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SFI GEC PALAKKAD

Chapter 6

STEEL

6.0 Introduction

Steel is the most popular and effective building material. Different forms of steel are extensively used in construction, automobiles, machineries, tools and in all fields of daily life. *Steel is an alloy of iron and carbon.* It also contains other alloying elements like Sulphur, Phosphorous, Manganese, Silicon Chromium etc. Steels are basically classified based on carbon content. (Percentage of carbon) Steels are broadly divided into the following.

STEEL

a). Low alloy Steels

i) Low carbon steel (Mild steel)

ii) Medium carbon steel

iii) High carbon steel

b). High alloy Steels.

i) Stainless steel

ii) Tool steel

1. Mild steel: Bureau of Indian Standards (BIS) stipulates the contents of carbon and other elements in mild steel as (I.S. 226: 1969).

Carbon content	-	0.25 % (max)
Sulphur	-	0.055 %
Phosphorous	-	0.055 %

a) Properties of mild steel

1. Its structure is fibrous with a dark bluish colour.
2. It is tough, elastic than cast iron and wrought iron.
3. It is malleable and ductile.
4. Permanent magnetization is possible.
5. It can be easily welded, riveted and forged.
6. Its specific gravity is 7.8.
7. It is equally strong in tension, compression and in shear.
8. It is difficult to harden and temper.

b) Uses of mild steel

1. As rolled steel sections like angle, channel, plates, I, T and bar sections used in construction works.
2. Mild steel round bars are used as steel reinforcements.
3. Mild steel tubes are used construction.
4. Sheets made of mild steel are used as roof coverings.
5. Used in manufacture of various tools, machine parts and equipments.

2. Medium Carbon steel

The carbon content in the medium carbon steel is from 0.3 to 0.6 % and the manganese from 0.60 to 1.65%. Increasing the carbon content to approximately 0.5% with an accompanying increase in manganese allows medium carbon steels to be used in the quenched and tempered condition.

The uses of medium carbon-manganese steels include shafts, axles, gears, crankshafts, couplings and forgings.

Steels in the 0.40 to 0.60% Carbon range are also used for rails, railway wheels and rail axles.

3. High Carbon steel

High-carbon steels contain from 0.60 to 1.00% Carbon with manganese contents ranging from 0.30 to 1.5%. High-carbon steels are used forcutting edges, compression springs, farming and gardening equipment, high-wear applications and high-strength wires.

6.1 Hot rolled steel

This type of steel is manufactured by rolling hot steel when it is in semi solid state. The temperature may be from 90 to 1250°.

6.1.1 Cold rolled steel

The cold rolled sections are formed from sheets, plates or flats in rolling machines or by press breaking. Cold-formed steel sections are used in car bodies, railway coaches and different types of steel structures. The different types of cold formed sections are angle sections, channel sections, I sections, T sections, flats, tubular sections, plates, round and square bars etc.

6.2 Structural steel sections (Market forms of steel)

6.2.1 Angle sections

Angle section consists of two legs, which are of equal or unequal size. These sections are specified as ISA (Indian Standard Angle). ISA 40x40x3

means size of two legs is 40mm and thickness is 3 mm. These are available in sizes of from 20x20x3 to 200x200x25.

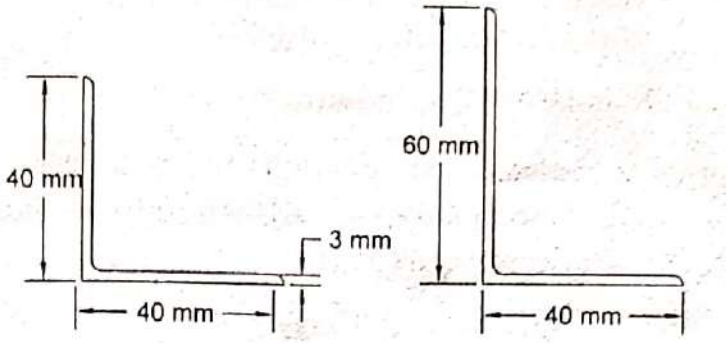

Fig. 6.1 Angle sections

Indian Standard Bulb Angle (ISBA) is another type of angle with a bulbed portion at the end of the legs.

Angle sections are used in structural steel work especially in the fabrication of steel trusses.

6.2.2 Channel sections

Channel sections consist of a web with two equal flanges as shown in figure. A channel section is designated by the height of the web and width of flange. These sections are available in sizes varying from 100mm x 45mm to 400mm x 100mm. The specifications are

ISJC – Indian Standard Junior Channel

ISLC- Indian Standard Light Channel

ISMC- Indian Standard Medium Channel

ISSC - Indian Standard Special Channel

Channel sections are widely used as structural members of the steel framed structures. These are also used to make built up columns and truss members.

6.2.3 I-sections

These are also known as rolled steel joists (RSJ). It consists of two flanges connected by a web. It is designated by overall depth, width of flange and weight per metre length. Available sizes are 75x50 to 600x210mm. The specifications are

ISJB – Indian Standard Junior Beam

ISLB- Indian Standard Light Beam

ISMB- Indian Standard Medium Beam

ISWB–Indian Standard Wide flange Beam

ISHB- Indian Standard Heavy Beam

These are used as beams, lintels, columns and members of steel frames. These are also used in grillage foundations. Also used for built up columns. It is very economical in carrying lateral loads.

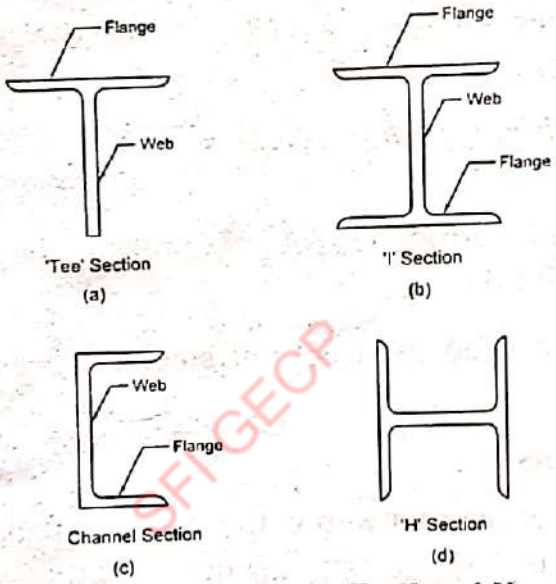

Fig. 6.2 Channel, Tee I and H sections

6.2.4 T-sections

This section has a shape of letter T and it consists of flange and web as shown in figure. It is designated by overall dimensions and thickness. The specifications are:

ISNT – Indian Standard Normal Tee

ISHT - Indian Standard Heavy Tee

ISWC- Indian Standard Wide Tee

ISST - Indian Standard Short Tee

ISMT – Indian Standard Medium weight Tee

These sections are widely used as members of steel roof trusses and to form built up sections. Also used in the fabrication of water tanks.

6.2.5 Flat sections

Flat sections are plate like sections with more length and less width. These sections are available from 3 to 40 mm thickness and 10 to 400mm width.

Flat sections are used for grillwork, built up beams and columns. These are also used in plate girder bridges.

6.2.6 Steel plates

Steel plates are specified with its thickness. It is available in a maximum area of 30 m^2. Steel plates of thickness 5mm to 50mm are used in the construction of industrial structures. Steel plates of thickness less than 5 mm are called steel sheets.

They are used as column bases and flanges for columns. These are also used in plate girder bridges and gantry girders.

6.2.7 Corrugated sheets

Corrugated sheets are formed by passing steel sheets through grooves. These grooves bend and press steel sheets and corrugations are formed on the sheets. Corrugated sheets are usually galvanized and are referred as galvanized iron sheets or G.I. sheets. Corrugated sheets are used for roof covering and cladding.

6.2.8 Round bars

Round bars are available in circular cross-sections with diameters varying from 5mm to 250 mm. Both solid and hollow sections are available. Hollow sections are called pipes. It is denoted by ISRO. ISRO 10 means the round solid bar with 10mm diameter.

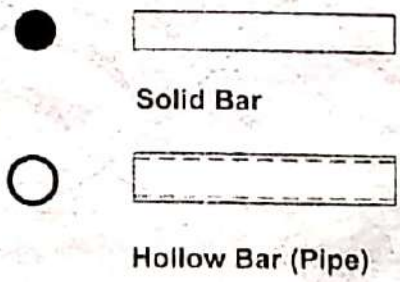

Fig 6.3 Solid and hollow round bars

Round bars are widely used as reinforcement in concrete construction of steel grillage works, etc. The commonly used bars have diameters varying from 5mm to 32mm.

6.2.9 Square bars

Square bars are available in square cross section. Both solid and hollow sections are available. Square bars are denoted with ISSQ. ISSQ 12 means solid square bar with 12 mm side. These bars are widely used in the construction of steel grill works, for windows and gates.

6.3 Types reinforcing bars

The steel bars used in reinforced cement concrete are called reinforcing bars or rebars. These are of two types.

Plane steel bars: Round sections, which are made up of mild steel, medium tensile steel or high tensile steel are used in reinforced cement concrete. But the present trend in India is to go for tor steel bars. Plane steel bars are available from 5mm to 32 mm for reinforcing purpose.

