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A Comparative Study on Conventional, Preengineered and Precast Construction Methods using BIM in India

Abhishek Bendre
M.Tech Construction Management (PG)
D. Y. Patil College of Engineering, Akurdi, Pune, India

Prof. Dr. S. M. Shiyekar
Professor, Department of Civil Engineering
D. Y. Patil College of Engineering, Akurdi, Pune, India

A. Abstract

Rapid urbanization, the housing shortage and government schemes like Pradhan Mantri Awas Yojana (PMAY) and the National Infrastructure Pipeline are driving the major transformation of the Indian construction industry. The demand for faster, economical and "green" infrastructure development is becoming more and more difficult for conventional construction approaches. This research compares the conventional R.C.C, precast construction and Pre-Engineered Building (PEB) construction and further adds the integration of BIM system in order to compare their performance in terms of cost, time, efficiency and sustainability.

The research method used in this study was a combination of the two, namely mixed methods which included both qualitative analysis (literature-based) and BIM-based research (simulation-based). The study provides a clear evidence on the benefits of pre-engineered and precast systems in terms of reducing the project duration and efficiency of material usage as compared to conventional RCC construction system. While the upfront cost of precast is a little bit more expensive, the cost savings realized in time saved, labor reduction, and rework are significant. BIM integration enabled enhanced quantity estimation, clash detection, scheduling and project coordination.

BIM enabled precast and pre-engineered construction technique is found to be a feasible and sustainable approach for recent construction projects in India particularly for large scale housing and industrial constructions.

Keywords: Conventional Construction, Precast Construction, Pre-Engineered Buildings, BIM, Cost Analysis, Time Analysis, Sustainability, Indian Construction Industry.

II. INTRODUCTION

A. Background and Context

The construction sector forms part of the largest sector and is also playing significant role in the development of infrastructures in India. It accounts for almost 9% of the

Indian GDP and employs over 50 million people in India. With the acceleration of urbanization, rising housing needs and big infrastructure projects, the industry is now under pressure to use quicker, more efficient construction methods.

The traditional construction of Indian buildings has been mainly based on cast-in-situ conventional reinforced cement concrete (RCC). While these techniques are popular, versatile, and accepted, they are time-consuming and labor intensive, and sometimes can be subject to material losses and weather conditions.

The employment of modern construction technology like PreCast Construction and PreEngineered Buildings (PEB) are gaining popularity as efficient alternative solutions. With these systems, it is possible to produce structural components in a factory that ensure better quality control, quicker construction, and less activity on site.

Building Information Modeling (BIM) is a key technological solution for these new construction systems. BIM allows for digital modeling, quantities, clash detection, scheduling and project coordination through the project lifecycle.Development of Construction Techniques in India
Indian construction practices have evolved slowly compared to developed countries.

While countries such as Japan and Singapore adopted prefabrication systems decades ago, India continued relying on conventional RCC due to low labor costs and flexible construction practices.

However, recent reforms such as GST, RERA, Smart Cities Mission, and PMAY have encouraged the adoption of industrialized construction systems.
Large developers and infrastructure companies are increasingly adopting precast and PEB technologies to reduce project delays and improve construction quality.

B. Role of BIM in Modern Construction

BIM acts as an integrated digital platform connecting design, estimation, scheduling, and execution processes. In precast construction, BIM plays a critical role in ensuring

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dimensional accuracy and coordination between structural and MEP systems.

BIM allows:

- 3D visualization of building components
- 4D scheduling and construction simulation
- 5D quantity and cost estimation
- Clash detection and coordination
- Improved project management and communication

The use of BIM significantly reduces errors, rework, and construction delays.

C. Problem Statement

Although the precast and BIM technologies have their benefits, they have not taken root in India because of expensive initial investment, lack of skilled workforce, lack of logistical support and incorrect cost perceptions.

Comparative study based on the construction environment in India is required to assess the feasibility of using precast construction methods and RCC construction methods, through BIM based analysis.

