Module 1

Introduction to the concept of cost-effective construction

Green Building

A Green Building is a sustainable building with high efficiency in resource usage (energy, water, and materials) while reducing impacts on health and the environment during its lifecycle through good building practices.

Necessity and Benefits of Green Buildings

1) Buildings are one of the primary pollutants that affect urban air quality and cause climate change. Promoting green buildings is key to addressing the challenge of environmental conservation and climate change.
2) The costs for the design and construction of the green building are high, however, the operational costs are low.
3) It efficiently utilizes energy, water, and other resources.
4) It protects occupant health and improves employee productivity by using healthier air quality and greater natural/daylight.
5) Reducing waste, pollution, and environmental degradation.
6) It will reduce the Heat waves (caused by climate change) or Urban Heat Island Effect.

How do Green Buildings work?

1) Green building involves using efficient building materials and practices.
2) It optimizes the utilization of on-site sources and sinks by bio-climatic architectural practices.
3) It uses minimum energy to power itself by using efficient equipment to meet its lighting, air-conditioning and other needs.
4) More utilization of renewable energy sources.
5) Efficient waste and water management practices
6) Comfortable and hygienic indoor working environment

Challenges in the implementation of Green Building

1) **Expensive:** The main challenge of a green building is to achieve all its benefits at an affordable cost. The equipment and products used in the construction of green buildings are way too expensive when compared to conventional ones.

2) **Limited Awareness:** A huge number of Indian users do not know about green buildings and their benefits. Also, the users who know little about green buildings believe it to be an expensive and financially unachievable option.

3) **Implementation issue:** Even though India is setting ambitious targets for green building agenda, sadly most of it is not supplemented with proper government rules and regulations to spur growth.

4) **Additional clearances & approvals:** Builders and developers have to go through a hard time when it comes to approvals, adding to that burden is the list of approvals for green building compliances.

5) **Fewer incentives to encourage adoption:** Presently, there are very few incentive plans available to encourage the adoption of green building in India. Also, the ones that exist are not uniform since they differ across various states and cities, due to the diverse governing bodies.

6) **Lack of skilled manpower and subject matter experts:** is one of the biggest factors holding back Green Building adoption in India. From policymakers to architects, engineers to contractors and workers, none of the groups possess sufficient knowledge and skills required for green building construction.

Introduction to the concept of cost-effective construction

The materials which are economical and have many advantages over other type of materials are called cost-effective construction materials.

Every material has its advantages and disadvantages. So, the material with more advantages and lower cost are called cost-effective construction materials. Man and his activities produce a lot of waste and at the same time, man consumes many things. The

building materials are the largest in terms of weight being above 5 tonnes per capita per year consumed by a man than other things. The building wastes are disposed of at unwanted places, but these materials become useful resources when they are positioned in wanted places.

Today, this is to be done in a technologically feasible (possible) economically viable and socially desirable manner. This becomes an existing and challenging field. Scientists, technologists, environmentalists, engineers and economists and others have to play an important role for effective waste management.

Stones

Uses & Availability

Many types of stones are available such as basalt, marble, limestone, sandstone, quartzite, travertine, slate, gneiss, laterite, and granite which can be used as construction materials. The stones used for building construction should be hard, durable, tough, and should be free from weathered soft patches of material, cracks, and other defects that are responsible for the reduction of strength and durability. Stones for construction purposes are obtained by quarrying from solid massive rocks. Each type of stone is used for various construction applications based on its properties. For instance, certain types like basalt and granite have superior characteristics like high compressive strength and durability and hence employed in major construction works. However, there are stones that their characteristics (such as low compressive strength and presence of deleterious materials in their constituents) makes them suitable for minor construction works for example gneiss. So, stones are used for building material and also for decorative purposes.

Laterite stone

Laterite stones are manual or machine-cut block pieces from quarries or mines containing lateritic crusts. Laterite is a soft rock composed of iron & aluminum oxides as the main ingredient. Due to the weathering actions, in hot & wet tropical areas, lateritic soil gradually gains strength to become a hard mass. It is used as building stone, but its outer surface needs to be plastered. It contains a high percentage of iron oxide and can be easily cut into blocks. It has a lower content of nitrogen, phosphorus, potassium, lime, and magnesia, which makes it less fertile. Due to its high iron oxide content, It has a rusty-red colour in appearance. This stone occurs in soft and hard varieties and its compressive strength is between 1.9MPa and 2.3 MPa and its strength is increased with seasoning. Its colour may be brownish, red, yellow, brown and grey. Laterite soil is mainly found in the Eastern Ghats and the Western

Ghats. It is also found in the southern part of Maharashtra, Karnataka, Andhra Pradesh, West Bengal, Orissa, Jharkhand, Kerala, Assam, etc.

Laterite soil is mainly formed due to 1) Weathering 2) Leaching of parent rock 3) Repetition of wet and dry seasons.

How laterite stone blocks are made?

