

# Precast Concrete Buildings: A Study on Innovation, Application, and Future Prospects in the Indian Construction Industry

Nikhil Mandle<sup>1</sup>, Dr. Ruchi Chandrakar<sup>2</sup>

<sup>1</sup> Research Scholar , Department of Civil Engineering , Kalinga University Raipur (CG), India  
*mandlenikhil17@gmail.com*

<sup>2</sup> Assistant Professor,, Department of Civil Engineering , Kalinga University Raipur (CG), India

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**Abstract:** This paper presents a comprehensive investigation into the structural, economic, and environmental performance of precast concrete construction, with a focus on its applications in the Indian context. Through experimental analysis, cost modeling, and life cycle assessment, the study evaluates the feasibility and impact of precast systems compared to traditional cast-in-situ methods. Findings reveal significant improvements in construction speed, quality control, durability, and sustainability. Despite these advantages, industry adoption in India remains limited due to technical, logistical, and organizational barriers. This paper outlines key innovations, adoption strategies, and future research directions to promote precast technology as a mainstream solution for sustainable urban infrastructure development.

**Keywords:** Precast concrete, modular construction, durability, sustainability, India, life cycle cost, adoption barriers.

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## 1. Introduction

The increasing demand for rapid, sustainable, and cost-efficient construction has shifted focus toward industrialized building systems. **Precast concrete construction**, which involves off-site fabrication and on-site assembly of concrete components, is gaining global attention. Countries like **Singapore, Finland, and the UAE** have demonstrated successful implementation across public and private sectors. In India, however, adoption remains below 10%, primarily limited to metro infrastructure and select housing projects.

This research addresses the gap between potential and practice, evaluating precast concrete in terms of **structural behavior, time and cost efficiency, durability, sustainability, and industry readiness**. The study aims to formulate practical recommendations and strategic insights for wider implementation of precast systems in India's built environment.

## 2. Literature Review

Extensive studies highlight the benefits of precast construction in reducing on-site labor, enhancing quality, and accelerating timelines. **Gibb (1999)** and **PCI (2021)** report improved precision and reduced environmental impact in precast-based projects. However, Indian construction remains largely in-situ due to lack of awareness, codes, and localized standards (**Singh & Dinesh, 2018**).

Recent innovations such as **self-compacting concrete (SCC)**, **geopolymer concrete**, and **precast seismic joints** have further expanded precast applicability. Indian guidelines (IS 15916:2010, IS

456:2000) are still evolving, and limited empirical data exists on comparative performance in Indian conditions—an area this study addresses.

### 3. Methodology

A **mixed-method approach** was used:

- **Experimental Analysis:** Precast beams, columns, and wall panels tested under load and cyclic stress.
- **Analytical Design:** Comparison with IS 456 and IS 13920 recommendations.
- **Simulation (FEA):** Finite element models (ANSYS, ABAQUS) used to study joint behavior and crack propagation.
- **Economic Assessment:** Cost and time comparison with cast-in-situ buildings.
- **Sustainability Metrics:** Life Cycle Assessment (LCA) conducted using openLCA software and India-specific data.
- **Industry Survey:** Semi-structured interviews with engineers, contractors, and developers in Pune, Hyderabad, and Delhi.

### 4. Results and Discussion

#### 4.1 Structural Performance

Precast elements achieved **8–10% higher load-bearing capacity** than cast-in-situ elements due to better compaction and curing. Finite element simulation aligned within **±5%** of experimental values. Beam-column joints using grouted sleeves displayed **ductile failure modes** suitable for seismic zones.

#### 4.2 Economic and Time Efficiency

Precast construction reduced **project time by 45–50%** and **life cycle cost by 12–15%**. A typical G+4 building using precast took **90 days** versus **164 days** for cast-in-situ, saving on labor, supervision, and indirect costs.

**Table 1 Economic and Time Efficiency**

Cost Component (₹/m <sup>2</sup> )	Precast	Cast-in-Situ
Structural Frame	2600	2300
Labor & Formwork	700	1400
Finishing	850	1050
<b>Total</b>	<b>4150</b>	<b>4750</b>

### 4.3 Durability and Maintenance

Precast components exhibited **lower carbonation depth (5–8 mm)** and **higher chloride resistance**. Maintenance needs were 30–40% lower due to improved joint integrity and material quality.

### 4.4 Sustainability Indicators

**Table 2 Life Cycle Assessment showed**

<b>Indicator</b>	<b>Precast</b>	<b>Cast-in-Situ</b>
GWP (kg CO <sub>2</sub> /m <sup>2</sup> )	35	48
Water Use (L/m <sup>2</sup> )	150	250
Construction Waste (kg/m <sup>2</sup> )	10	22

Precast aligns with **IGBC and GRIHA** sustainability benchmarks.

### 4.5 Industry Barriers

Despite technical feasibility, the following barriers were identified:

- **High initial setup cost** for precast yards
- **Lack of skilled workforce**
- **Resistance to design standardization**
- **Poor integration of digital tools**

### 5. Recommendations

- **Policy Incentives:** Tax benefits and fast-track approvals for precast projects
- **Standardization:** Publish BIS detailing guidelines for seismic zones
- **Capacity Building:** Integrate precast in engineering curricula and CSDCI certifications
- **Regional Precast Hubs:** To reduce transportation costs
- **BIM and Digital Twin Integration:** For efficient project coordination and lifecycle monitoring

### 6. Conclusion

This research confirms that **precast concrete construction offers substantial advantages** over conventional methods in terms of speed, durability, sustainability, and long-term cost-efficiency. Its application in India remains underutilized due to logistical, economic, and institutional barriers. Through strategic interventions and policy support, precast systems can significantly contribute to the country's **urban development, affordable housing, and green infrastructure goals**.

## 7. Future Scope

Future studies should include:

- Full-scale **seismic performance testing** of precast joints
- Use of **smart materials and embedded sensors** in precast units
- Evaluation of **mobile precast plants** for rural or disaster relief projects
- Development of **low-carbon and net-zero precast concrete mixes**

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