SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT-I- MATERIALS AND CONSTRUCTION-I – SDE 2301

NATURAL MATERIALS

Natural building materials

Wood, clay, straw, mud, sand.
Construction material is any material which is used for construction purposes.

Renewable and Non Renewable resources

Natural Resources
Resources that occur in nature are known as Natural Resources.
These cannot be produced by our man-kind.
Examples:
Sun light
Minerals

Natural Resources can be classified into TWO categories:
1. Renewable resources
2. Non-Renewable resources

Renewable Resources

Resources that can be replenished naturally in the course of time are called Renewable Resources. The energy resources which can be used to produce again and again are known as renewable energy resources

Non-Renewable Resources

Resources that exist in limited supply and cannot be replaced if they are used up are called Non-Renewable Resources.

Types of Renewable Energy
- Solar
- Biomass
- Wind
- Water
- Geothermal

Renewable energy: Renewable energy is energy which is generated from natural sources i.e. sun, wind, rain, tides and can be generated again and again as and when required.
Use of renewable energy can increase energy security and reduce dependence on imported fuels, while reducing or eliminating greenhouse gas emissions associated with energy use.

Solar Energy
Solar energy is a renewable energy obtained by the use of electromagnetic radiation from the Sun. It is possible to transform it into thermal or electric energy.

Types of solar power

• Thermal solar energy: It consists of using solar energy to produce thermal energy. It can be used to warm water, for heating, etc.

• Photovoltaic solar energy: It's an energy source that produces electric energy from solar energy by using a semiconductor device called photovoltaic cell.

Solar energy is the energy, the earth receives from the **sun,** primarily as visible light and other forms of electromagnetic radiation. Solar energy can be converted into electrical energy by using solar plates.

Examples:

• solar cooker
• Solar heater
• Solar cell

Advantages:

• Solar energy doesn't produce carbon dioxide.
• It does not affect our environment.

Disadvantages:

• It is not constant, it depends on weather condition, time and location.

Solar energy is radiant light and heat from the sun harnessed using a range of ever-evolving technologies such as solar photovoltaic cells.

The Sun is a powerful source of energy that provides the Earth with as much energy every hour as we collectively use in a year worldwide.

Energy from the sun is harnessed in two ways:

1. Active solar involves capturing and redistributing sunlight through the use of solar panels, pumps or solar fans to generate power usually on a large scale.
2. Passive solar works to reduce the amount of energy traditionally used to power a location, such as a building or house. An example is building a house in the natural direction of sunlight to trap heat.

Save Money: A lot of money can be saved as the money paid in the form of Power bill will be reduced.

Green energy: Pollution produced by the burning of fossil fuels like petrol, cutting trees for timber can be decreased to a great extent.

Upfront cost: Some people hold off on purchasing solar panels because they imagine that they can't afford the initial expense. But, the amount spent on installing Solar panels can be gained in a few years, as they save on Electricity produced from traditional sources such as coal, wood etc.

Maintenance: Homeowners unfamiliar with solar technology sometimes fear that complex repairs will be needed. In fact, solar panels have no moving parts, so there's no wear and tear. Rain is generally sufficient to keep the panels free from dust and grime.

Wind Energy

- The Electrical energy that is obtained from harnessing the wind with
- wind mills or wind turbines is called **Wind Energy.**
- Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth.
- Wind turbines convert the kinetic energy in the wind into mechanical
- power.
- Large wind farms consist of hundreds of individual wind turbines which are connected to the electric power transmission network.
- Wind energy is created when the atmosphere is heated unevenly by the Sun, some patches of air become warmer than others.
- These warm patches of air rise, other air rushes in to replace them – thus, wind blows.
- The wind is a by-product of solar energy. Approximately 2% of the sun's energy reaching the earth is converted into wind energy.
- The surface of the earth heats and cools unevenly, creating atmospheric pressure zones that make air flow from high- to low pressure areas.

Wind power is good renewable, clean and free source of energy for power production.
• Reduce dependence on fossil fuels including imported oils.
• Reduce emission of greenhouse gas and other pollutant.
• One major concern is the noise – be improved.

Energy conversion in Wind Power Plants

- A wind turbine extracts energy from moving air by slowing the wind down, and transferring this energy into a spinning shaft, which usually turns a generator to produce electricity.
- The power in the wind that's available for harvest depends on both the wind speed and the area that's swept by the turbine blades

Wind Turbine- "rotary engine in which the kinetic energy of a moving fluid is converted into mechanical energy by causing a bladed rotor rotate"

- Turbine blades spin from the wind and make energy, instead of Using energy to make wind
- Wind rotates the turbine blade
- Spins a shaft connected to a generator
- The spinning of the shaft in the generator makes electricity

<u>Advantages of Wind Power</u>

- Wind energy is a green energy source and does not cause pollution.
- The potential of wind power is enormous – 20 times more than what the entire human population needs.
- The operational costs associated with wind power are low.
- The wind is free and with modern technology it can be captured efficiently.

- Once the wind turbine is built the energy it produces does not cause green House gases or other pollutants.
- Although wind turbines can be very tall each takes up only a small plot of land. This means that the land below can still be used. This is especially the case in agricultural areas as farming can still continue.
- Many people find wind farms an interesting feature of the landscape.
- Remote areas that are not connected to the electricity power grid can use wind turbines to produce their own supply. Wind turbines have a role to play in both the developed and third world.
- Wind turbines are available in a range of sizes which means a vast range of people and businesses can use them. Single households to small towns and villages can make good use of range of wind turbines available today.

Disadvantages of Wind Power

- Wind is a fluctuating (intermittent) source of energy and is not suited to meet the base load energy demand unless some form of energy storage is utilized (e.g. batteries, pumped hydro).
- The strength of the wind is not constant and it varies from zero to storm force. This means that wind turbines do not produce the same amount of electricity all the time. There will be times when they produce no electricity at all.
- The manufacturing and installation of wind turbines requires heavy upfront investments – both in commercial and residential applications.
- Wind turbines can be a threat to wildlife (e.g. birds, bats).
- Many people feel that the countryside should be left untouched, without these large structures being built. The landscape should have left in its natural form for everyone to enjoy.
- Wind turbines are noisy. Each one can generate the same level of noise as a family car travelling at 70 mph.
- Large wind farms are needed to provide entire communities with enough electricity.

Hydro Power

- Hydro power is the energy derived from the falling water or running water.
- Falling water is channelled through water turbines.
- The pressure of the flowing water on turbine blades rotates a shaft and drives an electrical generator, converting the motion into electrical energy.
- But hydroelectric power doesn't necessarily require a large dam. Some hydroelectric power plants just use a small canal to channel the river water through a turbine.

Hydroelectric power (hydropower) systems convert the kinetic energy in flowing water into electric energy.

• Falling or flowing water turns a propeller like piece called a turbine.

• The turbine turns a metal shaft in an electric generator which produces electricity.

Ocean Thermal

• The oceans cover 75% of the world surface.
• It is the largest renewable energy source available to contribute to the security of energy supply reduce greenhouse gases emission.

The ocean contains two type of energy

• Ocean thermal energy conversion from the sun's heat.
• Mechanical energy from tides and waves.

Advantages

• No fuel required
• No air pollution
• Can easily work during high peak daily loads
• Prevents floods

Disadvantages

• Disrupts the aquatic ecosystems
• Disruption of surrounding areas
• Requires large areas
• Large scale human displacement

Geo-Thermal Energy

- **Geothermal energy** is thermal energy generated and stored in the Earth.
- Thermal energy is the energy that determines the temperature of matter.
- The geothermal energy of the Earth's crust originates from the original formation of the planet (20%) and from radioactive decay of minerals (80%).
- Geothermal energy is the heat from the Earth. It's clean and sustainable.
- Geothermal heat pumps can tap into this resource to heat and cool buildings.
- The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface.
- Resources of **geothermal energy** range from the shallow ground to hot water and hot rock found a few miles beneath the Earth's surface, and down even deeper to the extremely high temperatures of molten rock called magma.

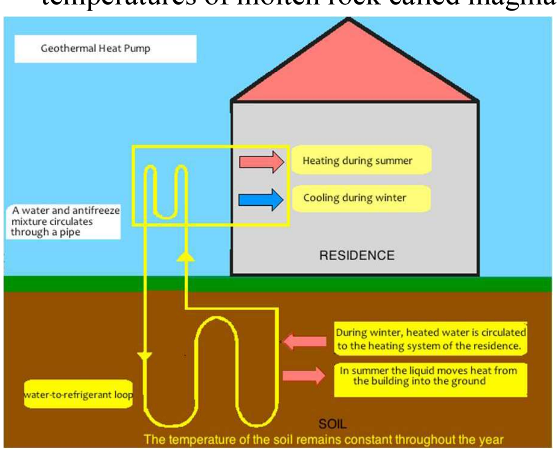


Fig.1. Geothermal energy

<u>Biomass</u>—renewable energy from plants and animals

Biomass is renewable organic material that comes from plants and animals. Biomass was the largest source of total annual U.S. energy consumption until the mid-1800s.

Biomass continues to be an important fuel in many countries, especially for cooking and heating in developing countries. The use of biomass fuels for transportation and for electricity generation is increasing in many developed countries as a means of avoiding carbon dioxide emissions from fossil fuel use.

Biomass contains stored chemical energy from the sun. Plants produce biomass through **photosynthesis.** Biomass can be burned directly for heat or converted to renewable liquid and gaseous fuels through various processes.

<u>Biomass sources for energy include</u>

- **wood and wood processing wastes —** firewood, wood pellets, and wood chips, lumber and furniture mill sawdust and waste, and black liquor from pulp and paper mills.
- **Agricultural crops and waste materials —** corn, soybeans, sugar cane, switchgrass, woody plants, and algae, and crop and food processing residues
- Biogenic materials in **municipal solid waste** — paper, cotton, and wool products, and food, yard, and wood wastes
- Animal manure and human sewage.

<u>Biomass Energy Conversion</u>

1. Energy from the sun is transferred and stored in plants in the form of chemical energy. When the plants are cut or die, wood chips, straw and other plant matter is delivered to biogas plant. When biomass is burnt, it releases energy in the form of
heat.

2. The biomass plants burn wood or other forms of waste to generate steam. The energy from the steam is directed via pipes to run turbines.

3. The steam rises up to run turbines that produce electricity or generate heat for homes and industries.

4. In most countries, biomass plants have been built in the countryside to provide electricity to the local population. There are waste-to-energy plants that burn trash to produce electricity and power millions of homes. Energy can also be used by burning the scrap wood or wood chips that are left over after trees have been trimmed.

<u>Converting biomass to energy</u>

Biomass is converted to energy through various processes, including

- Direct combustion (burning) to produce heat
- Thermochemical conversion to produce solid, gaseous, and liquid fuels
- Chemical conversion to produce liquid fuels
- Biological conversion to produce liquid and gaseous fuels

<u>Non-Renewable Resources</u>

1. Oil

2. Natural gas
3. Coal
4. Nuclear resources

Oil

- Liquid petroleum -crude oil- is the only non-renewable resource in fluid form.
- A fossil fuel that is being used up faster than new reserves are discovered, the oil supply may only last through the middle of this century.
- Industrial nations, with the U.S. far in the lead, are the biggest consumers of crude oil.
- Gasoline, heating oil, and diesel fuel are the primary uses of the resource, although manufacturers utilize oil as the base for such products as plastics and industrial chemicals.

Natural gas

- Natural gas is a fossil fuel formed when layers of buried plants, gases, and animals are exposed to intense heat and pressure over thousands of years.
- The energy that the plants originally obtained from the sun is stored in the form of chemical bonds in natural gas.
- It is primarily composed of methane, but contains ethane, propane and butane as well.
- Once drillers extract natural gas, processing plants remove the propane and butane for use as liquefied petroleum gas (LPG), a household and industrial fuel.
- According to the current usage statistics and the volume of world reserves, the supply of natural gas should last another century.

Coal

- Coal, which is a primary resource of energy in India, is the product of millions of years of pressure on original organic matter from plants buried underground.
- It is a combustible black or brownish-black sedimentary rock usually occurring in rock strata in layers or veins called coal beds or coal seams.
- Anthracite, the purest form of coal, contains about 94 - 95% of carbon.
- At the power plant, coal is commonly burned in a boiler to produce steam. The steam is run through a turbine to generate electricity.
- The global supply of coal, given the current rate at which it is used, should last at least two more centuries.

Nuclear energy

- Nuclear power, or nuclear energy, is the use of exothermic nuclear processes, to generate useful heat and electricity.
- The term includes nuclear fission, nuclear decay and nuclear fusion.
- Presently the nuclear fission of elements in the actinide series of the periodic table produce the vast majority of nuclear energy in the direct service of humankind.
- In nuclear fission, neutrons smash into the nucleus of Uranium atoms and release energy in the form of heat. Water is converted to steam by this heat and it is used to drive the turbines.

- Nuclear (fission) power stations, excluding the contribution from naval nuclear fission reactors, provided about 5.7% of the world's energy and 13% of the world's electricity in 2012.

Steps to be taken for conservation of Natural Resources

- Use various resources only when needed.
- Avoid the wastage of resources.
- Avoid the use of material from wild life sources.
- Use energy efficient electrical appliances.
- Utilize renewable energy sources as much as possible. Encourage use of solar cooker, pump etc
- We should recycle the waste and waste water for agriculture purposes.

Zero Energy Building

• A zero-energy building is a building with zero net energy consumption.
• The total amount of energy used by the building on an annual basis is roughly equal to the amount of energy generated on the site through renewable sources.
• These buildings consequently contribute less overall greenhouse gas to the atmosphere than similar non-ZNE buildings

Why?

• To overcome energy crisis
• Reduces Energy Consumption
• Reduces Green House Gases (Carbon Emissions) & Global Warming
• Reduces Dependence on Fossil Fuels
• Protects Our Environment for Future Generations

Soil as building material

The inorganic material on the earth's surface, produced by weathering of rocks, being either residual or transported. The study of soil, its behaviour and application as the engineering material is known as soil mechanics.

Soil is the mixture of mineral, organic matter, gases, liquids, and the countless organisms that together support life on earth. It is the un aggregated or un cemented deposits of mineral and/or organic particles or fragments covering large portion of the earth's crust.

It includes widely different materials like boulders, sands, gravel, clays, and silts and the range in the particle sizes in a soil may extend from grains only a fraction of micron (10-4) in diameter up to large size boulders.

Soil type

- Gravel: Small pieces of stone varying from the size.
- Sand: Similar small pieces of stone (usually quartz), which are small but each grain, is visible to the eye.

- Silt: The same as sand except that it is so fine that you cannot see individual grains.
- Clay: Soils that stick when wet - but very hard when completely dry.
- Organic Soil: Soil mainly composed of rotting, decomposing organic matters such as leaves, plants and vegetable matter. It is spongy when wet, usually smells of decaying matter, is dark in color and usually damp.

Soil classification

Soil and earth are synonymous when used in relation to building construction. The term ‘soil’ refers to subsoil, and should not be confused with the geological or agricultural definition of soil, which includes the weathered organic material in topsoil. Topsoil is generally removed before any engineering works are carried out, or before soil is excavated for use as a building material. Mud is the mixture of one or more types of soil with water. There are several ways in which soil may be classified: by geological origin, by mineral content (chemical composition), by particle size or by consistency (mainly related to its moisture content).

Soil usability

•Gravel: alone is of no use for mud wall building - the tiny lumps of stone have nothing to bind them together.
•Sand: similar to gravel, it is of no use for wall making by itself - but if mixed with clay, it is the ideal mud wall building soil.
•Silt: by itself is also no good for building walls. It will hold together but is not strong. Furthermore, it will not compact so it is also of no use for pressed blocks or rammed earthwork.
•Clay: can be rammed or compressed but in drying out they often shrink. During the monsoon they get damp and expand again and crack form.
•Organic Soils: are mainly useless for wall building.

Bearing capacity is the capacity of soil to support the loads applied to the ground. The bearing capacity of soil is the maximum average contact pressure between the foundation and the soil which should not produce shear failure in the soil.
Sometimes, on soft soil sites, large settlements may occur under loaded foundations without actual shear failure occurring; in such cases, the allowable bearing capacity is based on the maximum allowable settlement.

All the structures whether they are buildings, dams, bridges etc. are built on soils. A foundation is required to transmit the load of the structure on a large area of soil. The **foundation of the structure should be so designed that the soil below does not fail in shear nor there is the excessive settlement of the structure**. The conventional method of foundation design is based on the concept of bearing capacity.

Soil when stressed due to loading, tend to deform. The resistance to deformation of the soil depends upon factors like water content, bulk density, angle of internal friction and the manner in which load is applied on the soil. **The maximum load per unit area which the soil or rock can carry without yielding or displacement is termed as the bearing capacity of soils.**

Soil properties like shear strength, density, permeability etc., affect the bearing capacity of soil. Dense sand will have more bearing capacity than loose sand as unit weight of dense sand is more than loose sand.

If the bearing capacity of soil at **shallow depth** is sufficient to safely take the load of the structure, **a shallow foundation is provided**. Isolated footing, combined footing or strip footing are the option for the shallow foundation.

Deep foundations are provided when soil immediately below the structure **does not have the adequate bearing capacity.** Pile, piers or well are the options for deep foundations. Mat or raft foundations are useful for soil which is subjected to differential settlement or where there is a wide variation in loading between adjacent columns.

EARTH TECHNIQUES

Various mud construction method

- Cob
- Rammed earth
- Adobe
- Wattle and daub
- Compressed earth bocks

•Mud as a construction material has been extensively used since Neolithic times.
•Mud construction is mainly found in places which are relatively dry.

Mud Construction

- Mud: A mixture of a water, soil, silt and clay.
- It is essential material.
- 58% of buildings in India are made of mud and bricks.
- Mud does not need much energy to manufacture.
- Mud is found in places which are relatively dry.
- Mud houses use minimal energy, is comfortable all year around.
- Mud house construction is durable and can be easily rebuilt.

- COB is good for anything except height. It is particularly good for curved or round walls.
  - PISE OR RAMMED EARTH is strong and ideal for solid, squat, single storey houses.
  - ADOBE or SUN DRIED BRICKS can easily cope with two storey houses.
  - PRESSED BRICKS smooth and very strong and can build three storey.
  - WATTLE & DAUB is elegant and fine for Seismic Zones.

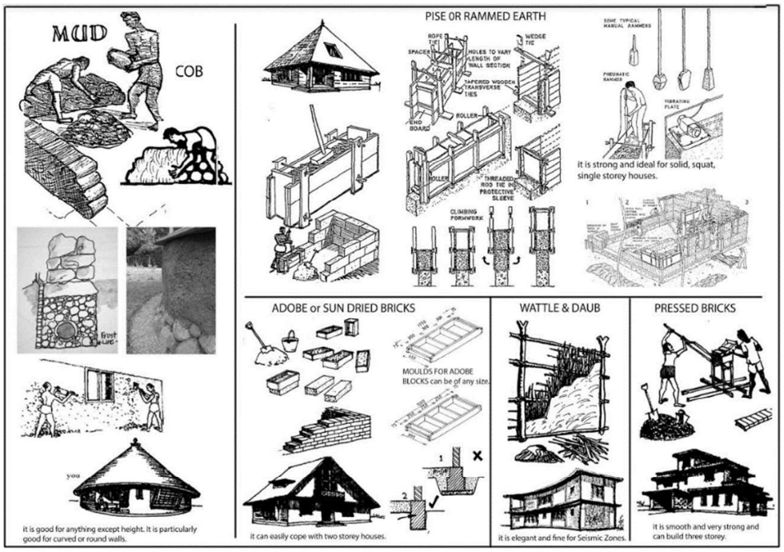


Fig.2. Earth Techniques

Cob

• A very stiff mud is prepared by mixing mud and water (1:3) and is molded into huge egg shapes

• For making a wall, a row of cob is placed in a proper line to avoid cracks.

• Cob is good for round and curved walls.

Cob or cobb or is a building material consisting of clay, sand, straw, water, and earth, similar to adobe.

Cob is fireproof, resistant to seismic activity, and inexpensive.

It can be used to create artistic, sculptural forms and has been revived in recent years by the natural building and sustainability movements.

The walls of a cob house were generally about 24 inches thick, and windows were correspondingly deep-set, giving the homes a characteristic internal appearance. The thick walls provided excellent **thermal mass** which was easy to keep **warm in winter and cool in summer.** Walls with a high thermal mass value act as a thermal buffer inside the home and large roof overhang are present.

Fig.3. Interior spaces using natural material

RAMMED EARTH

Rammed earth, is a technique for building walls using the raw materials of earth, lime and gravel. It is an ancient building method that has seen a revival in recent years as people seek more sustainable building materials and natural building methods. Rammed-earth walls are simple to construct, incombustible, thermally massive, strong, and durable.

