PREFABRICATION

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.

Prefabricated building is the completely assembled and erected building of which the structural parts consist of prefabricated individual units or assemblies using ordinary or controlled materials.

Prefabricated construction is a new technique and is desirable for large scale housing programmes.

PRINCIPLES: (AIMS)

1) To effect economy in cost
2) To improve in quality as the components can be manufactured under controlled conditions.
3) To speed up construction since no curing is necessary.
4) To use locally available materials with required characteristics.
5) To use the materials which possess their innate characteristics like light weight, easy workability, thermal insulation and combustibility etc.

NEED FOR PREFABRICATION

1. Prefabricated structures are used for sites which are not suitable for normal construction method such as hilly region and also when normal construction materials are not easily available.
2. PFS facilities can also be created at near a site as is done to make concrete blocks used in plane of conventional knick.
3. Structures which are used repeatedly and can be standardized such as mass housing storage sheds, godowns, shelter, bus stand security cabins, site offices, fool over bridges road bridges. Tubular structures, concrete building blocks etc., are prefabricated structures

PROCESS OF PREFABRICATION

An example from house building illustrates the process of prefabrication. The conventional method of building a house is to transport bricks, timber, cement, sand, steel
and construction aggregate etc. to the site and to construct the house on site from these materials.

In prefabricated construction only the foundations are constructed in this way. While sections of walls, floors, and roof are prefabricated structures with windows and door frame included and transported to the site lifted into place by a crane and boiled together.

**USES OF PREFABRICATION**

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

2. Pouring concrete sections in a factory brings the advantages of being able to re-use moulds and the concrete can be mixed on the spot without having to be transported to and pumped wet on a congested construction site.

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

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

5. The technique is also used in office blocks, warehouses and factory buildings.

6. Prefabricated steel and glass section are widely used for the exterior of large buildings.

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

8. Prefabrication can also help minimize the impact on transfer from bridge building.

9. Radio towers for mobile phone and other services often consist of multiple prefabricated sections.

10. Prefabricated has become widely used in the assembly of aircraft and space craft with component such as wings and fuselage sections often being manufactured in different countries or states from the final assembly site.
ADVANTAGE OF PREFABRICATION

- Self supporting readymade components are used so the need for formwork shuttering and scaffolding is greatly reduced.
- Construction time is reduced and buildings are completed sooner allowing on 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, power materials space and overheads are lower.
- Time spent in bad weather or hazardous environments at the construction site is minimized
- Materials for scaffolding is stored partly or in full and used
- Availability of precise structure and expect workmanship.
- Work time is reduced.
- Fewer expansion joints are required.
- Interruptions in connecting can be omitted.
- Work is done with a better technology.
- Less workers are needed.
- Members can be used again.

DISADVANTAGES OF PREFABRICATION

- 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 structures require heavy-duty cranes & precision measurement and handling to place in position.
- Large groups of buildings from the same type of prefabricated elements tend to look drab and monotonous.
Local Jobs are lost.

The main reasons to choose precast construction method over conventional in situ method
1. Economy in large scale project with high degree of repetition in work execution.
2. Special architectural requirement in finishing
3. Consistency in structural quality control
4. Fast speed of construction
5. Constraints in availability of site resources (e.g. materials & labour etc.)
6. Other space & environmental constraints
7. Overall assessment of some or all of the above factors which points to the superiority of adopting precast construction over conventional method.

The following details gives the cost implications of precast construction & conventional in-situ method.

MATERIALS USED:
Prefabricated building materials are used for buildings that are manufactured off site and shipped later to assemble at the final location some of the commonly used prefabricated building. The materials used in the prefabricated components are many. The modern trend is to use concrete steel, treated wood, aluminium cellular concrete, light weight concrete, ceramic products etc. While choosing the materials for prefabrication the following special characteristics are to be considered.

