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Research Paper

A Case Study on Measures for Growth of Precast Concrete Construction Industry in India

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Abstract

INDIA is facing a huge housing demand of more than 60 million housing units. The cast in-situ construction technology cannot meet this huge demand at the fast pace required. Some of the developed countries have successfully met similar housing demands by adopting the Precast/Prefabricated Concrete (PPC) construction technology. The PPC technology can offer faster construction with better quality and be a feasible solution to meet the huge housing demand in India. However, many Indian contractors perceive that PPC construction is costlier and less suitable than cast in-situ construction and hence, do not adopt PPC construction methods.

Keywords: *Housing, PPC, Cast in-situ, Precast/Prefabricated concrete.*

1. Introduction

Food, Clothes and Shelter are the basic needs for every human being. Today with the shortage of land and increase in construction costs, availing a proper household has become a nightmare for many people in developing countries. The developed countries, though not having any shortage of households, the households become so costly that they are not affordable. Due to urbanization and increase in population in the developing countries like India, the demand to supply gap of the households is always increasing. 330 million urban households (McKinsey Global Institute, 2014) around the world live in substandard housing or are financially stretched by housing costs. About 200 million households in the developing countries are located in slums. In the developed countries like United States, the European Union, Japan, and Australia, more than 60 million households are financially stretched by housing costs. Also, by 2025, there will be a shortage of about 440 million households in the urban areas around the world. In India, Construction is the second largest economic activity after agriculture and one of the important parts of the industrial sector. It has two major sectors namely ***real estate sector*** and ***infrastructure sector***. The infrastructure segment is classified into roads, railways, urban infrastructure, ports, airports and power (IICCI, 2008). Below figure shows India's economic growth over the years. The real estate market contribution to national ***GDP*** is 6.3% in 2013 and estimated to double at 13% by 2025. Out of total 6.3% GDP, the residential segment forms the major part with 90-95%, the corporate and industrial segments forms 4-5% and the commercial segment contributes 1% (IICCI, 2012). Residential segment has become the mainstay of the Indian real estate market because of the huge demand for housing due to ***urbanization***.

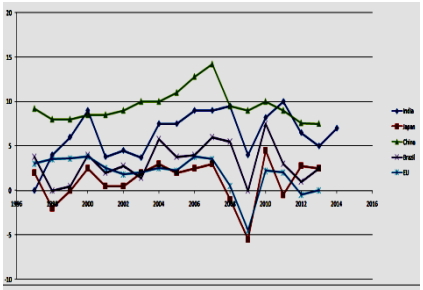


Fig.1: Showing Growth Rates of Different Countries - (MOSPI,2012)

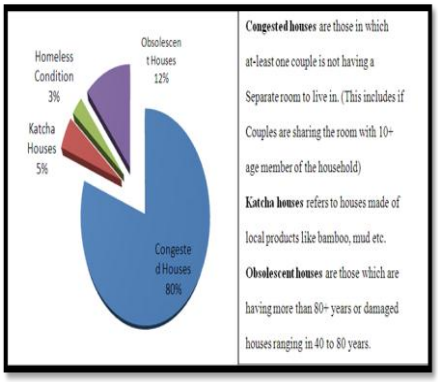


Fig. 2: Urban housing shortages in India (MOSPI, 2012).

Urbanization has also resulted in the deterioration of the housing conditions of the people, especially the Economically Weaker Sections (EWS) of the society. This led to the development of slums and squatter settlements. It was estimated that there were about 49,000 slums in Urban India during the period 2008-2009. Out of which 57 % were built on public land mostly owned by local bodies and state government (NSS Report No. 534, 2009). The housing shortage at the end of 11thFive Year Plan (2007-

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2012) was estimated to be 24.71 million. 88 % and 11% of this corresponds to the housing shortages of EWS and Low Income Group (LIG) population, respectively.
Thus, the economy and speed of construction become the utmost priority without compromising on the quality of construction. Hence, emphasis has to be given to affordable and mass housing construction in the country.
Table 1 gives the details of four income groups considered are (1) Below Poverty Line (BPL), (2) Economically Weaker Sections (EWS), (3) Low Income Group (LIG) and (4) Middle Income Group (MIG).

