TWO MARKS

1. Define Prefabrication.

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located.

2. Write the advantages of Prefabrication. (May/June-2012)(May/June-2013)

- Self-supporting ready-made components are used, so the need for formwork, shuttering and scaffolding is greatly reduced.
- Construction time is reduced and buildings are completed sooner, allowing and earlier return of the capital invested.
- On-site construction and congestion is minimized.
- Quality control can be easier in a factory assembly line setting than a construction site setting.
- Prefabrication can be located where skilled labour is more readily available and costs of labour, power, materials,, space and overheads are lower.

3. What are the types of prefabrication? (May/June-2013)

1. Light prefabrication
2. Heavy prefabrication

4. Write the disadvantages of Prefabrication. (May/June-2012)

- Careful handling of prefabricated components such as concrete panels or steel and glass panels is required.
- Attention has to be paid to the strength and corrosion-resistance of the joining of prefabricated sections to avoid failure of the joint.
- Similarly, leaks can form at joints in prefabricated components.
- Transportation costs may be higher for voluminous prefabricated sections than for the materials of which they are made, which can often be packed more efficiently.
- Large prefabricated sections require heavy-duty cranes and precision measurement and handling to place in position.

5. Write down the applications of Prefabrication in precast concrete.

Precast concrete is used in the following:

1. Pipes and tanks
2. Poles, Pipes, sleepers and pavement
3. Lintel beams
4. Beams and girders
5. Building blocks
6. Wall panels
7. Manhole covers

6. **What are the materials can prefabricated structures be made of?**

The materials used in prefabricated components are many. Some of the materials are mentioned below:

- ✓ Concrete
- ✓ Steel
- ✓ Timber
- ✓ Aluminium
- ✓ Lightweight and cellular concrete
- ✓ Ceramic products
- ✓ Gravel, slag, mortar, cement, Water.

7. **What are prefabricated structures?**

Structures which are used repeatedly and can be standardized such as mass housing, storage sheds, godowns, shelters, bus stands, security cabins, site offices, foot over bridges, road bridges, tubular structures, concrete building blocks etc... are prefabricated structures.

8. **When are prefabricated structures useful?**

Prefabricated are useful for sites, which are not suitable for normal construction methods such as hilly regions, and also when normal construction materials are not easily available. Prefabricated structures facilities can also be created at or near a site is done to make concrete blocks used in place of conventional bricks.

9. **When prefabricated structures should is not used?**

There is not such thing. Any properly designed prefabricated structures can be used in full or parts. The need to use prefabricated structures depends on the time frame of the project, facilities at site, site conditions, site supervisions etc..

10. **How does the cost of prefabricated structures compare with the cost of site-fabricated structures?**

If structures or elements are manufactured on mass scale such as mass urban houses, storage sheds etc., these will work out cost beneficial. Transportation is a major expense.

11. **How does prefabricated structure compare time wise with site fabrication?**

If planning design and manufacturing are commenced well in time, prefabricated structure will be faster than site work.

12. **What precautions should be taken while using prefabricated structure?**

For high-rise and large-span structure and for the structures for seismic areas, good attention should be paid to design, the elements and joints that will develop desired strength and rigidity.

13. **Are there any limitations to transportations of prefabricated structures?**

Transportation, loading, unloading and stacking is important in prefabricated structures elements.

14. **What is the practice abroad in this field?**

Maximum stress is laid on the use of prefabricated structure and elements because of less and costly labour. Also, good manufacturing facilities are available abroad.

15. **Do you see prefabricated structure as industry? Is it feasible that I keep prefabricated structure ready and deliver off-the-shelf to a conductor?**

Yes, if a modular system of construction is adopted.

What is 'modular' construction

Modular construction is the standard system of construction such as spacing and sizes of columns, spaces for commercial, resident and storage structures etc.

16. **Any other points you would like to tell us?**

In India, particularly in rural areas, cheap skilled and unskilled labour is available. Natural building materials such as stones are also available. So use of prefabricated structure, particularly in rural areas, will not be justified, from cost and employment to local population point.

17. **If there is just one point about prefabricated structure that you would like to tell our readers, what will it be?**

The advantage of using prefabricated structure is that they are fabricated in a proper factory having good machinery and under expert supervision. Therefore, prefabricated structure will have good quality.

18. **What are the admixtures used in prefabricated structures?**

- ✓ Water reducing admixtures
- ✓ Air entraining admixtures
- ✓ Set-accelerating admixtures
- ✓ Corrosion inhibitors
- ✓ Coloring admixtures

19. **Define Pigments.**

A pigment is a material that changes the color of reflected or transmitted light as the result of wavelength-selective absorption. This physical process differs from fluorescence, phosphorescence, and other forms of lumininescence, in which a material emits light.

20. What is meant by mould?

Moulds are generally made of steel, or timber and plywood. They are manufactured for repeated used, to achieve high standards or accuracy and to be capable of generating good quality concrete finishes. Moulds are special structural components are constructed to produce the specified quality.

21. Define Modular-co ordination. (Apr/May-2010)(Nov/Dec-2013)

Modular coordination is a concept for coordinating dimensions and space for which building and components are dimensionally it used and positioned in basic units (or) modules. The standard specify that the module basic M-100mm. As the basic unit be used in a square of M.

22. What are the basic principles of modular co-ordination?

1. Actual Dimension
2. Basic Module
3. Components
4. Maximum dimensions
5. Minimum Dimensions

23. What is meant by Standardization?

The word 'system' is referred to a particular method of construction of buildings by using prefabricated components which are inter-related in functions and are produced to a set of instructions. With certain constraints, several plans are possible, using the same set of components. The degree of flexibility varies from system to system. However, in all the system, there is a certain order and discipline.

24. Write the systems of pre-fabrication. (May/June-2012)

- ✓ Open prefab system
- ✓ Partial prefab open system
- ✓ Full prefab open system
- ✓ Large panel prefab system
- ✓ Wall system
- ✓ Cross wall system
- ✓ Longitudinal wall system
- ✓ Floor system
- ✓ Staircase system
- ✓ Box type system

25. **Write the advantages and disadvantages of standardization.**

Advantages of standardization

- ✓ Easier in design as it eliminates unnecessary choices.
- ✓ Easier in manufacture as there is limited of variants.
- ✓ Makes repeated use of specialized equipment's in erection and completion easier and quicker.

