DEPARTMENT : CIVIL ENGINEERING

YEAR & SEM : III B.Tech I Sem

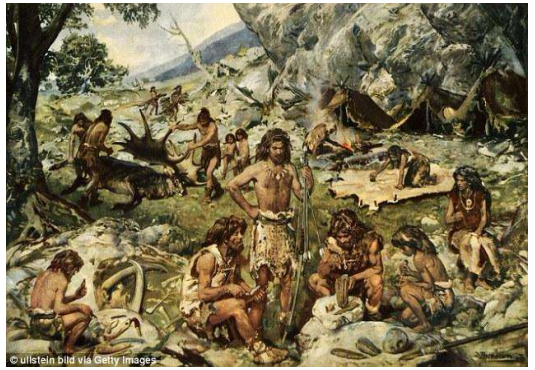
SUBJECT : BUILDING MATERIALS & CONSTRUCTION (20A01503)

PREPARED BY : RAM PRASATH S

INTRODUCTION TO BUILDING MATERIALS

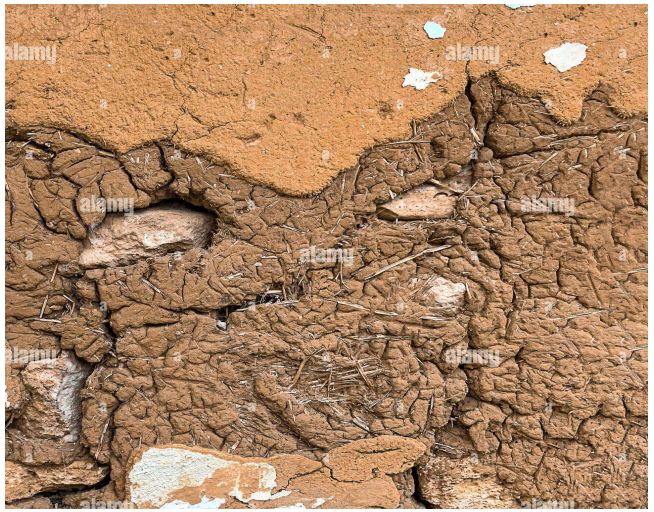
Introduction

- In the earliest stages of humanity, construction was very small scale. Natural shelters like **caves** and other **natural rock formations** were utilized. In the Palaeolithic period (2.5 million years ago-10,000 BCE), humans lived in shelters like caves and other natural rock formations or created **crude shelters** with stone and animal skins.
- During the broad period described as the Stone Age, **mud and clay** were also used to make simple shelters across the world. Easily forageable resources like **leaves, branches, straw and animal bones** were incorporated too.
- These materials were used to build shelters with the basic intention of providing dwellers with protection from the elements and possible hostile animals.



Introduction

- The Neolithic Age (9000-5000 BCE), characterized by the adoption of agriculture, saw the rise of more permanent structures. **Cob** was another important material used in this time – it was made by combining clay-based soil with sand, straw and water, with the exact ingredients differing between different countries.
- Other structures 'built' during this time would have been incredibly basic – a 'bridge' may have simply been a **tree or log** pushed over a stream.



Traditional Building Materials

- In construction, traditional materials are those which have been used to construct shelters and buildings for a long time in a locality, region or nation.
- As an example, **blocks of ice** have been used for millennia to build igloos in the Arctic, however, ice is not used – or regarded – as a building material at all in more temperate zones.
- Despite regional variations, traditional materials often continue to be used up to the present day whether for functional, planning or aesthetic reasons, often in conjunction with more modern materials.
- **Mud, Timber, Straw, Stone, Clay (bricks), Slate, Lead, Copper, Iron, Stucco, etc.,**

Organic Building Materials

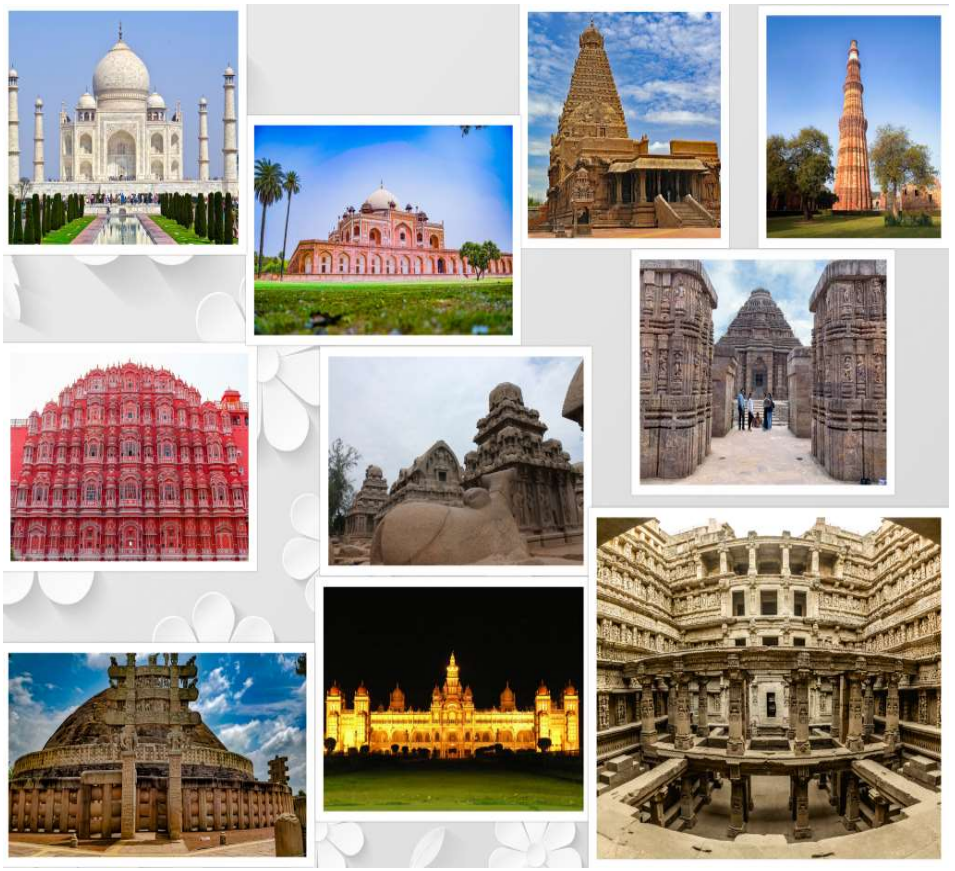
- **Organic building materials** are a new-age remedy for battling the environmental pollution to whom we are exposed all the time.
- The amount of energy that is used daily, and the contamination created in the process of using man-made construction materials is astounding and terrifying at the same time. Harmful chemicals used in growing all the time, lead to many people becoming sick or allergic.
- Organic materials such as **wood, straw, bamboo, cellulose insulation, clay, natural paints and oils or waxes** could be used instead to create low energy buildings that are solid, safe and better for the environment.
- Organic building materials can breath, absorbing and giving off moisture for a healthy indoor environment.

Stone

- Stone is a natural material of construction and is obtained from quarries. Since prehistoric days it has been used for constructing different components of buildings like foundations, walls, lintels, floors, roof etc. It has also been used for constructing bridges, wires, dams etc. *Stones that are used for construction of structures are known as* **building stones.**
- Most of the ancient temples and forts of India were built with stones. The Taj and the Victoria Memorial (Calcutta) were built in white marble had from Rajasthan. Red Fort and Jama Maszid (Delhi) were built with red sand stone from Agra. Parliament House, Rashtrapati Bhawan and the Central Secretariat (Delhi) were built with red and grey sand stones from Rajasthan.

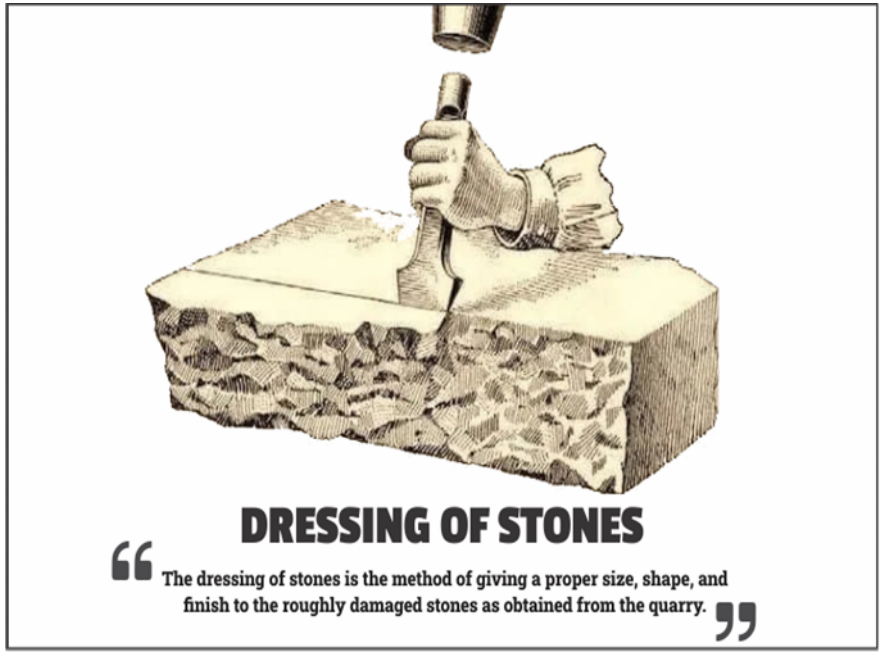
Stone - Uses

- As stones ballast (broken stone) for railway track; for road construction; for preparing cement concrete required for foundations, flooring, hollow and solid blocks, artificial stones and reinforced cement concrete.
- As crushed stone (stone dust) is used as a substitute for sand.
- As blocks in the construction of buildings; lintels; arches; walls; columns; abutments and piers of bridges; in weirs and in dams etc.,
- As thin slabs for roofing and for flooring buildings and pavements.



Dressing of Stones

- Dressing of stone is a process of providing a proper shape, size and smooth finish to the rough-surfaced broken stone which is collected from a quarry.
- This process is done by either hand tools or machinery. Hand tools are used as a pickaxe, chisel etc. Stone dressing process is required more technical skilled labours and fair understanding of drawing, materials and specifications.



Dressing of Stones - Objects

- **Reduce the size:** The big sizes of rock pieces are needed to reduce its size in a lift-able size piece, that's why it needs the size correction.
- **Proper shape:** The proper shape of the stone is required because the stone is used in a different place like foundation, arch, floors etc.
- **Proper finish:** Stones are mainly used in for decoration purpose that's why it needs a proper glossy finish.

Dressing of Stones – Stages

- **Sizing:** Sizing is the process where we remove the extra portion of a stone by hand tools like hammer, chisel etc. It's done to give a stone to a proper shape.
- **Shaping:** Shaping is the process where we remove the sharp sides of a stone block.
- **Planning:** Planning is the advanced type of dressing where the stone is cleaned of all kind of irregularity.
- **Finishing:** Finishing of stone is the process of rubbing of the stone surface by silicon carbide.
- **Polishing:** It is the last stage if dressing and polishing are done only on marble, limestone and granite.

Dressing of Stones - Types

- Pitched Dressing
- Hammer Dressing
- Chisel Drafting
- Rough Tooling
- Punched Dressing
- Close Picked and Fine Tooling
- Boasted Finish
- Scabbling
- Reticulated Finish
- Vermiculated Finish

Dressing of Stones - Types

Pitched Dressing

- The edges of the stone block is levelled with a hammer in pitched dressing.

Dressing of Stones - Types

Hammer Dressing

- In this type of dressing process, the large part of the rocks are levelled with a hammer but due to hammering hammer marks are shown in the rock.
- Hammer dressed stones do not have any sharp edges, and it's perfectly fitted in the masonry. Those blocks are square in shape, and vertical sides are 8 to 10 cm from the face.
- Hammer dressing process is done by Waller's hammer.

Dressing of Stones - Types

Chisel Drafting

- In the chisel drafting method, drafts and groove are made at all the four edges, and extra stone at the centre is also removed by this method.

Dressing of Stones - Types

Rough Tooling

- Rough tooling is the process where the edges are squared by hammer and chisel. Then all the series of the groove is created with this method.

Dressing of Stones - Types

Punched Dressing

- This dressing method of stone 1 cm vertical or horizontal groove is sunk into the stone.

Dressing of Stones - Types

Close Picked and Fine Tooling

- To get a refined surface, a punched stone is again dressed. This method gives you a fine texture and attractive look.

Dressing of Stones - Types

Boasted Finish

- In this method stone covered with parallel marks through their direction. This marks may be horizontal or angle.

Dressing of Stones - Types

Scabbling

- This type of method is done in the query, and irregular edges of the stone are broke by scabbling.

Dressing of Stones - Types

Reticulated Finish

- This is done when 2 cm wide margin on it's aside. 6 mm deep sunk is done.

Dressing of Stones - Types

Vermiculated Finish

- In this finish, there is more curved and worm-eaten type appearance. It is not more popular because it required a lot of labours.

Modern Building Materials

Some of the most important building materials are:

- Timber
- Brick
- Stone
- Concrete
- Metal
- Plastics and
- Glass.

Bricks

- Bricks are obtained by moulding clay in rectangular blocks of uniform size and then by drying and burning these blocks.
- As bricks are of uniform size, they can be properly arranged, light in weight and hence bricks replace stones.

Bricks - Classification

- Bricks can broadly be divided into two categories.

  (i) Unburnt or sundried bricks

  (ii) Burnt bricks

(i) Un burnt or Sun dried bricks

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

Bricks - Classification

(ii) Burnt Bricks

- The bricks used in construction works are burnt bricks and they are classified into the following four categories.
    1. First Class bricks
    2. Second class bricks
    3. Third class bricks
    4. Fourth class bricks

Bricks - Classification

First Class bricks:

- These bricks are table moulded and of standard shape.
- The surface and edges of the bricks are sharp, square, smooth and straight.
- The comply all the qualities of good bricks and used for superior work of permanent nature.

Bricks - Classification

Second class bricks:

- These bricks are ground moulded and they are burnt in kilns.
- The surface of bricks is some what rough and shape is also slightly irregular.
- These bricks are commonly used at places where brick work is to be provided with a coat of plaster.

Bricks – Classification

Third class bricks:

- These bricks are ground moulded and they burnt in clamps.
- These bricks are not hard and they have rough surfaces with irregular and distorted edges.
- These bricks give dull sound when struck together.
- They are used for unimportant and temporary structures and at places where rainfall is not heavy.

Bricks – Classification

Fourth class bricks:

- These are over burnt bricks with irregular shape and dark colour.
- These bricks are used as aggregate for concrete in foundation, floors, roads, etc because of the fact that the over burnt bricks have compacted structure and hence, they are some times found stronger than even first class bricks.

Bricks – Composition

COMPOSITION OF GOOD BRICK EARTH

Silica– 50% to 60%
Alumina – 20% to 30%
Lime – 2 to 5%
Iron oxide – ≤ 7%
Magnesia – < 1%

Bricks – Manufacture Process

- The manufacturing of brick, the following operations are involved:

1. Preparation of clay
2. Moulding
3. Drying
4. Burning

Bricks – Manufacture Process

Preparation of clay :- The preparation of clay involves following operations:

a) Unsoiling :- Top layer of 20cm depth is removed as it contain impurities.

b) Digging: - Clay dug out from ground is spread on level ground about 60cm to 120cm heaps.

c) Cleaning:-Stones, pebbles, vegetable matter etc removed and converted into powder form.

d) Weathering:- Clay is exposed to atmosphere from few weeks to full season.

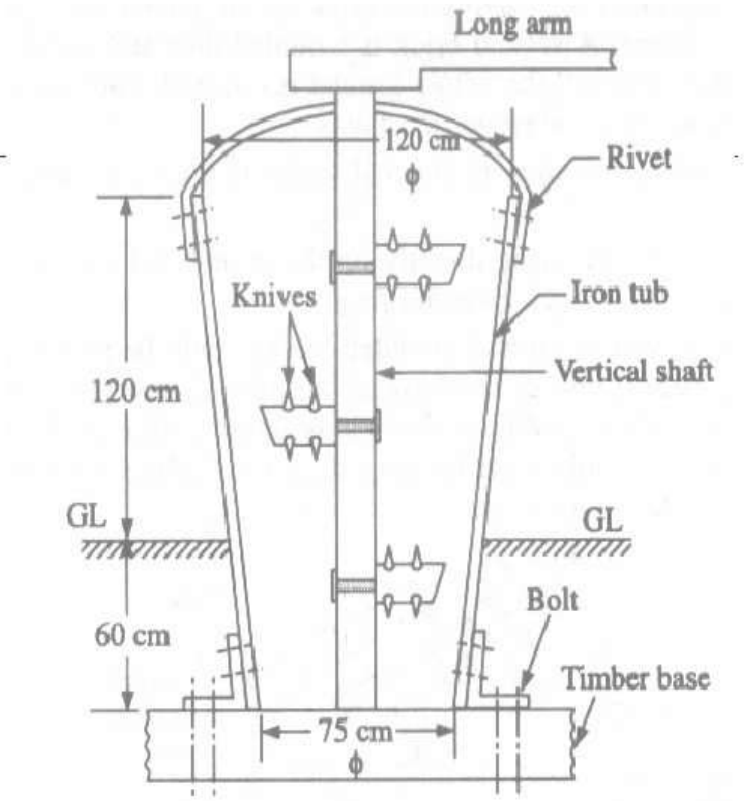
e) Blending:- Clay is made loose and any ingradient to be added to it is spread out at top and turning it up and down in vertical direction.

f) Tempering:- Clay is brought to a proper degree of hardness, then water is added to clay and whole mass is kneaded or pressed under the feet of men or cattle for large scale, tempering is usually done in pug mill as shown in the fig.

Bricks – Manufacture Process

Process:-

- Clay with water is placed in pug mill from the top.
- When the vertical staff is rotated by using electric pair, steam or diesel or turned by pair of bullocks.
- Clay is thoroughly mixed up by the actions of horizontal arms and knives when clay has been sufficiently pugged, hole at the bottom of tub, is opened cut and the pugged earth is taken out from ramp for the next operation of moulding.



Pug Mill

59

Bricks – Manufacture Process

Moulding:

- Clay, which is prepared form pug mill, is sent for the next operation of moulding.
- Following are the two ways of moulding:

    1. **Hand Moulding:** Moulds are rectangular boxes of wood or steel, which are open at top and bottom. Steel moulds are more durable and used for manufacturing bricks on large scale.

- Bricks prepared by hand moulding are of two types.

    a) Ground moulded bricks

    b) Table moulded bricks

Bricks – Manufacture Process

2. **Machine moulding**

- This method proves to be economical when bricks in huge quantity are to be manufactured at the same spot.
- It is also helpful for moulding hard and string clay.
- These machines are broadly classified in two categories:

  (a) Plastic clay machines

  (b) Dry clay machines

Bricks – Manufacture Process

Drying

- Moulded bricks cannot be burnt directly, as they may get damaged.
- So before burning they should be dried either naturally or artificially for about two weeks.

Natural Drying:

- It is also called hack drying, which comprises placing moulded bricks in rows on their edges, slightly above the ground called a hack.
- These bricks are air and sun-dried that is strong enough to use for the construction of small structures.

Bricks – Manufacture Process

Artificial Drying:

- When bricks are needed to dry on a large scale, then this artificial drying is preferred.
- They are in special dryers which receive heat from specially made furnaces for artificial drying.

Bricks – Manufacture Process

Burning

- This is very important operation in the manufacturing of bricks to impart hardness, strength and makes them dense and durable.
- Burning of bricks is done either in clamps or in kilns.
- Clamps are temporary structures and they are adopted to manufacture bricks on small scale.
- Kilns are permanent structures and they are adopted to manufacture bricks on a large scale.

