



## Comparative Study of Prefabrication Constructions with Cast-in-Situ Constructions

Anant Bhosale<sup>1</sup>, Sushma Kulkarni<sup>2</sup>

<sup>1</sup> P.G. Student, Department of Civil Engineering, Rajarambapu Institute of Technology, Rajaramnagar, Maharashtra, India

<sup>2</sup> Director, Rajarambapu Institute of Technology, Rajaramnagar, Maharashtra, India

**Abstract** — The conventional method of concreting i.e. cast- in-situ is mostly used for various types of constructions. There are many drawbacks of this method like less quality, lesser speed of construction, high labour requirement etc. These drawbacks ultimately affect the structure. To overcome these drawbacks a new method of concreting can be adopted called as precast concrete method. Precast concrete method is accepted worldwide for its advantages over conventional concrete method. The main aim of this paper is to present a prefabricated construction based on time and cost utilization over than in-situ construction. A literature survey and field visits are carried out to predict the time and cost behaviour. Precast construction technology is quite popular and comfortable method of construction in developed countries attributes the several advantages. However, in India, conventional construction method is still widely accepted despite incurring higher cost and slow production rate.

**Keywords**- Precast technology, mold cost, panelization, frame, prestress, transportation

### I. INTRODUCTION

Prefabrication has been widely regarded as an endurable construction method in terms of its impact on the protection of the environment. An important aspect of this perspective is the influence of prefabrication on the reduction of construction waste and subsequent waste management activities, including classification, reuse, recycling and waste disposal. Prefabrication is a productive construction technique in terms of time, quality, cost, productivity, safety and functionality. The construction boom in India is developing at an accelerated rate of growth. It provides ample opportunity in India for a new entrant in the prefabricated sector. Today, prefabricated concrete buildings are the advanced construction techniques available around the world. Due to their wide applicability, prefabricated systems for buildings are becoming a popular choice for many constructions. Prefabricated concrete available in many shapes, sizes, including structural elements and non-reinforced parts. The concept of prefabricated construction includes those buildings, where most structural components are standardized and produced in factories at a location away from the building, and then transported to the assembly site.

These components are manufactured by industrial methods i.e mass production in order to build a large number of buildings in a short time at low cost.

The salient features of this construction process are as follows:

1. The division and specialization of the labour workforce.
2. The use of tools, machinery, and other equipment, usually automated, in the production of standard, interchangeable parts and products.
3. Precast concrete elements' erection is faster and less affected by adverse weather conditions.
4. Factory casting allows increasing efficiency, high quality control and greater control on finishes.

### II. CAST-IN-SITU CONSTRUCTIONS

Concrete is the most essential part of the modern structure. The concrete provides compressive strength to the structure which helps the structure to withstand compressive forces. There are different methods of concreting one of which is the conventional method of concreting denominated like cast in situ that is generally used for the construction. This is the oldest method of concreting and used for many years in the construction industry. Cast-in-situ is the conventional method of concreting. In this method concrete is prepared on site and poured into formwork and then cured. It often requires more work and even takes more time. It has some limitations or drawbacks. The most important drawback of the in-situ molding method is that the quality of the concrete cannot be assured and more time required for the construction. In recent times when quality is more important in a minimum time, the cast-in-situ method is less advantageous. In order to overcome the drawbacks of the concreting method in situ and to follow the terms of the modern era a new concreting method called prefabricated concrete can be adopted.

### **III.PRECAST CONCRETE STRUCTURES**

#### **3.1 Types of Prefabricated Building Systems**

##### **3.1.1. Large-Panel Systems**

The vertical and horizontal connection of large floor and wall concrete panels in a multi-storeyed buildings, such that the panels form rooms by enclosing spaces in a box-like manner within the building, is referred to as the large-panel system. The panels resist gravitational loads and provide flexibility in the interior layout. Wall panels are usually the height of a single storey. The horizontal floor and roof panels span have one- or two-way slabs. With proper joints, the horizontal panels transfer lateral loads to the walls. There are three possible configurations based on the wall layout:

- i. Cross-wall system: the gravity-resisting walls are placed in the short direction of the building
- ii. Longitudinal-wall system: the gravity-resisting walls are longitudinally placed
- iii. Two-way system: the placement of the walls is in both directions.

