UNIT 2

SPECIAL BUILDING MATERIALS

"Imagine what we could build together if we used faith, hope and love as our building materials?"

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Learning Objectives

At the end of this lesson you shall be able to

- Understand various types of cement concrete composites and its advantages.
- Explain the properties, advantages and uses of various special building materials.
- List the miscellaneous materials used in building construction.
- Explain properties, types and advantages of miscellaneous materials.

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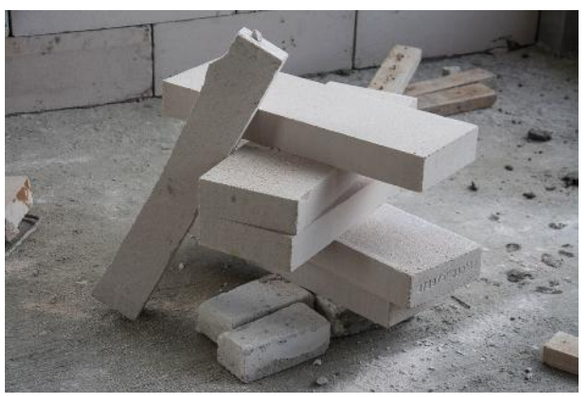
2.1 Introduction

The building material used for centuries was stone and wood, later bricks. During the 19th century, cast iron and steel were used. The 20th century brought concrete and reinforced concrete into civil engineering field. The end of 20th century had significant use of cement concrete composites, plastic, glass, new forms of steel, aluminum and insulation materials.

2.2 Cement Concrete Composites

2.2.1 Light weight concrete (LWC)

Light weight concrete is made by using light weight aggregates like foamed slag, bloated clay, sintered fly ash, rice husk, etc. It is also achieved by introducing larger voids using aluminum powder or by omitting the fine aggregate from the concrete mix.



(i) Advantages of LWC

1. Light weight concrete reduces the dead load of the structure.
2. It increases the progress of construction of the structure.
3. It lowers the haulage and handling charges.
4. If walls and floors are made of light weight concrete, the foundations will be lighter resulting in considerable economy in the construction.
5. The thermal conductivity of light weight concrete is relatively low, which prevents the heat transfer from roof and walls, resulting lower temperature inside the building.
6. In case of buildings where air conditioning is to be installed, the use of LWC has been found advantageous both in thermal comfort and low power consumption.

2.2.2 Autoclaved Aerated Concrete (AAC)

AAC is a lightweight precast form concrete building material. It is composed of quartz sand, calcined gypsum, lime, cement, water and aluminium power. Aluminum powder is used at a rate of 0.05%–0.08% by volume (depending on the pre-specified density). AAC products are cured under heat and pressure in an autoclave. The various forms of AAC are blocks, wall panels, floor and roof panels, cladding panels and lintels.

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(i) Advantages of AAC

1. The most important advantage is its lower environmental impact.
2. Improved thermal efficiency reduces the heating and cooling load in buildings.
3. Excellent soundproofing material and acoustic insulator.
4. Highly fire and termite-resistant.
5. Manufactured in a variety of forms and sizes.
6. Reduces project cost.
7. Absorbs moisture from air and releases humidity.
8. Instalation of electrical and plumbing lines are easy.
9. Shipping and handling is more economical.
10. It is a durable material.

2.2.3 Fibre Reinforced Concrete (FRC)

The inherent weakness of concrete is development of micro-cracks due to drying shrinkage. The technique of using fibres in the mix help in overcoming this weakness to a great extent. Fibre Reinforced Concrete is a composite material consisting of cement mortar or concrete with uniformly distributed discrete fibres of high tensile strength.

The various types of fibres used in FRC are steel, Polypropylene, Nylon, Asbestos, Coir, Glass, Carbon, etc.

(i) Advantages of FRC

1. It increases the tensile strength of the concrete.
2. It reduce the voids in concrete.
3. It increases the durability of the concrete.
4. It has been recognized that the addition of small, closely spaced and uniformly dispersed fibres to concrete would act as crack arrester.
5. Improve its static and dynamic properties.

