Study on Methods of Precast Systems for Indian Construction Industry

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Abstract— Housing crisis is one of the major issue India facing today. In India, urban housing shortage is estimated at nearly 18.28 million households in 2012. India, a developing country, is also facing a huge housing demand of more than 60 million housing units. By 2022, this is expected to reach 110 million. The Cast In-situ Construction technology cannot meet this huge demand at the fast pace required. 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. This paper tries to answer the question "How does one decides whether to go for prefabrication adjacent to worksite or prefabrication in a factory?" and the challenges facing by the precast technology in India.

Index Terms— Hosing crisis, Cast In-situ Construction, Precast technology, Challenges.

1 INTRODUCTION

Urbanization is taking place at a rapid speed in india. Population situated in urban areas in India, according to 1901 census, was 11.4%. This count increased to 28.53% according to 2001 census, and crossing 30% as per 2011 census, standing at 31.16%. The urban population of India is expected to rise to 576 million by 2030 [1].

The increase in urban population combined with rapid urbanization, and it has resulted in land shortage, housing shortage, congested transits, and has severely affected the basic amenities like water, power and open spaces in towns and cities [2].

According to a report submitted by a technical committee committee to the Ministry of Housing and Urban Poverty Alleviation (MHUPA), India's urban housing shortage is estimated at nearly 18.78 million households in 2012. Besides those living in obsolescent houses, 80 percent of these households are living in congested houses and are in requirement of new houses. The report also highlights that nearly one million households are living in non-serviceable katcha houses, while over half a million households in homeless conditions [3].

As per the 2011 study report conducted by by Ernst & Young and the Federation of Indian Chambers of Commerce and Industry, the construction industry in India is facing 30% labor shortage. The shortage is expected to reach about 65% by 2021.

If the construction industry does not focus on the mechanization and continues to depend heavily on labor for construction, then it would be difficult to meet the growing demand for housing in the country. Moving towards large scale mechanization and innovative construction methods like precast concrete construction (PCC) seems to be the feasible solution, if it is well planned, designed and implemented properly. If PCC is adopted without adequate planning and design and then implemented by inadequately skilled personnel, then the benefits would not be fully realized and many would wrongly blame the PCC technology.

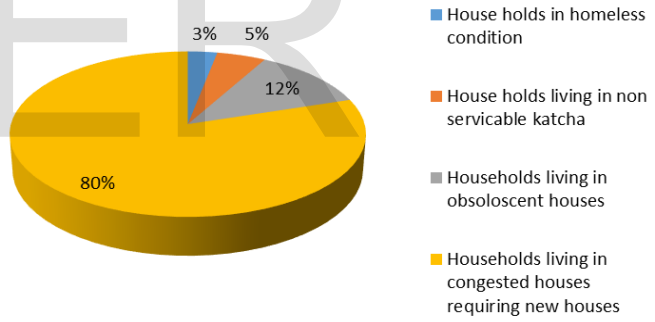

Figure 1: Distribution of urban population in India, who faced housing shortage in 2012 (MOSPI, 2012).

2 STATUS OF PRECAST CONCRETE CONSTRUCTION IN INDIA

Prefabrication in India began with the emergence of the "Hindustan Housing Factory". The company was developed by the first Prime Minister of India, Pandit Jawaharlal Nehru, as a solution to the housing crisis that resulted from the arrival of large number of refugees from West Pakistan in the 1950s. The Hindustan Housing Factory pioneered the production of pre-stressed concrete railway sleepers to replace dilapidated wooden sleepers on Indian Railways. The company changed its name shortly thereafter to reflect the diversity of its operations. It is now known as the Hindustan Prefab Limited or HPL [4].

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The construction industry in india is around USD 500 million and precast has only 2% share vis-à-vis the traditional method of construction. A majority of Indian structures both residential, commercial and infrastructure are being built in the cast in place or in-situ mode; there is a growing popularity for precast technology within the Indian construction community but was mostly limited to civil structures such as tunnels, bridges& flyovers an under passes.

3 Barriers to prefabrication in India

3.1 Onsite prefabrication barriers

1. High initial investment: to prepare precast yard at site, it requires huge initial investment. And most of the contractors won't show much interest to invest all the mobilization cost in precast yard preparation.
2. Lack of space availability at site: space must be available at site for the preparation of precast yard and for the storage of manufactured precast elements. Due to the rapid urbanization it's becoming difficult to find space availability.

