

# Review of Precast Concrete Technology in India

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**Abstract**— The rapid growth of population in Indian urban regions is leading towards the huge demand for basic amenities & resources like housing, infrastructure, resources, etc. The government of India (GOI) intends to provide housing to every citizen by 2022. To achieve the target, the Indian construction industry needs a method of rapid construction technology like precast concrete. Various technical studies show that the application of precast technology is only 2% (approx.) of the total Indian construction industry. Presently the adaptation of precast concrete construction (PCC) technology is limited to infrastructure projects like Metro, Monorail, Bridges, etc. This research paper studied the different methods and components of precast concrete technology. This paper also reflects the various factors which should be taken care of to increase the adaptation of PCC technology in the Indian construction industry. The research suggested that the application of PCC technology is a sustainable method to achieve a high quality along with lesser consumption of resources like cost and time during the construction.

**Keywords:** *Precast concrete, construction, components, buildings, Resources*

## I. INTRODUCTION

The traditional construction methods in India needs to be improvised by using modern technology. Adaptation of modern tools and technology can provide an improvised quality of construction while using minimum resources like time, cost, manpower, materials, etc. The application of precast concrete construction technology is constantly providing efficient and improvised quality for the last fifty decades. Developing countries like India needs to full fill the huge demand of housing, commercial buildings & infrastructure projects.

The rapid increase in the urban population has resulted in huge demand for majorly housing, infrastructure developments, and commercial zones. The Ernst & Young and FICCI submitted a report which shows 65% of labor shortage by 2021 [1]. The GOI planned the proposal of "Housing for All" under the scheme of Pradhan Mantri Awash Yojana (PMAY). To achieve the target of PMAY-2022, the application of precast technology is not only improvising the construction quality but also reducing the execution time of the project.

It's been observed that the use of PCC is limited to government sectors mainly due to factors like high amount of initial investments, a smaller number of trained persons, space requirements, vertical and horizontal hindrance in transportation of modules, lack of standardization of joining details in IS codes and certification of precast modules by BIS etc.

The various components for precast concrete construction require adequate and systematic planning & designing to

minimize the errors in fabrications. The joining of different components like slab, beam, and columns requires specific details which helps the precast structure not only to transfer the loads but also to act as monolithic systems. The exterior precast modules need to be assembled in a proper manner to avoid any moisture and water leakage problems. The use of precast wall panels also provides us an additional benefit of heat insulation.

## II. METHODOLOGY

Study of Precast Concrete Technology, Background and Current Scenario



Need of Precast Concrete Technology in India



Study of Latest Techniques in Precast Concrete Technology



Study of Barriers for implementation of precast construction in India



Finding conclusion

## III. PRECAST CONSTRUCTION TECHNOLOGY BACKGROUND AND CURRENT SCENARIO

Precast concrete construction plays a major role in the era of modernism and contemporary architecture. The application of precast methods can lead to the efficient utilization of resources and also reduces the time duration and cost of construction. The application of precast concrete construction was started by the Romans, who began to mix soft rocks like lime stone, sand and water to create an early form of concrete like material and pouring this mixture into wooden molds. The use of molds provided an accuracy with dimensions and increases the durability of construction[2]. Later in early days of 20th century, the British city engineer developed an improvised version of construction in the terms of precast concrete structure. On June 18th, 1954, the precast institute was introduced in order to provide technical assistance and relevant information[3].

Nowadays, the application of precast concrete construction is widely used for superstructure of a building. The precast concrete involves different components and connection as follows:

#### A. Components & connections of Precast Concrete Technology

Based on the method of production namely tilts and hollow core, structural precast elements can be classified into two categories. First one includes columns, beams, canopy, wall panels, cladding, balcony, staircase, and landing considered as tilts and the second one is slabs called as the hollow core [2].

1) *Precast Slab*: The precast slab is categorized into two parts, namely hollow and solid slab. The hollow portion of slab is in the zones of zero stresses, which reduces the overall dead load of structural system and provides better insulation.

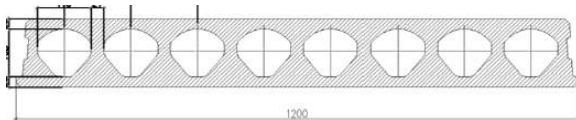


Fig. 1. Hollow core precast slab

On the other hand, the solid slab uses the method of tilting bed with lateral longitudinal reinforcement. These slabs are required in common areas like toilets to serve the various MEP services.