2.2.4 Self Compacting Concrete (SCC)

Self compacting concrete is highly flowable, non-segregating concrete that can spread into place, fill form work and encapsulate the reinforcement without any mechanical consolidation. The spread of self compacting concrete typically ranges from 1 to 32 inches depending on the requirements for the construction. Materials used for self compacting concrete are cement (43 or 53 grade), aggregates (less than 20 mm), Water and super plasticizers (chemical admixtures).

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DO YOU KNOW?

World's Longest Bridge Over Water

The bridge spans Jiaozhou Bay, on the sudden coast of Chinas Shandong peninsula in north eastern China. It travels 26.4 miles long. Chinese workers finished this construction in four years, starting at each side and meeting in middle. The structure has 5,200 pillars and cost 2.3 billion dollars.

(i) Advantages of SCC

- No need of mechanical vibrators.
- Faster construction improve working conditions.
- Greater freedom in design.
- Less noise due to absence of mechanical vibrators.
- Improves the quality, durability and reliability of concrete.

2.2.5 Ferrocement

Ferrocement is defined as a thin walled reinforced concrete. It is reinforced with small diameter wire mesh instead of steel rods. Wire mesh is usually made of steel 0.8 to 1.0 mm diameter with 5 to 50 mm spacing. The CM generally used is in ratio of 1:2 or 1:3.

(i) Properties of ferrocement

1. It has high strength per unit mass.
2. It has good capacity to resist shock.
3. Highly versatile form of reinforced concrete.
4. It does not need form work.
5. It is impervious.

(ii) Uses of ferrocement

1. Partition wall.
2. Window frames, shutters, sunshades, etc.
3. Cupboard shelves.
4. Precast roof elements.
5. Domestic water tank.
6. Furniture.
7. Manhole covers.
8. Boats.

2.3 Glass

Glass is a hard, brittle, transparent or translucent material. It is used in numerous applications in our daily lives. Glass is made from natural and abundant raw materials (sand, soda ash and lime stone) that are melted at very high temperature.

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Activity 1

Collect pictures of special glasses and prepare an album

2.3.1 Properties of glass

1. It absorbs, refracts and transmits light.
2. It can take up a high polish.
3. It has no definite crystalline structure.
4. It has no sharp melting points.
5. It is an excellent electrical insulator.
6. It is available in beautiful colours.
7. It is usually unaffected by air or water.
8. It has excellent resistance to chemicals.
9. When it is heated, it becomes softer and ultimately transformed into liquid.

2.3.2 Uses of glass as building material

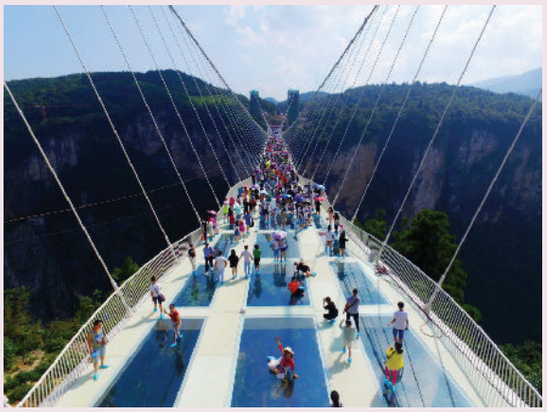
1. Glass can be used for window panels.
2. Glass blocks can be used for partitions.
3. Structural glass can be used for insulation, panel walls, wall facings enclosures, etc.
4. Potash lead glasses are used for making electric bulbs.
5. Tinted glass can be used for decorative glass works.
6. Fibre glass reinforced plastics can be used to construct furniture, lamp shades and bathroom fittings.

DO YOU KNOW?

World's Tallest and Longest Glass Bridge

World's tallest and longest glass bridge is in China. The length of the bridge is 430 m. It was opened on 20th August 2016.

Zhangjiajie Grand Canyon



2.3.3 Special glasses

The following are some of the special glasses.

1. Fibre glass
2. Foam glass
3. Bullet proof glass
4. Structural glass
5. Glass block
6. Wired glass
7. Ultraviolet ray glass
8. Perforated glass

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2.4 Rubber

Rubber is also known as Elastomer. It is produced as a natural product from rubber trees and also manufactured by chemical processes. The former is known as natural rubber and the latter is synthetic rubber. Natural rubber has high strength and good resistance to tear as well as flexure. However it is easily affected by solvents.