• They can be labour- intensive to construct without machinery (powered tampers), however, and they are susceptible to water damage if inadequately protected or maintained. The second method has developed from the cob wall so as to standardize or regularize the thickness of the wall.

Building a rammed-earth wall involves compressing a damp mixture of earth that has suitable proportions of sand, gravel and clay (sometimes with an added stabilizer) into an externally supported frame or mould, creating either a solid wall of earth or individual blocks.

Historically, such additives as lime were used to stabilize the material, whilst modern construction uses lime, cement or asphalt emulsions.

Some modern builders also add coloured oxides or other items, such as bottles or pieces of timber, to add variety to the structure.

• It is also an attempt to increase the strength of the wall by ramming it. It is known as the Rammed Earth method.

• Two parallel planks are held firmly apart by metal rods and clips or bolts, or by small crosspieces of wood.

• Stiff mud is thrown in between these two planks and rammed down with either a wooden or metal ramrod.

ADOBE

Adobe is a natural building material made from sand, clay, water, and some kind of fibrous or organic material (sticks, straw, and/or manure), which the builders shape into bricks using frames and dry in the sun.

• Adobe buildings are similar to cob and mudbrick buildings. Adobe structures are extremely durable, and account for some of the oldest existing buildings in the world. In hot climates, compared with wooden buildings, adobe buildings offer significant advantages due to their greater thermal mass, but they are known to be particularly susceptible to earthquake damage.

- Straw is useful in binding the brick together and allowing the brick to dry evenly.
- The mixture is roughly half sand (50%), one-third clay (35%), and one-sixth straw (15%) by weight.
- Bricks are made in an open frame, 25 cm (10 in) by 36 cm (14 in) being a reasonable size, but any convenient size is acceptable. The mixture is molded by the frame, and then the frame is removed quickly. After drying a few hours, the bricks are turned on edge to finish drying. Slow drying in shade reduces cracking.

Compressed Stabilised Earth Block

This press could get regular blocks in shape and size, denser, stronger and more water resistant than the common adobe. Since then many more types of machines were designed and many laboratories got specialised and skilled to identify the soils for buildings. Many countries in Africa as well as South America, India and
South Asia have been using a lot this technique.
The soil, raw or stabilized, for a compressed earth block is slightly moistened, poured into a steel press (with or without stabiliser) and then compressed either with a manual or motorized press. CEB can be compressed in many different shapes and sizes. For example, the Auram press 3000 proposes 18 types of moulds for producing about 70 different blocks.

Compressed earth blocks can be stabilised or not. But most of the times, they are stabilised with **cement or lime**. Therefore, we prefer today to call them Compressed Stabilised Earth Blocks (CSEB).

The input of soil stabilization allowed people to build higher with thinner walls, which have a much better compressive strength and water resistance. With cement stabilization, the blocks must be cured for four weeks after manufacturing. After this, they can dry freely and be used like common bricks with a soil cement stabilized mortar.

<u>Good soil for compressed stabilised earth blocks</u>

The selection of a stabilizer will depend upon the soil quality and the project requirements.

- **Cement** will be preferable for **sandy soils** and to achieve quickly a higher strength.
- **Lime** will be rather used for very **clayey soil,** but will take a longer time to harden and to give strong blocks.

<u>Classification of Sands</u>

Natural Sources of Sand:
The sand particles consist of small grains of silica (SiO_2). It is formed by the decomposition of sandstones due to various effects of weather.
According to the natural sources from which the sand is obtained, it is of the following three types:
(1) Pit sand
(2) River sand
(3) Sea sand
(1) Pit Sand:
This sand is found as deposits in soil and it is obtained by forming pits into soils. It is excavated from a depth of about 1 m to 2 m from ground level. The pit sand consists of sharp angular grains which are free from salts and it proves to be excellent material for mortar or concrete work. For making mortar, the clean pit sand free from organic matter and clay should only be used.

When rubbed between the fingers, the fine pit sand should not leave any stain on the fingers. If there is any stain, it indicates the coating of oxide of iron over the sand grains.

(2) River Sand:

This sand is obtained from banks or beds of rivers. The river sand consists of fine rounded grains probably due to mutual attrition under the action of water current. The colour of river sand is almost white. As river sand is usually available in clean condition, it is widely used for all purposes.

(3) Sea Sand:

This sand is obtained from sea shores. The sea sand, like river sand, consists of fine rounded grains. The colour of sea sand is light brown. The sea sand contains salts. These salts attract moisture from the atmosphere. Such absorption causes dampness, efflorescence and disintegration of work. The sea sand also retards the setting action of cement.

Due to all such reasons, it is the general rule to avoid the use of sea sand for engineering purposes except for filling of basement, etc. It can however be used as a local material after being thoroughly washed to remove the salt.

Classification of Sand:

According to the size of grains, the sand is classified as fine, coarse and gravelly.
The sand passing through a screen with clear openings of 1.5875 mm is known as the fine sand. It is mainly used for plastering.
The sand passing through a screen with clear openings of 3.175 mm is known as the coarse sand. It is generally used for masonry work.
The sand passing through a screen with clear openings of 7.62 mm is known as the gravelly sand. It is generally used for concrete work.

Sands for construction works:

For different construction of works requires different standards of sands.

For brick works: It requires the finest module of fine sand should be 1.2 to 1.5 and silt content should not be more than 4 %.

For plastering works: It requires the finest module of fine sand, it should not be less than 1.5 and silt content should not be more than 4 %.

For Concerting Works: The coarse sand should be used with the finest modulus 2.5 to 3.5 and silt contents should not be more than 4%.

Bulking of Sand:

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

Properties of Good Sand:

(i) It should be chemically inert.
(ii) It should be clean and coarse. It should be free from any organic or vegetable matter. Usually 3 to 4% clay is permitted.
(iii) It should contain sharp, angular, coarse and durable grains.
(iv) It should not contain salts which attract moisture from the atmosphere.

Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing.
The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm.

Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word.

Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-Sand is its availability and transportation cost.

Since manufactured sand can be crushed from hard granite rocks, it can be readily available at the nearby place, reducing the cost of transportation from far-off river sand bed.

Thus, the cost of construction can be controlled by the use of manufactured sand as an alternative material for construction. The other advantage of using M-Sand is, it can be dust free, the sizes of m-sand can be controlled easily so that it meets the required grading for the given construction.

Particle size distribution:

The actual size of the aggregate particles influences the concrete mix. In practice it is desirable to have particles of different sizes.
The aggregate is usually split into at least two different portions for ease of batching:
The common dividing point is 5mm (or 4.75mm).
Material larger than 5mm is termed coarse aggregate or gravel and the material smaller than 5mm is termed fine aggregate, fines or sand.

The distribution of the different sizes of particles in the coarse or fine aggregates is termed grading. The grading may be coarse or fine depending on the distribution of the particles and may be continuous (particles of different sizes) or single sized (particles of predominantly one size).
The particle size distribution is extremely important in the design of any concrete mix. For most practical concretes it is desirable to have the particle sizes evenly distributed from the maximum size of coarse aggregate down to the smallest sand particles. This will enable the

aggregate to compact in the densest form leaving the minimum number of voids to be filled by the more expensive cement paste. It will also minimize the risk of segregation of the plastic concrete during handling & placing.
The test method covers the determination of the particle size distribution of fine and coarse aggregates by sieving, is Sieve Analysis of Fine and Coarse Aggregates.

Aggregate-The fine and coarse aggregates generally occupy 60% to 75% of the concrete volume (70% to 85% by mass) and strongly influence the concrete's freshly mixed and hardened properties, mixture proportions, and economy. Fine aggregates generally consist of natural sand or crushed stone with most particles smaller than 5 mm (0.2 in.). Coarse aggregates consist of one or a combination of gravels or crushed stone with particles predominantly larger than 5 mm (0.2 in.) and generally between 9.5 mm and 37.5 mm (3⁄8 in. and 11⁄2 in.)

Aggregate

Grading is the particle-size distribution of an aggregate as determined by a sieve analysis using wire mesh sieves with square openings.
Aggregates may affect the following properties of concrete

- Strength
- Durability
- Structural Performance
- Economy

Most common forms of aggregates, are as follows

- Sand
- Gravel
- Crushed stone

Other than the above there are light weight aggregates that are used to specific purposes. Following are few of the commonly used light-weight aggregates

- Shale
- Slate
- Slag
- Pumice
- Scoria
- Perlite
- Vermiculite
- Diatomite

Fine aggregate

Following are the properties of fine aggregates that can be used in concrete

- Material is of fine Sand and/or crushed stone, which is totally inert to chemical reactions
- Size of the fine aggregate should be < 5 mm
- Fine aggregate content is usually 35% to 45% by mass or volume of total volume of aggregates

Coarse aggregate

Following are the properties of fine aggregates that can be used in concrete

- Material is mainly Gravel and crushed stone, which is totally inert to chemical reactions
- Size of the fine aggregate should be > 5 mm
- Typically size of coarse aggregate is between 9.5 and 37.5 mm
- Fine aggregate content is usually 35% to 45% by mass or volume of total volume of aggregates.

PCC means Plain Cement Concrete. **RCC** means Reinforced Cement Concrete. **PCC** is normal concrete without any reinforcing elements like steel. Since **PCC** is weak in tension it cannot be used as structural elements where tensile forces acts.
Reinforced concrete (RC) (also called reinforced cement concrete or **RCC**) is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength or ductility.

The Mixing ratio depends upon the grade that you want. PCC is mostly M-15 (concrete grade), so the ratio would be **1:2:4**. One part of cement, two parts of sand and four parts of Aggregate.

'**Aggregate**' is a term for any particulate material. It includes gravel, crushed stone, sand, slag, recycled concrete and geosynthetic **aggregates**. **Aggregate** may be natural, manufactured or recycled. • **Aggregates** make up some 60 -80% of the concrete mix.

Fig.4. Experimentation with local materials

Bamboo

Bamboo — Tall perennial grasses found in tropical and sub-tropical regions. They belong to the family Poaceae and sub-family Bambusoidae.

Bamboo Mat Board — A board made of two or more bamboo mats bonded with an adhesive.

Roof Skeleton — The skeleton consisting of bamboo truss or rafter over which solid bamboo purlins are laid and lashed to the rafter or top chord of a truss by means of galvanized iron wire, cane, grass, bamboo leaves, etc.

Node — The place in a bamboo culm where branches sprout and a diaphragm is inside the culm and the walls on both sides of node are thicker.

Sliver — Thin strips of bamboo processed from bamboo culm.

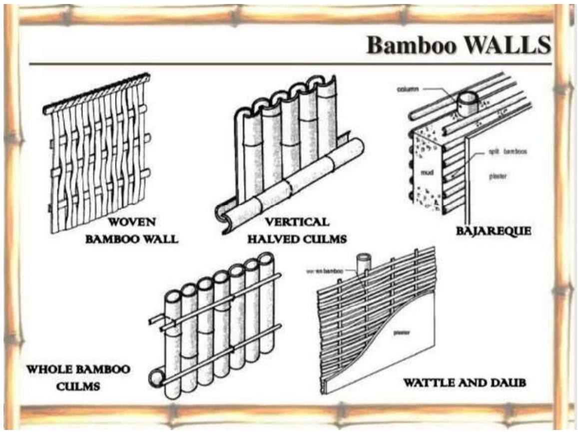


Fig.5. Bamboo Techniques

Properties

Bamboo as a building material is: Strong, Ductile **-** a solid material's ability to deform under tensile stress, rapidly renewable, Inexpensive, locally sourced, Beautiful.

Roof Battens — A roof member directly supporting tiles, corrugated sheets, slates or other roofing materials.

Preservation and Chemical Treatment

Chemical preservation (with or without the help of special equipment) ensures long term protection. protect bamboo against biological attacks and degradation. Chemical preservatives are toxic. Curing bamboo with borax and boric acid is the most popular bamboo preservation method (for indoor use)

Reeds & Palm

Reed is a natural building materials that possess many useful benefits in contemporary building practices. Reeds grow around lakes, swamps and other water canals and have no environmental impact if dismantled after construction as they are biodegradable.

Common reed is a very tall grass reaching its best height of about 4m. During winter the straw becomes a hard yellowish stem which makes it possible to use in construction.

Palm trees are readily used as a building material for house walls, rafters and roofing. The fibrous wood is pulled apart and woven together as thatch for roof covering.

Palmyra leaves can be used for thatching; and the petiole part of the leaves can be used for making ropes."

Thatching

Thatching is the craft of building a roof with dry vegetation such as straw, water reed, sedge, rushes, or heather, layering the vegetation so as to shed water away from the inner roof. It is a very old roofing method and has been used in both tropical and temperate climates.

Thatch is still employed by builders in developing countries, usually with low-cost, local vegetation.

The thatch is applied to the roof by pinning bundles of reed side by side on the roof and fixing a sway or ligger two thirds up along the bundle. Then opening the string and tying the bundle together. Each bundle has then had to be dressed into the other courses.

Benefits of Thatch

- Thatch is a natural product of reed, grass or heathers, when properly cut, dried, and thatched, forms a waterproof roof.
- It is a naturally weather-resistant material and when properly maintained does not absorb a lot of water.
- Thatch is also a natural insulator, and the air pockets within a straw thatch roof insulate the building in both warm and cold weather.

A thatched roof will ensure that a building will be cool in summer and warm in winter.

Coconut is a perennial crop with a long life span which needs abundant number of nutrients for a sustainable growth and yield. Plaited coconut leaves were extensively used for thatching roofs of houses, for sunshades, matting for floor as well as walls. Shelters made from coconut fronds are cheaper and cooler than brick and mortar structures. For construction of Pandals (big halls) for meetings, marriages etc plaited leaves are used.

LIME

Lime has been used as a cementing material since the ancient times. The Ezyptians and Romans made remarkable application of this material for various constructional processes. Even in India, various engineering structures like palaces, bridges, temples ,forts, monuments etc were constructed with lime as cementing material and some of these structures still exist in perfectly good construction.
At present ,the cement has replaced lime to a great extent .But at places where lime is locally available and when there is acute shortage of cement, the lime certainly provides a cheap and a reliable alternative to the cement.

Calcination: The heating to redness in contact with air is known as the calcination.

Hydraulicity: It is the property of lime by which it sets or hardens in damp places, water or thick masonry walls where there is no free circulation of air.

Lime: is obtained by burning limestone.

Due to calcination of limestone, the moisture and carbon dioxide are removed from it. The product which remains thereafter is known as the lime. Its chemical composition is (CaO)oxide of calcium.

$$CaCO_3 \xrightarrow{\text{Heating}} CaO + Co_2$$

(Lime stone) (Lime) (Carbon dioxide)

Quick Lime: The lime which is obtained by the calcination of comparatively pure limestone is known as the quick lime or caustic lime. Its chemical composition is (CaO)oxide of calcium and it has great affinity to moisture. It is amorphous ie. not crystalline and highly caustic having no affinity for the carbonic acid. The quick lime as it comes out from kilns is known as the lump lime.

Setting: The process of hardening of lime after it has been converted into paste form is known as the setting. It is quite different from mere drying. In case of drying, the water evaporates only and no setting action takes place.

Slaked lime : The product obtained by slaking of quick lime is known as slaking lime or hydrate of lime.It is in the form of white powder and its chemical composition is $Ca(OH)_2$ or hydrated oxide of calcium.

$$CaO + H_2O \xrightarrow{\text{slaking}} Ca(OH)_2 + \text{Heat}$$

(Quick lime) (Water) (Hydrated lime)

Slaking: When water is added to the quick lime in sufficient quantitiy ,a chemical reaction takes place.Due to this chemical reaction,the quick lime cracks,swells and falls into a powder form which is the calcium hydrate ($Ca(OH)_2$ and it is known as the hydrated lime.This process is known as the slaking.

CLASSIFICATION OF LIME

The limes which are obtained by calcinations of limestone are broadly classified into the following three categories:

1. Fat Lime
2. Hydraulic Lime
3. Poor Lime

(1) Fat Lime: This lime is also known as the *high calcium lime, pure lime, rich lime or white lime.* It is popularly known as the fat lime as it slakes vigorously and its volume is increased to about 2 to 2 ½ times the volume that of quick lime. It is prepared by calcining comparatively pure carbonate of lime which is composed of about 95 percent of calcium oxide. The percentage of impurities in such limestone is less than 5 percent.

Properties of Fat lime

1. It hardens very slowly.
2. It has a high degree of plasticity.
3. It is soluble in water which is changed frequently.
4. Its colour is perfectly white.
5. It sets slowly in presence of air.
6. It slakes vigorously.

Uses of Fat lime

1. It is used in white washing and plastering walls.
2. With sand, it forms lime mortar which sets in thin joints. Such mortar can be used for thin joints of brickwork and stonework.
3. With surkhi, it forms lime mortar which possesses good setting and hydraulic properties. Such mortar can be used for thick masonry walls, foundations etc. The surkhi is the powder obtained by grinding of the burnt bricks.

(2) Hydraulic Lime: This lime is also known as the water lime as it sets under water. It contains clay and some amount of ferrous oxide. Depending upon the percentage of clay, the hydraulic lime is divided into the following three types:

i. Feebly hydraulic lime
ii. Moderately hydraulic lime
iii. Eminently hydraulic lime

Following facts to be noted:

i. The increase in percentage of clay makes the slaking difficult and increases the hydraulic property.
ii. With about 30 percent of clay, the hydraulic lime resembles natural cement.
iii. The hydraulic lime can set under water and in thick walls where there is no free circulation of air.
iv. The colour of hydraulic lime is not perfectly white. It is therefore appearing less sanitary than the fat lime.
v. If hydraulic lime is to be used for plaster work, it is to be ground in fine powder and then it is mixed with sand. The mortar thus prepared is kept as heap for one week or so and it is then ground again. Such mortar can then be used for plaster work.

(3) Poor Lime: This lime is also known as the impure lime or lean lime. It contains more than 30 percent of clay. It slakes very slowly. It forms a thin paste with water. It does not dissolve in water through it is frequently changed.it sets or hardness very slowly. It has poor binding properties and its colour is muddy white.

This lime makes a very poor mortar. Such mortar can be used for inferior type of work or at places where good lime is not available.

USES OF LIME

The lime is an important engineering material and its uses can be enumerated as follows:

1. It is used as chemical raw material in the purification of water and for sewage treatment.
2. It is used as a flux in the metallurgical industry.
3. It is used as a matrix for concrete and mortar.
4. It is used as a refractory material for lining open-hearth furnaces.
5. It is used in the production of glass.
6. It is used for making mortar for masonry work.
7. It is used for plastering of walls and ceilings.
8. It is used for the production of artificial stone, lime-sand brick, foam silicate products, etc.
9. It is used for the soil stabilization and for improving soil for agricultural purposes.
10. It is used for whitewashing and for serving as a base coat for distemper.
11. When it is mixed with Portland cement, the mortar attains valuable properties and such a mortar can be used in place of the costly cement mortar.

A **fence** is a structure that encloses an area, typically outdoors, and is usually constructed from posts that are connected by boards, wire, rails or netting. A fence differs from a wall in not having a solid foundation along its whole length.

Temporary Shelter means a tent or shelter that is not permanently affixed and is commonly used by people as shelter from weather but not camping.

The term 'temporary shelters' is commonly used in a broad sense to denote shelters built immediately after a disaster to meet needs of shelter before permanent houses are rebuilt. 'Transitional shelters' is another terminology that is very common and again indicates the provisional nature of the shelters.