The advantage of large panel system is speedy construction, insulation, fire resistance and paint-ready surface finishing. It is suitable for residential apartments and hotels.

Depending on the construction method, the joints can be classified as wet and dry. Wet joints are constructed with the concrete poured between the precast panels. To ensure structural continuity, protruding reinforcing bars from the panels are welded, looped, or otherwise connected in the joint region before the concrete is placed. Dry joints are constructed by bolting or welding together steel plates or other steel inserts cast into the ends of the precast panels. Wet joints more closely approximate cast-in-place construction, whereas the force transfer in structures with dry joints is accomplished at discrete points.

##### **3.1.2. Frame Systems**

Frame system is better suited for the buildings which require more flexibility, such as industrial buildings, multi-level car parking, offices, shopping malls and sports facilities. Precast frames can be constructed in two ways: spatial beam-column sub- assemblages and linear elements. The former construction allows the placement of connecting faces away from critical regions but are difficult to form, handle and assembly, and as such the use of linear elements is preferred. The beams can be seated on corbels at the columns, for ease of construction and to help the shear transfer from the beam to the column. The beam-column joints accomplished in this way are hinged.

##### **3.1.3. Slab-Column Systems With Shear Walls**

In this system, the slab-column structure is used to resist gravitational loads while shear walls are relied upon to sustain the effects of lateral loads. Two sub-systems in this category are:

###### **i)Lift-slab system with walls**

Precast concrete floor slabs are lifted from the ground up to the desired height by lifting cranes. The slab panels are lifted to the top of the column and then moved downwards to the final position. To keep the slabs in the position till the connection with the columns has been achieved the temporary supports are been used.

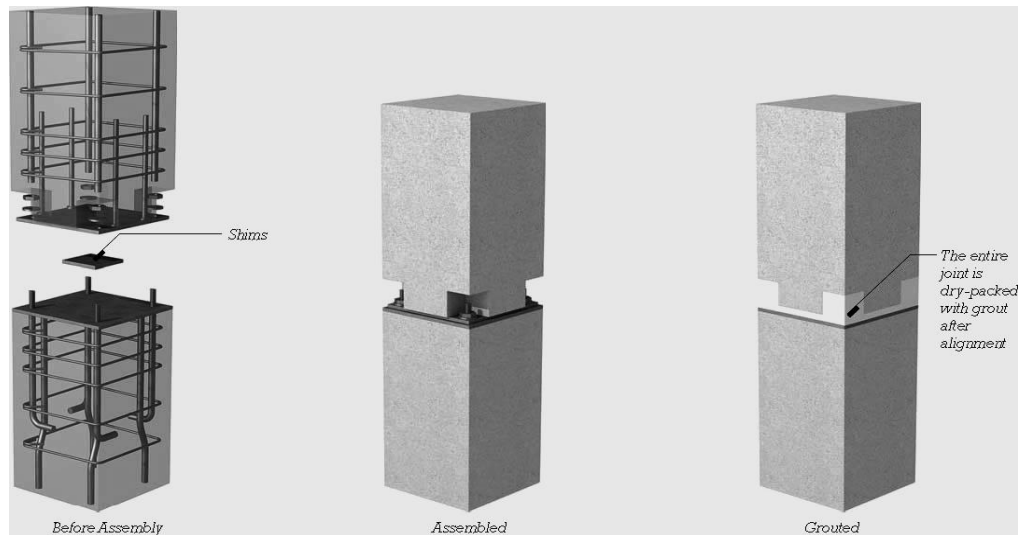
In the connections, the dowel bars that project from the edges of the slabs are welded to the dowels of the adjacent elements and transverse reinforcement bars are installed in place. Then the connections are filled by concrete that is poured at the site. Most buildings of this type have some kind of lateral load-resisting elements, mainly consisting of precast shear walls, etc. In case lateral load-resisting elements such as shear wall are not present, the lateral load path depends on the ability of the slab-column connections to transfer bending moments. When the connections have been poorly constructed, it is not possible, and the lateral load path may be not completed. However, properly constructed slab-column joints are capable of transferring moments.

