1. Advance Construction Materials

Fibres :

→ The fibres is a filament or thread like piece of any material. This term sometimes also refers to a raw material that can be drawn into threads.

→ Fibre is a small piece of reinforcing material possessing certain characteristics properties. It is a long and thin material, can be circular or flat.

→ Fibres is described by a parameter called 'Aspect Ratio'. It is the ratio of length of the fibre to its diameter or - least lateral dimension in case of flat fibres. It ranges from 30 to 150. Generally 1% of fibre is used in - concrete.

→ Fibres are used in concrete to control cracking due to plastic shrinkage and drying shrinkage.

→ Fibres are considered as a construction material to enhance the flexural and tensile strength.

Types of fibres :

Following are the various types of fibres used as a - construction material :

1) Steel fibres
2) Carbon fibres
3) Glass fibres
4) Plastic fibres

(1) **Steel fibres :** Steel fibres is one of the most commonly - used fibres. The diameter may vary from 0.25 to 0.75mm.

→ The key characteristic of steel fibres is their high tensile capacity i.e 280 to 440 N/mm², as well as high Young Modulus.

- The steel fibres is likely to get rusted & loose some of its strength.
- Use of steel fibres makes significant improvements in flexural, impact and fatigue strength of concrete.
- Steel fibres can be an additive (ideal) to specific applications as they possess good electric, magnetic and heat conductivity.

Properties of steel fibres:

Following are the properties of steel fibres:

(a) Steel fibres are more tough and hard.
(b) They are more elastic in nature and avoid corrosion & crack strains.
(c) They increase the tensile strength of concrete.

Uses of steel fibres:

Following are the uses of steel fibres:

(a) These fibres has been extensively used in various types of structures, particularly for overlays of roads, airfield pavements, bridge decks.
(b) They are used in precast concrete construction.
(c) They are used in tunnel lining work.

(2) Carbon fibres:

- Carbon fibres have very high tensile strength 2110 to 2815 kg/mm² and young's modulus.
- These are very costly.
- It has been reported that cement composite made with carbon fibres as reinforcement will have very high modulus of elasticity and flexural strength.
The limited studies have shown good durability.

~ Properties of Carbon-fibres :

Following are the properties of carbon-fibres :

(a) Carbon fibres are chemically inert and resistant to corrosion.

(b) They have high tensile strength.

(c) Carbon fibres have low thermal expansion and the fibres content about 85% carbon has good flexural strength.

(d) They are available in low weight.

~ Uses of carbon fibres :

Following are the uses of Carbon Fibres :

(a) The use of carbon fibres for structures like cladding, Panels and shells will have promising future.

(b) Carbon fibres are most commonly used in reinforcing composite material.

(c) These are used in reinforced carbon concrete, in which they increase tensile as well as compressive strength of the concrete.

(d) Glass fibres :

→ Glass may be softened and drawn mechanically into threads for glass wools that is finer than silk. A glass strand composed of 60 filaments. Each filament having a diameter of 0.0036 mm possesses the tensile strength 19500 kg/m² approximately. However glass fibre may have a tensile strength approaching 40,000 kg/m².

→ A strand glass fibre may be 1/15 of the diameter of human hair but have a tensile strength of steel. These may be woven into fabric and used in loosely packed form for both sound and thermal insulation in building.

→ The thermal conductivity of the material ranges from 0.035 to 0.045 kcal/m-hr-deg depending on the bulk density. Tests have shown that 25mm of glass wool is equivalent in terms of thermal insulation of 42mm of brick or 62cm of concrete.

→ Properties of glass fibres:

Following are the properties of glass fibres:

(a) Glass fibres has good thermal insulation.

(b) It has excellent corrosion resistance and moisture resistance.

(c) It has good tensile strength.

→ Uses of glass fibres:

(a) The glass reinforced plastic is used in the manufacturing of corrugated sheeting, mainly used for roof lights and also used for interior panelling and decorations.

(b) It is also used for sound deadning and thermal insulation in walls, floors and ceiling.

(c) The glass fibres are used for packing and making fabrics and felts.

(4) Plastic fibres:

→ Polypropylene, nylon, polyethylene, rayon, acrylic and polyester fibres are found to be suitable to increase the impact strength. They may possess very high tensile strength, but their low modulus of elasticity and higher elongation do not contribute the flexural strength.

→ As for example polypropylene has a tensile strength of

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560 to 765 N/mm², Young's modulus of 5750 N/mm² and ultimate elongation 15-25 percent. It imparts better fracture-toughness, better chemical stability and a great resistance against explosive loads.

Plastics:

→ High Polymers are the magic construction materials of the coherent era. They include engineering materials like plastics, rubbers, fibreglass etc.

→ Plastics specially have occupied an indispensable position in our day to day life. They have replaced a number of traditionally used materials.

→ All modern industries like radio, telephone, electric motors, automobiles etc. are basically dependent upon plastics.

→ Plastic is any substance which shows the property of plasticity. Plasticity is the property, by virtue of which, a material undergoes a permanent deformation, when subjected to heavy and continuous stress of pressure.

Plastic as a construction Material:

→ Plastic is a general name given to a wide range of synthetic materials that are based on Polymers. Their plasticity makes it possible for plastics to be moulded, extruded or pressed into solid objects of various shapes. The construction industry uses plastic for a wide range of applications because of its versatility, strength to weight ratio, durability,

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corrosion resistance, and so on.

→ Plastics can be manufactured into forms such as pipes, cables, coverings, panels, films, sheets and so and can be formed or expanded to create low-density materials, and be dissolved into solvents.

→ Some of these plastics main uses in the construction industry are:
cladding panels, cables, pipes and gutters, windows and doors, shuttering, wall lining, floor coverings, ceiling panels, roof coverings, sinks, basins, baths, showers.

→ The advantage of using plastics in construction are that it is lightweight yet strong which makes it easier to transport and shift around sites. It is also resistant to rot and corrosion and has strong wearing ability due to it being capable of achieving high scale. Plastics are also available in a wide range of colours and shades.

→ The disadvantage of plastics are that it has a high embodied energy content and a low modulus of elasticity, means that it is generally unsuitable for load bearing applications.

→ Properties of Plastics:
Following are the properties of plastics:
(a) Plastics are very light in weight.
(b) Plastics have low electrical and thermal conductivity.
(c) Plastics can be transparent, translucent or opaque.
(d) Plastics can be formed and moulded into any shapes.
(e) Plastics have good sound absorption properties, good

tensile strength, good resistance to peeling and good dimensional stability.

→ Plastics are durable, cost effective, and energy saving

→ Plastics are easy to install.

Types of Plastics:-

→ Plastics are classified on the basis of reaction by which they are formed.

Following are the two types of plastics :- (on the basis of Reaction)

(1) Thermosoftening plastics

(2) Thermosetting plastics   Chains of single monomer

(1) Thermosoftening plastics:- These are also called as thermoplastics and are formed by additional polymerisation. These plastics can be softened by heating, reshaped and reused as many times as desired.

→ These are soluble in suitable organic solvents.

→ The common examples are polythene, polyvinyl, Cellulose nitrate, etc.   carboxylic acids

alcohols

(2) Thermosetting Plastics:- These types of plastics are formed by condensation polymerisation. These plastics cannot be remoulded and reused. The thermosetting plastics are insoluble in organic solvents. Means & there is elimination of water molecule

→ The common examples are bakelite, Polyester etc.   form acetone

→ The difference between thermosoftening plastics and thermosetting plastics are as follows:-

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Difference between thermosoftening and thermosetting Plastics:

Thermosoftening	Thermosetting
1) These are formed by Polymerization by addition	1) These are formed by polymerization by condensation
2) They consist of linear structure of long chains with negative number of cross-links.	2) They have three dimensional networks of chains, joined prominent cross-links.
3) The secondary bonds between the chains are very weak which can be easily broken by heat or pressure.	3) These bonds retain strength upon heating, which do not get broken on applying heat or pressure.
4) Heat converts these plastics into a fluid type material. Hence they can be reshaped and reused.	4) They retain their original shape and structure even on heating. so, they cannot be re shaped or reused.
5) They are usually weak, soft and less brittle.	5) These are strong, hard and less brittle.
6) Because of weak bonds they are soluble in organic solvents.	6) Because of strong bonds they are insoluble in the organic solvents.

→ Different types of Plastics used in the construction are:-

(1) PVC (2) RPVC (3) HDPE (4) FRP (5) GRP (6) CPVC
(7) Coloured Plastic sheets

(1) PVC (Polyvinylchloride) :-

→ It is one of the most commonly used polymers produced by polymerization of vinyl chloride. It is widely employed in fabrication of Plastics.

→ PVC is usually available in the form of a white amorphous powder commercially, having a density of about 1.4 g cm^{-3}.

→ PVC can be manufactured in expanded or cellular form. It is available in two forms, in flexible and in rigid form. It can be easily moulded and extruded into rigid shape. The joints are obtained by solvent-welding.

