members or studs are spaced at 4 to 6 times the brick length.

Timber partitions

- Timber partitions consist of wooden frame work, properly supported on floor and fixed to the side walls.

- This frame work, made of horizontal and vertical members, can either be plastered or covered with boarding etc., on both the sides.

- Wooden partitions are light weight, but are costlier. It is likely subjected to decay, or eaten away by termites. Also, it is not fire resistant. It's use is reducing day by day.

Two types of wooden partitions may be used:

- Common or stud partition.

- Trussed or braced partition

Common or stud partition

- It consists of a frame work of vertical members called stud and short horizontal pieces called noggings.

- Horizontal pieces impart rigidity to studs.

Trussed or braced partitions

- Trussed or braced partitions are provided where there is no means of supporting the partition except at their ends.

- The frame work is similar to the stud partition, but inclined members called braces, steel straps and bolts are additionally used.

Brick masonry: Definition of different terms

Definition - Brick masonry is a highly durable form of construction. It is built by placing bricks in mortar in a systematic manner to construct solid mass that withstand exerted loads.

Terms used in masonry

Course - A course is a horizontal layer of masonry unit. Thus, in stone masonry, the thickness of a course will be equal to the height of the stones plus thickness of one mortar joint

Header

- A header is full stone unit or brick which is so laid that its length is perpendicular to the face of the wall.

- Thus, the longest length of a header lies at right angles to the face of work.

Stretcher- A stretcher is full stone unit or brick which is so laid that its length is along or parallel to the face of the wall.

Header course

- A course of brick work showing only headers on the expose face of the wall is known as header course or heading course. Engmaching Courses

- Thus a header course of bricks will show all the bricks units measuring 10 cm × 10 cm of the face of the wall.

Stretcher course

A course of brick work showing only the stretchers or the exposed face of the wall is known as the stretcher course or stretching course.

Bed

This is the lower surface of a brick or stone in each course. This is the surface of stone or brick perpendicular to the line of pressure.

Bond

Bond is a term in masonry, applied to the overlapping of bricks or stones in alternate courses, so that no course continuous vertical joints are formed and the individual units stretcher are tied together.

Quoins

- The exterior angle or corner of a wall is known as quoin. The stones or bricks forming the quoins are known as stone quoins.
- If the quoin is laid in such a manner that its width is parallel to the face of the wall, it is known as quoin header.
- If however, the length of the quoin is laid parallel to the face of the wall, it is known as quoin stretcher.

Face - It is the surface of the wall exposed to the weather

Back- The inner surface of the wall which is not exposed to weather is termed as back.

Hearting - The inner portion of the wall between the facing and backing is known as the hearting.

Side- It is the surface forming the boundary of bricks or stones in a direction transverse to the face and bed.

Joint

- The junction of adjacent units of bricks or stones is known as joint.
- Joints parallel to the bed of bricks or stones is known as bed joint.
- Joints perpendicular to the face of the wall is known as cross joint or vertical joint.

Closer

- It is a portion of a brick with the cut made longitudinally and is used to close up bond at the end of the course.
- A closer helps in preventing the joints of successive sources (higher or lower) to come in a vertical line. Closers may be of various types, defined below.
    - Queen closer
        - It is a portion of a brick obtained by cutting a brick lengthwise into two portions.
        - Thus, a queen closer is a brick which is half as wide as the full brick. This is also known as queen closer half.

- When a queen closer is broken into two pieces, it is known as queen closer quarter. Such a closer is thus a brick piece which is one quarter of the brick size.

- King closer
  - It is the portion of a brick which is so cut that the width of one its end is half that of a full brick, while the width at the other end is equal to the full width.

  - It is thus obtained by cutting the triangular piece between centre of one end and the centre of the other (lay) side. It has half header and half stretcher face.

- Bevelled closer
  - It is a special form of a king closer in which the whole length of the brick (i.e., stretcher face) is bevelled in such a way that half width is maintained at one end and full width is maintained at the other end.
- Mitred closer
  - It is a portion of a brick whose one end is cut splayed or mitred for full width. The angle of splay may vary from 45° to 60°. Thus, one longer face of the mitred closer is of full length of the brick while the other longer face is smaller in length.

Bat
It is the portion of the brick cut across the width. Thus, a bat is smaller in length than the full brick.

Sill
The bottom surface of door or a window opening known as a sill. Sill is thus the horizontal member of brick, stone, concrete or wood provided to give support for the vertical members of the opening, and also to shed off rain water from the face of the wall immediately below the opening.

Lintel
It is a horizontal member of stone, brick, wood, steel, or reinforced concrete, used to support the masonry and the superimposed load above an opening.

Plinth course
Plinth is defined as the portion of the structure between the surface of the surrounding ground and floor level of the building.

String course
It is the continuous horizontal course of masonry, project from the face of the wall for shedding the rain water off from the face. It is generally provided at every floor and sill level.

Corbel
A corbel is a projecting stone which is usually provided to serve as support for joist, truss etc

Cornice

- It is a projecting ornamental course near the top of the wall or at the junction of wall and the ceiling.
- It penetrates the full width of the wall. It weathered and throat to dispose off rain water.
- In order to prevent over turning of cornice, extra weight in the form of parapet wall should be provided.

Coping

- It is a covering of stone, concrete, brick of terracotta, place on the exposed top of a wall, to prevent seepage of water.
- It may also be provided on the top of compound wall.
- Coping is suitably weathered and throated.

Weathering
It is term used to denote the provision of the slope on the upper surface as sills, cornices, string courses, copings,etc.

Throating

- It is a groove provided on the under side of projecting elements such as sills, cornices, string courses, copings, etc.
- So that rain water can be discharged clear of the wall surface.

Parapet

- It is the portion of low height wall constructed along the edge of the roof to protect the users.
- Parapet acts as a protective solid balustrade for the users.
- In the case of pitched roof, parapet is constructed to conceal the gutter at the eaves level.

Arch
Arch is structural construction of masonry constructed by mechanical arrangement of wedge shaped blocks of stones or bricks arranged in the form a curve supporting wall or load above the opening.

Gable
It is a triangular shaped masonry work, provided at the ends of a sloped roof.

Frieze
It is a course of stone placed immediately below the cornice, along the external face of the wall, intended to improve the appearance of the wall.

Blocking course
It is another course of stone placed immediately above the cornice. Apart from improving the appearance of the wall, it adds to the stability of the cornice against overturning.

Toothing
These are the bricks left projecting in alternate courses for the purposes of bonding future masonry work.

Spalls
Spalls are the chips or small pieces of stones obtained as a result of reducing big blocks of stones into the regular stone blocks.

Stoolings
These are the horizontal stones provided to receive jambs and mullions. These are formed at the ends of sills, transomes and heads.

Template or bed block
It is defined as the block of stone or concrete provided under a beam or girder to distribute the concentrated load over a greater area of the bearing surface.

Column
It is a vertical load bearing member of masonry, which is constructed in an isolation from the wall, and whose width does not exceed four times its thickness.

Pier or pilaster

- Pier is an isolated vertical mass of stone or brick masonry to support beams, lintels, arch etc, the width of which exceeds four times its thickness.

- If it is made monolithic with the wall and projecting a little beyond to support the ends of a beam or truss etc, then it is called a pilaster.

Buttress
It is a sloping or stepped masonry projection from a tall wall intended to strengthen the wall against the thrust of a roof or arch

Offsets
These are the narrow horizontal surfaces which are formed by reducing the thickness of the wall. Walls of tall buildings are formed with offsets. Similarly, offsets are also provided in masonry footings.

Thresholds

- Thresh holds is the arrangement of steps provided from the plinth level of external door or verandah to the ground level.

- These may consist of stone, brick or concrete and are constructed at the last stage of construction activities of the building. wilding

Bond

English bond

- This bond consists of alternate courses of headers and stretchers.

- This is the most commonly used bond, for all wall thicknesses. This bond is considered to be the strongest.

- The bond consists of alternate courses of headers and stretchers.

- In this bond, the vertical joints of the header courses come over each other; similarly, the vertical joints of the stretcher courses also come over each other.

- In order to break the vertical joints in the successive courses, it is essential to place queen closer after the first header (quoin header) in each heading course.

- Also, only headers are used for the hearting of thicker walls.

Stone masonry

Introduction to stone masonry

- Stone masonry is the art of building the structure with stones bonded together with mortar.

- Stone masonry may be adopted for the construction of foundations, columns, walls, lintel,arches, floors etc., of a building.

- Dams, retaining walls and other structures can also be built up in stones.

- Stones are derived from rocks available in nature.

- Stones are used in construction after properly cutting and dressing to the required shapes.

- But stones are not available everywhere. It transportation and handling cost is considerably high, which restricts its use.