Nowadays, laterite stone blocks are cut by using machines. The line is drawn on both the axis over the cutting ground & the string is tied as a boundary marker. The machine moves over the railing Patti, cutting the laterite layer in a straight given line. Once the stone is cut as per the required size on both axes, the stone blocks are pulled out by using a spade & pickaxe.

Advantages:

The following are the advantages of using Laterite stone in construction.

1) They keep the building cool in the summer season as they are quarried natural stones.

2) Laterite stones have good thermal insulation properties.

3) The stone provides a rustic natural look to the building.

4) The stone hardens & gains strength as time progresses.

5) Due to its larger size, it is cost-effective by reducing labour & other material charges.

6) Plastering is not compulsory for laterite masonry works.

Disadvantages:

1) The strength of the block is not uniform.

2) Laterite stone blocks are available in limited regions.

3) Stone dressing is needed before masonry work to match the sizes.

4) Laterite stones are avoided in multistory buildings due to their weight & chemical composition.

Laterite blocks are available in different sizes of:
390 x 190 x 190mm
490 x 190 x 190mm
590 x 190 x 190mm

Fig.2 showing different sizes of laterite stone

Uses of Laterite stones as building material

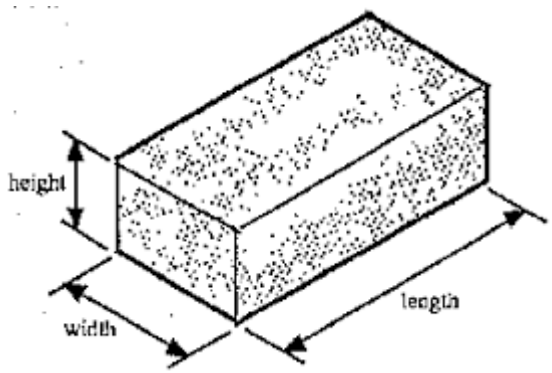
1) Used in wall construction and rough stone masonry work.

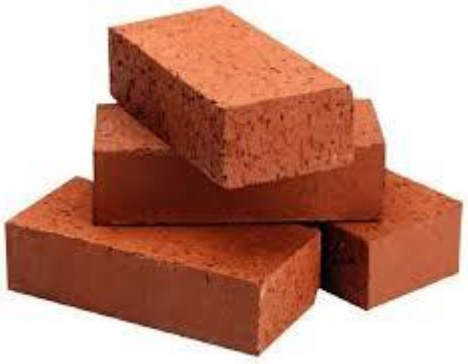
2) Crushed laterite stones are used in road surfaces.

Bricks

Brick is a construction material in Civil Engineering industry and is one of the oldest construction material. *Bricks* are a regular size rectangular unit and are made of clay. They are usually used for most of the building works. Bricks are most generally used as a substitute

for stone when the stone is not available. Bricks are obtained by moulding plastic mass of suitably proportioned earth/clay in timber or steel moulds. Brick is used to making wall, pavement and brick structure or for the partition of room. It is most popular and leading construction material because of its low cost, durability, and light weight and easy to work with.





Advantages of Bricks over Stones:

1) Light weight
2) Uniform shape and size
3) Moulded to required size
4) Easy laying
5) Cheaper
6) Fire resistance
7) Thinner sections
8) less mortar for bonding
9) Easy transportation
10) Produced in large quantities

Raw Materials of Brick:-

Sl. No.	**Constituent and its %**	**Function**	**Excess Qty. Leads to**
1	Clay (20 to 30%)	Plasticity	Shrinkage
2	Silica (50 to 60 %)	Prevents cracking and shrinkage	Brittleness
3	Lime (10 %)	Prevents shrinkage Helps binding	Swells and disintegrate
4	Iron oxide (4 to 5 %)	Gives red colour	Becomes dark blue
5	Magnesia (Small quantity)	Imparts yellow tint and decreases shrinkage	Decay of bricks

Manufacture of Bricks:

The following are the process of manufacture of brick.

1) Preparation

2) Moulding

3) Drying

4) Burning

PREPARATION:

The upper layer removed (free from vegetation, gravel and lime)

- Clay exposed to the atmosphere in wet condition
- Clay mixed with ingredients to become homogeneous and attain a uniform colour
- Clay mix kneaded for moulding.

MOULDING:

- Steel or wooden moulds.
- Open both at the top and bottom.
- Prepared according to the size of the brick.
- Clay mix filled in the mould, levelled and excess qty. is removed.
- The mould is lifted and the procedure is repeated.

DRYING:

- Moulded bricks are stacked in layers.
- Dried for about 6 weeks (depending on weather conditions).

BURNING:

- Clamps (or) Kilns are used to burn.
- Stacked and burnt at about 800^0 C using coal, firewood etc.
- Burning imparts strength and hardness
- it should be properly burnt
- Over-burnt leads to brittleness
- Under-burnt leads to softness and hence less load-carrying capacity.

Uses of Brick:

The following are the uses of brick.