Disadvantages of standardization.

- ✓ Since the joints are at corners that are at places where the moments reach their maximum values, the forming of joints is difficult.
- ✓ The forming of in-situ joints is very difficult; hence the joints must be over dimensioned.
- ✓ No of joints are reduced and if larger precast members are needed.

26. **Mention the types of production techniques. (May/June-2013)**

1. Moulds
2. Connections
3. Columns
4. Beams
5. Floor units
6. Stair units
7. Wall panels

27. **List out the precautions taken while erecting precast elements. (May/June-2011)**

i) Check crane access to the site and erection platform to prevent cranes or trucks damaging the concrete floor during access.

ii) Obtain verification that the erection platform can support the erection loads.

iii)Ensure the locating dowels and leveling shims are correctly located. Dowels rather than blocks should be used to restrain the base of face-lifted panels when they are being positioned.

iv)Clear the site for truck and crane access ensuring room for crane outriggers, counterweight tail swing, and boom swing and under hook and overhead obstructions.

28. **State any two principles of prefabricated structures. (Nov/Dec-2013)**

1. 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 waste time, can be reduced.
2. 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.

16 - Marks

1. What is meant by prefabrication and mention the advantages and disadvantages. (Nov/Dec-2013)

Introduction about Prefabrication

Prefabrication buildings are the completely assembled and erected building, of which the structural parts consist of prefabricated individual units or assemblies using ordinary or controlled materials.

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located.

The term prefabricated is used to distinguish this process from the more conventional construction practice of transporting the basic materials to the construction site where all assembly is carried out. It means the members of the structure are precise either in factories or in temporary plants, establish on site and equipped then the précises RC members are shipped in one place where are to be sued and they are hoisted, set into their final, places and assembled to form a complete structure.

The concept of precast (also known as "prefabricated") construction includes those buildings, where the majority of structural components are standardized and produced in plants in a location away from the building, and then transported to the site for assembly. These components are manufactured by industrial methods based on mass production in order to build a large number of buildings in a short time at low cost.

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies to the construction site where the structure is to be located. The term is used to distinguish this process from the more conventional construction practice of transporting the basis materials to the construction site where all assembly is carried out. It means the member of the structure are precise either in factories or in temporary plants, establish on site and equipped then thee precise RC members are shipped in one place where they are to used, here they are hoisted, set into their final, places and assembled to form a complete structure.

The term prefabrication also applies to the manufacturing of things other than structures at a fixed site. It is frequently used when fabrication of a machine or any movable structure is shifted from the main manufacturing site to another location, and the section is supplied assembled and ready to fit conventional method of building a house is to transport bricks, timber, cement, sand, and construction aggregate, etc to the site, and to construct the house on site from these materials.

Uses:

Prefabrication is used in the manufacture of ships, aircraft and all kinds of vehicles and machines where sections previously assembled at the final point of manufacture are assembled elsewhere instead, before being delivered for final assembly.

The most widely-used form of prefabrication in building and civil engineering is the use of prefabricated concrete and prefabricated steel sections in structures where a particular part or form is repeated many times. It can be difficult to construct the formwork required to mould concrete

25. **Write the advantages and disadvantages of standardization.**

Advantages of standardization

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- ✓ Easier in manufacture as there is limited of variants.
- ✓ Makes repeated use of specialized equipment's in erection and completion easier and quicker.

Disadvantages of standardization.

- ✓ Since the joints are at corners that are at places where the moments reach their maximum values, the forming of joints is difficult.
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components on site, and delivering wet concrete to the site before it starts to set requires precise time management.

Prefabrication techniques are used in the construction of apartment blocks, and housing developments with repeated housing units. The quality of [refabricated housing units had increased to the point that they may not be distinguishable from traditionally-built units to those that live in them/ the technique is also used in office blocks, warehouses and factory buildings. Prefabricated steel and glass sections are widely used for the exterior of large buildings.

Prefabrication saves engineering time on the construction site in civil engineering projects. This can be vital to the success of projects such as bridges and avalanche galleries, where weather conditions may only allow brief periods of construction. Additionally, small, commonly-used structures such as concrete pylons are in most cases prefabricated.

Radio towers for mobile phone and other services often consist of multiple prefabricated sections. Modern lattice towers and guyed masts are also commonly assembled of prefabricated elements.

Prefabrication has become widely used in the assembly of aircraft, with components such as wings and fuselage sections often being manufactured in different counties or states from the final assembly site.

Advantages:

1. Self-supporting ready-made components are used, so the need for formwork, shuttering and scaffolding is greatly reduced.
2. Construction time is reduced and buildings are completed sooner, allowing and earlier return of the capital invested.
3. On-site construction and congestion is minimized.
4. Quality control can be easier in a factory assembly line setting than a construction site setting.
5. Prefabrication can be located where skilled labour is more readily available and costs of labour, power, materials,, space and overheads are lower.
6. Time spent in bad weather or hazardous environments at the construction site is minimized.
7. Less waste may be generated and in a factory setting it may be easier to recycle it back into the manufacturing process, for instance it is less costly to recycle scrap metal generated in a metal fabrication shop than on the construction site.
8. Molds can be used several times.

Disadvantages

1. Careful handling of prefabricated components such as concrete panels or steel and glass panels is required.
2. Attention has to be paid to the strength and corrosion-resistance of the joining of prefabricated sections to avoid failure of the joint.
3. Similarly, leaks can form at joints in prefabricated components.

4. Transportation costs may be higher for voluminous prefabricated sections than for the materials of which they are made, which can often be packed more efficiently.
5. Large prefabricated sections require heavy-duty cranes and precision measurement and handling to place in position.
6. Larger groups of buildings from the same type of prefabricated elements tend to look drab and monotonous.
7. Local jobs may be lost, if the work done to fabricate the components being located in a place far away from the place of construction. This means that there are less locals working on any construction project at any time, because fabrication is outsourced.