  (a) Intermittent Kiln

  (b) Continuous Kiln – Bull's Trench, Tunnel, Hoffman's Kilns

Ceramic Products

Ceramic Materials

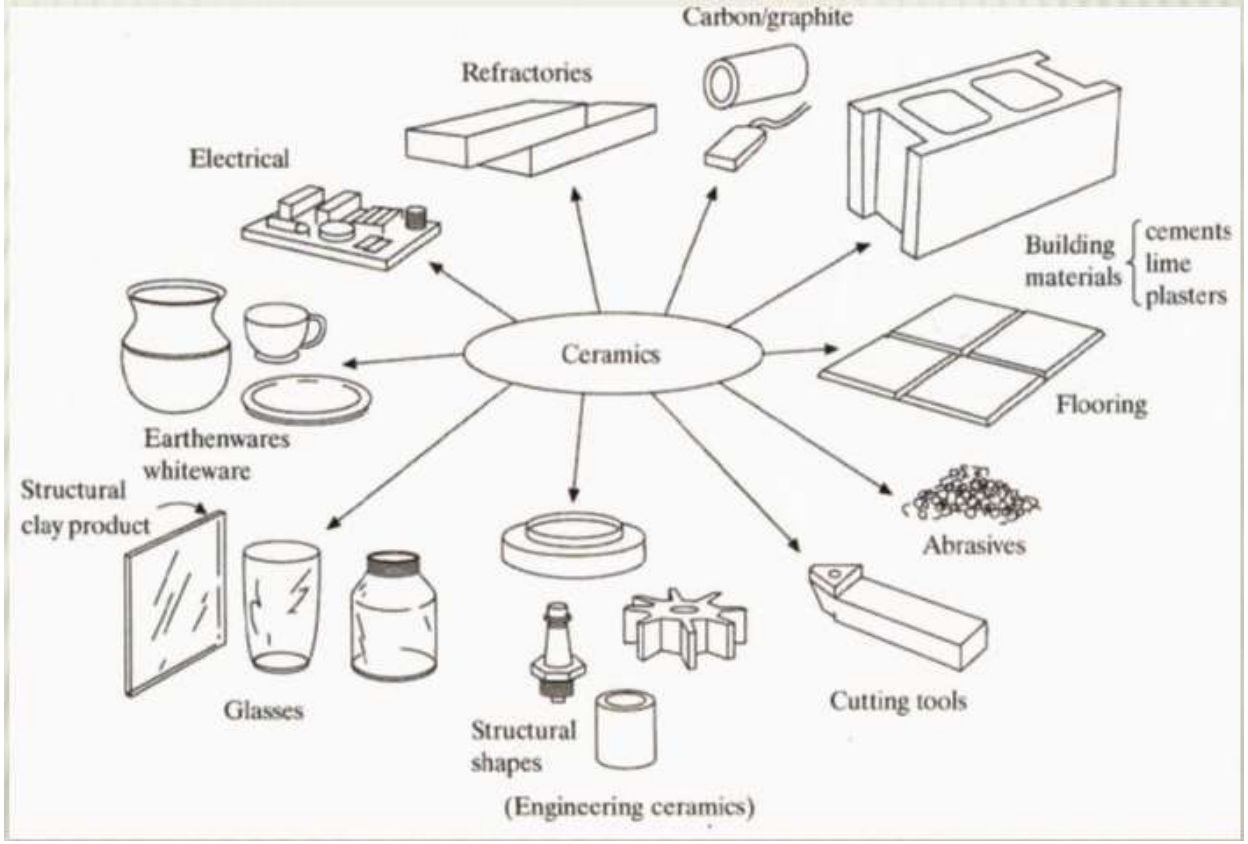
- Ceramic materials are inorganic materials consisting of metallic and non-metallic elements chemically bonded together to form complex compounds.
- Ceramic materials are usually ionic or covalently-bonded materials, and can be crystalline or amorphous.
- Important examples: Silica - silicon dioxide (SiO_2), the main ingredient in most glass products
- Alumina - aluminum oxide (Al_2O_3), used in various applications from abrasives to artificial bones
- More complex compounds such as hydrous aluminum silicate ($Al_2Si_2O_5(OH)_4$), the main ingredient in most clay products.

Ceramic Products

Ceramics properties

- High hardness, (high strength, stiffness, wear resistance)
- Brittle, Low ductility or malleability i.e. low plasticity
- Electrical and thermal insulating
- Chemical stability, and high melting temperatures
- Some ceramics are translucent, window glass (based on silica)
- Lower density than most metals
- Low resistance to fracture, highly resistant to compressive loads
- Corrosion resistance

Ceramic Products



Ceramic Building Products

- Tiles are used for covering building surfaces, namely roofs, walls and floors and depending upon the types of surface covered, they are called roofing tiles, wall tiles and floor tiles.
- Tiles for walls and floors may be either glazed or unglazed.
- Most types of tiles that are made from clay or a mixture of clay and other materials, then kiln-fired, are considered to be a part of the larger classification called Ceramic Tiles.
- These tiles are split into two: (a) Porcelain (b) Non-porcelain tiles.
- There is another type called Quarry tiles which are made directly from crude unwashed clay.

Ceramic Building Products

Porcelain Tile

- Generally made by the dust pressed method
- The clay used to build porcelain tiles is generally denser
- Commonly used to cover floors and walls, with a water absorption rate of less than 0.5 percent
- They can either be glazed or unglazed
- Porcelain tiles are one type of vitrified tiles and are sometimes referred to as porcelain vitrified tiles

Ceramic Building Products

Porcelain Tile Uses

- Porcelain is much harder than ordinary ceramic tiles and is usually selected, despite its higher price, for its hard-wearing nature
- Porcelain can be used in both wet and dry areas such as bathrooms, showers, and kitchens

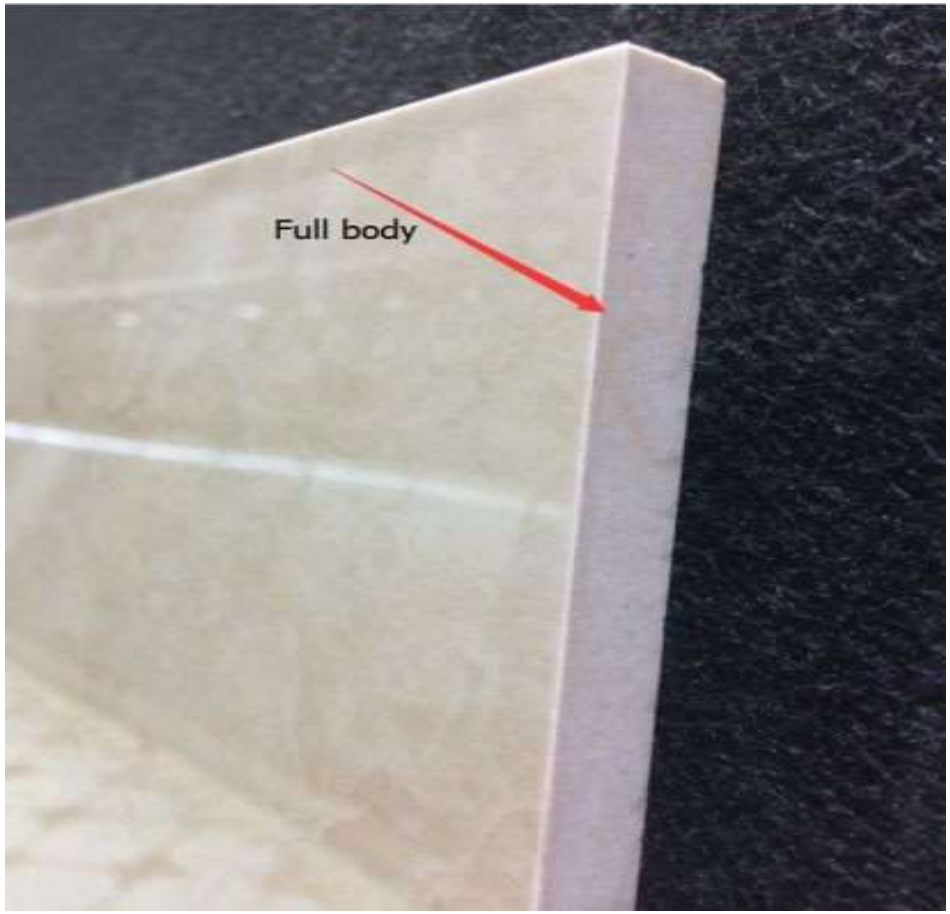
Disadvantages

- Porcelain is denser and therefore heavier to handle than other ceramic tiles
- For this reason, it is generally more expensive
- Being harder, it is more difficult to cut and drill and requires specialist tools, which can hamper fitting and increase costs

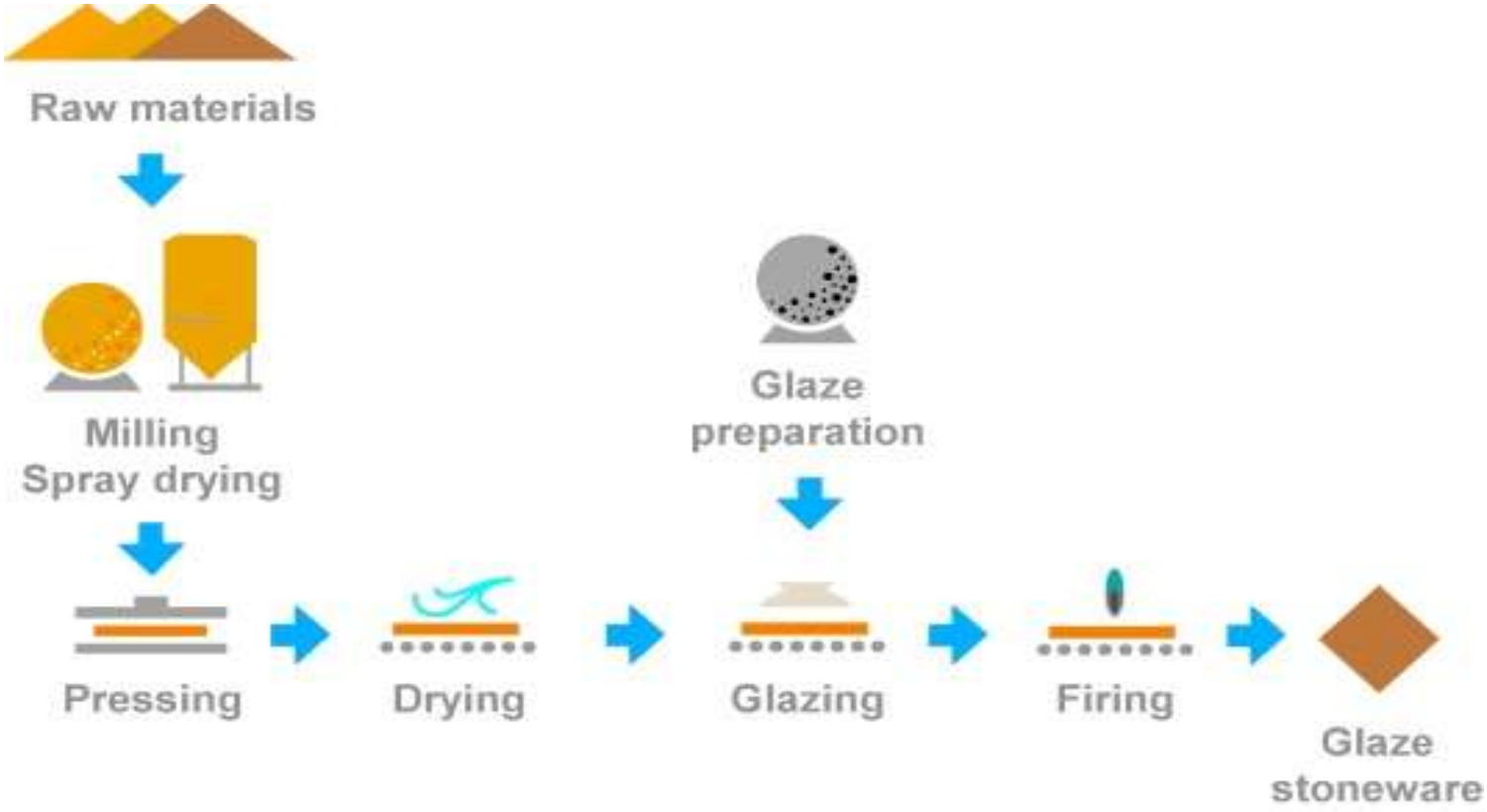
Ceramic Building Products

Types

- Glazed Porcelain Tiles
- Full Body Porcelain Tiles



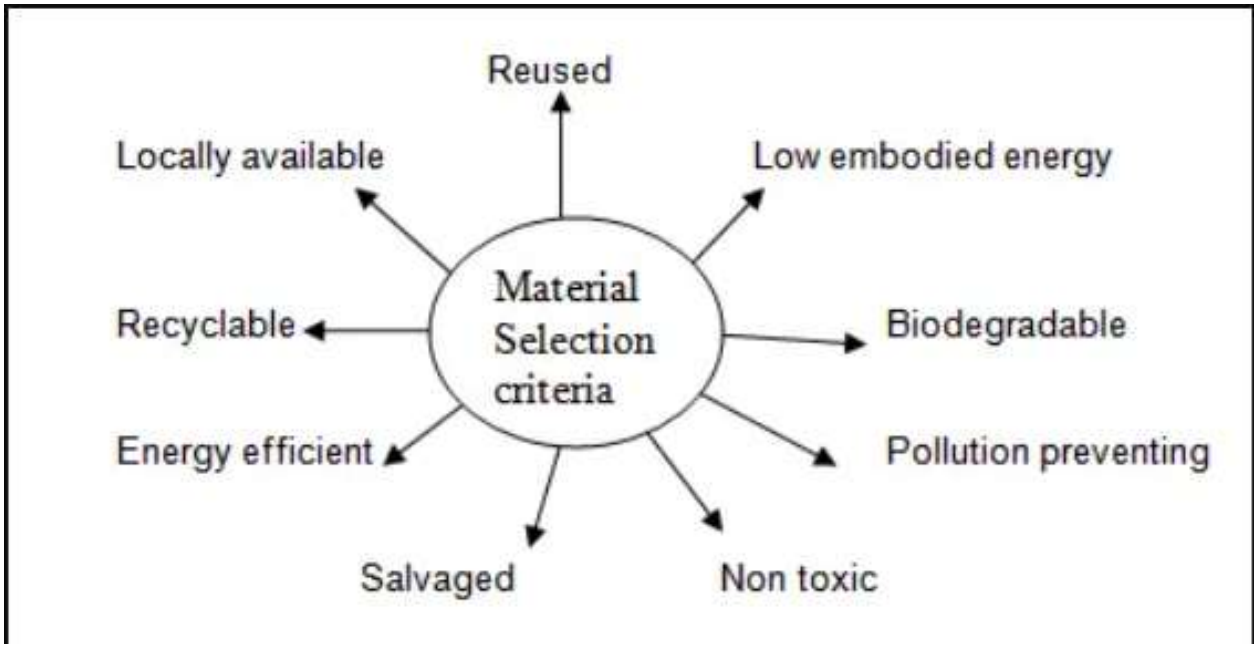
Manufacture of Ceramic Product



Building Materials for Low Cost Housing

- Growing urbanization has led to migration towards cities and resulted in an increased demand for affordable low-cost housing.
- Moreover, with sustainability gaining momentum, there is a need to balance both energy consumption and the environmental impact of materials used for building houses.
- Low-cost building materials not only increase access to permanent housing for people from low and middle-income groups but also contributes towards sustainability, particularly when locally available building material is used.
- The materials commonly used for modern low-cost construction are hollow concrete blocks, bamboo, extruded clay bricks, compressed earth bricks, concrete panels, along with non-conventional materials like polymers and recycled composite blocks, as they can reduce construction time by half.

Building Materials for Low Cost Housing



Utilization of Wastes for Alternative Building Materials

- In building construction industry, it has been seen that materials, which were being used about a century back, are still very popular.
- Variety of alternative building materials are available which provide better, efficient, durable and cost effective construction and also ensure judicious utilization of available limited resources with least possible degradation of environment.
- In the last decades, due to the modern lifestyle, the progresses in industry and technology had led to an important increase in the amount and type of wastes.
- The problem of waste accumulation every year is all over the world.
- These industrial and agricultural wastes are by-products, slag, rice husk ash, bagasse, fly ash, cement dust, brick dust, sludge, glass, tires, etc.

Utilization of Wastes for Alternative Building Materials

- The wastes represent a major problem for the environment because the air pollution (the dust and very fine particles which spread in the atmosphere) and leaching toxic chemicals (arsenic, beryllium, boron, cadmium, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, hydrocarbon compounds, etc.) when are dumped in landfills, quarries, rivers or oceans.
- The building material industry is a domain of interest for using the wastes and researchers have tried to produce new construction materials incorporating wastes.
- Near cement concrete other building materials are obtained by using wastes, such as: high strength concrete, which has in the mix different additions (silica fume, fly ash, etc.), asphalt concrete, bricks, pavements, roof tiles, prefabricated units, claddings, etc.

Utilization of Wastes for Alternative Building Materials

Waste Classification

- **By-product waste** is the waste produced by industry such as silica fume, slag, sludge, fly ash, sand paper, metals, glass, etc.
- **Organic wastes** are generally biodegradable materials usually micro-organisms, bacteria, etc.
- **Mineral wastes** are resulted from the industry processes.
- **Inert waste** is waste which is neither chemically or biologically reactive such as sand, drywall, and concrete etc.
- **Agricultural wastes** are resulted from agricultural domain.
- **Construction demolition wastes** are resulted from new construction, rehabilitation or the demolition.
- **Transportation industry wastes** are represented by used tires, asphalt and concrete aggregate.

Sustainable Materials in Construction

- At present the demand for a **more sustainable way of building** is no longer a matter of personal choice, and the sector has been now regulated for the purpose of implementing measures that improve the infrastructures´ and buildings´ environmental behaviour.
- They have to be highly durable and can incorporate different technologies, such as capturing energy, capturing $C0_2$ while removing pollution.
- They are used when, in the long term, they have a **lower environmental cost than the natural** materials.
- 'Green buildings' (made from sustainable materials) have been present for some time now, but only recently gained wide recognition.
- Green constructions are known to maximize resource conservation and minimize the negative effect on the environment. Also, these materials do not compromise on safety, quality, and other basic requirements of robust constructions.

Sustainable Materials in Construction

- Some organic and innovative materials being increasingly deployed in modern constructions are mentioned here:
  - **Hempcrete –** Made from the woody fibers of the hemp plant
  - **Bamboo**
  - **Ferrock –** Made of recycled material (steel dust and ground-up glass)
  - **Green charcoal bio-bricks –** Made from charcoal, soil, organic luffa fiber, and air
  - **Recycled plastic**
- Sustainable buildings arising from organic material help reduce the carbon footprint. The impact of climate change and increasing pollution levels are felt by all.
- Sustainable buildings thus aid the cause of maintaining environment stability.

Sustainable Materials in Construction

- **What is Building Sustainability?**

Sustainability is defined as meeting the needs of present generations without comprising the ability of future generations to meet their needs.

Sustainable Building or Green Building refers to the structure which are both Environmentally responsible and Resource-efficient throughout a building's life cycle.

Sustainable Building Design involves balance between Home Building and Sustainable Environment.

Sustainable Materials in Construction

- **Objectives of Green Building**

Low Impact: Minimize impact on natural environment

Energy Efficient: Reduced energy usage and water usage

Healthy: Protect occupant's health and increase productivity

Minimize waste: Designed and constructed in a manner that minimizes waste, pollution and environmental degradation.

Sustainable Materials in Construction

- **Goals of Sustainable Buildings**

There are number of motives for building green, including environmental, economic and social benefits.