1) Walls, Bridges, Dams and Culverts

2) Pavements, Kerbs Partitions and roads

3) Fire bricks used for fire resisting structures

4) Ornamental works

5) Perforated and hollow bricks for heat insulation

6) Compound walls, Columns, Stairs and Arches

7) Broken pieces for weathering courses.

Characteristics of Brick: -

following are the characteristics of bricks.

1) It should have a rectangular shape, regular surface and red coloured appearance.

2) It should confirm in size to the specified dimensions (19 x 9 x 9 cm).

3) It should be properly burnt. This can be ascertained by holding two bricks freely, one in each hand, and striking them.

4) A sharp metallic sound indicates good burning whereas a dull thud would indicate incomplete burning.

5) A good building brick should not absorb water more than 20 percent of its dry weight. Absorption should not exceed 25 percent in any case.

6) A good building brick should possess requisite compressive strength, which in no case should be less than 35 kg/cm^2.

7) A rough test for the strength of the brick is to let it fall freely from a height of about one meter on to a hard floor. It should not break.

8) Brick should be hard enough so that it is not scratched by a finger nail.

9) A good brick has a uniform colour and structure through its body. This can be checked by taking a brick from the lot and breaking it into two parts. The broken surface in both the halves should have same appearance and structure.

Qualities of Good Bricks:

The following are the qualities of good Brick.

Shape and size	Uniform with straight edges
Colour	Deep RED
Texture and Compactness	No fissures and holes
Hardness and Soundness	No finger nail impression
Compressive strength	[10.5 N/mm^2]
Water absorption	[Not more than 20%]
Density	[17 to 19 kN/m^3]
Shear strength	5 To 7 N/mm^2
Fire Resistance	High
Soluble salts	Free
Breakage	When dropped from 1m heigh should not break.

FIRST CLASS BRICKS:

✓Smooth and rectangular

✓Parallel, sharp and straight edges

✓Thoroughly burnt with deep red colour

✓Uniform texture

✓Water absorption 12% to 15% of its dry weight when immersed in cold water for 24 hrs

✓Metallic (or) Ringing sound by striking

✓Crushing strength not less than 10.5 N/mm^2

SECOND CLASS BRICKS:

✓Small cracks are allowed

✓Water absorption 16% to 20%

✓Crushing strength not less than 7 N/mm2

✓USES: all masonry works

THIRD CLASS BRICKS:

✓Under burnt

✓Soft and light

✓Dull sound

✓Water absorption is 25%

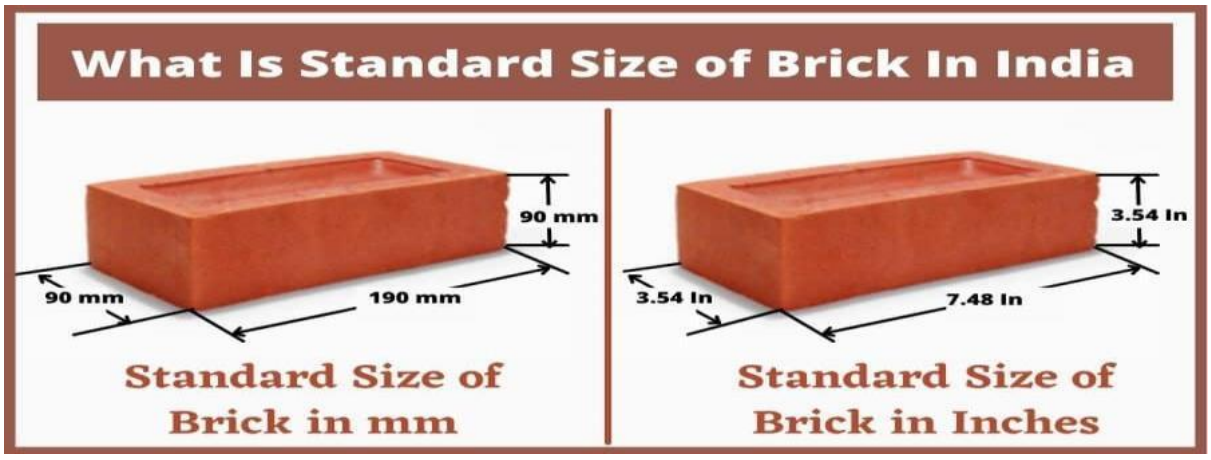
✓USES: Temporary structures

FOURTH CLASS BRICKS:

➢Over burnt

➢Bad shape and size

➢brittle



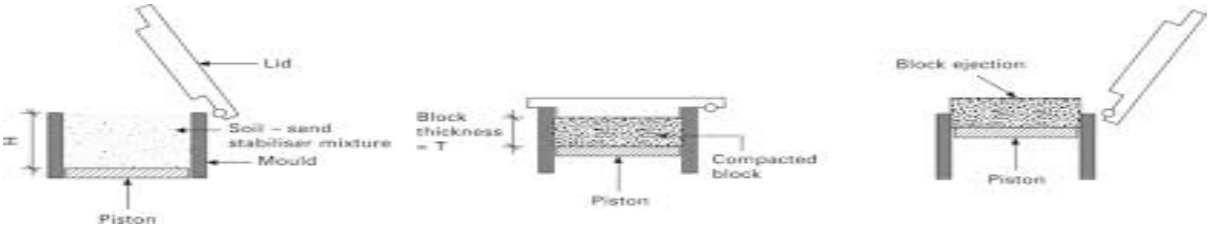
Tests on Bricks

following tests are conducted on bricks to determine its suitability for construction work.