2. Write the details about materials of prefabrication. (May/June-2013)

Prefabricated building materials used for small prefabricated buildings are steel, wood, fiberglass, plastic or aluminum materials. These materials are cheaper than regular brick and concrete buildings. Materials like steel, fiberglass, wood and aluminum are used as prefabricated building materials for sports buildings.

For making low cost houses, prefabricated materials like straw bale, Ferro cement, Calcium silicate products, composites and other cheap wood based materials are currently being used. Calcium silicate bricks are strong and durable. Ferro cement consists of a cement matrix reinforced with a mesh of closely-spaced iron rods or wires. In this type of construction, the techniques used are simple and quick.

While choosing the materials for prefabrication, the following special characteristics are to be considered:

a) Easy availability;

b) Light weight for easy handling and transport, and to economize on sections and sizes of foundations;

c) Thermal insulation property;

d) Easy workability;

e) Durability in all weather conditions;

f) Non-combustibility;

g) Economy in cost, and

The materials used in prefab components can be various and the modern trend is to use concrete, steel, treated wood, aluminum, cellular concrete, light weight concrete, ceramic products, etc. However, this section pertains to prefab concrete elements.

Concrete is a composite material that consists essentially of a binding medium within which are embedded particles or fragments of aggregates. In hydraulic cement concrete, the binder is formed from a mixture of hydraulic cement and water.

Aggregate is the granular material, such as sand, gravel, crushed stone, or iron blast-furnace slag, used with a cementing medium to form hydraulic-cement concrete or mortar. The term **coarse aggregate** refers to aggregate particles larger than 4.75 mm (No. 4 sieve), and the term **fine**

aggregate refers to aggregate particles smaller than 4.75 mm but larger than 75 mm (No. 200 sieve).

Aggregates

All aggregates shall comply with the requirements of IS: 383-1970.

The nominal maximum size of coarse aggregate shall be as large as possible subject to the following:

a) In no case greater than one-fourth the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all pre-stressing tendons and reinforcements and fill the corners of the form.

b) It shall be 5 mm less than the spacing between the cables, strands or sheathings where provided.

c) Not more than 40 mm; aggregates having a maximum nominal size of 20 mm or smaller are generally considered satisfactory.

Coarse and fine aggregates shall be batched separately.

Gravel is the coarse aggregate resulting from natural disintegration and abrasion of rock or processing of weakly bound conglomerate. The term **sand** is commonly used for fine aggregate resulting from natural disintegration and abrasion of rock or processing of friable sandstone. **Crushed stone** is the product resulting from industrial crushing of rocks, boulders, or large cobblestones. **Iron blast-furnace slag,** a by-product of the iron industry, is the material obtained by crushing blast-furnace slag that solidified under atmospheric conditions.

Mortar is a mixture of sand, cement, and water. It is essentially concrete without a coarse aggregate. **Grout** is a mixture of cementitious material and aggregate, usually fine aggregate, to which sufficient water is added to produce a pouring consistency without segregation of the constituents. **Shotcrete** refers to a mortar or concrete that is pneumatically transported through a hose and projected onto a surface at a high velocity.

Cement is a finely pulverized material which by itself is not a binder, but develops the binding property as a result of hydration (i.e., from chemical reactions between cement minerals and water). Cement is called **hydraulic** when the hydration products are stable in an aqueous environment.

The most commonly used hydraulic cement for making concrete is **Portland cement**, which consists essentially of hydraulic calcium silicates. The calcium silicate hydrates formed on the hydration of Portland cement are primarily responsible for its adhesive characteristic, and are stable in aqueous environments.

The cement used shall be any of the following, with the prior approval of the engineer-in-charge:

a) Ordinary Portland cement conforming to IS: 269-1976

b) Portland slag cement conforming to IS: 455-1976, but with no more than 50 percent slag content;

c) Rapid-hardening Portland cement conforming to IS: 8041-1978 and

d) High strength ordinary Portland cement conforming to IS: 8112-1976.

Weather Flexibility: precast concrete suitable for exposure to a variety of climatic conditions. On a regular basis at the regional experience of freeze-thaw cycles, concrete structural design, may properly bear the loss.

Reduce reliance on the weather: pre-cast concrete to improve efficiency, because the weather will not delay production. In addition, on-site weather conditions do not seriously affect the progress. This is because it requires less time to install pre-fabricated buildings and other methods, such as actors, in-situ concrete. Precast concrete, installation requirements can be easily and immediately backfilled - there is no need to wait for it to heal.

Waterproof: precast concrete products in the quality control of the production environment, with high-quality sealants offer a superior solution to water requirements. Standard waterproof sealant is specially formulated to uphold pre-cast concrete, so that more than watertight seam precast concrete structures possible.

Easy to install. While the precast concrete is very heavy, almost all of the other competitive materials, and installation of machinery, and need to be addressed. In addition, the installation rate is more dependent on product handling and placement of excavation. Pre-rigging does not require the use of special (such as fabric slings) which must be used in order to avoid dealing with structural damage, such as glass fiber materials. In addition, product design and manufacture of prefabricated simple connection, many components can be installed in a very short time.

Modularity: Since many precast concrete products, structures or almost any size modular systems can accommodate.

Availability: With thousands of manufacturers in North America, pre-cast concrete products can be ordered from the plant, in most cities or regions. As the production and storage of prefabricated structures in advance factories, they can always work on-site needs. This will ensure competitive prices and supply, and can save days, weeks or even more than last month, investment projects, in-situ concrete.

Efficiency: Precast concrete products arrive at the scene ready to install. There is no need for raw materials such as steel and concrete, there is no need to spend time setting the form of concrete or cement would be to wait for treatment.

Spectator: precast concrete products, functional and decorative. They can be shaped into an endless array of sizes and configurations forming. Precast concrete production can be in almost any color and a variety of completion (acid etching, sand blasting, smooth casting, exposed stone), in order to achieve the required web site construction and application appearance.

Low maintenance: pre-cast concrete almost no maintenance, making it almost all of the design solution an ideal choice.

