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# Promoting precast concrete for affordable housing – An overview on promotional policies worldwide and challenges and possibilities in India

Arifullah P. Sherfudeen, Nitish Kumar, Raghavan N., Radhakrishna G. Pillai and Satyanarayana N. Kalidindi

Housing crisis is one of the major issues the world is facing today. Worldwide, about 330 million households in urban areas are at substandard levels. In developing countries, about 200 million households are located in slum areas. By 2025, at least 1.6 billion citizens in the world are expected to be lacking adequate housing. India, a developing country, is also facing a huge housing demand of more than 60 million (6 crores) housing units. By 2022, this is expected to reach 110 million (11 Crores). The Cast In-situ Construction (CIC) technology cannot meet this huge demand at the fast pace required. In the past, some of the developed countries have successfully met similar huge housing demands by adopting the Precast Concrete Construction (PCC) technology. This paper reviews the promotional policies for PCC adopted in select developing countries and the impact of PCC in these countries. This paper also brings out various issues hindering the growth of PCC in India based on interviews with different stakeholders. Also, an attempt has been made to identify the current promotional policies in India and the areas of potential improvement for promoting PCC in India.

**Keywords:** *Housing shortage; affordable housing; cast in-situ construction; precast concrete construction; construction policies.*

## INTRODUCTION

Food, Clothing and Shelter (In Hindi: *Roti, Kapada aur Makaan*) are the basic needs for every human being. Providing affordable housing to the citizens is reckoned as one of the most important goals of many governments worldwide. The word 'affordability' can be defined as the ratio of 'the housing rent' to 'the income of the household'. The housing rent can also include taxes, maintenance costs, and utility costs [1]. The 'affordability' can be different for different income groups such as Below Poverty Line (BPL) group, Economically Weaker Sections (EWS), Low Income Group (LIG), and Middle Income Group (MIG). In this article, an in-depth review of housing shortage and the need for affordable housing, especially for India, have been presented.

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### 1.1 Affordable housing – Global challenges

Today, with the shortage of urban land and increase in land and construction costs, availing an uncongested household in an urban area has become a nightmare for many citizens in developing countries. Though developed countries do not have any significant shortage of housing, the housing has become so costly that it is not affordable for many citizens. Due to the rapid urbanization and increase in population in developing countries like India, the demand-to-supply ratio of housing is significantly increasing. About 330 million urban population around the world are having substandard housing facilities or are financially stretched by huge housing costs [2]. It is anticipated that by 2025, there may be a shortage of about 440 million households in the urban areas around the world [2]. In the developed countries

(like United States, European Union, Japan, and Australia), more than 60 million households are financially challenged by huge housing costs. In the developing countries, about 200 million households are located in slums [2]. Most of the governments, especially in the developing countries, are considering the housing shortage as a serious issue and have started framing policies to counter the same.

## 1.2 Affordable housing – Indian scenario

Figure 1 shows India's economic growth rate since 1997; with growth rates lying between 5 and 10 percent. In India, the construction sector is second to agriculture in terms of labour employed and contributes a significant 8 percent to India's Gross Domestic Product (GDP) [3].

Construction has two major sub-sectors, namely, Infrastructure sector and Real Estate sector. The infrastructure sector is classified into roads, railways, urban infrastructure, ports, airports, power plants, etc. [4]. The real estate sector is broadly classified into residential, commercial, industrial and corporate segments [4]. The real estate market's contribution to the national GDP is 6.3 percent in 2013 and is estimated to be 13 percent by 2025 [5]. Out of this 6.3 percent GDP, the residential segment forms the major part with 90 to 95 percent, the commercial segment contributes one percent, and the corporate and industrial segments form 4 to 5 percent [6]. In essence, the residential segment has become the mainstay of the Indian real estate market because of the huge demand for urban housing.

