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Implementation of Precast Technology in IndiaÙ Opportunities and Challenges

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Abstract

Rapid economic growth and limited availability of affordable land have restricted the horizontal mode of construction leading to vertical construction in most of the Indian cities. Urban India is mostly marked by tall buildings that are being built. Due to the economic slowdown and some governmental interventions, these building projects are seeing significant time and cost overrun, ultimately impacting the end-user. As these market pressures rise more and more, real estate developers are considering to adopt emerging technologies to compensate for these construction issues. Indian construction industry is undergoing a paradigm shift from traditional methods of construction to modern methods of construction. Precast technology is one such move which is expected to enhance the productivity of the construction process, thereby, optimizing the requirement of resources on the site, reducing waste generation and resulting in a faster delivery of the projects. While internationally precast technology is considered as a mature technology, in India, it is not widely utilized, despite the advantages. Commonly cited constraints are high costs in comparison to traditional construction, economies of scale, logistics, skill level required, end user friendliness, etc. Primarily, this study focusses on identifying the challenges faced by the precast technology under various categories. This study also presents a cost analysis model for precast technology versus traditional construction to address some of the challenges. Presented cost model is applied to two projects wherein precast technology and conventional technology are utilized to construct the project and an inference is drawn comparing the time and cost aspects of precast technology. Amicable solutions are proposed for adoption of precast construction from an Indian perspective.

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Keywords: Precast technology; challenges; cost; traditional construction; emerging technology.

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1. Introduction

Shortage of housing has been one of the most enduring problems faced by India. It is starkly evident by the fact that about 13.7 million of households have been identified as living in slums by the census 2011 report [1]. This problem has been growing exponentially with increasing urbanization. In urban areas, India faces a shortage of over 20 million houses at present. Reports indicate that by 2031, about 600 million people will live in cities, compared to 434 million in 2015 [2].The union cabinet approved the Housing for All scheme by 2022 with a target to construct 20 million houses for the urban poor population to cater the housing scarcity.

The massive housing deficit, highlighted by the problem of affordability cannot be tackled through conventional technology utilized in the construction industry. Emerging technologies will play a vital role in effective implementation of policies like Housing for All [3]. Precast is one such emerging technology in India that can play a pivotal role. The precast technology involves the manufacturing of different components of construction in a controlled environment such as factory and delivering them to site for erection and assembly [4]. For a building, the precast components can include elements such as columns and beams, floor slabs, in-filled walls, bathrooms, and staircases, etc. These building components are manufactured under a controlled environment in a specific factory setting and subsequently transported and installed at the project site. Precast elements can be manufactured at offsite as well as onsite.

Use of precast technology in construction has numerous advantages. As the precast elements are produced in a factory, better quality of concrete can be achieved because of the controlled environment. Precast mode of construction has a lesser dependency on labor force compared to conventional technique which helps in minimizing the disarray in coordination, scheduling, and sequencing of the project. There is no need for curing on site after assembly of members because the members are cured in a factory for the desired duration. The cost of the formwork is eliminated by using precast which can result in savings. Cost to carry out post concrete repairs can be eliminated by using precast members. Precast also enhances occupational health and safety as minimum operational risks are involved. Its use can lead to significant wastage reduction at the site [5] because on-site construction activities are minimized. Through effective planning and design, material quantity required for doing the same construction can be reduced by using precast technology [4]. This can be compounded by the fact that it helps in waste reduction making precast a more sustainable and environment-friendly technology for construction. The biggest advantage of precast is that it accelerates the construction process thereby reducing the duration of the project [6].

Despite the well-documented benefits, the use of precast concrete in Indian construction sector is limited. One of the major reason for not accepting the precast technology by the stakeholders is the inability to ascertain the benefits to a project [7]. Use of precast technology is not understood to the core extent, and sometimes, it is viewed as a costlier technology. A pilot study [8] demonstrated that decisions to use precast are still largely based on circumstantial evidence rather than rigorous data, as no formal measurement procedures or strategies are available. This study is focused on identifying such challenges faced by the precast technology and providing amicable solutions to the challenges identified at the industry level.

2. Literature Review

Precast construction is a stage wise process consisting of producing elements in a factory set environment (as per the required dimensions taken from the drawings), transporting these elements to the site, erecting them at the site and assembling them. Precast is a preferred method and has flexibility in planning and production process until the precast components are delivered as per the schedule [4]. Numerous benefits are associated with adoption of precast on a construction site when compared to conventional systems. Main advantages of precast construction are: reduction in time, reduction of wastage in materials, the lesser requirement of labor at the site, improved quality of the product, enhanced safety at the site, etc. These benefits can help the project in delivering effectively and efficiently [9].