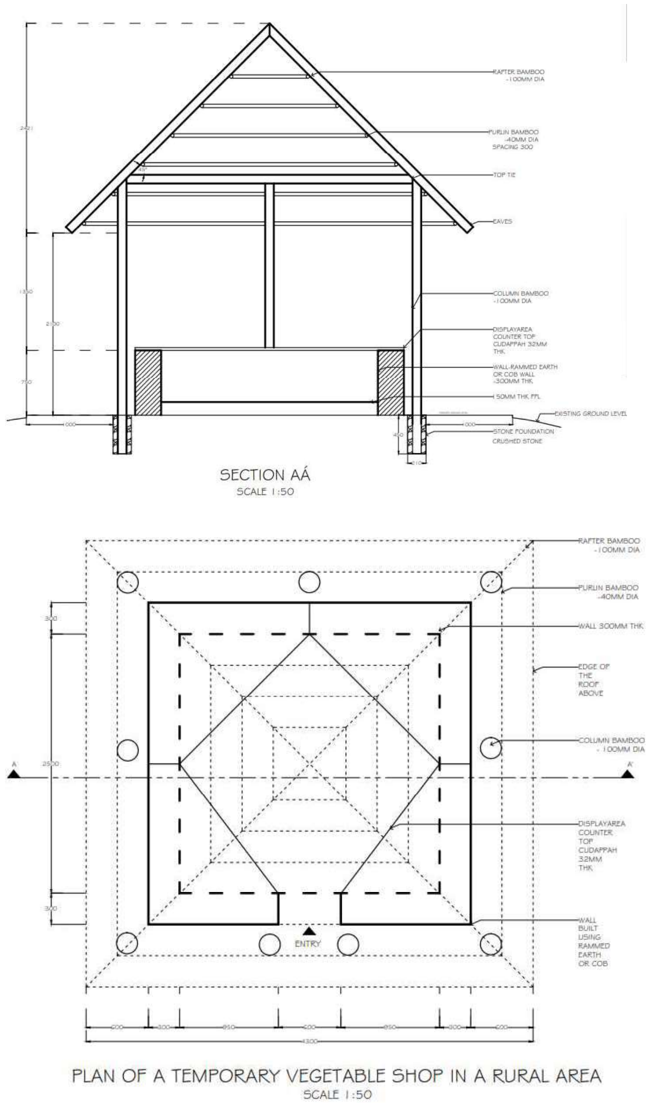


Fig.6. plan & section of temporary kiosk

<u>Wood</u>

Wood is a porous and fibrous structural tissue found in the stems and roots of trees and other woody plants.

It has been used for thousands of years for **both fuel and as a construction material.**

It is an organic material, a natural composite of cellulose fibres (which are strong in tension) embedded in a matrix of lignin which resists compression.

WOOD:

The organic matter obtained from trees is called wood.

TIMBER:

Timber denotes wood which is suitable for **building or carpentry and for various engineering and other purposes.**

<u>Timber</u>

Derived from the word timberian, that means to build

•Denotes wood which is suitable for building or carpentry.
•Three terms to be known in connection to the timber.

- Converted timber: sawn and cut into suitable commercial sizes.
- Rough Timber: obtained after felling a tree
- Standing Timber: Timber contained in living tree

• Valuable properties:

Low heat conductivity
Ability to mechanical working
Small bulk density
High Strength

•Drawbacks

Decay
In flammability
Fluctuation in properties due to changes in moisture.

General Properties

Colour: a darker colour in wood indicates greater durability.
Odour: it is present only on freshly cut trees.
Hardness: is the ability of wood to withstand indentations caused by harder bodies.

Density: densest woods are generally the strongest.
Grain: Depending on the actual alignment, the grain may be straight, spiral, interlocked, wavy or irregular.
Spiral Grain
Interlocked Grain
Wavy Grain
Texture: In hardwoods, the texture depends upon the size and distribution vessels and rays. In softwoods, it is determined by the size and distribution of tracheid.
Workability: the relative case in which wood is shaped cut and fastened together than the others.

Warping: is the general term used to describe any variation from a true surface.

Moisture content: is a percentage of the mass of water over the mass of wood fiber in a piece of timber.

Specific Gravity: is the ratio found by dividing the weight of a substance by the eight of an equal volume of pure water.

Mechanical properties

Tensile Strength: Timber is stronger in tension along the rain but it's quite difficult to determine this because of the difficulties in conducting test.

Compressive Strength: The strength along the grain is important for columns, props, and post.

Shear Strength: Shear strength is important in the case of the beam and slabs.

Bending Strength: This refers as the strength of the timber as a beam.

Cleavability: High resistance for cleavage is important for nailing and screwing while low splitting strength is important for used as firewood.

Torsion Strength: is used to determine the torsion strength of the timber and the specimen is loaded up to failure.

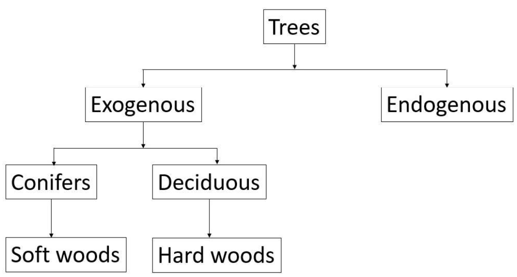
Hardness: is important in case of timber for paving blocks flooring bearings and other similar purposes.

Stiffness: This property is important to determine the deflection of a timber under a load.

Classification of Trees

For the engineering purposes, the trees are classified according to their mode of growth.

Exogenous and Endogenous



The structure of wood visible to the naked eye or at a small magnification is called the macrostructure.

The components present in tree are as follows:

1.Pith 2. Heart wood 3. Sap wood 4. Cambium layer 5. inner bark 6. Outer bark 7. medullary rays.

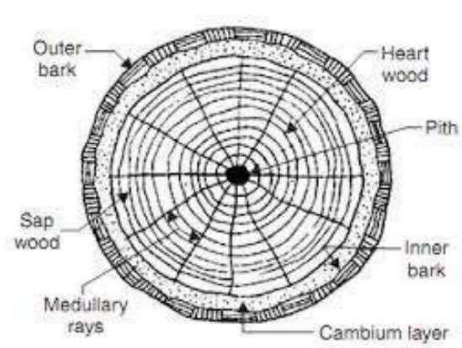


Fig.7. Cross section of Exogenous tree

Exogenous trees

These trees increase in bulk by growing outwards and distinct consecutive rings are formed in the horizontal section of such a tree. These rings are known as the annual rings because one such ring is added every year and these rings are useful in predicting the age of tree. The trees which grow outwards and increase in bulk by the formation of successive annual rings area

known as exogenous trees. In these trees, each annual ring presents a layer of wood, deposited every year.
The timber, which is mostly used for engineering purposes belongs to this category.
Examples: Deodar, kail, sal, teak, shisham, chir etc.

Exogenous tree is further divided into the following two types:

- Conifers or evergreen trees
- Deciduous or broad leaf trees.

Conifers or evergreen trees

The conifers are also known as the **ever-green trees** and leaves of these trees do not fall till new ones are grown. As these trees bear **cone-shaped** fruits, they are given the name **conifers**.
These trees yield soft woods which are generally
light coloured,
resinous,
Light in weight and weak
They show distinct annual rings.

Deciduous or broad leaf trees

The deciduous trees are also known as the **broad –leaf trees** and leaves of these trees fall in autumn and new ones appear in spring season. **The timber for engineering purposes is mostly derived from deciduous trees.**
These trees yield Hard woods which are usually
close-grained
strong
heavy
dark coloured
durable and
non-resinous
They do not show distinct annual rings.
These trees are most useful for important engineering works.

Endogenous Trees

These trees grow inwards and fibrous mass is seen in their longitudinal sections. The timber from these trees has very **limited engineering applications.**
Example –bamboo, palm etc.,
Wood is classified into two types according to their properties
Hard wood
Soft wood

Hard wood

It is obtained from deciduous.
It is heavy in weight.
It is dense closed grained and hence strong. It does not show distinct annual rings.

It is resistance to fire.
It is relatively smooth bark.

Uses-Oak is a hardwood and is used to make expensive furniture/flooring and strong framed structures.

Soft wood

It is obtained from conifers.
It is light in weight.
It is light in colour.
It is weak and can split easily.
It is annual rings are distinct.
It can readily catch fire.
It often gives out resinous matter from bark.

Softwood trees grow much quicker than the hardwood ones, they are therefore cheaper to buy and far more available. Softwood is used for construction of houses and furniture, and outdoor use such as fencing.

Table 1. Comparison of soft wood and hard wood

No	Item	Soft woods	Hard Woods
1	Annual rings	Distinct	Indistinct
2	Colour	Light	Dark
3	Density	Low	High
4	Fire resistance	Poor	More
5	Medullary rays	Indistinct	Distinct
6	Source	Coniferous trees with needle-shaped leaves.	Deciduous trees with flat-board leaves
7	Strength	Strong for direct pull and weak for resisting thrust or shear. Also strong along the grain	Equally strong for resisting tension, compression and shear. Also strong along and across the grain.
8	Structure	Resinous and split easily	Non-resinous and closed-grained.
9	Weight	Light	Heavy

The soft woods form a group of **ever-green trees**.
The hard woods form a group of **broad-leaf trees**.
It is to be noted that the terms soft woods and hard woods have commercial importance only. It is quite likely that some variety of soft wood **prove to be stronger** than some variety of hard wood.

The examples of soft woods are chir, deodar, fir, kail, spruce, etc.and cedar-very soft, pine-very hard.
The examples of hard woods are babul, mahogany, oak, sal, teak, walnut etc.
balsa (very soft) Ebony (very hard)
Hardwoods are commonly **used** in the **construction** of walls, ceilings and floors, while softwoods are often **used** to make doors, furniture and window frames.
Commonly **used** softwoods include **pine**, beach, ash, and cedar.

<u>Processing of Timber</u>

Felling of Trees, Seasoning of timber, Conversion of timber, Preservation of timber.

Meaning of Seasoning: When a tree is newly felled, it contains about 50 percent or more of its own dry weight as water. This water is in the form of sap and moisture. The water is removed before the timber can be used for any engineering purpose. In other words, the timber is to be dried. This process of drying of timber is known as seasoning of timber and the moisture should be extracted during seasoning under controlled conditions as nearly as possible at a uniform rate from all parts of the timber.

<u>Methods of Seasoning:</u>

Natural seasoning
Artificial seasoning

<u>SEASONING OF TIMBER</u>

SEASONING - the controlled process of reducing the moisture content (MC) or sap of the timber so that it is suitable for the intended use in building construction.

Why Is Seasoning Required

- Every time the MC reduces, the timber shrinks especially tangentially, and its weight also reduces.
- Consequently, it will show fewer tendencies to warp, split or shake.
- The sap in timber is a food for fungi and wood parasites. Dry well seasoned timber has resistance to decay and rot.
- Dry well seasoned timber is stronger & durable.
- Dry well seasoned timber is easier to work with and consequently safer especially for machine working.
- Timber with higher moisture content is difficult to finish i.e. paint, varnish, etc. Dry well seasoned timber is takes high polish.
- Dry well seasoned timber has more life.

Fresh timber from trees contains 30-40% sap or moisture.

For construction grade timber the timber MC must be below 12-15% MC to reduce the chances of Dry Rot and other fungi infestations.

<u>Natural Seasoning of Timber</u>

Air Seasoning of Timber

In this process, timber sleepers, planks, etc., cut from the wood logs are stacked in the open air. This method requires careful preparation of;

(a) Stock ground: It should be level, free from debris and on dry land. It may be a few “cm” below the ground level.
(b) Stack Pillars: These are constructed at regular intervals out of bricks or masonry
or concrete and may be of 50 cm height from the ground level. Their top surfaces should be flat and level with each other.
(c) Stack Proper. These are made of sawn timber shapes (sleepers, planks). One stack should have timber of one shape and same length and width.
The timber shape to be seasoned is stacked in layers in such a manner that:

1. enough space is left between one layer and another layer above it;
2. enough space is left between one part and another part in the sum layer:
3. enough space is left between one stack and another stack.

The stack length and height depend upon the length of the wood part being seasoned. A single stack may be 3 to 4 meters in height.

The most essential consideration in making such a stack is ensuring free circulation of air around each part of the wood placed in a stack.

It is also essential that the stack should be safe from direct winds and direct scorching heat. This is because, in air seasoning of timber, the loss of water is due to evaporation.

<u>The advantages of natural (air) seasoning are:</u>
It is highly economical;
It requires little supervision;
It is applicable to thicker timber parts as well as a thin section.
<u>Disadvantages of Air Seasoning:</u>
It is a very slow process;
It keeps the valuable land and timber blocked for longer periods (and hence in some cases may be uneconomical).
Seasoning is not always uniform in all the sections of timber.

<u>Artificial Seasoning of Timber (Kiln)</u>
This is the modern method of seasoning any type of timber in a short time. It involves drying the timber in a specially designed kiln where there is perfect control over temperature, humidity and air circulation. With the help of kiln seasoning of timber, it is possible to reduce the moisture content to as low level as 6 percent.

The method involves broadly the following steps:

(a) Timber is stacked properly in the kiln keeping open spaces for air circulation. The kiln is then heated to low initial temperatures, only slightly higher than the atmospheric temperature outside.
It is kept at that temperature for some time.

This initial low heat is essential to avoid cracking or splitting of timber which would become certain if the temperature is suddenly raised to high drying rates.

In that case, moisture from the surface of the wood will dry out fast (causing shrinkage) whereas moisture in deeper cells will be slow in moving out.

In slow heating, this risk is adequately covered.

(b) Once the timber has been at low heat and good humidity for some time, the temperature of the kiln is raised.
Humidity is reduced, and air circulation is made faster.

In this way a continuous process of loss of moisture from the deeper cells to the outer cells of the timber and from there to 'outside' the kiln starts.

(c) During the heating process, all efforts are made to maintain a uniform circulation of the air so that all the parts of timber in a pile receive the same amount of heat.

Fabrics

In architecture, fabric structures are forms of constructed fibers that provide end users a variety of aesthetic free-form building designs.Custom-made fabric structures are engineered and fabricated to meet worldwide structural, flame retardant, weather-resistant, and natural force requirements.

Fabric structures are considered a sub-category of tensile structure.

Fabric or cloth is a flexible artificial material that is made by a network of natural or artificial fibres.
the term fabric describes the way different parts of something work together to form a single entity.

Membrane materials
the fabric is coated and laminated with synthetic materials for increased strength, durability, and environmental resistance.

Cotton canvas
The traditional fabric for fabric structures in light cotton twill, light canvas, or heavy proofed canvas.

Polyesters
Polyesters are laminated or coated with PVC films are usually the least expensive option for longer-term fabrications.

Vinyl-laminated polyesters

A laminated fabric usually is composed of a reinforcing polyester scrim pressed between two layers of unsupported PVC film.
film joined by heat, pressure, and an adhesive to form a single ply. A good chemical bond is critical to both preventions of delamination and development of seam strengths. The seam is created when vinyl- coated fabrics are welded together. The adhesive enables the seam to meet shear forces and load requirements for a structure at all temperatures.

The adhesive prevents wicking of moisture into the scrim's fibers, which also prevents fungal growth or freezing that could affect the exterior coating's adhesion to the scrim.

Adhesives are water-based to comply with EPA regulations. Uses- for awnings, tents and low-tension frame structures.

Vinyl-coated polyester

It is made up of a polyester scrim, a bonding or adhesive agent, and exterior PVC coatings and provides the tensile strength, elongation, tear strength, and dimensional stability of the resulting fabric.
Vinyl-coated polyester is manufactured in large panels by heat-sealing an over-lap seam with either a radio-frequency welder or a hot-air sealer.
The PVC coating liquid (vinyl Organisol or Plastisol) contains chemicals to achieve the desired properties of color, water and mildew resistance, and flame retardancy.
Fabric can also be manufactured that contains high levels of light transmission or can be made completely opaque. After the coating has been applied to the scrim, the fabric is put through a heating chamber that dries the liquid coating. PVC coatings are available in a range of colors.

Vinyl-coated polyester is the most common fabric for producing flexible structures such as custom-designed awnings, canopies, walkways, tent halls, smaller air-supported structures and light member-framed structures.

Fiberglass

Glass fibers are drawn into continuous filaments, which are then bundled into yarns. The yarns are woven to form a substrate.

The fiberglass carries a high ultimate tensile strength, behaves elastically, and does not suffer from significant stress relaxation or creep. The PTFE(Polytetrafluoroethylene) coating is chemically inert, can withstand temperatures from 100 °F upwards to 450 °F+.
Because of its energy efficiency, high melting temperature and lack of creep, fiberglass-based fabrics have been the material of choice for stadium domes and other permanent structures.
Its ability to provide natural daytime lighting and its highly reflective surface.

Blackout fabric

Blackout fabric, also known as blockout material, is an opaque fabric.

Blackout fabric consists of a laminate that sandwiches an opaque layer between two white exterior layers.
Heating and lighting of a structure may be controlled because the fabric does not allow light to permeate the top or walls.
The opaque quality also prevents stains, dirt, repairs, or slightly mismatched panels on the structure's exterior from being noticed from the inside.
Blackout fabric also has its disadvantages. Heating may be necessary, as the tent's interior may be colder than using non-opaque fabric.

Netting

Netting is considered a type of mesh, usually tight with small holes. Netting finds use in stadium interiors behind goals, golf ranges and courses, playground equipment and structures, horticulture, zoos, construction sites and other areas where protection or containment is needed.
Netting consists of a nylon, polyester or polypropylene with extruded or spun yarns that is knotted or knitted to form the material.

Textile and Fabric Structures

Textile architecture is architecture of "skin and bones". As fabric can only resist tension, a supporting system of compressive elements is needed. This is called a primary structure and it transmits the external, vertical loads to the ground.

In membrane architecture, a thin fabric skin works as a load transmitting surface in a dynamic structure.

The fabric is in doubly curved anticlastic or synclastic form.
Anticlastic form is based on a double curved pattern with the curves pulling to opposite directions, such as in a saddle shape.
In synclastic form the curves pull in the same direction, such as in a paraboloid shape.
There are various different types and forms of primary structures in textile architecture. The framework can have many forms. The basic structures are planar or doubly curved membrane and cablenet structures.
Textiles in architecture have been used earlier to build tents by the nomads in different cultures around the world. **Skin, barks, woven mats, canvas, and woolen fabrics** were used by people to build shelters for themselves and the animals.
Tipis, Yurts, and the black tent, which was made by Bedouins, are few examples that show that textiles with high tensile strength were being used to build structures even in the pre-historic era.
Tents are a prime example of vernacular architecture. Built by unknown builders, they form part of the roots of our traditional architecture. Tents are not the first type of dwelling of the humankind. They are, however, the first type of dwelling using **textile as a cover**. In some tents, textile functions even as part of the load bearing structure. The valued qualities of tents are very much the same as the sought after in contemporary architecture; lightness, flexibility, contemporaneity, and even portability.

The structural behaviour of architectural fabric structures

Fabric structures are a form of tensile structure in which a membrane is 'stretched' to form a structurally stable surface. Typically, the membrane is formed by a fabric, consisting of a woven base cloth, coated on both sides with an impermeable polymer, and sometimes a durable topcoat, held in position by tension forces imposed by a structural framework, a cabling system, internal air pressure or a combination.

Architectural fabrics

Typically, fabric structures are formed using PTFE coated glass, or PVC coated polyester, although there is an increasingly wide range of other materials available.

The fabric itself it generally very thin, approximately 1mm thick. It has very little compressive strength, but very high tensile strength. Woven glass fabrics are stronger in tension than steel. Different types of membrane are available depending on the use, longevity and tensile strength required.

Textile is no more used only for interior applications like carpets & curtains but used in civil engineering for temporary structures. New textile materials invention & methods textile is used in permanent applications of houses & civil engineering. Current era we are more focused in construction, houses & building design have more sunlight, greener, high performance, cost saving & sustainable structure. To fulfill that requirements textile, play a fundamental role.

Categories

Textile used in civil application are divided in two categories:

Buildtech, Geotextile

Buildtech: Textile used in building houses & Construction called Buildtech. Textile have increased usage indoor & outdoor for surface & hidden applications. Textile traditional use in houses carpets & curtains, but textile is also used in acoustic & thermal insulation, protection of building against sun, wind, fire, water. Textile fibers are used with concrete to enrich its properties & lowering the cost & protection against UV & electromagnetic radiations. Textile integrated LED & other electroluminescent material used for energy saving & use of more sunlight.

GEOTEXTILE

Geotextile is the combination of two words 'Geo' comes from the Greek word meaning 'Earth' & textile. Geotextile defined as “Any permeable textile material used for filtration, drainage, separation, reinforcement and stabilization purposes as an integral part of civil engineering structures of earth, rock or other constructional materials”.

Types of Geotextile The geotextiles are further prepared in three different categories:

Woven Fabrics: Woven geotextile are manufactured weaving technology as standard clothing textile. Geosynthetic are of woven type, which can be subdivided into categories based upon their method of manufacture. this type has characteristic appearance of two sets of parallel threads of yarn that is warp and weft. Geotextile it is compose of two sets of parallel yarns. Interlaced to form a planner structure which include multifilament woven, monofilament woven, slit film woven.

Nonwoven fabric Nonwoven manufactured from either short staple fiber or continuous filament yarn. The fiber can be bonded by thermal, chemical, mechanical or mechanical techniques. Fibers are bonded together into a planar structure, which include following:

Nonwoven mechanically needle punched Nonwoven heat set.
Staple fiber and continuous filament fiber.