5. What is meant by modular co-ordination and briefly explain about it. (April/May-2011)

MODULAR CO-ORDINATION

Modular coordination is a concept for coordinating dimensions and space for which building and components are dimensionally it used and positioned in basic units (or) modules. The standard specify that the module basic M-100mm. As the basic unit be used in a square of M.

- **Basic Module**

It is the fundamental module used in modular co-ordination. The size of basic module is selected for building and its components. The value of basic module chosen is 100 mm for maximum flexibility and convenience. The symbol for basic module is M. After adopting this, further work is necessary to outline suitable range of multi modules with greater increments, often referred to as preferred increments.

- **Modular co-ordination (M)**

1. Planning grid in both directions of the horizontal plan shall be:
a. 3 M for residential and institutional buildings
b. For industrial buildings:
   15 M for spans up to 12 m;
   30 M for spans between 12 m and 18 m and
   60 M for spans over 18 m.
   The center lines of load bearing walls shall coincide with the grids lines.

2. In case of external walls, the grid lines shall coincide with the centre line of the wall or a line on the wall 50 mm from the internal face;

3. The planning module in the vertical direction shall be 1 M up to and including a height of 2.8 m; above the height of 2.8 m, it shall be of 2 M;

4. Preferred increments for sill heights, doors, windows etc., shall be 1 M;

5. In the case of internal columns, the grid line coincides with the centre line of columns. In case of external columns and the columns near the lift and stairwells, the grid line coincides with the centre lines of the column in the top most storeys or line in the column 50 mm from the internal face of the column in the top most storeys.

BASIC DEFINITIONS

Basic module: The fundamental module used in modular coordination, the size of which is selected for general application to buildings and components.

Component: A building product formed as a distinct unit, having specified sizes in three dimensions. Building components include items of equipment, fixtures, fittings and fixed furnitures.

Dimensional coordination: A convention on related sizes for the coordinating dimensions of building components and the buildings incorporating them, for their design, manufacture and assembly . The purposes of dimensional coordination are: (1) to permit the assembly of components on site without cutting on fitting; and,
(2) to permit the interchangeability of different components.

Infra-modular size: A size smaller than the basic module.

Modular axis: A line in a modular grid, which defines the position in plan of a main load-bearing element (for example wall, row of columns).

Modular component: A component whose coordinating sizes are modular.

Modular coordination: Dimensional coordination employing the basic module or a multimodule. The purposes of modular coordination are: (1) to reduce the variety of component size produced; and, (2) to allow the building designer greater flexibility in the arrangement of components.

Modular element: An element whose coordinating sizes are modular.

Modular floor height: Vertical dimension of the modular floor zone between the modular plane of the upper surface of floor covering and the modular plane of the finished ceiling.

modular floor plane: Horizontal modular plane continuous over the whole of each storey of a building and coinciding with the upper surface of floor covering, the upper surface of rough floor or the upper surface of structural floor.

Modular grid: A rectangle coordinate reference system in which the distance between consecutive lines is the basic module or a multimodule. This multimodule may differ for each of the two dimensions of the grid.

Modular line: A line formed by the intersection of two modular planes.

Modular plane: A plane in a modular-space grid.

Modular room height: Vertical dimension within one storey between the modular plane of the upper surface of floor covering and the modular plane of the finished ceiling.

Modular size: A size that is a multiple of the basic module.

Modular space grid: A three-dimensional rectangular coordinate reference system in which the distance between consecutive planes is the basic module or a multimodule. This multimodule may differ for each of the three dimensions of the space grid.

Modular storey height: Vertical dimension between two modular floor planes of two consecutive floors.

AIMS OF MODULAR COORDINATION

a. Major Objective:

The principal object of modular coordination is to assist the building design, construction professional building industry and its associated manufacturing industries, by standardization in such a way that building components fit with each other, with other components and with building assembly on site, thereby improving the economics of building.

b. Specific Objectives:

Modular coordination thus:

• facilitates cooperation between building designers, manufacturers, distributors, contractors and authorities;

• in the design work, enables buildings to be so dimensionally coordinated that they can be erected with standard components without undue restriction on freedom of design;

• permits a flexible type of standardization, which encourages the use of a number of standardized building components for the construction of different types of building;

• optimizes the number of standard sizes of building components;

• encourages as far as possible the interchangeability of components, whatever the material, form or method of manufacture;

• simplifies site operations by rationalizing setting out, positioning and assembly of building components; and,

• ensures dimensional coordination between installations (equipment, storage units, other fitted furniture, etc.) as well as with the rest of the building.

6. Define the term standardization and mention its uses and advantages.

STANDARDIZATION

➢ **Definition**

The standardization is the process of adoption of generally accepted uniform procedures, dimensions, materials, or parts that directly affect the design of a prefabricated product or a facility.

➢ **Advantages of standardization**

1. Easier in design as it eliminates unnecessary choices.
2. Easier in manufacture as there is limited of variants.
3. Makes repeated use of specialized equipment's in erection and completion easier and quicker.

➢ **Factors influencing standardization**

1. To select the most rational type of member for each element from the point of production, assembly, serviceability and economy.
2. To limit the number of types of elements and to use them in large quantities.
3. To use the largest size to the extent possible, thus resulting in less number of joints.
4. To limit the size and number of prefabricate by the weight in the overall dimension that can be handled by the handling and erection equipment and by the limitation of transportation.
5. To have all the prefabricates approximately of same weight very near to the lifting capacity of the equipment.

7. Write the detail about systems of prefabrication in prefabricated structures.

SYSTEM ON PREFABRICATION

The word 'system' is referred to a particular method of construction of buildings by using prefabricated components which are inter-related in functions and are produced to a set of instructions. With certain constraints, several plans are possible, using the same set of components. The degree of flexibility varies from system to system. However, in all the system, there is a certain order and discipline.

Prefabricated Construction Systems

The system of prefabricated construction depends on the extent of the use of prefab components, their materials, sizes and the technique adopted for their manufacture and use in building. The various prefabrication systems are outlined below.