3.2 Factory based prefabrication barriers

1. Taxation: There is tax on concrete items precast/ manufactured at a location outside the site, which is quite inimical to the use of precast items. 18% ***Goods*** & Services Tax (***GST***) Rates is Applicable on ***Precast*** in India.
2. Transportation: The transportation cost of precast components from the plant to the site is directly proportional to the transportation distance between the plant and site. And another constraint related to transportation is the allowable weights and sizes of loads that are limited by the carrying capacity of bridges and pavements and by the horizontal and vertical clearances in tunnels and underpasses. The project has to be handled in such a way that the component sizes do not exceed the weight andn size limitations specified by highway agencies. These transportation related limitations might constrain the creativity of the designer.

3.3 Barriers to design

1. Lack of standardization and codes: A nationwide standardization is an important factor in the success of industrialized systems of the country and involves a well-defined set of policies for modularization and quality control. At present, the Indian precast concrete construction industry does not have appropriate standards for shapes and sizes of elements, their transportation, handling and erection processes. There is a need to standardize precast concrete elements like steel products which are already standardized. And certification of precast concrete elements requires good testing facilities and suitable codes are developed and put in practice by Bureau of Indian Standards (BIS).
2. Joints and connection issues: Most of the precast concrete projects in India are reported to have water/moisture leakage/seepage issues through the exterior joints and connections. Also, the connection designs becoming very difficult due to the lack of proper standards and lack of readily available standard connection fixtures. The IS codes and standards on precast concrete do not provide sufficient guidelines to improve water tightness of joints and connections in precast concrete structures. As a result, poor and ad-hoc practices are followed at site leading to leakage and seepage through joints and connections.

3.4 Negative perception

There exist mixed perceptions about precast concrete among the Indian construction industry personnel. Many stakeholders perceive, though wrongly, that precast concrete technology is not a safe technology in terms of structural performance during extreme events or natural calamities like earthquake, etc. This leads to reluctance among the designers and architects in adopting this technology. Another interesting factor hindering the growth of precast in India is related to the consideration of 'Vastu Shastra' during house construction. Also, post construction modifications are relatively difficult in a precast concrete house. These forces lead many builders to opt for cast in situ instead of precast technology.

4 How one does decides whether to go for prefabrication adjacent to worksite or prefabrication in a factory?

The broad question this paper tries to to answer is "How does one decide whether to use prefabrication adjacent to job site or prefabrication in a factory". Here we are considering two alternatives:

1. Prefabrication adjacent to site
2. Prefabrication in a factory

The main three factors in any construction are Quality, Time and Cost. This study gives the Quality, Time and Cost differences between Onsite prefabrication and Offsite prefabrication.

4.1 Survey findings

A total of 10 participants were participated in the survey. The survey results shows the better option between Prefabrication adjacent to site and Prefabrication in a factory to go for.

According to respondent information, out of 10 representatives, 7 are working in the field and the remaining 3 are belongs to Precast manufacturing factory. All the participants are worked in precast projects and have minimum of 5 years' experience in the field of construction.

The factors considered in the survey are listed below

1. Number of suppliers
2. Location of suppliers
3. Labor cost
4. Production rate
5. Robustness
6. Quality of finishes
7. Quality control
8. Safety
9. Stacking of products
10. Risk in return of investments
11. Ease of handling equipment; labor competency
12. Flexibility in structural design

13. Adaptability of resources, production machinery
14. Waste reduction
15. Weather

TABLE I: Advantages and Disadvantages for each factor with respect to both alternarives