High strength deformed steel bars (Tor steel bars): These bars are cold twisted deformed. Tor steel bars are manufactured as per the specifications of Tor steel Research Foundation of India. These bars have longitudinal ribs (small projections) in the form of continuous helix. These are transverse ribs placed in between the longitudinal ribs. These help to develop high bond strength due to interlocking between concrete and steel. Yield strength of tor steel is higher than that of mild steel. These are available in various sizes of diameter 5.5,6,8,10,12,16,18,22,25,32 and 40mm. These are used for reinforced concrete works.

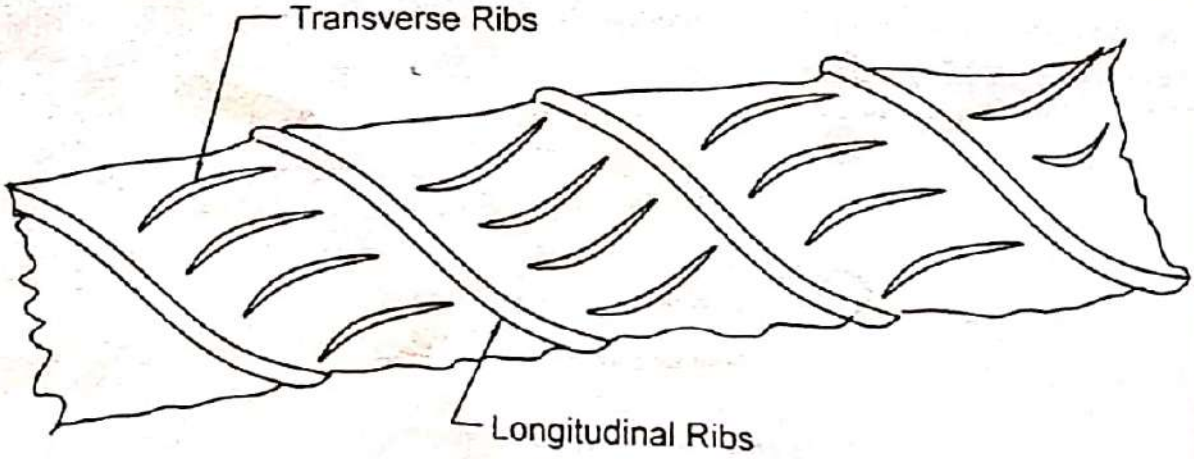

Fig. 6.4 Ribbed Tor steel

The I.S. Specifications of various grades of steel bars are given below. 24

Table 6.1 I.S. Specifications of steel bars

Type of steel	I.S. Specification	Yield stress
Mild steel (Plain bars)	I.S. 432 (Part I) – 1966	250 Mpa
High Strength Deformed bars (Cold twisted deformed bars)	I.S. 1786 – 2008	415 Mpa 500 Mpa 550 Mpa 600 Mpa

The advantages of tor steel bars are

1. These bars have good bonding capabilities.
2. These can be used for major reinforcement works.
3. It has better structural properties.
4. The yield strength of these bars is high.
5. Substantial saving in reinforcement cost when these bars are used.
6. These can be bent for 180° without any cracks.
7. These bars can be welded.

TMT steel bars

Heat treatment is a thermal process undergone by the steel in the solidstate.This includes hot rolling, microalloying and controlled cooling. The most common practiceis finishing online heat treatment while rolling, commonly known as thermo-mechanical treatment(TMT)process. Bars done through this process are called TMT bars.

6.4 Built-up sections

When single structural steel sections are not sufficient to provide the required strength and stability for structural members, a combination of same or different steel sections are jointed together to form Built up steel sections. This can be made with same or different types of individual members like angles, channels, I sections or plates etc. of different sizes. Some of the commonly used sections are given below. These sections are jointed by welding or riveting. Some times steel plates are also kept in between these sections.

Chapter 7

TIMBER

26

7.0 Introduction

Timber is one of the oldest materials used in construction. It is not only used in construction, but also it caters other needs of human beings. The timber was used in the raw form in ancient days, but it is treated, converted, preserved and used now. Timber is obtained from trees. Trees are classified into two types. They are.

1. Exogenous trees: These trees grow outwards and increase in bulk by forming concentric rings from the centre. These are used for engineering construction.

E.g.: Teak, deodar and sal.

These are further classified into conifers (soft wood) and deciduous (hard wood). Conifers are evergreen trees. These are soft, light and weak. But deciduous are broad leaf trees. They are hard, heavy, dark coloured and durable.

2. Endogenous trees: These trees grow inwards by depositing each fresh layer of fibrous mass in longitudinal direction. E.g. Bamboo.

7.1 Varieties of timber

There are different varieties of timber available in Kerala. Some of the important ones found in Kerala and used in construction and other are listed below.

Aini: (Anjili) Its color is yellowish brown. It is elastic, close-grained, and strong. It takes polish and suitable for underwater works. It is easy to saw when green. It is used for building construction, structural work, paving, furniture and for ship building etc.

Banyan: It is brown coloured. Only under water, it is strong and durable. It is used for scaffolding, thatched roofs, rafters, temporary bridges and fancy goods etc.

Bamboo: It is an endogenous tree. It is flexible, durable and strong. Bamboo is used for scaffolding, thatch roofs, temporary bridges etc.

Benteak: (Venthek) It is strong and takes up a smooth surface. It is very brittle and liable to warp easily. It is used for paneling works, as it takes good polish.

Bijasal: (Venga) It is coarse-grained, durable and strong with light brown colour. It is difficult to work. White ants do not easily attack it. It is used for ordinary building constructions, cart wheels etc.

Casuarine: (Kattadi or Choola) is a tropical conifer type tree. The tree has delicate, slender ultimate branches and leaves. The stems of this trees are used as posts for fencing and scaffolding works.

Mahagony : It has a generally straight grain and is usually free of voids and pockets. It has a reddish brown color which darkens over time, and displays a beauitful reddish surface when polished. It has excellent workability, and is very durable and slow to rot. These properties make it a favorable wood for boat making, doors and windows and furniture.

Coconut: It is reddish in colour. Outer portion is hard and inner portion is soft. It is difficult to saw. It takes polish. The stem of the coconut tree is used as posts, poles and piles. It always needs preservative treatment. It is also used for furniture work. It is used for formwork in concrete construction.

Hopea: (Kambakam) Its color varies from light to deep brown. It is extremely strong, tough and difficult to work with. It is durable, termite resistant and easily seasonable. It is used for ordinary house constructions, piles, railway sleepers, boat building etc.

Indian elm: It is a red colored, hard and strong wood. Used for door and window frames, carts etc.

Irul: (Irumullu) It is a hard, strong and durable timber. It has a pinkish white colour. It is rather difficult to work. It requires careful seasoning. It is used for railway sleepers, bridges, agricultural equipments, paving blocks, heavy construction etc.

Jack: (Pilavu) Yellow coloured, compact and even grained. It is not easy to work and maintains its shape well. It has to be seasoned slowly and carefully. Used for plane furniture, boat construction, door panels and frames.

Kathal: Its color varies from yellow to deep brown. It is heavy, hard and is durable under water and in damp conditions. It cracks under direct sunlight. White ants do not attack it. It is used for piles, wooden bridges and door/ window panels.

Laurel: (Karimaruthu) It is strong, hard and tough with dark brown in colour. It is likely to crack and to the attack of dry rot. White ants do not attack it. It takes a smooth finish. It is used for house constructions, boats constructions, railway sleepers, structural works etc.

Mango: Its color is deep gray. It is easy to work and it maintains its shape well. It is moderately strong. It is used for cheap furniture, packing boxes, toys, ship building, panels for doors and windows etc.

Palms: It has ripe wood in the outer crust. This dark brown coloured ripe wood is strong and durable. It is fibrous. It is used for furniture, roof covering, rafters, joists etc.

Rosewood: It is dark violet or purple brown in color. It is costliest among timbers in India. It is strong, tough, hard and durable. It is polishable to a high degree. It is close grained with good ornamentation. It maintains its shape well. It is available in large sizes. It is used for furniture of superior quality, aircraft plywood, cabinetwork, ornamental carvings etc.

Rubber wood: It is yellowish white in colour. It has a tendency to split and warp. It is easy to saw and workable with hand tools. It takes good form if properly treated. It gives a very good finish. Treated rubber wood can be used for furniture, panel work etc. Untreated rubber wood can be used for packing case, match splints and boxes.

Satin wood: It is very hard, durable and coarse grained. Its colour is yellow. It is used for furniture, ornamental works, tool handles etc.

Simul: It is white coloured, loose grained and light in weight. It is used for packing cases, cheap furniture, and tea boxes.

Teak: It is known as king of timbers. Its color is deep yellow to dark brown. It is moderately hard, durable and fire resistant. It can be easily seasoned and worked. It takes up a good polish. White ants and dry rot do not attack it. It does not corrode iron fastenings. It has very high dimensional stability. It shrinks little. It is among the most valuable timber trees of the world.

It is used for house construction, railway carriages, flooring, structural works, shipbuilding, furniture, mallets, agricultural instruments, well kerbs, piles etc. Its use is limited to superior work only as it is comparatively very costly.

Tamarind: It is a dark brown coloured wood. It is knotty and durable. It is used for formwork in concrete construction. It is also used for well kerbs, agricultural instruments.

7.1 Seasoning of timber

The fresh timber contains about 50% or more of its own dry weight as water. The water is to be removed before it used for any engineering purposes. In other words, the timber is to be dried. The process of drying of timber is known as *'seasoning of timber'*. The moisture content should be removed under controlled conditions, at a uniform rate from all parts of the timber. But if the drying is irregular, the shrinkage of timber will also be irregu-

Then the load is applied on the top plate placed over the test specimen. Load at the time of breaking the tile is recorded and transverse strength is obtained using the formula for split tensile strength. The test is conducted for saturated and dry condition.