- Open prefab system
    a. Partial prefab open system

b. Full prefab open system

- Large panel prefab system
- Wall system
    a. Cross wall system
    b. Longitudinal wall system
- Floor system
- Staircase system
- Box type system

1.Open Prefab System

This system is based on the use of the basic structural elements to form whole or part of a building. The standard prefab concrete components which can be used are,

1. Reinforced concrete channel units
2. Hollow core slabs
3. Hollow blocks and battens
4. Precast planks and battens
5. Precast joists and tiles
6. Cellular concrete slabs
7. Pre-stressed / reinforced concrete slabs
8. Reinforced / pre-stressed concrete beams
9. Reinforced / pre-stressed concrete columns
10. Pre-cast lintels and sunshades
11. Reinforced concrete waffle slabs / shells
12. Room size reinforced / pre-stressed concrete panels
13. Reinforced / pre-stressed concrete walling elements
14. Reinforced / pre-stressed concrete trusses

The elements may be cast at the site or off the site.

Foundation for the columns could be of prefabricated type or of the conventional cast in-situ type depending upon the soil conditions and loads. The columns may have hinged or fixed base connections depending upon the type of components used and the method of design adopted.

There are two categories of open prefab systems, depending on the extent of prefabrication used in the construction as given below.

i. Partial prefab open system
ii. Full prefab open system

Partial Prefab Open System

This system basically emphasizes the use of pre-cast roofing and flooring components and other minor elements like lintels, sunshades, kitchen sills in conventional building construction. The structural system could be in the form of in-situ framework or load hearing walls.

1. **Full Prefab Open System**

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

2. Large Panel Prefab System

This system is based on the use of large prefab components. The components used are precast concrete large panels for walls, floors, roofs, balconies, staircases etc. The casting of the components could be at the site or off the site.

Depending upon the extent of prefabrication, this system can also lend itself to partial prefab system and full prefab system.

3. Wall System

Structural scheme with precast large panel walls can be classified as.

a. Cross wall system
b. Longitudinal wall system

Cross Wall System

In this system, the cross walls are load bearing walls. The façade walls are non-load bearing. This system is suitable for high rise buildings.

Longitudinal Wall System

In this system, cross walls is non-load bearing. Longitudinal walls are load bearing. This system is suitable for low rise buildings. A combination of the above systems with all load bearing walls can also be adopted. Pre-cast concrete walls could be:

i. Homogeneous walls
ii. Non-Homogeneous walls

Homogeneous Walls

The walls could be solid, hollow or ribbed.

Non-Homogeneous walls

These could be composite or sandwich panels. Based on the structural functions of the walls, the walls could also be classified as,

a. Load bearing walls
b. Non-load bearing walls
c. Shear walls

Based on their locations and functional requirements the walls are further classified as,

i. **External walls,** which can be load bearing or non-load bearing depending upon the layout. They are usually non-homogeneous walls of sandwiched type to impart better thermal comforts.
ii. **Internal walls,** which provide resistance against vertical loads, horizontal loads, fire etc. and are normally homogeneous.

4. Types of Pre-cast Floors

Depending upon the composition of unit, precast flooring units could be homogeneous or non-homogeneous.

i. **Homogeneous Floors** could be solid slabs, cored slabs, ribbed or waffle slabs.

ii. **Non-Homogeneous Floors** could be multi-layered ones with combinations of lightweight concrete or reinforced/ pre-stressed concrete, with filled blocks.

Depending upon the way the loads are transferred, the pre-cast floors could be classified as one way

1. **One way system** transfers loads to the supporting members in one direction only. The pre-cast elements of this category are channel slabs, hollow core slabs, hollow blocks and battens plank system, channels and tiles system, lightweight cellular concrete slabs.
2. **Two ways system** transfers loads in both the directions imparting loads on the four edges. The pre-cast elements under this category are room sized panels, two way ribbed or waffle slab systems etc.

5. Staircase System

Staircase system consists of single flights with in-built risers and treads in the element only. The flights are normally unidirectional, transferring the loads to supporting landing slabs or load bearing walls.

6. Box Type System

In this system, room size units are prefabricated and erected at site. Toilet and kitchen blocks 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 are joined to make rigid connection among them. The box unit rests on plinth foundation which may be of conventional type or pre-cast type.

Joints

The joints should be provided in the light of their assessment with respect to the following considerations.

i. Feasibility

The feasibility of joint shall be determined by its load-carrying capacity in the particular situation in which the joint is to function.

ii. Practicability

Practicability of joint shall be determined by,

a. The amount and types of materials required in construction.
b. Cost of materials, fabrication, and erection
c. The time for fabrication and erection

iii. Serviceability

Serviceability shall be determined by the joints/ expected behavior to repeated or possible overloading and exposure to climatic or chemical conditions.

iv. Fire- Proofing

Resistance offered against any fire accident.

v. Appearance

The following are the requirements of an ideal structural joint.

a. It shall be capable to transfer the imposed load and moments with a known margin of safety.

b. It shall occur at logical locations in the structure and at points which may be most readily analyzed and easily reinforced.
c. It shall accept the loads without marked displacement or rotation and avoid high local stresses.
d. It shall accommodate tolerances in elements.
e. It shall require little temporary support, permit adjustment and demand only a few distinct operations to make.
f. It shall permit effective inspection and rectification.
g. It shall be reliable in service with other parts of the building.
h. It shall enable the structure to absorb sufficient energy during earthquake so as to avoid sudden failure of the structure.

Pre-cast structures may have continuous or hinged connections subject to providing sufficient rigidly to withstand horizontal loading. When only compressive forces are to be taken, hinged joints may be adopted. In case of prefabricated concrete elements, load is transmitted via the concrete. When both compressive force and bending moment are to be taken, rigid or welded joints may be adopted. the shearing force is usually small in the column and can be taken up by the frictional resistance of the joints. Here, load transmission is an accomplished by steel inserted parts together with concrete.

When considering thermal shrinkage and heat effects, provision of freedom of movement or introduction of restraint may be considered.