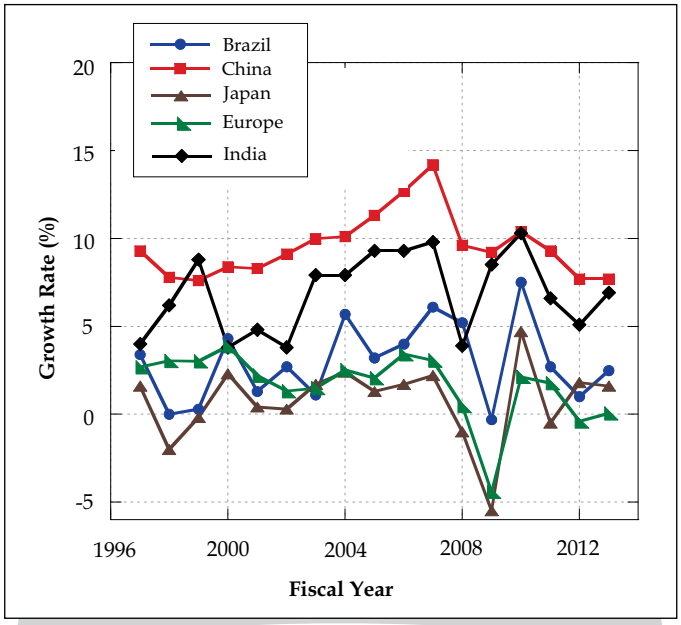
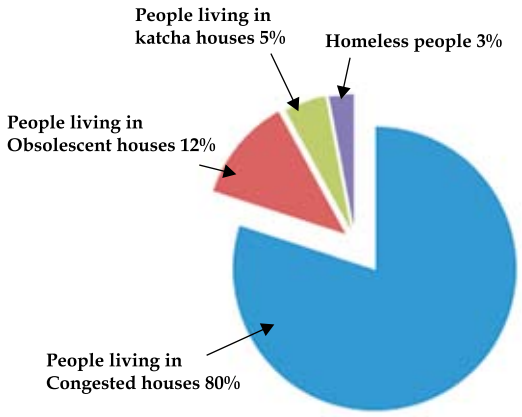



*Figure 1. India's economic growth rate when compared to other developing nations (CREDAI, 2014)*

As per the 2011 Census, India's population was 1211 million, out of which 377 million (i.e., ≈ 32 percent of India's population) live in urban areas [7]. Among this, about 35.4 percent (i.e., about 133 million) are migrants from other cities and rural areas. Among these migrants, about 60 percent (i.e. 80 million) are from the rural areas [8]. The increase in urban population coupled with the rapid urbanization (denoted as 'Urbanization-Migration', herein) 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. The Urbanization-Migration has also resulted in the deterioration of the housing conditions of the population, especially the EWS of the society, and the formation of slums and squatter settlements. NSS Report No. 534 reported that there were about 49,000 slums in Urban India in the period 2008-2009, out of which 57 percent were built on public land owned by local bodies and state government (i.e. encroachments) [9]. As per 2011 Census, the number of slum households increased to about 13.78 million. In 2012, about 18.78 million urban population faced housing shortage of various types. Figure 2 shows a distribution of this housing shortage. About 80, 12, and 5 percent of the citizens were living in congested houses,




**Congested houses (15 million)** – houses with at-least one couple without a separate room to live in. Also, if couple is sharing the room with 10+ age member of the household.

**Katcha houses (1 million)** – houses made of local products like thatch, bamboo, mud, or other low-quality materials

**Obsolescent houses (2.3 million)** – houses older than 80 years or damaged houses that are 40 to 80 years old.

*Figure 2. Distribution of urban population in India, who faced housing shortage in 2012 (MOSPI, 2012)*

**Table 1.Affordability ratio of different income groups (Wadhwa et al., 2009)**

| Income group | Size (sq. ft.) | Ratio of 'EMI / Rent' to 'household income' | Ratio of 'cost of housing' to 'household income' |
|---|---|---|---|
| EWS – LIG | 300 to 600 | > 30% of household's gross monthly income | > 4 times household gross annual income |
| MIG | > 1200 | > 40% of household's gross monthly income | > 5 times household gross annual income |

**Table 2. Affordability levels and income categories (Wadhwa et al., 2009)**

| Income Category (in INR per annum) | Affordability to pay the EMI / Rent (% of income) | Affordability to pay the cost of house (multiple of annual income) |
|---|---|---|
| BPL (≤ 2690) | 5 | 2 |
| EWS (2691 - 3300) | 20 | 3 |
| LIG (3301 - 7300) | 30 | 4 |
| MIG (7301 - 14,500) | 40 | 5 |

obsolescent houses, and *katcha* houses, respectively. Also, about 3 percent of the urban population were homeless in 2012. It should be noted that Figure 2 does not show the households with decent standard of living or at least good access to utilities. NSS Report No. 534 estimated the housing shortage at the end of 11$^{th}$ Five Year Plan (2007-2012) to be 24.71 million; 88 and 11% of this correspond to the housing shortages of EWS and LIG population, respectively [9]. Also, according to Cushman and Wakefield, if India has to meet this huge housing demand, an investment of INR 22.2 trillion in construction is required [10]. This is about 12 times more than the current contribution of ≈ 8 percent to the national GDP.