Materials required for stone masonry

The following two materials are used for stone masonry.

- Stones
- Mortar

Stones

- The stones used for masonry should be hard, durable, tough and sound, and free from weathering, decay or defects like cavities, cracks, sand hole, injurious veins patches of loose or soft materials etc.
- The stones should be obtained only from the approved quarry.

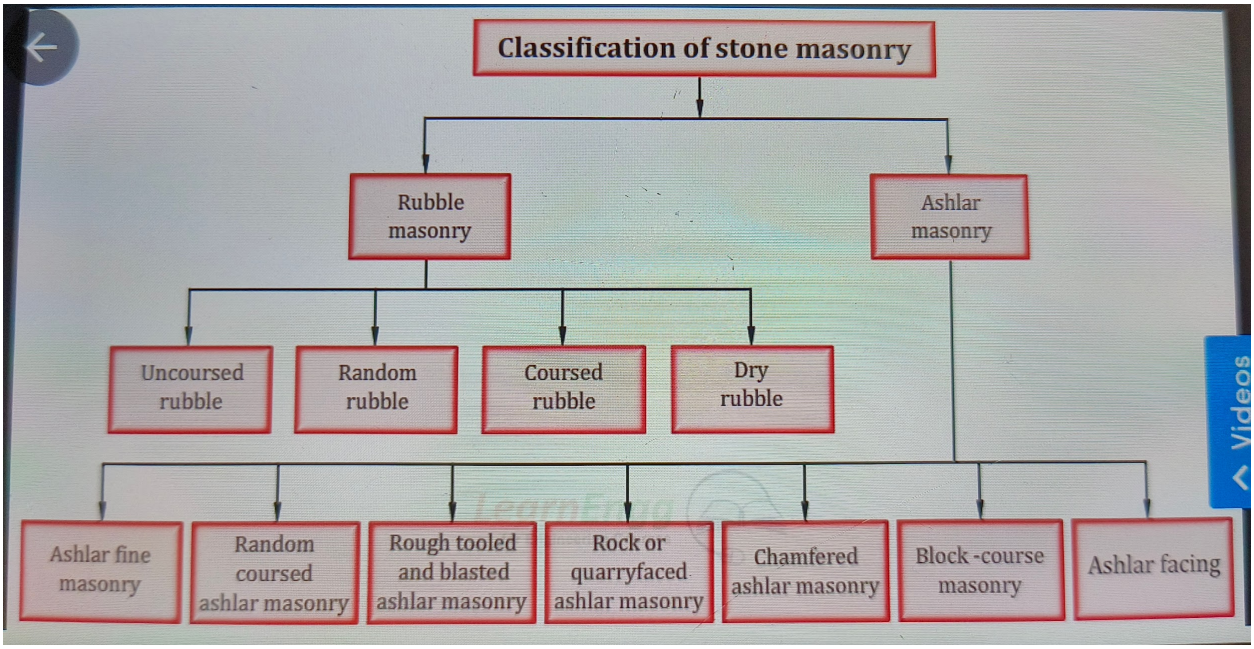
Mortar

- Mortar is a binding material for stone blocks used in the construction of stone masonry.
- Cement or lime is mixed with sand and water to a form a uniform paste.
- The selection of suitable mortar depends upon the load coming on the structure, strength desired and the colour of the stone used to obtain good combination of colours on the face work.
- It is a general practice to use 1:3 cement mortar in stone masonry. Sometimes about 10 to 15% of cement is replaced by hydrated lime to improve the workability of the mortar.
- If about 10 to 15% of lime is replaced by cement in a mortar, it is known as lime cement mortar.
- This increases the strength of the lime mortar and makes it more plastic.

Classification of stone masonry

Depending upon the arrangement of stones in the construction, degree of refinement used in shaping the stone and finishing adopted, stone masonry can be classified as follows.

- Rubble masonry
- Ashlar masonry



Ashlar masonry

- Ashlar masonry consists of blocks of accurately dressed stone with extremely fine bed and end joints.

- The blocks may be either square or rectangular shaped. The height of stone varies from 25 to 30 cm.

- The height of blocks in each course is kept equal but it is not necessary to keep all the courses of the same height.

- Ashlar masonry may be subdivided into the following categories

    1. Ashlar fine tooled
    2. Ashlar rough tooled
    3. Ashlar rock, rustic or quarry faced
    4. Ashlar chamfered
    5. Ashlar block in course
    6. Ashlar facing

Rubble masonry

- In the rubble masonry, the blocks of stone those are either undresses or comparatively roughly dressed.

- The masonry has wide joints, since stones of irregular sizes are used.

- The rubble masonry are following types

    - Random rubble

        - Uncoursed
        - Built to course
    - Square rubble
        - Uncoursed
        - Built to course
    - Miscellaneous types
        - Polygonal walling
        - Flint walling
    - Dry rubble masonry

Glossary of terms

String course

- It is the continuous horizontal course of masonry, projecting from the face of the wall for shedding rain water off the face.
- It is generally provided at every floor and sill level. A string course breaks the monotony of a plane surface, and thus imparts aesthetic appearance to the structure.
- The string course is suitably weathered and throated so as to throw off water clear of the wall surface.

Corbel

- A corbel is a projecting stone which is usually provided to serve as support forr joist, truss, weather shed etc. Corbels are generally moulded and given ornamental treatment.
- Corbels should extend at least two thirds of their length into the wall, so that they do not overturn or come out of the wall.

Cornice

- It is a projecting ornamental course near the top of a wall or at the junction of the wall and the ceiling.
- It penetrates the full width of wall. It is weathered and throated to dispose of rain water .
- In order to prevent overturning of cornice, extra weight in the form of parapet wall should be provided.

Blocking course

It is another course of stone placed immediately above the cornice. Apart from improving the appearance of the wall, it adds to the stability of the cornice against overturning.

Grouting

- The method of using grout to repair cracks in concrete, fill gaps in tiles, seal joints and stabilize the soil, etc. is called grouting.

- Grouting is used to provide additional strength to a building's foundation and structure. It is also used to repair cracks in concrete, fill gaps in tiles, seal joints, and stabilize soils.

Moulding

A narrow strip of wood shaped to a curved profile that's used to accent and emphasize the ornamentation of a structure and to conceal surface or angle joints.

Template or Bed block

It is defined as the block of stone or concrete provided under a beam or girder to distribute the concentrated load over a greater area of the bearing surface.

Throating

It is a groove provided on the underside of the projecting elements such as sills, cornices, coping etc so that rain water can be discharged clear of the wall surface.

Through stone

- A through stone is a stone header. Through stones are placed across the wall at regular interval.

- If the thickness of the wall is small, through stone may be of length equal to the full width of the wall. If, however the wall is considerably thick, two through stones with an overlap are provided.

- Through stones should be strong, and non-porous, and should be of sufficient thickness.

Parapet

It is the portion of low height wall constructed along the edge of the roof to protect the users. Parapet acts as protective solid balustrade for the users.

Coping

- It is a covering of stone, concrete, brick of terracotta, placed on the exposged top of a wall, to prevent seepage of water.

- It may also be provided on the top of compound wall. A coping is suitably weathered and throated.

Pier or Pilaster

Pier is an isolated vertical mass of stone or brick masonry to support bear lintels, arch etc; the width of which exceeds four times its thickness.

Buttress

It is a sloping or stepped masonry projection from a tall wall intended to strengthen the wall against the thrust of a roof or arch.

Chapter 4 - Doors, windows, and lintels

Glossary of terms used in doors and windows

Frame- It is an assembly of horizontal and vertical members, forming an enclosure, to which the shutters are fixed.

Shutters

These are the openable parts of a door or window. It is an assembly of styles, panels and rails.

Head

This is the top or uppermost horizontal part of a frame.

Sill

This is the lowermost or bottom horizontal part of a window frame. Sills are normally not provided in door frames.

Horn

These are the horizontal projections of the head and sill of a frame to facilitate the fixing of the frame on the wall opening. The length of horns is kept about 10 to 15 cm.

Style

Style is vertical outside member of the shutter of a door or window.

Top rail

This is the top most horizontal member of a shutter.

Glossary of terms used in windows

- Light - The area between the outer parts of a window, usually filled with a glass pane.
- Frame - This holds the light in place and supports the window system.
- Lintel - A beam over the top of a window.
- Jamb - The vertical parts forming the sides of the frame.
- Sill (or cill) - The bottom piece in a window frame, often projecting beyond the line of the wall.
- Mullion - A vertical element between two window units or lights.

- Transom - A horizontal element between two window units or lights.
- Head - The uppermost member of the frame.
- Sash - The frame holding the glazing.
- Casement - A window (or sash) attached to its frame by one or more hinges.