- Light weight for easy handling and transport and to economic an sections and sizes of foundations
- Thermal insulation property
- Easy workability
- Durability in all weather conditions
- Non combustibility
- Economy in cost
- Sound insulation

CHARACTERISTICS OF MATERIALS
- Easy availability
- Light weight for easy handling and transport and to economies on sections and sizes of foundations.
- Thermal insulation property
- Easy workability
- Durability to all weather conditions
- Non combustibility
- Economy in cost

**MATERIALS ARE ALUMINUM, STEEL, WOOD, FIBERGLASS AND CONCRETE**

Prefabricated metal buildings use galvanized steel and galvalume as the chief materials for building. Galvalume is a form of steel coated with aluminium zinc. This is to protect the building against corruption rust and fire. It also provides a study and protective covering to the prefabricated building. Almost all the components of a metal building such as beams, frames columns wall & roofs are made of steel. Most fabricated military buildings use steel or aluminium frames. 

[Synthetic materials are used for the walls & roofs. To provide enhanced security a combination of both metal and cloth materials are used plastic flooring materials can be quickly assembled and are very durable]

Prefabricated building materials used for small prefabricated buildings are steel, wood, fibre glass plastic or aluminium materials. These materials are cheaper than regular brick and concrete buildings. Materials like steel, fibre glass, wood and aluminium are used as prefabricated building materials for sports buildings. These materials provide flexibility and are preferred for making structures and accessories like stands and seats for stadium and gyms.

For making low cost houses prefabricated materials like straw bale, 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 & quick.

Using prefabricated material one can make durable, water and fire resistant and cheap prefabricated buildings Most of the prefabricated building materials are eco-friendly & affordable.

**MODULAR COORDINATION**

The modular coordination is defined as the basic module is in adopted the size of which is selected for general application to building and its components. The value of the
basic module chosen is 100 mm for maximum flexibility and convenience. The symbol used for basic module is M

1M = 100mm

100mm = 1M = It is international standard value.

Dimensional coordination employing the basic module or a multimodule. The purposes of modular coordination are

i. To reduce the variety of component size produced

ii. To allow the building designer greater.

**AIMS OF MODULAR COORDINATION**

- Major Objective
- Specific Objective

**MAJOR OBJECTIVE**

The principal object of modular coordinate 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.

**SPECIFIC OBJECTIVES**

Modular coordination thus

- Facilities 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. This encourages the use of a number of standardized building components for the construction of different types of buildings.

- Optimize the number of standard sizes of multimodal’s will suit particular applications.

However if modular coordination is to be achieved the values of multimodal’s should not be chosen arbitrarily and only standardized multimodal’s shall be used pay using multimodal’s it is possible to achieve a substantial reduction in the number of modular
sizes particularly for components having at least one dimension equal to one of the dimensions of the functional element of which they are a part.

A further reduction in the number of modular sizes for components having may be achieved by mean of as general series of multi modular sizes based on selected multimodal’s for horizontal coordinating dimensions are 3M , 6M, 12M, 30M & 60M

The multimode 15M may also be used for special applications

MODULES

Modules are a standard unit of size used to coordinate the dimensions of buildings and components. They are of two types:

1. Multi modules
2. Basic modules

MULTI MODULES

Multi modules are standardized selected whole multiples of the basic module different single T beam has resulted the beam to fall 2 basement down. The beam just placed for connection.

BASIC MODULE

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

MODULAR CO-ORDINATION DIMENSION:

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

2) In case of external walls, the grid lines shall coincide with the centre line of the wall 50mm from the internal force.

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

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

5) In case of internal columns, the grid lines coincide with the centre lines of columns.

   In case of external columns and columns near the lift and stair wells the grid lines shall coincide with centre lines of the column in the top most storey or a line in the column 50mm from the internal face of column in the top most storey.

**Modular Grid**

A rectangular 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.