Fig. 2. Solid precast slab

2) *Precast Columns & Beams*: For simple column beam connections, precast columns are provided with corbel. The beam system is categorized as per the position in a structural system. When floor loading is symmetrical, internal beams are used and when floor loading is predominantly non-symmetrical, external beams are used.

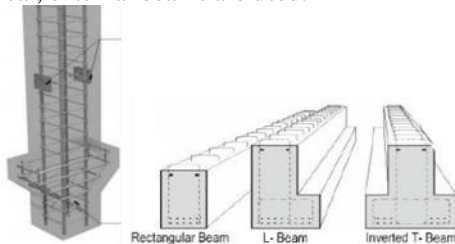


Fig. 3. Precast column with corbel and beams

3) *Precast Wall Panels*: Precast wall panels offer superior finish surfaces and eliminate the need of plaster and touch-ups. Further lateral stability of the structure will be greatly improved by these wall panels.

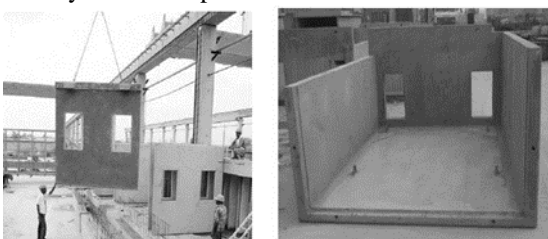


Fig. 4. Precast wall panels

4) *Precast Staircase*: When precast staircase is used, shuttering and reinforcement are not needed on site and also provides a high-quality finish. It can be cast as a single unit or individual unit of all flights and landing separately.



Fig. 5. Precast Staircase

#### B. Connections For Precast Construction:

Precast systems need the connections not only for transferring the load but also for providing continuity and monolithic behavior to the entire structure. These connections can be classified as horizontal and vertical joints. The design of these connections is based on durability, economy, and standardization [2][4].

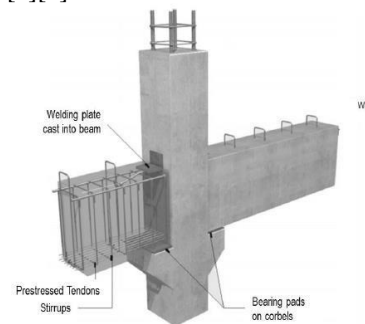


Fig. 6. Connection details for Beam & Column

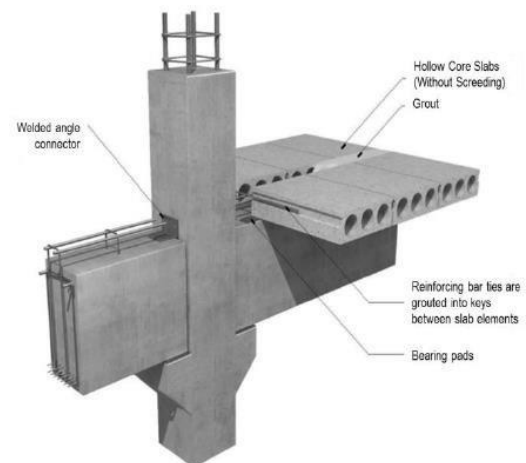


Fig. 7. Connection details for the hollow slab to beam

#### C. Assembling And Erection of Precast Structure:

Precast construction includes various structural components which are standardized and manufactured in plants or yards in a location and transported to the site location

for its assembly. Moulds of standardized structural components are used for their mass production maintaining good quality. The sequence of different works involved in precast construction are:

- Precast Elements Layout,
- Production in manufacturing unit,
- Stacking,
- Transportation
- Erection of components.

#### IV. NEED OF PRECAST TECHNOLOGY IN INDIA

The rapid speed of the urban population in India from 1901 to 2011 led to a shortage of land, housing, congested transit, and basic amenities. The study of Ernst & Young and the FICCI show that there will be about a 65% labor shortage in the construction industry by 2021. The adequate planning and implementation of precast construction can fulfill the requirements of housing demands. The precast construction contains only 2% of shares in the Indian construction industry of USD 500 million. The use of the precast systems in India is mostly limited to infrastructure projects like bridges and flyovers. The GOI has accepted the use of precast concrete construction method in order to fulfill the housing demands. They already proposed to provide housing to everyone by 2022 majorly based on the precast concrete technology. As per the technical report submitted by the Ministry of Housing and Urban Poverty Alleviation, out of 18.78 million dwelling units there are approximately 96% which belongs to EWS and LIG households.