It often emphasizes taking advantage of Renewable Resources:

- ✓ using sunlight as passive solar, active solar and photovoltaic equipments
- ✓ Using plants and trees through green roofs, rain gardens etc
- ✓ Reduction of rain water run-off

Sustainable Materials in Construction

- **Principles of Sustainable Building**

  - STRUCTURAL EFFECIENCY: to minimize the environment impact associated with all life-cycles.
  - ENERGY EFFECIENCY :to reduce the operating energy use.
  - WATER EFFECIENCY: reducing water consumption and protecting water quality.
  - MATERIAL EFFECIENCY: materials should be renewable,recycleable and environment-friendly.

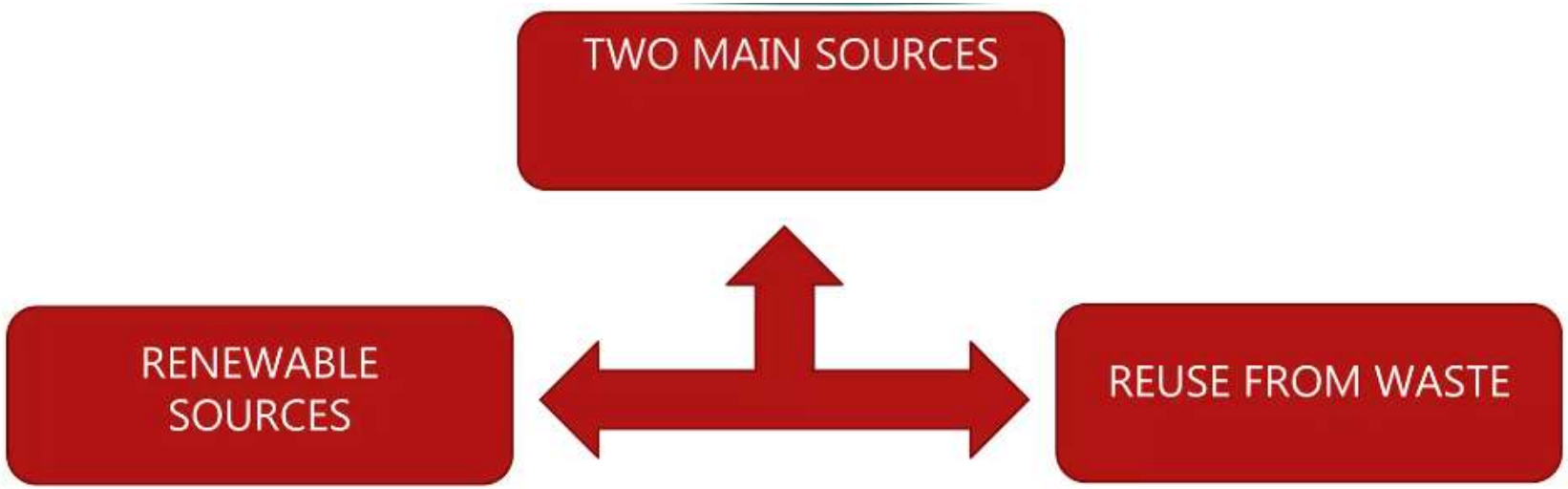
Sustainable Materials in Construction

- **What is a Sustainable Material?**

  - A sustainable material is any material that can be put to **effective use in the present without compromising its availability** for use by latter generations.
  - These are mainly **renewable** materials or the materials which can be **recycled and reused**.

Sustainable Materials in Construction

- **Sources of Sustainable Material**



Sustainable Materials in Construction

- **Types of Sustainable Material**

MATERIALS FROM RENEWABLE SOURCES

- Materials significantly of plant origin.
- Can be obtained from renewable sources like solar energy, wind energy, bio-gas etc.
- E.g.: wood, natural fibers, polymers etc.

REUSE FROM WASTE PRODUCTS AS RAW MATERIALS

- They are typically the products of recycled matter.
- Materials that can be dismantled and reused again.
- E.g.: old plumbings, doors, crushed glass, wood chips etc.

Sustainable Materials in Construction

- **Merits and Demerits of Sustainable Building**

MERITS	DEMERITS
Efficient technologies	Initial cost is high
Easier maintenance	Availability of materials
Improved indoor air quality	Need more time for construction
Energy and water efficient	Need more skilled labors
Improved health	
Water conservation	

Concepts of Energy Efficient Building Envelopes

- A building envelope is a physical barrier between the external environment and the internal conditioned space, keeping the residents comfortable.
- A building envelope consists of fenestration (doors and windows), roofs, walls, and insulations.
- Since a building envelope separates the unconditioned exterior environment from the conditioned interior space, it is one of the key factors that impact building energy consumption.
- Building envelopes of energy-efficient buildings are not simply barriers between interior and exterior; they are building systems that create comfortable spaces by actively responding to the building's external environment, and substantially reduce the buildings' energy consumption.

Concepts of Energy Efficient Building Envelopes

- **Energy-efficient building envelopes:**
  - have high thermal resistant materials in the facade of the building,
  - use vapor barriers and are effective in vapor control,
  - have efficient window and door seals,
  - have effective airflow control to minimize infiltration of outdoor air.

Energy Conservation Building Code (ECBC)

- The Energy Conservation Building Code (ECBC) was developed by the Govt. of India for new commercial buildings on 27th May 2007.
- The purpose of Energy Conservation Building Code (ECBC) is to provide minimum requirements for energy-efficient design and construction of buildings and their systems.
- **The ECBC provides design norms for:**
  - Building envelope, including thermal performance requirements for walls, roofs, and windows;
  - Lighting system, including day lighting, lamps and luminaries' performance requirements;
  - HVAC system, including energy performance of air distribution systems;
  - Electrical system; and
  - Water heating and pumping systems, including requirements for solar hot-water systems.

GLASS AND PLASTICS

Fenestration

- The arrangement of all the cutouts in the building which are a natural source of air, light and ventilation are known as fenestrations.
- The building elements which are a part of the fenestration designs are doors, windows, louvers, curtain wall glazing, vents, skylights, storefront glass, etc.
- Daylighting is introduced into the building through the fenestrations so as to complement or replace the artificial electrical lighting.
- A well-automated control system can modulate the amount of daylight that can be admitted and cut the electrical lighting thus reducing electricity costs.

Fenestration

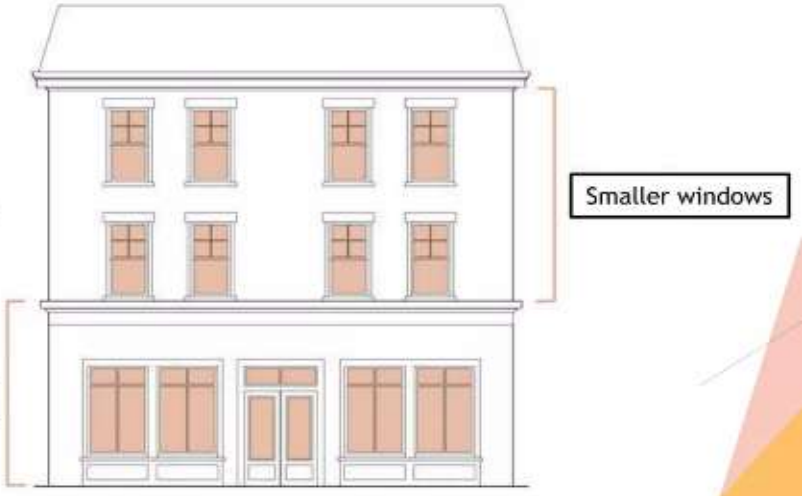
- A good fenestration design has the following benefits-
  - Improves the comfort level of the occupants by providing good air, light, and ventilation.
  - Increases the amount of daylight but does not allow heat absorption into the building through efficient glazing systems.
  - Good fenestrations can result in energy savings by reducing the air conditioning and heating costs.
  - A good louver design can let natural diffused light into the building but reduce the glare and direct sunlight.
  - Good shading devices like chhajjas, jaalis, and pergolas can be aesthetically designed such that they allow diffused light into the interiors and reduce solar gain and glare.

Fenestration

Fundamentals of Fenestration:

- How much of a building exterior is covered with openings, in particular windows and doors, how transparent the enclosing glass is, and how the openings are arranged are issues of fenestration.

In a building with mixed use(commercial space on gr. Floor and residential above), it is desirable to allow maximum open viewing from the street on the ground floor,
however the upper floors require more privacy.



Fenestration

Need for fenestration :

- Incorporating windows and fenestration into a building design is a fundamental and integrated design activity.
- Decisions about the size, shape, type, and characteristics of such fenestration are increasingly driven not just by aesthetic concerns, but by demands for energy efficiency.
- One of the most common arguments for windows from an urban design standpoint are that they provide eyes on the street and inhibit street crime.

Different types of fenestration lends a different character to each room

Fenestration

Impact of fenestration in environment

- Fenestration influences the social character of public spaces. Fenestration affects how welcoming the building is and whether it participates with other buildings in creating a visually harmonized and immersive landscape.

Fenestration on building facades is key to making public spaces social.

Fenestration

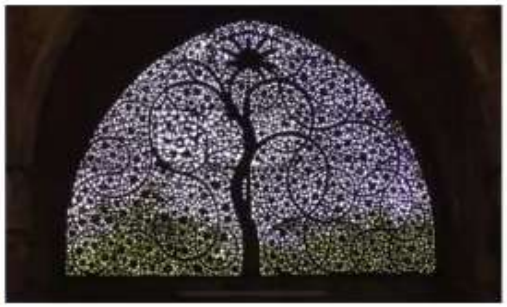
Factors affecting Daylight performance :

- **Building Orientation :** A proper orientation of the building is the major factor which affecting performance of daylight penetration.
- **Types of Windows :** Windows have a bigger impact on the quantity of daylight penetration.
- **Type of Glass :** The glass used for windows in building provides light and allow vision. Different type of glass have different energy-performance characteristic. That is the ability to resist heat transfer (U-value;UV), ability to control solar heat gain through the glazing (Solar Heat Gain Coefficient; SHGC) and the amount of light passes through a glazing material (visible transmittance; VT).

Fenestration

Types of windows(and its effects):

- **Jalis or perforations:** It is just an obstructed vision(provides privacy)
- **Normal glazed opening:** clear vision
- **Bay window or Jharokhas:** It is a transitional space between the exterior and the interior which results in a beautiful combination of space + light + visual link + exterior view.



Jalis or perforations

Normal glazed opening

Bay window or Jharokhas

Fenestration

Materials in use :

- Windows, doors and skylights are available in a wide variety of materials, including aluminium, steel, fiberglass, vinyl and wood.

Wooden windows

Fibreglass windows

Aluminium windows

Fenestration

Materials in use :

- Frames and sashes made from vinyl or fibreglass have multiple interior chambers which can be foam-filled to increase efficiency.
- Foam filled windows increase insulation, leads to cooler summers and warmer winters indoors.

FOAM FILLED WINDOWS

Fenestration

GLAZING:

Glazing is the term for the transparent material, usually glass, used in a window, door or skylight. Usually the glazing is contained in something called an insulating glass (IG) unit which consists of at least two panes of glass separated by a spacer bar and sealed around the edges to make them airtight.

- The more glazing layers, the better. For example, triple glazed products have three layers of glass and are up to 50 percent more efficient than double glazed products.
- A thin layer of polyester film may be used to replace one pane of glass and reduce the overall weight.
- Low-E glass has a fine metal coating designed to reduce heat loss in winter and heat gain in summer by up to 30 percent.
- Tinted glass will reduce summer cooling costs but may increase heating costs in the longer heating season.

Fenestration

GLAZING:

- IG units are typically filled with an inert gas such as argon or krypton to reduce heat transfer through the glass.
- The spacer bar may be made of foam, plastic, glass or stainless steel to reduce heat loss. The spacer bar has a desiccant in it that absorbs moisture after the unit is sealed to prevent fogging.
- Some windows have metal or plastic grilles inside the IG unit to give the artistic effect of many individual panes of glass. These popular features also reduce the amount of solar heat entering the home.

Fenestration

EMERGING GLAZING TECHNOLOGIES:

- **Vacuum IG units**—which have no air or inert gas inside—transfer significantly less heat than standard gas-filled units.
- **Aerogel glazing** uses a highly insulating, low-density silica-based solid between the glass panes. This aerogel eliminates the need for low-E glass and inert gas fills.
- **Electrochromic glazing** (sometimes called "smart" glazing, switchable glazing or active glazing) can be darkened with the flick of a switch to reduce the amount of solar heat and light passing through the glass.

Fenestration

Types of Fenestration:

A good daylighting strategy is necessary in order to decrease energy consumption for artificial lighting. To provide effective internal illumination, the placing of the right openings in the right positions with suitable type of window and glazing is important.

SASH

- A sash window is the traditional style of window in the United Kingdom

CASEMENT

- A **casement** is a window that is attached to its frame by one or more hinges.

Fenestration

JALOUSIE

- A **jalousie window** or louvre window is a window composed of parallel glass, acrylic, or wooden louvers set in a frame.

CLERESTORY

- a **clerestory** is a high section of wall that contains windows above eye level. It is used for daylighting purposes.

Fenestration

STAINED GLASS

- A window composed of pieces of colored glass, transparent, translucent or opaque, frequently portraying persons or scenes. Typically the glass in these windows is separated by lead glazing bars. Stained glass windows are especially common in churches

SKYLIGHT

- A flat or slope window used for daylighting, built into a roof structure that is out of reach.

Fenestration

DIOCLETIAN WINDOW

- Thermal, or Diocletian, windows are large semicircular windows which are usually divided into three lights by two mullions. The central compartment is often wider than the two side lights on either side of it.

FRENCH WINDOW

- A French window is a large door-sized lattice light, typically set in pairs or multiples thereof. They often overlook a terrace and are commonly used in modern houses.

Fenestration

BAY WINDOW

- A multi-panel window, with at least three panels set at different angles to create a protrusion from the wall line.

MULTI-LIT WINDOW

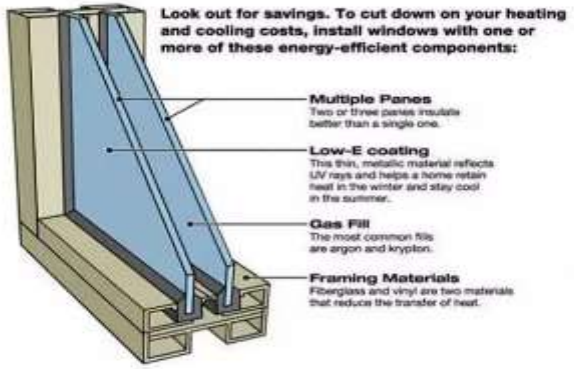
- A window glazed with small panes of glass separated by wooden or lead *glazing bars*. Due to the historic unavailability of large panes of glass, the multi-lit was the most common window style until the beginning of the 20th century, and is still used in traditional architecture.

Fenestration

DOUBLE - PANED GLASS

- Double-paned windows have two parallel panes (slabs of glass) with a separation of typically about 1 cm; this space is permanently sealed and filled at the time of manufacture with dry air or other dry nonreactive gas. Such windows provide a marked improvement in thermal insulation (and usually in acoustic insulation as well) and are resistant to fogging and frosting caused by temperature differential. They are widely used for residential and commercial construction in intemperate climates.

Triple-paned windows have been commercially manufactured and marketed with claims of additional benefit but have not become common.



Fenestration

Site Study:

Glazed Windows

Casement

Sash

Glass

- **Glass As a Building Material**
  - Glass Building Material is a mixture of raw materials like silica, sodium potassium carbonate, lime or lead oxide, manganese oxide which are grounded, sieved, and mixed in specific proportion to make glass.
  - Glass Building Material has unique properties as a transparent glazing material in the construction industry.
  - It has various architectural applications in doors, windows, partitions, etc.

Glass

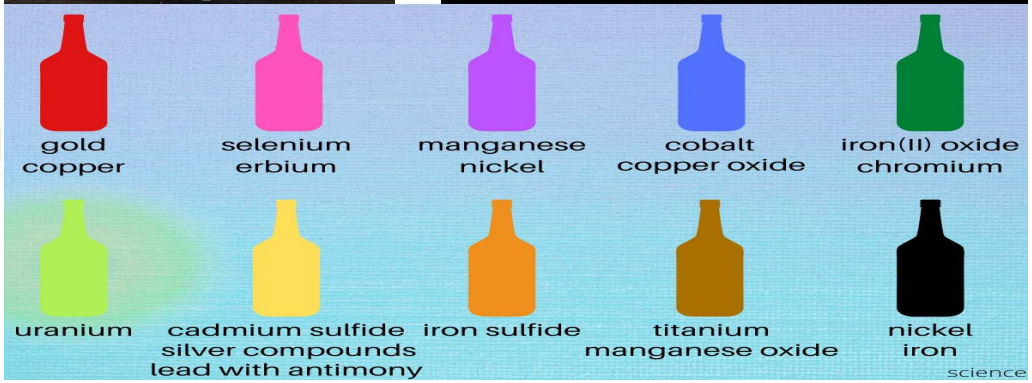
- **What is a Glass?**
  - Glass Building Material is one of the oldest & multifaceted materials utilizing in the building industry. Glass has been used to enhance the aesthetic view of structure and is fascinating material ever since it was discovered
  - It is an open hard substance created by giving heat to sand or quartz, glass forms an inorganic, transparent, or translucent material which can be molded into any shape.
  - It is a transparent glazing material, providing the architect's new designs and possibilities to enhance the look and features of the building.
  - Glass Building Material adds beauty & elegance to the look and feel of the structure, it is one of the most versatile materials to be used in the construction industry.

Functions of Glass

- It is most typically used as transparent glazing material in the building envelope, including windows in the external walls.
- Glass is also used for internal partitions and as an architectural feature.
- When used in buildings, glass is often of a safety type, which include reinforced, toughened and laminated glasses.

Constituents of Glass

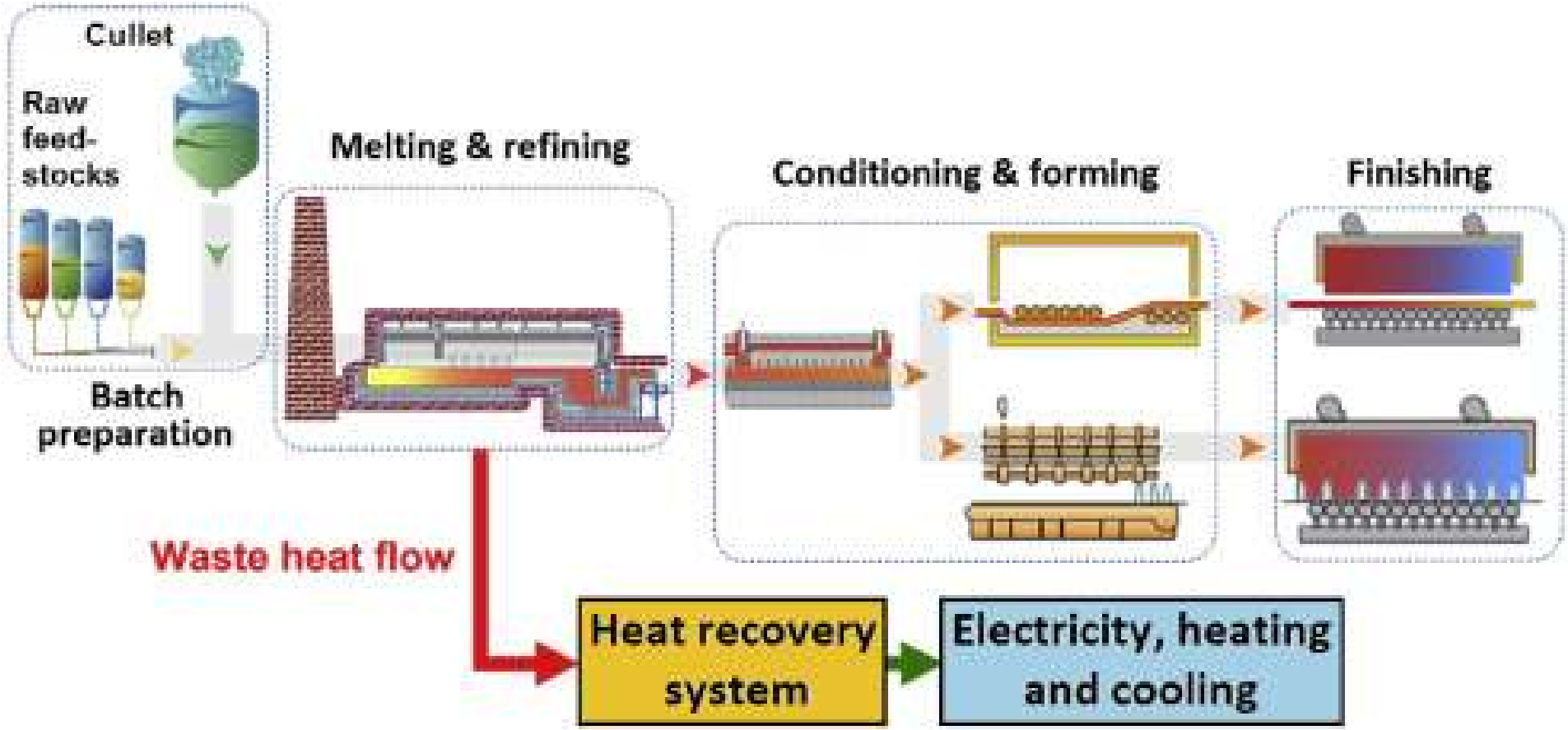
- The main constituents of glass are silica, sodium or potassium carbonate, lime, manganese dioxide, cullet and colouring materials.