Doors- types of doors

Doors commonly used in building are classified into the following types, depending upon

- Types of material
- Arrangement of different components
- Method of construction
- Nature of working operations

Types of door based on material

Wooden door

- Wooden doors are mostly used for residential building.

Aluminium Doors

Aluminium is a lightweight, strong, durable and affordable material that's often used to construct security doors and garage doors. On its own, aluminium is a poor insulator and conducts heat easily.

Steel doors

Steel offers outstanding security, and is commonly used in the construction of screen doors and grilles.

Glass door

Glass doors look fantastic, although their performance in terms of things like insulation and strength depends very much on the way they're constructed.

PVC door

PVC doors are widely used in water splash areas like toilets or bathrooms.

The advantages of PVC doors are,

- Variety of sizes to match unique requirements.

- Good strength
- Easy to install
- Maintenance free
- Uniformity of color saves cost of painting or polishing

Types of door based on arrangement of components

Battened and ledges
This is the simplest type of door, specially suitable for narrow opening.

The door is formed of vertical bonds, known as battens, which are usually tongued and grooved and are fixed together by horizontal supports known as ledges.

Battened, ledges and braced doors
These doors are improved versions of battened and ledged doors, in which additional inclined members, called races are provided to give more rigidity.

Battened,ledged and framed doors
This door is also an improved form of simple battened and ledged door, in which frame work for the shutter is provided in the form of two verticals known as styles.

Battened, ledged , braced and framed doors
- This door is the modification over type 3 door described above, with the provision of additional braces, provided diagonally between the ledges, to increase its length durability and appearance.
- This door consists of battens, two vertical members (styles), three ledges and two braces.

Types of door based on method of construction

Framed and panelled door
- These types of doors are widely used in almost all types of building, since they are strong and give better appearance than batten doors.
- This door consists of a frame work of vertical members (called styles) and horizontal members called rails which grooved along the inner edges of the frame to receive the panels.

- The panels are made from timber, plywood, particle board, A.C sheets or even of glasses.

Glazed door

- Glazed or sash doors are provided where additional light is required to be admitted to the room through the door or where the visibility of the interior of the room is required from the adjacent room.

- Such doors are commonly used in residential as well as public buildings like hospitals, schools, colleges etc.

- The doors may be either fully glazed or they are partly glazed and partly paneled.

- In the latter case, the ratio of glazed portion to paneled portion is kept 2:1; The bottom one third height is panelled and the top two third height is glazed.

Flushed door

- Flush doors are becoming increasingly popular these days because of their pleasing appearance, simplicity of construction, less cost, better strength and greater strength.

- Flushed doors are of two types, earnEngg

    - Solid core flush door

    - Hollow and cellular core flush door

Solid core flush door

- Such a door consists of the wooden frame consisting of styles, and top and bottom rails is used for holding the core.

- The core consists either of core strips of timber glued together under great pressure and faced on each side by plywood sheets or of block board, particle board or combination of particles board and block board faced with plywood sheets.

- In the laminated core, the wooden strips are of maximum width of 25 mm glued together and the length of each strip is equal to the length of the laminated core.

Hollow core and cellular core flush door

- A hollow core flush door consists of frame made up of styles, top rail, bottom rail and minimum two intermediate rails, each of a minimum 75 mm width.

- The inner space of the frame is provided with equally spaced battens each of minimum 25 mm width, such that the area of voids is limited to 500 sq.m.

- A cellular core flush door consist of a frame of styles, top rail and bottom rail, each of a minimum of 75 mm width, with the void space, filled with equidistant battens of wood or plywood, each of a minimum 25 mm in width.

Louvered door

- Louvered doors permit free ventilation through them and at the same maintain the privacy of the room.
- However, these doors harbour dust which is very difficult to be cleaned.
- These doors are generally used for latrines and bath rooms of residential and public buildings.

Types of door based on working operations

Collapsible steel door

- Such doors are used in godowns, workshops, public buildings etc., for provided increased safety and production to property.
- The door neither requires hinges for opening and closing nor any frame for hanging them.
- It acts like a steel curtain which can be opened or closed by horizontal push.
- The door is fabricated from vertical double channels joined together with the hollows on the inside, so that a vertical gap is created.
- The shutters operate between two iron of T shape, one fixed to the floor and other to the lintel.
- Rollers mounted on horizontal piece are provided both at the top and the bottom ends of vertical pieces.
- The doors is also provided with handles, locking arrangement, stoppers etc.

Swing door

- A swing door has its leaf attached to the door frame by means of special double action spring hinge, so that the shutter can move both inward and outward as desired.
- Generally such doors have single leaf but two leafs can also be provided.
- When the door is to be used a slight push is made and then action of spring brings the shutters in closed position.

Revolving door

- Such doors are provided only in public building such as libraries, museums, banks,
- Such a door provide entrance to one and excite to the other person simultaneously, and closes automatically when not in use.
- The door consists of a centrally placed mullion to which four radiating shutters are attached. This door is also suitable for air conditioned building or for buildings situated at a place where strong air blow through the air throughout the air.

Folding door

- Folding door is a type of door which opens by folding back in sections. They are usually to be found indoors.
- Folding doors may also be known as accordion doors or accordion partitions.
- Folding doors are designed to provide quick and easy space division with moderate sound attenuation and a pleasing visual appearance.

Sliding doors

- In such a door the shutters slides on the sides with the help of runners and guide rail.
- The door may have one sliding shutter, two shutters or even three shutters depending upon the size of opening.

Rolling steel shutter door

- These doors are commonly used for garages, godowns, shops fronts show windows, etc., since they are quite strong and offer proper safety to the property.
- The door consists of a frame, a drum and a shutter of thin steel plates, about 1 to 1.25 mm thick and interlocked together.
- The diameter of the drum varies from 200 to 300 mm. For Englisering Couress
- A horizontal shaft and springs are provided in the drum, due to which the shutter is opened or closed by small push or pull.

Windows - different types of windows

Casement window

- These are the main or common types of windows usually provided in buildings.

- The shutters of the window open like shutters of the doors.
- The window has a frame which is rebated to receive the shutters.
- The shutters consists of styles, top rails, bottom rails, and intermediate rails, thus dividing it into panels.
- The panels may either be glazed or unglazed or partly glazed.
- In case of windows with double shutters, the outer shutters may have wire gauged panels for fly proofings.

Sash or glazed door

- A sash window is a type of casement window, in which the panels are fully glazed.
- The frame of each shutter consist of two vertical styles, top rail and a bottom rail.
- The space between top and bottom rail is divided into small panels by means of small timber members placed horizontally and vertically.
- These timber members known as slash bars or glazing bars are rebated to receive glass panels.
- Glass panels are fixed to these slash bars either means of putty or by timber beads commonly known as glazing beads secured to the slash bars by means of nails.

Bay window

- Bay windows project outside the external wall of the room.
- This projection may be triangular, circular, rectangular or polygonal in plan.
- Such a window (shown in figure) is provided to get an increased area of opening for admitting greater light and air.
- They also provide extra space in the room and improve the overall appearance of the building.

Gable window

- It is a vertical window provided in the gable end of a pitched roof.
- It also increase the appearance of building.

Dormer window

- A dormer window is a vertical window provided on the sloping roof.

- Such a window provides ventilation and lighting to the enclosed space below the roof and at the same time, very much improve the appearance of the building.

Clearstory window

- These windows are provided in a room which has greater ceiling height than the surrounding rooms or when a lean-to-roof of low height is there adjacent to the room.

- It is generally provided near the top of the main roof and they open above the lean- to-roof or roof slab of adjoined rooms.

- The window shutter is made to swing on two horizontal shutters provided on side styles.

- It can be opened or closed by mean of two cords, one attached to the top rail and other to the bottom rail of the shutter.

Lantern window

- Lantern windows are provided over the flat roofs, to provide more light and air to the inner apartments/rooms of a building.

- The windows project above the roof level. They may be of several shapes in plan.

- They admit light either through vertical faces or inclined faces, as shown in Figure.

- The roof slab has an appropriate opening below the window.

Sky light

- A sky light is provided on a sloping roof, to admit light. The window projects above the top sloping surface. They run parallel to the sloping surface.

- The common rafters are suitably trimmed and the sky light is erected on a curb frame shown in Fig.

- The opening so made is properly treated by lead flashing to make the roof, surrounding the opening, water-proof.

Corner window

- This is a special type of window which is provided in the corner of a room.

- This window has two faces in two perpendicular directions. Due to this, light and air is admitted from two directions.

- Such a window very much improves the elevation of the building. However, special lintel has to be cast over the window-opening.

- The jamb post of the window at the corner is made of heavy section, as shown in figure.