Joining techniques / materials normally employed are:

- Welding of cleats or projecting steel
- Overlapping reinforcement, loops and linking steel founded by concrete
- Reinforced concrete ties all around slab
- Pre-stressing
- Epoxy grouting
- Bolts and nuts connections
- A combination of the above

9. What are the principles or concept of prefabrication technique and explain detail. (N0v/Dec-2013)

Prefabrication Techniques:

1. Small Prefabrication
2. Medium Prefabrication
3. Large Prefabrication
4. Cast in situ Prefabrication
5. Off site or factory Prefabrication
6. Open system of Prefabrication
7. Closed system of Prefabrication
8. Partial Prefabrication

9. Total Prefabrication

2. **Small Prefabrication:**

The first 3 types of prefabrication are mainly classified according to their degree of precast elements using in that construction. For eg :- brick is a small unit precasted and used in buildings. This is called as small prefabrication. That the degree of precast alement is very low.

3. **Medium prefabrication :**

Suppose the roofing system and horizontal members are provided with precast elements these constructions are known as medium prefabricated construction , here the degree of precast elements are moderate.

4. **Large prefabrication :-**

In large prefabrication most of the member like wall pannels , roofing/flooring systems, beams and columns are prefabricated. Here degree of precast elements are high.

5. **Cast-in-site prefabrication : Off-site (factory) prefabrication**

One of the main factor which affect the factory prefabrication is transport, The width of road wall, mode of transport, vehicles are the factors which prefabrication.Which is to be done On-site or factory.

Suppose the factory situated at a long distance from the construction site and the vehicle have to cross a congested traffic with heavy weighed elements the cost In-site prefabrication is preferred only when number of houses and more for small elements the conveyance is easier with normal type of lorry and trailors. There fore we can adopt factory (or) OFF site prefabrication for this type of construction.

1. **Open system of prefabrication**

   In the total prefabrication system, the space frames are casted as a single unit and erected at the site. The wall fitting and other fixing done on site. This type of construction is known as Open system of prefabrication.

2. **Closed system of prefabrication**

   In this system,the whole things are casted with fixing and erected on their position.

3. **Partial prefabrication**

   In this method of construction the building element (mostly horizontal) required are precast and then erected. Since the casting of horizontal elements (roof/floor) offen take more time due to erection of form work the completion of building is delayed and hence this method is restored. In most of the building sites this method is popular more. So in industrial buildings where the elements have longer spans. Use of double tees channel units cored stabs , slabs, hyperboloid shells etc , are some of the horizontal elements .

This method is efficient when the elements are readly available when the building reached rooflevel. The delay caused due to erection of form work delay due to removal of form work eliminated completly in this method of construction suitable for any type of building provided lifting and erection equipments are available.

4. **Total prefabrication**

   Very high speed can be achived by using this method of construction. The method can be employed for frame type of construction or for pannel type of or the total prefabrication can be on site or off site . The choice of these methods depend on the situations when the factory produced elements are transported and erected site we call if off site prefabrication if this method is to be adopted then we have a very good transportation of the products to site. If the elements are cast near the building site and erected the transportation elements can be eliminated,but we have consider the space availability for establishing such facilities though it is temporary. The choice of the method of construction also depends on the following.

   I. Type of equipment available for erection and transport.
   II. Type of structural scheme (linear elements or pannel)
   III. Type of connection between elements
   IV. Special equipments devised for special method of construction

5. **Prefabricated materials**

   Prefabricated building materials are used for buildings that are manufactured off site and shipped later to assembled at the final location. Some of the commonly used prefabricated building.

10. Briefly explain the details about manufacturing or production process of prefabrication structures. (May/June-2012)

PRE-CAST CONCRETE MANUFACTURING TECHNIQUES

Traditional construction techniques involve forming a building's structure at the site, using brick, wood, siding, or other materials. These techniques are manually intensive and time consuming. An alternative approach is to use pre-cast concrete building elements. These can be produced off-site at a manufacturing facility. They are then transported to the construction site for installation. These building elements offer time savings benefits over traditional structural elements because they arrive at the construction site ready for installation.

Manufacturing pre-cast concrete building elements is a relatively simple process in that there are few steps and fewer materials. The basic process is to pour cement into a form, or bed, and allow it to cure. The form is essentially a mould for the concrete. Changing the shape of the form alters the final shape of the concrete. There are many random elements in the manufacture of construction elements. Differences in individual element size, color, and shape, constraints on resources, and randomness in production times contribute to scheduling difficulties.

Simulation Technique For Construction Elements Manufacturing

Simulation is frequently applied to manufacturing facilities to improve production processes where the system has many random interacting components. The use of simulation in construction processes is not a new concept.

Pre-cast building elements manufacturing process

Manufacture of pre-fabricated concrete building elements is essentially performed in a job shop environment. That is, each element produced may be very different from all other elements. The manufacture of pre-fabricated concrete elements differs somewhat from the traditional job shop problem, however. In the traditional job shop, parts are processed by different machines. In the pre-cast job shop, however, parts are processed by the same machine (form). In essence, the "machine" has a significant setup time required to create multiple unique parts. The parts are then batch processed through a "curing operation."

The basic steps to pre-fabricated construction element manufacturing include the following:

1. Form construction. This may include placing wooden frames for architectural openings inside the form. It may also include installing wooden bulkheads to create elements of different lengths.
2. Set-up.
3. Pull and stress supporting cables (rebar).
4. Pour cement.
5. Lay down insulation (optional).
6. Pull and stress supporting cables for second layer of concrete (if insulation installed).
7. Pour second layer of concrete (if insulation installed).
8. Cure.
9. Strip (remove element from form). This may include sawing through the concrete to create elements of varying lengths, if wooden bulkheads were not used prior to pouring concrete.
10. Apply finish.

Each of these steps introduces some variability into the manufacturing process. Perhaps most significant source of variation, however, is customer choice. Each customer may request pre-cast elements of different sizes with different patterns of openings, different finishes, and different colors. Further, the element's intended use impacts the depth of concrete poured as well as the number of supporting cables used. A pillar for a parking structure may need to be significantly stronger than that for a home garage wall.

This variability creates difficulties in scheduling. The time to set-up an element with many architectural features takes significantly longer than a plain unit. This must be carefully managed to maintain production. A form requiring many complex pieces and few simple ones may take so long to set-up that the concrete pour is delayed. This in turn delays the time when the building elements can be removed from the form, possibly delaying the next pour operation. Thus, each day an effort is made to balance complex pieces with simple ones so that the complex pieces are distributed over a number of production days.