Classifications of Glass

1. Soda-lime glass – Soda-ash glass, Soda glass, Soft glass, Window glass
2. Potash-lime glass – Hard glass, Bohemian glass
3. Potash- lead glass – Lead glass, Flint glass
4. Boro-silicate glass – Pyrex glass
5. Common glass – Bottle glass

Manufacturing process of glass



Properties of glass

- **Physical Properties**
  - ✓ The amorphousness property of glass enables it to be continuously worked from furnaces
  - ✓ It absorbs, refracts or transmits light
  - ✓ It is resistant to weather and chemicals except alkalies
  - ✓ Glass may be clear, colourless, diffused and stained
  - ✓ It is an excellent electrical insulator
  - ✓ It can be cleaned easily

Properties of glass

- **Engineering or Mechanical Properties**
  - ✓ Transparency
  - ✓ Strength
  - ✓ Workability
  - ✓ Transmittance
  - ✓ U value
  - ✓ Recycling property

Types of glass

1. Sheet glass
2. Float and Plate glass
3. Frosted glass, Ground glass or Obscured glass
4. Wired glass or Reinforced glass
5. Block glass
6. Tempered glass
7. Tempered curved or Bent glass
8. Laminated or Sandwich glass
9. Bullet-Resisting or Bullet-Proof glass
10. Insulating glass
11. Heat-Absorbing and Glare Reducing glass
12. Fire Rated glass
13. Reflecting glass/Coated glass or Transparent mirror glass
14. Intelligent window glass

Types of Glass

SHEET GLASS

- Made by blowing molten glass in to a large hollow cylinder which is split longitudinally and then flattened over a plane disc.
- Used for all engineering purposes.

Types of Glass

PLATE GLASS

- Very strong and more transparent
- Made by pouring hot glass on casting table by process of grinding , smoothing and polishing.
- Used for looking glass, large paned glass for glazing of shop front , wind screen of vehicles.

Plate Glass

Types of Glass

WIRED GLASS

- Wired mesh is put in the glass while rolling during manufacture of glass which keeps the pieces of glass held together.
- Do not shatter into pieces.
- Used for fire resisting doors and windows.

Types of Glass

BULLET PROOF GLASS

- Do not allow bullet to pierce through it.
- Made by sand witching vinyl-resin plastic between several layers of plate glass.
- Thickness of glass vary from 15mm to 75mm or even more.
- Used for glazing bank tellers booths and cash booths, jewellery stores, display cases

Types of Glass

INSULATING GLASS

- Very high resistance to heat flow
- Provide insulating effect
- It is made of two or more plates of glass separated by 6mm to13mm of dehydrated captive air.
- Edges are sealed of the glass.

Types of Glass

LAMINATED GLASS

- When breaks , does not fly off in splinters.
- Two or more sheets of glass are attached with plastic resin between them.
- Ensures safety at places where glass is liable to shatter.

Types of Glass

GROUND GLASS OR OBSURED GLASS

- Made by grinding one side of the glass or melting powdered glass upon it.
- Used where light is required without transparency therefore useful for public toilet, office doors, partition etc.

Types of Glass

TEMPERED PLATE GLASS

- Much stronger than ordinary glass
- Made by glass plate which is heated then cooled to temper it immediately.
- Used for glazed entrance doors, making table tops, shelves, counters etc.

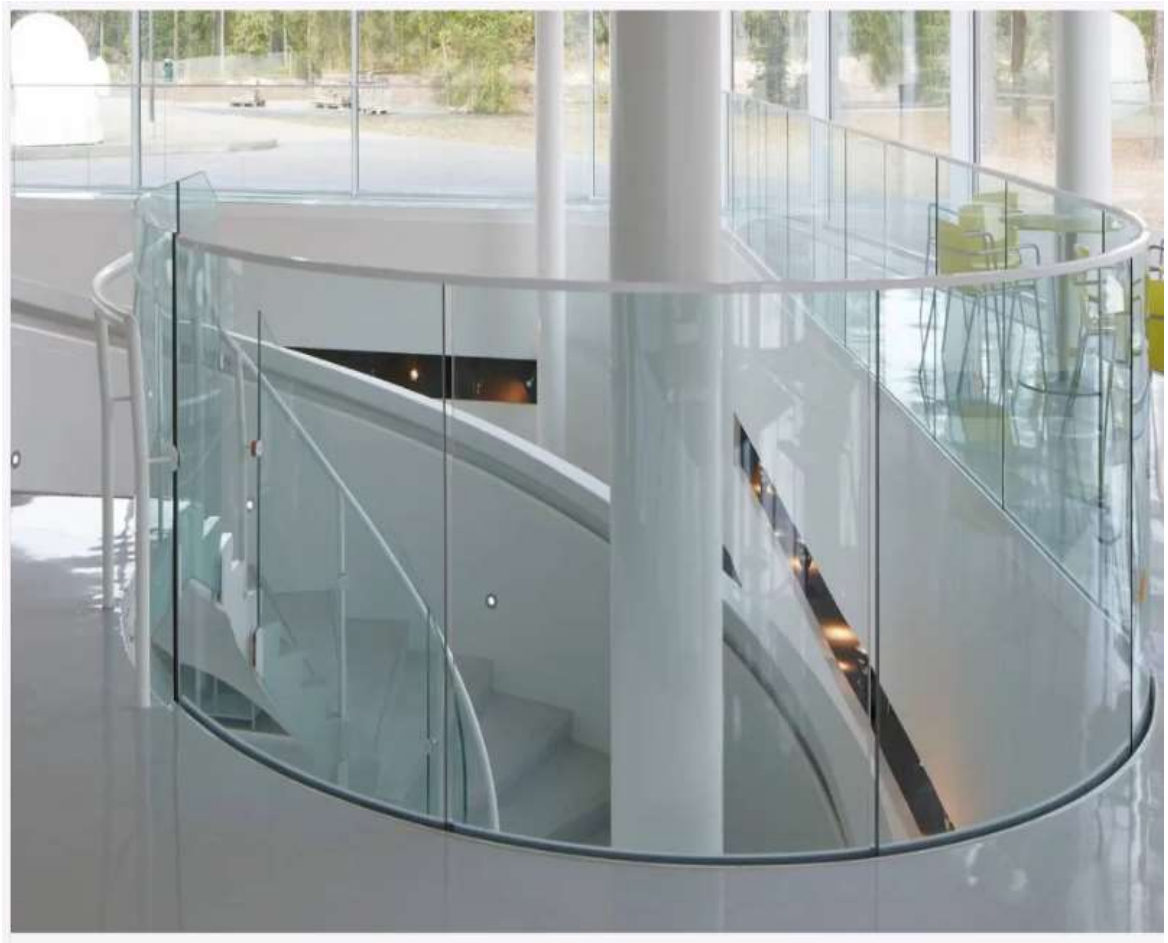
Types of Glass

GLASS BLOCKS

- Hollow transparent units, made by fusing together two pressed semi – blocks.
- Sizes – 10cm thick and 15cm, 20cm, 30cm square
- Sealed edges with grit bearing plastic so that a good bond is provided with mortar.
- Used in the construction of non- load bearing external panel walls and partition walls, skylights, insulation.

Types of Glass

Tempered curved or Bent glass



Types of Glass

Heat-Absorbing and Glare Reducing glass

Types of Glass

Fire Rated glass

Types of Glass

Reflecting glass/Coated glass or Transparent mirror glass

Types of Glass

Intelligent Window glass

Special types of glass

Painted glass

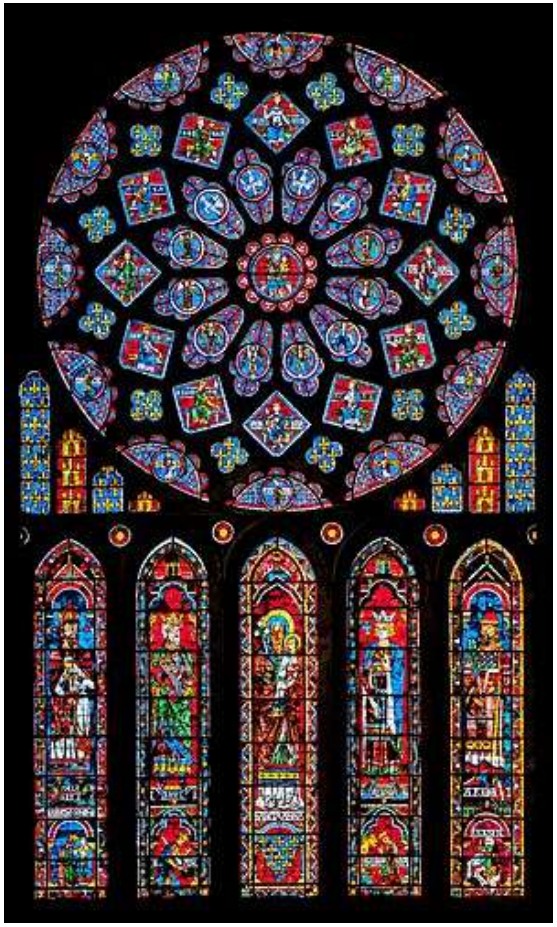
Special types of glass

Inlaid glass

Engraved glass

Special types of glass

Stained glass



Sand Blasted glass

Special types of glass

Tinted or Coated glass

Advantages of Glass

- Transparency
- Dustproof and Waterproof
- Colour Availability
- Aesthetically Appealling
- Recyclable
- UV Stable
- Weather and Rust Resistant
- Easily Moulded
- Insulator of Electricity
- Sustainable Material
- Visible Transmittance
- Abrasion Resistance

Disadvantages of Glass

- Cost
- Brittleness
- Impact Resistant
- Etching on glass surface
- Corrosion due to Alkali solution
- Heat Transparency
- Unsafe for Earthquake-prone areas
- Heat absorbent
- Maintenance
- Glare

INTRODUCTION

- A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are mouldable.
- Plastics are typically organic polymers of high molecular mass, but they often contain other substances.
- They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural.
- Synthetic resigns may be phenol, formaldehyde, cellulose vinyl, alkyl, etc. The moulding compounds are catalysts, fillers, hardeners, lubricants, pigments, plasticizers, solvents, etc.

Polymerisation

Polymerisation is the chemical process of monomers joining together to form polymers, often it takes many thousands of monomers to make a single polymer. 2 types of polymerisation reactions are listed below.

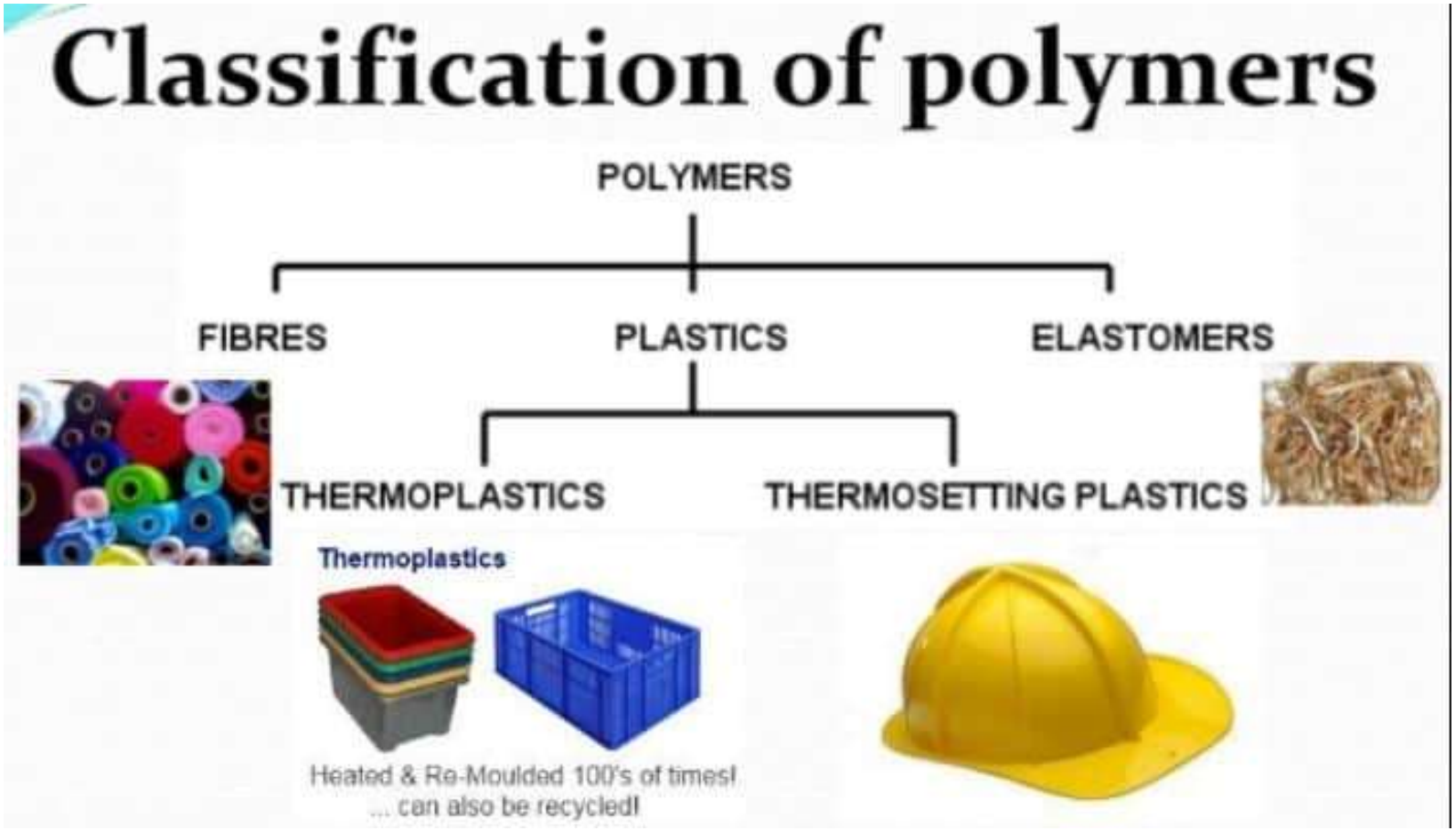
1. Addition polymerisation- where monomers addon to each other with the addition of a catalyst, these are usually alkenes such as ethene and propene. Alkenes can act as monomers because they have a double bond.

Polymerisation

2.Condensation Polymerisation - This is when monomers join or polymerise with a byproduct such as water, carbon dioxide or ammonia. This usually requires two different types of monomers that join alternately.

3. Co-polymerization – Two or more different monomers are added together to form a polymer. Phenol formaldehyde is produced by reaction of phenol and formaldehyde.

Classification of Plastics



Classification of Plastics

Thermoplastic polymers (thermoplastics)

- TP Solid materials at room temperature, but they become viscous liquids when heated to temperatures of only a few hundred degrees.
- This characteristic allows them to be easily and economically shaped into products.
- They can be subjected to this heating and cooling cycle repeatedly without significant degradation of the polymer.

The most important thermoplastics are:

- **Acrylics (Plexiglas):** lenses, window glazing
- **Fluorocarbons (Teflon):** nonstick coatings, bearings, seals
- **Polyamides (Nylons, Kevlar):** fibers
- **Polycarbonates (Lexan):** helmets, bullet-resistance windows, wind-shields
- **Polyesters (Dacron, Mylar, Kodel):** gears, cams, rollers
- **Polyvinyl chloride (PVC):** pipes, cable insulation, packaging, flooring, toys
- **Polyethylene:** bottles, cans, packaging materials

Classification of Plastics

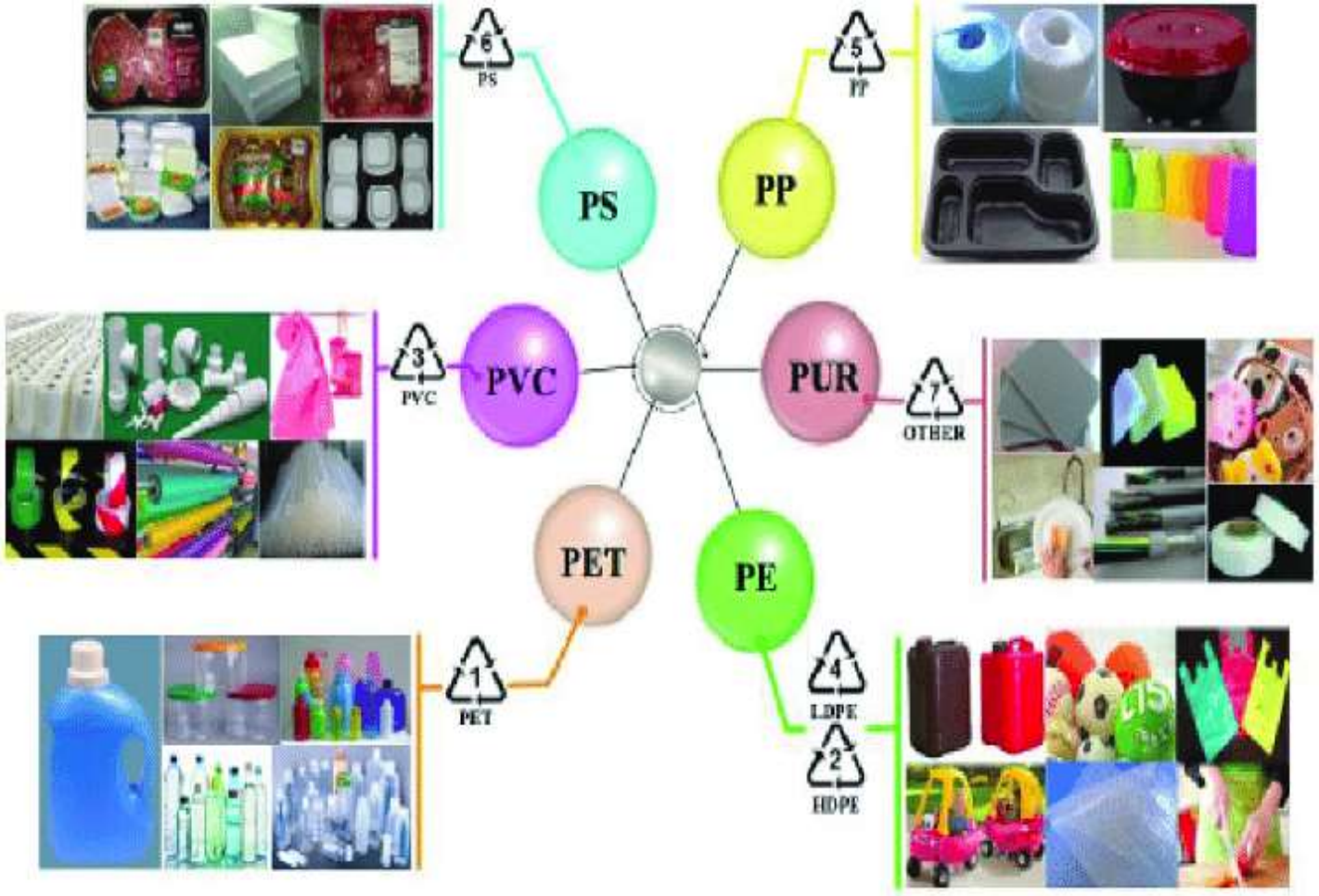
Thermosetting polymers (Thermosets)

TS cannot tolerate repeated heating cycles as thermoplastics can. When initially heated, they soften and flow for molding, but the elevated temperatures also produce a chemical reaction.