Pivoted window

- In these windows, the shutters are allowed to swing round pivots fixed to the window frame.
- The window frame has no rebates. The frame of the window shutter is similar to that of an encasement window.
- The shutter can swing or rotate either horizontally or vertically.

Metal window

- Metal windows, made of mild steel is becoming increasingly popular in private as well as public buildings, because of their strength and less cost.
- However, windows made of other metals, such as aluminium, bronze, stainless steel etc., are also used for those buildings where high degree of elegance finishing etc., is required.

French window

- French window is each of a pair of glazed doors in an outside wall, serving as a window and door, typically opening on to a garden or balcony
- A French window (when hinged French door) is a large door-sized lattice light, typically set in pairs or multiples, they often overlook a terrace and are commonly used in modern houses.

Purpose of arches and lintels

Purpose of arches

Arch, in architecture and civil engineering, a curved member that is used to span an opening and to support loads from above.

Purpose of lintel

- To span any opening like a window, door, cupboard etc., in a building.
- To take loads from the wall constructed above the lintels and to distribute to the walls on either side of the lintel over which they are placed.
- To facilitate the fixing of doors and window frames wherever they are used.
- However sufficient bearing of lintel ends on supports is very essential.

- They are designated as flexure members and should be checked for the forces of tension, compression due to bending and shear. After designing the depth of R.C.C lintel, it shall be adjusted to course heights of brick or stone.

Chapter 5 Floors,Roofs and Stairs

Glossary of terms in floors

Backing - Backing is the bottom-most layer of a floor. When used with vinyl flooring, it can be made of felt or fiberglass. Carpet backing refers to the underside of carpet. It helps to extend the life of carpet.

Back layer -

The back layer is the bottom layer or base of laminate flooring. It is typically made of a sturdy and moisture-resistant material, such as melamine.

Berber

- Berber carpet is named for a type of woolen, textured carpet made by Berber tribes in Morocco and other parts of North Africa.

- The yarns on Berber carpet are in loops that connect directly to the backing. Berber carpet is known for being able to withstand a lot of foot traffic and for being easy to clean.

Carpet pile - Carpet pile refers to the fibers on the top layer of carpet.

Ceramic

- Ceramic is a type of clay that is often used to make tile floors.

- Ceramic tile is often glazed to improve its moisture-resistance and for aesthetic reasons.

Cut pile

- Cut pile carpet features fibers that are cut, rather than looped. Cut pile carpet types include plush and shag.

- They usually feel much softer than loop pile carpets such as Berber.

Decorative layer

- The decorative layer is the layer of laminate flooring that gives the flooring its appearance.

- The decorative layer can feature a photo image that imitates the look of wood grain or the swirl and textures of marble or ceramic.

Expansion space

- Expansion space refers to gaps left when wood or laminate flooring is installed.

- The space allows the flooring to expand as a result of exposure to humidity without pushing the floorboards out of position.

Felt- Felt is a type of material often used as a backing for vinyl floors. It is installed using a permanent adhesive.

Fiberboard core - Fiberboard core is the middle layer of laminate flooring. It is made from softwood fibers and is designed to provide stability and impact-resistance to the flooring.

Fiberglass - Fiberglass is a type of material used as vinyl floor backing. It is a loose-lay backing and is often installed with non-permanent adhesives.

Finish- The finish is the coating on the top of a hardwood, laminate, tile or vinyl floor. It is designed to protect the surface of the floor from scuffs and wear. It also provides a decorative touch.

Floating - A floating floor has boards or planks attached together but is not secured to the underlayment or subfloor beneath. It is often quicker and easier to install a floating floor than one that is attached.

Frieze - Frieze (pronounced free-ZAY) is a cut pile type of carpet with a lot of texture. The high-pile fibers of the carpet are twisted multiple times to give it its distinct look and to help it withstand high traffic.

Grain - Grain refers to the visible, vertical patterns on a piece of wood.

Grout- Grout is a mortar or paste that holds tiles in place. It is often made of cement, epoxy or urethane.

Hardwood - Hardwood is a type of flooring made from the wood of deciduous trees that have broad leaves. Species of hardwood include cherry, maple, oak and poplar.

Impact resistance

- Impact resistance refers to how well a type of material can withstand the force of items being dropped on it.

- A floor with a high impact resistance will continue to look good even if things are regularly dropped on it or dragged across it.

Lacquer - Lacquer describes a type of finish used on hardwood flooring. Usually, lacquered wood has a very shiny finish.

Laminate - Laminate flooring is often designed to imitate the look of wood or tile flooring but is made from synthetic materials. It is available in a wide range of colors, styles and thicknesses.

Loop pile

- Loop pile carpet has fibers that are not cut but are instead shaped into loops and attached to the backing.

- Berber is a popular style of loop pile carpet.

Marble

- Marble is a type of stone sometimes used as a material for flooring.

- Marble has a distinct appearance and usually features swirls or veins of color.

- It does tend to be more high-maintenance and more expensive than other flooring options.

- Imitation marble is available for people looking for the look and elegance of the stone without the cost and upkeep requirements.

Overlap reducer - Sometimes simply called a reducer, an overlap reducer is meant to provide a transition between different types of flooring, often between flooring of different heights.

Overlap stair nose

An overlap stair nose is a piece of molding fitted onto the edge of the top stair. It is meant to help transition from the material used on the stairs to the material used on the floor.

Porcelain

- Like ceramic, porcelain is made from clay and is often used to create a tile floor. It is harder than ceramic and has better moisture resistance, but is also more brittle and fragile.

- The material is stain-resistance and very easy to keep clean. It can be slippery, especially if it gets wet.

Refinish

- Refinish means to add a new coat of finish to the top of a hardwood floor.

- The goal of refinishing is to minimize the appearance of scratches, scuff marks and other signs of damage.

Remnant

- A carpet remnant is often the end of a roll of carpet. Usually, remnants are too small to be used to cover an entire floor.

- You might buy a remnant to use as a throw rug or to carpet a portion of a room.

Solid wood

- Solid wood is a type of hardwood flooring made from whole pieces of wood from a hardwood species, such as oak, cherry or maple.

- It is one of the most durable types of flooring, but also tends to be among the most expensive.

Subfloor

- The subfloor is the structure that provides support to the top layer of flooring, such as hardwood or laminate.

- Often, a subfloor is laid over the joists and is made of plywood or cement.

Substrate

Substrate is a general term used to describe the materials that are beneath the top layer of flooring. It is sometimes used in place of subfloor or underlayment.

Tike

- Tile flooring consists of pieces of manufactured material, such as ceramic or porcelain.

- While ceramic and porcelain are among the two most commonly used types of tile, other options exist, such as marble, quartz and metal.

- Tile can often be treated to make it moisture, stain and slip-resistant.

Tongue and Groove

Tongue-and-groove refers to the way certain pieces of flooring fit together.

Veneer

- A veneer is a very thin material applied on top of another material.

- A veneer of an expensive wood might be applied on top of a less-expensive wood to make a floor more cost-effective, without sacrificing looks or quality.

Vinyl

Vinyl is a type of flooring made up of synthetic materials, such as polyvinyl chloride (PVC). Often, it consists of multiple layers, which helps to make it more resilient and better able to resist scratches, stains and other marks.

Wear Layer

- The wear layer is the top layer of a laminate floor. It is a clear finish designed to protect the floor from marks and stains.

- It can also make the floor waterproof and can the design on the decorative layer from fading.

Types of floors

Solid floor - The floors supported directly on the ground are known as solid floors. The floors supported directly on the ground are known as solid floors.

Suspended floors-

- The floors supported above the ground level are called suspended floors.
- The lowest layer just above ground surface is that of compacted earth fill.
- The second layer may either of lean cement concrete or lime concrete or stones rammed properly.
- The third course may be either of cement concrete or bricks or stones arranged and packed properly.
- Over the third layer of floor base, floor finish or flooring is laid.

Types of flooring based on materials

The various types of ground floor finishes commonly used are as follows:

- Mud and muram flooring
- Brick flooring
- Stone flooring
- Concrete flooring
- Granolithic flooring
- Terrazzo flooring
- Mosaic flooring

Cast in situ - In situ terrazzo is a technique where a terrazzo mix composed of cement or resin and marble chips is poured and polished on site. Large areas can therefore be installed with this technique, and often with few or any joints, giving it a monolithic appearance.

Concrete flooring Monolithic

A monolithic floor is a generic term used to describe a product which is not produced in a factory but cast as a single piece in-situ. It cannot be associated with any other remade product.

Concrete flooring bonded

A bonded screed floor is where a screed has been installed over the top of the concrete slab and bonded to the slab using an adhesive.

Terrazzo tile flooring

Terrazzo is a flooring material traditionally made by exposing marble chips on the surface of concrete and then polishing until smooth. Now, however, you can buy terrazzo in tile form. It's often used in public buildings because it's long-lasting and can be refinished repeatedly.