The objective for the adoption of precast construction is to reduce the overall cost and to increase the profitability to all the stakeholders. Considering this objective, the European Union and the UK have an average share of 20-25% about precast systems in construction sector and 40-50% share in northern European countries. Usage of precast

systems is very low in other parts of the world. Cost plays a pivotal role to prefer the emerging technologies such as precast construction. Many case studies [6], [10], [11] have shown that the cost of precast construction tends to be on a higher side as compared to traditional construction. Most of the housing construction is constructed utilising precast mode particularly in European countries such as Germany, Netherlands and Finland. 24% of the housing is constructed using precast concrete construction in Germany. It attributes to 70% of the housing share in Finland and 10% is attributed to precast mode of construction in Netherlands. [12]

Attributes to decide the adoption of precast are numerous and would vary from project to project as the other project factors vary. The actual value of precast is not understood when it is measured in terms of direct cost, and a simple cost comparison would always push precast to the downside [8]. At the same time, if precast is applied from the design stage with the right planning, it has also resulted in significant cost and time savings [13], [14], [15]. This study presents a cost model for precast technology in comparison with conventional methods of construction for a building project.

In most of the developing countries like India, the cost of executing the project with conventional method is always cheaper than the cost incurred in adopting emerging technologies (such as precast) due to various reasons such as labour dominated industry with low wages, lack of research and development, logistics issues, lack of congenial relationship between stakeholders, lack of technological advancement in construction and inadequate training of labour for working with emerging technologies [16]. This study is focused on identifying the challenges faced by the precast technology in terms of design and documentation related factors, technology, and procurement related factors, resource competency related and end-user related factors.

3. Objectives & Methodology

Primarily, this research focusses on identifying the opportunities and challenges associated with the implementation of precast technology in India. To achieve the goal set for the research, the following objectives were formulated:

- To present a cost model for precast technology in comparison with conventional methods of construction for a building project
- To analyze time and cost for precast projects in comparison with conventional method of construction
- To determine the major challenges that are faced by precast technology at a project site and industry level
- To provide amicable solutions to the challenges faced by precast technology

To achieve the above objectives, following steps were planned (as shown in Figure 1):

- Understanding the national and international perspective of precast technology through literature review

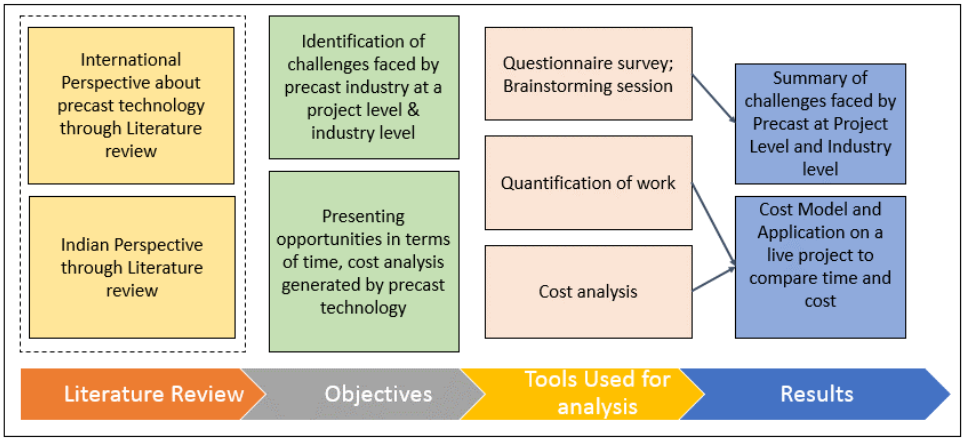

Figure 1: Project Methodology

- Presenting a cost analysis model for a precast building project and differentiating the additional expenses incurred for precast technology in comparison to a traditional construction
- Comparing time and cost for two similar projects constructed using precast and conventional method of construction and to analyze the impacts thereby identifying the challenges faced by precast technology
- Identification of challenges faced by precast technology at project level which is further grouped into four broad categories namely documentation, end user perspective, skill development, etc. Floating of questionnaire to understand the importance level of identified challenges
- Providing amicable solutions through a brainstorming session with industry experts