→ This is the cheapest and most widely used plastics.

Properties of PVC :-

Following are the various properties of PVC:

(a) It is flexible, strong, tear resistance, and good ageing property.

(b) It becomes soft beyond 80°c when heated to more than 130°c it disintegrates and gives off hydrogen chloride.

(c) The electrical properties are not as good as those of rubber, but it offers more resistance to oxygen, ozone and sunlight.

(d) It has light weight and resistance to wear.

Uses of PVC :-

Following are the uses of PVC:

(a) It is used for flooring, wall facing, various extrusions like hand rails, skirt boards, pipes, fillets etc.

(b) It is used for cable jackets, lead-coate insulation, fabric coating etc.

(c) It is used for corrugated roofing sheets, rainwater goods.

(d) It is used to manufacture water pipes and its accessories, raincoats, and shower curtains etc.

(e) It is used in plastic paper pipe systems for pipelines of waters and sewers.

(f) It is used in magnetic strip cards, vinyl siding, window profiles, plumbing and conduit fixtures, gramophone records etc.

2) RPVC (Rigid Polyvinyl Chloride)

The rigid polyvinyl chloride (RPVC) is also known as Ultra-plasticized polyvinyl chloride (UPVC). This material is available in a range of colours and finishes including a photo-effect wood finish and is used as a substitute of painted wood.

Properties of RPVC:-

Following are the properties of RPVC:-

(a) RPVC is more durable and hard.

(b) It has high tensile strength.

(c) It is more rigid and has high resistance to chemical action.

(d) It is corrosion resistant.

Uses of RPVC:-

Following are the uses of RPVC:-

(a) RPVC is used as a substitute of painted wood.

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(b) It is used in plumbing and drainage works.
(c) It is often used as a low maintenance material in building industry.

3) HDPE (High Density Polyethylene):

→ This is obtained by low pressure polymerization process. This is a thermoplastics polymer produced from the monomer ethylene.

→ Following are the various properties of high density polyethylene:

(a) It has specific gravity 0.96 and softening temperature 120°-130°C.

(b) It is wax like in appearance, translucent, odourless.

→ HDPE piping systems have been used for municipal and industrial water applications for over 50 years. Within Building & construction Divisions, HDPE pipes are used for ground source geothermal applications, also known as earth energy or geoexchange systems.

4) FRP (Fibre-reinforced plastics):

→ The Fibre glass reinforced plastics is formed by using two materials in conjuction with each other to form a composite material of altogether different properties.

→ In the FRP, the glass fibre provide stiffness and strength while resin provides a matrix to transfer loads to the fibres.

→ FRP bars are used as internal reinforcement in concrete structures.

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→ FRP bars, sheets and strips are used for strengthening of various structures constructed from concrete, masonary, timber and even steel. Fibre reinforced plastics are also used in the construction of special structures requiring electrical neutrality.

5) GRP (Glass Reinforced Plastic):

→ This is a composite material made of a plastic reinforced by fine glass fibre. This plastic is formed by combining the glass fibres and plastic resins. The glass fibres are very strong in tension but weak in compression, whereas the plastic resins are strong in compression and weak in tension.

→ It is a very popular composite material to use because not only it is very strong but also surprisingly light.

6) CPVC (Chlorinated Polyvinyl Chloride):

→ CPVC stands for chlorinated polyvinyl chloride. It is a thermoplastic pipe fitting material made of compounds.

→ CPVC products are specially used for portable water distribution and corrosive fluid handling industry etc. It is very cost-effective system.

7) Coloured Plastic Sheets:

Plastic film is a thin continuous film material. Thicker plastic material is often called a "sheet". Plastic sheets are generally low cost, easy to manufacture, durable, strong for their weight, electrically, and thermally insulative, and resistant to shock, corrosion, chemicals, and water.

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The uses of plastics in construction activities and its commercial forms

Sl.no	Use	Commercial Forms
1)	Doors and windows, building hardware	Substrate for sliding doors, door paper, door pull, knob, blind, screen, curtain, door rollers, frame panels, covering for handrails, laminates for joinery etc.
2)	Sanitary fittings	Ventilation fans, duct, sanitary textures, w.c seat, septic tank, hot water pipe, chemical and medicine cabonates, flushing-cistern, moulding, cistern.
3)	structural members carrying stresses, vibrations, impact etc.	Tension and compression members, automobile parts, components with stresses, valves, gears, frame, spacers, Neoprene bridge-bearings.
4)	Exterior Walls	sheathing, window sills, louvers, sign panels, siding boards, spraying materials, paints, thin and light wall tiles, wall linings.
5)	Interior Floors	Floor tiles, composite flooring, material carpet, water-proofing sheets for the unfloored part of the house.

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6)	Exterior Roof	Corrugated sheets, gutter, water proofing materials, thermal insulations etc.
7)	Interior walls Finishes	Decorative panels, composite plywood jointer, wall paper, texture paints, adhesives, distempers etc.
8)	Ceilings	Ceiling louvres, spraying materials, paints etc.
9)	Water Supply Fittings	Pipes, showers, shower heads taps, bend, cocks, tanks etc.
10)	Insulation	Insulation sheets, panels, etc.
11)	Moisture barrier films	Thin films, sheets, spraying materials, linings of cotton

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Artificial Timbers:

→ Artificial Timber or Industrial Timber is nothing but timber products, manufactured scientifically in the factories or which is converted in a factory by some mechanical processes.

→ Such timber possesses desired shape, appearance, strength and durability.

Properties of Timber: (Artificial)

A good artificial timber should possess the following properties.

(a) **Weather Resistance:** It should possess adequate resistance against weathering effect such as alternate drying and welting, alternate heating and cooling because of temperature variations, wind effects etc.

(b) **Durability:** It should be capable of resisting the various action due to fungi, insects, chemical, physical and mechanical agencies.

(c) **Fire resistance:** The artificial timber should offer sufficient resistance against fire so that it does not easily ignite. It helps in fire protection in the buildings.

(d) **Workability:** The artificial timber should be easily workable and should not clog the teeth of saw. It should be capable of being easily planed or made smooth.

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(e) Elasticity :- The timber should be capable of regaining its original shape when load causing / causing deformation is removed. This property is important when it is to be used as bows, carriage shafts, sports goods, wooden beams and wooden floors.

(f) Toughness and abrasion :- It should be capable of offering resistance to shocks due to vibration and should not deteriorate due to mechanical wear.

(g) Soundness :- It should have sufficient weight. An artificial timber with sufficient weight is considered as sound and strong.

(h) Hardness :- It should have sufficient hardness ie. the resistance against penetration. When the artificial timber is hard, it resists the abrasive action as for it is used flooring, mallets, tool handles, railway and bearing shafts.

(i) Resistance to shear :- The artificial timber have closely interlocked is very strong in shear across even along the grains.

(j) Strength :- The artificial timber should be strong enough to withstand the loads whether being applied slowly or suddenly. It should possess enough strength in direct compression and transverse direction.

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Uses of Artificial Timber:

Following are the uses of artificial timber:

(a) Artificial timber is corrosion resistant, and hence it can be used where the corrosion is likely to occur in the structures.

(b) It is convinient in maintenance and superficial similarity to wood.

(c) It is used to make various structural member.

(d) It is used in maintenance work.

(e) It is also used as ceiling proofing material in the building construction.

(f) It is used to make doors and window frames.

(g) It is used for making the planks, square and round shape for furniture.

(h) Density can be varied in between 0.8 to 1.2 kN/m³ depending on the requirements.

Types of Artificial Timbers:

Following are the various types of artificial timbers:

(a) Veneers
(b) Plywoods
(c) Particle Board
(d) Fibre Board
(e) Batten Boards
(f) Impreg Timbers

(a) Veneers:

- Veneers are nothing but thin layers of wood which is obtained by cutting the wood with the sharp knife in rotary cutter.
- In rotary cutter, the wood log is rotated against the sharp knife or saw and cut it into thin sheets. These thin sheets are then dried in kilns and finally veneers are obtained.
- Veneers are used to manufacture different wood products like plywood, batten boards, particle boards.

(b) Plywoods:

- Ply means thin. Plywood is a board obtained by adding thin layers of wood or veneers on one above each other.
- The joining of successive layers is done by suitable adhesives. The layers are glued and pressed with some pressure either in hot or cold condition.
- In hot conditions 150 to 200°c temperature is maintained and hydraulic press is used to press the layers.
- In cold conditions room temperature is maintained and 0.7 to 1.4 N/mm² pressure applied.
- Plywood has so many uses. It is used for doors, partition walls, ceilings, panelling walls, formwork for concrete etc.
- Due to decorative appearance, it is used for buildings like theatres, auditoriums, temples, churches, restaurants etc in architectural purpose.

→ Advantages of Plywoods:-

(i) It is light in weight, still many times stronger than solid wood of same thickness.

(ii) It is resistant to cracking, warpings, splittings and has uniform strength in all the directions.