Knitted fabric Interlocking a series of loops of yarn together. All of knitted geosynthetic are formed by using the knitting technique in conjunction with some method of geo-synthetic manufacturer. knitted geotextile are subset to woven geotextile and are found as filters on pipes in two stage filter. multilayer geotextiles reformed by bonding together nonwoven or woven geotextile. They give high protection geotextile. PET and PP are mostly used synthetic in civil engineering.

Fiber used for Geotextile

Natural & man-made fibers both are used in geotextile manufacturing.
Natural Fibers -Natural fibers that can be used in geotextile manufacture are get from Jute, Sisal, Flax, Hemp, Ramie and Coir. Natural fibers provided high modulus & strength and low breaking extension & elasticity.

Advantages of natural fibers

Natural's fibers are offered some of the mentioned below
advantages Low cost
Strength/durability
Availability
Biodegradability/ environment friendly

Geo textile functions -The mode of operation of geotextile in any application can be defined by the following functions:

Application of Geotextile in Separator

Road construction for time saving, long lasting road life & economical, Railway Ballast to protect against pumping phenomena, Geotextile placed between subgaurd & overlying layer, Sea and riverbed protection to protect soil, grow grass for stabilization, Embankment Stabilization.
, Non-permanent Roads

Application of geotextile in drainage

Filter around trench drain and edge drain to prevent soil from migrating into aggregates.
Filters beneath pavement permeable bases, blanket drain and base courses.
Drains for structure such as retaining wall and bridge abutment.
Tunnel lining system to protect the concrete
Geo-textile wraps for slotted or joined drain and well pipes.
Chimney and toe drains for earth dams and levees to provide seepage control.

Filter function Geotextile in filter function, structured that liquids can pass through its thickness while it prevents the passage of soil particles from the geotextile fabric. It has suitable level of permeability and average pore size & pore size distribution small to prevent soil migration.

Application of geotextile in filter

Perforated pipe wrapped with geotextile to collect water
Filter between earth & gabions to protect structure at
slope Filter between permeable embankment
Filter preventing erosion.

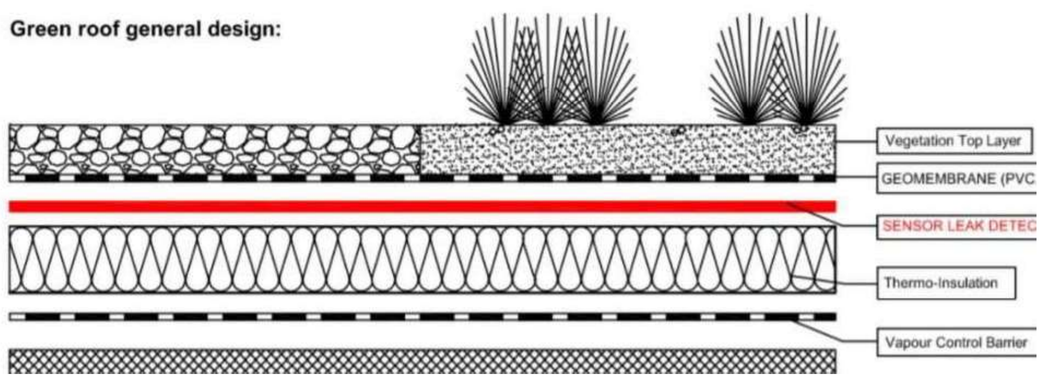


Fig.8. Green roof

Living/green roofs

Green Roofs or Living roofs are used in most of building & attractiveness for better Environment. Living roofs have features vegetation, growing media and waterproofing • Membranes, water retention, drainage and irrigation systems.

Advantages of green roofs

Living roofs increase the green area ratio on building sites and allow the design of commercial and recreational roof gardens and terrace areas.
Reduced Maintenance – Green roofs geotextile materials protected against UV radiations, snow & storm situations.
Water retention – Continuous supply of water to the root zone in the absence of irrigation, rain

water in retained & supply through capillary action.
Superior Environment – By green roofs Planted area increased which reduce greenhouse gases effect & plants absorbed pollutants.
Reduced Energy Costs – Living roofs provides insulation properties & radiation is minimized which guarantee building is cooler in the summer and warmer in winter.

JUTE -is a long, soft, shiny vegetable fibre that can be spun into coarse, strong threads. It is produced from plants in the genus Corchorus, which was once classified with the family Tiliaceae. Jute is the name of the plant or fiber that is used to make burlap. Jute fibers are composed primarily of the plant materials cellulose and lignin. Jute is also called "the golden fiber" for its color and high cash value.
Geotextile is the fabric which enhances the engineering properties of soil when applied in or on soil.
Natural Geotextile like, Jute Geotextile (JGT) deserve separate mention because of its natural resource, annual renewability and unique features
There is hardly any difference between synthetic geotextiles & JGT function-wise excepting the aspect of long term durability of synthetic GT.
The term geosynthetics encompass both manmade and natural geotextiles.

Jute Fibre

Jute is mainly composed of polysaccharides and lignin but it also contains smaller amount of fats and waxes, pectin, nitrogenous, coloring and inorganic matters.

Strength and Extensibility Jute is a strong but low extensible fibre mainly due to composite like structure with highly oriented long chain molecules.

Moisture absorption due to presence of numerous polar –OH groups, jute fiber shows good moisture absorption capacity.

Water holding Capacity of jute fibre is 500%

<u>Advantages of jute geotextile</u>

Abundant quantity (INDIA is producing 20lakh m/t of jute per year)

Great moisture retention capability.

Ease of installation.

Bio-degradable properties.

Lower cost compare to synthetic geotextile.

High initial tensile strength.

High tenacity—comparable to man-made fibres

High initial modulus—even higher than coir

Low elongation at break—lowest among all natural fibres—can provide good membrane support under load.

Highly hydrophilic –highest among all fibres

High roughness Co-efficient- ensures better load transference

<u>Environmental Advantages of JGT</u>

During 100 days of jute growing period, 1 hectare of jute plant can absorb about 15 MT of CO_2 from atmosphere and liberate about 11 MT of O_2.

Main use of jute sticks (a retting output) is as fuel and household uses.

Yield of jute sticks is 2.5times the fibre by weight.

Jute sticks annually saves 5.06 million tons of forest wood (in India and Bangladesh) and help in preserving ecological balance.

Jute leaves left in the field are good manures and increase fertility of land.

Leather

Leather is a material created by tanning animal or cattle hide and skin. Leather is durable and also flexible. It is produced in cottage industries as well as heavy industries at manufacturing scale. Leather is found in four forms like full grain, top grain, corrected grain and split. Leather is used to produce different types of goods like shoes, hats, jackets, trousers, belts, furniture coverings etc. Tiles made from leather scraps Epitomizing luxury and elegance, leather has been used for a long time as a building material for niche interiors owing to the richness and glamorous feel it gives. leather straps and pieces, obtained from car seats, furniture, tanneries, etc., can also be used to make richly hued leather tiles and panels. These are cheaper and easy to install.

SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT-II- MATERIALS AND CONSTRUCTION-I – SDE 2301

SYNTHETIC MATERIALS

Natural building materials

Glass has been a fascinating material to humankind since it was first made in about 500 BC. It is one of the most versatile and oldest materials in the building industry. From its humble beginnings as a window pane in luxury houses of Pompeii to sophisticated structural members in new age buildings, its role in architecture has evolved over the years.
Glass is a non-crystalline, amorphous solid that is often transparent and has numerous applications over diverse fields.
Types of glass (1) Soda-lime glass (2) Potash-lime glass (3) Potash-lead glass (4) Common glass
Soda-lime glass: This is also known as soda-glass or soft glass. It is mainly a mixture of sodium silicate and calcium silicate.
Properties:

(i) It is available in clean and clear state.
(ii) (ii) It is cheap.
(iii) It is easily fusible at comparatively low temperature.

Uses: It is used in the manufacture of glass tubes and laboratory apparatus, plate glass, window glass, etc.

Potash-lime glass: Also known as bohemian-glass or hard glass. It is mainly a mixture of potassium silicate and calcium silicate.
Properties:

(i) it fuses at high temperature.
(ii) it is not easily affected by water and other solvents.
(iii) it does not melt so easily.

Uses: used in manufacture of glass articles which have to withstand high temperatures such as combustion tubes, etc.,

Potash-lead glass: Also known as flint glass. It is a mixture of potassium silicate and lead silicate.
Properties:

(i) It fuses very easily
(ii) Easily attacked by aqueous solution.
(iii) Posses great refractive power.
(iv) Specific gravity is about 3 to 3.50.
(v) Turns black and opaque.

Uses: It is used in the manufacture of artificial gems, electric bulbs, lenses, prisms etc.

Common glass: Also known as bottle glass. Manufacture of sodium silicate, calcium silicate and iron silicate.
Properties:

(i) It fuses with difficulty.
(ii) It is brown, grey or yellow in colour.

(iii) (iii) easily attacked by acids.

Uses: it is mainly used in the manufacture of medicine bottles.

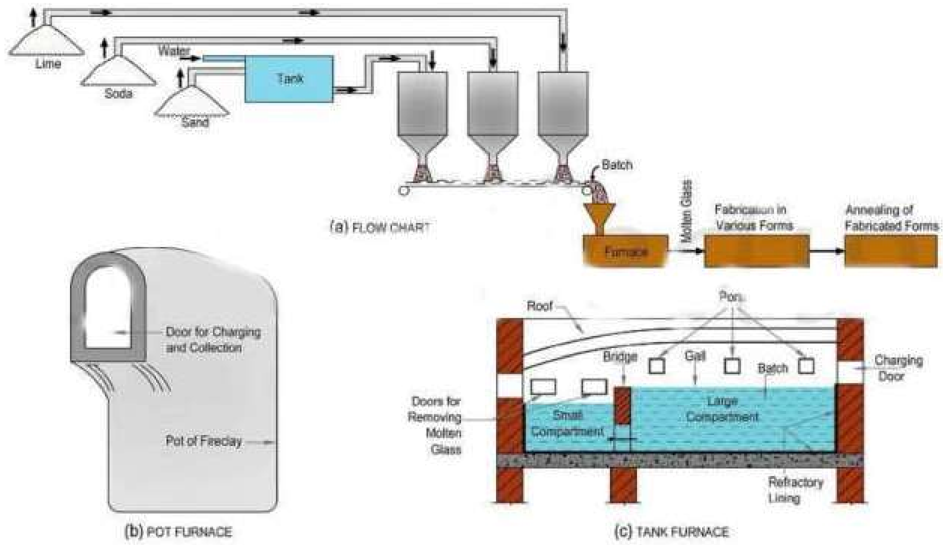


Fig.1.Manufacture of Glass

MANUFACTURE OF GLASS:

The procedure adopted in the manufacture of glass may broadly be divided into the following five stages:

(i) Collection of raw materials

(ii) Preparation of batch

(iii) Melting in furnace

(iv) Fabrication

(v) Annealing.

1.Collection of raw materials

Depending upon the type of glass to be manufactured, suitable raw materials are collected.

Raw materials required for each type of glass.

Soda-lime glass - Chalk, soda ash and dean mild.

Potash-lime glass- Chalk, potassium carbonate (KIC0s) and clean sand.

Potash-lead glass - Litharge (PbO lead monoxide) or lead sesquioxide, potassium carbonate and pure sand.

Common glass - Chalk, salt cake (Na,SO4), coke, ordinary sand, etc.

In addition to raw materials, cutlet and decolouriser are also added for each type of glass. Gullet indicates waste glass or pieces of broken glass. They increase the fusibility of glass which is produced and they also reduce the cost.

The raw materials generally contain traces of iron compounds. Ferrous oxide imparts a green colour to glass and ferric oxide imparts a very light yellow tint. To avoid such effects. decolourisers are added. The usual substances used as decolourisers are antimony oxide (Sb203), arsenic oxide (As_20_3), cobalt oxide (C_oO), manganese dioxide (MnO_2) and nickel oxide (NiO).

2. Preparation of batch

The raw materials, cutlet and decolouriser arc finely powdered in grinding machines. These materials are accurately weighed in correct proportions before they are mixed together. The mixing of these materials is carried out in mixing machines until a uniform mixture is obtained. Such a uniform mixture is known as batch or frit and it is taken for further process of melting in a furnace.

3. Melting in furnace

The batch is melted either in a pot furnace or in a tank furnace. The heating is continued until the evolution of carbon dioxide, oxygen, sulphur dioxide and other gases stops.

Pot furnace:

In this furnace, pots are adopted as units. A typical glass melting pot is shown in figure. A pot is a vessel made of fire-clay. This process resembles crucible steel process. These pots are placed in specially prepared holes in the furnace. The charging and collecting doors are kept projecting outside so that raw materials may be added and molten glass may be taken out conveniently.

The pots are filled with raw materials. The furnace is heated by means of producer gas. When the mass has melted down, it is removed from the pot and it is taken for the next operation of fabrication.

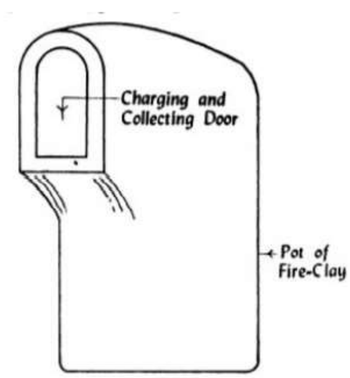


Fig.2.Glass melting pot

The melting of glass by pot furnace is an intermittent process. It is used to melt small quantities of glass at a time or to prepare special types of glass.

This furnace resembles reverberator furnace adopted for puddling of wrought-iron. tank furnace adopted for melting of glass. It is constructed with reinforced masonry. The roof is given special shape to deflect the flames of heated gas. Ports are provided for the entry of pre-heated producer gas. Doors are provided for charging and for taking out molten glass. A bridge separates the tank into two unequal compartments. The batch is heated in large compartment and it contains somewhat impure glass. It flows through opening of bridge into small compartment. Gall or floating impurities arc collected at the top of large compartment. Refractory lining is provided to the interior surface of tank.

The tank is filled with raw materials. The furnace is heated by allowing producer gas through ports. The charging of raw materials and taking out of molten mass are simultaneous. This is a continuous process and it is adopted to melt large quantities of glass at a time.

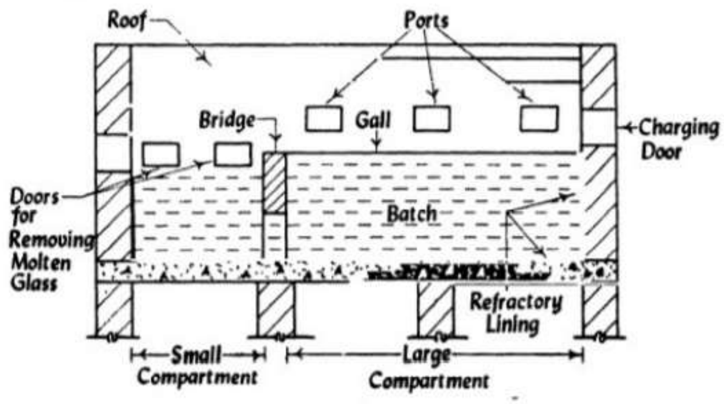


Fig.3.Section of a tank furnace

4. Fabrication

The molten glass is given suitable shape or form in this stage. It can either be done by hand or by machine. Hand fabrication is adopted for small scale production and machine fabrication is adopted for large scale production. Following are the different ways of fabrication:

- Blowing
- Casting
- Drawing
- Pressing Rolling
- Spinning

5. Annealing

Glass articles, after being manufactured, are to be **cooled down slowly and gradually**. This process of slow and homogeneous cooling of glass articles is known as **annealing of glass**. Annealing of glass is a very important process. If glass articles are allowed to cool down rapidly, the superficial layer of glass cools down first as glass is a bad conductor of heat. The interior portion remains comparatively hot and it is, therefore, in a state of strain. Hence such glass articles break to pieces under very slight shocks or disturbances.
Following are the two methods of annealing: (i) Flue treatment (ii) Oven treatment.

- Flue treatment: In this method, a long flue is provided and it is constructed in such a way that there is gradual decrease in temperature from one end of flue to the other. The red-hot articles of glass arc allowed to enter at the hot end of flue and they are slowly moved on travelling bands. They become cool when they reach the cool end of flue. This method is useful for large scale production.
- Oven treatment: It this method, the red-hot glass articles arc placed in ovens, in which arrangement is made to control the tempera-ture. After articles are placed in ovens, the temperature is slowly brought down. This method is useful for small scale production.

SPECIAL VARIETIES OF GLASS

Float Glass or Plate glass: Float glass manufactured from sodium silicate and calcium silicate so, it is also called as soda-lime glass. It is clear and flat, so it causes glare. Thickness of the float glass is available from 2mm to 20mm, and its weight range from 6 to 36 kg/m2 . The application of float glass includes shop fronts, public places, glass blocks, railing partitions etc.
This molten glass coming out of the furnace is allowed to float on the molten tin. The glass thus formed is known as float glass and it is then further annealed to remove all the stresses. It is widely used for residential buildings, commercial complexes, furniture articles,etc.
It is superior to ordinary sheet glass and grants the following advantages
It consumes 30% to 40% less energy and is thus environmentally friendly.

i. It is aesthetic in appearance and its use has opened unlimited possibilities of innovation in architectural design.
ii. It is available in larger sizes and various thicknesses.
iii. It is cost effective as compared to the corresponding cost of brick wall, finishing material, paint, maintenance, etc,
iv. It is ideally suitable for solar applications due to high light transmission and it results in higher efficiency.
v. It is tougher and more scratch-resistant.
vi. It makes the windows that transmit more natural light and the mirrors that give true images.
vii. It possesses high optical clarity and superior safety properties. ix. There is no refraction defect due to uniform thickness and superior optical clarity and thus there is less eye strain.

Some manufacturers produce float glass with a special thin coating on one side which, allows the sun's energy to pass through in one direction while reducing the thermal transfer the other way. It is known as energy efficient glass. The principle behind this is the difference in thermal wavelength of energy transmitted from the sun and that transmitted from the heat within the room. Some manufacturers produce float glass with a special thin photo catalytic coating on one side. This coating uses the ultraviolet rays from the sun to steadily breakdown any organic dirt on the surface using the photo catalytic effect and thus loosen the dirt from the glass. This type of float glass is known as self-cleaning glass. **Self-cleaning glass** also has hydrophilic properties which means that when rain runs down the pane of glass, it will wash away the dirt previously loosened. Both, the photo catalytic and hydrophilic effects allow the glass to stay cleaner for a longer period than untreated glass. Small particles of dirt will loosen and (providing there is rain)be washed off fairly quickly, however, bird droppings and other large bits of dirt, will take longer to be cleaned off. Self cleaning glass may, from time to time, need additional cleaning and great care needs to be taken with such cleaning to avoid damaging the surface coating. Abrasive cleaning is carried out, the self-cleaning properties may take a period of time to become active again.

Tinted Glass: Certain additions to the glass batch mix can add color to the clear glass without compromising its strength. Iron oxide is added to give glass a green tint; Sulphur in different concentrations can make the glass yellow, red or black. Copper sulphate can turn it blue.

Toughened Glass This type of glass is tempered, may have distortions and low visibility but it breaks into small dice-like pieces at modulus of rupture of 3600 psi. Hence it is used in making fire resistant doors etc. They are available in same weight and thickness range as float glass.

Laminated Glass: This type of glass is made by sandwiching glass panels within a protective layer. It is heavier than normal glass and may cause optical distortions as well. It is tough and protects from UV radiation (99%) and insulates sound by 50%. Used in glass facades, aquariums, bridges, staircases, floor slabs, etc.

Shatterproof glass: By adding a polyvinyl butyral layer, shatter proof glass is made. This type of glass does not from sharp edged pieces even when broken. Used in skylight, window, flooring, etc.

Double glazed units: These are made by providing air gap between two glass panes in order to reduce the heat loss and gain. Normal glass can cause immense amount of heat gain and upto 30%of loss of heat of air conditioning energy. Green, energy efficient glass can reduce this impact. Insulated glazed glass units contains a glass is separated into two or three layers by air or vacuum. They cannot allow heat through it because of air between the layers and acts as good insulators. These are also called as double glazed units.

Chromatic glass: This type of glass can control daylight and transparency effectively. These glass are available in three forms- photochromatic (light sensitive lamination on glass), thermochromatic (heat sensitive lamination on glass) and electrochromatic (light sensitive glass the transparency of which can be controlled by electricity switch.) It can be used in meeting rooms and ICUs.

Glass wool: Glass wool is a thermal insulation that consists of intertwined and flexible glass fibers, which causes it to "package" air, and consequently make good insulating materials. Glass wool can be used as filler or insulators in buildings, also for soundproofing.