**Type of Modular Grid**

There are different types of grid patterns which are used to locate the positions and dimensions of building spaces components are

Elements in building design

- Continuous grid
- Superimposed grid
- Displacement of grid (or) Tartan grids
- Interrupted grids as neutral zones.

**Continuous grid**

Where all dimensions in either direction are based on one increment only.

**Superimposed grids**

When the modular grid of 100 mm increment is superimposed on a multi-modular grid.

**Displacement of grid or tartan grids**

Where there is a homogenous and repetitive relation between at least two basic increments.

Eg:- 1M +2M (or) 3/2 M + 3M

**Interrupted grids (or) neutral zones**

Where there are non modular interruptions of grids neutral zones are created to cope with the economics of building design.
STANDARDIZATION

Standardization is to the creation and use of guidelines for the production of uniform interchangeable components especially for use in mass production. It also refers to the establishment and adoption of guidelines for conduct to global marketing the term is used in describe the simplification of procurement & production to achieve economy.

ADVANTAGES OF STANDARDIZATION

1) Easier in design as it eliminates unnecessary choices
2) Easier in manufacture as there are limited number of variants.
3) Makes repeated use of specialized equipments in erection and completion
4) 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 of the extent possible, thus resulting in less number of joints.
4) To limit the size and number of prefabricate by the weight in overall dimension that can be handled by the handling and erection equipment and by the limitation of transportation.
5) To have all these prefabricates approximately of same weight very near to the lifting capacity of the equipment.

SYSTEMS

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.

CHARACTERISTICS OF A PREFABRICATION SYSTEM:-

The following characteristics among others are to be consideration devising a system.

1) Intensified usage of spaces.
2) Straight and simple walling scheme.
3) Limited sizes and number of components.
4) Limited opening in bearing walls.
5) Regulated locations of partitions.
6) Standardized service and stair units.
7) Limited sizes of doors and windows with regulated positions.
8) Structural clarity and efficiency.
9) Suitability for adoption in low rise and high rise blocks.
10) Ease of manufacturing, storing and transporting.
11) Speed and ease of erection.
12) Simple jointing system.

PREFABRICATED CONSTRUCTION SYSTEMS:-
The system of prefabricated construction depends on the extent of the use of prefabricated components, their material, sizes and the technique adopted for their manufacture and use in building. The various prefabrication systems are outlined below.

1) Small prefabrication
2) Medium prefabrication
3) Large prefabrication
4) Open prefabrication system
   a. Partial prefabrication open system
   b. Full prefabrication open system
5) Large panel prefabrication system
6) Wall system
   a. Cross wall system
   b. Longitudinal wall system
7) Floor system
8) Stair case system
9) Box type system

SMALL PREFABRICATION
The first 3 types 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 element is very low.

MEDIUM PREFABRICATION
Suppose the roofing systems and horizontal member are provided with precast elements. These constructions are known as medium prefabricated construction. Here the degree of precast elements are moderate.

LARGE PREFABRICATION
In large prefabrication most of the members like wall panels, roofing/flooring systems, beams and columns are prefabricated. Here degree of precast elements are high.
OFF-SITE (FACTORY) PREFABRICATION

One of the main factors which affect the factory prefabrication is transport. The width of road walls mode of transport vehicles are the factors which factor the prefabrications 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-situ prefabrication is preferred even though the same condition are the cast in site prefabrication is preferred only when number of houses are more for small elements the conveyance is easier with normal type of lorry and trailors. Therefore we can adopt factory (or) OFF site prefabrication for this type of construction.

OPEN PREFABRICATION SYSTEM:

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

1) Reinforced concrete channel units
2) Hollow core slabs
3) Hollow blocks and battens
4) Precast plank and battens
5) Precast joists and tiles
6) Cellular concrete slabs
7) Prestressed / reinforced concrete slabs
8) Reinforced / prestressed concrete slabs
9) Reinforced / prestressed concrete columns
10 Precast lintels and sunshades
11 Reinforced concrete waffle slabs / shells
12 Room size reinforced / prestressed concrete panels
13 Reinforced / prestressed concrete walling elements
14 Reinforced / prestressed concrete trusses

The elements may be cost at the site or off the site.
Foundation for the columns could be of prefabricated type 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 prefabricated systems depending on the extent of prefabrication used in the construction as given below.