(iii) It is available in many sizes, and is defect free, easy to cut, bend and variety of decorative finishes are available.

(C) Particle Boards:-

→ In particle Boards or chip boards, particle or chips (obtained from low grade wood, wood particles or rice husks, smaller diameter logs derived from thinnings etc) are mixed with strong adhesives or dissolved in the resins and are compressed together under high (↑) Pressures to form a board.

→ Properties of particle board largely depends upon the adhesives and particle shapes.

→ Particle Boards are used for flooring, partitioning or wall panelling, ceiling tiles for auditorium, computer centres, false ceilings, doors core material, furnitures for residential and office uses etc. It is also used in making computer tables, book shelves, etc.

(D) Fibre Boards:-

→ Fibre Boards are also called as pressed woods or reconstructed woods.

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→ Fibre boards are rigid boards manufactured with wood fibres, wood waste like saw dust, small pieces of woods.

→ Wood is chipped into small pieces of about 20mm size and are boiled in hot water. These wet particles are then passed into an autoclave, where it is subjected to steam pressure of 2300 kN/m² for about ½ minute and thereafter to a pressure of 7000 kN/m² for a few seconds.

→ Fibre boards are used for several purposes in the construction industry such as for wall panelling, ceiling partitions, flush doors, flooring materials etc.

→ They are also used as sound insulating material.

(e) Batten Boards:

→ In all these boards, thin veneers are used on the faces and are glued to the core. Veneers may be decorative or non-decorative. Grains of veneers are at right angle to those of cores.

→ In batten boards core consist of about 8cm wide wooden strips called as battens. If the width of the strips is less than 2.5cm, it is called as block boards. In laminated boards, width of core strips are less than 7mm.

→ Batten boards and block boards are used for making partitions, packing cases, furniture panelling, ceiling, interior decoration work, bus bodies etc., however are liable to crack or split. Laminated boards are stronger than block boards and are not liable to crack or split

(4) Impreg Timbers:-

→ Impreg timber is a timber covered fully or partly with resin.

→ Thin layers of wood or veneers are taken and dipped in resine solution.

→ Generally used resin is phenol formaldehyde.

→ The Resin solution fills up the voids in the wood and consolidated mass occurs. Then it is heated at 150 to 160°C and finally impreg timbers develope.

→ This is available in markets with different names such as sunglees, sunmica, formica etc.

→ Impreg timbers has good resistance against moisture, weathering, acids and electricity. It is strong, durable and provide beautiful resistance.

→ It is used form making wood moulds, furnitures, decorative products.

→ Strength of artificial timbers:-

→ This artificial timber should be strong enough to withstand the loads whether being applied slowly or suddenly.

→ It should possess enough strength in direct compression and transverse direction.

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Miscellaneous Materials:

Acoustic Materials:

- Acoustics is the science that deals with the production, control, transmission, reception and effect of sound.
- It is the science of controlling sound within the buildings.
- When the sound intensity is more, then it gives a great trouble or nuisance to the particular area like the auditorium, cinema hall, studio, recreation centre, entertainment hall, college reading hall etc. Hence it is very important to make that area or room to be sound proof by suitable Material called as the 'Acoustic Materials'. It is measured in decibles (db).
- Acoustic material plays a vital role in the various areas of building construction, so as to control the outside as well as inside sound of the various buildings such that sound will be audible without any nuisance or disturbance.

Types of Acoustic Materials:

- Acoustic Plaster
- Acoustic tiles
- Fibrous plaster
- Foam glass
- compressed fibre boards
- Thermocol
- Perforated Plywood
- Acoustic Pulp
- straw Board
- Asbestos cement boards
- Hair felt

etc.

Some types of Acoustic Materials are explained below:

→ Acoustic tiles:

→ These materials are available in market under diff. treade names. It is manufactured in the factory.

→ Advantages of such tiles is that the absorption of sound is uniform from tile to tile and can be easily fixed to any surface and they are costly but most suitable for smaller area where acoustical treatment is required.

→ Acoustic Pulp:

→ This is mainly composed of asbestos and cellulose fibre mixed with certain binders and preserving chemicals.

→ This dry fibrous material, on addition of water - becomes plastic and can be applied to the wall and ceiling surface to a thickness of upto 2cm.

→ The material is applied in layers of 6mm thickness, in the same manner as plaster. Being plastic it can be - easily shaped and finished.

→ Fibrous plastic:

→ This type of material is also known as acoustic plaster. It is made by mixing of cement and granular insulating material.

→ The preparation of the cement should be properly - maintained so as the plaster should be more effective for acoustic.

→ Acoustic Plaster boards are also used and can be fixed on the wall.

Acoustical Boards or Tiles :

- They are usually made of either compressed cane or wood fibre or mineral wool.
- These are boards and tiles have uniform physical and sound absorption characteristics.
- They are prefinished at the factory and can be painted or coloured to give desirable decorative appearance and light reflection characteristics.
- These are very costly as compared to other acoustical materials.

Properties of Acoustic Material :

1) Sound energy is captured and absorbed.
2) It has a low reflection and high absorption of sound.
3) Higher density improves the sound absorption efficiency at low frequencies.
4) Higher density material help to maintain a low flammability performance. Hence acoustic materials should have higher density.
5) It controls the sound and noise levels from machinery, other sources for environmental amelioration (betterment) and regulatory compliance.
6) Acoustic material reduces the energy of sound waves as they pass through.
7) It suppresses echoes, reverberation, resonance and reflection.

Uses of Acoustic Material :-

1) Acoustic materials can be used for noise reduction and noise absorption. It makes the sound more audible which is clear to listen without any disturbances.

2) It suppresses echoes, reverberation, resonance and reflection.

3) Sound proof doors and windows are designed to reduce the transmission of sounds.

4) A vinyl acoustic barrier blocks/controls airborne noise (street traffic, music) from passing through a wall - ceiling or floor.

5) Acoustic foam and ceiling tiles absorb sound so as to minimize echo and reverberation within a room.

Wall claddings :-

→ Wall cladding is a type of decorative covering intended to make a wall look like it is made of a different - sort of material than it actually is.

→ Some of the most common examples are on the outside of the buildings, but cladding can also be used as an - aesthetic material / element in the interior decorations.

→ The most common types are :-
Stone claddings, Brick claddings, Metal claddings, Timber claddings, concrete claddings, Glass claddings, etc.

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→ Wall cladding can give a building a new look and a new life. For the building it can be used to increase the service life of the structure which increase the value of the buildings.

→ It can also improve the thermal, acoustical, natural daylight Performance, and appearance.

→ It is used as weather resistant material in the exterior wall of the buildings.

Plaster Boards

→ Plasterboard is a panel made of calcium sulphate dihydrate (gypsum) usually pressed between a facer and a backer. It is used to make interior walls & ceilings.

→ This 'drywall' construction became popular as a quicker alternative to the traditional lath & Plaster.

→ Plasterboard is used to help builders and designers meet building regulations for fire protection, acoustic insulation and thermal efficiency.

→ It is light weight and easy to install, and are used to create features such as curved walls.

→ Plasterboards also helps to control moisture, vapour and water.

→ These boards are readily available in the market with different variety.

→ The boards neither expand nor contract due to the change in temperature.

Micro Silica :-

→ Micro silica is a light-grey cementitious material composed of atleast 85 percent ultrafine, amorphous non-crystalline (glassy) spherical silicon dioxide (SiO_2).

→ It is also called as silica fume. It is by-product during the manufacturing of silicon metal or ferro-silicon alloys by reduction of high purity quartz in a submerged arc electrical furnace heated to 2000°C with coal, coke and wood chips as fuel.

→ Micro silica or silica fume is an excellent admixture for concrete as it leads to better engineering properties.

→ It reduces thermal cracking, improves durability and increases strength.

Properties of Micro-silica :-

Following are the properties of Micro-silica :-

(a) Specific gravity = 2.20

(b) Its Bulk density varies from 200 to 350 kg/m^3.

(c) It has a minimum surface area of 15,000 m^2/kg.

(d) The content of SiO_2 is at least 85%.

(e) It gives long term corrosion protections.

Advantages of Micro-Silica :-

It gives better application when added with portland cement.

(a) Micro-silica increases the compressive strength.

(b) It improves the sulphate resistance.

(c) It reduces water permeability
(d) It improves abrasion and chemical resistance.
(e) It reduces efflorescences

Uses of Micro-Silica:

→ This material has very recently found its application in our country in the nuclear power plants and bridge construction.

→ Micro-Silica have been used extensively in off shore concrete platforms, high rise multistoried buildings etc and various other structures demanding high performance in very aggressive environmental conditions

Artificial Sand:

→ Artificial Sand, also called crushed sand or manufactured sand, refers to rocks, mine tailings, or industrial waste granules with a particle size less than 4.75 mm which are processed by mechanical crushing and sieving, but does not include soft or weathered granules.