Applications of glass wool include structural insulation, pipe insulation, filtration and soundproofing. Glass wool is a versatile material that can be used for the insulation of walls, roofs and floors. It can be a loose fill material, blown into attics, or, together with an active binder sprayed on the underside of structures. During the installation of the glass wool, it should be kept dry at all times, since an increase of the moisture content causes a significant increase in thermal conductivity.

Glass blocks: Hollow glass wall blocks are manufactured as two separate halves and, while the glass is still molten, the two pieces are pressed together and annealed. The resulting glass blocks will have a partial vacuum at the hollow center. Glass bricks provide visual obscuration while admitting light.

These are partially evacuated and completely sealed hollow units which are formed by fusing together two-halves of pressed glass. The edges are coated with a grit bearing plastic material so that permanent and effective bond with the mortar is ensured. The glass blocks are available in square sizes with dimensions as 150mm,200mm and 300mm with the approximate thickness of 100mm.One or both the faces of the blocks are suitably treated to obscure the glass and to diffuse light. These blocks possess high insulating value and they are set in cement mortar.

<u>The glass blocks possess the following advantages:</u>

i. They are easy to clean and hence they can be well maintained.
ii. They are excellent in light transmission.
iii. They provide very good insulation against cold, heat and noise.

The glass blocks are not intended to carry superimposed loads. But they possess adequate strength to carry their own weight up to a maximum height of 6m. They are also able to resist the effect of lateral wind pressure for individual panels not exceeding 11 m2 in area.

Glass blocks or Glass bricks are manufactured from two different halves and they pressed and annealed together while melting process of glass. These are used as architectural purpose in the construction of walls, skylights etc. They provide aesthetic appearance when light is passed through it.

<u>Fibre Glass:</u> The fibre glass is composed of minute glass rods and each rod resembles the parent material in all respects. It is soft to the touch and it is flexible in nature. It does not absorb water and it is proof against fire, vermin, water and acids. It can be prepared either in the form of continuous strands just like silk or in the staple form just like wool. For making this type of glass, the molten glass is spun at very high speed to produce continuous fine glass fibres. This is a special type of glass and it is used for thermal insulations, sheets, fibre glass reinforced plastics, etc., In recent years, great progress has been made in making optical fibres which can guide light and thus transmit images round corners. These fibres are used in endoscopes for examination of internal human organs. Glass fibres has many uses from roof insulation to medical equipment and its composition varies depending on its application.

<u>Foam Glass:</u> The foam glass is prepared in the form of rectangular blocks. The finely grounded glass and carbon are thoroughly mixed and the mixture is then melted in a furnace. At the time of melting, the mixture expands and assumes the form of a black foam. The resulting glass material contains more than 350 million inert air cells per m3. The foam glass floats in water and it can be cut like wood. It is fire fireproof, rigid and an excellent heat insulator. FOAM GLASS A novel gassy material and is a kind of thermal insulation, not flammable building material, in which there are numerous closed tiny pores. Advantages about -light weight, high strength, low thermal conductivity.

Wired Glass:

Wired glass is a type of glass into which a wire mesh is embedded during production. Wired glass has an impact resistance similar to that of normal glass but the wire mesh acts as a reinforcement. If the glass breaks due to impact, the pieces of glass are held by wire reinforcement in position. Wired glass has high resistance to fire as it does not break when exposed to fire. Due to such property, it is also called fire rated glass or fireproof glass.

<u>PROPERTIES OF GLASS</u>

Transparency: This property allows visual connection with the outside world. Its transparency can be permanently altered by adding admixtures to the initial batch mix. By the advent of technology clear glass panels used in buildings can be made opaque. (Electro chromatic glazing)

U value: The U-value is the measure of how much heat is transferred through the window. The lower the U-value the better the insulation properties of the glass– the better it is at keeping the heat or cold out.

Strength: Glass is a brittle material but with the advent of science and technology, certain laminates and admixtures can increase its modulus of rupture (ability to resist deformation under load). **Greenhouse effect:** The greenhouse effect refers to circumstances where the short wavelengths of visible light from the sun pass through glass and are absorbed, but the longer infrared re-radiation from the heated objects are unable to pass through the glass. This trapping leads to more heating and a higher resultant temperature.

Workability: It is capable of being worked in many ways. It can be blown, drawn or pressed. It is possible to obtain glass with diversified properties- clear, colorless, diffused and stained. Glass can also be welded by fusion.

Recyclable: Glass is 100% recyclable, cullets (Scraps of broken or waste glass gathered for re-melting) are used as raw materials in glass manufacture, as aggregates in concrete construction etc. **Solar heat gain coefficient:** It is the fraction of incident solar radiation that actually enters a building through the entire window assembly as heat gain.

Visible transmittance: Visible transmittance is the fraction of visible light that comes through the glass.

Energy efficiency and acoustic control: Energy-efficient glazing is the term used to describe the double glazing or triple glazing use in modern windows in homes. Unlike the original single glazing or old double glazing, energy-efficient glazing incorporates coated (low-emissivity) glass to prevent heat escaping through the windows. The air barrier also enhances acoustic control.

Glass Wool Manufacturing Process

1. Batch: Glass wool is made mainly of sand, soda-ash, limestone and recycled glass; stored in silos, they are weighed, mixed and poured into a furnace.

2. Melting: The mixture is then melted at a temperature exceeding 1,400°C in an electric or gas furnace.

3. Fiberizing: The liquid glass passes via a feeder to a fiberizing machine, where it is propelled through tiny holes by a centrifugal spinner - creating the fibers. These are sprayed with a binder and shaped into a blanket.

4. Forming: Then the blanket passes through a curing oven. During this process, the blanket can be compressed to achieve its final thickness.

5. Cutting: The blanket is then cut to the required width. Off-cuts are recycled. A facing can eventually be glued to the blanket.

6. Packaging: The end of the line is generally equipped with a rolling machine for mats and a stacking machine for boards.

7. Palletization: The glass wool can be compressed to up to a tenth of its volume. A total of 36 rolls of glass can be packed onto a single pallet.

PLASTICS

Plastics are belonged to the family of organic materials. ¬ Organic materials are those materials obtained directly from carbon and chemically combined with oxygen, hydrogen and other non-metallic compounds. ¬ These organic materials are classified into two types.

They are

1. Natural organic materials: The wood, coal, petroleum and natural rubber are under the categories of natural organic.

2. Synthetic organic materials

- The plastics, synthetic rubbers, ceramics glass are under the categories of synthetic organic.
- Technically, these organic materials are called as Polymers.

Plastic is a material consisting of any of a wide range of synthetic or semisynthetic organic compounds that are malleable and can be molded into solid objects.

There are many ways of classifying plastics. They can be classified considering various aspects, as according to their :

1. Behaviour with respect to heating,

2.Structure, and

3.Physical and mechanical properties

Classification of Plastics

Behaviour with respect to heating

(i) **Thermo-Plastic:**

- The thermo-plastic or heat non-convertible group is the general term applied to the plastics which become **soft when heated and hard when cooled.**
- The process of **softening and hardening may be repeated for an indefinite time**, provided the temperature **during heat is not so high as to cause chemical decomposition.**
- It is thus **possible to shape and reshape these plastics by means of heat and pressure**.
- One important advantage of this variety of plastics is **that the scrap obtained from old and warn-out articles can be effectively used again.**
- Depending on the resin, thermoplastics can **serve low-stress applications** such as plastic bags or can be used in **high-stress mechanical parts**. Examples of thermoplastic polymers include polyethylene, PVC, and nylon.

Thermo-Plastics

- Polyethylene, polypropylene, polystyrene & polyvinyl chloride (PVC) most common thermoplastics.
- Any object made from thermoplastic can be remolded into a new shape.
- Thermoplastics creep considerably more than thermosets, particularly at higher temperature
- Can be used for light structural properties.

Thermosetting materials

- The thermo-setting or heat convertible group is the general term applied to the plastics which **become rigid when moulded at suitable pressure and temperature**.
- When they are heated in temperature range of 127°C to 177°C, they **set permanently and further application of heat does not alter their form or soften them.** But at temperature of about 343°C, the charring occurs. This charring is a peculiar characteristic of the organic substances.
- The thermo-setting plastics are soluble in alcohol and certain organic solvents, when they are in thermo-plastic stage. This property is utilized for making paints and varnishes from these plastics.
- The thermo-setting plastics **are durable, strong and hard**. They are available in a variety of beautiful colours. They are mainly used in **engineering application of plastics.**

Most popular thermosets are unsaturated polyester, phenol-formaldehyde and polyurethane.

Polyester used in manufacture of fiberglass product and composite material

Phenol-formaldehyde used in lavatory seats, electrical fittings and equipment decorative laminates.

Properties of Plastics

- Density of plastics is very low as compared to metals.
- Strength of plastics is sufficient to make low weight, high strength machine parts.
- Antifriction and self- lubricating properties of plastics enables it to be a good replacement of metal parts.
- Plastics components offer noiseless operation of moving parts, corrosion resistance, water proofing ,leak proof joints, etc.
- Its production is very easy due to low melting point and excellent flow ability in liquid state into the mould cavity.
- Low cost of manufacturing in case of plastics.
- Plastics exhibits insulation for heat and electricity.
- Plastics are chemically stable when subjected to solvents, oxidizing agents, gases, etc.
- Plastics are less brittle than glass, yet they can be made equally transparent and smooth.
- They possess good toughness.
- Plastics can be easily molded to desired shape.
- They having very good damping characteristics, colour ability, deformability and weather ability.

Plastic's Role in Construction

In the construction industry, materials like wood, metal, and glass are incredibly common because they are ideal for building homes and other buildings designed to last for decades – if not centuries. However, since the 1950s, the role of plastics in the construction industry has continued to increase due to its innumerable benefits.

The benefits of plastic in the construction industry include:

Lightweight durability – Even though plastics are some of the most durable materials available in construction today, they are incredibly lightweight and easy to move around the jobsite.

Corrosion and rot resistance – Whereas many materials commonly found in the construction industry – including wood and metal – rot, rust, or corrode when exposed to the elements, this is simply not the case for plastics.

Weather ability – Plastic can achieve very tight seals that many other materials cannot, which makes it ideal for weatherization related projects.

Cost effectiveness – Plastics are very economical, especially when they are compared to materials like wood, metal, and even glass.

Injection moulding is a process used for mass-producing plastic components. The process is economical, reliable offering high-quality components with great consistency dimensionally.

The moulding cycle starts with the closed mould. The injection screw injects the molten plastic, with the necessary speed & pressure into the mould, which is clamped shut tightly. Once the mould cavity is filled the screw stop, holds pressure on the material until the gate solidifies to prevent material flowing back, referred to as mould packing or cycle hold time. Cooling time starts, the screw reverses back to accumulate material for the next injection shot. Cooling time is decided by the component thickness. Once the cooling time is complete, the mould opens ejecting the moulded component.

Fabrication

Following are the processes involved in the fabrication of articles of plastics:

(1) Blowing

(2) Calendering

(3) Casting

(4) Laminating

(5) Moulding

Blowing:

This method of lubrication of articles of plastics is more or less the same as that one employed in the glass industry. A lump of plastic material is taken and by blowing, it is converted into hollow plastic articles such as jars, bottles, toys, etc.

Calendering:

In this process, the plastic material is allowed to pass between the cylindrical rollers. The process is used to prepare plain flat sheets of plastics.

The process consists of closely placed four revolving cylinders. The first three cylinders are heated and the last one is kept cold. The plastic material passes between first three cylinders and it is converted into thin sheets.

It is cooled while passing through the surface of cold cylinder. If cloth is to be provided with plastic coating, the cloth is inserted along with plastic material between second and third heated rollers. The roller may be provided with artistic designs which will appear on the finished product.

Casting:

This process is similar in principle to that of metal casting. The resin is heated and when it is in plastic form, it is poured into the mould. The curing of articles is then done either with or without the application of heat. During curing, the low pressure may be applied, if necessary.

This process is used to prepare plastics of beautiful colours and it is most suitable for cellulose plastics. The optical properties of transparent plastics are much better, if they are cast. Apart from moulding the useful products, the casting is also widely used for potting and encapsulation, particularly in the electrical industry.

Laminating:

In this process, the thermo-setting resins are just applied on sheets of paper, asbestos, cloth, wood, glass, fibre, etc., and they are subjected to heavy pressure by allowing them to pass through rollers to form plastic laminates. The thickness of sheets varies from 0.12mm to 15mm. They possess excellent mechanical and electrical properties. Due to the pleasing finish surface, they are used for ornamental and decorative purposes.

Moulding:

This is the most commonly adopted process for the fabrication of plastic articles. The general process consists in placing the raw materials in a mould and then heating it. The moulding can be done by various methods such as compression moulding, extrusion moulding, injection moulding, jet moulding and transfer moulding. The choice of moulding method will depend on the article to be prepared.

<u>These methods are briefly described as follows:</u>

Compression moulding

Extrusion moulding

Injection moulding

Jet moulding

Transfer moulding

Compression Moulding:

In this method, the moulds to receive the plastic material are prepared. The moulds are usually heated and then the plastic material is placed in the moulds. The moulds are closed and they are heated to a temperature of 100°C to 200°C under a pressure of 10 to 50 N/mm^2. The plastic material gets the shape of moulds on account of heat and pressure.

In case of thermo-plastic, the moulds are cooled before the articles are taken out. Thus the moulds are to be heated and cooled alternatively in the preparation of thermo-plastic articles. Thus, for production of thermo-plastics, this method proves to be uneconomical as considerable time is lost in cooling the moulds. In case of thermo-setting plastics, it is not necessary to cool the moulds as articles of such plastics get the shape due to chemical action.

Extrusion Moulding:

In this method, the resin powder is fed through hopper at the inlet end of the revolving screw. At the outlet end, the material is heated and Extrusion moulding it is extruded or forced through a nozzle as shown in figure. The plastic material as it comes out from nozzle is received in moulds and it is cooled with air jets or water bath.

The method of extrusion moulding is adopted for thermo-plastic resins to form continuous lengths of narrow ribbons, sheets, pipes, rod, etc. The method is also sufficiently versatile to be adopted for the production of single items such as bottles.

One of the recent developments in extrusion moulding is the **co-extrusion moulding** in which different materials or various combinations of the same material are extruded simultaneously to produce a laminar composite.

It is used for structural reasons to strengthen an inexpensive but weak plastic with a thin coating of stiff but expensive plastic. It can also be adopted to develop decorative effect by coextruding plastics of different colours.

The principle of extrusion moulding is simple and hence it forms a large percentage of the plastic processed throughout the world.

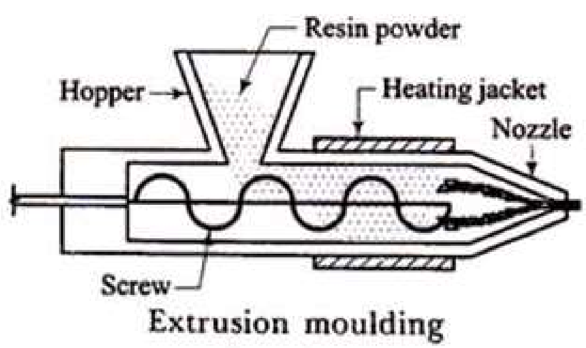


Fig.4.Extrusion moulding

Injection Moulding:

This is comparatively a modern method of moulding. The plastic material is loaded, heated and then injected into the mould. It is then allowed to cool before being taken out from the mould.

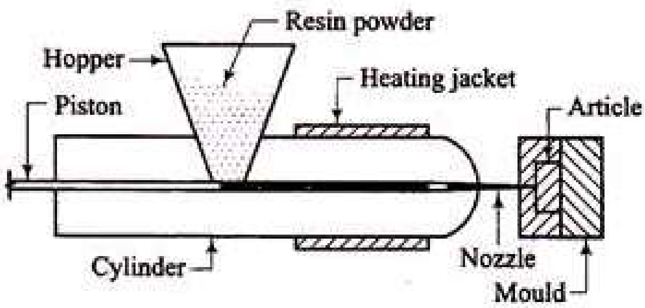


Fig.5.Injection moulding

As shown in figure the resin powder is allowed to fall through a hopper and it is then pushed by a piston into a hot cylinder. The plastic material is melted and it is then forced to fall in the cool mould under a pressure of about 160 N/mm2 through nozzle. The article gets the shape of mould and becomes solid.

The process of injection moulding is very much suitable for thermo-plastic resins. The complete process is automatic and the articles can be prepared within 10 seconds to one minute. It is thus adopted to prepare the plastic articles of small size on a large scale.

The injection moulding is thus a cyclic process and a high dimensional accuracy can be achieved in most materials although account must be taken of factors such as moisture absorption, post-moulding shrinkage, etc.

The injection moulding machines are usually rated according to their shot size and clamping force. The quality of mould to be used also plays an important role for the success of the moulding operation.

Jet Moulding:

In this method, the plastic material is moderately heated. It is then allowed to pass through nozzle, which is preheated to a high temperature. This method of moulding may be adopted for thermo-plastics as well as for thermo-setting materials.

Transfer Moulding:

When the process of injection moulding is applied to the thermo-setting resins, it is known as the transfer moulding. In this process, the moulds are also heated before the plastic material is injected through the nozzle. Thus the thermo-setting resins are heated in this process in two chambers, namely, cylinder and mould.

The pressure on mould is maintained till the chemical action to prepare the plastic article is completed. The plastic materials are removed from the moulds either mechanically or manually.

Engineered wood is manufactured from scraps of lumber and byproducts, such as saw dust, that have been reformed using heat, glue and pressure to make a usable solid-wood alternative. In an effort to meet the demands for a construction material that is lower costing but equally durable. Engineered woods are with a laminate or wood veneer. This is a construction material that has grown in popularity because of advancements in the engineered wood's quality being produced today. Particle board is a commonly known engineered wood used in the manufacturing of many kitchen cabinets and countertops, and another equally popular and more durable engineered wood is plywood. Fiberboard and are the other popular versions on the market today. All of the previously mentioned board types use the similar methods to manufacture the board, but the type of raw material wood used will vary the final texture and strength between them. Processes that are achieving higher densities and the advancement into the inclusion of fire retardant materials are helping to improve the reputation of engineered woods.

Engineering Timber Products

Veneers - Thin sheet of wood, 0.4 mm to 0.6 mm in thickness obtained by different knife cutting process.

Plywood - is made by gluing together veneers.

• It has a good strength both across as well as along the grain.

• Plywood has better splitting resistance due to grains in adjacent layers running at the right angle and nailing and screwing even closed to the edges in safe.

Particle boards - is a board manufactured from particles of wood or other cellulose materials.

This is made up of small chips of wood bonded together with resin (urea formaldehyde) and formed into sheets by compression in a hot press. It is not as strong as plywood and block board but it is not expensive. Chipboard is often covered with a plastic laminate or wood veneer and used in furniture, also called Chipboard.

Advantages

• uniform thickness

• very light weight

• eco-friendly as it is made up to waste wood particles

Disadvantages

• age usually not more than 5yrs

• very sensitive to water and moisture. Swells if comes in contact.

Uses

• Used to make ready-made furniture,

• kitchen cabinets,

• false ceiling,

• wall panels, and partitions

Batten board- it is a board having a core made up of strips of wood usually 8 cm wide each laid separately or glued or otherwise joined to form a slab.

Block board - these are boards having a core made up strips of wood each not exceeding 25 mm.

This is built up with a core of solid elongated blocks of softwood bonded together with adhesive and covered with a sheet of plywood on either side. Alternative facing materials include thin layers of MDF or chipboard.

Structure-Strips of softwood glued together and faced with veneers. Softwood strip are 12 – 25mm wide Does not split Alternating growth ring.

Advantages

Lighter in weight (use of softwood)

• Very strong due to different directions of veneer

• Does not split easily

• Comes in large sizes and also large thicknesses

• Lesser tendency to sag or bend

• Costs Less

• Can screw into the edges

• Better than Particle Board and even MDF

• Resistance to attack from water, heat, chemical, fungi and insect attack.

Disadvantages

• Not as strong as plywood or good quality solid wood

• The nails may sometimes enter the gaps

• Edges need to be covered

Uses/Application

• Furniture - long book shelves , tables and benches

• Kitchen storage

• Interior finishing - shop fittings

• Block board Doors and Solid core flush doors

• Wall cladding - lengthy wall panels

• Ship interiors

• Theater stages

Laminates

A wood laminate is a thin sheet of material used to cover the core of a wood project in order to change the appearance of the material.

Characteristics

• The advantage to a laminate is that they help to lower the overall construction cost while still providing the same sort of aesthetic beauty as solid hardwood cabinets.