Timber flooring

It is a floor that entirely made of wood, preferably hardwood. Timber has always been used as a favorite flooring material of most homeowners because of its beauty, durability, and beauty.

Roofs : Glossary of terms

Span: It is clear distance between the supports of an arch, beam or roof truss.

Rise: It is the vertical distance between the top of the ridge and the wall plate.

Pitch: It is the inclination of the sides of a roof to the horizontal plane. It is expressed either in terms of degree or as a ratio of rise to span.

Ridge: It is defined as the apex line of the sloping roof. It is thus the apex of the angle formed by the termination of the inclined surfaces at the top of slope.

Eaves: The lower edge of the inclined roof surface is called eaves. Rain water from roof surface, easily drained off from eaves

Hip: It is ridge formed by the intersection of two sloping surfaces where the exterior angle is greater than 180 degree.

Valley: It is a reverse of a hip. It is formed by the intersection of two roof surfaces, making an external angle less than 180 degree.

Hipped end: It is the sloped triangle surface formed at the end of a roof.

Verge: The edge of a gable running between the eaves and ridge, is known as a verge.

Ridge piece, ridge beam or ridge board: It is a horizontal wooden member in the form of a beam or board which is provided at the apex of a roof truss. It supports the common rafters fixed to it.

Common rafters or spars: These are inclined wooden members running from the ridge to the eaves. They are beveled against the ridge beam at the head, and are fixed to purlins at intermediate point. They support the battens or boarding to support the roof coverings. Depending upon the roof covering material, the rafters are spaced 30 to 45 cm centre to centre.

Purlins: These are horizontal wooden or steel members used to support common rafters of a roof when span is large. Purlins are supported on trusses or walls.

Hip rafters: These are the sloping rafters which form the hip of a sloped roof. They run diagonally from the ridge to the corners of the walls to support roof coverings. They receive the ends of the purlins an ends of jack rafters.

Valley rafters: These are the sloping rafters which run diagonally from the ridge to the eaves for supporting valley gutters. They receive the ends of the purlins and ends of jack rafters on the both sides.

Jack rafters: These are the rafters shorter in length, which run from hip or valley to the eaves.

Eaves board or facia board: It is a wooden plank or board fixed to the feet of the common rafters at the eaves. It is usually 25 mm thick and 25 mm wide. The ends of the lower most roof covering material rest upon it. The eaves gutters if any can also be secured against it.

Barge board: It is a timber board used to hold the common rafters forming verge.

Wall plates: These are large wooden members, which are provided on the top of stone or brick wall for the purpose of fixing the feet of common rafters. These are embedded from sides and bottom in masonry of the walls, almost at the centre of their the thickness. Wall plates actually connect the wall to the roof.

Post plates: This is similar to the wall plate except that they run continuous, parallel to the face of the wall, over the tops of the post and support rafters at their feet.

Battens: These are thin strips of wood, called scantlings, which are nailed to the rafters for lying roof materials above.

Boarding's: They act similar to battens and are nailed to common rafter to support the roofing material.

Template: This is a square or rectangle block of stone or concrete placed under a beam or truss, to spread the load over a larger area of the wall.

Cleats: These are short sections wood or steal (angle iron) which are fixed on the principal rafters of trusses to support the purlins.

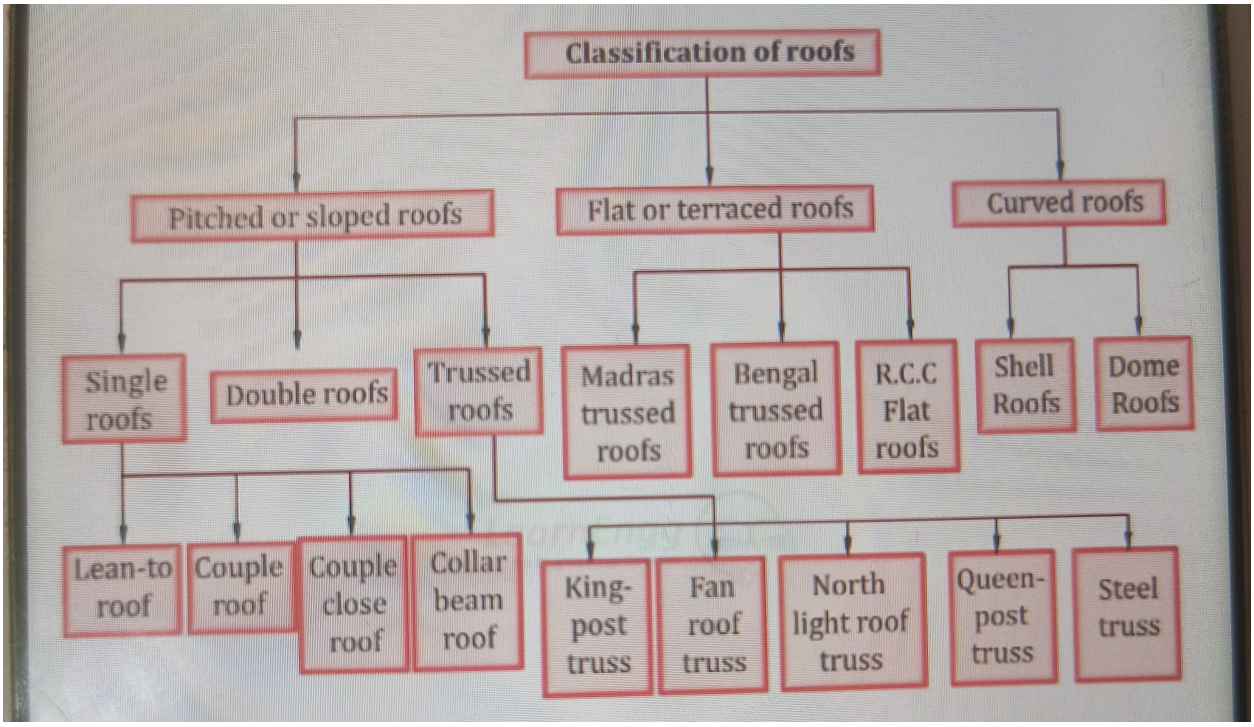
Truss: A roof truss is a frame work, usually of the triangle, designed to support the roof covering or ceiling over rooms.

Types of roof

Roofs are divided into three categories.

- Pitched or sloping roof

- Flat roofs or terrace roofs
- Curved roofs



Concept and function of flat

- Flat roof is the one which is either horizontal or partially horizontal with slope less than 10 degree.
- Even perfectly horizontal roof has some slope at top so that rain water can be drained off easily and rapidly.
- Similar to the upper floor, the flat roofs can be constructed of flag stones, R.S.J and flag stones, reinforced cement concrete, reinforced brick work, jack arch roof or precast cement concrete units.
- However, the flat roof differ from the upper floor only from the point of view of top finish, commonly called terracing, to protect from adverse effects of rain, snow, heat etc.

Function of flat

- The roof can be used as terrace for playing, gardening sleeping and for celebrating functions.
- Construction and maintenance is easier.

- They can be easily made from fire proof, in comparison to pitched roof.
- They avoid the enclosure of the triangular space. Due to this, the architectural features of the building very much improved.
- Flat roof have better insulating properties.
- They require lesser area of roofing material than pitched roof.
- They are more stable against high wind.
- They do not require false ceiling, which is essential in pitched roof.
- In multi storey buildings, the flat roof is the only choice, since overhead water tank and other services are located on the terrace.
- The construction of upper floors can be easily done over flat roofs, if so required in future.

Concept of pitched roof

A pitched roof is a roof that slopes downwards, typically in two parts at an angle from a central ridge, but sometimes in one part, from one edge to another. The 'pitch' of a roof is its vertical rise divided by its horizontal span and is a measure of its steepness.

Function of pitched roof

Pitched roofs are built to withstand snow, ice, water and wind. Shaped as a triangle, they are stable, stronger and ensure perfect water drainage. Some roofing tiles, like natural slate, are extremely tough, waterproof and fire-resistant.

Hipped roof

A hip roof, hip-roof or hipped roof, is a type of roof where all sides slope downwards to the walls, usually with a fairly gentle slope. Thus, a hipped roof has no gables or other vertical sides to the roof. A square hip roof is shaped like a pyramid.

Function - They provide more stability to structures. The slope design on all sides of the structure helps solidify the structure's exterior, making it more resilient to natural elements such as wind and rain.

Sloped roof- Sloped roofs are designed to allow precipitation like rain and snow to slide right off. The pitch reduces the beating taken by a roof, which helps to minimize damage when your roof begins to age. The lifecycle costs are lower for 50 years because the roof components are both durable and maintenance-free.