→ Artificial sand is a specific purpose produced materials, which will satisfy the strength, durability, size, shape, grading requirement of fine aggregate in concrete mix. The stone metal or crushed stone waste below 20mm from good parent rock is fed to the disintegrator.

Properties of Artificial Sand:

Following are the properties of Artificial Sand:

(a) The density of artificial sand lies in between 18 to 25 kN/m³
(b) It does not contain any organic impurities.

(c) Specific gravity of artificial sand lies between 2.65 to 2.8.

Advantages of Artificial Sand :-

(a) Artificial sand is well graded.
(b) This sand have superior surface texture.
(c) It can be compacted properly to reduce the voids.
(d) Less quantity of cement material required.
(e) It can be produced by required or desired quantity.
(f) If economy at large is considered, artificial sand many times proves to be economical.

Uses of Artificial Sand :-

→ Artificial sand often used as filler between aggregate and cement.
→ It can also be used in concrete, brickwork etc.
→ They can also be used for concrete projects like ports / water conservancy.

❖ Bonding Agents :-

→ Bonding Agents are natural, compounded or synthetic material used to enhance the joining of the individual members of a structure without using mechanical fasteners.
→ These products are often used in repair applications such as the bonding of fresh concrete, sprayed concrete, fresh mortar and old concrete.
→ The most commonly used types of bonding agents are generally made of natural rubber, synthetic rubber or any other organic Polymer.

→ With the addition of bonding agents to repair mortar on concrete, the reduced water-cement ratio is adopted for the same workability, thereby reducing drying shrinkage.

→ Following are the various types of emulsions used as bonding agents in the construction work.

(1) Epoxy Latex :-

→ These emulsions are produced from epoxy resins mixed with the curing agents.

→ Most of the epoxy resins are prepared on the job site just before the use because phase separation occurs in packed emulsions.

→ Equal parts of epoxy and curing agents are mixed, then blended for 2 to 5 minutes and allowed to set for 20 minutes to enable polymerization to begin.

(2) Styrene Butadiene (SBR) :-

→ This latex is compatible with cementious compounds which is a copolymer.

→ This latex may coagulate if subjected to high temperatures, freezing temperatures, several mechanical action for prolonged period of time.

(3) Polyvinyl Acetate Latex (PVA) :-

→ This type is most commonly widely used as a bonding agent for plaster.

→ Because of its compatibility with cement, it is widely used as a bonding agent and a binder for cementitious water based paints and water proofing coatings.

(4) Epoxy Bonding agents :-

→ For the bonding of freshly placed concrete, various products are available.

→ Most products contains resins that are 100% solids.

→ Products are available in variety of consistencies, ranging from a highly filled paste (for overhead tank) to liquids with a viscosity of 100 cp, which is similar to water.

→ Adhesives :-

→ Adhesion is the attraction between unlike surfaces.

→ Adhesives are bonding agents used to join different materials generally by gluing.

→ Construction adhesive is a general-purpose adhesive used for attaching drywall, tiles and fixtures to walls, ceilings, and floors.

→ It is most commonly available in tubes intended for use with a caulking gun.

Advantages of Adhesives :-

→ Adequate strength is produced by using adhesives.

→ Corrosion may be prevented between different materials joined by adhesives.

→ The adhesive application process is economical, easy & speedy.

→ Leakage problem of water can be stopped by the application of adhesives.

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Disadvantages of Adhesives:

- Adhesives requires time to attain desired strength.
- Adhesives are unstable at high temperature.

Different types of adhesives used in construction work:

Adhesives may be found naturally or produced synthetically. There are different types of adhesives used in construction, some of them are given below:-

(1) Polymer adhesives
(2) Hot melt adhesives
(3) Acrylic adhesives
(4) Resin adhesives
(5) Epoxy adhesives
(6) Pressure adhesives

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Prefabrication :-

- Prefabrication is the practice of assembling components of structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction sites where the structure is to be located.
- The term 'prefabrication' describes assemblies that are manufactured under factory condition and then transported to construction site for incorporation into buildings or civil engineering works.
- In simple words prefabrication is the creation of a building's components offsite, generally factory, and then assembling the building onsite.
- The method controls construction costs by economizing on time, wages and materials.
- Prefabricated units may include doors, stairs, windows, walls, wall panels, floor panels, roof trusses, room size components and even entire building.
- The term is used to distinguish the process from the more conventional construction practice of transporting the basic material to the construction site where the assembly is carried out.

Necessity of prefabrication:-

- Prefabrication provides satisfactory results to the construction industry.
- Improved productivity and profitability.

→ Environmental benefits associated with its use:
→ Maintenance cost is low.
→ It reduces waste generation and ecofriendly
→ It saves time and accelerates the construction process

Scope of prefabrication:

→ Prefabrication is more efficient, low cost, time saving, reduce the wastage, reduce the manpower, maintenance is less, and also the materials can be reused

History of prefabrication:

→ Prefabrication has been used since ancient times, for example, it is claimed that the world's oldest known engineered roadway, the sweet track constructed in england around 3800BC, employed prefabricated timber sections brought to the site rather than assembled on site.
→ Sinhalese kings of ancient Sri Lanka have used prefabricated buildings technology to erect giant structures, which dates back as far as 2000 years where some sections were prepared separately and then fitted together, specially in the kingdom of Anuradhapura and kingdom of polonnaruwa
→ After the great lisbon earthquake of 1755, the portuguese capital, especially the Baixa district was rebuilt by using prefabrication on an unprecedented scale.

- In 19th century Australia a large number of prefabricated house were imported from the United kingdom.
- The method was widely used in the construction of prefabricated housing in the 20th century, such as in the UK as temporary housing for thousands of urban families 'bombed out' during world war II.
- The Crystal Palace, erected in London in 1851, was a highly visible example of iron and glass prefabricated construction, it was followed on a smaller scale by oxford Rewley Road railway station.
- Prefabrication in India began with the emergence of the Hindustan Housing Factory.
- The company was developed by the first Prime Minister of India, Pandit Jawaharlal Nehru from west pakistan in 1950s.
- The Hindustan Housing Factory produced the pre-stressed concrete railway sleepers to replace dilapidated wooden sleepers on Indian Railways.
- Then the company changed its name known as the Hindustan Prefab Limited or HPL.

Current use of prefabrication:

- The most widely used form of prefabrication in buildings and in civil engineering is the use of prefabricated concrete and prefabricated steel sections in structures where a particular part or form is repeated many times.

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→ Pouring concrete sections in a factory brings the advantage of being able to reuse moulds and the concrete can be mixed on the spot without having to be transported to and pumped wet on a congested construction site.

→ Prefabricating steel sections reduces on site cutting and welding costs as well as the associated hazards.

→ Prefabrication techniques are used in the construction of apartment blocks, and housing developments with repeated housing units.

→ This techniques is also used in office blocks, warehouses and factory buildings.

→ Prefabricated steel and glass section are widely used for the extention of large buildings.

→ Detached houses, cottages, log cabins, caravans etc. are also sold with prefabricated elements.

→ Prefabricated bridge elements and systems offer bridge designers and contractors significant advantages in terms of construction time, safety, environmental impact, constructability and cost.

→ Radio towers for mobiles and other services of tens consist of multiple prefabricated sections.

→ Prefabrication has become widely used in the assembly of aircraft and spacecraft, with components such as wings etc often being manufactured in different countries or states from the final assembly site.

→

Types of prefabricated systems:-

→ The system of prefabricated construction depends on the extent of the use of prefab components, their material, sizes and the technique adopted for their manufacture and use in the building.

→ It is a method of construction of buildings by using prefabricated components which are inter-related in functions.

→ The degrees of flexibility varies from system to system.

→ The various types of prefabrication system are:

(i) Open prefab system
(ii) Large panel prefab system
(iii) Frame system
(iv) Lift slab system
(v) Box-type system

(i) Open prefab System:- This system is based on the use of basic structural elements to form whole or part of building. The standard prefab concrete components which can be used are: prefabricated slabs, prefabricated beams, columns, precast lintels and chajjas etc.

→ Foundation for the columns could be prefabricated or conventional cast-in-situ depending upon the soil cond and load.

→ The columns may have hinged or fixed base connections depending upon the type of components used and method of design adopted.

→ There are two categories of open prefab systems depending on the extent of prefabrication used in construction as :-

(a) Partial Prefab open system
(b) Full prefab open system.

(a) Partial prefab open system :-

→ This system basically emphasizes the use of precast roofing and flooring components and other minor elements like lintels, chajjas, kitchen sills in conventional building construction

(b) Full prefab open system :-

→ In this system almost all the structural components are prefabricated.
→ The filler walls may be of bricks or any other local materials.

(ii) Large panel prefab system :-

→ This system is based on the use of large prefab components.
→ The components such as precast concrete large panels form walls, floors, roofs, balconies, staircase etc.
→ Both horizontal and vertical members are load bearing.
→ The prefabricated large panel walls can be classified as :-

(a) cross wall system
(b) longitudinal system

(a) Cross wall system:

→ Cross walls are load bearing and facade walls are non-load bearing.