In order to meet the huge housing demand in India, it is necessary to go for mass housing construction methodologies, which can deliver quality and affordable houses [11]. In other words, the construction methods used should be made affordable to the BPL, EWS, LIG, MIG, and homeless citizens. The affordability ratios of some income groups is provided in Table 1. For example, EWS and LIG citizens spend more than 30 percent of their income as house rent or Equated Monthly Installments (EMI) for a new house; while the MIG citizens spend more than 40 percent of their income. The LIG citizens can afford to pay only a lesser proportion of their income for housing than the higher income groups. The income category and 'affordability' levels of some of these income groups are shown in Table 2.

## 1.3 Government of India's initiatives on housing shortage

Government of India has initiated several housing schemes in order to address the housing shortage. Some of the major schemes are shown in Table 3. The objectives of these schemes were/are to remove the existing impediments in the housing system and to create a condition, where economically backward citizens may gain secure and good

**Table 3. Indian government's Schemes on housing shortage**

| Schemes | Started from | Goal of the scheme |
|---|---|---|
| Indira Awas Yojana (IAY) | 1985 | To provide funding for the construction of housing to the citizens below poverty line living in rural areas. |
| National Housing & Habitat Policy in India (NHHPI) | 1998 | In housing and real estate sector,<br>• To involve multiple stake holders<br>• To Repeal Urban Land Ceiling Act<br>• To permit Foreign Direct Investment (FDI) |
| Jawaharlal Nehru National Urban Renewal Mission (JNNURM) | 2005 | To construct 1.5 million houses from 2005 to 2012. Two sub-missions namely Basic Services for the Urban Poor (BSUP) and Integrated Housing and Slum Development Programme (IHSDP) were initiated under this scheme for the development of LIG citizens. |
| National Urban Housing & Habitat Policy in India (NUHHPI) | 2007 | To encourage affordable housing to meet the housing shortage for all categories of the citizens. |
| Interest Subsidy Scheme for Housing the Urban Poor (ISSHUP) | 2008 | To enhance the affordability of the EWS and LIG citizens living in urban areas by providing interest subsidy on loans up to Rs. 1 lakh. |
| Housing For All by 2022 (MHUPA 2012) | 2012 | By the time the nation completes 75 years of its Independence, every family will have a *pucca* house with water connection, toilet facilities, 24x7 electricity supply and access |
| Rajiv Awas Yojana (RAY) | 2013 | To create a mortgage risk guarantee fund to EWS and LIG households. This was aimed at creating a 'Slum Free India' on "whole city approach". |

housing conditions. According to MHUPA, through the JNNURM scheme, about 14.41 lakh houses were approved in 947 cities; 8.31 lakh houses completed; 3.61 lakh houses are under progress [8]. MHUPA also reported that about 1.2 lakh houses were approved in 116 cities; 1154 houses (about 1% of approved) completed; 18281 houses (about 15% of approved) are under progress; no information is available on the remaining about 86% [8]. In addition to the above schemes, the Government of India has recently announced the ambitious scheme of "Housing For All by 2022". This scheme has divided the 'Urban Poor' citizens into 1) Slum dwellers, (2) non-slum dwellers (3) prospective migrants, and (4) homeless and destitutes; the scheme has developed different strategies to meet the needs of these groups. The four distinct components of this scheme are (1) Slum redevelopment, (2) Affordable housing through interest subvention, (3) Rental housing for migrants, and (4) housing for urban destitute and homeless.

## 1.4 Precast concrete construction – A possible answer to housing shortage

The total requirement of skilled and unskilled labour is 33 million per day for the Indian construction sector [12]. For the past few years, the industry is experiencing a scarcity of labour. Konka reported that the lack of skilled workers and other personnel in construction sites was identified to be the one of the most important causes for delays in various construction projects [13]. The shortage is expected to reach about 65% by next decade [14]. If the industry does not focus on mechanization and continues to depend heavily on labour on-site 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 planned, designed and implemented properly. If PCC is adopted without adequate planning and design and then implemented by inadequately skilled personnel, the benefits would not be fully realized and many would wrongly blame the PCC technology. Therefore, the challenge is in generating skilled engineers, designers, and workers in our country and then ensuring appropriate implementation of the PCC technology.