Stairs

Glossary of terms

Staircase

- Staircases are generally provided connecting successive floors of a building and in small buildings they are the only means of access between the floors.

- The staircase comprises of flight of steps generally with one or more intermediate landings provided between the floor levels.

Winder - The radiating or angular tapering step is called winder.

Landing - Landing is the horizontal slab provided between two flights. It is provided every 10 or 14 steps for comfort in climbing. Landing is also provided when there. is a change in the direction of the stalls.

Stringer - A stair stringer, which you might also see called a “string” or “stringer board”, is the housing on either side of a flight of stairs, either in an interior or used for an exterior location such as on a deck.

Newel - Also called Newel-post, upright post rising at the foot of a stairway, at its landings, or at its top.

Baluster- It is vertical member of wood or metal, supporting the hand rail.

Rise- Rise (r) is the vertical distance between two consecutive treads and riser is the vertical portion of the step.

Tread- Tread is the horizontal upper portion of a step where the foot rests. Going of step (g) is the horizontal distance of the tread minus the nosing.

Width of staircase - According to the Indian National Building Code, the minimum space for staircase in terms of width in a normal residential building should be 3 feet and 6 inches

Hand rail- It is a rounded or moulded member of wood or metal following generally the contour of the nosing line, and fixed on the top of balusters.

Nosing

- Sometimes, the tread is projected outwards for aesthetics or to provide more space; This projection is called nosing.

- Mostly, the nosing is provided by the finishing over the concrete tread.

Head room

- The vertical distance of a line connecting the nosing's of all treads and the soffit is referred to as the headroom.

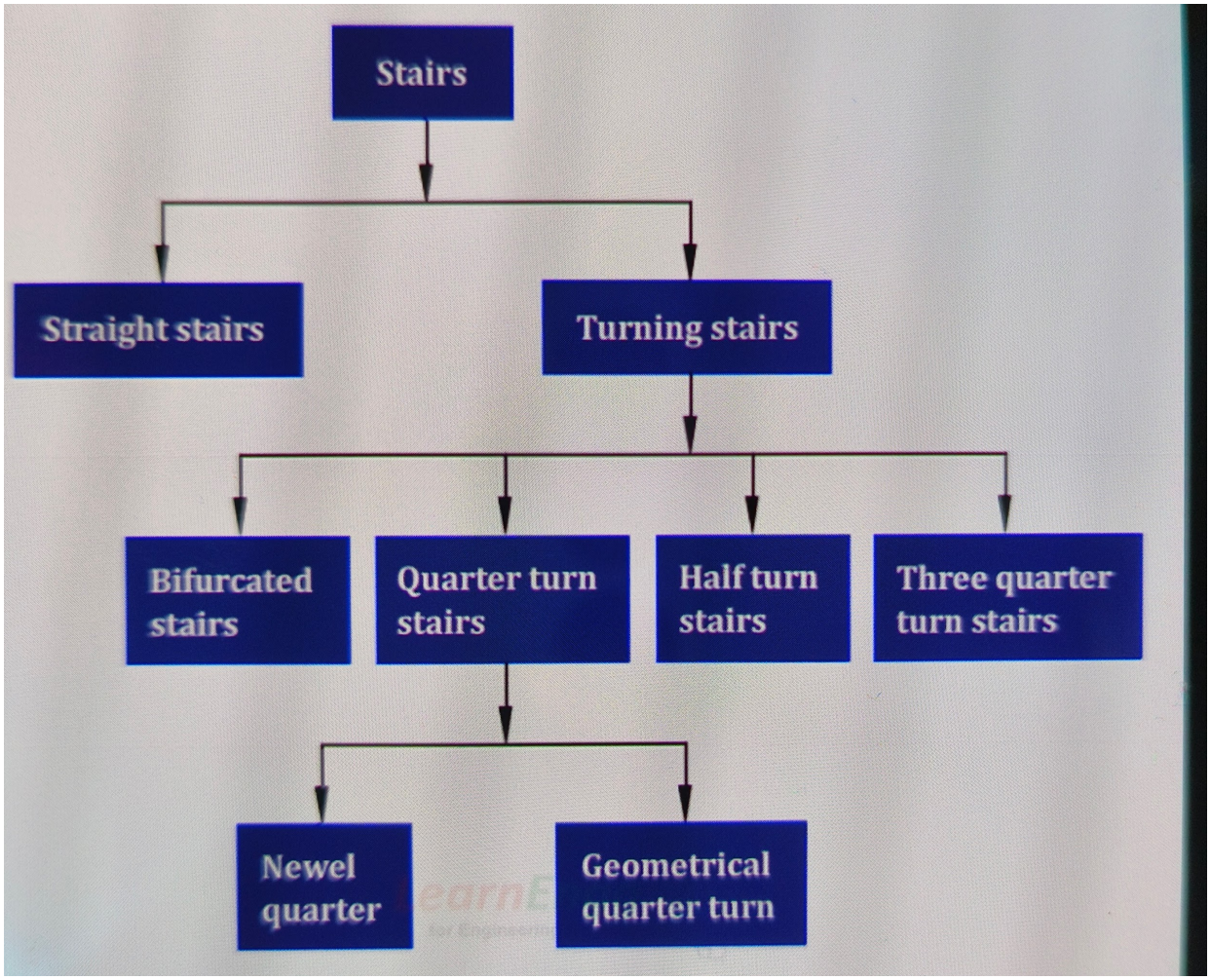
- A minimum of 2 in headroom is often recommended

Mumty room

Mumty" or "stair cover" means a structure with a covering roof over staircase and its landing built to enclose only the stairs for the purpose of providing protection from weather and not used for human habitation.

Types of staircase

Stairs can be classified in two broad heads.



Straight flight - In this type, stair runs straight between the two floors. It is used for small houses where there are restrictions in available width.

Dog legged - A dog-leg is a configuration of stairs between two floors of a building, often a domestic building, in which a flight of stairs ascends to a quarter-landing before turning at a right angle and continuing upwards. The flights do not have to be equal, and frequently are not.

Open well - This type of stair consists of two or more flights arranging a well or opening between the backward and forward flights. When all the steps are difficult to arrange in two flights, a short third flight of 3 to 5 steps may be provided along the direction perpendicular to the hall.

Quarter turn- A quarter turn stair is the one which changes its direction either to the left or to the right, the turn being affected either by introducing a quarter space landing or by providing winders.

Half turn staircase

- Half turn stair is the one which has its direction reversed, or changed for 180 degree.

These may be of three types

- Dog-legged or newel half turn stairsegory
    - It comes under the category at the beginning and end of each flight.

- Open newel half turn stairs
    - Open well or open newel half turn stair has a space or well between the outer strings.

- Geometrical half turn stair
    - The essential features of such stairs are that the stringers and hand rails are continuous without any intervening newel post.

Bifurcated stairs

- This type of stair is commonly used in public building at their entrance hall.
- The stair has wider flight at the bottom, which bifurcates into two narrower flights, one turning to the left and the other to the right, at the landing.

Spiral staircase A spiral staircase is a structure that is built around a central post that acts as an axis for its steps.

Cantilever staircase - A cantilever staircase is one where the solid stone steps (also known as treads) are embedded into a supporting wall on one end, with the other end 'free', visible and seemingly floating.

CHAPTER 6 PROTECTIVE FINISHES, DAMP AND TERMITE PROOFING

Plastering

Purpose of plastering

- To protect the external surfaces against penetration of rain water and other atmospheric agencies.
- To give smooth surface in which dust and dirt cannot lodge.
- To give decorative effect.
- To protect surfaces against vermit.
- To conceal inferior materials or defective workmanship

Types of plastering

Clay plastering -Clay plaster is a mixture of clay, sand and water often with the addition of plant fibers for tensile strength over wood lath.

Gypsum plaster (plaster of Paris)
Gypsum plaster also known as plaster of Paris is a white powder consisting of calcium sulphate hemihydrate. The natural form of the compound is the mineral bassanite.

Lime plaster
Lime plaster is a mixture of calcium hydroxide and sand (or other inert fillers). Carbon dioxide in the atmosphere causes the plaster to set by transforming the calcium hydroxide into calcium carbonate (limestone). Whitewash is based on the same chemistry.

Cement plaster
Cement plaster is a mixture of suitable plaster, sand, Portland cement and water which is normally applied to masonry interiors and exteriors to achieve a smooth surface.

Heat resistant plaster
Heat-resistant plaster is a building material used for coating walls and chimney breasts and for use as a fire barrier in ceilings

Types of plaster finishes

Grit finish - If you want rough and tough finished walls Grit Wash Plaster is the right choice for construction external walls. This is Better known as Exposed Stone Crete Plaster This process is hardy decorative finish can easily withstand all types of bad weather conditions.