4. Cost Analysis Model for Precast Technology

Based on the extensive literature review, following cost analysis model for an Indian precast building, in comparison to conventional, is formulated as shown in Figure 2. Cost model highlights that substructure cost would be the same for both conventional and precast building as both the buildings would have a conventional foundation

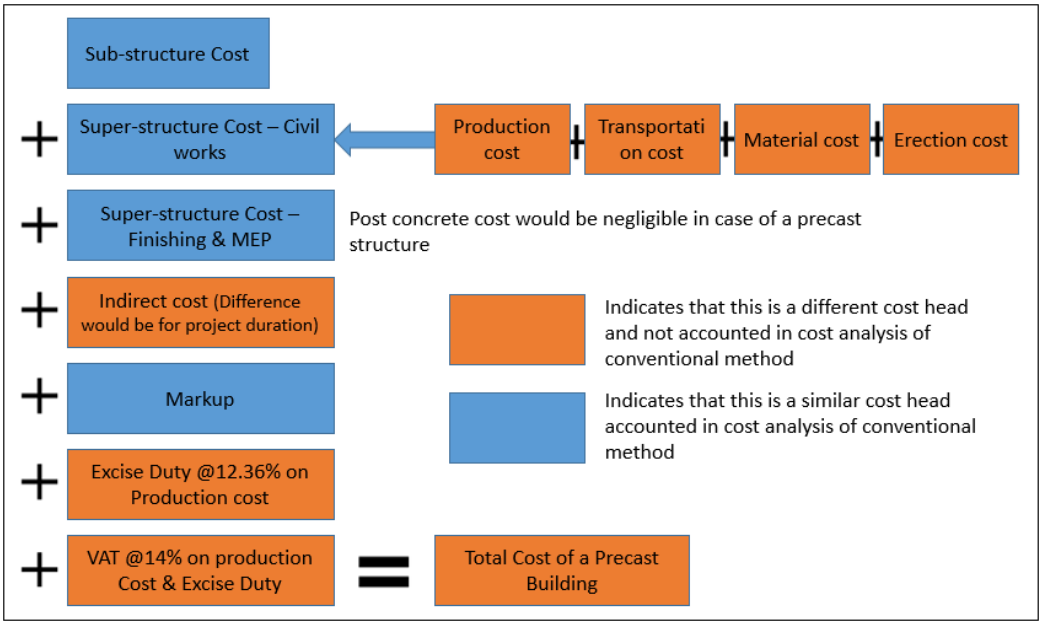

Figure 2 Cost Analysis Model

system. When it comes to the superstructure, the cost analysis for the precast building is entirely different. Conventional buildings shall have a traditional way of construction with formwork, rebar, and concrete whereas precast building will have precast segments, elements, their production cost, transportation cost and erection cost. Finishing works for the superstructure would have the same cost implication on the precast and conventional method of construction. The difference would arise with respect to the post concrete costs which is clearly visible from figure 3. It can be inferred that the quality of surface obtained with precast is superior to the surface achieved with conventional construction. In addition to direct costs, a considerable difference would be there in indirect costs owing to the reduction in project duration. As a burden to the present costs, we have excise duty, and Value Added Tax (VAT) applied to production cost for precast elements which is absent in conventional cost model.

Figure 1 Precast Building Vs Conventional Building

5. Case Study – Time and Cost comparison

Two live projects are taken to examine the time and cost implications on a precast vs. conventional building. Quantity-takeoff from drawings and unit rates taken from schedule of rates are primarily used to formulate bill of