## 1.5 Status of precast concrete construction in various countries worldwide

PCC is a time-tested alternative, which has been successful in catering to huge housing demands worldwide, especially in Europe. Table 4 shows the status of PCC in various countries around the world. Thomas reported that PCC provides cost savings with excellent scheduling performance

**Table 4. Status of precast concrete construction (PCC) in various countries**

| Countries | Precast concrete construction scenario | Source |
|---|---|---|
| United States of America (USA) | 7.9% of total concrete construction is done using precasting in the USA. The major use of precasting is in parking structures contributing to 12.9% of the market. Structural precasting contributes to 90.1%. Moreover 30% of housing in US is prefabricated. | [20] [21] |
| United Kingdom (UK) | 26% of total concrete production is used in precasting. 45% of precast concrete is used in housing projects. Conventional masonry still remains a choice for housing (90%). Some incidences of failures lead to modification in BS codes for precast concrete construction. | [20] [21] |
| Russia | Stable economic conditions in former Soviet Union helped in the rise of precasting industry. Market share is about 30%. | [22] |
| Europe (Germany, Netherlands, Finland) | Many European countries have been using precast concrete systems for housing. Precast concrete contributes to 10% of housing in Germany and Netherlands. 24% of housing is constructed using precast concrete in former East Germany. 70% of the total concrete construction is used in precast concrete construction in Finland. 74% of this relates to structural precast concrete. | [21] [22] [23] |
| Singapore | Efforts by the Housing Development Board of Singapore have enabled the growth of precast concrete housing. Precast concrete systems have been used in Singapore for high rise housing for the past 30 years. | [23] |
| Malaysia | Housing requirements in the country forced the Ministry of Housing to adopt Industrialized Building Systems (IBS) | [23] |
| Turkey | 1% of the total concrete produced is used in precast construction. | [21] |

when compared to cast in-situ construction (CIC) methods [15]. In general, the quality of PCC can be better than the CIC construction. India is yet to realize the huge potential of PCC. According to Balakrishna, PCC contributes to only about 2% of the total market value of concrete construction in India; whereas the CIC construction contributes to the remaining 98% [16]. In short, abundant opportunities exist for adopting PCC, instead of CIC, in Indian construction projects, especially in the residential housing sector.

## 1.6 Issues faced in the implementation of PCC in housing sector

Table 5 provides the various challenges faced by different countries in the implementation of PCC to meet large scale housing demands. Following are some of the reasons why precast concrete construction is not popular in India.

- Socio-economic changes and government regulations are two important factors, which hindered the application of PCC in India [17]
- Contractors' preference for employing low-cost labour as against making huge capital investments on equipment and infrastructure for PCC [14]
- For small construction projects, CIC is preferred to PCC because the former is less expensive [18]
- Lack of proper roads and equipment for the transportation of large precast concrete sections from manufacturing plants to erection sites [19]

**Table 5. Challenges faced in implementation of PCC in Housing sector in various countries**

| Place of Research | Issues Faced | Source |
|---|---|---|
| USA | • Lack of stable demand for precast concrete construction<br>• Less level of standardisation<br>• Lack of expertise in design and manufacturing<br>• Higher costs due to transportation<br>• Limitation in sizes of elements due to transportations | [22] |
| USA | • Incompatibility of elements from various manufacturers<br>• Communication issues<br>• Inability to meet challenging projects due to limitations in transportation<br>• Cost of transportation | [24] |
| USA and Turkey | • Perception of bad performance of buildings<br>• Lack of expertise in design | [25] |
| Malaysia | • Requirement of huge investments and large financing in IBS; Higher costs<br>• Lack of involvement of small contractors,<br>• Issues like moisture penetration and leakage,<br>• Lack of expertise and exposure to implementation of IBS | [26] |
| Malaysia | • Heavy investment and lack of financing<br>• Higher costs<br>• Lack of expertise in design and execution<br>• Lack of flexibility in payment terms<br>• Logistics issues<br>• Negative perceptions of the performance in the past | [27] |
| Australia | • Retrospective addition of Off-Site Manufacturing (OSM) to projects<br>• Lack of expertise in design and higher design cost<br>• Transportation cost and carriage cost<br>• Lack of adequate skilled expertise<br>• Requirements for huge financing and stringent payment terms | [28] |
| Hong Kong | • Lack of in-house expertise,<br>• Limited access to site and transportation<br>• Resistance to change over conventional methods | [29] |
| India | • Lack of demand for mass/mega housing projects<br>• Higher cost and lack of expertise<br>• Taxation issue not being addressed<br>• Lack of standardization,<br>• Lack of quality roads for adequate transportation of large and heavy elements to the construction site | [30] |

In addition to these factors, the authors believe that the lack of adequate skilled engineers, design documents, guidelines, and standardization is also a significant factor hindering the growth of PCC in India.