In addition to the issue of the complexity of a piece, the length of the forms drives decisions. Because it takes 10-16 hours to cure, regardless of the lineal feet of concrete poured, efforts are made to "fill-out" a bed each day. This may result in pieces being made before they are ready for installation at the construction site. These pieces are then stored in a construction yard where they are subject to damage. In addition, inefficiencies are introduced in the form of double handling of pieces.

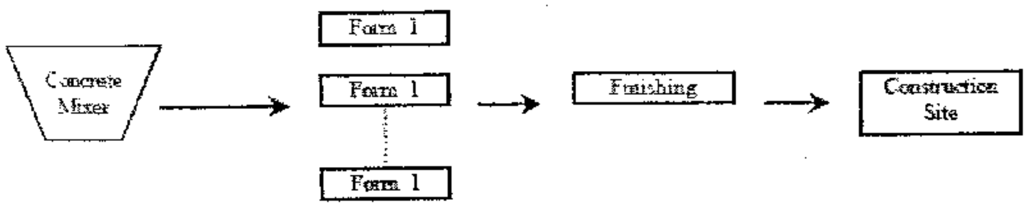

Figure: General flow of material pre-cast construction elements manufacturing.

- **In-Situ Cast Concrete Building**

In any case, techniques mentioned in connection with industrial building include the following:

- standardization (e.g. components, methods, processes or dimensional standardization and modularisation);
- prefabrication (manufacturing of components beforehand, similar to off-site fabrication);
- on-site fabrication (manufacturing of components on site or in a field factory);
- pre-assembly (materials, prefabricated components and/or equipment are joined together for subsequent installation);
- modular buildings (units enclosing a usable space and forming a part of the building structure);
- the building system (a product system with an organised entity consisting of components with defined relationships, including design rules);
- mechanization (the use of mechanical equipment instead of manual labour); and
- Automation (utilisation of programmable machines – e.g. robots – performing tasks, or of computerised tools for planning, design and operation).

11. Briefly explain about the transportation and erection. (Apr/May-2009)

SAFE HANDLING, TRANSPORTATION AND ERECTION OF PRECAST CONCRETE

When the units have reached the required strength, they are removed from the mould and labelled for later identification. They are then stacked on wooden battens or plastic pads.

The principles of site erection, the methods of making structural joints and the specification for materials are all in accordance with the requirements of BS 8110.

At the commencement of each project a method statement confirming how the building will be manufactured, transported and installed should be prepared.

The headings covered in this statement include:

- Safety (including the mandatory safety statement)
- Mould-work
- Materials
- Handling/Carnage and Transportation
- Site Installation (Procedure, Programme, Sequence)

The designs for temporary conditions during erection should take into account overall frame stability and the stresses in individual frame components and joints.

Load paths through a partially completed structure may be different for those in a completed frame. An example is the temporary state when floor units have been placed on one side only of an internal beam.

Here the connection should be checked for its resistance to torsion and if necessary, propped until the slabs on the other side of the beam are placed in position.

SITE ERECTION

The aesthetic options available with architectural precast concrete components, especially wall panels, are considerable. They can mimic a wide variety of other masonry alternatives, including brick and stone, providing many options for duplicating existing architectural styles used with surrounding buildings.

This holds true whether the styles are historic or contemporary. In many cases, architectural finishes also can be provided for structural precast components, combining functions and saving material cost and construction time. Precast components also mesh well with other materials, including curtain walls, and they can accommodate any required penetrations.

Special considerations will aid the installation of mechanical systems and vapor barriers, all of which can be accommodated easily.

Precast concrete's economy aids owners and designers in meeting their budgetary needs and helps make funds available that are typically needed for design consideration for other key elements. Its economy not only reduces the immediate in-ground cost but also continues to save operating expenses over the life of the building through extended durability and lower maintenance costs.

ERECTION PLATFORM

The builder must determine that the erection platform (floor slab, footing, suspended slab or surrounding ground, etc.) can support the construction and erection loads and provide verification to the crane owner/operator prior to the commencement of the work.

If a suspended slab is used to support the crane, or transporter, the slab should be designed for the crane point loads, wheel loads, or any other construction loads, by a registered engineer. A temporary propping system may be required.

ERECTION PREPARATION

Prior to commencing the handling and/or erection of precast concrete elements, the following items should be considered by the manufacturer or builder as appropriate.

(1) Check crane access to the site and erection platform to prevent cranes or trucks damaging the concrete floor during access. A compacted hard-fill ramp at a suitable gradient should be provided to a level slightly above the concrete floor.

(2) Obtain verification that the erection platform can support the erection loads.

(3) Ensure the locating dowels and leveling shims are correctly located. Dowels rather than blocks should be used to restrain the base of face-lifted panels when they are being positioned.

(4) Clear the site for truck and crane access ensuring room for crane outriggers, counterweight tail swing, and boom swing and under hook and overhead obstructions.

(5) Ensure that sufficient space is available for precast propping or panel bracing.

(6) The builder must ensure that adequate temporary base restraint is provided for any precast element to prevent a sliding failure (kick out) at the base or support of the element.

(7) Check that the means of temporary support, including falsework is adequate for the intended purpose and located correctly prior to the precast elements being placed lifting. This may already have been done if the element was manufactured off-site.

(9) Check that the lifting inserts are in their correct location and that recesses are cleaned out in preparation for lifting.

(10) Determine if it is necessary to equalize loads on lifting points.

(11) Ensure that the appropriate rigging equipment is available. This includes lifting beams and correct attachments for cast-in anchors or inserts.

(12) Wherever possible the lifting of tilt-slab panels should be undertaken from within the building envelope. In this way, the crane operator is able to keep the rigging and lifting eyes in view at all times.

(13) Erection should be possible without the need for any worker to be positioned underneath a precast element or on the underside of a tilt-up panel during erection.

TRANSPORT OF PRECAST ELEMENTS

Transport of precast elements inside the factory and to the site of erection is of the considerable importance not only from the point of view of economy but also from the point of view of design and efficient management. Transport of precast elements must be carried out with exterior care to avoid any jerk and distress in elements and handled as far as possible in the same orientation as it is to be placed in final position.