1) Partial prefabrication open system
2) Full prefabrication open system

**PARTIAL PREFABRICATION OPEN SYSTEM:**

The system basically emphasizes the use of precast 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 insitu frame work or load bearing walls.

**FULL PREFABRICATION 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.

**LARGE PANEL PREFABRICATION SYSTEM:**

This is based on the use of large prefabricated components. The components used are precast concrete large panels for walls, floor roofs, balconies, stair cases etc. The casting of the components could be at the site or off the site.

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

**WALL SYSTEM:**

Structural scheme with precast large panel walls can be classified as

1) Cross wall system
2) Longitudinal wall system

**CROSS WALL SYSTEM:**

In this system the cross walls are load bearing walls. The facade walls are non-load bearing. This system is suitable for high rise buildings.
**LONGITUDINAL WALL SYSTEM:**

In this system, cross walls are non-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.

**Precast concrete walls could be**

1) Homogeneous walls
2) Non-homogeneous walls

**Homogeneous walls** The walls could be solid or ribbed.

**Non-homogeneous walls:**

Based on the structural functions of the walls, the walls could 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 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.

**TYPES OF PRECAST FLOORS:**

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

1) **Homogeneous floors** could be solid slabs, cored slabs, ribbed or waffle slabs.

2) **Non-homogeneous floors** could be multilayered ones with combinations lightweight concrete or reinforced / pre-stressed concrete with filled blocks.

Depending upon the way, the loads are transferred, the precast floors could be classified as one way or two way systems.
ONE WAY SYSTEM:-

One way system transfers loads to the supporting members in one direction only. The precast elements of this category are channel slabs, hollow core slabs, hollow blocks and hollow plank system, channels and tiles system, light weight cellular concrete slab etc.

TWO WAY SYSTEMS:-

Transfer loads in both the direction imparting loads on the four edges. The precast element under this category are room sized panels two way ribbed or waffle sla system etc..
SYSTEMS PRODUCTION

The term production of systems is describes a series of operation directly concerned In the process of making or more apply of moulding precast units on the face of it there are very many techniques since almost every type prefabricates requires a specific series of operation in its production.

These techniques however may be grouped into three basic method of production. These are

1. The stand system
2. The conveyor belt or production line system
3. The aggregate system

Stand system

In the stand system the prefabricates mature at the point where they were moulded While the production team moves to successive stands the bed on which prefabricates.

Conveyor belt The conveyor belt system of production splits the whole production process in to a series of operation carried out at a separate successive and permanent point to the heat may be by means of conveyor belt trolleys & crane etc.

Aggregate system

The word aggregates describes a large, complex permanently installed set of machines and mechanical application which can carry out most of the separate operation involved in casting concrete components.

PRODUCTION

The location of precasting yards consist of storage facilities suitable for transporting and erection equipments and availability of raw materials are the critical factors which should be carefully planned and provided for effective and economic use of pre-cast concrete components in construction.

The manufacture of the components can be done in a centrally located factor of in a site where precasting yards set-up at or near the site of work.

FACTORY PREFABRICATION;

Factory prefabrication is restored in a centrally located plant for manufacture of standardized components on a long form basis.

It is a capital intensive production where work is done throughout the year preferably under a covered shed to avoid the effects of seasonal variations high level of mechanization can always be introduced in this system where the work can be organized in a factory like manner with the help of constant team of workmen.
The basic disadvantage in factory prefabricated, is the extra cost in occurred in transportation of elements from plant to site of work sometimes the shape and size of prefabricable are to be limited due to lack of suitable transportation equipment roads controls etc.