## 2 CHALLENGES IN IMPLEMENTING PCC IN INDIA

In comparison to CIC, the PCC offers several advantages such as (1) cost savings, (2) time savings, (3) enhanced quality, and (4) enhanced safety [31]. However, the implementation of PCC in housing sector is facing several challenges. To understand the various factors hindering the implementation of PCC in the Indian residential sector, interviews were conducted with various stakeholders in PCC industry. In this study, interviews were conducted in-person at the respondents' offices or sites in Bangalore, Chennai, Coimbatore and Pune, India. Interviews were conducted among nine stakeholder segments: (1) developers, (2) architects, (3) designers, (4) precast element manufacturers, (5) connection manufacturers, (6) transportation agencies, (7) construction contractors/consultants, (8) academicians, and (9) government representatives. In total 25 persons were interviewed and all the interviewees had an experience of at least 10 years in their respective fields. Data on various factors hindering the growth of PCC in Indian housing sector were obtained during the interviews. Figure 3 shows the number of times the various factors were mentioned by the different stakeholders as hindering the growth of PCC in India. These numbers indicates the perception of various stakeholders on the factors hindering the growth of PCC in India.

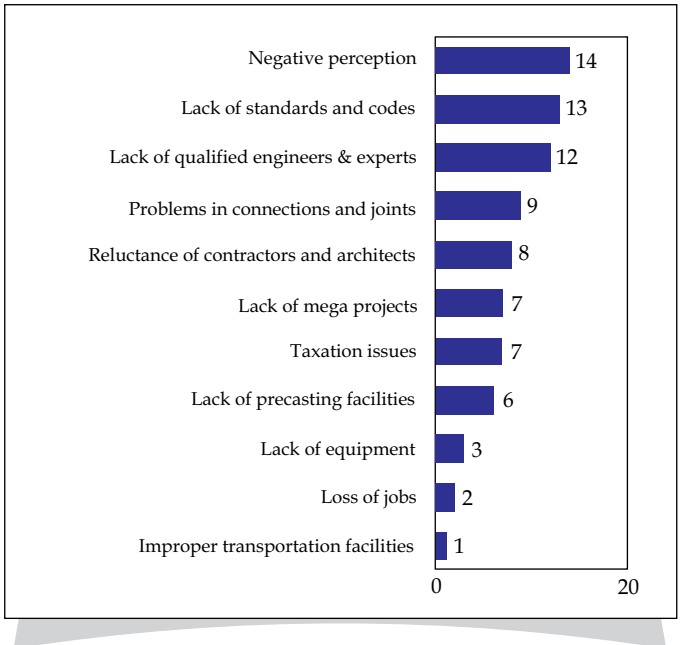



*Figure 3. The number of times the issues were mentioned during interviews, as factors hindering the growth of PCC in India (adapted from [32])*

All the stakeholders were aware of the problems faced by the industry. However, there was no consensus among them on critical issues. Developers stated that "negative perception" within the industry was a major issue in India, while the architects and designers mentioned that 'lack of qualified engineers and experts' in the design and architecture areas as a major reason for less development of PCC in India. Precast concrete manufacturers said that 'negative perception' and 'reluctance of architects' were the major issues. The personnel from construction majors had an opinion that the lack of appropriate standards and codes, lack of mega projects for precast concrete construction and lack of precasting facilities as major issues. The issues pertaining to the connections and joints in precast systems were the major concern of all academicians interviewed. Majority of the interviewees opined that the negative perception, taxation, and lack of proper standards are hindering the growth of PCC in India. Figure 4 shows the inter-relationship between various issues related to PCC in India. In the following sections, some of these issues are discussed in detail.