1. Water Absorption test
2. Crushing strength test
3. Hardness test
4. Shape and size
5. Colour test
6. Soundness test
7. Structure of brick
8. Presence of soluble salts (Efflorescence Test).

Stabilized Mud Blocks

Stabilized mud block or compressed earth block is a building material made primarily from damp soil compressed at high pressure to form blocks. If the blocks are stabilized with a chemical binder such as Portland cement, they are called compressed stabilized earth block or Stabilized earth block. Compressed earth blocks is prepared by mechanical pressing equipment to form block with mixture of inorganic soil, non-expansive clay and aggregate. Typically around 20MPa compressive load is applied to the mix to form SEB. Good Quality Soil + Stabilizer = Stabilized Mud Blocks



Manufacturing Process

1) Soil identification

2) Preparation of raw materials – breaking up soil, screening, Pulverisation of soil, sieving

3) Proportioning

4) Mixing and moulding

5) Curing

1) **Soil identification**

   Soil identification is required to produce good quality product.

Not all soil is suitable for preparation of mud block. Soil identification is done in laboratory. The following are the properties of soil is determined.

- Grain size distribution- to know quality of each grain size (Gravel, Sand, Silt & Clay).
- Plasticity characteristics- to know the quality and properties of the binders (clays and silts).
- Compressibility- to know the optimum moisture content, which will require the minimum of compaction energy for the maximum density.
- Humus content- to know if there are any organic materials which might disturb the mix.
- Top soil and organic soils must not be used.

2) Preparation of Raw Materials

- The basic materials required for the production of compressed stabilized earth building blocks are soil, stabilizer (Cement or lime) and water.
- In order to have uniform soil, it is often necessary to crush it so that it can pass through a 5 to 6mm mesh sieve.
- Different soil types may also need to be together so as to obtain good quality products. (Heavy clay can be improved by addition of a sandy soil).
- Various types and sizes of mixing equipment are available on the market.

3) Proportioning

The following are the mix proportion of material based on experimental determination to produce good quality mud blocks.

Cement (4 to 7%)

Sandy soil (55 to 60%)

Gravel (30 to 35%)

Water (18 to 20%)

Advantage of Stabilized Mud Block

1) A local material

2) A bio-degradable material

3) Limiting deforestation

4) Energy efficiency and eco friendliness

5) Cost efficiency

Disadvantages of Stabilized Mud Block

1) Proper soil identification is required.

2) Wide spans, high & long building are difficult to do.

3) Low technical performances compared to concrete.

4) Untrained teams producing bad quality products.

5) Over-stabilization through fear or ignorance, implying outrageous costs.

6) Under-stabilization resulting in low quality products.

7) Bad quality or un-adapted production equipment.

8) Low social acceptance due to counter examples (By unskilled people, or bad soil & equipment).

CONCRETE BLOCK

A Concrete Block is a 'Building Block' composed entirely of concrete that is then mortared together to make an imposing, long-lasting construction. These construction blocks can be 'Hollow' or 'Solid,' formed of ordinary or lightweight concrete in various specified sizes, depending on the precise requirements. Concrete blocks come in various shapes and sizes, and they can be solid or hollow. 39cm x 19cm x (30cm, 20 cm or 10cm) or 2-inch, 4-inch, 6-inch, 8-inch, 10-inch, and 12-inch unit configurations are the most popular concrete block sizes. Concrete blocks are made from cement, aggregate, and water. In concrete blocks, the cement-aggregate ratio is 1:6.

A building constructed with concrete masonry blocks

Types of Concrete Blocks

There are two types of concrete blocks:

1. Solid Concrete Blocks
2. Hollow Concrete Blocks

1. **Solid Concrete Blocks**

Solid concrete blocks, which are highly heavyweight and formed by aggregate, are primarily utilized in construction projects. They're sturdy and give structures a lot of solidities. These solid blocks are ideal for large-scale projects such as force-bearing walls. They're compared to bricks that come in big sizes. As a result, constructing concrete masonry takes less time than brick masonry.

2. Hollow Concrete Blocks

In masonry construction, hollow concrete blocks are typically employed. It reduces labour costs on the job site while also speeding up the construction process and saving cement and steel. These blocks reduce the natural weight of masonry structures while also improving physical wall qualities like noise and thermal insulation. Standard hollow concrete blocks come in two sizes: Full size and half size.