Table 1: Affordability ratio of different income gropus

Income group	Size in Sq.ft	EMI/Rent income ratio	Cost of housing to income ratio
EWS-LIG	300 - 600	>30% of households gross monthly income	>4 times household gross annual income
MIG	>1200	>40% of household's gross monthly income	>5 times households gross annual income

Table Affordability levels and income categories

Income Category (in Indian Rupees)	Affordability to pay EMI/Rent (% of Income)	Affordability to pay cost of house (multiple of annual income)
BPL (≤ 2,690)	5	2
EWS (2,691 - 3,300)	20	3
LIG (3,301 - 7,300)	30	4
MIG (7,301 - 14,500)	40	5

Precast concrete construction - An answer to housing shortage.
This paper explains about traditional Indian construction industry is still highly dependent on labour. The total requirement of skilled and unskilled labour is 34 million per day for the construction sector (Business Standard, 2013). The statistics show that the shortage of skilled labour from 1995 to 2005 was approximately 45%.
If the industry still continues to depend on the manpower for construction then it would be difficult to meet the growing demand for housing in the country. At the same time quality of construction cannot be sacrificed.

2. Scope

To study the relative economics of precast and cast in-situ residential construction in India.
The scope is limited only to major metropolitan cities in India.
The cost associated with labour, machinery, and materials aspects in cast in-situ and precast concrete construction will be studied.

3. Research Methodology

Review literature on the present status of precast concrete construction in India and other countries, on cost components of in-situ and precast concrete construction. Compare the issues and barriers hindering the growth of precast concrete construction in India and other countries.Analyze and interpret the data, collect data on types and volume of products, area of supply, average production, etc., from existing precast manufacturers in Chennai, Bangalore – by questionnaire/market survey., analyze and interpret the cost break-up.On-site data collection to find out the wastes in the construction processes (by work sampling and foreman delay survey).
The research findings / Pilot study: - This paper provides details regarding the pilot study and observations from the study. The process of production, transportation, erection and grouting of precast concrete elements will be discussed in this paper. For the pilot study, 2 construction projects, one each in Chennai, and Bangalore were selected. Table 3. Shows description of the projects and learning's from the projects.

Table 3: Details of construction projects chosen for Pilot Study

Construction Project Location	Type and volume of the project	Summary of learning's from the project
Bangalore	Residential Project 62Nos, G+12 towers	Types of precast elements Construction Methodology Lack of skilled manpower
Chennai	Residential Project 4Nos, G+12 towers	Issues related to storage Lack of proper erection plan Issues in concreting

All the ***two construction projects*** visited were having issues related to specialized and skilled manpower. Due to this, the project sites were facing schedule delays and considerable amount of rework. Thus from the pilot study it has been found out that two major issues hinder the growth of precast concrete construction in the residential sector in India. ***They are,*** Lack of awareness about the cost benefits of precast concrete construction. Apart from speedy construction and better quality, one more advantage of precast technology is the very high repetition of formwork when compared with the conventional methodology.

Table 4: Differences between CAST IN-SITU and PREFABRICATED Construction (Jaillonet.al., 2009)

Parameter	Conventional in-situ	Prefabricated construction
Construction cost	Low initial construction cost	Cost saving due to repetitive and standard modular production
Quality control	Low (Difficult to control the quality as the site condition always varies)	High (Better quality achieved at the factory production, but poor jointing of prefabricated elements may cause water seepage problems)
Crew sizes on site	Labour intensive	Less labour intensive
Construction time	Longer	Shorter (as few construction activities are on site, the productive time improved by approx. 12%)
Design flexibility	Relatively flexible to the design changes	Inflexible to design changes
Construction waste	High	Low (up-to 85% can be saved on wastage reduction)
On-site safety	Difficult to manage (as it involve many work trades)	Easy to manage (site tidiness is obviously improved a less work trades is on site, resulting in reduction in site accidents)

Compared to in-situ construction, the cost and consequently the complexity of prefabricated housing may be higher due to (1) setting up fabrication yards and transportation, (2) vertical transportation on site, (3) labour training and (4) jointing problems (Chiang et al., 2006)
A work done by Zhang et al., 2014 showcased the barriers for IBS in China. They are: (1) ***High Initial cost***, (2) ***Lack of skilled labours***, (3) ***Manufacturing capability***, involvement issues and product quality problems, (4) ***Lack of supply chain***, (5) ***Lack of***

code and standard, and (6) ***Lack of government incentive, directive and promotion***.

Few limitations of this technology are, it demands highly accurate planning and good amount of technical expertise; a failure may cause loss of time and money. Also changes can't be made at the time of construction.