4) Water absorption test

A cube of weight about 50gm is dried in an oven at a temperature of 100 to 110°C till they attain a constant weight and then cool; weigh when cool and immerse the dry specimen completely in clean water at 24 to 30°C for 24 hours. Remove the specimen, wipe off the surface water carefully with a damp cloth, and weigh the specimen correct to a gram, within three minutes after removing the specimen from water. Then the difference in weight is found out.

Water absorption = (Wet weight- dry weight)/dry weight x100

5) Shear strength test

For finding the shear strength, the rectangular test specimens of minimum 50mmx50mm cross section and 180mm length are cut or drilled out from the sample rock. Test is done using Johnson shear tool. Maximum load is found out and shear strength is obtained by dividing the maximum load by 2 times cross sectional area. i.e. S = W/2A, where S is shear strength, W is the maximum load and A is area of the cross section.

9.6 Common Building stones

1. Granite: Granite is an igneous rock and is hard and durable. Most of these rocks possess excellent building properties, like high strength, very low abrasion value, good resistance to frost and other weathering agencies, and are available in different appealing colours.

Uses: It is used for facing work, walls, bridge piers, columns, steps, etc. It is used where weight and durability are essential.

2. Laterite: Laterite is a sedimentary rock found in hot and wet tropical areas which is enriched in iron and aluminium and developed by intensive and long lasting weathering of the underlying parent rock. Moreover, many laterites contain quartz as relatively stable relic mineral from the parent rock. The iron oxides goethite and hematite cause the red-brown color of laterites. These stones are cut from quarries into blocks. This should be seasoned for one or two months to develop hardness. The compressive strength is 1.8 to 3.2 N/mm^2

Uses: Laterite stones are mainly used for masonry works. Many of the masonry bonds which are possible with bricks are also done with laterite stones.

3. Limestone: They are sedimentary rocks composed mainly of calcium carbonate. They are not useful as building stones.

Uses: They can be used as road aggregate for construction floors, steps, walls, etc. Limestone is also use for the manufacture of cement and lime.

4. Sandstone: These are sedimentary rocks and consist mainly of quartz. Sandstone occurs in many colours. The most suitable and durable type is that which is light coloured, having silica, cement and a homogeneous, compact texture.

Uses: It can be used for steps, flooring, facing work, columns, etc

5. Marble: These are metamorphic rocks and have been formed from limestone under high temperatures. Marbles vary greatly in colour, structure and texture.

Uses: Marble is used both as an ornamental stone and as a constructional material. As these stones can take brilliant polish, are used extensively for flooring.

6. Basalt and Trap: These are igneous rocks and generally heavier and darker than granites and also stronger, but may contain cavities and pores within them.

Uses: They are extensively used for rubble masonry, foundation works and road construction.

7. Slate: Slate is a metamorphic rock and splits into three sheets having smooth surfaces along natural bedding planes.

Uses: In building construction, its use is limited to roofing purpose for ordinary buildings or as paving stone or as insulating materials.

8. Gneiss: Gneiss is a metamorphic rock and closely resembles granite in its building properties. But, sometimes it may be rich in mica and useless as a building stone.

47

Uses: They can be used for street paving rough stone masonry work, etc.

9. Kankar: Kankar is a sedimentary rock and is a form of impure limestone.

Uses: It is used as road metal for the manufacture of hydraulic lime, etc.

10. Quartzite: Siliceous sand stones under the action of metamorphism yields quartzite. It is very dense and strong stone with crystalline structure.

Uses: It is used in rubble masonry and as aggregate for concrete.

9.7 Aggregates

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9.7 Aggregates

The granular materials chemically inert such as natural sand, gravels, crushed, stones or air-cooled iron blast furnace slag are called *aggregate*. These are used as filler materials in concrete and mortar for economy in construction. These are also known as inert fillers. It avoids cracking and gives more strength to concrete.

9.7.1 Qualities of an Ideal Aggregates

Ideal aggregates should have the following requirements according to I.S. 383-1970.

1. It should be hard, strong and durable, free from any coating.
2. It should not react with cement or steel.
3. It should consist of natural stones, gravel and sand or in various combinations of these materials.
4. Porosity should be limited.
5. It should be angular in shape, having rough surfaces.
6. Free from organic and deleterious substances like coal, mica, iron pyrites, shale, clay etc.
7. It should have low thermal conductivity.

9.7.2 Classification of Aggregates

The aggregates are classified based on the following criteria.

(1) According to nature of their formation.

(2) According to their size.

(3) According to their shape.

9.7.2.1 According to nature of their formation

Aggregates are classified according to nature of its formation. Those are

Natural Aggregates: The aggregates, which are obtained from natural deposits of sand and gravel or from the stone quarries by breaking hard rocks, are generally known as *natural aggregates*.

Artificial aggregates: The aggregates, which are obtained by breaking either bricks or blast furnace slag to the graded particles of desired size, are called *artificial aggregates* or *processed aggregates*. Formed slag, shale, expanded clay and cinder are the different types of artificial aggregates. These are used for lightweight concrete, lime concrete etc. Blast furnace slag is not used for reinforced concrete, because it leads to the corrosion of steel due to the sulphate content of the slag.

9.7.2.2 Classification of aggregates according to size

According to e size, aggregates are classified as under:

(a) Coarse aggregates

(b) Fine aggregates

(c) All-in-aggregates

Coarse aggregates: The aggregates most of which is retained on IS: 4.75 mm sieve are known as coarse aggregates.

These are further divided into

***(a)* Graded aggregates.** The coarse aggregates, which contain particles of all sizes from a given nominal minimum, (4.75 mm) to maximum (75 mm) is known as *graded aggregates*. The aggregates whose particles are so proportioned as to give a definite grading, is called a *well-graded aggregate*. These are suitable for concrete.

***(b)* Single sized aggregates.** The coarse aggregates, which contain particles of single sieve size, is known as *single sized aggregates*

(ii) Fine aggregates: The aggregates, which are passing through, the IS: 4.75 mm sieve are called fine aggregates. River sand is an example for fine aggregate. Fine aggregates are further classified into

(c) Broken brick fine aggregates: This is obtained by crushing brok brick (surkhi). It is used for preparing surkhi mortar and lightweight concre

(iii) All in aggregates: Aggregates, which contain both course, a fine aggregates are called all in aggregates.

9.7.3 Sand

Sand is a fine aggregate which is used in mortars and concrete. It is two types.

(a) Natural sand: The fine aggregates formed by natural disintegratio of rocks and deposited in the beds of steams, rivers and glaciers are calle natural sand.

(b) Qualities of good sand

1. It should contain quartz of white or light gray colour and free fro silt.
2. It should pass through 2mm I.S. sieve and retained on 90 micro I.S. sieve.
3. It should be free from all organic matter.
4. Loss of weight due to ignition should be less than 0.25 %.
5. It should be free from hygroscopic salts.
6. It should have coarse, angular, hard and sharp grains.
7. It should be chemically inert.
8. It should be strong and durable.

(b) Crushed stone sand: The fine aggregates made by crushing natura gravels are called crushed stone sand.

Fine aggregate (sand) is available from these sources.

River sand: This is obtained from riverbeds and riverbanks. This sand is bright and clear and consists of sharp or rounded particles. This sand is considered to be the best suitable sand for making mortar. Its interlocking value is less since it has more round corners. More suitable for plastering work.

Pit sand: This sand is obtained from pits dug at depth of 1.5 *m* to 2*m* in the soil. The particles are sharp, angular porous and free from harmful salts It is suitable for making mortar.

Sea sand: This is the sand available in seashores. This sand is brown in colour consists of rounded particles. Generally this sand also contains objectionable salts. So it is not recommended for construction. The salts presen

Chapter 10

CEMENT CONCRETE

10.0 Introduction

The concrete means a mixture of a binding material, aggregates as filler materials and water. There are various varieties of concrete like cement concrete, lime concrete and mud concrete. The cement concrete is a mixture of cement, sand, pebbles or crushed rock and water, which when placed in the skeleton of forms and allowed to cure, becomes hard like a stone. The cement concrete has attained the status of a major building material in the modern construction.

10.1 Ingredients

Although there are many materials in the preparation of different kinds of concrete there are only three basic ingredients. They are

1. Binding material like cement or lime
2. Aggregates like sand and broken stones
3. Water

When lime is used as binding material, it is called lime concrete. In modern days, lime concrete is not preferred. The discussion about in this book is confined only to cement concrete.

10.1.1. Cement

Lime was used as a cementing material till cement is invented. Now a days majority of the cement concrete work in building construction is done with ordinary Portland cement. Other types of cement such as rapid hardening cement and high alumina cement are also used under certain circumstances. The cement should meet all the standard requirements. Refer the chapter cement for more details.

10.1.2 Aggregates

The aggregates, which are bound by means of cement, form the bulk of cement concrete. Both fine and coarse aggregates are used in concrete. Hard, durable and clean aggregates are to be used for this. It should be completely free from organic and vegetable matter, clay, fine dust etc. The presence of such impurities prevents adhesion of aggregates and hence reduces the strength of the concrete. Refer the chapter aggregates for details.