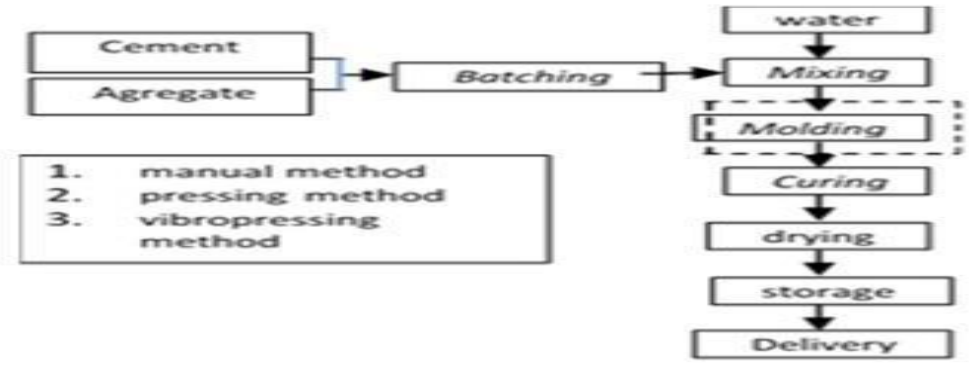
Manufacturing Process

- Cement/Aggregate ratio 1:6
- The aggregate consist of

✓ 60% fine aggregate (sand or stone dust)

✓ 40% coarse aggregate (6 to 12 mm size)

- Mixing
- Filling in the mould
- Compacting
- Vibrating
- Curing



Uses of Concrete Blocks:

1) Concrete Blocks are a great option for partition walls because they are quick and easy to install. The inclusion of steel reinforcement adds to the structures strength.

2) Exterior and Interior Load-bearing Walls, Partition Walls, Panel Walls, and Boundary Walls are common uses for Hollow Concrete Blocks.

3) Solid Concrete Blocks are perfect for Chimney and Fireplace building, but they also work well for Non-load Bearing Walls and Garden Walls.

4) Concrete blocks are also used in a variety of smaller landscaping projects. Many Outdoor Furniture & Patio ideas, for example, include Outdoor Seating, Decorative screens, Outdoor Bar, Flower Bed, and many others.

5) Concrete blocks can cover stored commodities from the effects of changing weather. It's no surprise that engineers prefer it to construct Material Bins.

Advantages of Concrete Blocks:

1) Due to narrower Concrete Blocks, the reduced wall thickness can be achieved which makes the space larger by increasing the carpet surface than a traditional brick masonry wall.

2) Concrete block building is more systematic, faster, and stronger than brick masonry because of the vast size of the blocks.

3) Gives better thermal insulation.

4) It effectively absorbs sound and protects the interiors from noise pollution. Using concrete blocks provides additional fire protection.

5) Protects precious agricultural land that is extensively mined to produce clay bricks.

6) Individual pieces can be manufactured to a larger customized size and shape, allowing for a quick building cycle turnaround.

7) Concrete Blocks, unlike traditional bricks, have a consistent size that lowers the need for plaster, making them a more cost-effective solution. The mortar consumption rate is lower than in traditional masonry construction, but the overall strength of the structure is increased.

Disadvantages of Concrete Blocks:

1) The expense of constructing a residence out of concrete blocks is significantly higher.

2) Some of the blocks may need to be cut to reach critical systems.

3) Concrete block homes aren't usually attractive from the outside.

4) Over time, concrete blocks may be subject to water seepage.

5) Some regional preferences may not be compatible with this material.

6) Windows and doors can easily detract from the environmental benefits.

Cement

Cement is a binding material. It was first invented by Egyptians. The manufacturing of cement was started in England around 1825. It is called Portland cement because when it hardens, it produces a material resembling stone from the quarries near Portland in England. It is obtained by burning together a mixture of naturally occurring argillaceous and calcareous materials at high temperatures. The product obtained on burning is called clinker. Clinker cools and grinds to the required fineness to produce a material known as cement.

Lime Pozzolana Cement

Pozzolonic materials namely fly ash, volcanic ash are added to the OPC so that it becomes Portland Pozzolonic Cement (PPC). Pozzolonic materials are added to the cement in the ratio of 15% to 35% by weight of lime. PPC is used in construction of houses, hydraulic structures, marine works, mass concreting such as dams, dykes, retaining walls foundations and sewage pipes. It is also suitable for use in common applications such as masonry mortars and plastering. The addition of pozzolana to lime will modify its characteristics. It reduces the risk of early leaching or frost damage and increasing the potential durability of the mortar. It reduces the maximum rise in temperature when used in large amounts (more than 15% by mass of cementitious material). Because of the slower rate of chemical reactions; which reduce the rise in temperature of concrete. PPC is cheaper than ordinary Portland cement.

Gypsum Board

Gypsum board is extensively used in drywall construction, where the plastering is eliminated. Gypsum board contains a gypsum rock core sandwiched between two layers of special paper. In making fire-resistant panels, glass fibres are mixed with the gypsum.

It is also available in the market with one surface covered with Aluminium and another surface covered with the heat-reflecting type of foil or with imitation wood grain or another pattern on the exterior surface so that no extra decoration is required. The different types of gypsum board generally available in the market are clued wallboard, backing board, core board, fire-resistant gypsum board, water–resistant gypsum board, and gypsum form board. Gypsum board possesses many attributes that make it an attractive construction material and also used in false ceiling in building.