The most important thermosets are:

1. **Epoxies :** fiber-reinforced materials
2. **Phenolics (Bakelite) :** knobs, handles, cases
3. **Polyesters :** fiber-reinforced materials
4. **Silicones :** waterproof and heat resistance materials

Commonly used plastics



Commonly used plastics

Symbol	Description	
1 PETE	Clear tough plastic such as soft drink, juice and water bottles.	
2 HDPE	Common white or coloured plastic such as milk containers and shampoo bottles.	
3 V	Hard rigid clear plastic such as cordial bottles.	
4 LDPE	Soft flexible plastic e.g. squeezable bottles such as sauce bottles.	
5 PP	Hard but flexible plastic such as microwave ware, takeaway containers, some yoghurt/ ice cream/jam containers, hinged lunch boxes.	
6 PS	Rigid, brittle plastic such as small tubs and margarine/butter containers.	
7 OTHER	All other plastics, including acrylic and nylon. Examples include some sports drink bottles, sunglasses, large water cooler bottles.	

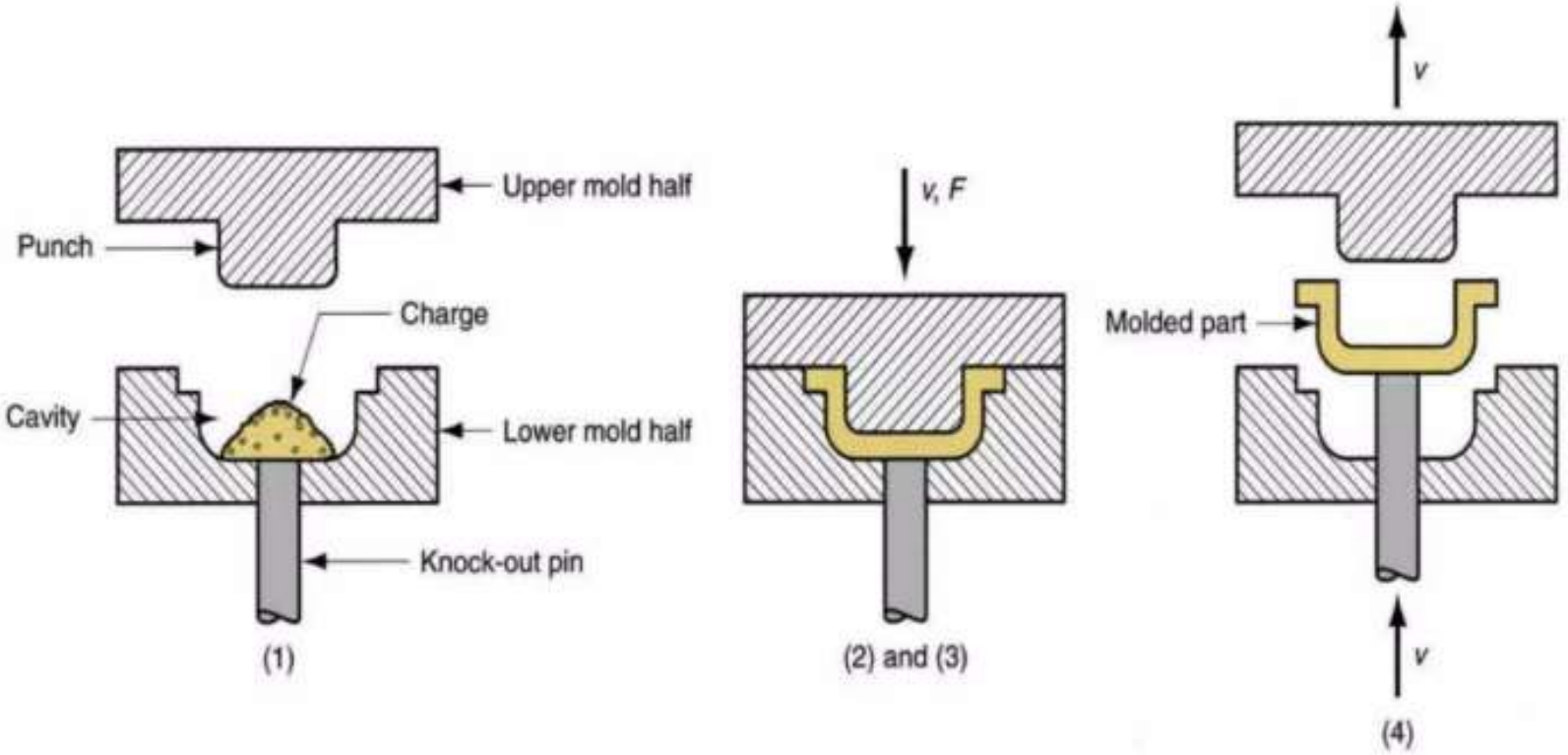
Moulding and Fabricating for Plastic Products

- Plastic manufacturing processes are used to convert plastic materials in the form of pellets, powders, sheets etc.
- Different types of plastic manufacturing processes are:

a. compression moulding
b. Transfer moulding
c. Injection moulding
d. Extrusion moulding
e. Blow moulding
f. Calendaring
g. Thermoforming
h. slush moulding
i. laminating

Moulding and Fabricating for Plastic Products

Compression Moulding



Moulding and Fabricating for Plastic Products

- First, the charge is loaded into the lower half of mold which is preheated to maintain the temperature of charge during the process.
- The placed charge is compressed by bringing both halves of mold close together.
- The charge is heated by means of the hot mold to polymerize and cure it into a solidified desired shaped molded plastic component.
- Then, the halves are opened & molded plastic part is removed by pressing knockout pins towards inside.

Moulding and Fabricating for Plastic Products

Advantages

- Low initial setup costs and fast setup time
- Heavy plastic parts can be molded
- Complex intricate parts can be made
- Good surface finish of the molded parts
- Wastes relatively little material as compared with other methods
- The molding process is cheaper as compared to injection molding

Disadvantages

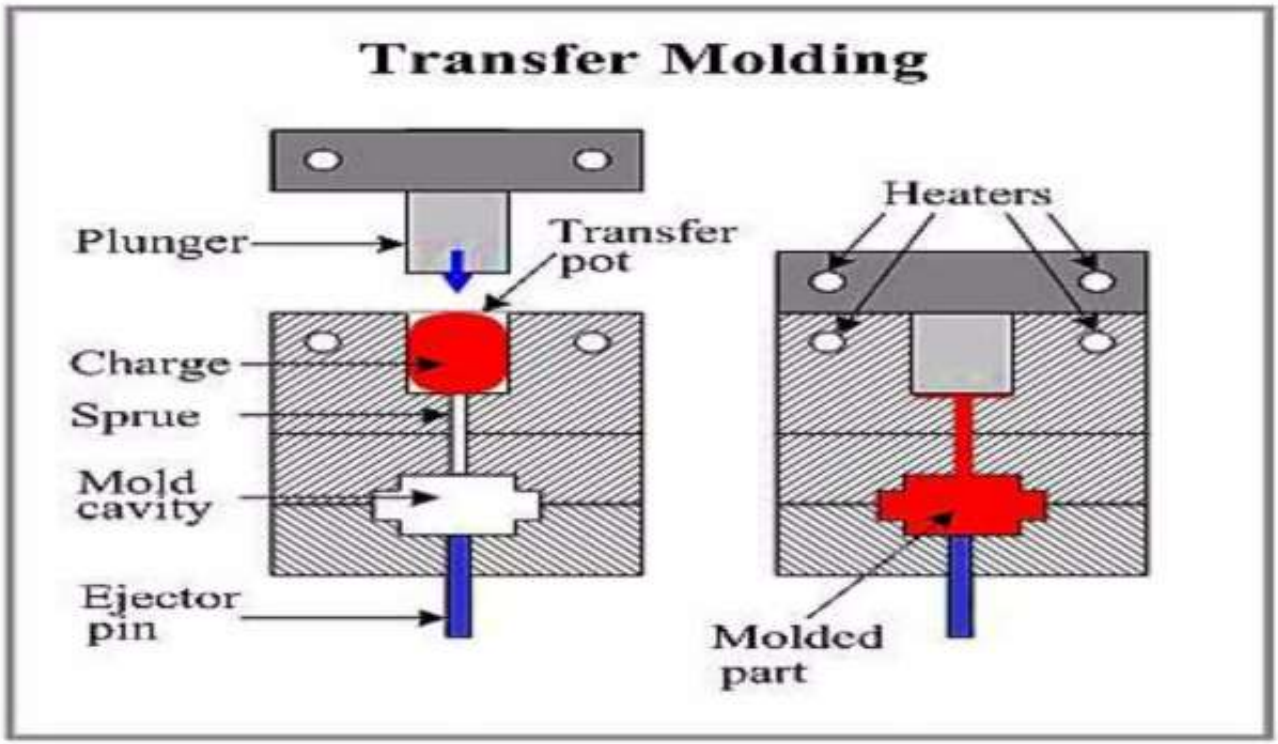
- Low production rate
- Limited largely to flat or moderately curved parts with no undercuts

Moulding and Fabricating for Plastic Products

Applications

- Electrical and electronic equipments, brush and mirror handles, trays, cookware knobs, aircraft main power terminal housing, pot handles, dinnerware plates, automotive parts.

Transfer Moulding



Moulding and Fabricating for Plastic Products

- It is similar to compression molding. The difference is, instead of loading the polymer into an open mold, the plastic material is preheated and loaded into a holding chamber called pot.
- The material is then forced into a preheated mold cavity using a ram or hydraulic plunger through a channel called sprue.
- The mold remains closed until the material inside is cured.
- Then, the final molded part is removed by using ejector pin.

Moulding and Fabricating for Plastic Products

Advantages

- Fast setup time and lower setup costs
- Low maintenance cost
- Plastic parts with metal inserts can be made
- Design flexibility
- Dimensionally stable
- Uniform thickness of parts
- Large production rate

Disadvantages

- Wastage of material
- Production rate lower than injection molding
- Air can be trapped in the mold

Moulding and Fabricating for Plastic Products

Applications

- Integrated circuits, plugs, connectors, pins, coils, studs, radio, television cabinets and car body shells.

Moulding and Fabricating for Plastic Products

Injection Moulding

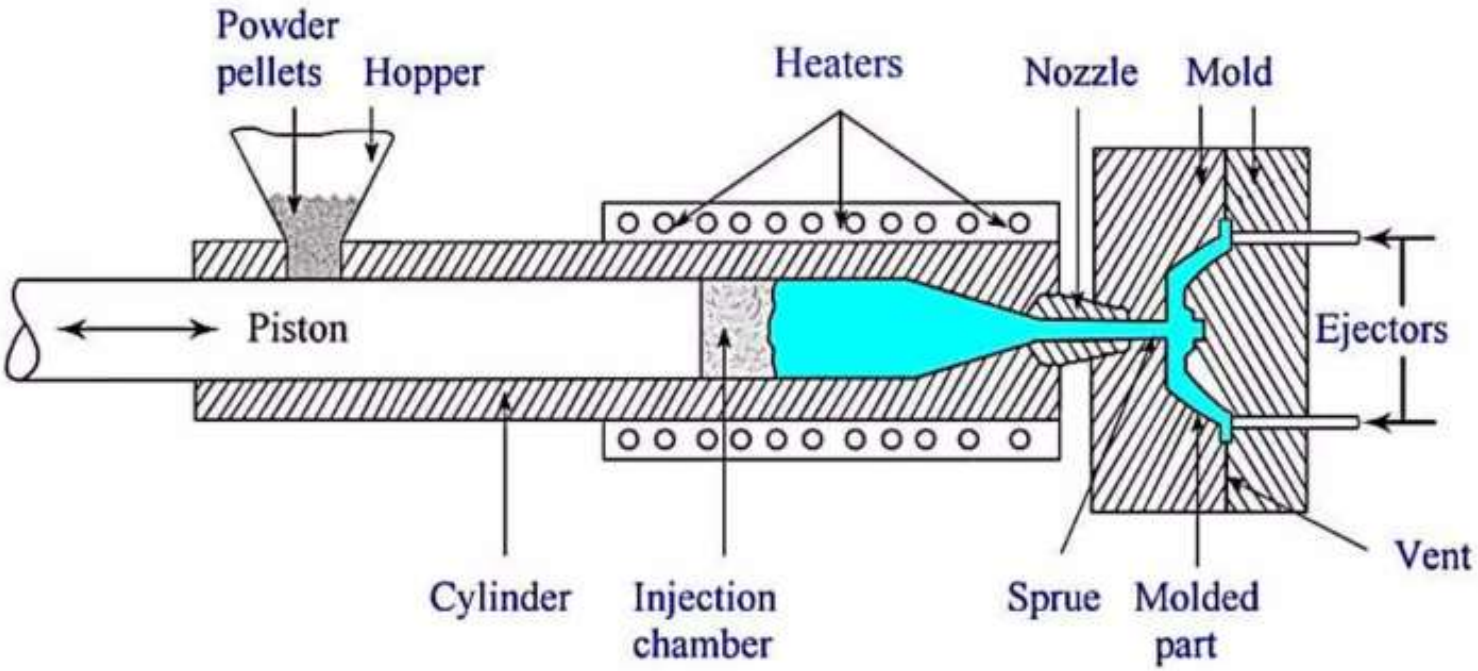


Figure 1 Injection molding setup

Moulding and Fabricating for Plastic Products

- Palletized material is fed with use of hopper into a cylinder where material melts due to heating coils.
- Molten metal is impelled through nozzle into the enclosed cavity.
- Outstanding characteristic of this mounding process is cycle time is very less. i.e. rate of production is very high.
- The complete injection molding process is divided into four stages: clamping, injection, cooling and ejection.

Moulding and Fabricating for Plastic Products

- **Clamping:** The two halves of the mold must be tightly closed, before the molten plastic material is injected into the mold.
  - One half of the mold is attached to the injection unit (nozzle) and other half is allowed to slide on the guide ways.

- **Injection:** During this process, the plastic material is melted by the application of heat and forwarded through the piston towards the nozzle and finally into the mold.
  - The amount of material that is injected into the mold is referred to as the shot volume.

Moulding and Fabricating for Plastic Products

- **Cooling:** The injected molten plastic begins to cool as soon as it comes in contact with the mold surfaces.
  - As the molded part cools, it will solidify into the desired shape of the product.

- **Ejection:** The molded part, which is attached to the rear half of the mold has to be ejected from the mold.
  - An ejector mechanism is used to push the part out of the mold.
  - Force must be applied to eject the plastic part because during cooling the molded part shrinks and adheres to the mold surface.
  - A mold release agent should be sprayed onto the mold surfaces prior to injection of the material.

Moulding and Fabricating for Plastic Products

Advantages

- Higher production rate
- Close tolerances on small intricate parts
- Minimum wastage of material
- Complex geometry can be easily produced

Disadvantages

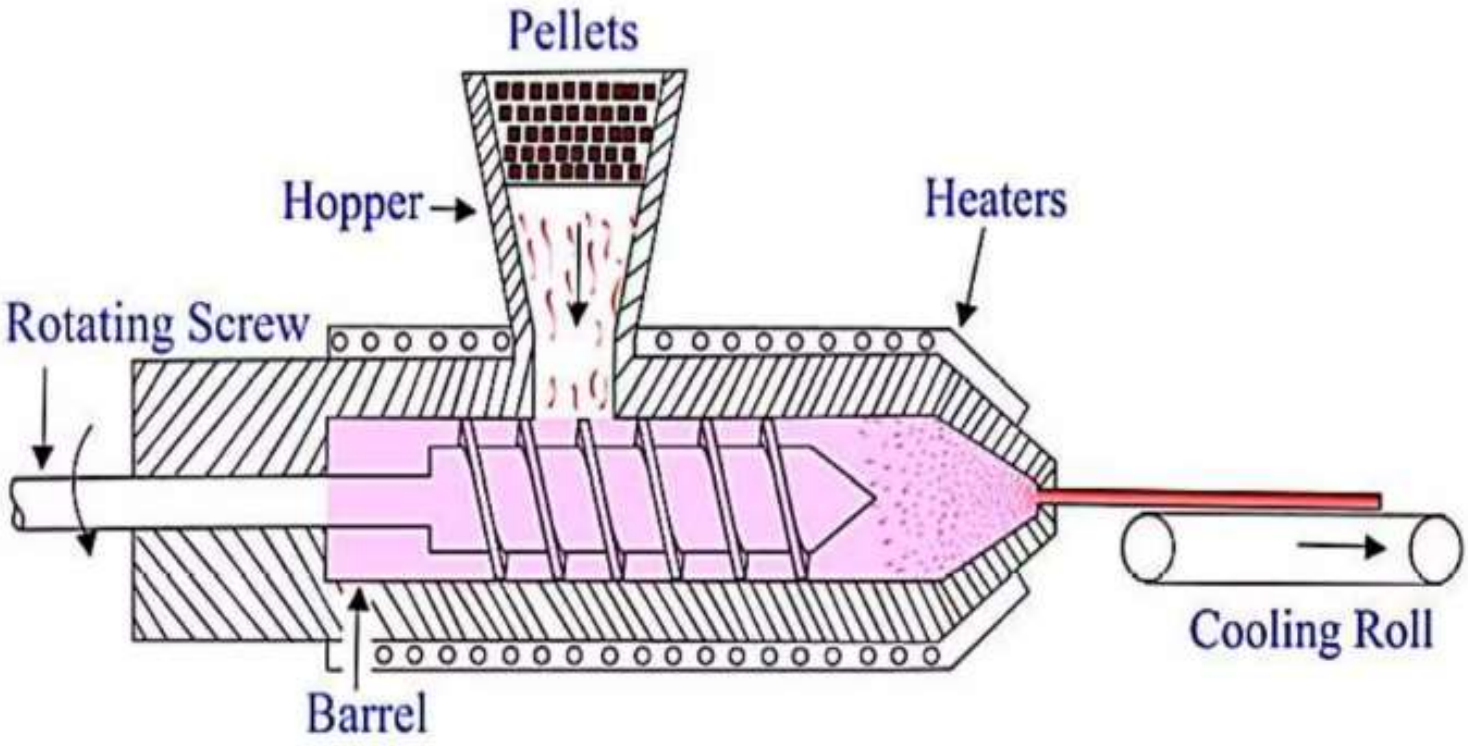
- Tooling cost higher
- High setup cost
- Large undercuts can't be formed

Applications

- household appliances, electronics, and automotive dashboards, buckets etc...

Moulding and Fabricating for Plastic Products

Extrusion moulding



Moulding and Fabricating for Plastic Products

- Similar to injection molding except long uniform sections are produced.
- The material which is fed through hopper, is conveyed forward by a feeding screw & forced through a die, converting to continuous polymer product.
- Heating is done in order to soften or melt the polymer. The temp is controlled by thermocouples.
- The product going out of the die is cooled by blown air or in water bath.