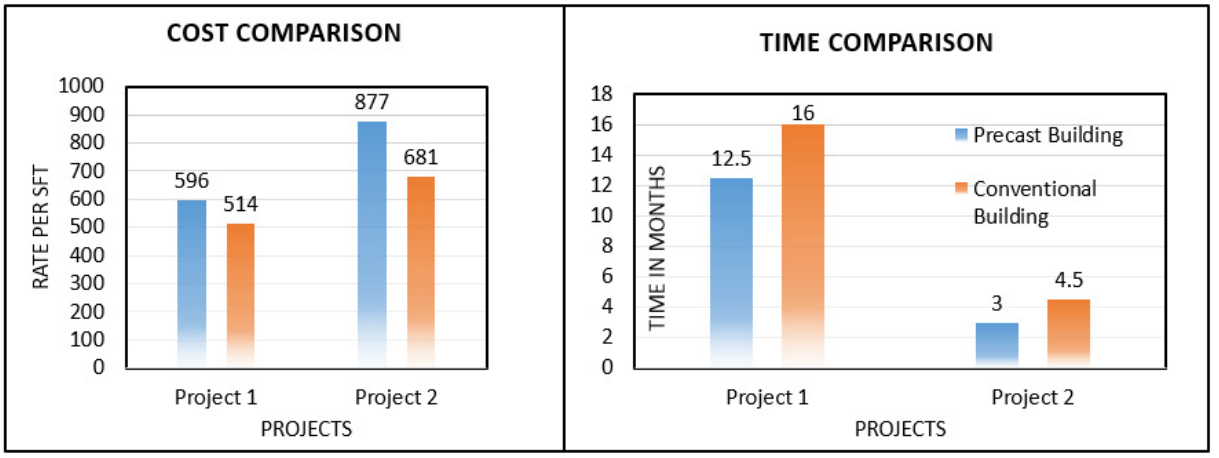

Figure 4 Time and cost comparison for precast vs. conventional building

quantities for both the projects. Projects considered for this study have precast as well as conventional buildings of similar size. Cost is analyzed in terms of the rate per square feet and time is analyzed in terms of the construction duration (months), and the comparison is shown in Figure 4. Project 1 is a residential project with 36000 sqft for

economically weaker section and project 2 is a luxury project consisting of the villa with 4500 sqft. Figure 4 shows that precast building is completed 22% faster in project 1 and 33% faster in project 2 when compared to the conventional building. Cost (includes civil works and finishing works) comparison as per figure 4 shows that precast building incurred 16% more than the conventional building for project 1 and 29% more than the conventional building for project 2. Time and cost analysis shows that precast technology can reduce the time to a considerable extent and certain challenges are associated with the technology making it costly. These challenges related to the precast technology are discussed in next section to make it a viable option.

6. Challenges faced by precast technology

Adoption of precast technology is constrained by a lot of challenges at the project level and at the industry level. Considering the challenges faced, there is a need to address these concerns for the adoption of precast technology at the sector level. Hence, the challenges are grouped into 4 categories namely:

- Standardization, Procurement, and Technological aspects
- Documentation and Design aspects
- Skill Development and human resources
- End-user perspective (acceptability and social dimensioning).

A questionnaire was prepared and floated to all the stakeholders such as architects, consultants, engineers, etc. associated with the adoption of precast technology. Data obtained from 50 responses is analyzed for relative importance index, and the list of challenges are presented in Table 1.

Table 1 List of challenges faced at project level

S.no	Challenges faced at project level	Category	RII (Relative importance index)
1	High Initial Investment in factory and economies of scale	Standardization, Procurement, and Technological aspects	0.84
2	Lack of Skilled Manpower	Skill Development and human resources	0.81
3	The additional burden of taxes viz. Excise & VAT	Standardization, Procurement, and Technological aspects	0.81
4	Leakage issue	End-user perspective	0.81
5	Joint stability Issues during Erection	Standardization, Procurement, and Technological aspects	0.8
6	Lack of Standardisation	Standardization, Procurement, and Technological aspects	0.79
7	Design change related issues	Documentation and Design related	0.77
8	Requirement for huge equipment & stock yards for material handling & storage	Standardization, Procurement, and Technological aspects	0.76
9	Lack of expertise and technical know-how	Skill Development and human resources	0.76
10	Complex design issues	Documentation and Design related	0.75
11	End user friendliness	End-user perspective	0.75
12	Scheduling-Lead Time & delivery	Standardization, Procurement, and Technological aspects	0.73
13	Need for standard manuals, schedule of rates	Documentation and Design related	0.73
14	Transportation for Long distances (location related)	Standardization, Procurement, and Technological aspects	0.72
15	Incorporation of MEP Services	Standardization, Procurement, and Technological aspects	0.68

Most of the respondents have pointed out that the economies of scale, high initial investment, the additional burden of taxes and lack of skilled manpower is pushing precast technology to be an economically unviable option for adoption in Indian construction sector. To overcome these challenges, a brainstorming session was conducted by inviting all the industry experts related to the adoption of precast technology, and amicable solutions are proposed by the industry panel experts as highlighted in figure 5.