S.No	Factors	Criteria	Prefabrication adjacent to the worksite		Prefabrication in factory	
			Attribute	*Advantage*	*Attribute*	*Advantage*
1	Number of material suppliers	Fewer is better	>5	No advantage	1	More advantage
2	Location of suppliers	Closer is better	Varies with site	Site dependent	Varies with site	Site dependent
3	Labor cost	Less is better	Relatively more	Less advantage	Relatively less	More advantage
4	Production Rate	More is better	Relatively less	Less advantage	Relatively more	More advantage
5	Robustness	Perfectly Robust	Potentially a bit less Robust	Potentially disadvantage	Potentially a bit more Robust	Potentially advantage
6	Quality of finishes	Perfect finishes	Consistent quality	Satisfies criteria	Consistent quality	Satisfies criteria
7	Quality control	Good quality control required	Relatively less	Less advantage	Relatively more	More advantage
8	Safety considerations: % of work steps done above head or in dim light	Less than 15% of total activity	0%	Less risky activities	0%	Less risky activities
9	Stacking of products	Space should be available	Varies with site	Less advantage	More space to store	More advantage
10	Flexibility in structural design	Allow for changes at later stage	No flexibility for late changes. The design needs to be freeze early.	No advantage	No flexibility for late changes. The design needs to be freeze early.	No advantage
11	Solid waste	Less waste generation is better	Generates comparatively more waste	No advantage	Generates less waste	Less wastage
12	Weather	No delays due to weather	Affected to a certain extent	Potential delays	Not affected at all	No weather delays

TABLE2
RATING OF EXPERTS FOR THE PREFABRICATION ADJACENT TO SITEALTERNATIVE

Prefabrication in a factory	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean
Number of supliers	10	9	5	4	9	6	8	8	10	10	7.9
Location of supliers	10	10	6	0	9	0	3	6	3	10	5.7
Labor cost	0	9	7	7	9	8	9	9	8	0	6.6
Production rate	10	10	7	10	9	9	9	10	10	9	9.3
Robustness	9	9	8	9	9	9	9	9	9	9	8.9
Quality of finishes	10	10	9	10	9	8	9	10	10	10	9.5
Quality control	9	10	10	10	10	9	9	10	10	9	9.6
Safety	9	9	8	9	10	8	9	10	9	9	9
Stacking of products	8	9	6	10	10	8	9	10	10	8	8.8
Risk in return of investment	0	5	4	0	9	5	0	7	4	5	3.9
Ease of handling equipment; Labor competency	10	10	8	10	9	9	9	10	10	10	9.5
Flexibility in structural design	0	3	4	0	7	0	0	0	0	0	1.4
Adaptability of resources, production machinery	9	9	9	9	9	7	8	9	9	9	8.7
Waste reduction	9	9	9	10	9	9	9	10	9	9	9.2
weather	8	10	10	10	9	10	10	10	10	9	9.6
TOTAL	111	131	110	108	136	105	110	128	121	116	117.6

TABLE 3
RATING OF EXPERTS FOR THE FACTORY PREFABRICATION ALTERNATIVE

Prefabrication in a factory	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean
Number of supliers	10	9	5	4	9	6	8	8	10	10	7.9
Location of supliers	10	10	6	0	9	0	3	6	3	10	5.7
Labor cost	0	9	7	7	9	8	9	9	8	0	6.6
Production rate	10	10	7	10	9	9	9	10	10	9	9.3
Robustness	9	9	8	9	9	9	9	9	9	9	8.9
Quality of finishes	10	10	9	10	9	8	9	10	10	10	9.5
Quality control	9	10	10	10	10	9	9	10	10	9	9.6
Safety	9	9	8	9	10	8	9	10	9	9	9
Stacking of products	8	9	6	10	10	8	9	10	10	8	8.8
Risk in return of investment	0	5	4	0	9	5	0	7	4	5	3.9
Ease of handling equipment; Labor competency	10	10	8	10	9	9	9	10	10	10	9.5
Flexibility in structural design	0	3	4	0	7	0	0	0	0	0	1.4
Adaptability of resources, production machinery	9	9	9	9	9	7	8	9	9	9	8.7
Waste reduction	9	9	9	10	9	9	9	10	9	9	9.2
weather	8	10	10	10	9	10	10	10	10	9	9.6
TOTAL	111	131	110	108	136	105	110	128	121	116	117.6

Everyone is asked to give the rating from 0 which refers least advantage to 10 refers most advantage for each factor in both the alternatives.