10.1.3 Water

Water is an important ingredient of concrete, because hydration takes place only in the presence of water. The water, which is used for making concrete, should be clean and free from harmful impurities such as oil, alkali, acid etc. In general the water, which is fit for drinking, should be used for making concrete.

It may be noted that sometimes the ingredients other than the above are added in concrete to give it certain improved qualities or for changing certain physical properties in its fresh and hardened stages. These ingredients or substances are known as the admixtures. The addition of an admixture may improve the concrete with respect to its strength, hardness, workability, water resisting power etc. Some of the common admixtures are alum, aluminum sulphate, barium oxide, bitumen, calcium chloride etc.

It is advisable to use potable water for making concrete but at places where seawater is available in excess and portable water is costly the seawater can be used for making concrete. But the problem of making cement concrete from seawater has to be studied from the following two aspects.

(a) Strength

(b) Corrosion of reinforcement

10.2 Advantages of concrete

1. Fresh concrete can be easily moulded into durable structural members of various sizes and shapes.
2. It has sufficient plasticity for working.
3. Ingredients of concrete are locally and easily available.
4. It can be easily transported from the place of mixing to the site where it is used.
5. It can be easily pumped to fill cracks and other small places for repair work.
6. It hardens with age. Hardening continues for a long time.
7. Hardened concrete has high compressive strength.
8. It is free from corrosion and less affected by atmospheric agents.
9. It forms a hard surface capable of resisting abrasion.
10. It is a good sound proofing material.

1. It proves to be more economical than other materials.
2. It's maintenance cost is also very less.
3. Concrete structures are more durable and not liable to decay.
4. Concrete members have better rigidity and appearance.
5. Concrete can be reinforced with steel and any types of members are made.
16. High quality control is possible. Properties can be altered by appropriate ingredients and by special processing techniques.
17. Complete mechanisation is possible in preparation and placing process.

10.3 Disadvantages

1. Although it binds rapidly it is weak in tension.
2. It has a tendency to be porous which is due to the presence of voids formed during and after placing.
3. It has a tendency to shrink.
4. Due to its low tensile strength it has to be reinforced which increases the cost.
5. Its coefficient of expansion is large which leads to cracks in large concrete structures.
6. Soluble salts present in concrete experience efflorescence.
7. Concrete structures are heavy in weight.
8. Concrete need more time to cure and to develop the needed strength and are not suitable for speedy construction.

10.4 Grades of concrete

Indian standard I.S: 456 – 2000 specifies seven grades of concrete designated as M_{15}, M_{20}, M_{25}, M_{30}, M_{35} and M_{40} and so on. Where M refers the mix and number specifies the compressive strength of 15cm concrete cube tested after 28 days in N/mm^2. The characteristic strength (denoted by *fck*) for various grades of concrete and approximate proportions and uses are given in the tables below. The minimum grade to be used for Reinforced Cement Concrete (RCC) works is M_{20}.

aggregates is called segregation and separation of water or cement gel is called bleeding. On the other hand if the concrete mixture is too dry it will be a harsh mix, difficult to handle. Because of these conflicting conditions, a proper water cement ratio is to be adopted.

10.8 Types of concrete

Over the time, a number of concretes have been developed to suit various requirements. There are some types of concretes, which are used under specific circumstances. Some of them are discussed below.

1. Reinforced cement concrete: Concrete is weak in carrying tensile forces. Steel reinforcing bars are embedded in concrete to rectify this in various structural members. This concrete, in which steel rods are embedded is called reinforced cement concrete (R.C.C.). All the structural members like beams, columns, slabs and foundations are constructed with reinforced cement concrete.

2. Light weight concrete: When coarse aggregates of lightweight are used for concrete, lightweight concrete is obtained. It is also obtained by adding some chemical to develop foam or gas bubbles during mixing. Bulk density of this concrete is less than 1800Kg/m^3 where as for the ordinary concrete has 2400Kg/m^3. This concrete is used where dead weight of the structure is to be reduced.

3. No fines concrete: When only coarse aggregates are used in concrete, it is called no fines concrete. It resists drying shrinkage and capillary action of water. It has all advantages of lightweight concrete. It has better insulating properties and no problem of segregation. There is a saving of fine aggregates. It is used for external load bearing walls, small retaining walls and as damp proofing material.

4. Fibre reinforced concrete: Apart from normal ingredients of concrete, it also consists of fibres in the form of asbestos, glass, nylon or coir. The advantages are

1. Crack free structure.
2. More durable.
3. Thin sections can be made out of it.
4. More tensile and fatigue strength.

5. Pre-stressed concrete: In pre-stressed sections, tensioned (stressed) wires are used in the place of reinforcing bars. This will induce compressive

stresses in concrete. resist more tensile stresses. there by more load can be carried by the sections. It has advantage of pre-stressed concrete section is thinner sections carry more loads. It is used for bridges, poles, railway sleepers, pipes, shells and folded plates. Cracks are limited in pre-stressed sections.

6. Air entrained concrete: Air entraining cement or similar agents are used for this concrete. It has high resistance against frost action and sulphate attack. This concrete is more workable, plastic and adhesive. No fear of segregation.

7. Coloured Concrete: The coloured concrete is made by adding colouring pigments or by using the coloured cement. It is used for the following purposes.

a) Ornamental finishes in buildings.

b) Underground pedestrian crossings etc.

c) Preparing park lanes.

d) Separating lines of traffic of road surfaces.

9. Vacuum concrete: The composition of vacuum concrete is same as ordinary concrete. After laying the concrete, extra water is removed by some arrangement called vacuum method. After this water left in concrete will be just sufficient for hydration of cement. Hence concrete hardens into very strong material.

10. Reactive Powder Concrete: Reactive Powder Concrete (RPC) is an ultrahigh-strength cementitious composite with advanced mechanical properties, superior physical characteristics and unprecedented ductility and extremely low permeability. This concrete is manufactured by using of the highly refined silica fume to the conventional concrete. This concrete can be used in chemically aggressive environments and where physical wear greatly limits the life of other concretes.

Questions :

1. What are the ingredients of concrete?
2. Discuss the following types of concrete

   a) Light weight concrete

Chapter 11

MODERN CONSTRUCTION MATERIALS

11.0 Introduction

Variety of modern and innovative materials are used in construction industry now a days, many of which have attained high momentum due to its ambience, cost, durability, reliability, friendliness and of easy to adopt technology. These materials have definite advantages over the conventional materials. Some of these materials are discussed in the following sections.

11.1 Architecture Glass

Architectural glass is glass that is used as a building material. It is most typically used as transparent glazing material in the building envelope, including windows in the external walls. It is also used as internal partitions for its architectural elegance. Glass is used invariably as components for aesthetics, structural safety, sound and thermal insulation, fire safety and solar control.

The types of glass used in construction are:

1. Normal (Annealed) Glass
2. Laminated Glass
3. Tempered or Toughened Glass
4. Heat Strengthened Glass
5. Reflective Glass
6. Insulating Glass

11.1.1 Normal (Annealed) Glass

Normal glass is synonymous with flat glass irrespective of the process of manufacture.

Float glass has a perfectly flat, brilliant surface, whereas **sheet glass** has slight distortions. Both are referred as normal (annealed) glass and can be processed to obtain many different varieties of glass for use in buildings.

Normal glass is used in residences, shopping malls, hotels, restaurants, etc. for windows, shelves, doors and partitions, Solar Applications, Display cases, Shop fronts, Greenhouse, Atriums & Railings etc.

Types of Normal (Annealed) Glass

1. Clear Glass It is normal annealed glass, though clear & transparent, it does posses some colour tint usually greenish. It is due to presence of some impurities such as iron. Clear glass has very high-energy transmission when exposed to sunlight. It provides a clear view of the objects across it.

Applications: Used in doors, windows, solar applications, shelves etc. It is also used for further processing to other glass types.

2. Tinted glass It is normal glass that is colored by the addition of metal oxides into molten glass. Tinted glass possesses filtering properties that help reduce eyestrain due to dazzle. Its absorption properties help diminish energy transmissions when exposed to sunlight. A tint like green allows more visible light and cut out infrared radiation.

Applications: Used in doors, windows and partitions etc.

3. Patterned, figured or rolled glass It is a decorative and translucent glass with figures or patterns on one face. In addition to diffusing light and obstructing visibility from the outside, the figures soften the interior lighting. This type of glass is usually more fragile and less convenient to clean.

Applications: Interiors of the buildings, opaque glazing like bathrooms etc

4. Wired glass It has wire mesh incorporated during its production. Wired glass is recommended for its fire protection property. In case of fire, the glass cracks but broken pieces tend to remain in position restricting the spread of flame and smoke for some time.

Applications: Used where nominal fire protection is required in windows doors & partitions etc.

5. Extra clear glass Extra clear glass is a high value glass, free from impurities such as iron. It has high light transmission of more than 92 percent and is free from interference with the true colour & sparkling of objects across it.

Applications: It is used for a sparkling display of expensive materials like jewellery, watches, crystal ware, fine fabrics, art wares, solar applications etc.

6. Ceramic printed glass Also known as silk-screened glass for its appearance like a silk screen. Certain areas of application make it important to mask a part or whole of glass for privacy or hiding the background or enhancing the look of a product or for purely aesthetical reasons. It is not affected by moisture, oil, soaps, chemicals or detergents and retains its original appearance though out the life of the glass.

Applications: curtain walls, shower installations, glass doors, spandrels and partitions etc.