→ Suitable for high rise buildings

(b) Longitudinal wall system:

→ cross wall is non-load bearing and longitudinal walls are load bearing.

→ Suitable for low-rise building.

* A combination of the above system with all load bearing walls can also be adopted.

→ Precast-floors: precast-flooring units could be homogeneous or non-homogeneous

Homogeneous floors:

→ could be solid slabs, cored slabs, etc.

Non-homogeneous floors:

→ could be multi-layered ones with combinations of light weight concrete or prestressed concrete.

(iii) Frame Systems:

→ components are usually the linear elements.

→ The beams are seated on the corbels of pillar usually with hinged joints.

→ joints are filled with concrete at site.

→ Complete frame are transported to the construction site.

(iv) Lift-slab system :-

→ These are partially prefabricated in plants (pillars) & partially precasted on site slabs.

→ It consist of one or more high pillars (max 5)

→ upto 30 storey high construction is possible.

→ consist of specially designed joints and temporary joints.

→ slabs are casted on the ground (one on top of another) and then lifted with cranes and elevators.

(v) Box type system :-

→ In this system room size units are prefabricated & erected at site.

→ Toilets and kitchens block could also be similarly prefabricated and erected at site.

→ This system derives its stability and stiffness from the box units which are formed by four adjacent walls which are joined to make rigid connection.

Classification of prefabrication :-

The prefabrication is classified as :-

(1) Small prefabrication
(2) Medium prefabrication
(3) Large prefabrication
(4) Partial prefabrication
(5) Open system prefabrication
(6) Closed prefabrication

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(7) Total Prefabrication
(8) Cast-in site prefabrication
(9) off-site prefabrication.

(1) Small Prefabrication :-
→ The prefabrication is done in the smallest scale.
→ For example :- Brick is a small unit precasted and used in buildings.
→ This is called as small prefabrication because the degrees of prefabrication is small.

(2) Medium Prefabrication :-
→ The prefabrication is done in the Moderate Scale.
→ Suppose the roofing systems and horizontal Members are precasted.
→ The degrees of prefabrication is moderate, that indicates Medium prefabrication.

(3) Large prefabrication :-
→ In large prefabrication most of the members like wall panels, roofing/flooring system, beams and columns are prefabricated.
→ The prefabrication is done in Larger scale.

(4) Partial Prefabrication :-
→ In this method of construction the building elements (mostly horizontal) are prefabricated and then erected.
→ This method is efficient when the elements are available →

readily when the building reached the roof level.
→ Since the casting of horizontal elements often take time (roof / floors) due to erection of form work the completion of the building is delayed.
→ The delay caused due to erection of formwork, also due to removal, this method is eliminated.
→ Suitable for any type of Building provided that the lifting and erection equipment are available.

(5) open system Prefabrication:
→ The space frames are casted as a single unit and then erected at-site.
→ The wall fittings and other fittings or fixings are done in the site.

(6) closed system Prefabrication:
→ In this system the whole things are casted with the fixings and erected on the positions.

(7) Total prefabrication:
→ Very high speed can be achieved by this type of prefabrication.
→ In total prefabricated construction, the erection of buildings or structures becomes basically a mechanical process of assembly and installment.
→ This process utilizes completed and standardized structural components: large blocks or panels etc.
→ This method requires good transportation facility.

→ If the elements are casted near the building site and erected, the transportation of elements can be eliminated but space availability is the major criteria.

(B) Cast-in-Site prefabrication:

→ The elements are prefabricated in site and erected.
→ This prefabrication is preffered for following reasons
(i) factory situated at a long distance from the construction site.
(ii) vehicle have to encoce a congested traffic.
(iii) heavy weighed elements are difficult to transport if good transportation facility is not available.

(C) Off-site prefabrication:

→ When the factory produced elements are transported & erected site we call it off-site prefabrication.
→ The manufacturing process is carried out off site in a factory or in a manufacturing unit.
→ This method requires transportation.
→ This method is more efficient.

Advantages of prefabrication:

The advantages of prefabrication are:
→ High Quality products
→ Saves time, material and cost.
→ Independent of adverse weather conditions.
→ Reduction of construction waste.
→ Safety to labourers as it ensures high degrees of safety.

- Mass production is easier and quick.
- protected and controlled production environment.
- Less production cost and labour related savings.
- Increase in the quality.
- possibility of alternations and reuse
- Correct shape, dimensions and sharp edges are maintained.
- It reduces the noise pollution.

Disadvantages of Prefabrication:

- Careful handling of prefabricated components such as concrete, steel and glass panels is required.
- Transportation costs may be higher for voluminous prefabricated sections.
- Similarly, leaks can form at joints in prefabricated components.
- Large prefabricated sections require heavy duty cranes and precision measurements and handling to place in position.
- Skilled labour and supervision is required.

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Theory and process of prefabrication:

→ The theory behind the method is that time and cost is saved if similar construction tasks can be grouped and assembly line techniques can be employed in prefabrication at a location where skilled labour is available, while congestion at the assembly site, which wastes time, can be avoided or reduced.

→ The method finds application particularly where the structure is composed of repeating units or forms, or where multiple copies of the same basic structure are being constructed.

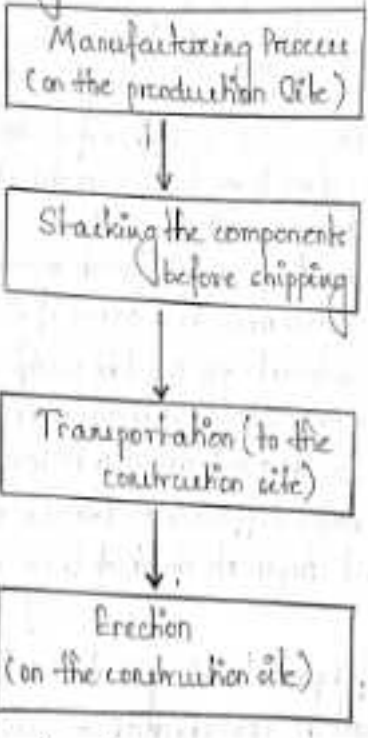
→ Prefabrication avoids the need to transport so many skilled labourers/ workers to the construction site, and other restricting conditions such as lack of Power, lack of water, exposure to harsh weather or a hazardous environment are avoided.

→ Against these advantages must be weighed the cost of transporting prefabricated sections and lifting them into position (as they will usually be longer, more fragile and more difficult to handle than the material and components of which they are made.

Process:

An example of house-building illustrates the process of prefabrication. The conventional method of building a house is to transport bricks, timbers, cement, sand,

steel and construction aggregate to the site and construct the house on the site from these materials. In prefabricated construction, only the foundations are constructed in this way, while sections of walls, floors and roofs are prefabricated in the factory (possibly with window and door frames included), transported to the site, lifted into place by a crane and bolted together.



Process of Prefabrication (chart)

Design principle of Prefabricated Systems:

Dissuniting of structures:

→ Dissuniting of structures means the frames are frequently dissunited at their corners or points of minimum moments into members to make the handling of these smaller members possible using simple equipments.

→ Dissuniting of structures into smaller members reduce the problems connected with the transportation and placing the structures.

Advantages of Dissuniting of structures:

1) Easy handling
2) Easy erection
3) No need of scaffoldings
4) Easy transportation
5) Easy housing.

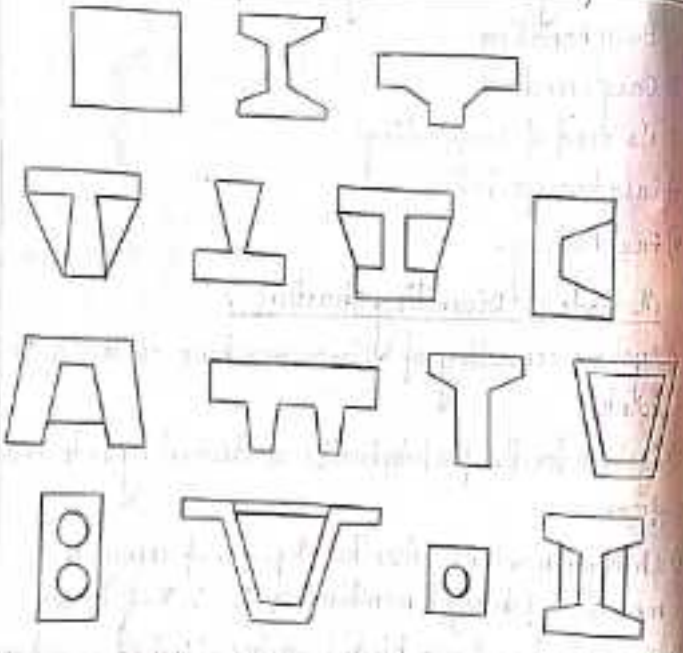
Methods of Dissuniting structures:

1) Systems consisting of linear members dissunited at the joints.
2) Systems for the prefabrication of dissuniting into entire frames.
3) Straight members dissunited at points of minimum moments. (straight members of I, T, U, V etc)
4) Two hinged or three hinged arches. (Arched structures).