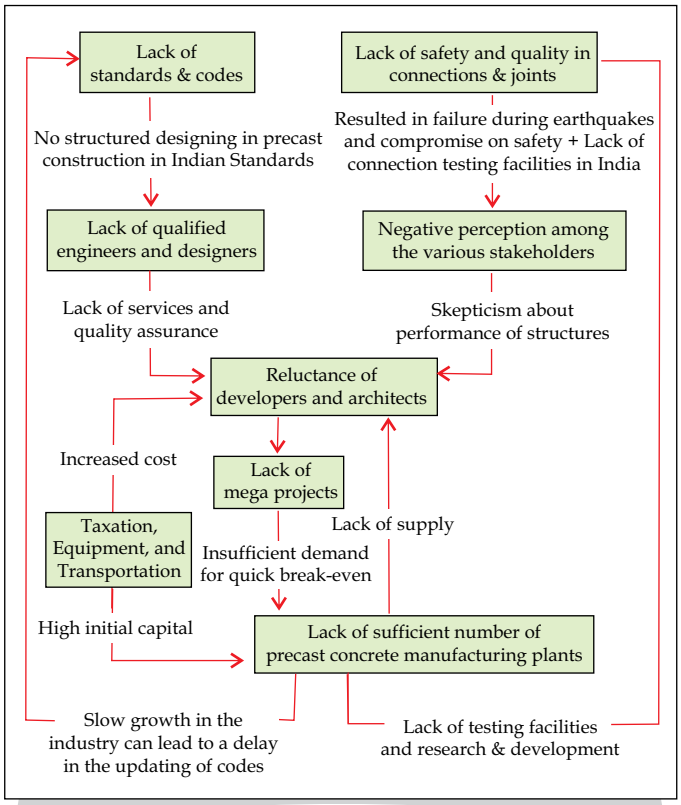



*Figure 4. Possible relations between various challenges related to PCC in India (adapted from Kumar [32])*

### 2.1 Negative perceptions

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

### 2.2 Lack of sufficient standards and codes

The lack of appropriate standards can lead to a lack of standard building systems, particularly purchase and testing of locally-manufactured fixtures for connections, etc. Hence, the cast-in fittings and connections for the PCC have to be imported. This leads to a significant increase in the cost of construction [23], [33]. Standardisation of products can reduce the delays and costs associated with PCC. Though more than 30 IS codes are available on precast concrete products and precast reinforced concrete products and construction, no details are available on the possibility of high rise construction by adopting PCC. Refer Table A1 and A2 in Appendix for the lists of some relevant IS codes.

### 2.3 Lack of government-supported mega projects

Lack of mega projects is an inhibitor to the growth of PCC sector [30]. PCC is economical for projects where large repetitions of elements are being carried out. If the government shows an increase in the interest to execute the mass housing projects with PCC technology, it can certainly catch the attention of many more developers.

### 2.4 Taxation issues

Khan studied various taxation issues associated with the PCC industry [34]. The taxes, duties, and cess charges range between 25 and 32 percent of the cost of precast elements [34]. The taxation also depends upon the classification of the stakeholders. Separate contracts attract more taxes than composite contracts as individual services increase. Transportation agencies are required to pay service taxes, if the turnover is more than INR 10 Lakhs. This significantly increases the cost of transportation of precast elements [34].

### 2.5 Joints and connections issues

Most of the PCC projects in India are reported to have severe water/moisture leakage/seepage issues through the exterior joints and connections. Also, the connection designs become difficult due to the lack of proper standards and lack of readily available standard connection fixtures. The IS codes and standards on PCC 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/seepage through joints and connections. In short, like in other countries, seepage can be avoided if properly engineered water-tight joints and connections are used and the site personnel are adequately trained on installation procedures.

### 2.6 Transportation issues

Lack of adequately-sized transportation vehicles and limited access to sites increases the cost of precast concrete construction. Generally in India, the access for a heavy vehicle (like precast concrete element transporting trailer) to a metro city is open only during night from 10 pm to 6 am. Hence, there is only a limited window of time available for material transportation. This results in requirements for higher coordination between stakeholders as materials or elements are not available whenever required. Design of elements is constrained by the capacity and dimensions of the trailer. Transportation charges account for about 9% of element cost, above the cost of manufacturing the element [34]. Also, the curvatures of many roads are generally so sharp that the transportation of large panels will be challenging and certainly would limit the size of the precast concrete elements. Therefore, the only option left is adopting captive manufacturing (on-site production of precast concrete elements) and that too depending upon the availability of land near the construction site.

## 3 PROMOTIONAL POLICIES ADOPTED IN DIFFERENT COUNTRIES

To rectify the various issues discussed above pertaining to PCC in India, the government needs to adopt various promotional policies. This section describes some of the promotional policies adopted by Singapore, Malaysia, and the United Kingdom (UK). Then, some suggestions on policies to promote PCC in India are provided.