The objectives of this research are:

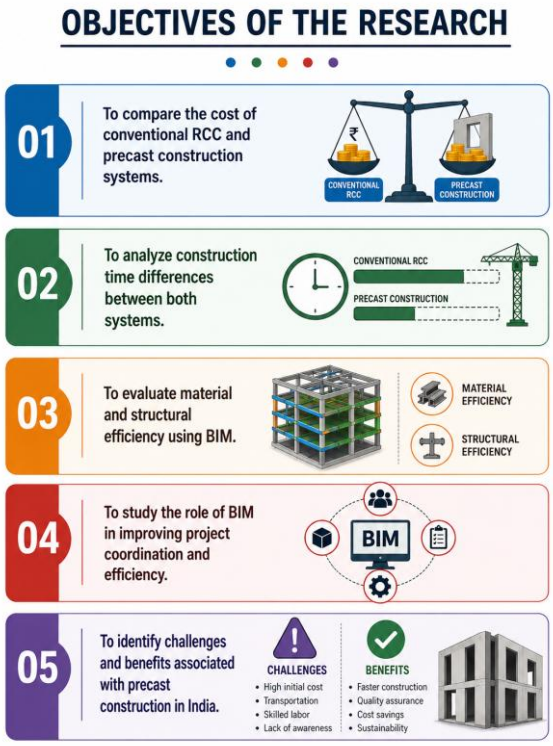

FIG 1

The objectives of this research are:

- To compare the cost of conventional RCC and precast construction systems.
- To analyze construction time differences between both systems.
- To evaluate material and structural efficiency using BIM.
- To study the role of BIM in improving project coordination and efficiency.
- To identify challenges and benefits associated with precast construction in India. MAKE IMAGE

D. Scope of Study

The study focuses on:

- G+4 residential building projects
- Conventional RCC and precast construction systems
- BIM-based quantity take-off and scheduling
- Cost, time, material efficiency, and sustainability analysis

The study excludes land acquisition costs and legal aspects of contracts.

III. LITERATURE REVIEW

The use of prefabrication and BIM in construction projects has been investigated by several researchers.

Research in developed nations has shown benefits of precast construction, such as increased quality, decreased reliance on labor and shortened construction times. Challenges identified by researchers in India are the logistics, skilled manpower and higher initial costs.

It was also concluded from the research that BIM definitely aids in the coordination of the project and reduces clashes during the execution phase. BIM-based precast construction results in dimensional accuracy and less construction waste.
Previous studies concluded that:

- Precast systems reduce construction time by 15–60%
- Material wastage is lower in precast systems
- BIM improves project scheduling and quantity estimation
- Conventional construction has lower initial cost but higher indirect expenses

The literature confirms that BIM-supported precast construction can improve project efficiency and sustainability in the Indian construction industry.

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IV. RESEARCH METHODOLOGY

A. Research Approach

This study adopts a mixed-method research approach combining quantitative BIM analysis and qualitative literature review.

Two construction systems were analyzed:

- Conventional RCC Construction
- Precast/Pre-Engineered Construction

Both models were developed using identical geometric and structural parameters to ensure accurate comparison.

B. Data Collection

1) Primary Data

A G+4 residential building was modeled using:

- Autodesk Revit 2024
- Navisworks Manage

Both conventional RCC and precast models were developed to LOD 300.

2) Secondary Data

Data was collected from:

- Research journals
- IS codes
- Government reports
- BIM case studies

C. BIM Modeling and Simulation

1) Modeling

Autodesk Revit was used for:

- Structural modeling
- Quantity take-off
- Material estimation

2) Simulation

Navisworks Manage was used for:

- 4D scheduling
- Construction sequence simulation
- Time analysis

D. Evaluation Parameters

The comparison was carried out based on:

- Cost analysis
- Time analysis
- Material efficiency
- Structural performance
- Sustainability
- Safety

V. DATA ANALYSIS AND RESULTS

A. Case Study Description

The selected case study is a G+4 residential building with:

- Building size: 25 m × 20 m
- Built-up area per floor: 3000 sq.ft
- Total built-up area: 15000 sq.ft
- Floor-to-floor height: 3 m

Both construction systems used identical foundation and structural layouts.

B. Cost Analysis

The material cost comparison was obtained from BIM-generated quantity take-offs.