11.1.2 Laminated Glass

It is composed of two or more layers of glass with one or more layers of a transparent/ pigmented and specially treated plastic Polyvinyl Butyral [PVB] sandwiched between the glass layers. The glass panes (layers) can be either normal glass or tempered glass. When the glass is broken, fragments tend to adhere to the plastic [PVB] interlayer thereby reducing the risk of injury and helping to resist further damage by weather.

Laminated glass does not shatter like ordinary glass. It absorbs impact, resists penetration, and remains intact even if broken, holding glass fragments in place and lowering the risk of injury.

Laminated glass tends to resist impact. In multi-ply configurations, it can even resist bullets, heavy objects, or small explosions. Laminated glass is an excellent barrier to noise. This makes it ideal for airports, hotels, data processing centers, recording studios, and any building near airports, highways, or train lines

Applications: Laminated glass is used in office buildings, hotels, restaurants, shopping malls, public walkways, hospitals, libraries, museums, churches, airport terminals, residences & apartment buildings, noise control applications, embassies, computer centers. High security places, for example, banks, teller, and drive-through windows, ticket windows, gas stations, currency exchanges, jewellery shops and burglar resistant showcases.

11.1.3 Tempered or Toughened Glass Tempered glass is an extremely strong glass which is heat treated to a uniform temperature of approximately 650°C and rapidly cooled to induce compressive stresses of 770 kg/m2 to 1462 kg/m2 on the surfaces.

Tempered or toughened glass gains its added strength from the compressed surfaces. The heat treatment process for tempered glass requires

that all fabrication be completed prior to toughening. Any attempt to cut, drill, grind or sand blast the glass after toughening may result in glass breakage. The heat treatment process does not change the light transmission and solar radiant heat properties of the glass.

Tempered Glass is four to five times stronger than normal glass of equivalent thickness. It is mainly used for safety & strength. Tempered Glass provides greater thermal strength. This substantially reduces the likelihood of injury to people, as there are no jagged edges or sharp corners like normal glass.

Applications: It is used in commercial applications such as safety glazing for entranceway, railings, partitions or fire knock-out windows. Tempered glass can be used in balustrades, escalator side panels, handrails, shower screens, bathtub enclosures, sliding/swing doors, squash, showcases, and partitions.

Also used as curtain walls of high-rise buildings, door openings, showroom and lobby facades, escalator side plates, viewing partitions of sports complexes in resorts and airports.

11.1.4. Heat Strengthened Glass

Heat strengthened glass is a type of tempered glass which has been strengthened thermally by inducing a surface compression of 422 to 658 kg/cm2 as compared to a range of 770 to 1462 kg/cm2 in case of fully tempered glass. Heat-strengthened glass provides necessary resistance to thermal stress associated with high performance glazing materials such as tinted glass and reflective glass.

Applications: Heat Strengthened glass is suitable for spandrel and vision panels of curtain walls and structural glazing as they safeguards against thermal breakages. It is used for making laminated glass panels for safety combined with strength. It is used in complex glass combinations like double-glazing as one lite of laminated glass for glass floors and roofs.

11.1.5 Reflective Glass

A metallic coating is applied to one side of the glass in order to increase the amount of reflection by the glass of both the visible and infra-red (light and heat) range of the electromagnetic spectrum. This coating can be applied to clear or body tinted glass. The reflective glass imparts a mirror like

appearance to the exterior of buildings under most daytime conditions. It reduces heat gain and glare from the exterior and allows optimum visible light transmission to the interior. It also reduces the air conditioning load of the buildings. An exceptional property of solar reflective glass is that the coating of metal oxides on the glass can be achieved without affecting the transparency of the glass.

Applications: Reflective glass is used in office buildings, high-rise buildings, Entrance, Privacy windows, Decorative walls, Spandrel glazing, Vertical and sloped glazing, Solar control applications, Building facades

11.1.6 Insulating Glass

It is a prefabricated unit made of two or more glass panes, separated by a cavity and edges-hermetically sealed together. This edge seal binds the individual sheets of glass together to maintain the mechanical strength of the joint. It also protects the cavity between the glasses from outside influences. The spacer can be aluminum, composite plastics etc. The spacer ensures the precise distance between the glass panes. The cavity normally filled with dry air but can be also filled with gases such as Argon, Krypton for better thermal performance or hydrogen fluro oxide for better acoustic performance. The low heat conductivity of the enclosed dry gas between the glass panes drastically reduces the thermal heat transmission through the glass. It also helps is reducing the direct solar energy specifically when the outer pane is a solar control glass.

Applications: • Office buildings, hospitals, hotels, houses and buildings with exceptionally high heating or cooling requirements. Airport control towers, windows of coaches of trains, and other environments that need regulated atmosphere and prevention of condensation. • Buildings near highways, railways and airports that need sound insulation property of insulating glass.

11.2 Ceramics

Ceramics are a material often used in construction, made from a mixture of minerals, typically silica sand, with a clay binder and some impurities, and water. They are fired at a higher temperature than bricks, so that the silica re-crystallises to form a glassy material that has greater density, strength, hardness, resistance to chemicals and a greater dimensional stability.

During firing, the water is driven off, though this may be reduced from 30% to 2-5% by drying before firing. At this water content, products are cast,

pressed, extruded or moulded from powder before being fired at 1,800-2,000 degrees for days or weeks at a time, depending on the ceramic and process details. Ceramics may have an as-fired appearance or be glazed.

The important types of ceramic products used in construction are the following.

1 Fire clay brick sand tiles

These are made from a type of clay (fire clay) which can withstand high temperatures. Main constituents of fire clay are silica and alumina.

Fire clay bricks are used for lining in chimneys, boilers, fireplaces etc..Fire clay tiles are used for flooring and roofing. Bath tubs, sinks are also made from fire clay.

2 Terracotta

Terracotta is nothing but 'burnt earth'. It is made from yellow to brownish-red clays with a uniformity and fineness between brick and vitrified wall tiles. Terracotta is often used for flooring tiles, unglazed chimneypots, waste water pipes, air bricks, copings and planters.

3 Faience

This is a glazed form of terracotta or stoneware. The base material may be fired to the 'biscuit' stage before glazing and re-firing, or a 'once-fired' process is adopted. Faience tiles are widely used in cladding work, dadoing and flooring.

4. Stoneware

This is similar in composition to fireclay, but is fired at a higher temperature than fireclay and contains a higher proportion of glass. As a result it is harder and less absorbent. Stone ware tiles and drainage pipes used in construction.

5. Vitreous china

It is a mixture of clay, feldspar and quartz which is molded, glazed and baked at extremely high temperatures. This has higher glass content than earthenware, and its water absorption is only about 0.5%, which makes it suitable for sanitary fittings. It is stronger than earthenware.

6. Vitrified tiles

Vitrified tile is a ceramic tile with very low porosity. Vitrified tiles are made by hydraulic pressing a mixture of clay, quartz, feldspar and silica, which make vitreous surface thus creating a single mass making them hard with low porosity. Different clay bodies reach vitrification at different temperatures.

The vitrified tiles are screen printed with colors and designs. In some cases a layer of 3-4 mm thick double layer pigment is applied to reduce wear and tear. Full body vitrified tiles have pigment in entire body (thickness) of the tile. This makes chips and scratches less noticeable.

Glazed vitrified tiles have a glazed surface. They offer a wide variety of design, art work and surface textures like wood grain, bamboo, slate or stone.

Vitrified tiles are used extensively used in modern days, as it gives an appearance similar to marble and granite. It is used in floors of houses, hotels, hospitals, restaurants, lobbies, auditoriums, shopping malls, and offices.

7. Porcelain

Porcelain is very similar to vitreous china, but is often made from purer materials under more strictly controlled conditions. A special type of clay either white or grey, to which kaolin (a white firing stiff clay) and white China stone (finely decayed granite, washed and prepared as small white blocks) is added. Porcelain is used for special uses, such as electrical insulators.

11.3 Plastics

Like in any other field, plastics are used in various applications of construction. These are briefly described below.

1. Flooring

Plastic materials like polyvinyl chloride (PVC) and polyethylene are used to make flooring less prone to wear and tear. It also decreases the sound pollution level and can be cleaned easily. Other floor coverings used are Asbestos plastic slabs, Vinyl asbestos slabs, Semi-flexible vinyl slabs, Vinyl carpets; Thermosetting resin based covering and Synthetic fibre tensile covering.

2. Roofing

To protect the outer surface of the roof from damage, two layers of different plastic materials are required. The upper part is made of colored

thermoplastic olefin or vinyl while the lower part consists of polyurethane foam which consumes less energy and keeps the interior of a house cooler.

3. Insulation

Insulation materials and application of foams in building construction are

1. Polystyrene
2. PVC
3. Phenolic
4. Formaldehyde urea
5. Polyurethane

4. Walls

Sandwich wall panels are made with various plastic compounds are given below.

1) PVC (polyvinyl Chloride), plasticized plates and polyurethane foams.
2) Asbestos cement covering and polyurethane foam core.
3) Polystyrene foam core and various coverings
4) Polyester laminated sheet and polyurethane foam core
5) Enameled iron covering and polyurethane foam core.
6) Covering with polyester laminated sheet glued to asbestos cement and polystyrene foam core.