###### **ii)Prestressed slab-column system**

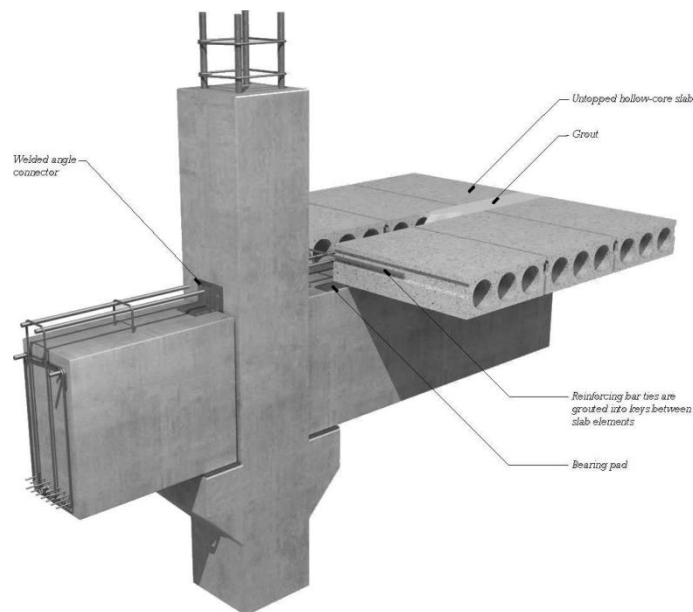
The prestressed slab-column system uses horizontal prestressing in two orthogonal directions to achieve the continuity. The precast concrete column elements are generally one to three stories high. The reinforced concrete floor slabs fit the clear span in between columns. After erecting the slabs and columns of a story, the columns and floor slabs are prestressed by means of prestressing tendons that pass through the ducts in the columns at the floor level and along the gaps left between adjacent slabs. After prestressing, the gaps between the slabs are filled with in situ concrete and the tendons then become bonded with the spans. Seismic loads are resisted mainly by the shear walls positioned between the columns at appropriate locations.

#### **3.1.4. Cell System**

This system is used for specific parts of a building, such as bathroom, kitchen and stairs. The advantage of the cell system is speedy construction and high productivity, as the fittings and finishing are carried out at the factory.



**Fig.1 Typical connection of precast concrete elements**



**Fig.2 Slab to beam connection**

#### **3.2 Construction Process**

Once the design procedure for the components is completed, each component has to undergo the following processes:

1. Concrete mixing and movement from the mixing point to the mould.
2. Setting of moulds: the moulds are cleaned and oiled and the side frames are fastened.
3. Placement of fixtures, reinforcements, electrical components and such as will form part of the components.
4. Casting: the concrete is poured, compacted and levelled.
5. Curing: naturally or artificially (by heating).
6. De-molding: the side frames are stripped and the components are taken out.
7. Finishing, patching and repairing of the components.
8. Placement of the finished components in the stockyard for delivery strength.
9. Transportation of the components to the assembly site.

#### **3.3. Transportation & Delivery**

The cost savings achieved by prefabrication are usually partially offset by transportation costs from the factory to the project site. In addition, road transportation regulations in countries like India may also pose as a barrier to the transportation of heavy prefabricated panels. These kinds of limitations have to be given serious consideration before the

adoption of prefabrication. It is of the essence that the delivery program is in sync with the erection cycle. As much as possible, elements should be delivered into position directly from the transportation. The regular process involves direct placement of the precast elements into the structure without on-site storage. Where on-site storage space is limited, considerations for offsite storage can be made; therefore additional incurred costs should be accounted for. However, site-stored elements are susceptible to damage and repetitive handling from site stacking.