• A disadvantage is that a laminated cabinet is slightly more difficult to refinish in the future and the overall cabinet lacks the strength of the hardwood it is being made to resemble.

Application

• Furniture

• Interiors,

• Doors and windows

•Wall cladding

Fiber board

A quality board, relatively cheap. This board is composed of fine wood dust and resin pressed into a board. This material can be worked, shaped and machined easily. Paint can be applied to it without the need for an undercoat or primer. Used in the building and furniture trades.

Hdf : High density fiber board

Mdf : Medium density fiber board

Ldf : Low density fiber board

Plywood is a composite material, made of timber, although we often consider it as a traditional working material. It is composed of individual plies / veneers of wood.

Characteristics

• It is very strong due to the way the plies are put together.

• Plywood is less likely to warp or split.

• Manmade boards of this type are supplied in a range of sizes and thicknesses.

• This is an advantage compared to natural woods, as manmade boards can be manufactured so that they are extremely wide. This makes plywood a popular material in the construction industry.

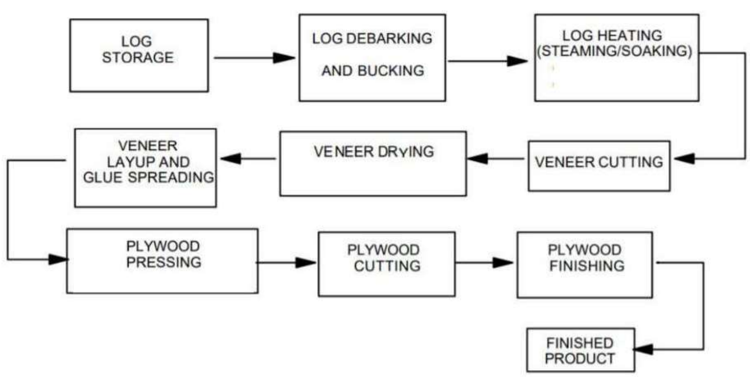
Softwood ply tends to be used in the construction industry for walls, roofs and floors. Hardwood ply tends to be used quality laminate flooring, kitchen units and some furniture. Marine plywood is used in boat hull construction. It is specially treated so that it is water resistant.

Plywood Structure

- Individual layers of plywood are called plies or veneers.
- Each ply has its grain running at ninety degrees to the next layer, as indicated by the arrows. (Panel strength and stiffness in both directions are maximized)
- The plies are glued together with synthetic resin, making a very strong composite material.
- Bonded under heat and pressure with durable, moisture-resistant adhesives
- Plywood is usually constructed so that an odd number of plies are used.

Plywood Manufacturing -General Plywood is a building material consisting of veneers (thin wood layers or plies) bonded with an adhesive. There are two types of plywood: softwood plywood and hardwood plywood. Softwoods generally correspond to coniferous species. The most commonly used softwoods for manufacturing plywood are firs and pines. Hardwoods generally correspond to deciduous species. For hardwood plywood, commonly used wood species include oak, poplar, maple, cherry, and larch. Softwood plywood is manufactured by gluing several layers of dry softwood veneers together with an adhesive. Softwood plywood is used for wall siding, sheathing, roof decking, concrete form boards, floors, and containers. Softwood plywood is classified under Standard Industrial Classification (SIC) code 2436, and North American Industrial Classification System (NAICS) code 321212 for "Softwood Plywood and Veneer". Hardwood plywood is made of hardwood veneers bonded with an adhesive. The outer layers (face and back) surround a core which is usually lumber, veneer, particleboard, or medium density fiberboard. Hardwood plywood may be pressed into panels or plywood components (e.g., curved hardwood plywood, seat backs, chair arms, etc.). Hardwood plywood is used for interior applications such as furniture, cabinets, architectural millwork, paneling, flooring, store fixtures, and doors. Softwood plywood plants typically produce softwood veneers and softwood plywood on the same plant site. However, most hardwood plywood and veneer plants either produce hardwood plywood or hardwood veneer. Hardwood veneer plants cut and dry hardwood veneers. Hardwood plywood plants typically purchase hardwood veneers and press the veneers onto a purchased core material.

Process Description -The manufacture of softwood or hardwood plywood consists of nine main processes: log storage, log debarking and bucking, heating the logs, peeling the logs into veneers, drying the veneers, gluing the veneers together, pressing the veneers in a hot press, plywood cutting, and other finishing processes such as sanding. Below Figure provides a generic process flow diagram for a plywood mill. The initial step of debarking is accomplished by feeding logs through one of several types of debarking machines. The purpose of this operation is to remove the outer bark of the tree without substantially damaging the wood. After the bark is removed, the logs are cut to appropriate lengths in a step known as bucking. The logs (now referred to as blocks) then are heated to improve the cutting action of the veneer lathe or slicer, thereby generating a product from the lathe or slicer with better surface finish. Blocks are heated to around 93°C (200°F) using a variety of methods--hot water baths, steam heat, hot water spray, or a combination of the three.



Generic process flow diagram for a plywood mill

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT-III- MATERIALS AND CONSTRUCTION-I – SDE 2301

BUILDING COMPONENTS

Definition of Building as per NBC (The National Building Code)

Any structure for whatsoever purpose and of whatsoever materials constructed and every part thereof whether used as human habitation or not and includes foundation, plinth, walls, floors, roofs, chimneys, plumbing and building services, fixed platforms, verandah, balcony, cornice or projection, part of a building or anything affixed thereto or any wall enclosing or intended to enclose any land or space and signs and outdoor display structures.

Tents/Shamianahs/Pandals, Tarpaulin shelters, etc., erected for temporary and ceremonial occasions shall not be considered as building.

- **Residential Building:** Buildings in which sleeping arrangements are provided with or without cooking arrangement. It includes single or multi-family dwelling, apartments, lodgings, restaurants, hostels, dormitories and hotels
- **Educational building:** These include any building used for school, college, education purposes.
- **Institutional Building:** these buildings used for different purposes, such as medical or other treatment. They include hospitals, sanatorium etc.,
- **Assembly Buildings:** These are the buildings where group of peoples meet or gather for amusement, social, religious, political, civil, travel and similar purposes. E.g. theatres, motion pictures, houses, assembly halls.
- **Business buildings**: These buildings are used for transactions of business, for keeping accounts and for similar other purposes.
- **Mercantile building:** These building is used as shops, stores, market for display and sale of merchandise either wholesale or retail, office, shops, storage services.
- **Industrial Buildings:** These are buildings where products or materials of all kinds and properties are fabricated, assembled, manufactured or processed.
- **Storage Buildings:** these buildings are used primarily for the storage or sheltering of goods, wares or merchandise, vehicles and animals, grains.
- **Hazardous Buildings**: These buildings are used for the storage, handling, manufacturing or processing of highly combustible or explosive materials or products.

Common Building Components

Basic Building Components
Super Structure
Substructure

Super Structure

The superstructure is that part of the building which is above the ground and which serves the purpose of building's intended use.

It includes

- Plinth
- Wall and columns

- Beams
- Arches
- Roofs and slabs
- Lintel and arches
- Chajjas (sunshades)
- Parapet
- Steps and stairs

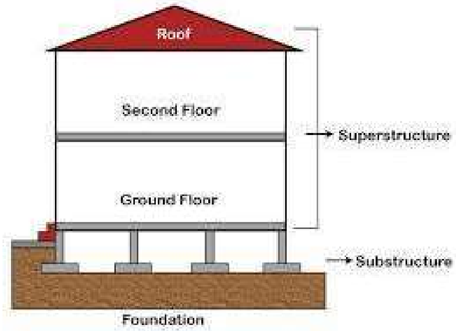

Fig.1.Building Components

SUBSTRUCTURE

- The substructure is the lower portion of the building, which is located below ground level which transmits the load of the superstructure to the sub soil.

it includes

- Foundations

Classification of building according to method of Load transfer

A building gets its structural integrity from load-bearing walls or a rigid frame work, which transfer and distribute the weight from the roof and top floors down to the foundation. According to the method of load transfer there are two types of structures-load-bearing structure and framed structure.

Foundation

A foundation is the lower portion of a building structure that transfers the building's gravity load into the earth. A strong foundation is required in order for a building to stand the test of time and survive for decades or even centuries.

Foundations are commonly separated into two distinct categories: shallow foundations and deep foundations.

A building's foundation is made by first digging a trench into the ground. Dig deep enough to reach the subsoil. Subsoil is more solid than topsoil, which is where plant roots grow.

Concrete is then poured into the trench, supported and strengthened further with steel rods. When the concrete dries, the steel holds it all together.

This is known as reinforced concrete, and once it is in place, the structure can be built on top.

Footing

A footing is a foundation that is constructed under the base of a wall or a column.The purpose of the footing is to distribute the weight of the building over a large area. The term footing is generally used in conjunction with shallow foundations, not deep foundations. Footing is placed directly below the lowest part of the structure it supports.

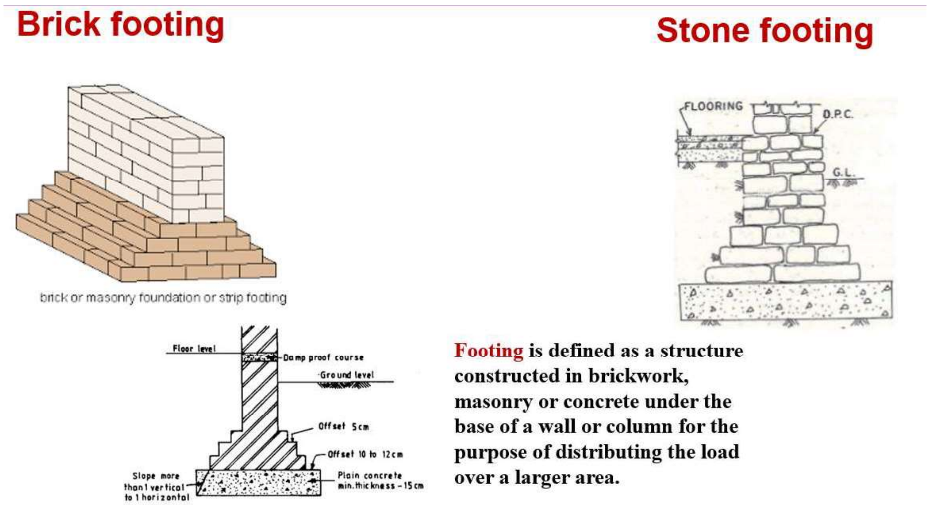

Fig.2. Footing

The foundations of the building transfer the weight of the building to the ground. While 'foundation' is a general word, normally, every building has a number of individual foundations. Most buildings have some kind of foundation structure directly below every major column, so as to transfer the column loads directly to the ground.

The basic function of foundation

- To Transmit the load from building to the subsoil, in such a way that settlement are within permissible limit
- the soil does not fail in shear
- Reduce the load intensity
- Even distribution of load
- Provide level surface

<u>Types of Foundation</u>

Foundations may be broadly classified as
(a) shallow Foundation
(b) Deep foundation

<u>Shallow Foundation</u>

Shallow foundations are constructed where soil layer at shallow depth (up to 1.5m) is able to support the structural loads.

- Strip footing

- Spread or isolated footing
- Combined footing
- Strap or cantilever footing
- Mat or raft Foundation

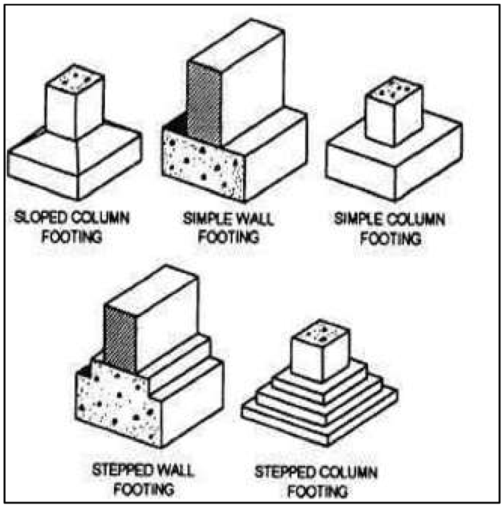

Fig.3. Types of footing

Strip Footing

A strip footing is provided for a load-bearing wall. A strip footing is also provided for a row of columns which are so closely spaced that their spread footings overlap or nearly touch each other. In such a case, it is more economical to provide a strip footing than to provide a number of spread footings in one line. A strip footing is also known as continuous footing.

Spread or Isolated Footing or Individual Footing

A spread footing also called as isolated footing, pad footing and individual footing is provided to support an individual column. A spread footing is circular, square or rectangular slab of uniform thickness. Sometimes, it is stepped or haunched to spread the load over a large area.

Combined Footing

A combined footing supports two columns. It is used when the two columns are so close to each other that their individual footings would overlap. A combined footing is also provided when the property line is so close to one column that a spread footing would be eccentrically loaded when kept entirely within the property line. By combining it with that of an interior column, the load is evenly distributed. A combined footing may be rectangular or trapezoidal in plan.

Strap or Cantilever Footing

A strap (or cantilever) footing consists of two isolated footings connected with a structural strap or a lever. The strap connects the two footings such that they behave as one unit. The strap is designed as a rigid beam. The individual footings are so designed that their combined line of action passes through the resultant of the total load. a strap footing is more economical than a combined footing when the allowable soil pressure is relatively high and the distance between the columns is large.

Mat or Raft Foundations

A mat or raft foundation is a large slab supporting a number of columns and walls under the entire structure or a large part of the structure. A mat is required when the allowable soil pressure is low or where the columns and walls are so close that individual footings would overlap or nearly touch each other.

Mat foundations are useful in reducing the differential settlements on non-homogeneous soils or where there is a large variation in the loads on individual columns.

Deep foundation

- Pile foundation
- Pier
- Well or caissons

Pile foundation

Our building is rested on a weak soil formation which can't resist the loads coming from our proposed building, so we have to choose pile foundation.

Pier Foundation: A Pier foundation consist of cylindrical column of large diameter to support and transfer large superimposed load to the firm strata below.

Generally, pier foundation is shallow in depth than the pile foundation.

Well Foundation: Well Foundation or Caisson are box like structures which are sunk from the surface of either land or water to the desired depth. They are much larger than the pier foundation or drilled caissons.

Caisson foundations are used for major foundation works like

- Bridge piers
- Docks
- Large water front structure such as pump house.

SUPER STRUCTURE

Plinth

- It's that portion of the building located between the ground level and the floor level.
- Plinth is that part of the building between surrounding ground surface and floor space immediately above the ground.

Damp Proof Course

It's a barrier of impervious material built into a wall to prevent moisture from rising on the walls.

Flooring is the general term for a permanent covering of a floor. Floors may be stone, wood, bamboo, metal, or any other material that can support the expected load.

WALL -An upright construction presenting a continuous surface and serving to enclose, divide or protect an area.

Walls are the most essential components of a building. The primary function of the wall is to enclose or divide space of the building to make it more functional and useful.

The commonly adopted traditional brick sizes are

Nominal size ---- 23cm x 11.4cm x 7.6cm (9” x 4 ½” x 3”) approximately.

Columns are vertical members along which beams and slab /roof is supported they are square, rectangular and circular in shape in c/s.

A cornice (from the Italian cornice meaning "ledge") is generally any horizontal decorative moulding that crowns a building or furniture element— the cornice over a door or window, for instance, or the cornice around the top edge of a pedestal or along the top of an interior wall. A simple cornice may be formed just with a crown moulding.

Sill-is the bottom horizontal portion of a wall opening. A lower starting point of a window or ventilator is considered the sill.

Door-A component in wood or metal or glass for opening or closing an entrance to a building or a room.

Window-An opening in the external wall of a building fitted with a frame containing panes of glass for admitting light and air.

Staircase-A structure made up of a flight or flights of steps for moving from one level to another in a building.

Lintel- it’s a horizontal structural member that spans an opening (door/ window) and holds the weight of the structure above it.

Chajjas are provided on external wall opening to get protection from rain, snow and heat. They are weather sheds. Their thickness tapers from 100 to 75 mm and projection is 60, 75, 90 cm.

Roof- it’s a uppermost component of a building and its main function is to cover the space below and provide protection from weather.

Parapet-is a low wall preventing people or objects from falling from the edge of the roof structure.

Coping (from cope, Latin capa) consists of the capping or covering of a wall. A coping may consist of stone (capstone), brick, clay or terracotta, concrete or cast stone.