Probability damage of precast elements will high if they are not handled with proper care these are all the few reasons that made precast industry poor in India.

One of the reasons cited for the low popularity of precast is due to less developed India's road network and transporting precast components over very long distances was impractical (Balakrishna, 2014). In that scenario, site casting of precast elements will be handy. Socio-economic change and the government regulations are the two important factors, which hindered the application of precast technology in construction so far in India (Dutta 2012).

4. Barriers to Prefabrication

The ***Top Four Attributes*** preventing extensive use of precast systems in India found out from the work done by Das and Jha (2011) are:

1. Contractors' unawareness of significant advantages offered by precast construction.

2. Non-availability of qualified structural engineers specialized in precast concrete systems.

3. Lack of standardization of concrete elements such as girder, slab, etc.,

4. Non-availability of contractors specialized in precast concrete systems.

Only about 2% of the total market value of concrete construction is shared by Precast/Prefabricated Concrete (PPC) construction; whereas the remaining 98% is for cast in-situ concrete (CIC) construction.

In short, various opportunities exist for adopting PCC instead of CIC in various construction sectors, especially housing sector Formwork represents the major portion of man-hours and Rework, or repair of surfaces, is quite extensive.

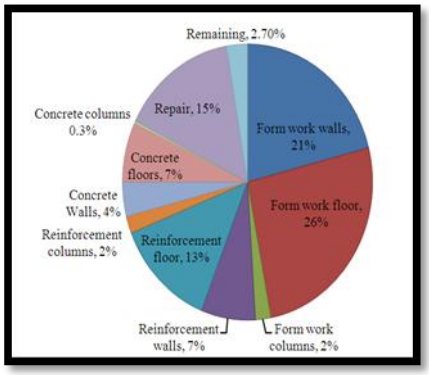
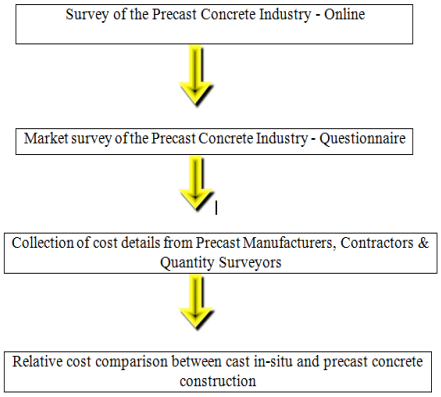


Fig. 3: Approximate relative breakdown of man-hours for a concrete structure (Lofgren and Gylltoft, 2001)

Table 5: Comparison between PREFABRICATED CONSTRUCTION / CAST INSTU

Sl. No	COST COMPONENT	% cost spent for Cast In-situ	% cost spent for Pre Cast
1	Direct labour in plant	8	3.2
2	Direct materials in plant	41.9	47.1
3	Plant overhead	25	25.2
4	Transportation	4.9	6.8
5	Assembling and jointing on site	20.2	17.7
Total		100	100

5. Methodology for comparison of precast economies



The following procedure is adopted for the relative comparison of economies between precast and cast in-situ concrete construction:

5.1. Online survey of the precast concrete industry

To know the status of precast concrete industry, an online survey comprising of the type and shape of precast products produced by precast manufacturers, services offered by the manufacturers/consultants and number of construction projects completed in the overall precast industry are collected from the details given in the website of the respective companies.

5.2. Market Survey of the Precast Concrete Industry

A questionnaire has been prepared to understand the number of precasting plant established by each company/manufacturer, type of production of precast elements, at what percentage efficiency the precasting plants are functioning, deployment of skilled workmen, area of precasting plant, etc., Then the questionnaire is circulated among the precast contractors and manufacturers. Once the responses are obtained, they are analyzed to get the results.

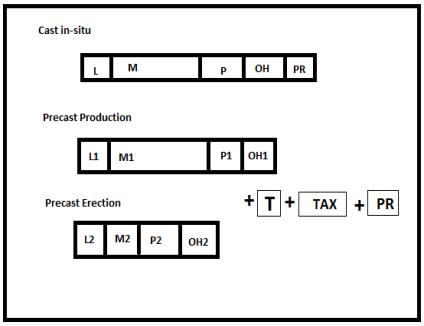


Fig. 4: Schematic comparison of relative economies between cast in-situ and precast concrete construction

5.3. Comparison of Economies

The cost details of cast in-situ concrete is obtained from the quantity surveyors.Precast concrete cost data should have to be collected from Precast Manufacturers and Contractors. The cost details of precast is divided into production and erection costs. Cost incurred for Labour, Material, Plant and Machinery, Over Heads and Profit is collected in cast in-situ and precast concrete construction. Cost incurred for transportation and taxation are collected from precast concrete manufacturers/contractors. A comparative model of comparison is shown in Figure 4.