Plaster of Paris, commonly known as POP, is basically dehydrated gypsum, or Calcium Sulphate, available in powdered form. When the dry powder is mixed with water, it rehydrates and sets in the shape of the mould into hard gypsum again. Plaster of Paris is manufactured by heating gypsum at 150° C. On heating gypsum, it loses water molecules and becomes Calcium Sulphate Hemihydrate. This product is known as the plaster of Paris. It is used for decorative works.

Fibre Reinforced Concrete

Fibre-reinforced concrete (FRC) is concrete made primarily of hydraulic cements, aggregates, and discrete reinforcing fibres. Fibers suitable for reinforcing concrete have been produced from steel, glass, and organic polymers (synthetic fibres). Fibres can be in the form of steel fibres, glass fibres, natural fibres, synthetic fibres, etc.

Why fibres in concrete

1) Main role of fibres is to bridge the cracks that develop in concrete and increase the ductility of concrete elements.

2) There is considerable improvement in the post-cracking behaviour of concrete containing fibres due to both plastic shrinkage and drying shrinkage.

3) Some types of fibres produce greater abrasion in concrete.

4) It imparts resistance to impact load.

Applications of fibres in concrete

1) It is used on account of the advantages of increased static and dynamic tensile strength and better fatigue strength.

2) It has been tried on overlays of air-field, road pavements, industrial footings, bridge decks, canal lining, explosive resistant structures, refractory linings, etc.

3) Used for the fabrication of precast products like pipes, boats, beams, stair case steps, wall panels, roof panels, manhole covers etc.

4) It is also being tried for the manufacture of prefabricated formwork moulds of "U" shape for casting lintels and small beams.

5) They also reduce the permeability of concrete and thus reduce the bleeding of water.

6) The major factors affecting the characteristic of fiber-reinforced concrete are a water cement ratio, percentage of fibers, diameter and length of fibres.

Steel Fiber-Reinforced Concrete:

Steel fiber-reinforced concrete is basically a cheaper and easier to use form of fibre reinforced concrete. Fibre reinforced concrete uses steel bars that are laid within the liquid cement, which requires a great deal of preparation work but make for a much stronger concrete. Steel fiber is a metal reinforcement. A certain amount of steel fiber (about 1 to 5% by volume) in concrete can cause qualitative changes in concrete's physical property. It can greatly increase resistance to cracking, impact, fatigue, and bending, durability, and others. SFRC is being used in structures such as flooring, housing, precast, bridges, tunneling, heavy-duty pavement, and mining.

Advantage of fiber-reinforced concrete:

1) Reduction of shrinkage and cracking.

2) The right fiber-reinforced concrete can also provide impact resistance, increase tensile strength and reduce voids in the concrete.

3) Minimizes the cavitation damage in structures.

4) Improves resistance against freezing and thawing.

Disadvantages fiber-reinforced concrete

1) it can adversely affect workability.

2) There may be a danger of fibers balling during mixing when distribution of fibers throughout is not uniform.

3) Fiber-reinforced concrete is heavier than non-fiber concrete.

4) There may be possibility of corrosion.

5) More expensive than ordinary concrete, although the cost could be offset by other factors.

Glass Fiber Reinforced Concrete

Glass fiber-reinforced concrete uses fiberglass, used in fiberglass insulation, to reinforce the concrete. Glass fibres allow the construction of very slim elements with good tensile strength. Glass-reinforced concrete (GRC) panels reduce the weight and thickness of the concrete by up to 10 times compared to conventional steel-reinforced concrete panels. Used to fabricate interior countertops, floors, exterior window surround elements, and façade wall panels etc,.

Synthetic of Fiber

Synthetic fiber-reinforced concrete uses plastic and nylon fibers to improve the concrete's strength. Polypropylene fibers can be divided into microfibers and macrofibers depending on their length and the function that they perform in the concrete.

Advantage of synthetic fibres

1) Most synthetic fibres have good elasticity.

2) Corrosion free concrete.

3) Controls and mitigates plastic shrinkage cracking.

4) Reduces segregation and bleed-water.

5) Provides three-dimensional reinforcement against micro-cracking.

6) Increases surface durability.

Natural Fibres

The natural fiber is directly obtainable from an animal, vegetable, or mineral source and convertible into nonwoven fabrics such as felt, paper or woven cloth. The use of natural fibers in making concrete is recommended since several types of these fibers are available locally and are plentiful. The idea of using such fibers to improve the strength and durability of brittle materials is not new. ex: straw and horsehair are used to make bricks and plaster long back. Sisal, Coir, Bamboo, Flax, Banana, Hemp, Jute are mainly used in concrete.

Overall effects of fibers in Concrete:-

1) Improved durability of the structure.

2) Increased tensile and flexural strengths.

3) Higher resistance to later cracking.

4) Reduced shrinkage cracks of early age concrete.