Moulding and Fabricating for Plastic Products

Advantages

- High production volumes
- Relatively low cost as compared with other molding process
- Design flexibility
- Short lead times
- Coating of wire can be done to achieves desired properties
- Continuous part can be produced

Disadvantages

- Limited complexity of parts
- Uniform cross section can only be produced

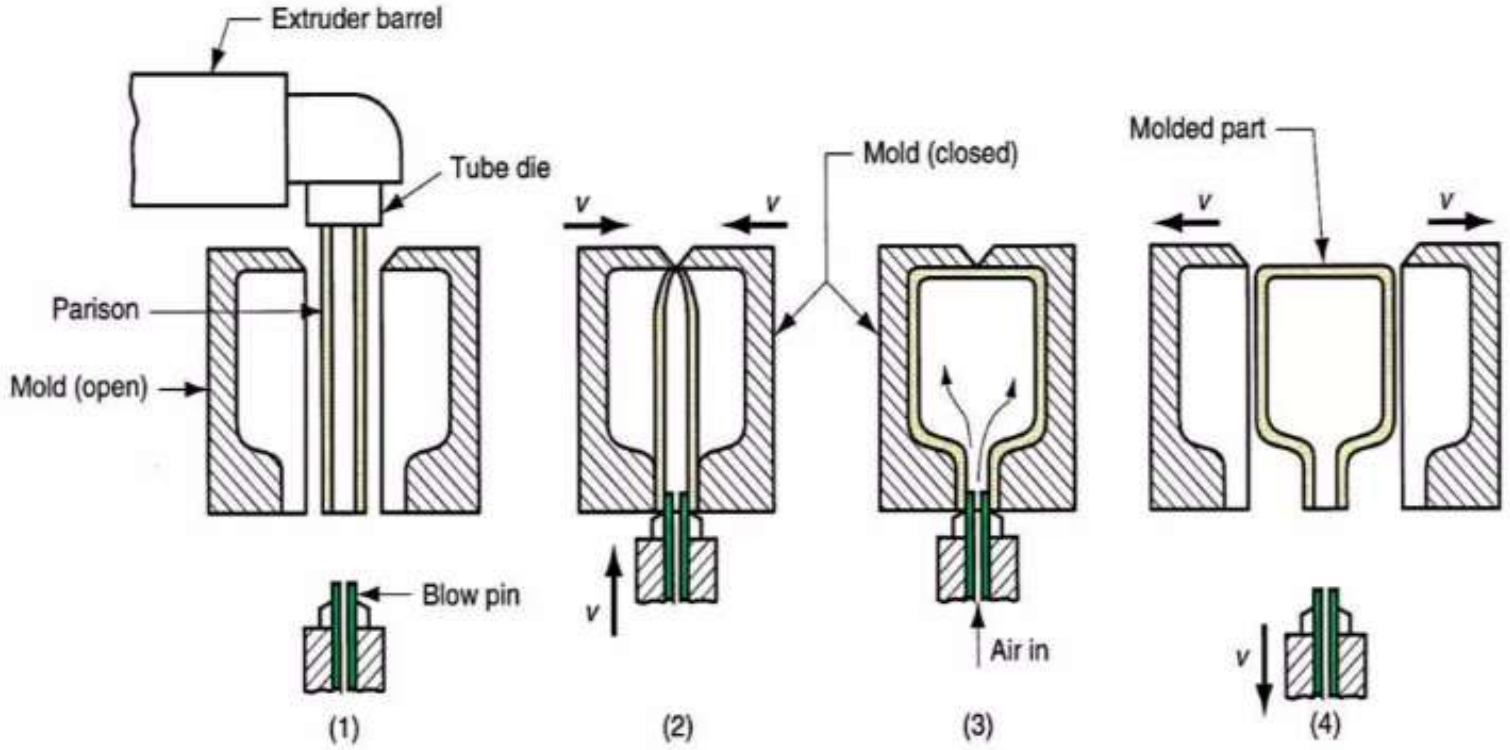
Moulding and Fabricating for Plastic Products

Applications

- The extrusion process is used for manufacturing rods, plates and tubes, wire and cable coating, hose liners, hose mandrels, filaments, sheet, multilayer film, medical packaging and food packaging, etc.

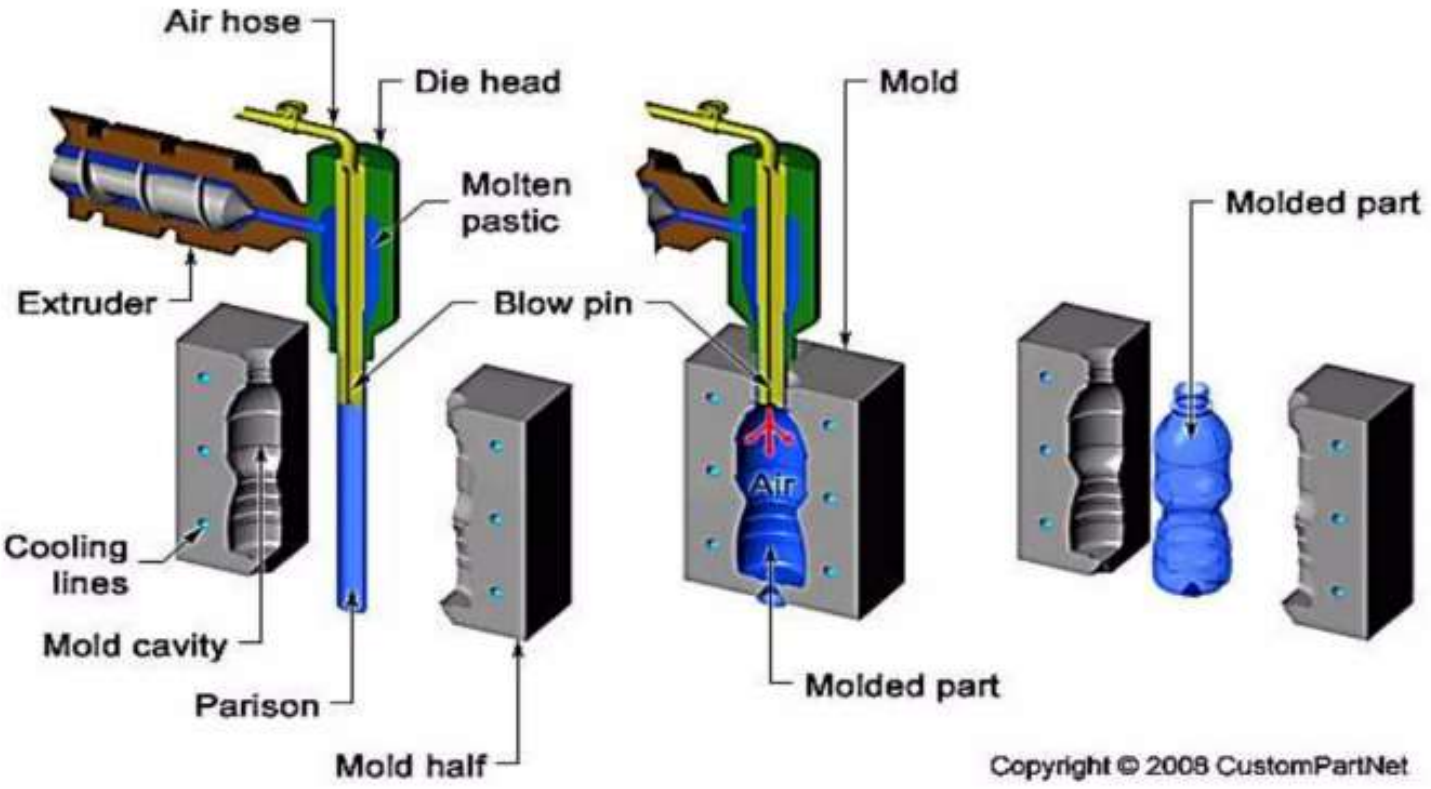
Moulding and Fabricating for Plastic Products

Blow moulding



Moulding and Fabricating for Plastic Products

Blow moulding



Moulding and Fabricating for Plastic Products

- Using this manufacturing process blind parts are made like bottle or sphere etc.
- Air is blown into a thin walled plastic cylinder called the parison. The parison is formed by melted plastic material being pushed through an extruder.
- When the parison reaches a certain length, the two halves of the mould close around the parison sealing it at the bottom.
- Compressed air is then used to inflate the parison to form the shape of the cavity inside the mould.

Moulding and Fabricating for Plastic Products

Advantages

- Low tooling cost
- Fast production rates
- Ability to mold complex part with uniform thickness
- Little scrap generated
- Large hollow shape can be produced
- Produced parts can be recycle

Disadvantages

- Limited to hollow parts
- Thick parts can't be manufactured

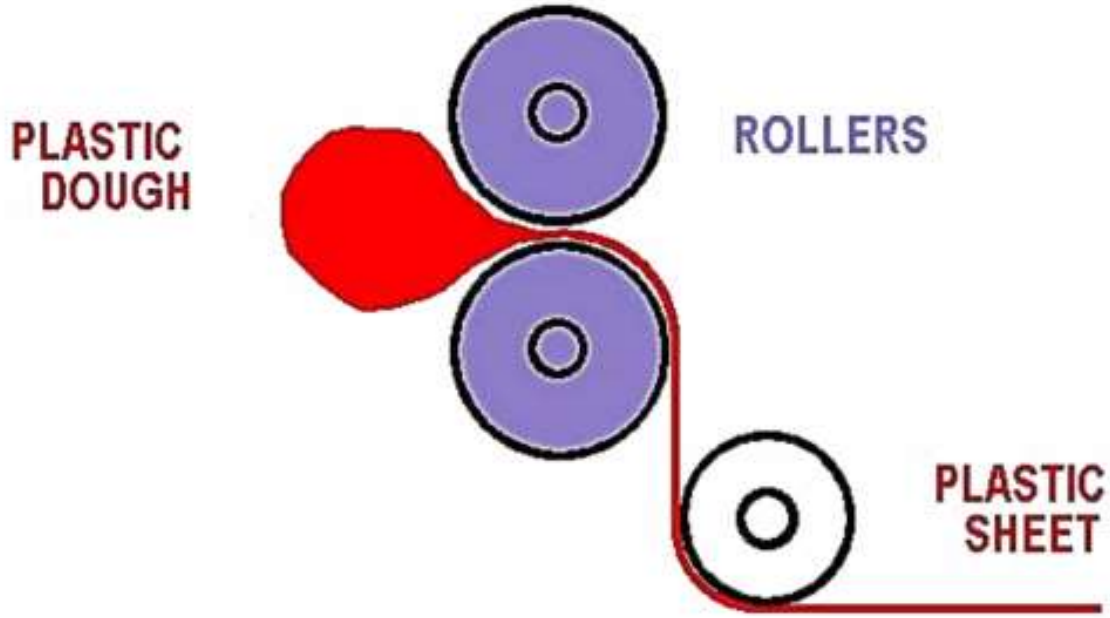
Moulding and Fabricating for Plastic Products

Applications

- bottles in different shape and size, jars, and containers, ducting, fluid oil tanks, mugs, and toys etc.

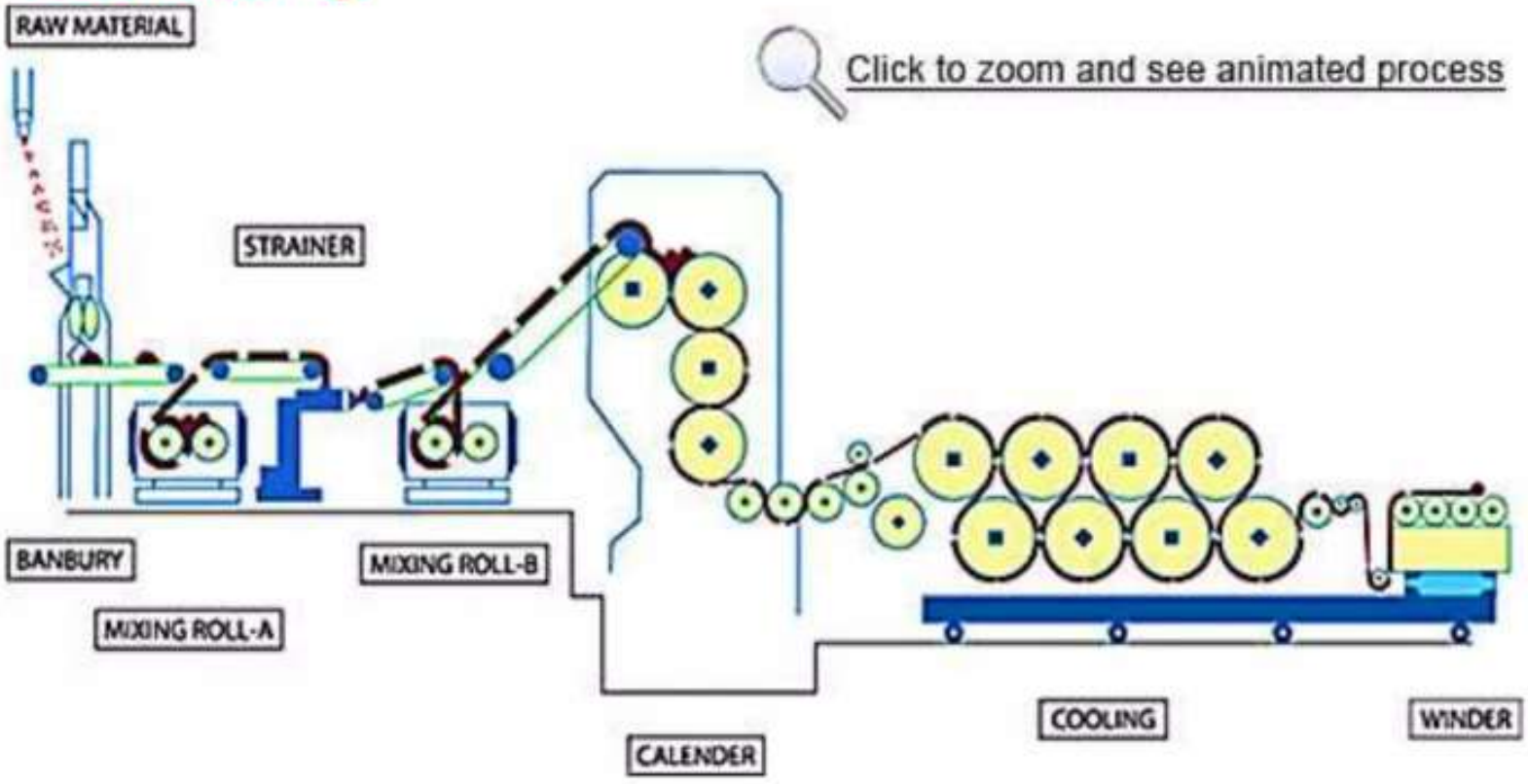
Moulding and Fabricating for Plastic Products

Calendaring



Moulding and Fabricating for Plastic Products

Calendaring



Moulding and Fabricating for Plastic Products

- 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.

Moulding and Fabricating for Plastic Products

Thermoforming

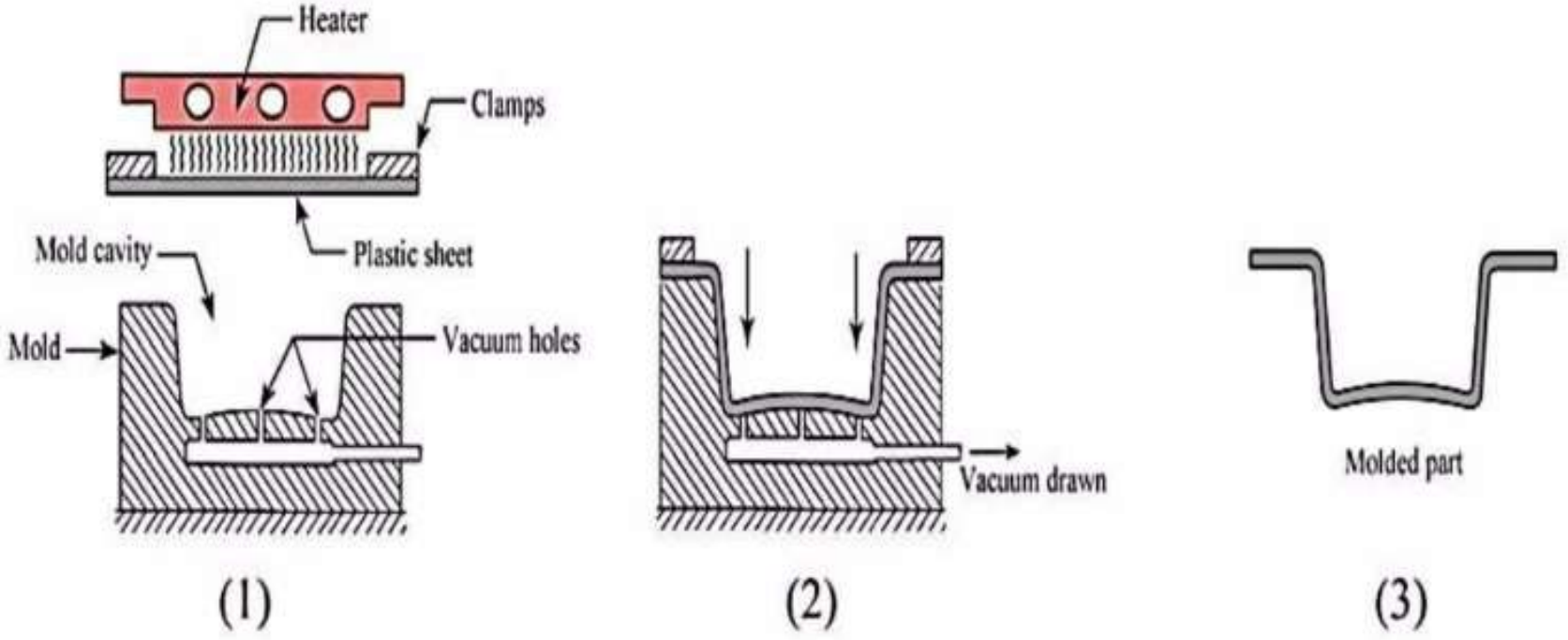
- Thermoforming is a plastic manufacturing process in which the thermoplastic sheets are formed with the application of heat and pressure in a mold.
- The thermoplastic sheet is held horizontally over a mold surface and clamped with a holding device. The sheet is heated up to predetermined temperature using a heating element called heater.
- The thermoplastic sheet softens with the application of heat and is pressed into or stretched over the mold surface by application of air pressure or by any other means.

Thermoforming

- The softened sheet conforms to the mold shape and it is held in place until it cools.
- The mold cavity is opened and the thermoformed part is released.
- The excess material is then trimmed out from the formed part. Excess material can be reground, mixed with unused plastic, and again reformed into thermoplastic sheets.
- There are mainly three different types of thermoforming process depending upon the pressure required i.e., vacuum thermoforming, pressure thermoforming and mechanical thermoforming.