TRANSPORT FROM STACKING YARD INSIDE THE FACTORY TO THE SITE OF ERECTION:

Transport of precast concrete elements from the factory to the site of erection should be planned in such a way so as to be in conformity with the traffic rules and regulations as stipulated by the authorities. The size of the elements is often restricted by the availability of the suitable transport equipment such as tractor-cum-trailers, to suit the load and the dimensions of the members in addition to the load carrying capacity of the bridges on the way.

While transporting elements in various systems, the is, wagons, trucks, care should be taken to ensure the base packing for supporting the elements are located at specified positions only. Subsequent packing must be kept strictly one over the other.

The various transporting devices used in the prefabrication construction are :

1. Wagons.
2. Trucks
3. Hand trucks
4. Narrow-gauge rail road.
5. Skids.
6. Combination devices(lifting and lowering with transportation)

7. Fork lift truck.
8. Dumpers and
9. Lorries.

ERECTION PRINCIPLES: (Nov/Dec-2013)

In the 'erection of precast elements', all the following items of work are meant to be included:

a) Slinging of the precast element;

b) Tying up of erection ropes connecting to the erection hooks;

c) Cleaning of the elements and the site of erection;

d) Cleaning of the steel inserts before incorporation in the joints, lifting up of the elements, setting them down into the correct envisaged position;

e) Adjustment to get the stipulated level, line and plumb;

f) Welding of cleats;

g) Changing of the erection tackles;

h) Putting up and removing of the necessary scaffolding or supports;

j) Welding of the inserts, laying of reinforcements in joints and grouting the joints;

k) Finishing the joints to bring the whole work to a workmanlike finished product.

In view of the fact that the erection work in various construction jobs using prefabricated concrete elements differs from place to' place depending on the site conditions, safety precautions in the work are of utmost importance. Hence only those skilled foremen, trained workers and fitters who have been properly instructed about the safety precautions to be taken should be employed on the job. For additional information, see SP 7 (Part 7): 2005 National Building Code of India: Part 7 Constructional practices and safety.

Transport of people, workers or visitors, by using cranes and hoists should be strictly prohibited on an erection site. In the case of tower rail mounted cranes running on rails, the track shall not have a slope more than 0.2 percent in the longitudinal direction. In the transverse direction the rails shall lie in a horizontal plane. The track of the crane should be daily checked to see that all fish plates and bolts connecting them to the sleepers are in place and in good condition. The operation of all equipment used for handling and erection shall follow the operations manual provided by the manufacturer. All safety precautions shall be taken in the operations of handling and erection.

For the design and construction of composite structures made up of prefabricated structural units and cast in-situ concrete, reference may be made to IS 3935. For design and construction of precast reinforced and prestressed concrete triangulated trusses reference may be made to IS 3201. For design and construction of floors and roofs using various precast units, reference may be made to good IS 6332, IS 10297, IS 10505, IS 13994, IS 14142, IS 14215 and IS 14242. For construction with large panel prefabricates, reference may be made to IS 11447. For construction of floors and roofs with joists and filler blocks, reference may be made to IS 6061 (Part 1 and 2).

EQUIPMENT REQUIRED FOR ERECTION:

Erection equipment such as cranes, derricks, hoists, chain pulling blocks are used.

CRANES:

For the erection of prefabricated buildings, the following cranes are used

1. Stationary
   a. Guyed derrick
   b. Climbing crane
   c. Tower crane with fixed base.
2. Cranes on rails
   a. portal crane
   b. tower cranes
3. Mobile crane
   a. truck mounted
   b. Crawler mounted.

1. STATIONARY CRANES:

A. GUYED DERRICK

- These are used on frame buildings for the erection of floor panel, columns and slab strips.
- The derricks being lighter in weight can be shifted from floor to floor operating from an erected floor.
- The columns are first erected, the beams are then laid connecting these columns in single storey height.
- On having completed one storey heigth of the frame and few slab strips around a column beam assembly, the derrick is lifted to the next floor level.
- Slab strips or battens at the bottom level is now completed with the help of this derrrick.
- So also the slabs at the levels of seating of the derrick is also completed. Before shifting the derrick to the next level the column beam assembly for one storey heogth above its seating level is completed.

B. CLIMBING CRANE:

- When tall buildings with over 20 storeys are constructed, the type of cranes are used.
- A horizontal jib and the balancing counter weigh is placed on the top of the shaft.
- This shaft itself is stationary and the crane operates 360 degree around a pivot on the shaft.
- The crane can be lifted upto a new position as the building goes up.
- Normally stair case walls are used for erecting and operating these types of cranes.
- On completion of the building erection, the crane is dismantled and taken out through the sides.
- Such cranes will have to be used when construction is carried out in congestion areas waith no access for crane track.
- Such a crane fitted on the building picks up the precast elements from any one of the sides of the building.

C. Tower crane with fixed base

- Where use of sail mounted or climbing cranes are not possible, tower cranes with fixed base are installed.
- This also is do in for very tall buildings.
- These cranes are fixed at the base and braced horizontally to the building portion already completed as the building go up the vertical most can be hoisted up by special hydraulic jacks provided for this purpose.
- The masts are telescopic and there is provision for adding additional mast pieces, upto 100m height can be built up with such mast.

2. Cranes on rails.

Portal crane.

- In storage yards and in buildings where the travel distance is short, portal crannes are used.
- They consists of two vertical legs and a horizontal beam.

A travelling trolley attached to the bottom flange of the beam carries the load horizontally, across the longitudinal axis.

These beams are sometimes designed to project out for some distance to pick up elements stacked along side of the track on which the portal crane moves. They are also called as goliath cranes. As no counter balancing dead weights are added on to the crane, these cranes are relatively lighter in weight and therefore easy to assemble and dismantle without the help of another crane.

3. Tower crane:

- Tower cranes are versatile equipment used in prefabrication.
- The serious drawback with such a cranes is that require heavy crane track, lengthy and expensive assemble and dismantling.
- It therefore follows that such a cranes are used on projects where erection of very large number of elements are involved.