Rough cast

- In this the mortar for the final coat contains fine sand as well as coarse aggregate in the ratio of 1: 1.5: 3 (cement: sand: aggregate).

- The coarse aggregate may vary from 3 mm to 12 mm in size.

- The mortar is dashed against the prepared plastered surface by means of large trowel.

- The surface is then roughly finished using wooden float. Such a finish is water proof, durable and resistant to racking and crazing, and may be used for external renderings

Smooth cast

- In this finish, smooth, levelled surface is obtained. The mortar for the finish may be made of cement and fine sand in the ratio of 1:3 mortar is applied with the help of wooden float.

- Steel floats are not recommended for external renderings since they give a very smooth finish which is liable to cracking and crazing under exposure to atmospheric conditions.

Sand faced

- This is obtained by plastering in two coats. The first coat is applied in 1:4 cement sand mortar for 12 mm thickness.

- It is provided with zig zag line.

- After curing it for 7 days, the second coat is applied in the thickness of 8 mm.

- The mortar for the second coat is prepared from cement sand mix ratio 1:1.

- The sand for this is perfectly screened so that uniform size is obtained.

- Sponge is used in the second coat when it is still wet. The surface of final coat is finished by rubbing clean and washed sand of uniform size by means of wooden float.

Acoustic plastering

Acoustic plasters consist of a base layer of absorptive substrate panels, which are typically mineral wool, or a non-combustible inorganic blow-glass granulate.

Plain plaster

This finish is just similar to sand faced finish except fine grained sand is used instead of coarse sand. No sponging is done to expose the sand grain . It is normally done on internal walls.

Pebble dash

- In this the final coat, having cement: sand mix proportioning of 1:3 is applied in 12 mm thickness.

- Clean pebbles of size varying from 10 to 20 mm size are then dashed against the surface, so that they are held in position.

- The pebbles may be lightly pressed into the mortar, with the help of wooden float.

Proportion of mortars used for different plasters , preparation of mortars, techniques of plastering and curing

Proportion of mortars used for different plasters

12 MM thick cement mortar in 1:4 ratios is recommended on the walls where smooth side exists. Either 9 or 4.5 MM thick and 15 MM thick cement plaster in 1:4 ratios is recommended on the rough side of the walls. 20 MM thick cement mortar in 1:3 with two coats is recommended in case of vertical Damp Proof Course (DPC).

Preparation of mortars

Step 1: Prepare your forced action mixer with rubber blades. The mixer is light and compact enough to moved by one person to where it is needed.

Step 2: Add the amount of water recommended for the mix into the mixer.

Step 3: Add the dry material to the mixer on a slow setting to avoid creating too much dust.

Step 4: Start the mixer and allow it to turn for several minutes until the concrete is thoroughly mixed.

Step 5: Pour the contents out of the mixer and into a wheelbarrow or other container. Ensure the mixer is cleaned after use to prevent the concrete from hardening inside.

Techniques of plastering

Step-I Preparation of surface for plastering

Step-2 Groundwork for plaster

Step-3 Applying first coat (or undercoat or delivering coat)

Step-4 Applying second coat (or completing coat or fine coat)

Techniques of curing

Curing of plaster refers to the process of maintaining the temperature and the moisture of plaster within the acceptable range for the hydration reaction such that the plaster develops into a hard mass with desirable properties".

Curing is not only the application of water over the plastered surface; preventing the loss of moisture is also the type of curing.

Spraying

- Spraying is carried out for curing structural elements such as columns, plastered surfaces, retaining walls, etc.

- In this method, curing is done by the application of water through spraying by pipes.

Wet covering

- The wet covering is adopted when sufficient water is not available.
- In this method, curing is done by covering the concrete members with wet gunny bags, wet jute mats, wet hessian cloth, etc.

Shading method of curing

The shading method of plastered is a simple method that involves preventing the exposure of the plastered surface to sunlight and heat thereby preventing the evaporation of water from the plastered surface.

Pointing - purpose - types of pointing

Purpose

- To improve the appearance of structure.
- To prevent the moisture and rain water from entering the interior of masonry walls through joints and to make them durable.

Types of pointing

- Flush pointing.
- Recessed pointing.
- Rubbed or grooved pointing.
- Beaded pointing.
- Struck pointing.
- Tuck pointing.
- V-pointing
- Weathered pointing.

Painting

Objectives

- To protect the surfaces from weathering agencies.
- To prevent wood from decaying.

- To prevent corrosion in metals.
- To provide decorative and pleasing appearance to the surfaces.
- To make the painted surfaces hygienically clean and safe.

Method of painting on new plastered wall

- Newly plastered surface may contain considerable moisture. Hence painting should be resorted to only after 3 to 6 months of plastering.
- Calcareous surfaces to lime and cement plastered surfaces are highly alkaline because lime is liberated during hydration of cement.
- Due to this, oil based paints and distempers are liable to alkali attack. Hence it is essential to apply alkali resistant primer.
- Absorption of liquid from a paint by a porous surface is known as suction.
- High suction may make the paint difficult to apply and leave the coating in an underbound condition.
- Preparation of plastered surface depends upon the type of paint to be applied over the surface.
- On drying, the new plastered surface shall be treated with dilute sulphuric or hydrochloric acid and then washed with water.
- The surface shall then be given a coat of sizing to fill up all the cracks and reduce suction of paint.
- The surface may also be given a coat of boiled linseed oil before applying the paint.
- After the oil has been absorbed by the surface, filling of cracks if any, shall be done by preparing a paste of chalk powder, plaster of paris and the paint to be used.
- The entire surface shall then be smoothened by rubbing it with sand paper.
- The surface thus prepared, shall generally be given four coats of the paint.
- The first two coats of the paint consist of white lead and boiled linseed oil.
- The third coat may be of white lead tinted to oil. The last coat may consist of large proportion of turpenitine oil.
- The surface is thus finally finished with a good brush.

- Ready made or ready mixed paints are also available in market which can be applied directly on the newly plastered surfaces.

Painting on old plastered wall surface

- If the old paint is firm and sound it shall be cleaned of grease, smoke etc., and then all dust, dirt and loose particles of paint shall be removed.

- If the old paint is badly blistered and flaked, it shall be completely removed by using any type of paint remover.

- If any portion of the wall shows signs of dampness, the causes shall be investigated and the damp surface shall be properly treated.

- A thin coat of white lead if required shall be applied on the wet or patchy portion of the surface before painting is undertaken.

- Application of new paints shall be carried out in similar way for new plastered surface.

Wood surface

Painting on new wood work

The painting on new wood work is done on the following steps. For good work 4 coats of paints are required, while for interior work, only 2 to 3 coats are applied.

Preparation of surface

- The surface is dusted off thoroughly to remove dust, shavings, foreign matter etc.

- Greasy spots, if any should be removed by rubbing with pieces of clean white muslin soaked in benzene or turpentine, allowed to dry.

Knitting

Knotting is the process of covering or killing all knots in the wood work with a substance through which the resin cannot come out or exude.

Priming

- After knotting, the surface is rubbed smooth with a abrasive paper.

- Priming consists of applying first coat of paint to fill all the pores.

- Usually, the ingredients of the paint are kept the same as in subsequent coats through in varying proportion.

Stopping

- It is process of rubbing down the wood surface by means of pumice stone after prime coat is applied and then filling up all cracks, all nail holes, dents etc., with putty.

- After putty dries up, the surface is rubbed again with pumice stone.

- The putty is made by mixing powdered chalk in linseed oil to the consistency of a thick paste.

Under coatings

- After stopping, second and successive coatings are applied.

- The under coatings should be of the same shade as that of the finishing coat.

- Sufficient time should be allowed for each coat to dry before next coat is applied.

Finishing coat

Finishing coat is applied after the under coat is perfectly dry. This coat is applied very carefully, by a skilled painter, so that finished surface is smooth, uniform and free from patches and brush marks.

Painting on old wood work

Before repainting old work, the old paint having cracks and blisters should be removed, by applying any one of the following solvents or paint removers.

- Applying solution containing 1 kg of caustic soda in 5 litres of water. The paint gets dissolved.

- Applying mixture containing one part of soft soap, two parts of potash and one part of quicklime, while in hot state. After 24 hours of application, the surfaces is washed with hot water.

- Applying mixture of equal parts of washing soda and quicklime to the required consistency. After 1 hour of application, the surface is washed with water.

- After removing the old paint, the surface is properly cleaned and then rubbed with pumice stone. The cleaned surface is given two or three coats of paint to obtain the desired finish.

Painting on metal surfaces

- In buildings, metal work consists of steel work and is painted for decoration and protection from weather so that it may become rusty.

- The painting on steel work may be done on a new surface or on an old painted surface as described below.