It is widely used in the construction industry, for sealing, shock absorbtion, electrical insulation, fire-proof insulation, in expansion joints, etc.

2.4.1 Uses of Rubber as building materials

The general uses of rubber as a building materials are as follows:

1. Rubber is used as a gasket to make doors and windows air tight.
2. Rubber latex is used for bonding rubber to metal, wood and similar surfaces.
3. It is used as shock absorber in construction work like bridge, etc.
4. Rubber is used as a sealent in water-retaining structures.
5. Rubber can be used as a joint filler.
6. Rubber is also used for flooring in buildings.
7. Rubber coatings and linings are used for corrosion protection in offshore engineering.
8. Rubber can be used as sound absorbers.

2.5 Unplasticized Polyvinyl Chloride (UPVC)

Regular PVC (Poly vinyl Chloride) is a common, strong, but light weight plastic used in construction. It is made softer and more flexible by the addition of plasticizers. If plasticizers are not added, it is known as UPVC (Unplasticized Polyvinyl Chloride).

2.5.1 Advantages of UPVC

- Gives perfect insulation (from heat and cold).
- Highly hygienic.
- No maintenance required.
- Sound proof.
- Available in various colour and sizes.
- Not affected by atmospheric agencies.
- Easy to clean.
- Safe and easy to operate.
- Not affected by insects.

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Activity 2

Prepare an album of UPVC doors and windows.

2.6 Aluminium

Aluminium is the world's most abundant metal and is the third most common element, comprising 8% of the earth's crust. But it is commercially produced mainly from bauxite which is hydrated oxide of Aluminium. The versatility of Aluminium makes it the most widely used metal after steel.

2.6.1 Properties of Aluminium

1. It is a good conductor of heat and electricity.
2. It is rarely attacked by nitric acid, organic acid or water.
3. It is highly resistant to corrosion.
4. It is light in weight, malleable and ductile.
5. It is a soft metal.
6. The melting point of aluminium is about 658^{0}C.
7. It possesses great toughness and tensile strength(124-290 N/mm^{2}).
8. Its specific gravity is about 2.70.

2.6.2 Uses of Aluminium as Building Material

Aluminum is used as an important building material especially in developing countries. The following are the important properties of aluminum that make it useful as a building material.

1. **Air tightness:** A well-designed aluminium door, window, etc., is perfectly airtight and sealed for dust and rain water.
2. **Appearance:** The finished aluminium will be having a pleasing appearance and depending on the decorative style of the building, shades of various colours can be selected.
3. **Ease in fabrication and assembly:** As aluminium is comparatively soft and ductile, the fabrication of doors, windows, etc., can be easily carried out. It can be easily dismantled, transported and re-erected.
4. **Handling and transport cost:** Aluminium is very light and hence the handling and transport cost is very low.

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5. **High corrosion resistance:** Aluminium has excellent corrosion resistance and it can resist weathering actions in extremely humid and dry conditions.
6. **High scrap value:** The scrap value of aluminium is very high.
7. **Maintenance cost:** Due to high corrosion resistance, its maintenance cost is very low.
8. **Noise control:** Aluminium is an excellent reflector of electromagnetic and sound waves. It is less affected by external noises as compared to buildings made from other materials.

2.7 Steel

Steel is an alloy of iron, carbon and other elements. Because of its high tensile strength it is a major component used in buildings, infrastructures, tools, ships, automobiles, machines, appliances and weapons. Iron is the base metal of steel.

The important market forms of steel used in building construction are as follows.

1. Steel bars of many shapes and grades or strengths. (These bars are used for reinforced concrete and also for fabrication of grills, gates, etc.)
2. High tensile steel for pre-stressed concrete work.
3. Various shapes of I, channel, angle, plates and other rolled section for structural fabrication.
4. Cold formed light gauge structural steel sections.
5. Stainless steel for special uses.