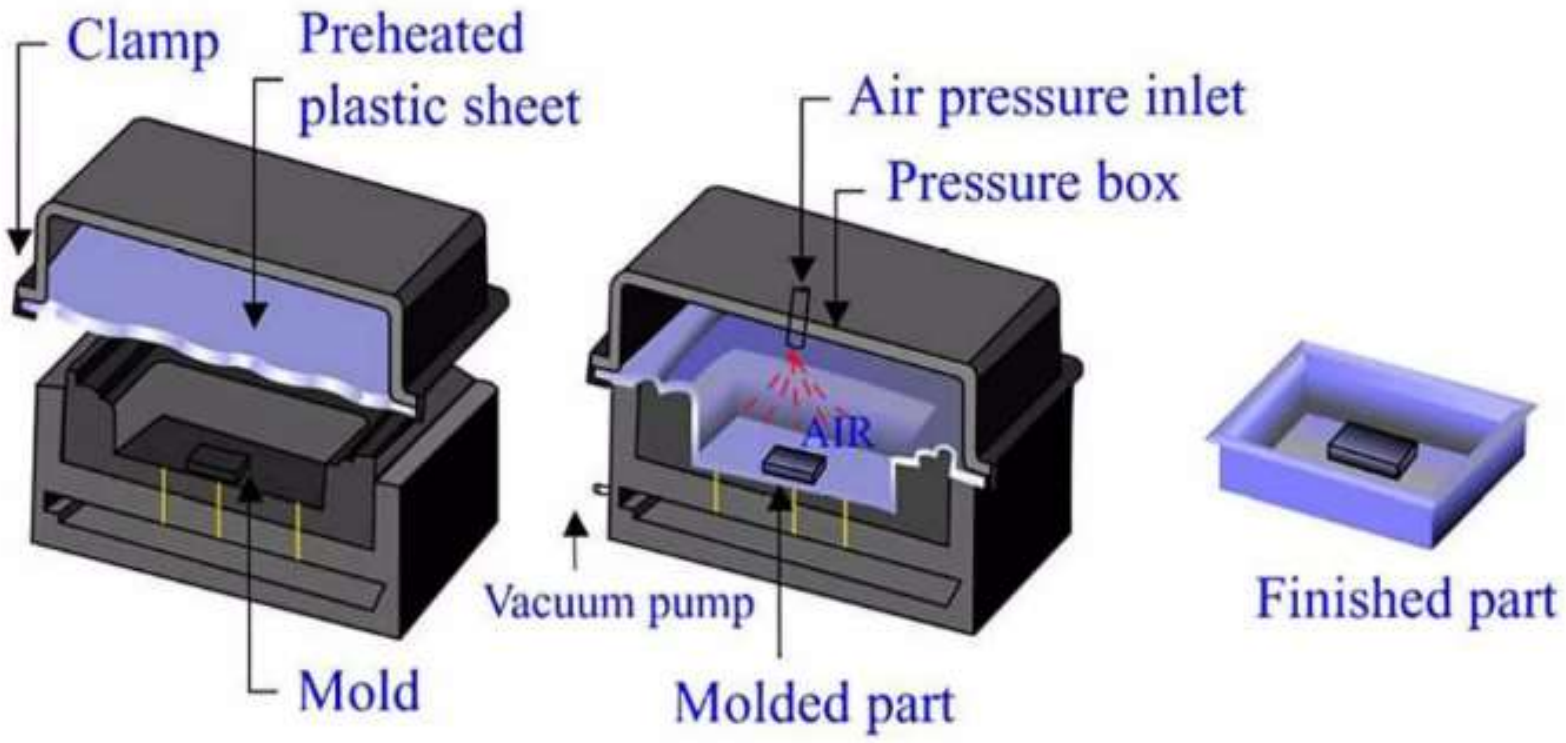
Moulding and Fabricating for Plastic Products

a. vacuum thermoforming



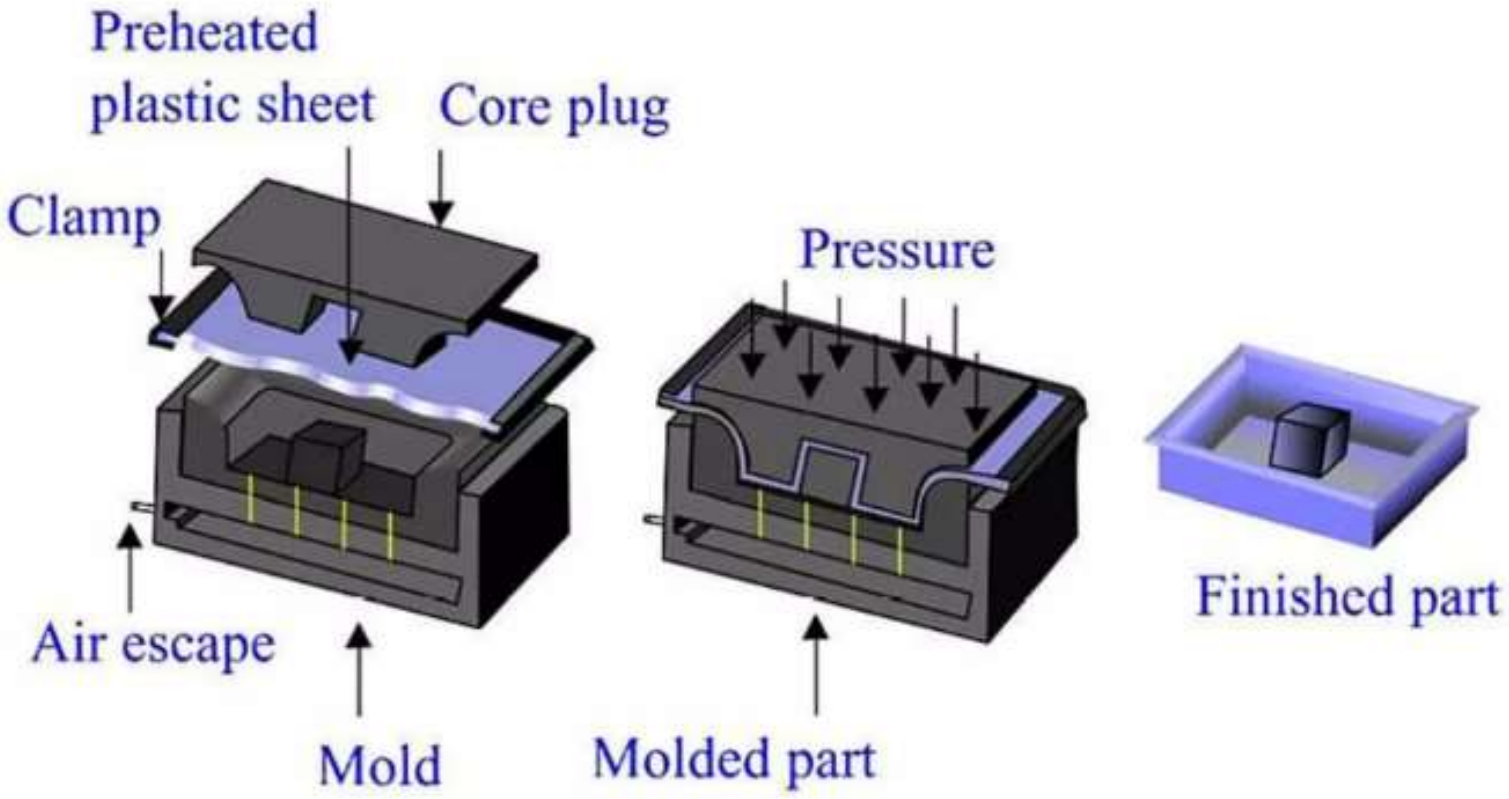
Moulding and Fabricating for Plastic Products

b. pressure thermoforming



Moulding and Fabricating for Plastic Products

c. mechanical thermoforming



Moulding and Fabricating for Plastic Products

Advantages

- Extremely adaptive to design requirement
- Rapid prototype development
- Low initial setup costs
- Low production costs
- Less thermal stresses than injection molding and compression molding
- Good dimensional stability

Disadvantages

- Poor surface finish
- Parts may have non-uniform wall thickness.
- All parts need to be trimmed
- Ribs and bosses cannot be molded easily
- Very thick plastic sheets can't be formed

Moulding and Fabricating for Plastic Products

Applications

- food packaging, automotive parts, trays, building products, aircraft windscreens, medical equipment, material handling equipment, electrical and electronic equipment, spas and shower enclosures etc.

Applications of Plastics

Agriculture	Foil tents, pouring tubes
Building	pipes, floor, covering panels, paintings
Automotive	Numerous part
Medical	Prosthesis, injectors, plasma bags
Chemical	Pumps, pipes, tanks
Tool industry	Case, insulations
Household	Household machines, bowls
Packaging	**transportation, pharmaceutics and foods**
Sport	Ships, rackets, fishing rod, bicycle
Army	Aircraft, copter, vehicles, missiles

Advantages and Disadvantages of Plastics

Advantages of Plastics	Disadvantages of Plastics
Plastic is light in weight.	Plastic is considered a non-renewable resource.
They have excellent finishing and can be easily molded.	Plastic is soft.
They hold very good toughness and strength.	Plastic causes CANCER
They possess a good capacity for shock absorption.	Plastics at low temperatures are embrittlement.
Plastic is chemically inert and corrosion-resistant.	Plastics show deformation under load.
Plastic possesses good thermal and electrical insulating properties due to having a low thermal expansion of co-efficient.	Plastics holds low heat resistance and poor ductility.
Plastic possesses good adhesiveness and is very good water-resistant.	Plastics are combustible.

Intelligent Use of Plastics in Buildings

- Pipes : Electrical Conduits, Rain Water & Sewage pipes, Plumbing, Gas Distributions.
- Cables : PVC Insulation on cables, Insulation Tapes .
- Floorings : Flooring tiles & Rolls .
- Domes / sky lights : Opaque as well as transparent.
- Roofing : Coloured or Double skinned for insulation.
- Windows & doors : Extruded sections for Door and windows and panels.
- Storage tanks : Storage tanks.
- Hardware accessories : Washers, Nut bolts, Sleeves, Anchoring wires.
- Temporary structures: Guard cabins, tents
- Insulation materials: PVC sheets, insulating membranes.

INSULATING MATERIALS

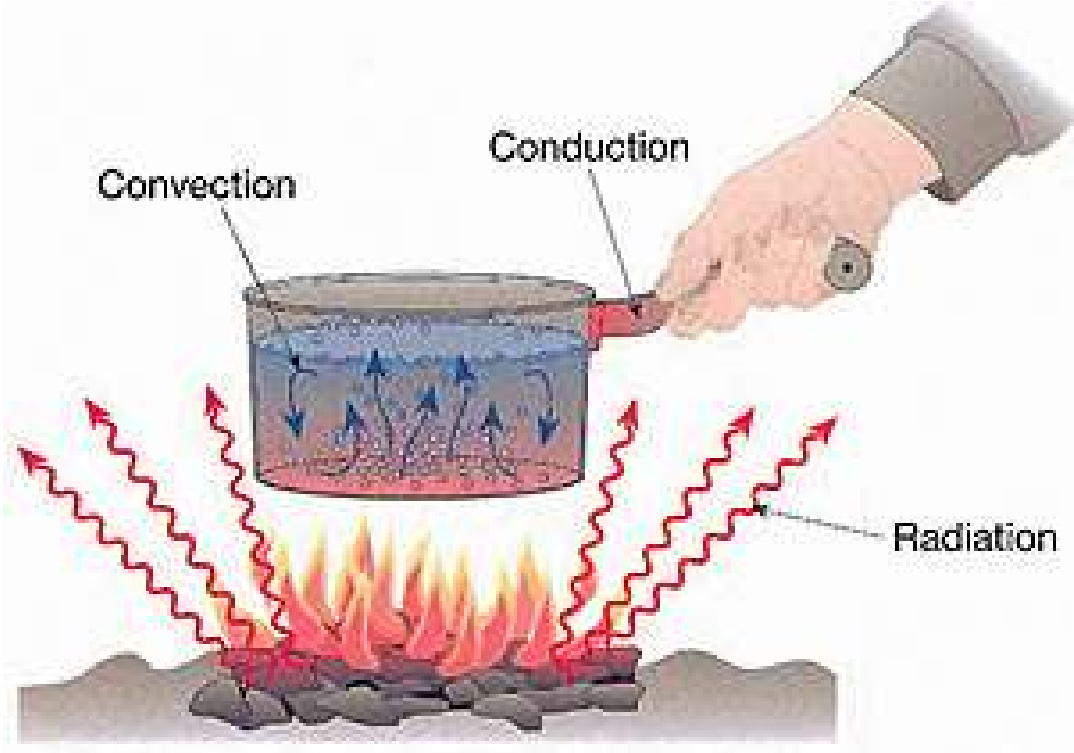
Thermal Insulation

- Thermal insulation is the reduction of heat transfer (i.e., the transfer of thermal energy between objects of differing temperature) between objects in thermal contact or in range of radiative influence.
- Thermal insulation can be achieved with specially engineered methods or processes, as well as with suitable object shapes and materials.
- Thus insulation provides comfort for its occupants and decreases the energy requirements of heating and cooling systems.

Heat Transfer Fundamentals

- Heat energy is transferred by three basic modes.

1. Conduction
2. Convection
3. Radiation



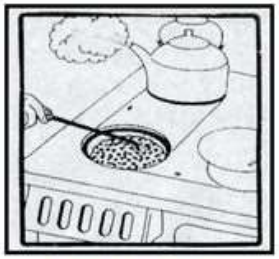
Heat Transfer Fundamentals

Fundamentals of Heat Transfer

Heat flows from a hot or warm medium to a cold medium in three ways :

1 Conduction

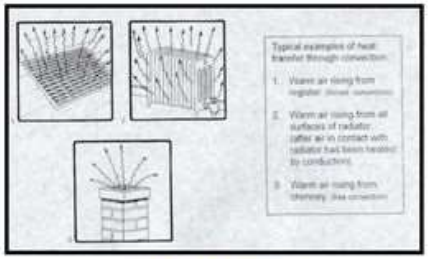
Heat transfer through solid or fluid materials



Conduction

2 Convection

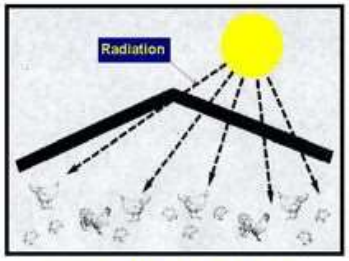
Heat transfer involves the physical movement of air



Convection

3 Radiation

Heat transfer from warm surface to cooler surface through air or vacuum



Sunlight Radiation

Thermal Properties of Insulating Materials

- **Temperature Limits** – Upper and Lower temperatures within which the material must retain all its useful properties.
- **Specific Heat Capacity or Specific Heat** – The amount of the heat energy required to increase the temperature of a unit weight of a substance by one degree. Water has a specific heat of 1.0 and absorbs large quantities of heat energy and air with a specific heat of 0.24, absorbs considerably less heat energy per kg.
- **Thermal Conductance (C)** – The rate of heat flow for the actual thickness of a material.

$$C = \frac{kA}{\Delta L}$$

Thermal Properties of Insulating Materials

- **Thermal Conductivity (k)** – The property of a material that indicates its ability to transmit heat energy by conduction.
- **Specific Heat Capacity or Specific Heat** – The amount of the heat energy required to increase the temperature of a unit weight of a substance by one degree. Water has a specific heat of 1.0 and absorbs large quantities of heat energy and air with a specific heat of 0.24, absorbs considerably less heat energy per kg.
- **Thermal Conductance (C)** – The rate of heat flow for the actual thickness of a material.

$$C = \frac{kA}{\Delta L}$$

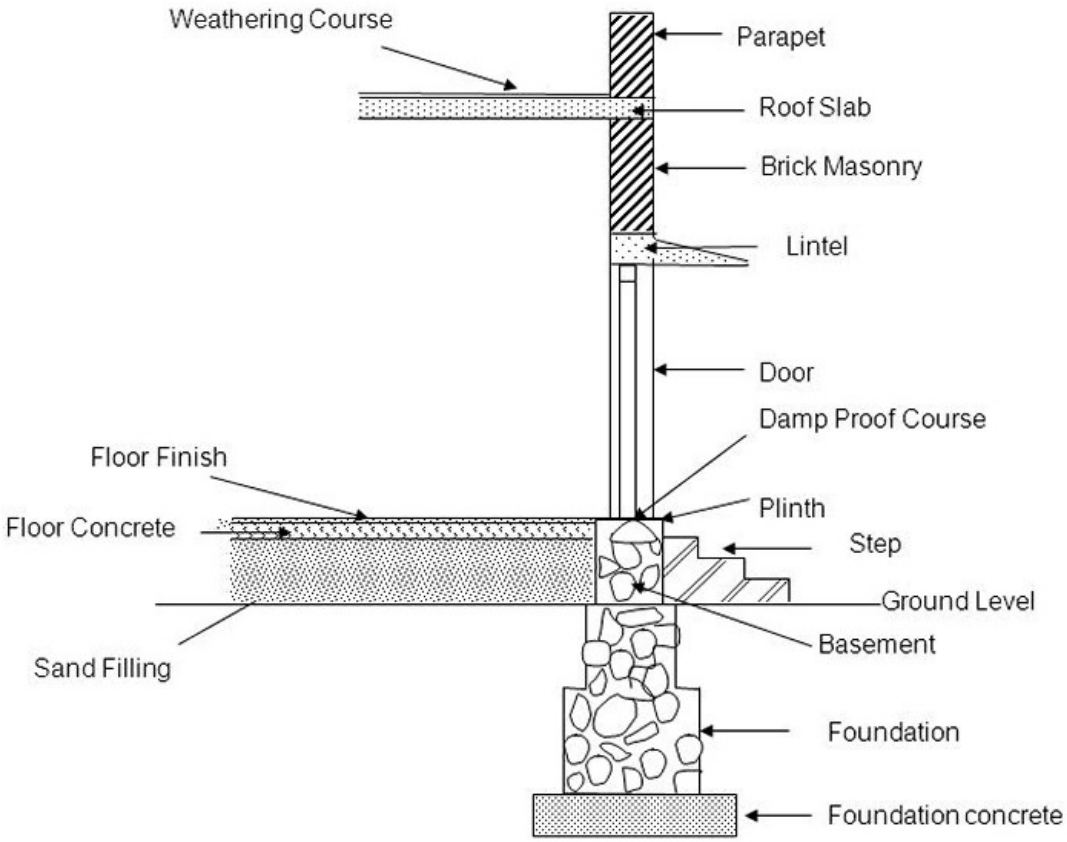
STRUCTURAL COMPONENTS

BUILDING COMPONENTS

1. Sub structure

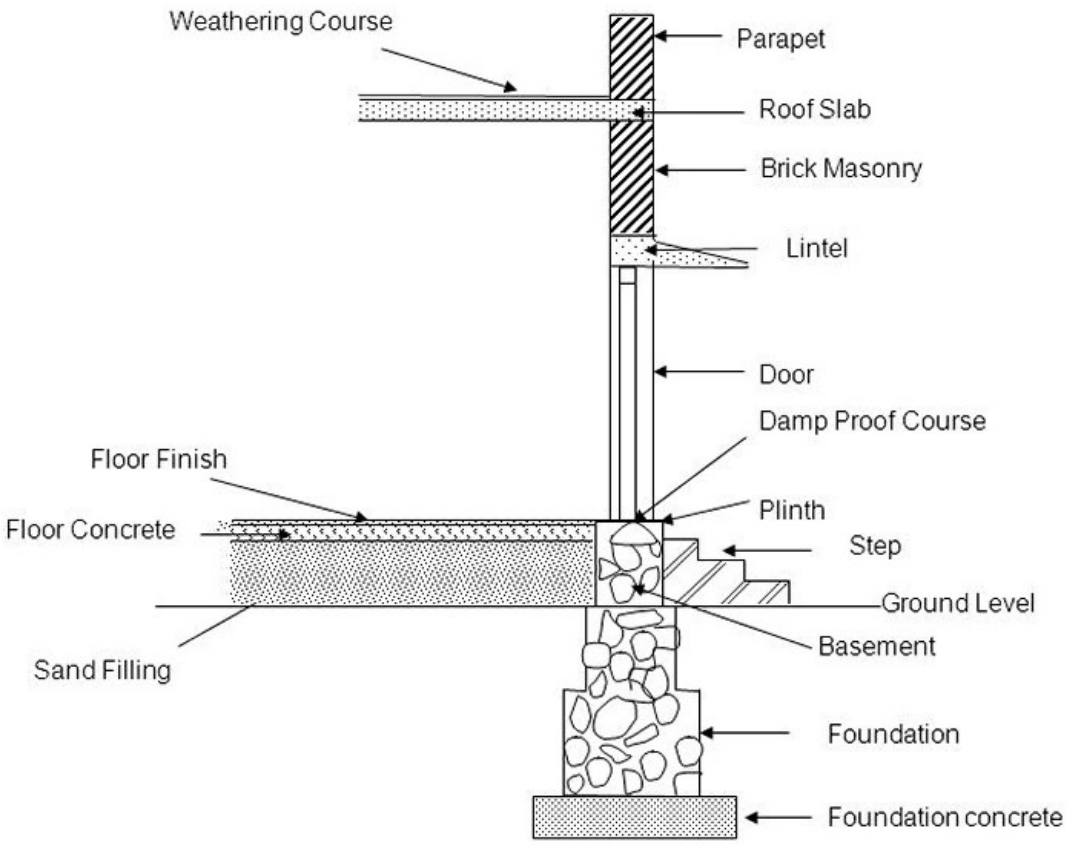
2. Super structure

Building Components



COMPONENTS OF A BUILDING

Building Components - Foundation



COMPONENTS OF A BUILDING

Foundation is the part of the structure which is in direct contact with the ground to which loads are transmitted.