1) Table 1: Comparison of Structural Material Cost

Sr. No.	Material	Conventional Construction (Rs.)	Precast Construction (Rs.)
1	Cement	17,86,400	24,66,360
2	TMT Steel	27,84,000	37,38,800
3	Sand	4,45,440	5,75,200
4	Coarse Aggregate	7,42,400	10,35,360
	Total Material Cost	**57,58,240**	**78,15,720**

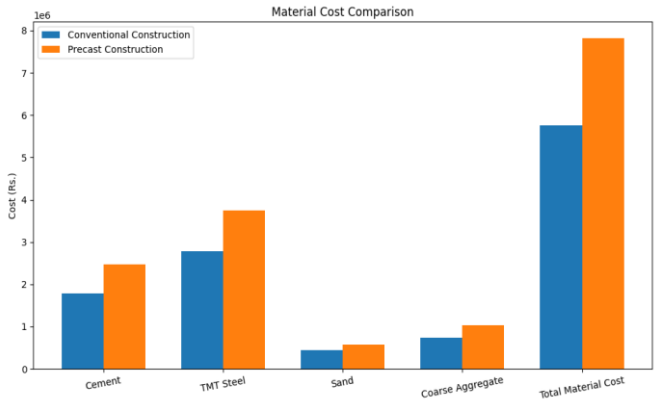

Fig 2 Material cost comprassion

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Table 2: Wall Construction Cost

Item	Conventional Construction (Rs.)	Precast Construction (Rs.)
Wall Construction Cost	19,76,000	58,44,000

2) Table 3: Total Construction Cost

Description	Conventional Construction (Rs.)	Precast Construction (Rs.)
Structural Material Cost	57,58,240	78,15,720
Wall Construction Cost	19,76,000	58,44,000
Total Cost	**77,34,240**	**1,36,59,720**

The analysis shows that precast construction has a higher initial material cost due to factory manufacturing, transportation, and erection requirements. However, indirect savings are achieved through reduced labor, reduced formwork, and minimized rework.

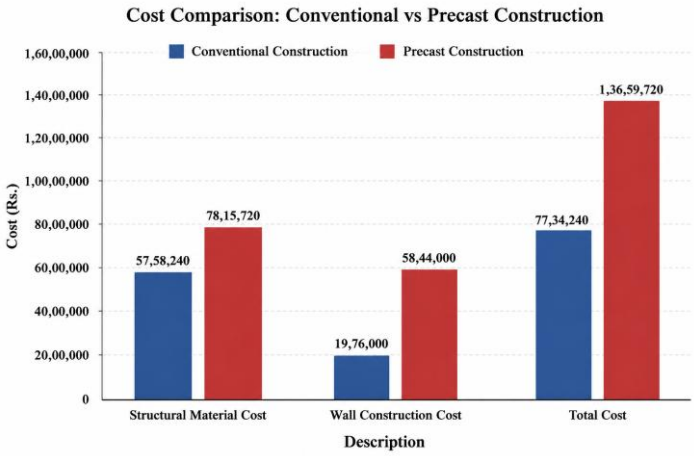

Fig.3 Total Construction Cost

C. Time Analysis

Conventional RCC construction follows a sequential process requiring:

- Formwork erection
- Reinforcement placement
- Concrete pouring
- Curing period

This increases overall project duration.
Precast construction allows parallel activities where structural components are manufactured off-site while foundation work continues on-site.

The BIM-based schedule analysis indicates that precast construction significantly reduces project duration by eliminating curing delays and reducing site dependency.

D. Structural and Material Efficiency

BIM quantity take-offs indicate that precast construction improves material efficiency through:

- Optimized structural sections
- Hollow-core slabs
- Reduced concrete volume
- Efficient reinforcement usage

The precast system also demonstrates improved stiffness, reduced deflection, and better load distribution.

VI. FINDINGS

The major findings of this study are:

1. Conventional RCC construction has lower initial material cost.
2. Precast construction significantly reduces project duration.
3. BIM improves quantity estimation and project coordination.
4. Precast systems reduce labor dependency and construction waste.
5. Structural efficiency is higher in precast systems.
6. BIM-enabled construction minimizes rework and clashes.
7. Precast construction offers better long-term durability and quality control.

VII. CONCLUSION

This comparative study verifies that there are significant advantages of precast and pre-engineered construction systems over the conventional RCC construction in terms of construction speed, structural efficiency and the quality control.

Despite initial material cost, precast construction can save time, labor and other costs.
The added investment is offset by dependency, and site-related inefficiencies.

BIM was successfully applied to quantity estimation, scheduling, coordination and visualization of a project. The adoption of BIM for precast construction can have a positive impact on the efficiency and sustainability of the construction sector in India.

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As a result, BIM supported precast construction can be seen as a viable and effective approach for the future construction projects of residential buildings and infrastructure in India.

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