### **3.4. Handling & Erection**

The erection and assembly of precast panels require heavy equipment such as cranes, especially in the case of high-rise buildings. Such costs and operations need to be given consideration in the case of implementation of prefabrication. A specialist team generally carries out erection and assembly of precast components. The main operations are the offloading, handling, installation of the components, lining and levelling of the cladding elements, jointing and subsequent waterproofing of the whole structure.

The on-site lifting equipment and attachments must be similar to those obtainable at the factory. In the case of on-site storage due to delay in delivery, appropriate stillages and racks are required to prevent damage to the precast elements.

### **3.5. Cost**

Cost savings mostly consist of the differences between fieldwork and shop fabrication productivity and support costs. Other savings may be associated with overhead reduction, transportation and installation efficiencies and future projects. In study of industrial construction projects found that in some cases, estimates in cost reduction were 40% for overall project cost and 25% for onsite labor costs. Cost reductions were attributed to the lower cost of offsite labor. Factory productivity is often better than field because of controlled conditions, closer supervision, and easier access to tools. Controlled conditions such as ground level work, climate control and consistent lighting directly impact productivity. Given the closer proximity of workers and workspaces, supervision requirements and time to access necessary tools decreases in the shop. Often in the field the supervisor or the worker in need of a tool must cover large distances to accomplish tasks.

### **3.6. Schedule**

Precast construction techniques requires less time for onsite construction as compared to Cast-in- situ concrete method, because the prepared materials are transported to site and can be directly lifted and placed on the desired position. Precast elements can be delivered in time for fast erection, reducing unnecessary handling and equipment use. By minimizing propping and bracing, and providing an immediate working platform with precast flooring, precast concrete allows other workforce to begin work more quickly, speeding the construction time and saving costs. Fast construction on site also means client gets his project in minimum time. Cast-in- situ method of concreting requires lots of time because concrete requires minimum 28 days to achieve 99% strength of its total strength. Thus after creating one element, only after 7 days a new component can be constructed which is dependent on previous one because concrete achieves 65% strength of its total strength in 7 days. This constraint not affects the precast elements construction as once element is produced it is stored and next element can be constructed soon after that. These ready elements are then transported and erected on site without any constraint.

### **3.7. Quality**

Quality control is a primary part of precast construction. A competent quality control is most significant in the process making of precast components in every project. The quality control system is implemented in precast industrial units. Water cement ratio can be properly adopted in precast concrete than in cast-in-situ concrete which can lead to better quality control. In the cast-in-situ method, concrete is prepared on the site which can be affected by weather. Plaster requirement is also very less in precast concrete as product have way better finish than cast-in-situ concrete method. Quality increases due to the controlled conditions under which construction is accomplished. The quality workmanship on site is variable factor. In precast industrial units it is eliminated due to consistency in production of precast elements.

## **IV. RESULTS AND DISCUSSIONS**

### **4.1. Mold Cost**

Since molds are often an expensive item, tool costs must be distributed in as many units as possible. The more elements that can be molded with any given mold, the more economical the project will be. Although each project will have some atypical conditions, the most successful and profitable projects maximize the repetition of elements. This means that careful planning is necessary to achieve good repetition without sacrificing design freedom. Before designing wall panels, the architect should visit precasters that produce prefabricated architectural concrete. If possible, the designer should visit the manufacturing plants as well as the ongoing projects. In this way, the designer can become familiar with the manufacturing process. Elements such as mold making, casting challenges and finishing designs or specific forms, plant and workplace manipulation methods, and approaches to connecting panels to a structure are important to fully

understand in order to maximize prefabricated potential . When a large number of prefabricated concrete units can be produced in each mold, the cost per square ft will be more economical.