2.7.1 Types of steel reinforcement

Steel rods used for reinforced concrete work should be of specified tensile strength and they should develop good bond with concrete. There are different types of steel like mild steel, Tor steel, TMT bars, etc. Steel rods of different diameter are used for R.C work.

The following types of bars are commonly available in market for reinforced concrete construction.

1. Hot rolled steel bars
   - i. Hot rolled plain round mild steel bars.
   - ii. Hot rolled ribbed mild steel bars (generally not recommended for use).
   - iii. Hot rolled high strength deformed (HYSD) bars.

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2. Hot rolled cold twisted deformed (CTD) bars like Tor steel bars. High strength is achieved by cold twisting.

3. Thermo mechanically treated (TMT) bars. High strength is achieved by controlled cooling.

2.7.2 Rolled Sections- Structural Steel

The two main types of structural steel members are:

(i) The conventional hot-rolled steel sections.

(ii) Cold- formed steel sections.

(i) Hot- rolled steel sections

Steel used for fabrication of trusses, column, beams, etc., is made by rolling hot steel into various shapes in specially designed rolling mills. Hot rolled steel sections are illustrated in figures. The various sections available are as follows:

1. **Angle sections:** Various sizes of equal and unequal angle sections are available. They are mainly used for truss work and filler joist floors.

2. **Channel sections:** Bureau of Indian Standards classifies channels as junior channels (ISJC), light channels (ISLC) and medium channels (ISMC).They are used widely for steel framed structures.

3. **I sections:** These sections are called rolled steel joists or beams. They are classfied as Indian standard junior beam (ISJB), Indian standard light beam (ISLB), Indian standard medium beam (ISMB), Indian standard wide flanged beams (ISWB) and Indian standard heavy beam (ISHB). They are used in multistoried buildings, bridge and other places where bending stresses are very high.

4. **T sections:** These sections are used to make built up sections and roof girders.

5. **Other rolled sections:** Plain sheets, corrugated sheets, plates, expanded metal, sheet piles, rail sections, flats of varying width and thickness are also rolled in rolling mills. They are used for fabrication.

(ii) Cold-formed steel sections

Cold formed light gauge steel sections are structural members, cold formed to the desired structural shapes from carbon or alloy steel (strips or flats)by press- brake operations. The thickness of the member ranges from 0.38 to 6.35 mm. They have much higher strength than hot-rolled sections.

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The advantages of the cold formed steel sections over hot rolled sections are:

1. Cold formed steel sections are thinner so that we can get more length of the material from the same weight of steel.
2. A more economical design for light loads and moderate spans can be made from these sections.
3. A more favorable strength to weight ratio can be achieved through these sections.
4. Aesthetically pleasing box sections can be made for fabrication. This can be made to look as wood by necessary painting (or) other treatments.
5. Cold formed steel sections have higher strength than hot rolled steel sections. These are extensively used in fabrication of roof trusses.

Activity 3

Collect various types of rods and rolled steel sections and display it in your class room.

2.7.3 Stainless steel

Stainless steel is a general term given to certain alloys of iron, chromium and nickel. This type of steel has high resistance to corrosion. It is designated by the percentage of chromium and nickel. Example: 18-8 stainless steel indicates 18 percent chromium 8 percent nickel.

(i) Advantages of Stainless steel

The following are the advantages of using Stainless Steel.

- Life-cycle cost benefits.
- Excellent corrosion resistance.
- 100% Recyclable.
- 80% Recycled content.
- High ductility and strength.
- Non-magnetic.
- Excellent high and low temperature properties.
- Resistance to unsightly staining.
- Aesthetic surface finish.

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2.8 Miscellaneous Materials

2.8.1 Admixtures in Concrete

Concrete is the most versatile material in the construction field. In order to modify the properties of concrete so as to make it more suitable under a wide range of climatic conditions and circumstances, admixtures are used in concrete.

Admixtures are the ingredients in concrete other than water, aggregates and cement that added to the mix batch immediately before or during mixing.

The following are the commonly used Admixtures

(i) Water reducing Admixtures
(ii) Air entrained Admixtures
(iii) Setting and hardening Admixtures

(i) Water reducing Admixtures

Water reducing admixtures are used in concrete to reduce the quantity of mixing water. Desired slump, required consistancy, high early strength, better durability can be achived by adding this admixture. Plasticizers and super plasticizers are commonly used water reducing admixtures.