6. Results & discussions

Comparison of relative economies of cast in-situ and precast concrete construction will be explained in detail. Cost incurred for various components like labour, material, plant and machinery, overheads and profits are compared.

6.1. Comparison of relative cost economies

Data collection
To compare the relative economies of cast in-situ and precast concrete construction, the cost details are needed. The cost details of cast in-situ construction are collected from the quantity surveyors and that of precast concrete construction are collected from the precast concrete manufacturers. This analysis compares the cost of 1 cubic meter of cast in-situ and precast concrete.

6.2. Cast in-situ concrete construction

The cast in-situ construction is the traditional method of pouring the concrete in which the concrete will be poured on the site location.

Assumptions:
1. Cost of Ready Mix Concrete (RMC) is Rs. 4,500/- per m^3.
2. Cost of reinforcement is Rs. 45/kg (100 kg to be used per m^3)
3. Cost of formwork (including staging) as per Central Public Works Department (**CPWD**) schedule of rates is Rs. 334/m^2. Consider approx. Rs. 350/m^2.
4. The ratio of m^2 of formwork to m^3 of concrete is 1:8.
5. The profit will be taken at a rate of 10% of total cost.
6. The overheads will be considered at a rate of 15% of total cost.

Cost of material
Cost of 1 $m^3$of concrete = Rs. 4,500/-
Cost of Reinforcement at 100kg/m^3= Rs. 4,500/-
Cost of formwork @ 8 m^2/m^3 of concrete =Rs. 2,800/-
Total material cost =Rs. 11,800/-

Table 6: Distribution of cost for 1 m^3 of cast in-situ concrete

Cast in-situ	Percentage as a function of total cost					
	Labour	Material	P&M	Over Heads	Profit	Total Cost
	18%	40%	17%	15%	10%	Rs. 29,500
	Rs. 5,310	Rs. 11,800	Rs5,000	Rs. 4,425	Rs. 2,950	

As shown in Table, the total cost of **1m^3** cast in-situ construction is **Rs. 29,500**.

6.3. Precast concrete construction

In precast concrete construction, four cost components i.e. ***production, erection, transportation and taxation*.** Also, in this analysis, the precast concrete is considered as procured from a precast manufacturer. So, there will a tax component. The calculations and assumptions were shown in the following:

Assumptions:
The labour cost for fabrication is considered as Rs. 2,000/- per mould.

1. Cost of Ready Mix Concrete (RMC) is Rs. 4,500/- per m^3.
2. Cost of reinforcement is Rs. 45/kg (100 kg to be used per m^3).
3. Cost of formwork is calculated as follows:

Considering an 8mm thick steel plate for making mould at a rate of Rs. 60/kg.
The material cost of mould is = (0.008*3*3)*7860 kg/m^3* **Rs.60/kg** = Rs. 34,000 (approx.)
Fabrication cost = Rs. 2000
Total cost of a mould = Rs. 36,000/-

Assuming 100 repetitions per mould, the cost of mould per usage of 1 m^3 concrete is Rs.360.
4. A time savings of 30% is achieved using precast concrete construction.
5. The profit will be taken as 10% same as that of cast in-situ concrete construction.
6. The overheads will be considered at a rate of 15% of total cost.

Cost of material
Cost of 1 $m^3$of concrete = **Rs. 4,500/-**
Cost of Reinforcement at 125 kg/m^3= Rs. **4,500/-**
Cost of formwork per $m^3$of concrete = Rs. **360/-**
Total material cost =**Rs. 9,360/-**

Table 7: Cost analysis of production of precast concrete

	Labour	Material	P&M	Transportation cost		Taxation cost	Over Heads
Precast - Cost of Production	15% of cast in-situ	5% savings due to optimized design	NA	11% of material cost	service tax = 12.36% of 0.25 times transportation cost	12.36% of material cost	15% of total cost
	Rs. 795	Rs. 8,890		Rs. 1,029	Rs. 31	Rs. 1,156	Rs. 2,100

Table 8: Cost analysis of erection of precast concrete

	Labour	Material	P&M	Over Heads
Precast - Erection	60% of cast in-situ	NA	70% of the cast in-situ	15% of the total cost
	Rs. 3,660		Rs. 3,500	Rs. 1,260

The total cost of 1 m3of precast concrete is Rs. 22,421/-. This means precast concrete costs 20-25% less than the cast in-situ construction.