##### A. Present Scenario Of Precast Technology In India

Presently in India, we have very few trained people available in the private industry to execute the precast concrete system. The service provided is more oriented to the various other methods and techniques available in the market construction. The end-user has a perception of higher budget and less quality towards the pre-cast concrete construction. Most of these projects in the country are carried by using conventional construction technologies without any innovations. Due to this, the benefits of using precast concrete technology are not being utilized completely and also makes the project management complicated in terms of speed and quality of construction. In Indian context majorly the infrastructure projects like metro, monorails, bridges, etc. are using the precast concrete construction technology. Rest the most of the residential and commercial projects are cast-in-situ based. The application of the steel structure is majorly adopted in industrial projects.

##### B. Comparison & Analysis Between Conventional And Precast Technique

A literature case study is taken to analyze the difference in the construction based on cost, time and schedule. The selected case study is a residential building of G+1 structure.

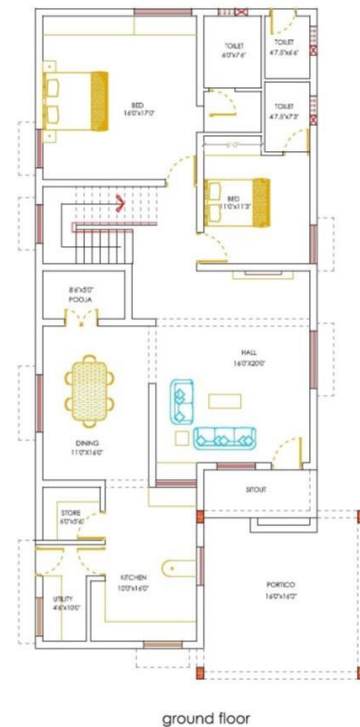


Fig. 8. Ground floor plan

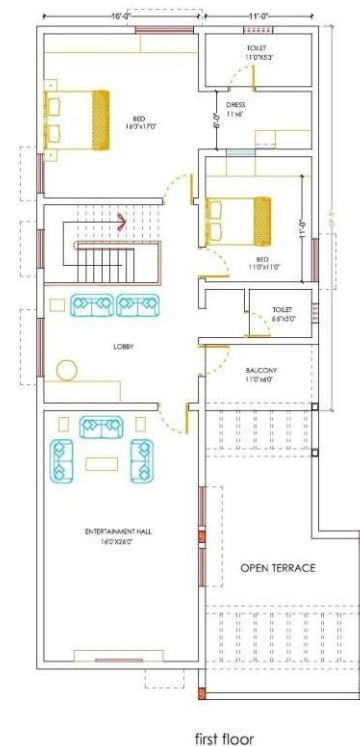


Fig. 9. First floor plan

1) *Project Duration Analysis:* The total project duration is sub divided into three major stages as sub structure, super structure and the finishing works. The method of construction for substructure of the conventional and precast are considered as same. But super structure for precast construction differs due to factory made walls and slab which only needs to be installed at site. The precast construction consumes lesser time in finishing works due to pre-installed electrical and plumbing works. The surface of precast wall panels is already finished



which also lead us reduction in time for plaster works. The total time duration calculated for two storied residential building is 65 days as described in Table I.

S. No	DESCRIPTION	DURATION
1.	Sub Structure - (Site cleaning, Earthwork, Foundation, Basement, Soil filling& Consolidation.)	22 Days
2.	Super Structure – (Wall panels framing and Roofing slabs.)	12 Days
3.	Finishing Works – (Electrical, Plumbing Painting, Tiling, and Windows, Extra items.)	31 Days

TABLE I. PROJECT DURATION OF CONVENTIONAL RESIDENTIAL BUILDING

The project duration for conventional method of construction is calculated with the help of CPWD data, and conventional contractor's experience. The major time consumption is at level of superstructure due to cast in site of slabs and walls and then further the installation of services. The finishing of surface requires and additional time after the completion of first two stages. The total time taken for the construction of the two storied residential building by conventional construction method is 128 days, the same is presented in Table II.