(ii) Air entrained Admixtures

Air entraining admixtures are generally ued for increasing the workability and resistance to freezing and thawing (Frost resistance) in concrete. These admixtures generate air bubbles to facilitate frost protection. Natural wood resins, animal and vegetable fats and oils, hydrogen peroxide and aluminium powder are the commonly used air entraning admixtures.

(iii) Setting and Hardening Admixtures

1. Set Retarders

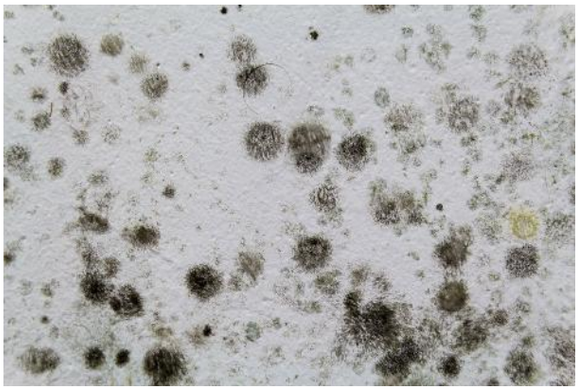
These agents are primarily used for delaying the setting time of concrete. The most common retarder is calcium sulphate or gypsum, which is used as an ingredient in the manufacture of Portland cement.

2. Set Accelerators

An accelerating admixture is a material added to the concrete for the purpose of shortening the setting time and accelerating early strength development of concrete. Soluble chlorides, carbonates, silicates and alumina have been used for this purpose.

2.8.2 Damp Proofing Materials

Damp proofing in construction is a type of moisture control applied to building walls and floors to prevent moisture from passing into the interior spaces. Dampness is the most frequent problems encountered in residences.



(i) Properties of damp proofing materials

An effective damp proofing material should have the following properties

1. It should be impervious.
2. It should be strong and durable .
3. It should be capable of withstanding both live and dead loads without damage.
4. It should be stable.
5. The material should be reasonably cheap.

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(ii) Classification of damp proofing materials

The materials commonly used to prevent dampness can be classified into the following four categories

(1) Flexible material

(2) Semi rigid materials

(3) Rigid materials

(4) Grout materials

1. Flexible materials like butyl rubber, hot bitumen (asphalt), plastic sheets, bituminous felts, sheets of lead, copper, etc.
2. Semi-rigid materials like mastic asphalt.
3. Rigid materials, like impervious brick, stone, slate, cement mortar, or cement concrete painted with bitumen, etc.
4. Grout material like mortar with waterproofing compounds.

2.8.3 Fly ash

Fly ash is obtained by combustion of coal in thermal power plants. Fly ash is a pozzolana, containing aluminous and siliceous material that forms cement in the presence of water. When mixed with lime and water, fly ash forms a compound similar to Portland cement. This makes fly ash suitable as a prime material in blended cement, mosaic tiles, and hollow blocks, among other building materials. When used in concrete mixes, fly ash improves the strength, durability and makes it easier to pump.

(i) Fly ash bricks

Fly ash bricks, is competitive when compared to the conventional clay bricks, as it provides enormous indirect benefits.