### 3.1 Singapore

Some of the steps implemented for the promotion of PCC were:

- **Major standardization efforts for prefabrication**: A lot of standards and codes have been produced in Singapore to promote prefabrication. These codes and standards have covered significantly all areas in the precasting process. Some of these documents published by the Building and Construction Authority (BCA) of Singapore are: (i) Structural Precast Concrete Handbook, (ii) Modular Coordination Guide, (iii) Guide to Precast Concrete and Prefabricated Reinforcement for Buildings, (iv) PREFAB Architecture, (v) Reference Guide on Standard Prefabricated Building Components and (vi) Precast Concrete Elements (Handbook)
- **Development of skills among workers:** BCA has started a number of training programs to educate and provide hands-on experience to the persons working in precasting technology.
- **Developing Building & Construction Authority (BCA):** The primary role of BCA is to develop and regulate Singapore's building and construction industry. BCA champions the development of an excellent built environment for Singapore. Its mission is to shape a safe, high quality, sustainable and friendly built environment.
- **Developing buildable design appraisal system:** Its primary role is to provide ratings to buildings based on design, construction methodology, and construction complexity. It provides higher ratings for PCC than CIC. It is not specifically aimed at promoting precasting but higher weightage is given to precasting if enough repetition is there and if it reduces the complexity of project execution.

### 3.2 Malaysia

A few of the important policies implemented by Malaysia are:

- In 2004, the government announced that all new government-initiated building projects were required to have at least 50% Industrialized Building System (IBS) content, calculated by using the IBS Score Manual developed by Construction Industry Development Board (CIDB)
- A newer treasury circular, 'Surat Pekeliling Perbendaharaan Bil 7 Tahun 2008', dated October 2008 had emphasized the full utilization of IBS in government projects [35]
- In the Malaysian budget (2005), the government had pledged to construct 100,000 units of affordable houses using the IBS concept [35]
- Through the Constitution Article 520, the government had imposed a construction levy of 0.125% of the total project cost, which was collected through CIDB. The government has exempted this levy for contractors who incorporate IBS in at least 50% of building components, commencing January 1, 2007 [35]

Malaysia has only recently started promoting the PCC practices. Therefore, sufficient data is not available to conclude the impacts on housing. However, as of February 2009, a total of 320 government projects worth USD 2.92 Billion (RM 9.43 Billion) were carried out using IBS. The CIDB had allocated USD 31 Million (RM 100 Million) to train domestic skilled and unskilled workers, targeted on IBS-related construction and other specialist trades [35].

### 3.3 Finland

Some of the steps implemented in Finland to promote precast concrete construction were:

- Adoption of international 3M dimensioning system: This was adopted to increase the quality and precision in PCC.
- Research and development of open element systems based on agreed principles: Open element system is defined as a method of prefabrication, where several manufacturers can deliver elements of same type as long as elements are compatible with all other building components [20].
- Development of standards and codes: Standards and codes were developed for various product designs. The Central Organization of Finnish Concrete Industry (SBK) published the Precast Concrete Element Standards in 1970 that regulated the manufacture of precast concrete elements. Currently, there are over 300 codes on concrete, which include design standards, product standards, testing standards and implementation of standards.
- Approval and Standards in Products: Product Approval Act has been based on the European Union (EU) Construction Products Directive Principle. The primary authorization procedure is CE (Conformité Européenne) marking. European Union standards are prepared by CEN (European Committee for Standardization). Almost all precast concrete products in Finland are European standard products. Each European standard product should have a CE mark.

### 3.4 United Kingdom (UK)

In 2013, Construction Industry Council of UK recommended the following measures to promote PCC in UK.

- Establishment of regulatory bodies centrally for providing standards and regulations to housing construction sector.
- Stable and predictable framework for regulations and standards should be framed.
- Release of 'Oven Ready' plots from the Government and local authority land-banks for mass housing projects. 'Oven Ready' plot refers to land that is purchased outright, typically with outline planning permission already granted.
- Introduction of tax deductions and other incentives designed to encourage the development of new products and the establishment of new manufacturing/ assembly facilities.
- Establishing an Institute for future housing research to increase the awareness and support the training and integration of Building Information Modelling (BIM) across all segments of the market, providing support and encouragement.

Table 6 shows the comparative analysis of the need for PCC and the promotional measures to improve PCC in various countries. It clearly suggests that India is lacking in most of the aspects and needs a push regarding the promotion of PCC.