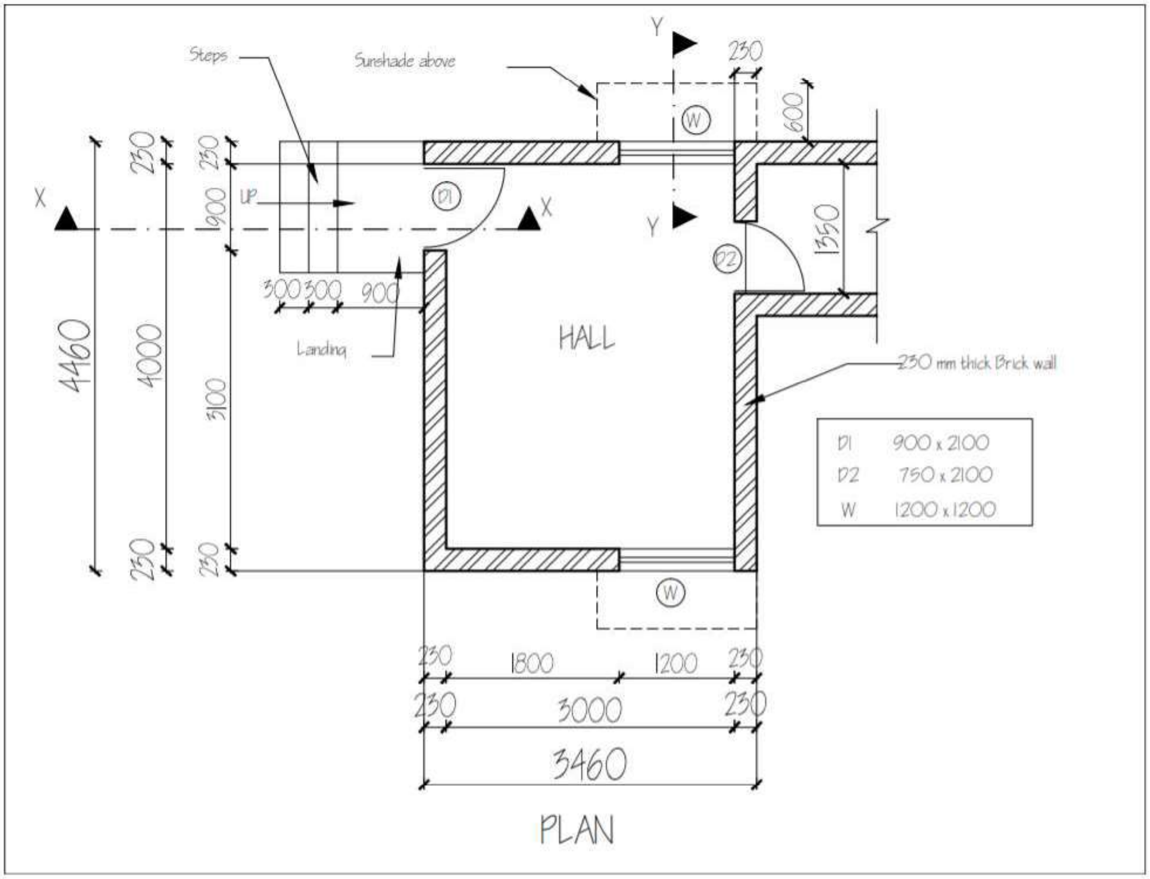

Fig.4. Plan

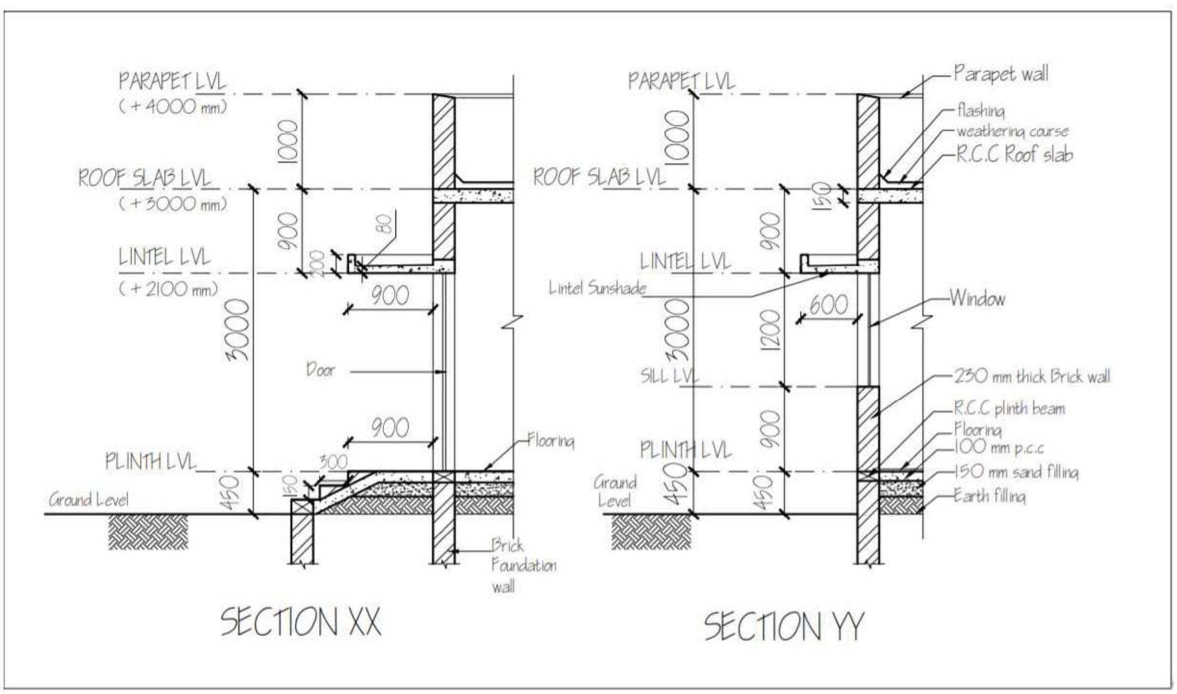

Fig.5. Section

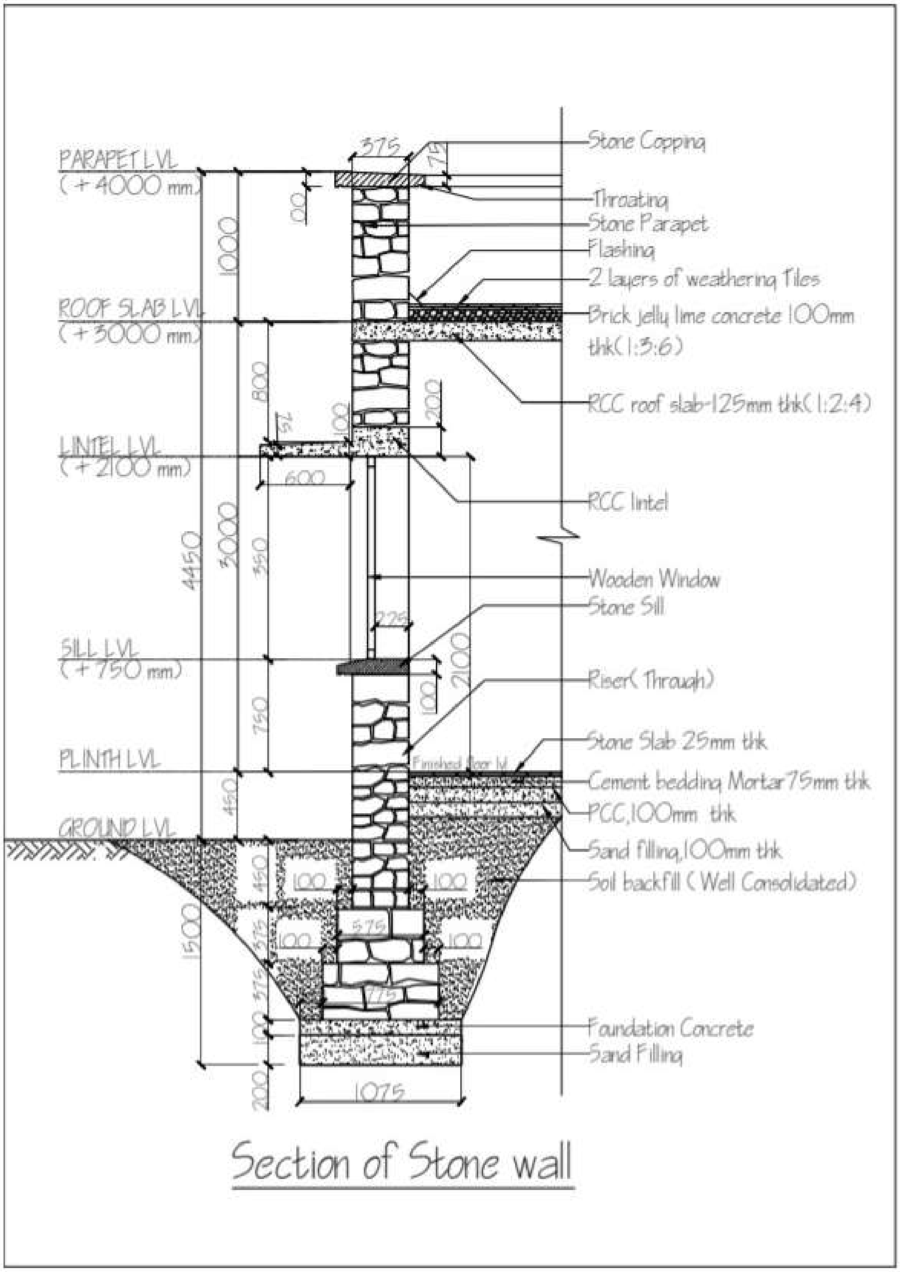

Fig.6. Section of Stone Wall

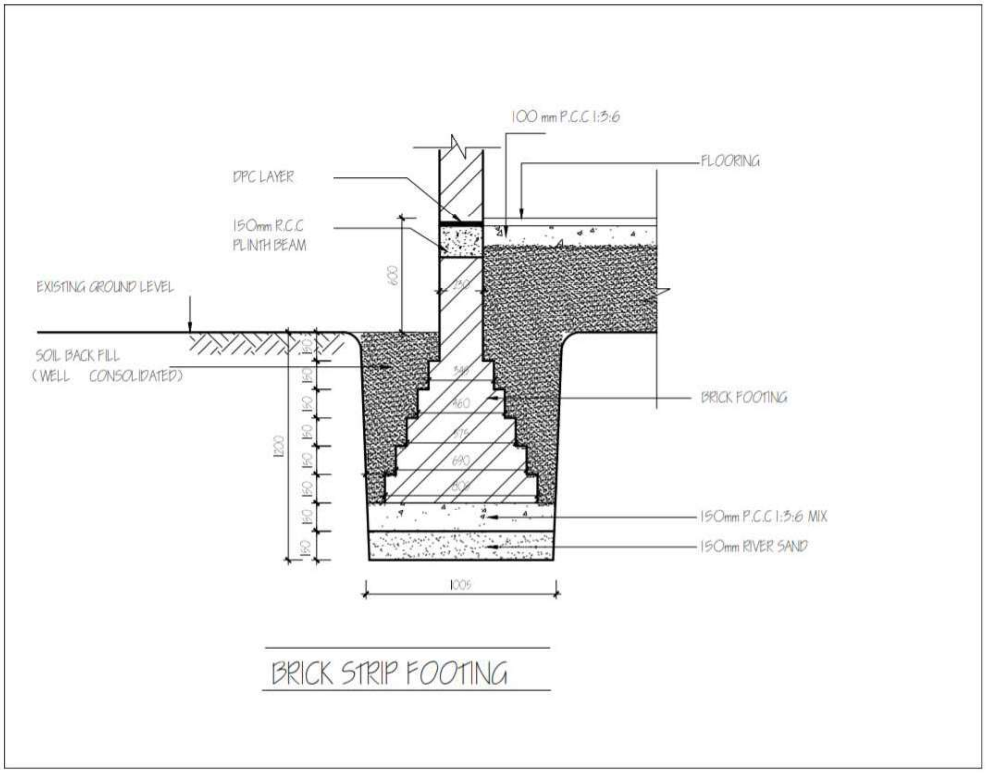

Fig.7. Brick strip footing

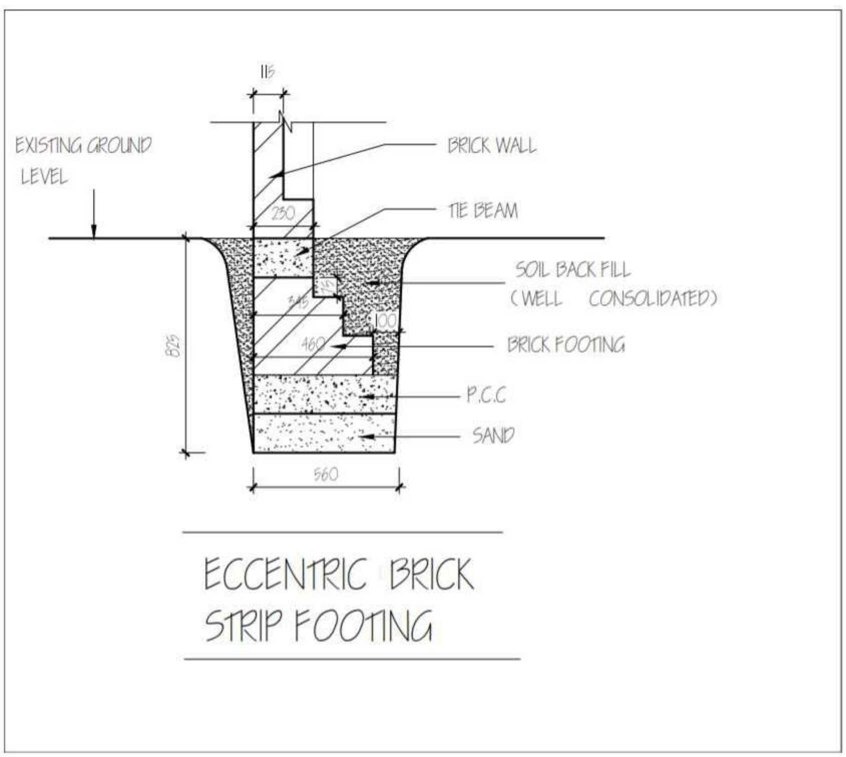

Fig.8.Eccentric brick strip footing

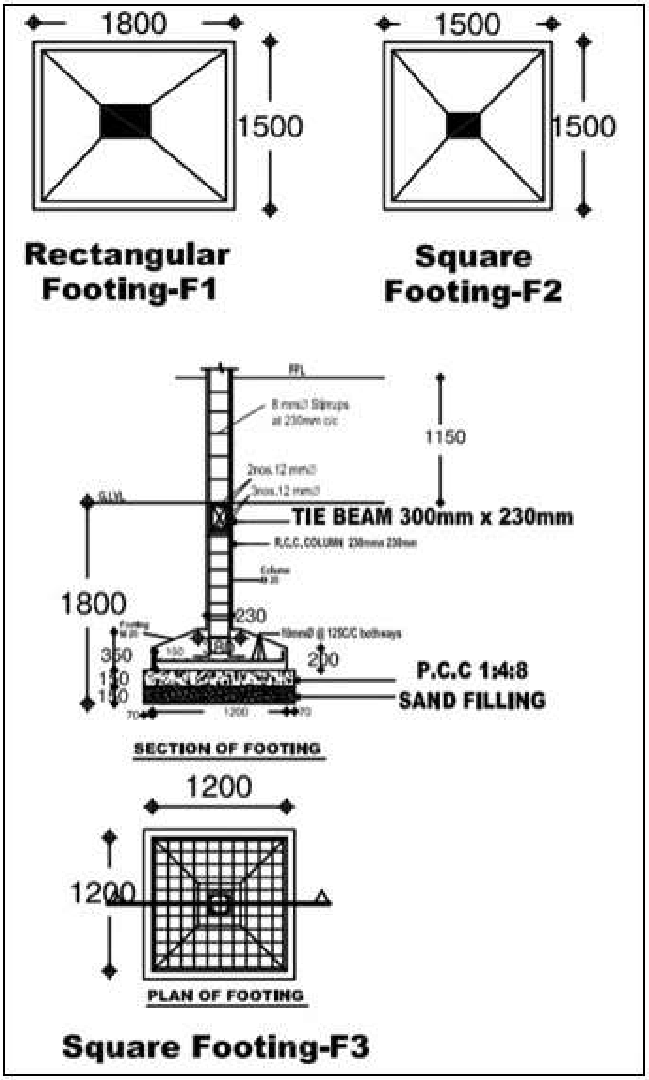

Fig.9. Isolated footing

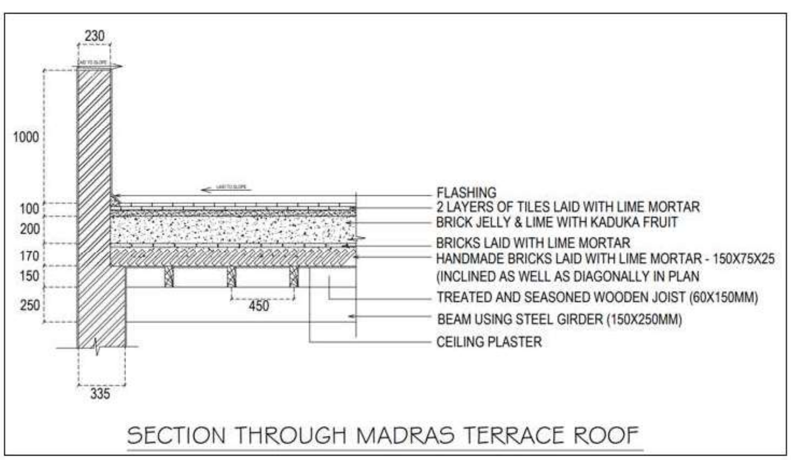

Fig.10. Section on madras terrace roof

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT-IV- MATERIALS AND CONSTRUCTION-I – SDE 2301

STRUCTURAL SYSTEMS

Structure:

Construction or framework of identifiable elements, different components, different parts, steps which actually need to be figured and need to be combined to act for a purpose and which will make the design stable. It will give a form and resist the stress and strain.

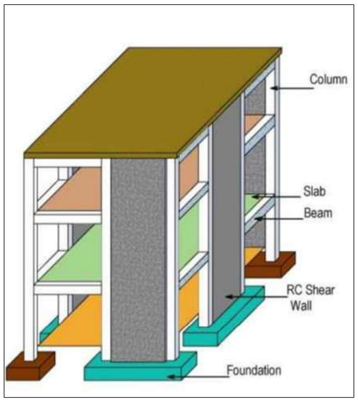

Fig.1. Parts of Structure

Structural Loads

Loads on structure is essential for its design and to decide up on the structural requirements
Load may be STATIC like self-weight, furniture, immovable objects
Load may be DYNAMIC like earthquakes, or impact load
Load may be MAN-MADE, like equipment
Load may be NATURAL like snow or wind load
Calculate the load in that precision or actual load is unpredictable, but based on the probability that it may occur. So, designing a building, design the structure of the building, should take account all possible load that may affect the building design.

Loads on structure is essential for its design and to decide up on the structural requirements.

- Loads are external forces acting on a structure. Stresses are internal forces that resist loads.

The following are loads forces and stresses to be considered in designing super structures of building, bridges and culverts.

1. Dead load
2. Live load
3. Wind load
4. Snow load
5. Earthquake load
6. Impact load

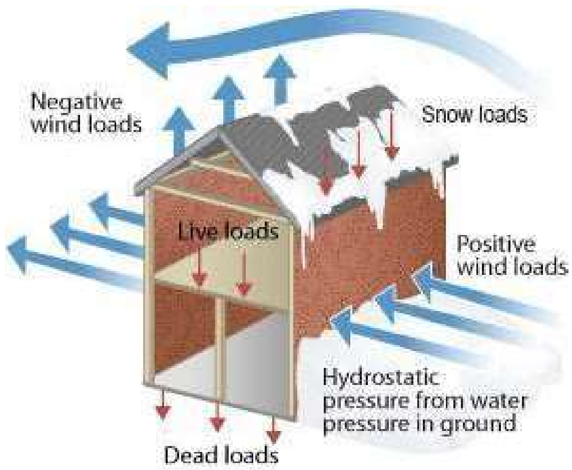

Fig.2. Structural loads

- **Dead Load:** Dead load comprises of the weight of all walls, partitions, floors and roofs including all other permanent construction in the building.
- **Live Load:** Live Loads consist of moving or variable loads due to people or occupants, their furniture, temporary stores, machineries.
- **Wind load:** It is considered as basic wind pressure which is equivalent static **pressure in the direction** of the wind.
- **Snow load:** Actual load due to snow depends upon the shape of the roof and its capacity to retain the snow. The load due to snow may be assumed to be 2.5 kg/m^3 per cm depth of snow
- **Earthquake load:** an earthquake load produced waves in every possible direction below ground. As per intensity or scale of earthquake, jerks and shocks are acting on the earth. As per the location of the building in the prescribed zone of earthquake coefficients of earthquake loads are decided.
- **Erection Load:** All loads required to be carried by the structure or any part of it due to storage or positioning of construction material and erection equipment including all loads due to operation of such equipment, shall be considered as erection loads.

Basic Structural Elements

- Wall
- Slab
- Beam
- Column

Types of Structures and their components

There are 2 types of structures

1)Wall Load Bearing Structure

Slabs >> Walls >> Foundation

2)RCC Frame Structure

Slabs >> Beams >> Columns >> Foundation

LOAD BEARING STRUCTURE

A load bearing wall transfers the loads from slabs above it to the foundation. These walls can be made of concrete, masonry or block materials. Most of the exterior walls of a building structure are considered as load bearing.

Removal of load bearing wall as a part of renovation must be conducted only after providing alternative support for the above-supported structures.

Load-bearing walls support the weight of a floor or roof structure above and are so named because they bear a load. By contrast, a non-load-bearing wall, sometimes called a partition wall, is responsible only for holding up itself.

Load bearing structure is the structure where the load of the **slab** or the **roof** will be carried out or that load will transmit through the wall.

Wall will be the **main component load bearing elements** of the structural system.

Two kind of loads preliminary;

- one is the gravity load that will come from the slab or the upper force that will transmit to the wall to the foundation;
- the other one is basically give lateral load, the wind load. So, then this kind of lateral load is also being taken care by the wall.
- So, impose load on the upper storey the slab or the walls transferred through the wall to the lower floor and eventually that will to the footing or foundation and to the soil.

Load bearing structure consists of heavy walls as because the whole load will be taken care by the walls. So, the thickness of the wall should be substantial and as the material that can be used to make this kind of wall is either **brick or stone sometime the block**. So, in the history, like till we got of the reinforcement or the steel in the picture of the construction industry, we have seen that the building's mostly dependent on this load bearing machinery walls.

Basically brick masonry or the stone masonry were used. So, earlier still we got concrete in construction, most of the masonry work that done even in Byzantine period and Gothic periods. So, many of the buildings are made of this masonry and acting as a load bearing structure.

Sometimes they being supported with the flying buttress to reduce the thickness of the wall and increase the interior space. So, this is another arrangement.

- The application of this load bearing structure will have some limitations because by increasing the thickness of the wall maybe for that we have to compromise with the interior space.
- Though masonry work is **good in compression**, but they **will not really act very well in case of tension.**
- So, that is why sometimes it is good for a low storey buildings say up to four storey, but beyond that there are some limitations.

Load Bearing Structural System: Load Transfer

- Wall acts as **Vertical Load Bearing Member**
- Slab acts as **Horizontal Load Bearing Member**

Load Transfer

Live Load & Dead Load

Slab

↓

Wall

↓

Foundation

↓

Soil

Load Bearing Structure: Suitability

Such type of structures is most suited where **Hard Strata of soil** is available at shallow depth

Load Bearing Structure: Wall Arrangement

- Cellular Wall Structure
- Simple Cross Wall Structure
- Double Cross Wall Structure
- Complex Wall Structure

Load Bearing Structure: Cellular Wall Structure

Number of walls each joined to its neighbour where External Walls form the boundaries of the building and Internal Walls divide the building into cells.

Fig.3. Cellular Wall Structure
(source: Nptel Course-Structure, Form, and Architecture)

Load Bearing Structure: Single Cross Wall Structure

In case of making a large number of identical rooms (hotels/hostels), this type of structural arrangement is found effective.

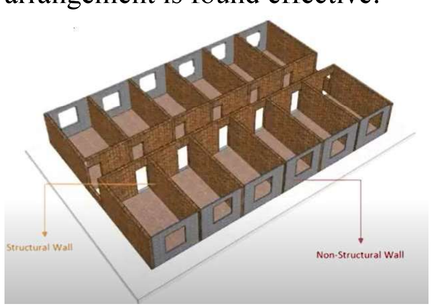

Fig.4. Single Cross Wall Structure
(source: Nptel Course-Structure, Form, and Architecture)

Load Bearing Structure: Double Cross Wall Structure

In order to maximize day light usages, complex system of cross walls set parallel to both major axes of the can be adopted.