**Table No.1 Master Mold Cost**

Sr. No	No. Of uses	Panel size (Sq.Ft)	Mold cost	Mold cost/ Sq.Ft
1	1	200	200000	1000
2	10	200	200000	100
3	20	200	200000	50
4	30	200	200000	33.33

#### 4.2. Duration Comparison

**Table No.2 Duration Comparison**

Operation	Precast	Cast-in-situ
	Number of Days	Number of Days
Excavation, Filling, etc.	Same	Same
Pouring & Curing concrete Strip Base	1	2
Pour. Cure. Strip Wall	-	2
Pour. Cure. Strip Top	-	2
Damp proof course	-	1
Erection on site	1	included
Total Duration	2	7

#### 4.3. Comparison of precast & Cast-in-Situ

**Table No.3 Comparison of precast & Cast-in-Situ**

Particular	Precast	Cast-in-Situ
Construction speed	Rapid Construction on site.	Comparatively slow construction on site casting, so reinforcement laying & fixing, formwork, setting of concrete required time.
Cost	Economical when the repetition of elements is more.	Economical when elements are irregular and non repetitive.
Quality control	Good quality control because it is manufactured in factory.	Quality may affect due to site conditions, due to bad supervision, unskilled labor.
Labour Requirement	Fewer labours are required but labours should be skillful.	More Labors required on site in this case.
Manufacturing conditions	High quality can be achieved because of the controlled conditions in the factory.	It is casted on site. The site conditions are irregular, so it may affect on strength.



Environmental conditions	It can be cast in any weather and get the same results, which allows you to perfect quality control. Weather is not a big factor in this case.	Environmental conditions like temperature, humidity, rain may affect on performance of concrete.
Durability	It is very durable as it is manufactured under controlled conditions. The durability is more than cast-in-situ method.	It is sufficiently durable but it required proper quality control.
Size & Shape	Repeatability-it's easy to make replicas of the same precast product, by maximizing repetition, overall cost can be reduced significantly.	In-situ concreting is suitable where the building is in uneven shape & there are no repetitive shapes, Can be possible to modify shape on site. There is more flexibility in execution than precast concrete method.

#### **4.4. Precast Construction Scenario in India**

Although precast technology is widely used in developed countries, the use of this technology in India is limited. Currently it is used in commercial towers and few government residential projects. From the interviews with Clients, Contractors, Engineers, Consultants & industry experts, following are the reasons why precast construction is not popular in India:

1. Contractors' preference for employing low cost labour as against high capital investment.
2. For small construction projects it is not economical because precast technology is useful when there are repetitions of elements.
3. Lack of proper transportation systems is major obstacle for precast technology as large precast elements are transported from factory to construction site for erection.
4. Lack of stable demand for precast elements.
5. Less level of standardization of technology
6. Lack of experts in design and manufacturing and lack of skilled labours.
7. Negative perception about precast technology in terms of performance during extreme weather conditions.
8. Lack of government supported mega projects.
9. Joints and connection issues
10. Taxation issues.

#### **4.5. Measures can be done to provide the growth of Precast Technology in India**

1. Standardization of precast concrete elements.
2. Investment in Research & Development.
3. Increasing number of qualified industry persons.
4. Incentives for adaptation of precast technology.
5. Improvement of transportations systems
6. Government support.
7. Investment in precast technology sector.

### **V. CONCLUSION**

In comparison to cast-in-situ techniques, the precast construction technology offers advantages such as 1) cost saving, 2) Time savings, 3) Quality enhancement 4) Less labour required, 5) Enhanced safety 6) Reduced wastage. But the implementation of Precast technology in Indian construction industry is have some challenges as discussed in results above. The proper measures should be adopted to promote the precast technology in India. The government should take initiative in this regard. In spite of having advantages mentioned above companies are not following the technique as number of precast concrete elements manufacturing units or industries are very few in India, so dependability on supply of precast element is very high and they find it very risky. The setup of precast yard requires very high initial investment, so in India investors should promote this technology. The design & planning is very critical in this

technique because design cannot be changed once project is started. So precautions need to be taken during planning and designing stage. India is witnessing stunning growth in urbanization. Because of this India is facing huge housing shortage. Cast-in-situ construction is not adequate to meet such huge housing demands. So precast construction technology is feasible that can be adopted for affordable mass housing projects to meet the housing demand.

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