5) Increased fire resistance of concrete.

6) Negative influence on workability.

7) Improved homogeneity of fresh concrete.

Fibre Reinforced Polymer Composites

It is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass, carbon, although other fibres such as paper or wood or asbestos are used. The

polymer is usually an epoxy, vinylester or polyester thermosetting plastic etc,. FRPs are commonly used in the aerospace, automotive, marine, and construction industries.

Properties of Fibre Reinforced Polymer Composite Concrete

1) Higher strength

2) Lighter weight

3) Higher performance

4) Longer lasting

Uses of Fibre Reinforced Polymer Composite Concrete

1) Used in the construction at Seismic areas.

2) Used in Defence structures.

3) Aerospace field

4) Ocean environments

5) automotive industry

6) Wind power generation

7) Rehabilitating existing structures and extending their life.

Bamboo

Bamboo can be utilized as a building material for scaffolding, bridges and as building components (flooring, reinforcement, roofing, walls, doors & windows etc,.). Bamboo, like wood, is a natural composite material with a high strength-to-weight ratio useful for structures.

Properties and Advantages

1) **Strength:** Bamboo is an extremely strong natural fibre, on par with standard hardwoods, when cultivated, harvested, prepared and stored properly.

2) **Flexibility:** bamboo is highly flexible. During growth, it may be trained to grow in unconventional shapes. After harvest, it may be bent and utilized in archways and other curved areas.

3) **Earthquake resistance:** it has a great capacity for shock absorption, which makes it particularly useful in earthquake-prone areas.

4) **Light weight:** Bamboo is extremely lightweight. Consequently, building with bamboo can be accomplished faster with simple tools than building with other materials. Cranes and other heavy machinery are rarely required.

5) **Cost-effective:** economical, especially in areas where it is cultivated and is readily available. Transportation cost is also much lesser.

6) **Durability:** as long-lasting as wood, when properly harvested and maintained.

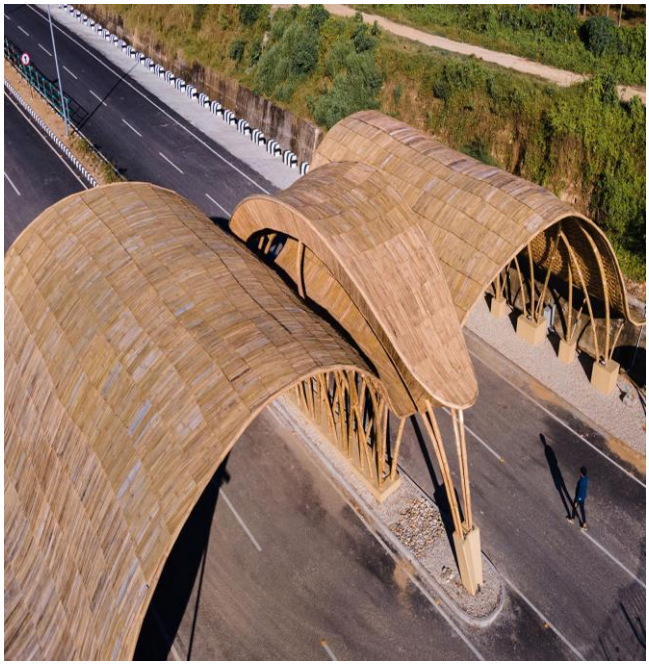
Limitations

Few considerations currently limit the use of bamboo as a universally applicable construction material.

1) **Jointing techniques:** although many traditional joint types exist, their structural efficiency is low. Considerable research has been directed at the development ofmore effective methods.

2) **Flammability:** Bamboo structures are not fire-resistant, and the cost of treatment available is relatively high.

3) **Lack of design guidance and codification:** the engineering design of bamboo structures has not yet been fully addressed. There is little or no data containing specifications of bamboo.



Recycling of building materials

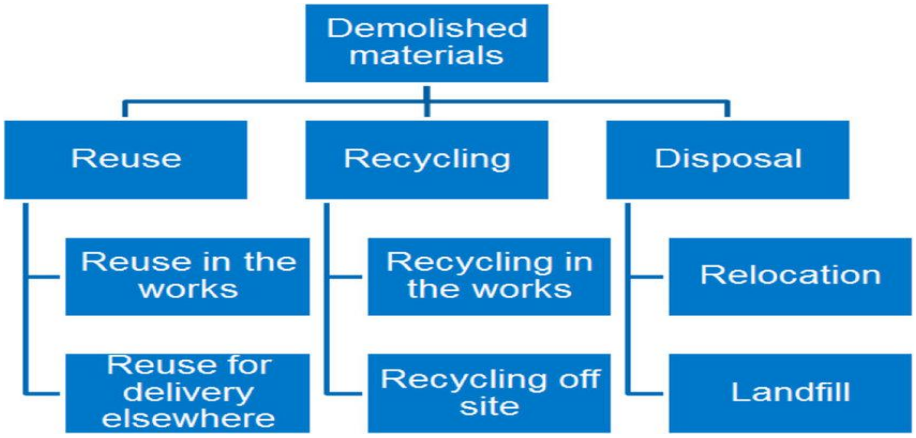
The building industry has not only become a major consumer of materials it has also become a source of pollution. Environmental integrated production, reusing and recycling is of great importance that shall ensure that the technical, environmental and economic feasibility of alternative systems is considered and is taken into account before construction starts.