**Table 6. Comparative analysis of the need and promotional guidelines for PCC**

| Issues/ Challenges/ Promotional measures | | India | Singapore | Malaysia | Finland | United Kingdom |
|---|---|---|---|---|---|---|
| Need to shift to PCC | a) Demand for housing | Very high | High | High | High | High |
| | b) Improving productivity & site working conditions | Not focused | Highly focused | Focused | Highly focused | Focused |
| | c) Promote sustainability (Green building) | Negligible | Yes | Yes | No | No |
| Promotional Guidelines | a) Research to examine barriers to the growth of PCC | Some research | Significant research | Significant research | Some research | Significant research |
| | b) Formation of construction regulatory authority | No | Yes (BCA) | Yes (CIDB) | Ministry of environment | Ministry of housing and local Govt. |
| | c) Utilisation of IBS in government buildings | No | Yes (≈70 %) | Yes (≈50 %) | Yes | Recommended |
| | d) Association of precasting industry members | Yes (PESSI) | Yes | Yes | Yes | Yes |
| | e) Scoring or rating of buildings | No | Yes | Yes | No | No |
| | f) Certification programs | No | Yes | Yes | Yes | Recommended |
| | g) Design codes and standardisation of elements | No | Yes | Yes | Yes | Yes |
| | h) Precast element handbook/ manual | Under preparation | Yes | Yes | Yes | Inconclusive |
| | i) Taxation reliefs | Negative | Inconclusive | Yes | No | Recommended |
| | j) Students education/ scholarship/certificate | No | Yes | Yes | Inconclusive | No |

## 4 MEASURES TO PROMOTE THE GROWTH OF PCC IN INDIA

Five major measures to promote the PCC in India are suggested in this section.

### 4.1 Investment in research and development

There is a growing need for research and development in the area of connections and joints for precast concrete systems for India. In the present scenario, many precasting firms are using connection systems, which are expensive and certified by foreign institutions and not by Indian authorities or testing facilities- increasing the cost. Also, the manufacturers are not willing to test and certify in India as Indian clients want an equivalent monolithic connection, which is very stringent. Some of these stringent measures are being practised based on the engineers' experience-based perceptions and due to the lack of sufficient design guidelines. There is a need to tie up the practicing industry and research institutions to provide safe, sound, and less expensive connection systems for Indian scenario.

### 4.2 Standardization of precast concrete elements

Indian construction industry and the public lack the confidence in precast concrete systems for the desired structural performance and quality as they have for structural steel products. Although precast concrete elements are manufactured products just as structural steel products, they do not enjoy more trust than steel products. This is because steel products are already standardised and are certified. Various steel products come in different lengths and dimensions and there is a positive perception within the industry. Credit for this goes to the IS standards that have facilitated the testing and certification processes for steel products. On similar lines, there is a need to standardise precast concrete elements. Certification of precast concrete elements requires good testing facilities, which are limited in India. Some of them are available in the institutes of national importance. Until suitable codes are developed and put in practice by Bureau of Indian Standards (BIS), these testing facilities should certify the products.

### 4.3 Increasing the number of qualified engineers and designers

There is a need to increase the number of qualified designers and engineers for PCC in India. Various institutions can offer courses on 'Precast Concrete Design and Construction' in undergraduate and graduate levels. Some institutions are willing to introduce the courses; but, it will take time to create a full-fledged academic curriculum. It is possible to provide a structured course with an industrial tie-up. Another option is to offer short courses or workshops on PCC, which can be attended by the practicing engineers/ designers/architects. Also, providing scholarships for these courses, which would help students to go an extra mile in this field. Architects should be trained to use PCC and use ingenuity to introduce variety in design even with standard and modular elements.

### 4.4 Incentives for adopting PCC

Government of India is planning to provide incentives to the customers by decreasing the Stamp Duty of current 7 percent to a nominal value for precast concrete housing projects for LIG and EWS groups. This would help in increasing the demand for precast concrete products. More such schemes can be implemented by the central and state governments. Another parallel incentive that can be implemented is the relaxation in the Excise Duty for PCC. Thus, both demand and supply would be incentivised.

### 4.5 Creation of land inventory

There is a need to create a land inventory for states and cities, which can be used as Special Residential Zones. These residential zones, if constructed with precasting technologies, should provide on-site manufacturing base for precast concrete projects. Government should also plan to reduce the time taken for the approval of large precast concrete housing projects. Reduction in the approval time, monetary benefits, and other incentives would give the market an incentive to go for PCC.

## 5 SUMMARY AND CONCLUSIONS

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. This study identified various factors hindering the growth of PCC industry in India. It was found that various stakeholders have different opinions and there exist no consensus among them on the factors hindering the growth of PCC in India. However, the major factors seems to be the negative perception on the PCC technology, lack of qualified engineers and experts, reluctance of architects in adopting PCC, inappropriate taxation measures, lack of standards and codes, lack of mega projects for PCC, and lack

of precasting facilities. The paper also provides an overview of various promotional measures adopted to improve PCC in other countries. A survey of various schemes adopted in India revealed that although India is implementing many schemes to meet the housing demands, the housing shortage is still very significant – making it necessary to implement PCC for all such projects. Finally, a set of measures, in five key areas, is suggested to promote the growth of PCC to reduce the housing shortage in India.

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