SITE PREFABRICATION:

In this scheme, the components are manufactured at site near the site of work as possible. This system is normally adopted for a specific job order for a short period. The work is normally carried out in open space with locally a valuable labour force. The equipment machinery and moulds are of mobile nature.

Therefore there is a definite economy with respect to cost of transportation. This system suffers from basic drawback of its non-suitability to any high degree of mechanization. It has no elaborate arrangements for quality control.

PROCESS OF MANUFACTURE:

The various processes involved in the manufacture of precast elements are classified as follows:

1) Main process
2) Secondary (auxiliary) process
3) Subsidiary process

MAIN PROCESS:

It involves the following steps.

1) Providing and assembling the moulds, placing reinforcement cage in position for reinforced concrete work, and
2) Fixing of inserts and tubes where necessary.
3) Depositing the concrete in to the moulds.
4) Vibrating the deposited concrete into the moulds.
5) Demoulding the forms.
6) Curing (steam curing if necessary)
7) Stacking the precast products.

SECONDARY (AUXILLARY) PROCESS:

This process is necessary for the successful completion of the process covered by the main process.

1) Mixing or manufacture of fresh concrete (done in a mixing station or by a matching plant).
2) Prefabrication of reinforcement cage (done in a steel yard of workshop)
3) Manufacture of inserts and other finishing items to be incorporated in the main
STAGES OF PREFABRICATED CONCRETE PRODUCT:

FLOW DIAGRAM OF STAGES OF PROCESSING

CONCRETE         MOULD         STEEL

MIXING         PREPARATION        CUTTING

FILLING          REINFORCING

- COMPONENT
- COMPACTION
- CURING
- DEMOULDLING
- STORAGE

STORAGE OF PRE-COST CONCRETE PRODUCTS BY STAGE

<table>
<thead>
<tr>
<th>Stage</th>
<th>process</th>
<th>Operational involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Procurement storage of raw materials</td>
<td>Unloading</td>
</tr>
<tr>
<td>2</td>
<td>Testing of raw materials</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Design of concrete mix</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Fabrication of reinforcement cages</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Oiling and laying of moulds in portion</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Placing of reinforcement cages inserts and fixtures</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Preparation of fresh concrete</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Transport fresh concrete</td>
<td></td>
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<tr>
<td>9</td>
<td>Depouring into moulding etc.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Curing of concrete</td>
<td></td>
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</tbody>
</table>
PRODUCTION TOLERANCE (T)

The limits of deviation in the dimensions (Δₜ) T/2 the shape of the prefabricates. This depends very much on the type of moulds, wooden, steel, concrete or plastic the tolerance also depends on the nominal dimension, nature of prefabricate and its position during casting

| Degreeof | ≤10 cm | ≥10 cm | 730 cm | 3 m  | ≥9 m |
| Accuracy |       |        |        |      |      |
|          | ≤30 cm | ≥3 m   | ≥9 m   |      |      |

| 4 | 1 mm | 2 mm | 3 mm | 4 mm | 6 mm |
| 5 | 2 mm | 3    | 4    | 6    | 10   |
| 6 | 3 mm | 4    | 6    | 10   | 15   |
| 7 | 4 mm | 6    | 10   | 15   | 25   |
| 8 | 6 mm | 10   | 15   | 25   | 30   |
TRANSPORT

Transport of prefabrication elements must be carried out and with extreme care
to avoid any flock and distress in elements and handled as far as possible to be placed in
final portion

Transport of prefab elements inside the factory depends on the method of production selected for the manufacture.

Transport of prefab elements from the factory to the site of action should be planned in conformity with the trafficable rules and regulations as stipulated by the authouritic the size of the elements is often restricted by the availability of suitable transport equipment, such as tractor-am-tailor, to suits the load and dimension of the member in addition to the load carrying capacity of the bridges on the way.