Design of cross section based on efficiency of material used:-

- The most simple section of precast structure is the RECTANGULAR SECTION.
- Now, this is used for light members to be produced in smaller units.
- I, T, U and V shaped solid or hollow cross section are used in prefabrication.
- Compared to rectangular section, the above sections save 30-50% concrete and 5-10% steel.

Cross-Section for precast structures - Beams & Columns



→ One of the great advantage of prestressed reinforced concrete structures over monolithic one lies in the possibility of forming cross-section from the view point of the theory of strength of materials.

→ The economy of the cross-section is measured by the form factor ϕ value of which is

$$\text{Form factor, } \phi = F/F'$$

F = area of the investigated cross section

F' = area of the rectangular cross section with the depth h and width b.

→ For rectangular cross section $\phi = 1$

→ The smaller the value of ϕ is more economical in c/c.

→ For I, T, U and Y shaped sections, $\phi < 1$.

→ For I profile steel sections $\phi = 0.32$ to 0.38

→ For prestressed concrete sections $\phi = 0.45$ to 0.50.

Profiled Structures, Trusses and Vierendeel :-

→ There is generally no difference between construction between profiled and solid beams.

→ The reason for different openings in the body of the profiled beams is merely to obtain economy in the materials / to lessen the dead load.

Vierendeel :-

→ The use of reinforced concrete structures having divided -

cross section as have circular columns and beams becoming increasingly common due to economic & aesthetic reasons.

→ The manufacturing of these structures in a horizontal position requires less materials for their shuttering, their reinforcement and concreting is also fairly simple.

→ other structures like tubes, pipes can be easily fitted in these structures.

✓ Joint and problems in joints due to joint flexibility in Joints:

→ Precast structures may have continious or hinged connections subject to providing sufficient rigidity or resistance to horizontal loads.

→ Depending on the force to be taken, hinged, rigid or welded joints may be adopted.

→ Load transmission is accomplished by steel inserted parts together with concrete.

Joint issues:

→ Adequate joints are required to transfer forces

→ Joint of the core structure and components are strong enough to transfer forces.

→ If joints are not strong or proper, it leads to leakage.

Requirements of joints:

→ Joints requires minimum material or labour.

→ It has the capability to transfer the imposed load and

moments.
- It enables the structure to absorb sufficient energy during earthquakes and other accidental loads.
- It shall accomodate tolerances in elements.

Joint flexibility:-
The joint flexibility means that when designing structures the members is designed as rigid or semi-rigid in which the columns and beams are connected together in such a way that there is flexibility at the joints.

Problem in design because of joint flexibility:-
- General design
  - Based on architecture
  - Based on structural analysis

General design based on architecture:-
- Modern layout in dimensions and gridlines setting out as this will enable easy standardization in precast design.
- Suitable size of panels positions of joints and edge details.
- Standardization of sections will ensure the minimizing of panel types and major design variation as far as possible.

General design based on structural system:-
- Overall structure framing design and stability at various stages of construction.
- Selection of structural Elements to precast.

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→ Types of connection design to ensure structural adequacy and practicality in situ execution.

→ Connection to allow for panel tolerances, adequate space within joints to avoid elasticity & congestion.

Major Consideration in design of precast concrete systems :-

→ Load assessments and load paths

→ Establishment of suitable structural form or system

→ Precast components selection and panelization with standardization

Joints Consideration while Designing :-

→ In precast connection, design - Apart from strength requirement, other consideration such as ease of manufacturing, erection and tolerance for work efficiency

→ In theory all joints connection can be designed with structural adequacy for its performance needs with precast elements manufactured as per design.

→ All joints shall also cater for water tightness, durability, fire, and aesthetic conditions.

→ The fixed end beam connection, the stresses and moments due to shrinkage, creep and temperature drop of the beam must be considered on the connection properties and for the structure as a whole.

Types of precast joint :-

→ Compressive joint → Tensile joint → Shear joint → Flexural and torsion joint

Joints may be
(a) Dry joint
(b) Wet joint

(a) Dry joint :-

→ The dry joint used for simply placing the two members on each other and connecting them.

→ It does not require cement mortar for casting but also continious.

→ It is done by welding or bolting.

(b) Wet joint :-

→ Wet joints are adequate to bear the forces. It is done by mortar or in-situ concrete.

Allowance for joint deformation :-

→ Joint deformation refers to how the joint behaves in regard to the four field theories.

→ Various structural elements are made in the plant or prefabricated when these elements are in the site there may be joint deformation.

→ An allowance is tolerance on dimensions of the prefab unit are given in the design.

→ This is the limiting value of the permissible deviation in the size or shape of the finished prefabricates from the design requirements.

→ The designer should be able to forecast or tell the max^m tolerance value or the allowance which will make the -

correct assembly and efficient functioning of the individual fabricated types).

Types of Prefabricated elements :-

There are different types of prefabricated elements in a structure. Some of the major types of prefabricated elements in a building is listed below

(1) Precast Beams
(2) Precast Columns
(3) Precast floor slabs
(4) Precast walls
(5) Precast staircase
(6) Flooring/roofing elements.

Precast beams are of two types :-

(i) Internal Beams - where floor loading is approximately symmetrical.

(ii) External Beams - where floor loading is predominantly non symmetrical.

Precast columns :- For structures of five storeys or less each column will normally be continuous to the full height of the building. For structures greater than five storeys two or more columns are spliced together.

Precast columns are of three types mainly

(i) Edge columns
(ii) Internal columns
(iii) Corner columns

→ Precast Staircase can be manufactured as :-

(i) A single precast unit containing all the flights and landings.

(ii) Separate precast flights and landings.

(iii) Parts of flights and landings are made in one piece.

Modular Coordination:-

→ Modular Coordination is a concept of coordination of dimension and space, in which buildings and components are dimensioned and positioned in term of basic unit or module known as '1M' which is equivalent to 100mm.

→ It is internationally accepted by the International Organization for Standardization (ISO) and many other countries.

→ The principle objective of Modular Coordination is to improve productivity in the building industry through industrialization, and to bring more flexibility in design and construction activities.

Advantages of Modular Coordination:-

→ Modular Coordination make single component into large combinations.

→ Cutting wastage are minimum in this component.

→ Base for standardization of mass production of the components.

Basic Module:-

→ The fundamental module used in modular coordination the size of which is selected for general application to building and its components.

→ It is denoted by 'M'.

→ The value of basic Module 'M' has been chosen as 10cm for maximum flexibility and convenience.

→ The different modules are:-

(i) Basic Module: M

(ii) Multi Modules: 3M, 6M etc.

(iii) Sub Modules: M/2, M/4 etc.

→ In prefabricated industry a larger module or larger modular unit is called as a project module (Mp).

Objectives of Modular Coordination:-

(a) Major Objectives:-

→ The principal objective of Modular Coordination is to assist the building design, construction professionals in building industry by standardization in such a way that the building components fit with each other, with other components and with building assembly on site thereby improving the economies of building.

(b) Specific Objectives:-

Modular Coordination facilitates cooperation between building designers, manufacturers, distributors, contractors and authorities.

→ P.T.O...

→ Enables building to be dimensionally coordinated so that they can be erected with standard components without undue restriction on freedom design.

→ Permits a flexible type of standardisation which encourages the use of number of standardized building components for the construction of different types of buildings.

→ Encourages as far as possible the interchangeability of components, whatever the material form or method of manufacture.

* Standardisation :-

→ It is defined as the process of adoption of generally accepted uniform procedures, dimensions, materials or parts that directly affect the design prefabricated product or a facility.

* Modular Coordination (MC) :-

→ Modular Coordination or MC is a dimensional System.

→ It is a dimension and space coordination concept in which building and components are placed at their designations based on the unit or basic module i.e. 1M.

→ MC is used for Quality control and increase in production.

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Aims of Modular Coordination:

→ Modular System provides a practical and coherent solution for coordination of the position and dimensions of elements or components and space in the building design.

→ The aims of modular coordination are as follows:

1) To achieve dimensional compatibility between building dimensions, span or spaces and the sizes of components or equipment by using related modular dimensions.

2) Making the planning simpler and clearer by distinct indication of location of the building component in the building, both in respect to each other or a modular grid.

3) Simplification of site work.

4) Providing practical and logical construction methods for the coordination of the position & dimensions of the elements, components and spaces in a building design, which will contribute to;

(i) increased design freedom.

(ii) Improve balance between quality and cost of the manufacturing the component.

Basics of Modular Coordination:

The main purpose of Modular Coordination is to achieve the dimensional compatibility between the building -

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dimensions, open or spaces and the size of components / equipments by using related Modular dimensions.

→ Modular coordination generally provide the easy grasped layout of the positioning of the building components in relation to each other and to the building and facilitate collaboration between planners, manufacturers, distributors and contractors.