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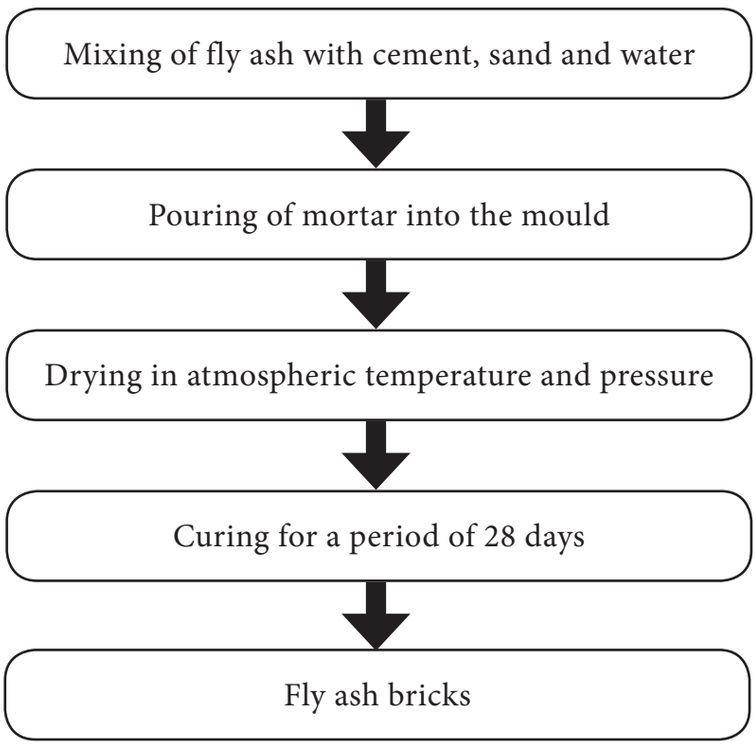
The utilization of fly ash bricks results in conservation of natural resources as well as protection of environment. These bricks are manufactured by mixing quarry dust / river sand, stone aggregates less than 6 mm in size, cement and fly ash. (Fly Ash quantity will be 10% to 20% of Cement).

Activity 4

Visit a fly ash bricks manufacturing unit nearby your location and prepare a report about the manufacturing process

Flow chart showing the manufacture of fly ash bricks



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(ii) Advantages and Disadvantages of Fly ash bricks

Advantages

1. It reduces dead load on structures due to light weight (2.6 kg, dimension: 230 mm X 110 mm X 70 mm).
2. High fire Insulation.
3. Due to high strength, practically no breakage during transport and use.
4. Due to uniform size of bricks, mortar required for joints and plaster reduces almost by 50%.
5. Due to lower water penetration, seepage of water through bricks is considerably reduced.
6. Gypsum plaster can be directly applied on these bricks without a backing coat of lime/cement plaster.
7. These bricks do not require soaking in water for 24 hours. Sprinkling of water before use is enough.

Disadvantages

1. Mechanical strength is low, but this can be rectified by adding mortar between blocks.
2. Limitation of size. Only modular size can be produced. Large size will have more breakages.
3. It is only good for the places like subtropical area or area where climate is warm because it doesn't absorb heat. But during cold it is not helpful.

2.8.4 Plaster of Paris

It is a kind of hydrated gypsum. When mixed with water, it slakes and generates heat and expands to certain extent. It is milky white in color and used for making moulds, filling gaps in masonry and plaster. It is mainly used for decorative false ceiling works in all types of buildings.

(i) Advantages and Disadvantages of Plaster of Paris

The following are the advantages of using Plaster of Paris.

1. It does not shrink while setting and thus avoids cracks.
2. It is durable and light weight.
3. It combines well with paint and helps in decoration of walls.
4. It is easily workable as it mixes with water.

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5. It has high resistance to heat and can be made as insulating material.
6. It has low thermal conductivity.
7. It can be moulded into various shapes.
8. It also sticks well to fibrous surfaces.
9. It does not interact chemically with paint and prevents alkali attack.
10. Its gypsum content provides smoothness and shine.

Disadvantages of Plaster of Paris

The following are the disadvantages of using Plaster of Paris:

1. Gypsum plaster is not suitable for exterior finish as it is slightly soluble in water.
2. It is more expensive than cement or cement-lime plaster.
3. It cannot be used in moist situations.
4. Skilled labour is required for precise application and thus labour cost for applying plaster of Paris is high.

2.8.5 Sound Insulating materials

Noise due to traffic, aircraft, barking dogs., equipment, machinery, etc., affects our peaceful and quiet living atmosphere. These divert our concentration resulting in stress, fatigue and less productivity. To overcome these problems, some type of sound insulating materials have to be used in the construction.

On the basis of acoustic properties, materials can be divided in to the following groups:

1. Sound reflection materials
2. Sound absorbing materials
3. Sound insulation materials

1. Sound reflection materials

These materials are generally placed in the ceiling, back of the stage and side walls of lecture halls. Materials such as wood, special plaster and concrete are sound reflection materials. The sound reflection property of materials is expressed by their sound reflection coefficients.