While transporting the prefab elements in various systems, such as wages, trucks, bullock cards etc. care should be taken to avoid excessive cantilever actions and desired supports are maintained. Special care should be taken in negotiating sharp beds uneven of slushy roads to avoid undesirable stresses in elements and in transport vehicles.

Before loading the elements in the transporting media, care should be taken to ensure the base packing for supporting the elements are located at specified portion only.

ERECTION

It is the process of assembling the Prefabrication element in the find portion as per the drawing. In the erection of prefab elements the following items of work are to be carried out.

1). Slinging of the prefab elements.
2). Tying up of erection slopes connecting to the erection hooks.
3). Cleaning the elements and the site of erection.
4). Cleaning the steel inserts before incorporation in the joints lifting and setting the elements to correct position.
5). Adjustments to get the stipulated level line and plumb.
6). Welding of deats.
7). Changing of the erection tackles.
8). Putting up and removing the necessary scaffolding or supports.
9). Welding the insorts laying the reinforced in joints.

The erection work in various construction jobs by using prefab elements differs with risk condition, hence skilled foremen, and workers to be employed on the job.
**Equipments required for erection**

Equipments required for the prefab elements in industry can be classified as.

1) Machinery required for quarrying of course and fine aggregates
2) Conveying equipment, such as but conveyor, chain conveyors etc.
3) Concrete mixers
4) Vibrators
5) Erection equipment such as cranes, derricks, chain pulley etc.
6) Transport machines
7) Work shop machinery for fabricating and repairing steel.
8) Bar straightening, bending and welding machines
9) Minor tools and takes, such as wheel barrerioir, concrete buckets etc…
10) Steam generation a plant for accelerated curing

**Planning co-ordination**

It is important to have the precaster erector/installer and builder working together to achieve best performance.

**Site Access and storage**

- Check for site accessibility and precast panels delivery to site especially low bed trailers
- Check whether adequate space for temporary storage before installation and ground conditions. (firm ground & levelled)
- Uneven ground will cause overstress & crack panels.

**Planning crane Arrangement**

- Plan the crane capacity and lifting gears based on
  - Heaviest weight of precast panels
- Lifting heights.
- Working radius
- Position of crane in relation to final panel location

**Plan other equipments**

- Boom lift and scissor lift for unhooking installed panels.
- Lifting gears
Skilled personnel’s

- Competent crane operators
- Rigger
- Signalled etc

General considerations for crane selection

- Total lifting weight
- Crane model
- Crane safe working load (SWL)

  (i.e) Based on 15% capacity build in F.O.S. 1.33
  - Lifting capacity must be 1.5 times the total weight i.e) F.O.S 1.5

- Lifting and swing radius
- Crane counter weight
- Crane boom length is relation to the vertical and horizontal clearance from the building.

Installation Process

Installation of vertical components

Verification of Delivered Panels

- Check the panels delivered for correct marking lifting hook and position etc.
- Surface finishing condition
- Pc Dimension compliance
- Reinforcement Provision/position
- Architectural Detail compliance

- Setting out

  Check the panels delivered for marking, lifting hook and condition.

- Set the reference lines & grids
- Check starter bars for vertical components before hoisting for installation
2. **Setting out Quality control point**
   - Ensure correct offset line
   - Check shim pedal/plate level and firm
   - Rubber gasket property secured
   - For external wall/column place backer rod.

3. **Hoisting, Rigging and Installation**
   - While tilting provide rubber pad to avoid chip off.
   - Lift and rig the panel to designated location
   - Adjust the panel in position and secure
   - Lifting of space adding items with balanced centre of gravity.
   - Ensure horizontal alignment correct
   - Ensure panel vertically to correct plumb
   - Check panel to panel gap consistency
   - Check stability of prop before releasing hoisting cable.