Powder of coating

- Powder coating is a process by which electrostatically charged powder is applied onto an earthed object.

- Spray painting and powder coating are carried out in a variety of industries.

- For example, items that are commonly spray painted include motor vehicles, buildings, furniture, white goods, boats, ships, aircraft and machinery.

Spray painting

- Spray painting, including electrostatic spray painting, is a process by which liquid paint is applied under pressure to an object.

- Spray painting may be carried out by hand or automatically. There are several methods used to atomise the paint for spraying:

- Using a conventional air compressor - air is driven across the mouth of a small outlet under pressure to draw liquid paint out of the container and produce an air-paint mist from the nozzle of the spray-gun
- Airless spray painting - the paint container is pressurised pushing the paint to the nozzle where it is atomised by the spray gun, or

- Electrostatic spray painting an electric pump drives the electrostatically charged liquid paint out of the nozzle which is then applied to the object which is earthed.

White washing

- White washing and colour washing of surfaces of building is necessary on both hygienic and aesthetic reasons.

- White wash is made of lime and water.

Colour washing

Preparation of colour wash

- Sufficient quantity of colour wash required for complete job shall be prepared in one operation to avoid difference in shade.

- Mineral colour shall be added to the white wash solution.

Distempering

- Distempers are considered to be water paints, consisting of whiting glue or casein as a binder and suitable proportion of fast colouring pigments.

- Distempering is the process of applying distempers over the various surfaces more easily.

- A distemper is composed of the following.

- A base such as whiting or chalk.
- A carrier.
- A binder such as glue or casein.
- Colouring pigments.

- Water bound distempers are available in powder or paste form, and they are mixed with hot water before use.
- Oil bound distempers are a variety of oil paint, in which the drying oil is so treated that it mixed with water.

Damp and termite proofing

Hot bitumen

Hot bitumen, 3 mm thick, may be applied on the bedding of mortar or concrete.

Bituminous felt

- It is a flexible material available in rolls. It is laid on flat mortar finished surfaces. An overlap of 100 mm is provided at the joints and full overlap at corners.
- The laps should be sealed with bitumen. It is likely to squeeze out under pressure and can accommodate slight movement.

Metal sheets

- Sheets of lead, copper and aluminum may be used as membranes in damp proofing.
- Among these metals, lead is the most ideally suited material. Lead and aluminum sheets need to be protected with a layer of bitumen.
- For economical and durability purposes, sometimes lead sheets are into a bituminous felt, that can be used as a damp proofing material.

Plastic sheets

A cheap method of damp proofing is by laying 0.5 - 1.0 mm thick plastic sheets made of black polythene. But it is not a permanent method.

Bricks

- Quality bricks absorbing water less than 4.5 per cent of their weight may be used for damp-proofing. for Engineering Courses
- These bricks are laid in 2-4 courses in cement mortar. Such a treatment is normally used in places where dampness is not excessive.

Mortar
Cement mortar in the ratio 1:3 is used for bedding layers over damp proofing course. It may be mixed with slaked lime to improve its workability.

Cement Concrete course
A cement concrete course of proportion 1:2:4 and thickness 75-150 mm is laid on masonry at plinth level. It prevents the rise of moisture into the wall by capillary action.

Methods of prevention of dampness in building

Following methods are adopted to make a building damp proof,

- Membrane damp proofing.
- Integral damp proofing.
- Surface treatment.
- Cavity wall construction.
- Guniting.
- Pressure grouting.

CHAPTER 7 GREEN BUILDINGS , ENERGY MANAGEMENT AND ENERGY AUDIT OF BUILDINGS & PROJECT

Concept of green building

Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction.

Introduction to Energy management and energy audit in buildings

Energy management of Buildings

- Energy management is the proactive, organized and systematic coordination of procurement, conversion, distribution and use of energy to meet the requirements, taking into account environmental and economic objectives".
- Energy management of buildings includes planning and operation of energy production and energy consumption units.
- Objectives are resource conservation, climate protection and cost savings, while the users have permanent access to the energy they need.

- It is connected closely to environmental management, production management, logistics and other established business functions.

Energy auditing

- As per Indian Energy Conservation Act 2001, Energy Audit is defined as "the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption".

- Energy auditing is a study of feasibility in a building and also first step in establishing energy management programe.

- It serves to identify energy use among the various services and to identify opportunities for energy conservation.

- The study should reveal to the owner, manager, or management team of the building the options available for reducing energy waste, the costs involved, and the benefits achievable from implementing those energy-conserving opportunities.

- The energy management program is a systematic on-going strategy for controlling a building's energy consumption pattern.

- It establishes and maintains an efficient balance between a building's annual functional energy requirements and its annual actual energy consumption.

Aims of energy management of Buildings

- The main objectives of energy management are resource conservation, environment protection and cost savings. The central task of energy management is to reduce costs for the provision of energy in buildings and facilities without compromising work processes.

- The simplest way to introduce energy management is the effective use of energy to maximize profit by minimizing costs. Energy management could save up to 70% of the energy consumption in a typical building or plant.

Energy management saves costs

- Now we already know this, using an EMS in a building may bring up to 29% savings on total energy consumption costs.

- Secondly, even a small measure undertaken, like replacing old CFL bulbs with more energy-efficient LED lights, can reduce the lighting energy consumption by more than 50% over a long period of time.

Reduces the risk of energy scarcity

- Though energy is just converted from one form to another, it's still susceptible to its scarcity.

- As per a study conducted by the US Energy Information Administration(EIA), the world's energy consumption is expected to grow by 48% by 2040. If not taken adequate steps, a sudden surge in energy demand may cause energy scarcity in the future.

To reduce greenhouse gas emissions
Though energy is just converted from one form to another, it's still susceptible to its scarcity

Renewables have overhead costs too
Even the energy obtained from renewable sources has substantial overhead costs and capital costs attached to them. So we need to consider this factor also.

To maintain energy price
- A balance between demand vs supply is essential to manage the cost of any commodity. And this goes with energy too. The fluctuations in energy prices will also affect the prices of electrical appliances.
- So, proper energy management will ensure the affordability of energy and its appliances in present times and for the future.

To meet statutory compliance
It's also becoming obligatory for industries to abide by energy compliances issued by regulatory bodies.

Managing energy also saves water
The hydroelectric power plants, though they are free from fossil fuel consumption, may degrade the quality of water resources in a variety of ways. Oxygen stratification, eutrophication, thermal pollution, and mercury pollution are the major challenges posed by hydroelectric facilities where they are constructed.

Types of energy audit

Preliminary energy audit
Preliminary energy audit is a relatively quick exercise to:

- Establish energy consumption in the organization

- Estimate the scope for saving

- Identify the most likely (and the easiest areas for attention

- Identify immediate (especially no-/low-cost) improvements/savings

- Set a 'reference point'

- Identify areas for more detailed study/measurement

- Preliminary energy audit uses existing, or easily obtained data.

Detailed energy audit

- A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy usi using systems

- This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost.

- In a comprehensive audit, one of the key elements is the energy balance. This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is then compared to utility bill charges.

- Detailed energy auditing is carried out in three phases: Phase I, II and III.

    - Phase I - Pre Audit Phase

    - Phase II - Audit Phase

    - Phase III - Post Audit
    - Phase

Targeted audit

An external Targeted Process Audit gives you written evidence that you made every effort to protect the personal data in your high risk process.

Audit questionnaire

Audit Questionnaire is defined as the set of printed or written questions with a choice of answers, devised for the purpose of a survey or statistical study.

Some of the general questions related to energy auditing are listed below.

- What function does this system serve?

- How does this system serve its function?

- What is the energy consumption of this system?

- What are the indications that this system is working properly?

- If this system is not working, how can it be restored to good working conditions?

- How can the energy cost of this system be reduced?

Energy surveying

- A building energy survey is a practical step to identify, quantify and prioritize tangible opportunities to reduce energy use, costs and carbon emissions in a building or on a site.

- It can also evaluate the feasibility of renewable energy opportunities.

- We can provide a detailed feasibility study to help you identify the most appropriate low carbon solution and help you take advantage of any feed in and renewable heat.

- We can also provide business case development, technical evaluations, analysis and reporting.

- Typically, buildings offer many opportunities to reduce energy use and costs. An energy survey enables these opportunities to be specifically identified, quantified and prioritized.

Audit report

- Energy audits identify energy consumed by a facility and locate energy conservation measures or projects.

- Typical audits start with a walkthrough and checklist and progress to monitoring and metering for information on real-time energy consumption.

- In audit report describe the overall purpose of the facility, hours and days of operation and any energy conservation devices in use.

- It explains energy accounting methods and include charts that reflect consumption patterns and energy costs so decision makers can understand conservation options.