Thus, the analysis shows a potential of 20%-25 % cost savings in precast concrete con-struction. Though, this is not the exact % of cost savings, precast concrete construction certainly is cheaper than cast in-situ con-struction.

Figures 5&6. Show the percentage of cost components for cast in-situ and precast con-crete construction respectively.

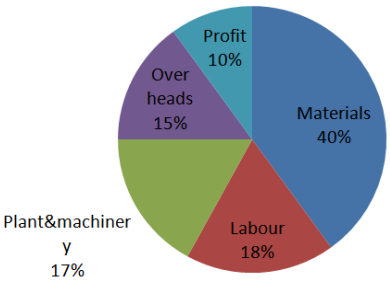


Fig. 5: Distribution of cost elements for cast in-situ construction (in %)

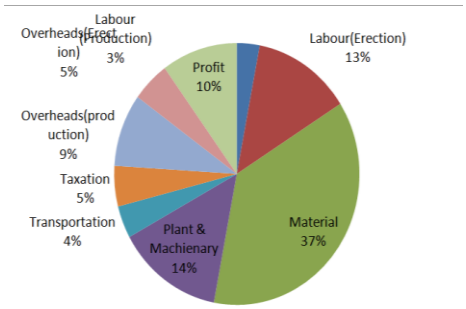


Fig.6: Distribution of cost elements for Pre cast construction (in %)

Cost comparison analysis between precast concrete construction and cast in-situ con-struction was explained.

The results shows a potential of 16% cost savings in precast concrete construction.

7. Conclusions

1. After carrying out an in-depth review of current practices and literature and analysis at the precast concrete construction sites, the following conclusions were made from the study:
2. Precast concrete construction will be a possible solution to mitigate the shortage of households in the residential sector.
3. Lack of awareness about the benefits of precast concrete is the major issue that hinders its growth in India.
4. The comparison of economies between cast in-situ and precast concrete construction shows a potential of 20-25% cost savings while adopting precast concrete construction.

8. Limitations of study

This study has following limitations:

Comparison of economies

1. The results of market survey are not published due to fewer responses from the precast manufacturers and contractors.
2. The cost comparison done is only based on the responses provided by quantity surveyors and precast manufacturers during the time of study. The data is less accurate as there is no exhaustive data available to bring strong conclusions.
3. The cost comparison does not consider the change in costs in different locations of the country.

9. Recommendations

This study was focused on resolving the immediate issues prevailing in precast concrete industry. However, further research is needed to remove all the barriers. They are:

1. Research on thermal insulation properties of different methods of precast concrete construction like hollow core, box -type, wall panel construction, etc. This will give advantages of each system of precast concrete construction.
2. Precast construction requires different sets of equipment during casting and erection processes. Cycle time and cost of different equipment can be explored and analyzed to do these activities more safely and efficiently.

References

[1] Abraham Warszawski, Moshe Avraham and David Carmel (1984), “Utilization of precast concrete element in buildings.” Journal of Construction Engineering and Management, Vol. 110, No. 4, December, 1984.

[2] Arditi, D., Ergin, U., and Guhan, S. (2000).”Factors affecting the use of precast concrete systems.” Journal of Architectural Engineering, 6(3), 79-86.

[3] Baldwin, Andrew N., Poon, Chi-Sun, Shen, Li-Yin, Austin, Simon A. & Wong, Irene. (2006), “Designing out waste in high-rise residential buildings: analysis of precasting and methods and traditional construction”, Loughborough University.

[4] Blismas, N., and Wakefield, R. (2007). “Drivers constraints and all the future of off-site manufacture in Australia.” Construction Innovation Special Edition, 2008.

[5] Badir, Y. F., Kadir, M. A., and Hashim, A. H. (2002). "Industrialized building systems construction in Malaysia." Journal of Architectural Engineering, 8(1), 19-23.

[6] Balakrishna B., (2014). “The Indian Precast Industry – Gaining Prominence”, The Master Builder, June-2014.