→ Modular Coordination is essentially based on :

- The use of modules (basic module, multimodule, submodule)
- A Reference system to define coordinating spaces and zones of building elements and for the components which form them.
- Rules for location of building elements within the reference systems.
- Rules for sizing building components in order to determine their work sizes.
- Rules for defining preferred sizes for building components and coordinating dimensions for building.

Modules :

→ Standard unit size used to coordinate the dimensions of buildings and components.

→ Basic Module :

→ It is the fundamental unit of size in modular coordination and for general application to building and components.

→ The size of basic module is 100mm denoted by 'M'.

Multi Module :-

- Multimodules are selected multiples of the basic module.
- It is usually expressed in 'M' with numeric prefix as 2M, 3M etc.

Sub Modules :-

- Certain submultiples of basic module which are used in simple fractions shall be chosen when absolutely necessary for an increment smaller than the basic Module.
- For practical considerations, the sub modular increments shall be expressed as 'M' with fractional prefix as M/2, M/4, M/5 etc.

Horizontal Planning module :-

Mh = 3M (300mm)

- The horizontal planning module for structural framework is based on the functional requirements of the building and the components to be used for economical design.

Vertical Planning module :-

Mv = 1M (100mm).

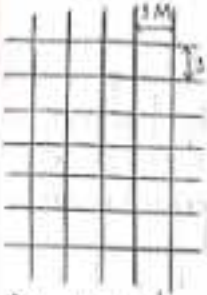
Modular Grid :-

- A Rectangular reference coordinate system in which the distance between consecutive gridlines is a basic module or a multimodule.
- To simplify the design process a mesh of lines, which have preferred space dimensions, are plotted in three directions for all types of buildings.

Types :- → P.T.O .....

(i) Basic Modular Grid :-

The fundamental modular grid, is that in which the intervals between consecutive parallel lines is equal to the basic module, smallest planning grid.



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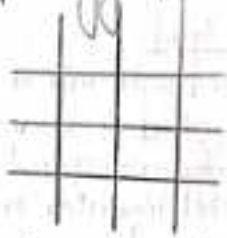
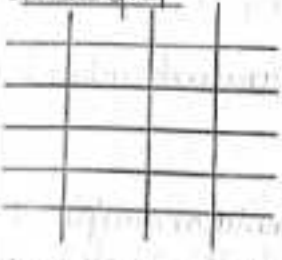
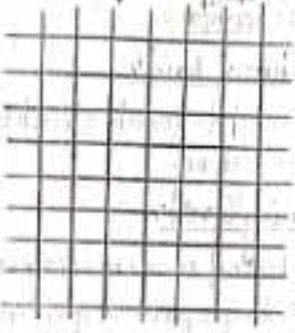


(ii) Square Grid

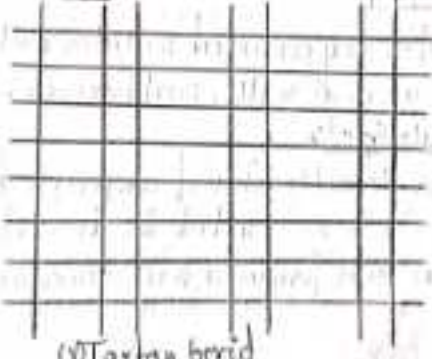
(i) Basic Grid





(iii) Rectangular Grid

(iv) Multi-Modular Planning Grid



(v) Tartan Grid

(iv) Multi Modular planning Grid:-

In addition to the basic modular grid, multimodular in which the intervals between consecutive lines are multimodular which may be used.

(v) Tartan Grid:-

It is used to describe an interrupted modular planning grid in which the intervals or bands of interruptions are regularly spaced in both directions and are of different modular order of the general modular planning grid.

Classification:-

Structural Grid:-

→ It is used to locate structural components such as beams and columns.

Planning Grid:-

→ It is based on any convenient modular multiple for regulating space requirements such as rooms.

Controlling Grid:-

→ It is based on any convinient modular multiple for location of internal walls, partitions, etc.

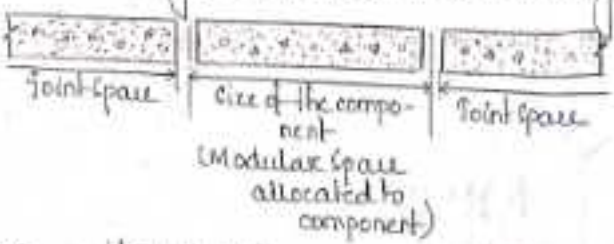
Basic Module Grid:-

→ It is used for detail location of components and fittings.
→ These grids can be used in both the horizontal and vertical planes thus forming a three dimensional grid system.

Dimensional Grids:

→ The modular grid network defines the space into which dimensionally coordinated components must fit in.

→ An important factor is that the component must always be undersized to allow for the joint which is fixed by the obtainable degree of tolerance and the assembly



Notations and Symbols:

1) Modular line

2) 6M — Modular Space

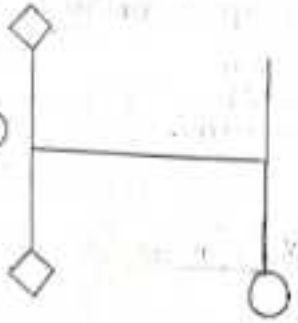
3) Modular line (Planning)

4) 18M — Location of Reference line

5)  Modulare Reference line

6)  Centre line of walls, columns and beam

7) (a)  (b) Facade Corners on Wall Surfaces

8)  Dimension Line

9)  Reference Line

Tolerences in

- The permissible deviation from a specified value of a structural dimension.
- Tolerence is the difference between maximum and minimum limits of a basic dimension.
- The modular dimensions provide convinient means of describing components in a catalogues and for allocating the spaces for them in design drawings.

Three type of tolerence are generally considering in modular coordination in building.

1) Manufacturing tolerence, which limit the dimensional deviation in the manufacture of components.
2) Positional tolerences, which limits the deviation of position for, erected components from their designated position.
3) Joint tolerences or gaps, which limits the variation of joint thickness.

→ The three tolerences are interrelated and therefore must be determined accordingly.

5mm RULE:

→ The rule is applied to all structural parts of building and components. The wall, slab, & components, elements which are structural part of vertical and horizontal division are placed one joint proportion on the boundaries of a modular plane, that is the actual dimension as a rule for the structural elements are 5mm less on all modular boundary plane. This rule is called as the 5mm rule for all horizontal & Vertical dimensions.

If the size of the grid is $n_1 M \times n_2 M$

Component size = $(n_1 - 10mm)M \times (n_2 - 10mm)M$

→ The 5mm rule is given by IS code, it is due to tolerence because tolerence is required to fit the component into available grid space.

Reference System :- (Modular Reference System)

→ The Reference system is a system of points, lines and planes to which the sizes and positions of building components or assemblies relate.

→ A Reference system should be used during the design stage and may also form the basis of the system of lines from which measurements on site are set out.

→ The Modular Reference system is the three dimensional system.

Modular lines :- A line of a modular reference system.

Modular planes :- A plane of modular reference system.

Modular Zone :- A zone between modular planes.

Modular Size :- The size of modular dimension.

Zone :- A space between reference planes within or in relation to which a building component is arranged. The space may be left unfilled.

→ Wall Zone :- The zone where the wall is accomodated and it includes the wall finishes.

→ Floor Zone :- The space in section where the floor assembly is accomodated, it extends from the top of the floor finish to the bottom of the ceiling of the floor below.

→ Roof Zone :- The zone stretching from the bottom of the ceiling of top floor to the top of the roof of the building.

Planning Approach:

→ The planning in modular coordination consist of the horizontal and vertical planning.

→ There are 2 basic approaches to planning in Modular Coordination.

(i) Face Planning (ii) Axial planning.

(i) Face planning:

→ It is used to position components of construction in relation to the grid.

→ It is represented by a pair of parallel lines.

→ The components is placed with the faces on the line.

→ The distance between the ede of parallel lines is always modular.

FACE PLANNING

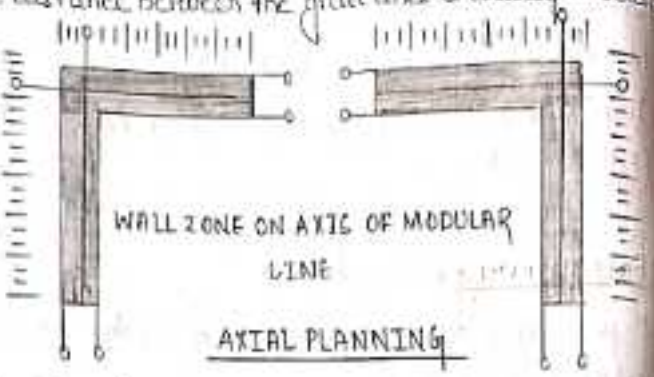
(ii) Axial Planning:

→ It normally determines the position of major components. (Ex> columns, crosswalls.