5. Wall Lining

- Adhering films – vinyl coated fabrics or paper vinyl sheet doubling on fabric or paper etc.
- Sprayed lining polyurethane
- Laminate – Melamine and phenolic plastics – polyester
- Wall tiles – polystyrene, PVC – tiles or mosaic
- Coating – polyvinyl acetate

6. Pipes

Commonly made up of polyvinyl chloride (PVC), CPVC, acrylonitrile butadiene styrene (ABS) or polyethylene, plastic pipes are flexible and very light in weight, making them easy to install. All of these plastic materials are also highly chemical and water resistant, making them suitable for many extreme environments.

7. Windows

Polycarbonate is used to manufacture building windows. This plastic material is strong, clear and very light in weight. Polycarbonate windows are considered more burglar-proof than regular glass windows. Two plastics materials, vinyl and fiberglass, are used commonly in the production of window frames. Fiberglass is extremely strong while vinyl is quite durable and also inexpensive. uPVC windows and ventilators are very common now a days.

8. Doors

Some construction projects use doors made from a stiff polyurethane foam core with a fiber reinforced plastic (FRP) coating. The sandwich structure of these doors makes them incredibly strong.

11.4 Composite Materials

Composite material, also called composite, is a solid material that results when two or more different materials, are combined to create a new substance whose properties are superior to those of the original components in a specific application.

Composite materials are used globally in building and construction and provide significant advantages over traditional building materials. Application areas include structural components, cladding and facades, roofing, doors and windows, acoustics, rehabilitation, and the fabrication of unique structures and components. Major types of engineered composite materials include

a) Reinforced concrete and masonry.

b) Composite wood such as plywood.

c) Reinforced plastics, such as fibre-reinforced polymer or fiberglass.

d) Ceramic matrix composites (composite ceramic and metal matrices)

e) Metal matrix composites.

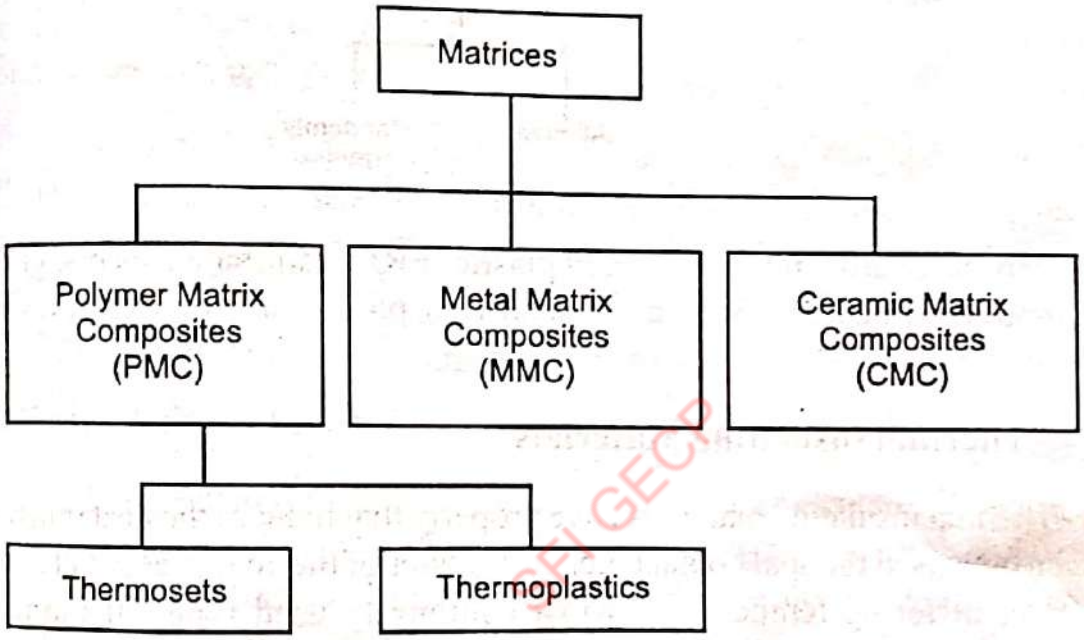
f) Other Advanced composite materials.

Classification of composites is based on two criteria.

i) Based on matrix.

ii) Based on reinforcement.

Classification based on matrix

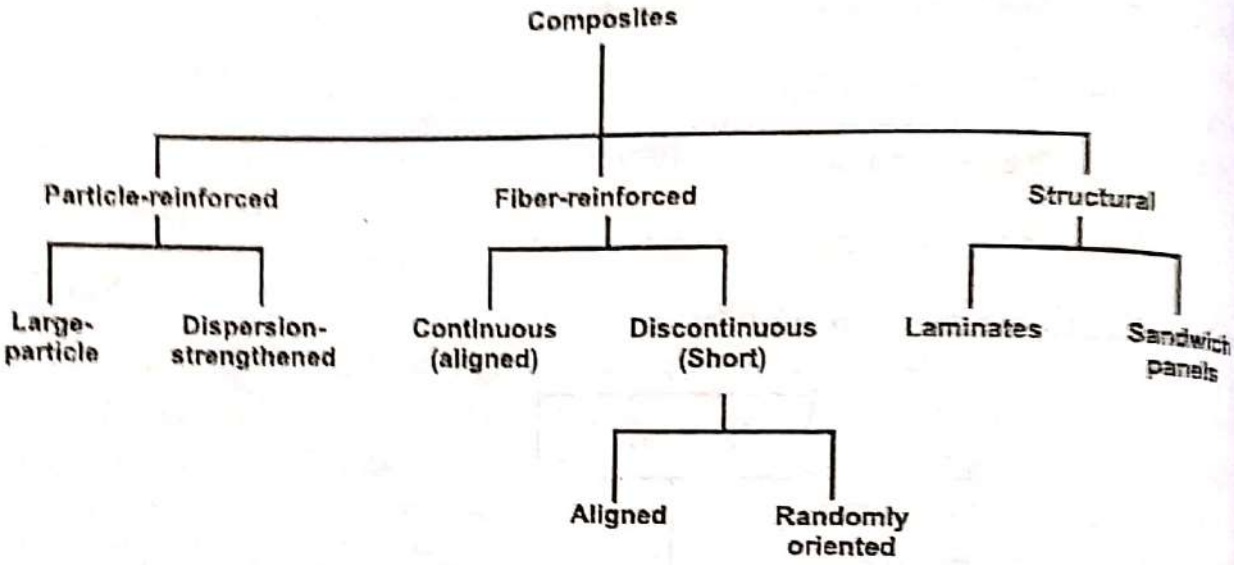


Examples for thermosets – Epoxy, polyesters etc.

Examples for thermoplastics – Teflon, PVC, Nylon, Polypropylene etc.

Examples for Ceramic Matrix Composite – Mullite

Classification based on reinforcement



Particle boards, fibre reinforced plastic (FRP), laminated sheets, glass fibre reinforced boards, ply boards, sandwich panels are the examples of composites.

11.5 Thermal Insulating Materials

Thermal insulating materials have property that reduces the heat transfer between objects in thermal contact, i.e. the transfer of thermal energy between objects of differing temperature. Most commonly used types of thermal insulating materials are the following.

1. Fiberglass

Fiberglass is the most common insulation used in modern times. It is made, by effectively weaving fine strands of glass into an insulation material; fiberglass is able to minimize heat transfer. Fiberglass is an excellent non-flammable insulation material. It is comparatively cheap also.

But since fiberglass is made out of finely woven silicon, glass powder and tiny shards of glass are formed. These can cause damage to the eyes, lungs, and even skin if the proper safety equipment is not used while handling it.

2. Mineral Wool

Mineral wool is of three types. Glass wool which is fiberglass manufactured from recycled glass. Rock wool which is a type of insulation

made from basalt rock. And slag wool which is produced from the slag from steel mills.

Mineral wool can be purchased in bats or as a loose material. Most mineral wool does not have additives to make it fire resistant, making it poor for use in where extreme heat is present. However, it is not combustible. It can be used only with any fire resistant material in such situations.

3. Cellulose

Cellulose insulation is the one of the most eco-friendly forms of insulation. Cellulose is made from recycled cardboard, paper, and other similar materials and comes in loose form.

Also it is one of the most fire resistant forms of insulation. However, there are certain downsides to this material as well, such as the allergies that some people may have to newspaper dust. Even though the insulation using cellulose requires more skill and hard to apply, cellulose is a cheap and effective means of insulating.

4. Polyurethane Foam

Polyurethane foams are an excellent form of insulation because of its insulating capacity, light weight and fire resistance. There are also low density foams that can be sprayed into areas that have no insulation. The only disadvantage is that polyurethane forms are not eco friendly.

5. Polystyrene

Polystyrene is waterproof thermoplastic foam which is an excellent sound and temperature insulation material. It comes in two types, expanded (EPS) and extruded (XEPS) also known as Styrofoam. The two types differ in performance ratings and cost. Polystyrene insulation has a uniquely smooth surface which no other type of insulation possesses. Typically the foam is created or cut into blocks, ideal for wall insulation. The foam is flammable and needs to be coated in a fireproofing chemical.

6. Aerogel and Pyrogel

Recently, materials like aerogel (for the construction of heat resistant tiles, capable of withstanding heat up to approximately 2000 degrees Fahrenheit with little or no heat transfer used by NASA), have become affordable and available. One in particular is Pyrogel XT. Pyrogel is one of the most efficient

industrial insulations in the world. Its required thicknesses are 50% – 80% less than other insulation materials. Although a little more expensive than some of the other insulation materials, Pyrogel is being used more and more for specific applications.