Sl. NO	Description	Duration
1.	Sub Structure - (Site cleaning, Earth work, Foundation, Basement, Soilfilling&Consolidation.)	22 Days
2.	Super Structure (Columns, Lintel& sunshade, Beams, Roof slabs, Brick work, Plastering.)	52 Days
3.	Finishing Works – (Electrical, Plumbing Painting, Tiling, and Installation of doors & Windows, Extra items.)	54 Days

TABLE II. PROJECT DURATION OF PRECAST RESIDENTIAL BUILDING

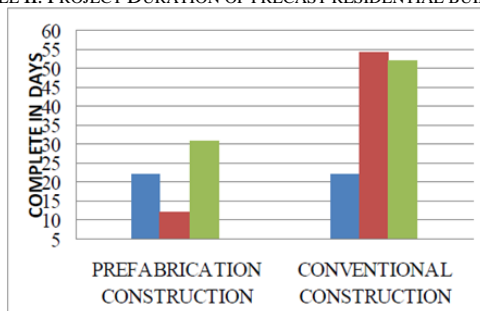


Fig. 10. Comparison of time between prefab and conventional at different stages

The comparison of project duration between the pre-cast construction method and the conventional construction method during the three stages is compared and the same is presented in figure 10. As traditional method was used for the

completion of sub- structure, the time duration for both the buildings was same.

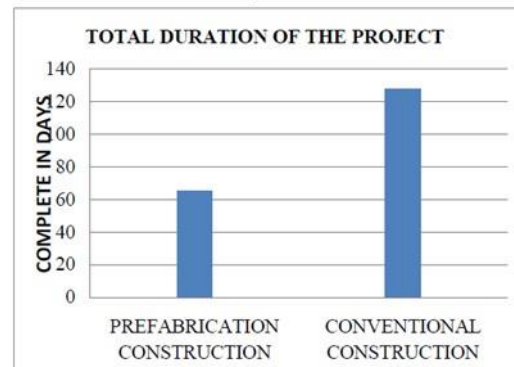


Fig. 11. Comparison of total project duration for both prefab and conventional construction of double storey building

The total project duration was calculated for both construction methods and the same presented in figure 11. The main observation from this analysis is that the duration of the pre-cast construction was lower than the conventional construction. The time difference duration between prefabrication and conventional construction methods is 63 days.

2) *Project Cost Analysis:* The cost analysis for precast construction is based on the data collected form the manufacture of precast. The cost of sub structure is considered similar for both the cases as the method is same for both. The precast method consumed an additional 14 lakhs (approx.) due to high initial infrastructure development cost in order to manufacture the modules. This cost can get reduced in case of mass production of similar modules. The stage finishing works shows a minor difference of Rs. 1Laks (approx.) due to similar specifications and nature of work. The total cost for a precast construction is 73, 00,000.00 (Sixty-nine lakes and nineteen thousand rupees only). While the total cost for a conventional method is Rs. 60, 19,000.00 (Sixty lakes and nineteen thousand rupees only).

SI NO	DESCRIPTION	COSTS
1.	Sub Structure - (Site cleaning, Earth work, Foundation, Basement, Soil filling& Consolidation.)	5,26,000.00
2.	Super Structure- (Wall panels framing and Roofing slabs.)	24,23,000.00
3.	Finishing Works – (Electrical, lumbing Painting, Tiling, and Installation of doors & Windows, Extra items.)	43,51,000.00

TABLE III. TOTAL COST FOR PREFABRICATION CONSTRUCTION

SI NO	DESCRIPTION	COSTS
1.	Sub Structure – (Site cleaning, Earth work, Foundation, Basement, Soil filling& Consolidation.)	5,26,000.00
2.	Super Structure – (Columns, Lintel& sunshade, Beams, Roof slabs, Brick work, Plastering.)	1024000.00
3.	Finishing Works – (Electrical, Plumbing, Painting, Tiling, and Installation of doors& Windows, Stair case, Extra items.)	44,69,000.00

TABLE IV. TOTAL COST FOR PREFABRICATION CONSTRUCTION

The Comparison of cost differences between pre-cast construction and conventional construction during three stages of construction is presented in figure 12 and the overall cost difference is presented in figure 1. The cost difference is 12, 91,000.00 rupees between the prefabrication and conventional construction methods.

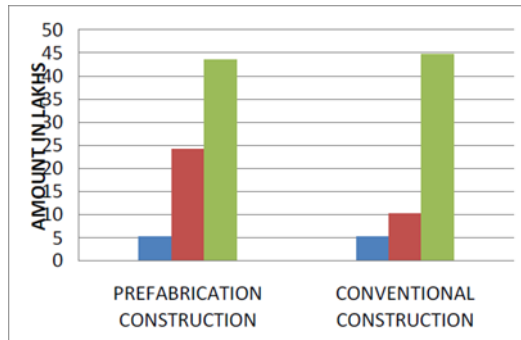


Fig. 12. Item wise comparison of cost difference between pre-cast and conventional construction