2. Sound absorbing materials

Absorption is expressed by the absorption coefficient. The materials with loose structure such as carpets, wool mats, perforated hard boards (where the sound energy is lost in the holes), etc., are called typical sound absorbing material.

3. Sound insulation materials

Dense materials such as bricks do not allow sound to pass through. There are many types of construction such as solid brick walls, cavity walls, double wall partitions with sound absorbing materials in between. The sound insulation property of a material is expressed by the reduction of noise in decibel.

2.8.6 Electrical insulating materials

The material which does not allow the electricity to pass through them is known as electrical insulating material. It provides the high resistive path to the electric current through which it is impossible to pass through. It is also used in the overhead transmission line.

The commonly used electrical insulating materials are glass, plastic, rubber and wood.

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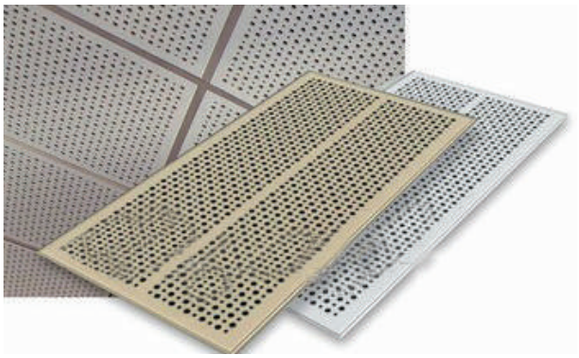

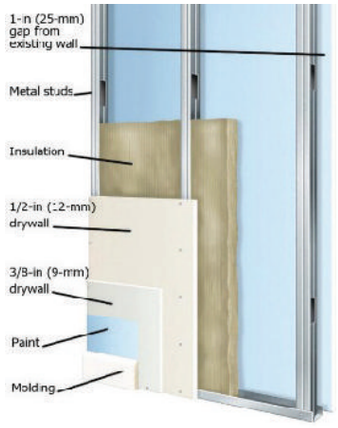

(i) Properties of Electrical Insulating materials

The insulating material should have the following properties.

1. The material must have high mechanical strength.
2. They must have high dielectric strength.
3. The material is highly resistive in preventing the flow of leakage current from the conductor to earth.
4. This material should be non porous and free from impurities.
5. The electrical and chemical property of the material should not be affected by the temperature.

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MODEL QUESTIONS

Part – I

Choose the correct answer. **(1 Mark)**

1. _____ concrete reduces the dead load of the structure.
   a. Auto claved Aerated
   b. Ready mix
   c. light weight
   d. Fibre reinforced
2. Ferrocement is defined as a _____walled reinforced concrete construction.
   a. Thin b. thick
   c. double d. cross
3. Aluminium is a good conductor of _____ and electricity.
   a. cool b. heat
   c. light d. very cool
4. An admixture is a material other than _____, aggregates and cement used in concrete making.
   a. oil b. steel
   c. water d. wood
5. Fly ash bricks are competitive in comparison to the conventional _____ bricks.
   a. Clay b. glass
   c. steel d. light weight
6. Gypsum plaster is _____ expensive than cement or cement lime plasters.
   a. more b. less
   c. moderate d. very low

Part – II

Answer in one or two sentences **(3 Marks)**

7. What is light weight concrete?
8. List few fibres used in fibre reinforced concrete.
9. Write a short note about glass.
10. What are the materials commonly used for electrical insulation?
11. Write short note on stainless steel.

Part – III

Answer in Brief **(3 Marks)**

12. What is ferrocement? Write its properties.
13. What are the two main types of structural steel members and explain about any one?
14. Describe the classification of Damp proofing materials.
15. What are the advantages and disadvantages of fly ash bricks?

Part – IV

Answer in detail **(10 Marks)**

16. Explain about Rubber and its uses in building.
17. Write briefly about Admixtures in concrete.
18. Write about plaster of Paris and mention its advantages and disadvantages.

Answers

1. (c) 2. (a) 3. (b) 4. (c) 5. (a) 6. (a)

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