4. **Grouting works**
   - Prepare and apply non shrink mortars to seal
   - For corrugated pipe sleeve on splive sleeve pour NSGT or proprietary grouts into pipe slab.
   - Keep installed panels undisturbed for 24 hrs.
   - Check joint widths are consistent before grouting
   - Grout used should be same grade of components and self compacting to prevent cracking.
   - Collect test cube sample for testing for critical element or load bearing elements

5. **Connecting joints**
   - Cast in situ joints install rebars as required
   - Set up forms for casting joints
   - Do Concreting
   - Remove forms after sufficient strength
- For external connections sealant shall be used
- Panel with welded connections welding as required

**Installation of Horizontal Elements**

1. **Setting out**
   - Set reference line/offset line to required alignment and level of slab/beam during installation
   - Put temporary prop to support the precast slab/beam elements
   - Before Hoisting chem. Dimensions
   - Check level and stability of shim
   - Check protruding/ starter bars are within the Specified tolerance to prevent any observation during the erection process

2. **Hoisting & Installation**
   - Put temporary props to support slab/beam
   - Lift and rig the elements in designated location
   - Align and check the level before placement
   - The beams shall prop atleast 2 location
   - Balcony planter box and shall be supported more than 2 location based on design considerations
   - Check level of precast elements

3. **Connections/Jointing**
   - Precast with cast-in-situ joints place the lap rebars as required
   - Set formwork for casting joints
   - Remove formwork after concrete strength is achieved
   - Supporting beams shall be designed to form part of formwork joints
   - The connecting/lapping rebars tied & secured
   - Same grade of concrete 10 to be used that of panel.

4. **Installation using Big canopy**
   - Big canopy high rise precast concrete construction system
   - This is used for faster and efficient

5. **Erection Purpose**
   - In Japan
     - Used to construct the 26 storey pre-cast concrete 30,763m²
The system realized 60% reduction in labor requirement for the frame erection.

- **In Singapore**
  - DBS China square used the system to erect is efficient and faster

6. **Installation constraints Management**

   **Example**

   The project requires precast panel to install 2 basements down.

   **Constraint**
   - Temporary Decking for various for various works.
   - Cross bracing with king posts
   - No direct access for panels

7. **Management**

   - Roller frame and plat form was laid.
   - The panels lowered in roller platform
   - Push to underneath deck where panel is required
   - Remove of one deck panel to lift and install panel in correct position.

8. **Mishandling of precast panels**

   **Case Study**
   - The hollow core slab was in the process of installation it was placed on the beam corbel
   - For making adjustment in position the panel was lifted.
   - During lifting the panel was broken

   **Case of Failure**
   - The panel was designed for simply supported condition
   - The lifting position with over 3 m cantilevered edge that has resulted panel damage.

   **Remediation**
   - Use appropriate lifting position
   - Seek advice from precaster

9. **Common Defects in precast panels**
The common defects to hole in precast panels before installation panel before installation.

- Panel not properly touch up.
- Damage due to insufficient protection during delivery
- Panel dimension deviation
- Panel twisted no rectangular
- Wrong rib and architectural detail
- Missing starter bar or as wrong position
- Corrugated pipe duct choked

10. Precast failures

   Bridge Deck collapse

- Causes reported as inadequate lap length of rebar at cantilevered deck and pier rebar.

   Single T beam collapse

- Cause reported as impact lend on the

TOLERANCE:

It is the sum of acceptable positive and negative discrepancies of actual dimensions from the theoretical one. The limits of tolerance are based on the manufacture and erection requirements.

ERECTION TOLERANCE:

These are the limits of deviation of the positioning in the assembly of the prefabricates. The position tolerance are normally defined by five components namely, deviation in positioning of the prefabricates in x, y, z, directions (Δx, y, z) and deviation in positioning with respect to another prefabricate (Δp) and the deviation in the verticality of the prefabricate(Δp).

<table>
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<th>Degree of Accuracy</th>
<th>x, y</th>
<th>z</th>
<th>p</th>
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