Foundations

A weak foundation destroys the work which is built upon it.

Foundations

Functions of foundation

- Even distribution of load
- Reduction of load intensity
- Reduction of differential settlement
- Safety against sliding and overturning
- Safety against undermining
- Provide firm and level surface
- Protection against soil movement

Foundations

Requirements of a good foundation

- Constructed to sustain dead load and imposed load and transmit them to underlying soil
- Rigid-to avoid differential settlement
- Taken to sufficient depth
- Performance should not be affected due to any unexpected future influence

Foundations

Factors for the design

1. Bearing capacity of the soil
   - Ultimate bearing capacity
   - Safe bearing capacity
   - Allowable bearing capacity

2. Settlement of foundations
   - Uniform settlement
   - Differential settlement

Classifications of Foundation

Types of Foundations

- Shallow Foundations D<=B
- Deep Foundations D>B

D - Depth of foundation

B – Width of foundation

Classifications of Foundation

Shallow foundations

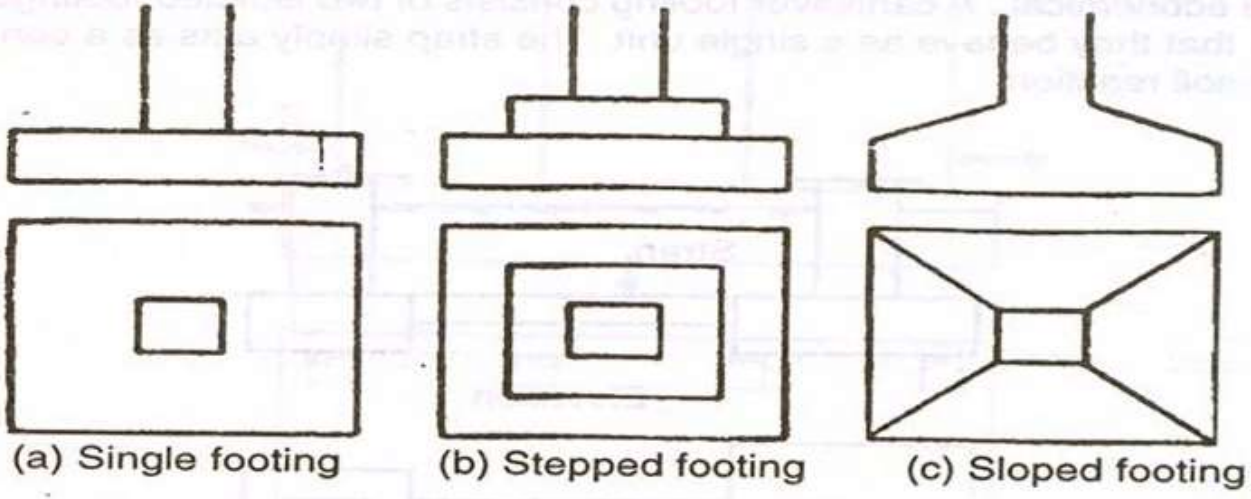
Types of shallow foundations

- Isolated or column footing
- Wall or strip footing
- Combined footing
- Continuous footing
- Cantilever footing
- Raft or mat foundation

Classifications of Foundation

Isolated or column footing

When the load on the column is less, a spread is given under the column



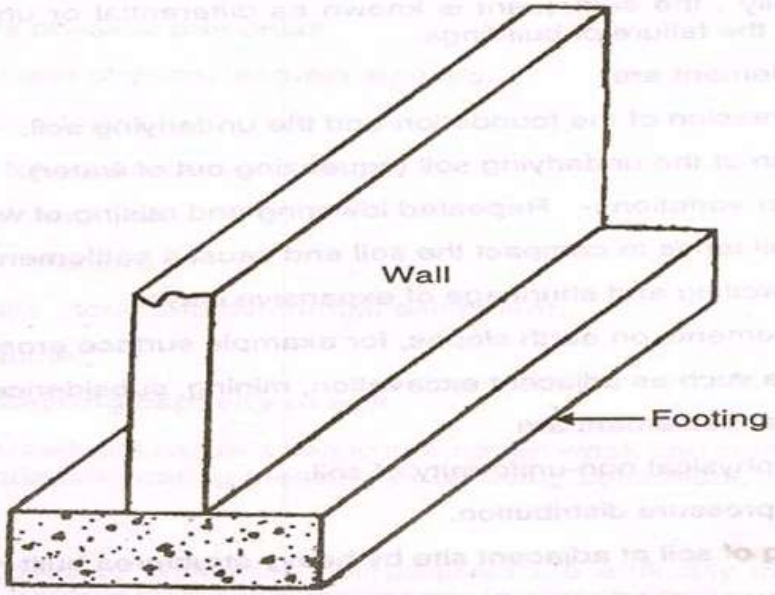
Classifications of Foundation

Isolated Footing

Classifications of Foundation

Wall or strip footing

- The foundation which is provided through out the length of a continuous structure is called strip footing.



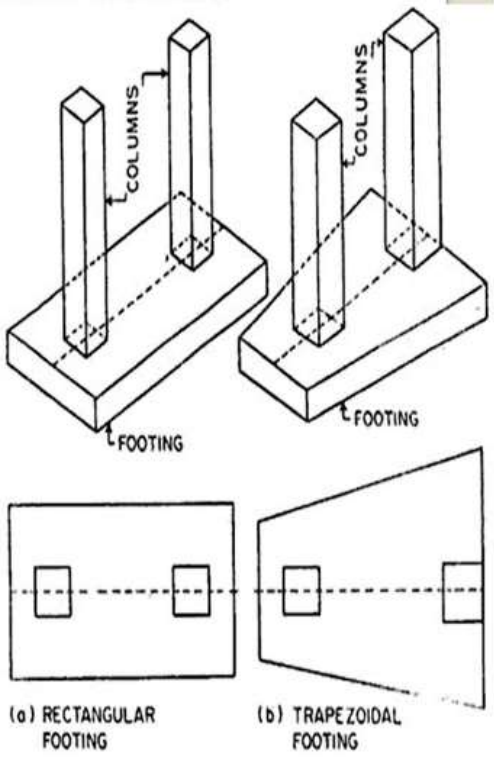
Classifications of Foundation

Wall or Strip Footing

Classifications of Foundation

Combined footing

- When a foundation or footing is constructed for two or more columns is called as combined footing
- Two individual footings overlap
- When bearing capacity is less
- when footings are constructed near boundaries of the plot
- Trapezoidal footing – when column loads vary considerably



Classifications of Foundation

Combined Footing

Classifications of Foundation

A single continuous reinforced concrete slab is provided as foundation for three or more columns in a row. Continuous footing is more suitable to prevent the differential settlement in the structure and for the safety against earthquake.

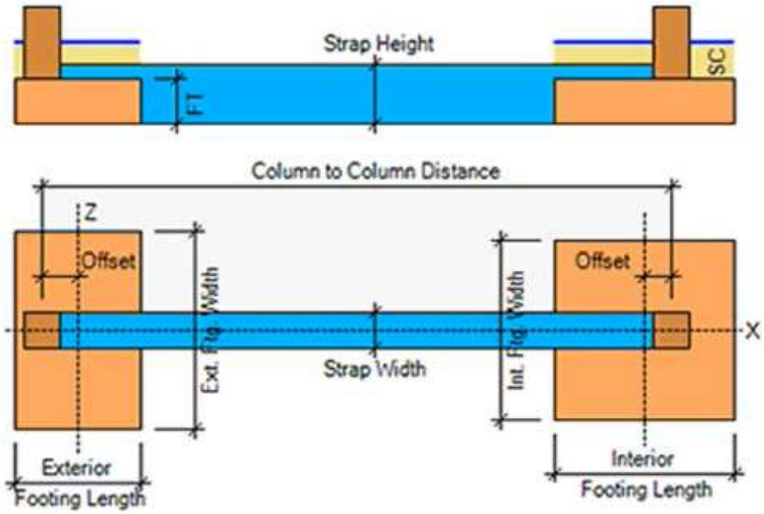
Classifications of Foundation

Continuous footing

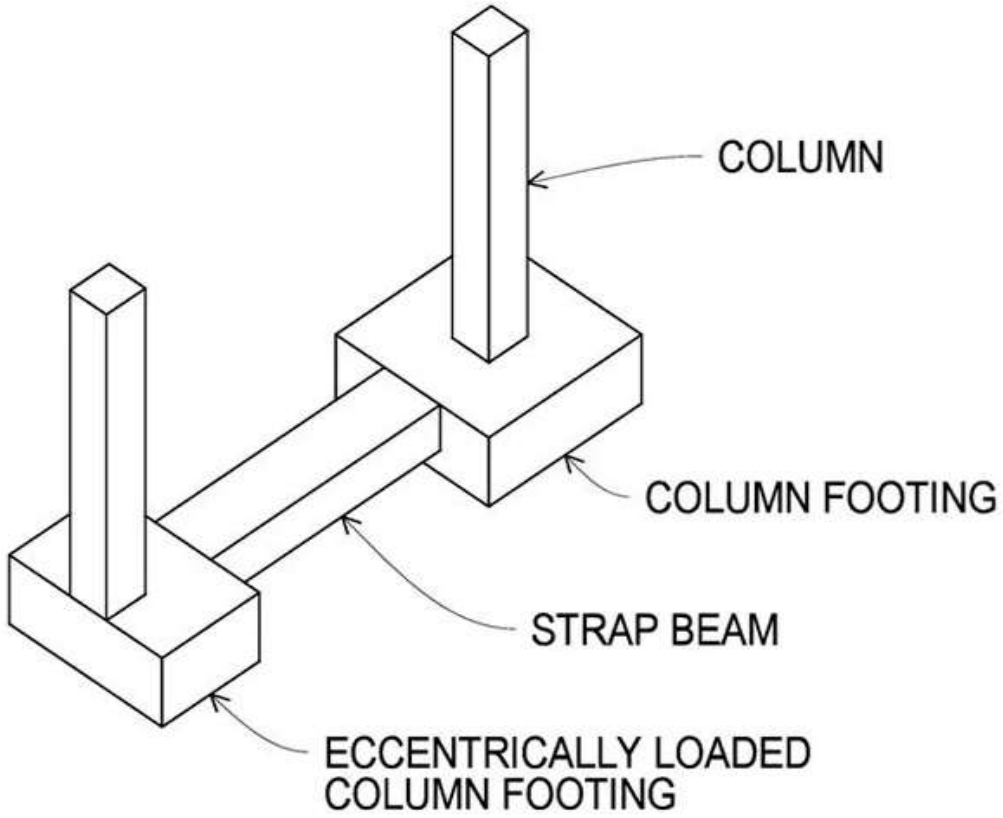
Classifications of Foundation

Cantilever Footing (Strap)

- Consists of an eccentric footing for the exterior column and a concentric footing for the interior column.
- A strap or a cantilever beam connects them.



Classifications of Foundation



Strap footing

Classifications of Foundation

Strap Footing

Classifications of Foundation

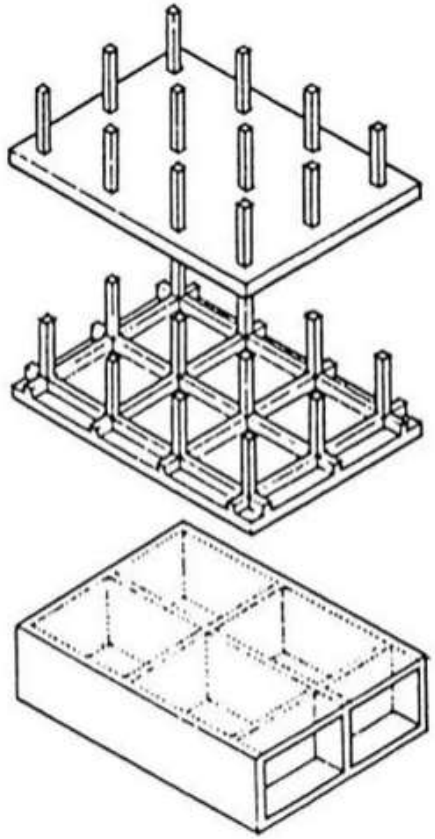
Raft or mat foundation

- A raft foundation is a combined footing which covers the entire area beneath a structure and supports all the walls and columns

Classifications of Foundation

Raft or Mat Foundation

Classifications of Foundation



mat
A thick, slablike footing of reinforced concrete supporting a number of columns or an entire building.

ribbed mat
A mat foundation reinforced by a grid of ribs above or below the slab.

cellular mat
A composite structure of reinforced concrete slabs and basement walls serving as a mat foundation.

Mat foundation

- **Raft foundations are suitable when**

1. The building loads are heavy
2. The allowable soil pressure is small
3. Individual footings would require more than half the building area
4. In highly compressible soil
5. Weak spots and loose pockets in soil mass are suspected

Classifications of Foundation

- **Raft foundations are suitable when**

1. The building loads are heavy
2. The allowable soil pressure is small
3. Individual footings would require more than half the building area
4. In highly compressible soil
5. Weak spots and loose pockets in soil mass are suspected

Classifications of Foundation

Deep Foundation

- The foundations having very large depth compared to width are called deep foundations

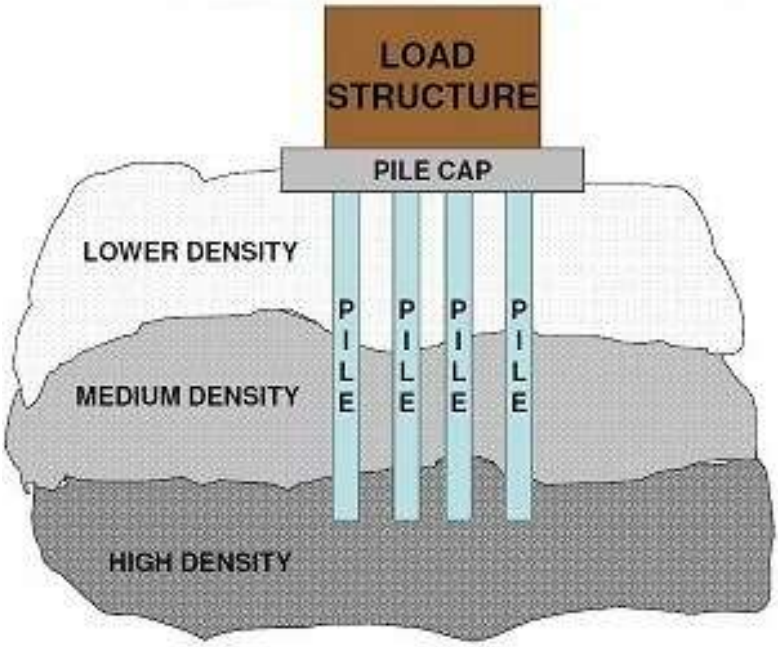
  E.g. Pile foundations

  Well foundations

Classifications of Foundation

Pile Foundation

- Piles are long slender members driven into ground or cast at the site. Pile foundations are common where the soil conditions are unfavorable for the use of shallow foundations



Classifications of Foundation

Suitability of pile foundations

- Loose foundation soil but hard strata is available at a depth of 10-15 m
- Heavy dead and live loads
- Near seashore or riverbed where scouring action of water occurs
- Position of water table is likely to fluctuate appreciably
- Canals or deep drainage lines near by

Classifications of Foundation

Classification of Piles

1. Method of load transfer
2. Function or action
3. Composition and material
4. Installation

Classifications of Foundation

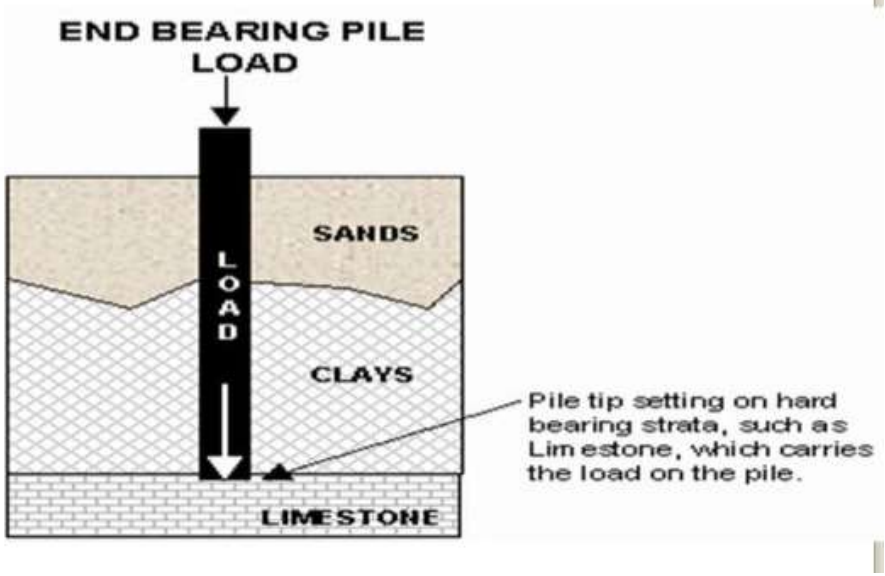
Classification based up on method of load transfer

1. End bearing Piles
2. Friction Piles

Classifications of Foundation

End bearing piles

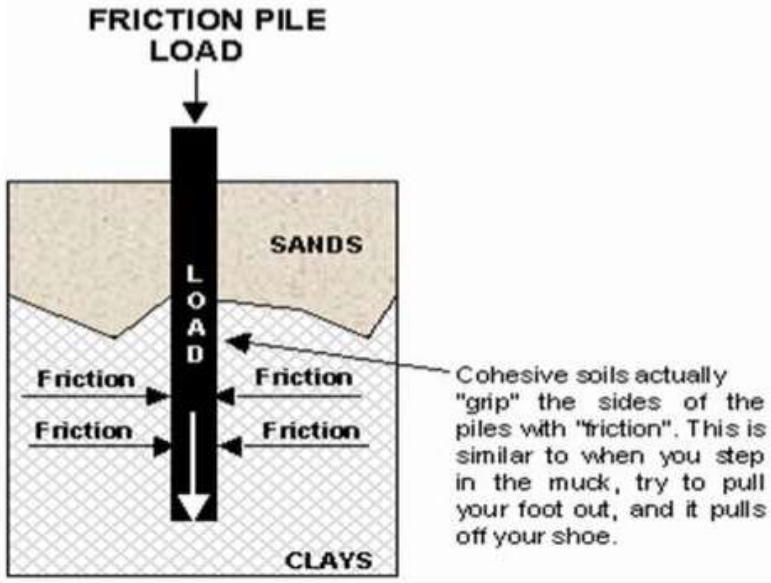
End bearing piles-Used to transfer load to a suitable bearing stratum



Classifications of Foundation

Friction piles

Friction Piles- used to transfer the loads to a depth by friction along the surface area of the piles.



Classifications of Foundation

Classification based up on function or use

1. Compaction Piles
2. Tension or uplift piles
3. Anchor Piles
4. Fender Piles
5. Sheet Piles