→ The grid lines in this plan will run along the centre line of

the components.

→ The distance between the grid lines is always modular



AXIAL PLANNING

Dimensions of Prefab Components:-

→ Flooring and Roofing:-
- → Length - multiple of 3M
- → Width - multiple of 1M
- → Thickness - multiple of M/4

→ Beams:-
- → Length - multiple of 3M
- → Width - multiple of M/4
- → Depth - multiple of M/4

→ Columns:-
- → Height - multiple of 1M for height upto, 28M and height above 28M is multiple of 2M
- → Lateral dimension - multiple of M/4

→ Wall:-
- → Thickness - multiple of M/4

→ Staircase:-
- → Width - multiple of 1M

→ lintels:-
- Length - multiple of 1M
- Width - multiple of M/4
- Depth - multiple of M/4

→ Sunshade:-
- Length - multiple of 1M
- Projection - multiple of 1M

→ Precast toilets (Precast Concrete)

Internal Coordinating dimensions:-
Length, Breadth and height - Multiples of 1M with 2nd preference of 0.5M.

Indian Standards for Modular Co-ordination:-

(1) IS 4998 : 1983 Glossary of terms relating to modular coordination (Second revision)

(2) IS 6820 : 1987 Recommendations for modular coordination building industry: Application (First revision)

(3) IS 7921 : 1987 Recommendations for modular coordination in building industry: Horizontal Coordination (First revision)

(4) IS 7922 : 1987 Recommendations for modular coordination in building industry: Vertical coordination (First revision)

(5) IS 12093 : 1987 Recommendations for modular coordination, coordinating sizes for doorsets and windows.

(6) IS: 13613 : 1992 Recommendations for m-c in building industry Location of structural walls & floor slabs.

Earthquake Resistance Construction

Introduction:-

→ An earthquake is a sudden tremor or movement of the earth's crust, which originates naturally at or below the surface.

→ About 90% of all earthquake results from tectonic events primarily movements on the faults. The remaining is related to volcanism, collapse of subterranean cavities or man-made effects.

→ An earthquake (also known as a quake, tremor etc) is the shaking of the surface of earth resulting from a sudden release of energy in the earth's lithosphere that creates seismic waves.

→ Tectonic earthquakes are triggered when the accumulated strain exceeds the shearing strength of the rocks.

List of Natural and Manmade earthquake sources

Natural Sources

- Tectonic Earthquake
- Volcanic Earthquake
- Rockfalls / Collapse of cavity
- Microseism (faint-earth tremor caused by natural phenomena)

Manmade Sources

- Controlled Sources (Explosives)
- Reservior Induces Earthquake
- Mining Induces Earthquake
- Cultural Noise (Industry, Traffic etc)

Microseism:- The term is most commonly used to refer the dominant background seismic noise signal on earth which is most commonly caused by rayleigh waves and caused by water waves in the ocean and lakes.

Earthquake Resistance Construction:-

- It is the fabrication of a building are a structure that is able to withstand the sudden ground shaking that is characteristic of earthquake; thereby minimizing the structural damage and human deaths & injuries.
- Suitable construction methods are required to ensure that proper design objectives for earthquake-resistance are met.
- Construction methods can vary dramatically throughout the world, so one must be aware of local construction methods and resources availability before concluding whether a particular earthquake-design for resistance will be practical and realistic for the region.
- Earthquake-resistant or aseismic structures are designed to protect buildings to some or greater extent from earthquakes. While no structures can be entirely immune to damage to damage from earthquakes, the goal of earthquake-resistant construction is to erect structures that fare better during seismic activity than their conventional counterparts.

P.T.O ⇒

Building Configuration

- This term defines a building's size and shape, and the structural and non structural elements.
- Building Configuration determines the way seismic forces are distributed within the structure, their relative magnitudes and problematic design concerns.
- IS 1893 (Part-1): 2002 has recommended building configuration system in Section 7 for the better performance of buildings during earthquake.
- An important features in building configuration is the regularity and symmetry in horizontal / vertical plane.
- Seismic behavior of irregular shaped plans (figure given below) differs from regular shape because the first can be subjected to their asymmetry and/or can present local deformations due to the presence of reentrant corners or excessive openings. Both effects give origin to undesired stress concentrations in some resulting members of the buildings.
- On the contrary, the ideal rectangular or square plan, structurally symmetric with enough in plane stiffness in its diaphragm, presents an ideal behavior, because it has the same displacement at every point in the slab.
- Therefore building shaped like a box, such as rectangular both in plan and elevation, is inherently stronger than one that is L-shaped or U-shaped, that is a building with wings.

P.T.O. ...

Regular Configuration:

- Regular configuration is ecimically ideal. These configurations have low weights to base ratio, symmetrical plane, uniform section and elevation and thus have balanced resistance.
- These configurations would have maximum torcional resistance due to location of shearwalls and bracing, uniform floor heights, short spans and direct load play a significant role in ecimic resistance of the building.

Irregular Configuration:

- Irregular configuration buildings are those that differ from the 'regular' definition and have problematic stress concentrations and forces.

Reference:

- Lateral load resisting structure
- Building characteristics
- Effect of structural irregularities - vertical irregularities, Plan Configuration Problems

Earthquake Resistance design of structures
- Pankaj Agarwal
- Manish Shrikhande

P.T.O. ...→

Additional Strengthening measures in masonary building

Corner Reinforcement

→ Corner reinforcement are also called as torsional reinforcement.

→ The torsional moment are high near the corners thus force, torsional reinforcement is essential to prevent corners slab from lifting and prevents cracks.

→ The Non-engineered building construction (Masonary construction) system should be strengthened by horizontal bands or bond beams at critical levels as vertical Reinforcing bars at corners and junctions of walls.

* Horizontal bands in masonary buildings are seismic bands consisting of reinforcement concrete. One of the most important methods of increasing the seismic resistance of masonary buildings is by incorporation of horizontal bands. Past records shows that higher rate of masonary building undergoes sudden collapse under earthquake motion. The use of horizontal bands will tie all the elements to be confined together as a single unit this would have a total resistance from the whole building, other than having an individual contribution. Horizontal bands can be also termed as seismic bands which consist of reinforced concrete running float throughout all the external and internal masonary wall elements.

→ P.T.O.

→ The bands form a horizontal framing systems that transfer the horizontal shear induced by the earthquake from the floors to structural walls. It also connects all the structural walls to improve integral action.

→ Depending upon its location in the building it may be termed as roof, gable, lintel, sill, and plinth band.

→ The reinforcing details of these bands are available in IS 4326, 13920, IAEE etc.)

→ In combination with vertical reinforcement, it improves the strength, ductility and energy dissipation capacity of masonary walls. Levels of strengthening arrangements may vary with the type of construction and seismic zones.

→ The descriptions of each strengthening measures with its individual functions are as follows:

→ Plinth Band:- The band is provided at the plinth level of walls on the top of the foundations, which is useful in sustaining differential settlements particularly when foundation soil is soft or has uneven properties.

→ This band will serve as DPC as well. (Damp proof course)

→ This band is hence not necessary if we have a stronger soil and substructure.

→ Gable band:- Gable band is provided at the top of gable masonary below the purlins.

→ This band shall be made continuous with the roof band at the eave level. It restricts the out-of-plane failure of gable wall, which is susceptible to earthquake forces.

→

→ Those buildings that have sloped roof i.e truss construction gable bands are necessary.

→ Roof band:- Roof band is similar to lintel band but is provided below the roof or floors. It improves the in-plane rigidity of horizontal floor diaphragms.

→ Such band need not be provided in case of rigid diaphgream, but need to be provided in building with flat timber or RCC slab.

→ If the building roof is made of reinforced concrete slab or brick roofs, there is no need of these bands, as slab behaves as a horizontal band.

→ Lintel band:- This is band is provided at lintel level in all internal and external longitudinal as well as cross wall except partition walls. It provides integrity to the structure and resistance to out-of plane wall bending.

→ The lintel band if provided in partition wall will also enhance their stability. The purpose of lintel & roof band is to prevent the collapse of roof.

→ The lintel band undergoes bending and pulling action during earthquake shaking.

→ To resist these actions, the construction of lintel band requires special attentions.

→ Sill band:- The band is similar to lintel band but it is provided at sill level. This band reduces the effective height of masonary piers between openings. This is expected to reduce shear cracking in piers. It has not been recommended so far in codes.

→ Vertical steel:- The vertical steel is provided at corners and junctions of walls and around jambs of doors and windows.

→ The vertical steel in walls shall be embedded in plinth masonary of foundation, roof slab, or band so as to develop its tensile strength of the bands. It should pass through the lintel bands and floor slabs in all storied. It is either a steel bar of 10mm to 12mm dia. or a bamboo.

→ For providing vertical steel in stone masonary a casing pipe is recommended around which masonary be built upto a height of 600mm. The pipe is raised & cavity is filled by 1:2:4 grade of concrete mix in case of steel bars.