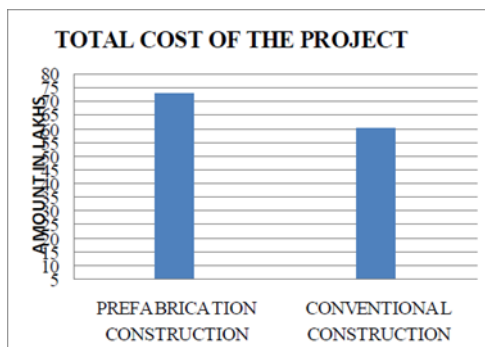


Fig. 13. Total comparison of cost difference between pre-cast and conventional construction

## V. LATEST ADDITION IN PRECAST CONCRETE TECHNOLOGY

The addition of carbon fiber reinforcing grid in precast cladding panels can reduce the overall weight up to 66% as compared to the conventional precast panels. The panels can be integrated easily with the insulation for getting heat resistance. The addition of carbon content eliminates the requirement of different coating and sealants. A UK based company developed a method that can incorporate the various patterns, numbers or any text in the concrete surfaces. They applied thermo chromatic pigment and heating technology with wire into the concrete mix. This technology works along with microprocessor control devices that allow us to change pattern, color or displaying any dot matrix on the surface of clock. This technology is not developed commercially but applied at few places in the form of panels. Usually the precast concrete panels provided with standard exposed concrete finished. But nowadays a UK-based company offering various ornate patterns which are actually cast into surface of precast panels. These panels are available for both exterior and interior surfaces like cladding, flooring, etc. The application BIM technology with the precast concrete construction is upgrading the method of resolving errors during the

fabrication. BIM is providing a more efficient way to process of design, planning, preparing the modules. It also assists in process of procurement of material on site. The enables us to generate more accurate bill of quantities which plays a major role in the overall all cost of project.

## VI. BARRIERS TO PRECAST CONSTRUCTION IN INDIA

There are various barriers for using precast technology in India based on literature study which are as follows [5].

### A. Investment

The initial investments are very high for setting up a precast construction plant near or at site. This method of construction requires big players of construction industry to participate and encourage the application of precast construction technology. As this construction technology requires a high initial investment therefore it's difficult to apply this method to smaller scale project. The government should provide additional benefits for setting up a precast construction yard.

### B. Space Availability

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### C. Taxation

The taxation system in Indian applies 18% GST to the rate which further increases the overall cost of construction. The transportation of precast components from other state requires to pay an additional tax, which increase the overall cost of project. The government can provide an additional subsidy to encourage the application of this method.

### D. Transportation

The sizes of individual precast components depends on availability of transportation vehicles. The components must reach on its scheduled time and also without getting any damage. The damage may affect the strength of structure or the process of assembling.

### E. Infrastructure

Maximum load-carrying capacity of bridges and pavements also affects the module size of the precast components. The vertical and horizontal clearance of roads, bridges and underpass are also required to be checked before finalization of the components.

### F. Standardization

There is a lack of standardization, codes, and certification by BIS to check the quality of manufacturing. The erection of precast elements also needs to be verified with some standards to ensure the quality of construction.

### G. Joints & Connections

The issues with joints and connections lead to the problem of leakage, seepage. This is because the IS codes and standards on precast concrete does not have sufficient

guidelines to improve the water tightness of structure at the junctions.

#### H. Perception

The negative and mixed perception of Indian stakeholders of the construction industry resists the adoption of precast construction system. The major cause for this perception is because of the initial investments and the less understanding of precast concrete technology.

### VII. CONCLUSIONS

The application of Precast Construction technology is very effective and efficient in terms of executing large scale construction projects like housing, commercial, institutional buildings etc. It is also very efficient with respect to saving time, requirement of manpower, providing better construction quality, less wastage of materials, flexible in executing all sets of design requirements like façade, repetitive module blocks. The initial investment for establishing a precast yard is very high but it also provides the benefit of speedy construction which can contribute towards mitigating delays in large scale construction projects. All these advantages can only be achieved with the help of adequate planning and designing. The case study reflects that the application of precast concrete technology can provide a superior quality in lesser time duration. The adaptation of precast concrete technology is a

smarter and sustainable way to fulfil the housing demands in India. The major issues are a smaller number of precast concrete manufacturers in India which resists the adoption of the technology. Another concern is the standardization of various components of precast concrete and its joinery details needed to be elaborated by IS codes. This paper concludes that the application of precast concrete technology can fulfil the need of housing in India within the defined time duration.

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