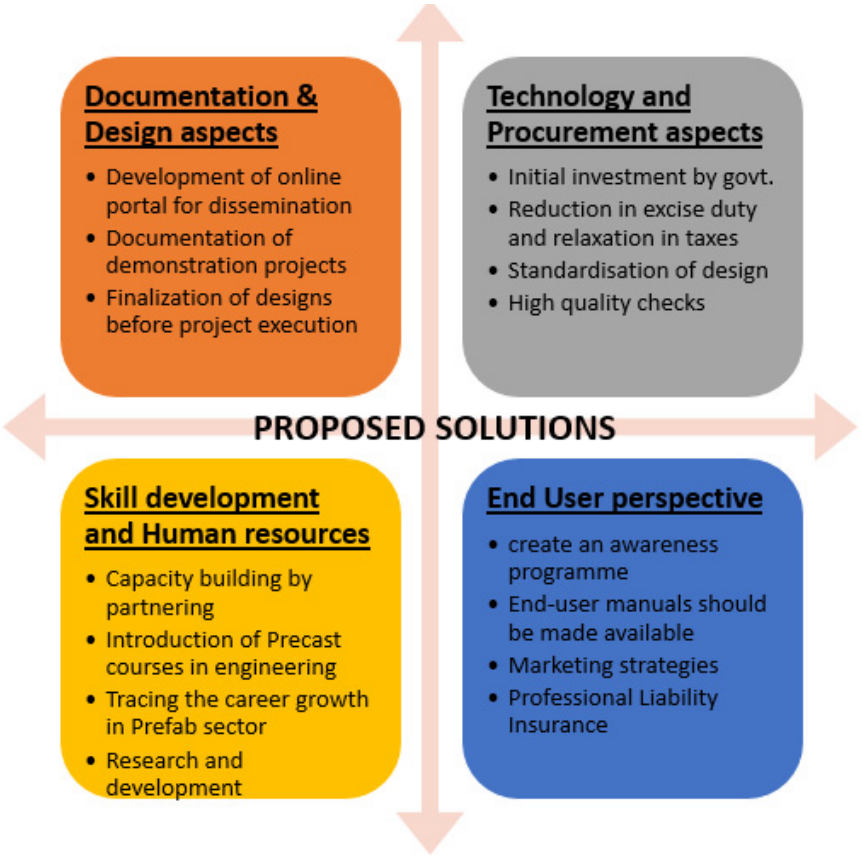

Figure 5: Proposed Solutions

Amicable solutions include government/major playerÑ investment in the precast sector, reduction of additional taxes, skill up gradation of resources by capacity building, dissemination of information about precast technology through an online knowledge portal and ensuring quality through stringent third party testing. Precast technology has the potential to reduce the project duration to a considerable extent and employing the proposed solutions can make it a cost viable option for all the stakeholders. Universities and Institutions should also take part in promoting the precast technology with research and development work and creating awareness by offering courses in this stream.

7. Conclusion

The main aim of the research has been accomplished by proposing a cost analysis model for precast technology and comparing the time and cost aspects of precast buildings vs. conventional construction in two live projects. Time savings of 20-35% have been demonstrated using precast technology in comparison to the conventional method of

construction. In contrary, cost comparison showed us that there is enormous cost variation when compared to the traditional/conventional method of construction. The cost incurred in adopting precast technology is 15-30% more than the cost of traditional/conventional technologies for the projects considered in the research. This analysis and comparison have paved way to identify that there are constraints associated with adoption of precast technology. A questionnaire survey was conducted to collect responses about constraints from all the stakeholders involved with the adoption of precast technology. Respondents have ranked economies of scale, high initial cost, lack of skilled workforce, and leakage issues as the top four constraints. A brainstorming session is conducted with a set of industry experts to propose amicable solutions to the challenges faced by precast technology in its adoption. Experts reviewed and suggested that government or major players have to take the lead in investing in precast manufacturing units thereby supplying precast elements to all the sites so as to utilize the economies of scale to full extent. Taxation is a critical issue owing to double taxation and excise duty. The team of experts proposed to reduce the additional taxes which are loaded on precast technology to open up the opportunities. High-quality stringent checks to ensure that the leakage issues are reduced in the building projects where precast technology is utilized. The skill level of workforce required for implementing precast technology has to be upgraded through effective training programs. One major observation from the research is that cost savings potential can be utilized if the precast technology is adopted to projects where there is scope for huge repetition and standardization. Precast technology shall be a game changer for Indian construction sector.

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