Need of recycling of building materials

1) Reduces the demand for new resources.

2) Cuts costs related to the production and transportation of new materials.

3) Eliminates the need to send waste to landfill sites.



Some examples of reusable / recyclable/ biodegradable building materials include:

- Wood (reusable/recyclable/biodegradable)
- Earthen Materials (reusable/biodegradable)
- Steel, Aluminium, Iron, Copper (reusable/recyclable)
- Bricks (reusable/recyclable)
- Concrete (may be crushed and recycled)
- Gypsum/Drywall (recyclable, sometimes biodegradable)
- Tiles, Granite, Linoleum Flooring (biodegradable)

1. Brick

Brick waste is generated during demolition and may be contaminated with mortar and plaster. Brick waste is sometimes blended with other materials like timber and concrete. Currently, bricks are recycled by crushing and using them as filling materials.

2. Concrete

Concrete wastes can be generated due to demolishing existing structures, testing of concrete samples, etc. Commonly recycling measures of concrete wastes use crushed concrete as aggregate.

The crushed concrete aggregate has been used as a replacement for natural aggregate in new concrete and has also been employed in the construction of road bases and trenches.

3. Ferrous Metal

Ferrous metal is another type of wastes which not only highly profitable but also can be recycled nearly completely. In addition, ferrous metal can be recycled multiple times.

4. Masonry

Masonry waste is produced as a result of demolition of masonry buildings. It can be recycled by crushing the masonry waste and used as recycled masonry aggregate. A special application of recycled masonry aggregate is to use it as thermal insulating concrete. Another potential application for recycled masonry aggregate is to use it as aggregate in traditional clay bricks.

5. Non-ferrous Metal

Aluminium, copper, lead, and zinc are examples of nonferrous materials wastes produced at construction sites. The majority of these materials can be recycled.

6. Paper and Cardboard

Paper and paper board is another type of waste materials which is estimated to comprise one-third construction and demolition wastes by volume. These waste materials are recycled and reprocessed to produce new paper products.

Quarrying

The process of extracting minerals from rocks buried beneath the earth's surface is called "**Mining**". Materials that lie near the surface are simply dug out, by the process known as "**Quarrying**".

Quarrying Process

Stage 1: Identifying the mine site and planning the map to extract the mines from the operational site.

Stage 2: Remove the top layer of the soil from Quarry site.

Stage 3: Drill holes, Insert explosions, and blast the rocks in mining sites.

Stage 4: Transport material for processing.

Stage 5: Process materials using crushing and screening technologies.

Stage 6: Addition of other materials if needed using additional processing methods.

Stage 7: Transporting finished mining products to customers.

Major Environmental Concerns

Quarrying has a significant impact on the environment. It can become a major environmental concern because it destroys the flora and fauna around it.

1) Land Degradation

Quarrying destroys natural vegetation by scraping the upland soil and thereby also destroys the habitats of many wild animals. It cleans the surface vegetation, which destroys the humus in the soil which is essential for plant growth. Fine dust particles spread in the air around a quarrying site destroy natural vegetation.

2) Erosion

Quarrying in hilly areas causes erosion of hill sides, mine dumps, and tailings dams, which can result in the siltation of canals, streams, and rivers, which significantly affects surrounding areas. Due to quarrying, which reduces the availability of water for plant growth, which may result in population and decline in plant ecosystems. Quarrying also causes coastal erosion, resulting in flooding in coastal areas.

3) Air Pollution

Deep quarrying activities can affect local hydrology causing the water flow as well as quality. The quarrying process generates a lot of dust which causes air pollution.

4) Water Pollution

Quarrying activities cause pollution of surrounding water resources and groundwater. High concentrations of chemicals such as arsenic, sulphuric acid, and mercury produced from quarrying operations spread over the water surface.

5) Noise Pollution

Quarrying site involves the use of explosives to break huge chunks of rocks, which leads to massive noise pollution.

6) Damage to Biodiversity

Although habitats are not directly removed by quarrying activities, they are indirectly affected and damaged by environmental impacts such as groundwater depletion that causes some habitats to dry out or others to flood. Even noise pollution can also have a significant impact on some species and affect their successful reproduction.

7) Sinkholes

At the time of quarrying activities, quarry site can develop cavities in the subsoil or rock, which can refill with sand and soil from overlying strata, when sudden failure of the earth creates a large depression at the surface without warning can cause serious hazards to life and property nearby quarry site.

8) Improper disposal of Quarry Waste

Many man-made activities and machinery activities on a quarry site generate significant amounts of waste. Dumping of quarry waste without a proper site can harm the environment.