11.6 Acoustic Insulating Materials

Noise is defined as unwanted sound. This unwanted sound may be of single frequency and of constant or varying intensities or it may be a combination of various frequencies of different intensities. Noises may be of outdoor or indoor origin. Outdoor noises are caused by road traffic, railways, aero planes, lifts, blaring loudspeakers and various types of moving machinery in the neighborhood or in adjacent buildings.

Sound insulation is the process of soundproofing an enclosed space, such as a room. Sound proofing is any means of reducing the sound pressure with respect to a specified sound source and receptor. Sound insulation techniques are often used in business settings, as well as in recording studios, radio or television stations and other type of buildings. Materials used for sound insulation are called acoustic insulating materials. Commonly used insulating materials are given below.

1) **Acoustic Foam** – This material, commonly called Studio Foam, has a distinctive wedge or pyramid shape that is highly effective at absorbing sound. They attach to walls as panels, hang from ceilings as baffles, or sit in corners as bass traps.

2) **Sound Insulation batts** – Sound insulation are batts made of mineral wool, rock wool, and fiberglass, designed to fit in between the studs of walls. The batts fit snugly between studs to take up airspace that can transmit sound.

3) **Acoustic Panels/Boards** – These are decorative versions of sound insulation and sound absorbing foam. They are available in many appealing colors, patterns, and fabrics to serve a dual purpose in the home and workplace.

4) **Acoustic Fabrics** – Acoustical fabrics are thicker and heavier than other fabrics and used in theater curtains, blackout curtains, and studio blankets.

5) **Acoustic Coatings** – Materials like Mass Loaded Vinyl (MLV) is a dense rubber like material, used in many different situations such as car

soundproofing, machinery, appliances, and as an underlayment. The mass of the material acts as a sound barrier.

6) **Floor Underlayment** – Soundproofing a hardwood or tile floor requires the decoupling of the flooring surface and the subfloor to reduce the noise transmission. Cork, felt, and polymers are commonly used as underlayment materials.

7) **Architectural Soundproofing** – This group includes anything used in the structure of a building, such as soundproof windows, soundproof walls, doors, and decoupling products used to install them.

11.7 Decorative Panels

Decorative panels are mainly used for walls to improve the ambience of rooms, lobbies etc. These are inevitable parts in interior design of any buildings. The panels are to be waterproof, moisture-proof, fire-retardant and termite-proof. Different patterns and 3D effects are available for decorative panels. Right from conventional wooden panel to most modern PVC or Vinyl Gypsum panels are adopted as per the requirements of interior design. The main types of decorative panels are the following.

- **Natural wood wall Panels:** These are made of natural wood. Price of the panels is determined by the type of species of wood used. These panels come in diverse designs. They fit into classic interiors as well as for simple looks without any décor. Teak, Rose wood, Oak and cedar woods are used for it.

- **Chip board, Fibre board, MDF wall Panels:** Panels made of these materials are easy to work, made to any shape, but less strong and not suitable for moist environment. Panels made of veneer and MDF suit libraries, offices and big living rooms.

- **Gypsum Panels**: Also called as 3D panels, today they are one among the most popular decorative panels in the marke. They are made of a mix of plaster and other materials. These panels are quite strong but must not be used in areas which endure regular and repeated mechanical impact. such as in narrow corridors. They are also sensitive to moisture and can be used ideally in office, living room or bed room but not in a balcony. 3D panels look quite stylish.

- **Fabric Panels:** They are decorative panels which are soft to touch. Most popular designs are rectangles and squares and are used to decorate night clubs and restaurants. They can be installed as head of beds or for one wall in the bed room.

- **Leather Panels:** They are similar to fabric decorative panels. They have the same soft texture. They are expensive and incredibly beautiful. They are warm to touch. One can use decent leather that does not have same external characteristics but is cheaper and more practical. They can be used in bedrooms, office rooms, hallways and living rooms. They resemble tiles in design.

- **Glass Panels:** are designed to create photographic images that require durable base. They have several disadvantages. But with careful operation can last quite a long time.

- **PVC Panels:** The plastic wall panels are also new material made of a rigid polyvinyl chloride with a minimum amount of plasticizer. The panels can be safely used for almost any room, even in the shower, because they have a number of advantages: water-resistance, fire resistance, they are hygienic, long-life. Plastic panels are the most popular option among others.

11.8 Water proofing materials

Many situations, the building envelopes are to be made water proof for various purposes especially like water retaining structures, roofs, washroom walls and floors etc. This also requires in repair and rehabilitations works. In water proofing a layer of impervious material is applied which prevents water from penetrating, which makes the structure waterproof or water-resistant so that it remains relatively unaffected by water or resisting the ingress of water.

Commonly used materials for waterproofing in building are cementitious material, bituminous material, liquid waterproofing membrane and polyurethane liquid membrane etc

1. Cementitious materials

Cement mortar or slurry based materials added with suitable adhesives are used in places like wet areas such as toilets and bathrooms. This is a semi-flexible or rigid type of waterproofing and not exposed to weathering or

sunlight. Many companies produce these materials which are commonly used for waterproofing and easy to apply.

2. Liquid Waterproofing membrane

As the name suggests, Liquid waterproofing membrane comes in liquid form and after application it dries to form a seamless, smooth and continuous barrier to water. A primer coat and two coats of top coats which are applied by spray, roller, or trowel. It offers more flexibility than the cementitious types of waterproofing.

The liquid cures into a rubbery coating on the wall. The elongation properties of the coating can reach as high as 280%. The durability of the waterproofing coating depends on what type of polymer the manufacturer use for the making of the liquid waterproofing.

Acrylics water proofing membranes, Polyurethanes, Bituminous emulsion etc are the important materials used as liquid membranes.

a) Acrylic liquid membrane.

Acrylic polymer resins are main constituent of acrylic water proofing membrane. Pigments, plasticizers and fire retardants are also added. These are comparatively cheaper. Many brands are available in market.

b) Polyurethane liquid membrane

Polyurethane based liquid emulsion is used for surfaces which exposed to weathering. Polyurethane Liquid Membrane can offer higher flexibility. Polyurethane is very sensitive to moisture content present, therefore before application, one has to be very careful evaporating the moisture content of the concrete slab, otherwise peeling or de-bonding of membranes may happen after some time.

Though this membrane is costly, it offers good water proofing due to its high flexibility.

c) Bituminous emulsion membrane

Bitumen or Asphalt emulsions are used for coating for water proofing. The most common applications of bituminous coatings include areas that are beneath screed wet. It is an excellent protective coating and waterproofing agent, especially on surfaces such as concrete foundations.

3. Pre formed water proofing membrane

Unlike from liquid membranes, pre formed membranes are sheets made of flexible materials like bitumen, PVC or rubber etc. These are pasted by means of heating or gluing on the surface to be water proofed. Most common type is bituminous membrane.

Bituminous sheets (Tar Felt sheets) are used as bituminous membrane waterproofing. It is popular due to their proven performance. It is suitable for low sloped roofs. Bituminous waterproofing membrane have torch on membrane and self-adhesive membrane.

Self-adhesive compounds comprise asphalt, polymers and filler; additionally, certain resins and oils may be added to improve adhesion characteristics. The self-adhesive type membrane adheres to surface and the surface water proof.

Torch on membrane are to adhered by heating the membrane with a torch. Bitumen melts and adheres on the surface well.

4. Water proofing paints

A number of water proofing paints of different manufactures are available in the market. These can be applied on the surfaces after cleaning and removing the moisture like any other painting. Mainly used on exterior walls, terraces, sunshades and floors. Many of them last for certain years. The verities are

1. Masonry paint –made from ceramics and latex. Used for It is mostly used for concrete/cinder blocks, bricks, cement, stones
2. Acrylic paint – are water based and used for concrete, wood, masonry and clay tiles.
3. Epoxy paint - This paint is made from epoxy-based resin also known as polyepoxides. Epoxy Paint is used in majority form for industries such as for commercial, industrial, construction, agricultural and for electronics.

11.9 Modern uses of Gypsum

Other than the conventional uses of gypsum in cement manufacturing, fertilizer production etc. variety of materials and building components using gypsum turned out in large volumes in modern construction industry. Important uses are described in the following sections.

11.9.1 Gypsum board

(Also known as dry wall, plasterboard, wallboard, sheet rock, or gypsum panel) is a panel made of calcium sulfate dihydrate (gypsum), with or without additives, typically extruded between thick sheets of facer and backer paper, used in the construction of interior walls and ceilings.

Gypsum boards are used for partitions and lining of walls, ceilings, roofs and floors. The properties of gypsum board can be modified to fire resistant, humidity resistant and impact resistant.

Advantages of gypsum board include its low cost, ease of installation and finishing, fire resistance, non-toxicity, sound attenuation, and availability.

Disadvantages include: difficulty in curved-surface application and low durability when subject to damage from impact or abrasion.

11.9.2 Gypsum fibre board

The board is the paperless gypsum board taking fiber reinforced gypsum as the base. The inorganic fibers or organic fibers are often used as the reinforcing materials which are beat with building gypsum and retardant and then are paved, dehydrated, shaped, and dried into gypsum boards.

The boards have light weight, high strength, fireproof and soundproof properties, as well as high toughness, and are easy to be processed.

These boards are used for partitions, cupboard work and ceiling.