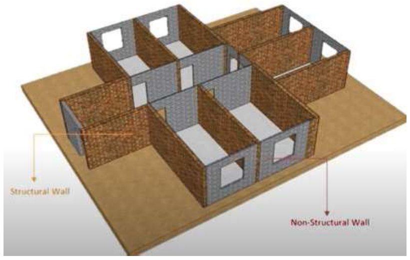

Fig.5.Double Cross Wall Structure
(source: Nptel Course-Structure, Form, and Architecture)

Load Bearing Structure: Complex Wall Structure

Combination of cellular and cross-wall arrangements are included to meet the purpose of creating various sized spaces within a building.

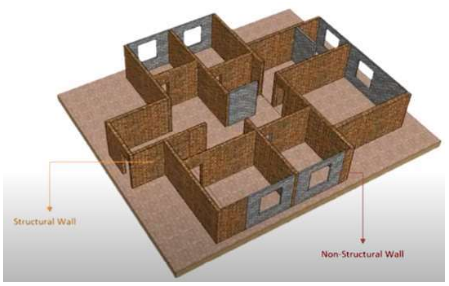

Fig.6.Complex Wall Structure
(source: Nptel Course-Structure, Form, and Architecture)

The American Architect Louis Kahn famously used load bearing construction for the Indian Institute of Management, Ahmedabad (image at right). His structures clearly express the construction system rather than conceal it under decorative skins. In this structure, **concrete** is used exclusively for members in **tension**, which are ties that tie together the two ends of the brick arches.

Advantages

• In load bearing structural system, external & internal walls serve as a structural element as well as serve the purpose of enclosure for protection from weather i.e. rain, sound, heat, fire etc.
• Comparatively, construction cost is cheap for low rise buildings
• Design of load bearing structure is simple
• Load bearing structures can be constructed without expensive plant and machines as compared to a framed structure.

Disadvantages

• As walls are thicker, Carpet Area Efficiency of planning is Less in Load Bearing Structure
• Wall Thickness cannot be maintained uniformly throughout as the thickness of wall increases with increase in height of the structure
• Limitation of span (i.e. room sizes) and

• Limitation of Height as limited storey buildings can only be constructed
• Limitations for providing openings in walls, which will affect the light and ventilation in room
• Walls have to be built first as they support the slab / roof and hence all walls have to be built simultaneously which is time consuming.
• Load bearing structure has limitations to resist Earthquake.

FRAMED STRUCTURE

A framed structure is a structure having the combination of structural components i.e. beam, column and slab connected together to resist the gravity and different lateral loads.

Capable to overcome the large forces, moments developing due to the applied loads.

Imposed loads on Slab transferred through Beam and then Column to lower floor and eventually to foundations to soil.

- Frame structures are the structures having the combination of beam, column and slab to resist the lateral and gravity loads.
- These structures are usually used to overcome the large moments developing due to the applied loading.
- Concrete frame structures are a very common - or perhaps the most common- type of modern building.
- As the name suggests, this type of building consists of a frame or skeleton of concrete.
- Horizontal members of this frame are called beams, and vertical members are called columns.
- Humans walk on flat planes of concrete called slabs.

When we say concrete in the building trade, we actually mean reinforced concrete.

Its full name is reinforced cement concrete, or RCC.

RCC is concrete that contains steel bars, called reinforcement bars, or rebar's.

Framed Structure: Load Transfer

• **Column** acts as **Vertical Load Bearing Member**
• **Slab and Beam acts as Horizontal Load Bearing Member**

Load Transfer

Live Load & Dead Load

Slab/Floor

↓

Beam

↓

Column

↓

Foundation

↓

Soil

Materials
R.C.C
Steel
Composite

Framed Structure: Components
- Slab
- Beam
- Column
- Footing/Foundation

Basically based on the joint how they are actually combined together, how they are connected to the footing.

Framed Structure: Types

Rigid Frame Structure - Rigid structures having columns & beams, made monolithically & acting together to tolerate the moments created due to imposed load on structure

Rigid frame structures bear the moment, shear & torsion very efficiently

- Pin Ended
- Fixed Ended

Braced Frame Structure- In this structure, bracing is commonly provided between columns & beams to surge their resistance besides the sideways forces and lateral forces because of the imposed load.

This frame system offers more effective resistance against the wind forces & earthquake

- Gabled Frames
- Portal Frames

Rigid Frame Structure: Pin Ended

• A pinned ended rigid frame system commonly has Pins as their support conditions
• If its support conditions are removed, this frame system is reflected to be non-rigid.

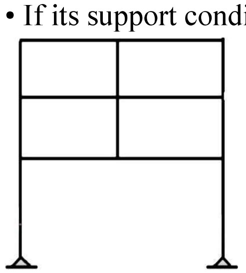

Fig.7. pin ended

Rigid Frame Structure: Fixed Ended

In this kind of rigid frame systems end conditions are generally fixed.

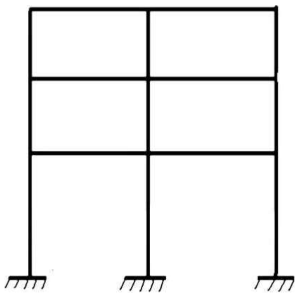

Fig.8. fixed ended

Braced Frame Structure: Gabled Frames

• Gabled frame structures have the peak at their top

• These frames systems are used to create pitched roof in the places with chances of heavy rainfall or snowfall.

And this kind of frame structure, this portal structure not only for heavy rainfall or snow fall, but also create the longer span compared to the other load bearing structure or typical framed structure with the beam column combination.

The steel being used to make the portal, also reduce the cross section of those columns. (I Section).

Fig.9. Gable frames

Braced Frame Structure: Portal Frames

• Portal structural frames generally look like a door frame

• This frame system is much in use for construction of commercial & industrial buildings.

Framed Structure:

Advantages

• Thickness of wall can be maintained uniform throughout and considerably thinner wall reduces Dead Load

• Due to simple geometry consists with Beam and Column, construction of framed structure is speedy

• Rigid and stable framed structure could able to resist tremendous vertical (dead load) and lateral loads (wind) and also the Seismic Load

• Large unobstructed space can be achieved with framed structure and utilization of space is flexible

• Adaptable to almost any shape and can be used for High-rise structure as well

• Prefabrication is possible to make the construction easy.

Disadvantages

• Framed structure construction requires expensive plant and machines
• As frame is an active structural element, any change in the structural element may endanger the safety of the building
• Cost of construction is relatively higher compared to load bearing structures • Skilled Labour is required
• In the case of normal reinforced concrete, span lengths are usually restricted to 40 feet to resists the lateral deflections.

Reinforced concrete (**RC**), also called **reinforced cement concrete** (**RCC**), is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength or ductility. The reinforcement is usually, though not necessarily, steel reinforcing bars (rebar) and is usually embedded passively in the concrete before the concrete sets.
RCC there will be concrete, like M20 or M25, M15 **-** the different grade of concrete. So, basically it depends on the mixture.
M20 means after it is curing, it will able to have the compressive strength of 20 Newton per millimeter square. So, like that you can go for the higher side and then mix of your cement, sand and stone chip. So, that will change. So, it may go from M25 1:1:2, M20 1:1.5:3, M15 1:2:4.

Concrete and its Applications

Concrete

Concrete is made of the following raw material, in specified quantities, to achieve required properties.
Concrete - It is **strong in compression** and very **weak in tension**. Because it has essentially zero strength in **tension**, it is almost always used as **Reinforced concrete**, (R.C.C) a composite material. It is a mixture of sand, aggregate, **cement** and water.

Raw material:

- Coarse Aggregate
- Fine Aggregate
- Cement
- Water
- Steel reinforcement
- Chemical Admixtures (if required)

Reinforcements

Steel is generally used as reinforcements for Reinforced cement concrete (RCC)
Recent advancements to material technology has introduced various other reinforcements, in place of steel,
FRP rods, bamboo, can also be used as reinforcements.
FRP products are supplied on a variety of different size wood or plastics reels along with different lengths depending on the customer's requirements. Traditional GRP is composed of high strength E-glass fibers impregnated with a variety of specialized proprietary resins.

Steel reinforcements are of three categories

- Steel rods – main reinforcement
- Stirrups – holds all the steel rods and keeps them in place
- Binding wires – helps in binding the steel rods and stirrups together – after binding they are mostly welded, to avoid breaking lose

Concrete Cover

The concrete cover is the least distance between the outer surface of concrete and the surface of the reinforcement.

In all reinforced concrete elements, a minimum thickness of concrete cover must be provided.

The thickness of the concrete cover is calculated according as per Indian standard code.

The minimum thickness of concrete cover should not be less than the diameter of the bar.

Purpose of Concrete Cover

To prevent the steel reinforcement from corrosion due to environmental effects.

To provide thermal insulation to protect the reinforcement bars from a fire.

To provide sufficient embedding to reinforcing bars to enable them to be stressed without slipping.

BEAMS

A beam is generally a horizontal member

A beam is principally subjected to transverse gravity (or vertical loading)

The term transverse loading is taken to include the end moments

Beams are classified according to their sizes, manner in which they are supported, and its location in a structural system.

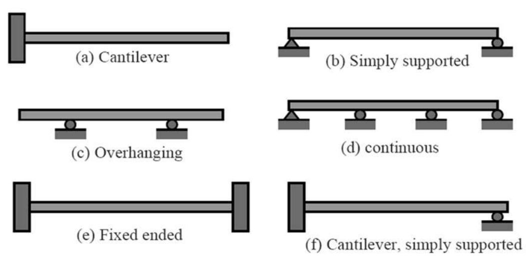

Fig.10. Beams

R.C.C SLABS

Slab:

Slabs are constructed to provide flat surfaces, usually horizontal, in building floors, roofs, bridges, and other types of structures. The slab may be supported by walls, by reinforced concrete beams usually cast monolithically with the slab, by structural steel beams, by columns, or by the ground.

TYPES OF SLABS

- **Conventional Solid Slab**

1. One way slab
2. Two way Slab

- **Flat slab**

1. Slab without drop and column without column head(capital).
2. Slab with drop and column without column head.
3. Slab without drop and column with column head.

4. Slab with drop and column with column head.
➢ **Waffle slab**

One Way Slab:

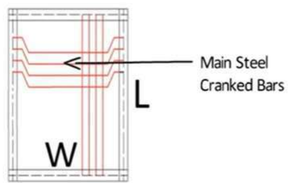

Fig.11. One way slab

One way slab is a slab which is supported by beams on the two opposite sides to carry the load along one direction. The ratio of longer span (l) to shorter span (b) is equal or greater than 2, considered as One way slab because this slab will bend in one direction i.e in the direction along its shorter span Due to the huge difference in lengths, the load is not transferred to the shorter beams. Main reinforcement is provided in shorter span and distribution reinforcement in a longer span.

Two Way Slab:

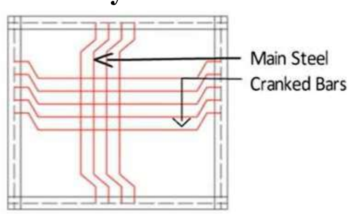

Fig.12. Two way slab

Two way slab is a slab supported by beams on all the four sides and the loads are carried by the supports along with both directions, it is known as two way slab. In two-way slab, the ratio of longer span (l) to shorter span (b) is less than 2.

In two way slabs, the **load** will be carried in both the directions. So, the main reinforcement is provided in both directions for two way slabs.

Example: These types of slabs are used in constructing floors of a multistoried building.

FLAT SLAB

- The flat slab is a reinforced concrete slab supported directly by concrete columns or caps.
- Flat slab doesn't have beams so it is also called a **beam-less slab**.
- They are supported on columns itself.
- Loads are directly transferred to columns.
- In this type of construction, a plain ceiling is obtained thus giving an attractive appearance from an architectural point of view. The plain ceiling diffuses the light better and is considered less vulnerable in the case of fire than the traditional beam slab construction.
- The flat slab is easier to construct and requires less formwork.
- This is one of the types of concrete slabs.

Flat Slabs are used at:

1. To provide plain ceiling surface giving better diffusion of light

2. Easy constructability with the economy in the formwork
3. Larger headroom or shorter storey height & pleasing appearance.
4. This kind of slabs are provided in the parking
5. Flat slabs are generally used in parking decks, commercial buildings, hotels or places where beam projections are not desired.

Advantages of Flat Slab:

1. It minimizes floor-to-floor heights when there is no requirement for a deep false ceiling. Building height can be reduced
2. Auto sprinkler is easier.
3. Less construction time.
4. It increases the shear strength of the slab.
5. Reduce the moment in the slab by reducing the clear or effective span.

Disadvantages of Flat slab:

1. In a flat plate system, it is not possible to have a large span.
2. Not suitable for supporting brittle (masonry) partitions.
3. Higher slab thickness.

<u>There are four different types of concrete Flat Slabs</u>

1. Slab without drop and column without column head(capital).
2. Slab with drop and column without column head.
3. Slab without drop and column with column head.
4. Slab with drop and column with column head.

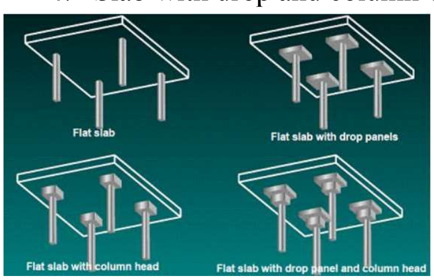

Fig.13.Flat slabs

WAFFLE SLAB

A two way joist slab system comprises of ribs constructed in the perpendicular direction.

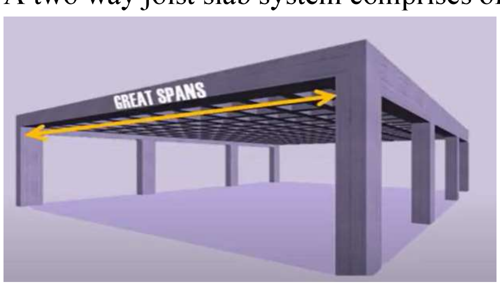

Fig.14.Waffle slab

Waffle Slab:-

Waffle slab is a reinforced concrete roof or floor containing square grids with deep sides and it is also called as grid slabs. This kind of slab is majorly used at the entrance of hotels, Malls, Restaurants for good pictorial view and to install artificial lighting.

This a type of slab where we find a hollow hole in the slab when the formwork is removed. Firstly PVC trays (pods) are placed on shuttering then reinforcement is provided between the pods and steel mesh is provided at top of the pods and then concrete is filled. After concrete sets, the formwork is removed and PVC pods are not removed. This forms a hollow hole in it in which hole is closed at one end. The concrete waffle slab is often used for industrial and commercial buildings while wood and metal waffle slabs are used in many other construction sites. This is one of the types of concrete slabs.

Where to use Waffle Slab & Waffle slab details:

A waffle slab has a holes underneath, giving an appearance of waffles. It is usually used where large spans are required (e.g auditorium, cinema halls) to avoid many columns interfering with space. Hence thick slabs spanning between wide beams (to avoid the beams protruding below for aesthetic reasons) are required. The main purpose of employing this technology is for its strong foundation characteristics of crack and sagging resistance. Waffle slab also holds a greater amount of load compared with conventional concrete slabs.

Types of Waffle slabs:

Based on the shape of Pods (PVC Trays) waffle slabs are classified into the following types:

1. Triangular pod system
2. Square pod system

Advantages of Waffle slabs:

1. Waffle slabs are able to carry heavier loads and span longer distances than flat slabs as these systems are light in weight.
2. Waffle slab can be used as both ceiling and floor slab.
3. Suitable for spans of 7m – 16m; longer spans may be possible with post-tensioning.
4. These systems are light in weight and hence considerable saving is ensured in the framework as the light framework is required

Disadvantages of Waffle slabs:

1. Waffle slab is not used in typical construction projects.
2. The casting forms or moulds required for precast units are very costly and hence only economical when large scale production of similar units are desired.
3. Construction requires strict supervision and skilled labour.

<u>FILLER SLAB</u>

Fig.15. Filler slab with terracotta pans

Filler slab technology is a simple and a very innovative technology for a slab construction.
The reason why, concrete and steel are used together to construct RCC slab, is in their individual properties as separate building materials and their individual limitation. Concrete is good in taking compression and steel is good in tension. Thus RCC slab is a product which resists both compression as well as tensile.
Filler slabs are one such cost - effective roofing system which is based on the concrete portions and instead placing filler material there. The material used as a replacement includes bricks, tiles, cellular concrete blocks.
The filler slab is a mechanism to replace the concrete in the tension zone. The filler material, thus, is not a structural part of the slab. By reducing the quantity and weight of material, the roof become less expensive, yet retains the strength of the conventional slab. The most popular filler material is the roofing tile. Mangalore tiles are placed between steel ribs and concrete is poured into the gap to make a filler slab. **The structure requires less steel and cement and it is also a good heat insulator.**

Advantages

- Consumes less concrete and steel due to reduced weight of slab by the introduction of a less heavy, low cost filler material like two layers of burnt clay tiles. Slab thickness minimum 112.5 mm.
- Enhances thermal comfort inside the building due to heat-resistant qualities of filler materials and the gap between two burnt clay tiles.
- Makes saving on cost of this slab compared to the traditional slab by about 23%.
- Reduces use of concrete and saves cement and steel by about 40%.

Columns

Column - is a structural element that transmits through compression the weight of the structure (building) on to the footing pedestal.
Columns are the structural components which transmit all vertical loads from the floors to the foundations. The means of transmission of vertical load is related to the particular structural system used for the framework.

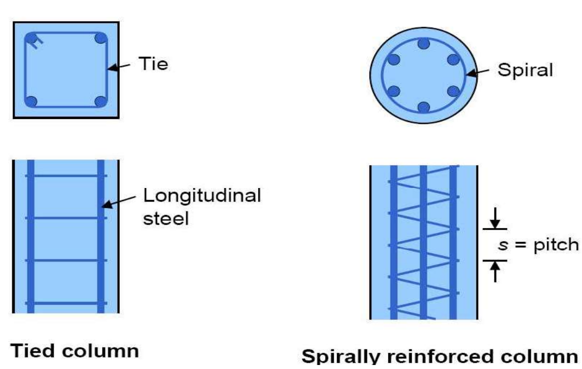

Fig.16. Column

Bonding is the arrangement of bricks in a structure such as a wall or column.Bricks are typically laid to an offset pattern to maintain an adequate lap between joints from one course to the next and to ensure that vertical joints are not positioned above one another on consecutive courses.

Principles of Brick Masonry construction

The strength of masonry work, however, depends very much upon the type of material used, nature of workmanship and supervision. The general principles which should be observed for a sound brick masonry construction are:

- The bricks used in a good work should be sound, hard and well burnt with uniform size, shape and colour. They should have no cracks or flaws and a fractured surface should be free from holes, grit or lumps of lime etc. The bricks when struck together should produce metallic ringing sound and they should not break when dropped from a height of 90 to 120 cm. on the ground. The bricks should not as a rule absorbs water more than 20% of their dry weight when immersed in water for twenty – four hours.
- The bricks should be thoroughly soaked in clear water before use for suitable period so that the water just penetrates the full depth of bricks. This not only helps in removing the dirt, dust and other soluble salts (which cause efflorescence) from the bricks, but also reduces their tendency of suction of water from wet mortar.
- The bricks should be laid on a full bed of mortar. They should be slightly pressed into the bed mortar while laying so as to ensure proper adhesion. All the courses should be laid horizontal and all vertical joints should be vertical.
- All the joints should be properly flushed and filled with mortar so that no cavity is left in between.
- Brick work is generally laid in the English bond. In all cases, it should be ensured that a proper bond is maintained throughout the work.
- Only specified mortar of a good quality should be used in the work, taking great care that uniform mortar joint is obtained throughout the construction. Thickness of joints should not exceed 13 mm in any case.
- Unless brick-on-edge is specified, the bricks must be laid on their proper beds with their frogs pointing upwards.
- The courses of bricks at the plinth, window sill, floor/roof level and at the top of parapet wall should invariably be laid with brick on edge.
- When the timber floor or roof is required to be supported on masonry walls, the ends of timber joists (supporting the floor or roof) should rest on corbels or brackets as far as possible. In cases where the ends of timber joists have to be built into the wall itself, it is necessary to apply suitable preservative treatment to the embedded portion of the joists and in addition some space should be left around them to minimize chances of attack by termite and to ensure free circulation of air.
- Bed blocks of stone, concrete or reinforced concrete should be provided at the ends of beam carrying heavy loads.