TABLE 4
MEAN RATING FOR BOTH ALTERNATIVES

All Experts		
	Prefabrication at worksite	**Prefabrication in a factory**
Mean Points	85.4	117.6

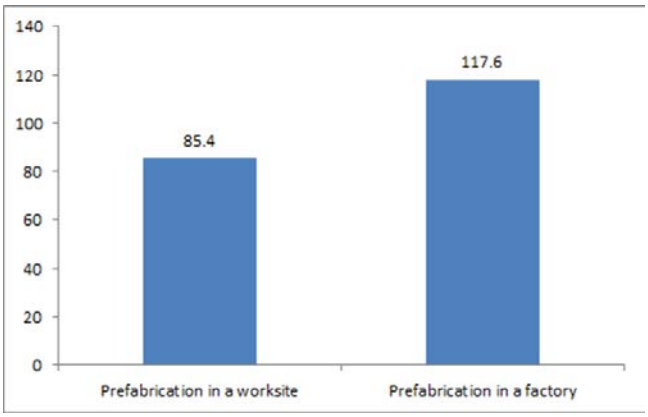

Figure 2: Mean Rating for both Alternatives

4.2 COST COMPARISON FOR BOTH ALTERNATIVES

1. Onsite Prefabrication Cost (Co): The Onsite Prefabrication Cost (Co) includes Precast yard preparation cost (Cy), Production cost (Cp), and installation cost (Ci).

$$Co = Cy + Cp + Ci + uc$$

Where uc represents cost deviations, resulting in incremental costs due to contingencies; Cp is determined by the design and production stages and Ci is determined by the design, production and on-site installation stages.

3. Factory based Prefabrication cost (Cf): The factory-based Prefabrication cost (Cf) includes production cost (Cp), transportation cost (Ct), installation cost (Ci) and Tax on the manufactured elements (GST).

$$C_f = C_p + C_t + C_i + Tax + uc$$

As shown in the below graph, initially onsite prefabrication cost will be high with respect to quantity of concrete because of yard preparation cost. Up to some scope of work factory-based prefabrication cost will be less i.e. up to Q_1. For large scope of works onsite prefabrication preferable if the cost is the main criteria.

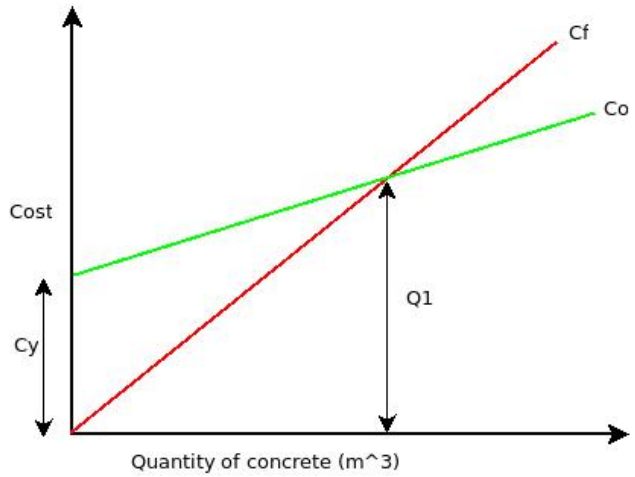

Figure 3: Cost comparision with respect to quantity of concrete

4.3 TIME COMPARISON FOR BOTH ALTERNATIVES

1. Total time for construction with onsite prefabrication (To): Here the total time (To) includes yard preparation time (Ty), production time (Tp) and installation time (Ti).

$$To = Ty + Tp + Ti$$

2. Total time for construction with factory based prefabrication (Tf): Here the total time (Tf) includes production time (Tp), transportation time (Tt) and installation time (Ti).

$$Tf = Tp + Tt + Ti$$

However, if we compare the both times, factory based prefabrication takes less total construction time compared to onsite prefabrication because there is no need to prepare yard for factory based prefabrication. $Tf < To$

5 CONCLUSION

India and most other developing countries are witnessing significant Urbanization-Migration. Because of this, most of the developing countries are facing huge housing shortage. Cast-In-Site (CIC) construction is not adequate to meet the current and future housing demands. Precast Concrete Construction (PCC) is a feasible technology that can be adopted to provide affordable mass housing and reduce the housing shortage. Survey is conducted by identifying various factors that influence the decision-making process of both precast alternatives. The findings mentioned above indicate that, factory based prefabrication gives the better quality compared to the onsite prefabrication. If we consider the cost factor in the selection of onsite or factory based prefabrication, it will vary with scope of the precast work and distance at which site located from the precast manufacturing factory

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