11.9.3 Glass Fibre Reinforced Gypsum walls

These walls are molded using glass fibre reinforced gypsum as pre fabricated with dimensions 12m long 3m wide and 124mm thick. These walls are cellular in form and weighs 45kg/sq.m. Using these walls, prefabricated buildings are done. As per the building plan, walls are arranged and fixed using cranes at site and jointed with concrete. The advantages are

76

Reduced time of construction and space saving.

Flexible in all aspects of home design

Light weight with high quality finish

Fire, Water, Termite and rot resistant

Earth quack resistant.

Environment friendly

FACT manufactures this type of walls under the trade name '*Prefab Gypwall*'

11.9.4 Gypsum plaster

Gypsum plaster, white cementing material made by partial or complete dehydration of the mineral gypsum, commonly with special retarders or hardeners added. Applied in a plastic state (with water), it sets and hardens by chemical recombination of the gypsum with water.

For especially hard finish plaster, the gypsum is completely dehydrated at high temperature, and such chemicals as alkali sulfate, alum, or borax are added. Fibre and lime or clay may be added to the plasters during manufacture. The plaster coats, except for some finish coats, are sanded.

Gypsum plaster offers good acoustic, thermal and fire resistance. No post curing is required. Painting can be done just after 48 hours.

11.10 Pre fabricated building components

Prefabrication is the method of construction which includes assembling components of a structure in a manufacturing or casting site. transporting complete assemblies or partial assemblies to the site where the structure is to be built. It is combination of good design with modern high performance components and quality controlled manufacturing procedures. This work is carried out in two stages,

a) Manufacturing of components in a place.

b) Erection in position.

The following are the main components which are frequently used in pre fabricated building are

1. Roof/Slab

Slabs are horizontal members to act as floors/roof. In prefab construction, it is achieved by placing slab segments over beams and grouted by concrete. The usual widths of these types of slabs are 0.5 m & spanning to the requirement up to a maximum limit of 5 m without pre-stressing. The different types of slab panels are

Solid flat slab b) Hollow core slab c) Single tee slab d) Double tee slab.

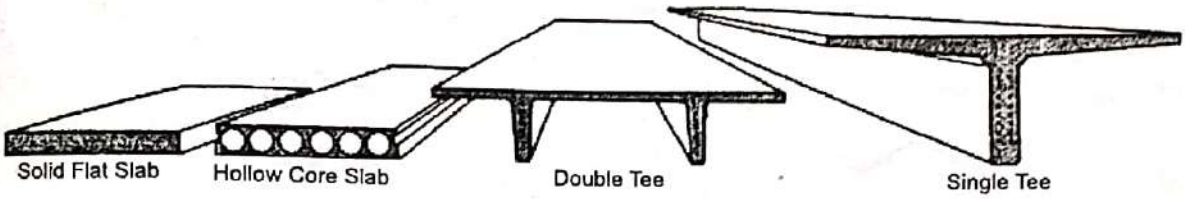


Fig. 11.2 Precast slab

2. Beams

The beams are cast for the clear distance between the columns. A square of 10 cm x 10 cm hole or a depth of 10 cm are provided on either side to achieve the connection with other beam reinforcement or column reinforcements by proper welding. After welding the concrete has to be done at the junction with proper care. Normally beams are placed over concrete haunch made on columns as shown in figure. Column and beam reinforcement, generally in the form of hooks, are left exposed. The two members are hooked together and covered with concrete at site to complete the joint. Typical sections of prefabricated beams are shown in the figure.

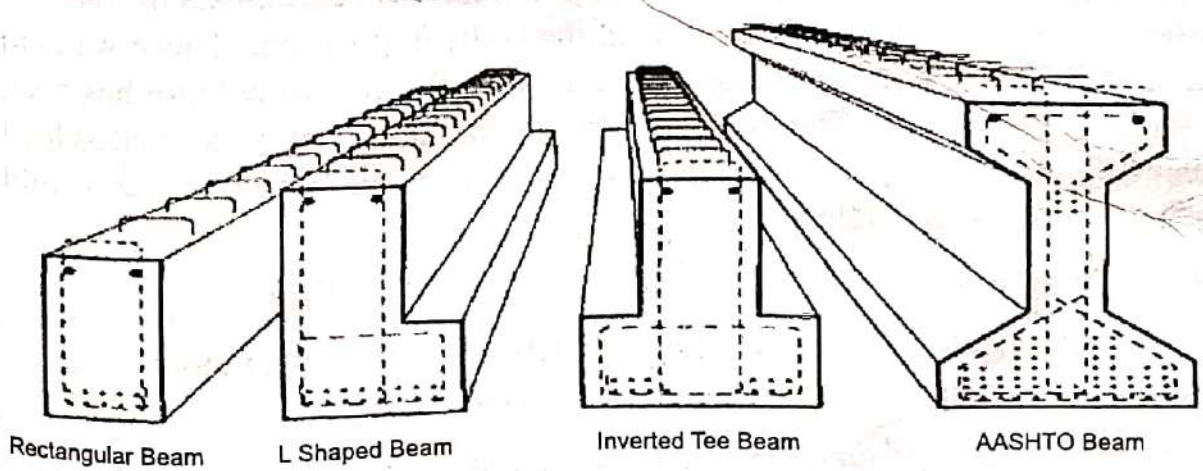


Fig. 11.3 Precast beam

3. Columns

A column is a vertical member carrying the beam and floor loadings to the foundation. Many type of columns available in prefabricated system.

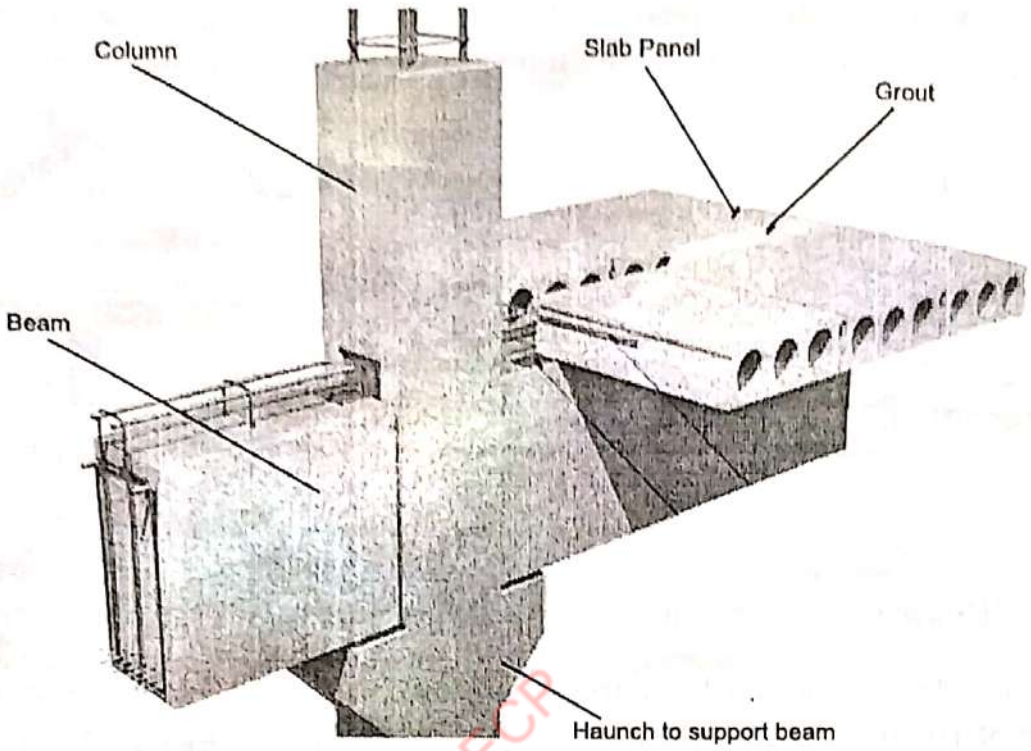


Fig. 11.4 Column joint

The main types of prefabricated columns are:

1. Edge columns – symmetrical in one direction.
2. Internal columns – symmetrical in all directions.
3. Corner columns – not symmetrical at all.

Haunches are provided at the top to support beams on columns. Grooves are provided on the required faces to keep the walls in position. These walls in grooves will act as a part of columns and since the area of column has been increased due to walls. This will give addition moment carrying as well as load carrying capacity of columns. At the same time this grooves give a mild ornamental look to building.

4. Wall panels

A wall panel is a single piece of material like concrete, timber, masonry etc usually flat and cut into a rectangular shape.

There are generally four types of prefabricated panels used as part of building envelopes:

1. **Cladding or curtain walls:** These types of prefab concrete panels do not transfer vertical loads but simply enclose the space. The wall panels are cast with all fixing like door, ventilation, and window frames.

2. **Load-bearing wall:** Load-bearing wall units resist and transfer loads from other elements and cannot be removed without affecting the strength or stability of the building.

3. **Shear walls:** Concrete shear wall panels are used to provide lateral load resisting system when combined with diaphragm action of the floor construction.

4. **Formwork for cast-in-place concrete.** In some cases, prefab panels are used as formwork for cast-in-place concrete. The prefab panels act as a form, providing the visible aesthetics of the system, while the cast-in-place portion provides the structural component of the system.

Questions

1. What are different types of architectural glass ?
2. List out the uses of ceramics in construction ?
3. Explain different types of thermal inpulating materials ?
43. Explain different types of acquastic inpulating materials ?
5. What are the composites ?
6. Explain the modern uses of gypsum ?
7. What are difficult pre-trabicated components ?