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Critical Review of Government Interventions on the application of Precast Construction Technology in the Housing Projects

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Abstract - There is an unparallel demand for housing in most of the countries due to rapid urbanization and a rise in population across the globe. Government agencies are playing a pivotal role in striking the balance between supply and demand through various policy interventions. Despite several initiatives and reforms, the supply and demand mismatch has not narrowed significantly. One of the key factors identified for the slow delivery of housing projects is the use of conventional technology for construction.

In the 1980s & 1990s, countries like Malaysia, Singapore, Hong Kong, China, and Dubai, among others, recognized the need for a paradigm shift from conventional to precast or industrialized construction systems and established various long-term plans/road maps for the implementation of this technology in the housing sector. With decades of strategic planning and a committed approach, many of these countries have showcased successful implementation of housing projects using this technology. India is also looking forward to spreading the application of precast and other offsite construction technologies for housing projects through various government schemes. The paper reviews the influence of these government interventions and incentives on the adoption of precast technology in the housing segment through a systematic literature review.

Keywords - Precast Construction Technology, Government Interventions, Schemes, Incentives, Housing Projects, Best Practices.

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INTRODUCTION

The rapid rise in the demand for housing coupled with the slow project delivery mechanism is unable to bridge the gap between the supply and demand across the globe. Consequently, supply backlogs are increasing and adding pressure on the government agencies to meet the required demand. A major roadblock is encountered by the government agencies in the realization of their plans & policies- the barrier of extremely slow construction and the massive rise in the cost of construction. It is recognized that conventional construction technology is one of the primary reasons for the imbalance in the execution of most of the real estate projects in the residential sector of India. As per (Nanyam et al., 2017), a huge housing shortage cannot be supplied only through the use of conventional construction technologies. Studies from countries like Singapore, Malaysia, South Africa, Dubai, and China among others also indicate an immediate need to shift to more dependable, faster, and sustainable construction technologies to suffice the growing demand (Rahman PEng et al., 2018), (Yunus & Yang, 2011), (Aigbavboa et al., 2017), (Elkaftangui & Basem, 2018), (Pan et al., 2018).

As per (O'Neill & Organ, 2016), after World War I, European countries started the use of precast components for house construction. These countries were exporting and importing these components from each other. In the UK, the alternate construction technology was christened 'Non-Traditional housing' and Building Research Establishment (Ross, 2002). In Britain, the government gave huge subsidies for the prefabrication technologies till the late 1940s. The dominance of North America and European countries was seen in the prefabrication construction

technology since the industrial revolution; government incentives and promotional activities strengthen the use of non-traditional or industrialized building systems in these countries. However, these countries also repeatedly faced the opposition from various stakeholders for instance Britain faced huge opposition from the various professionals for the use of prefabrication over traditional technology due to apprehensions like loss of job, structure safety, increased cost, skilled labour requirement, uncertain future among others (Shen et al., 2019), (Hamzeh et al., 2017), (O'Neill & Organ, 2016), (Ross, 2002).

MATERIAL AND METHODS

As the study aims to comprehend the Indian context, Singapore and Malaysia are identified as case studies for understanding the impact of government policies in promoting the prefabrication in construction, especially in housing. Three primary reasons behind the chosen countries are – 1) Both the countries are in Asia and hence the ecosystem is similar 2) both the countries are working on the promotion of prefabrication for the last 60 years and laid many long-term policy interventions, 3) Singapore is a developed country whereas Malaysia is trying to be in the league of developed countries with the help of construction advancements among others. The policy is a tool through which Government or the policymakers practice their authority to fulfill the objectives (Colebatch, 2018) of any program for the welfare of the society. To perform a Systematic Literature review, Papers from three databases -Web of Science, Scopus, and Google Scholar were considered. Total papers were more than 400, which were filtered after removing duplicates and not related to the subject. A total of 119 papers were considered; 29 papers were exclusively on countries, 56 papers were on barriers, and opportunities and 9 papers were on policies. Rest was on time, cost, quality, design, etc. Government interventions to promote the adoption of prefabrication construction technologies amongst the various stakeholders can be in various forms, details of a few of them are given in Table 1 below-

Table 1: Categories of Government Interventions

Intervention categories	Type	Description & Remarks	Source
Mandatory/ Directive/ Regulatory Policies	MP	Legal and compulsory in the form of mandates given by the government.	(G. Wu et al., 2019), (Luo et al., 2021)
Standardization/ Modularization/Technology R&D and transformations	SM/ R&D	Standardized and modular cost-effective solutions, design and manufacturing standards, technological innovation	(Din et al., 2012), (Elkaftangui & Basem, 2018), (G. Wu et al., 2019)
Guidance and Awareness	GA	Awareness Programmes, Credit-based courses, skill up-gradation programs, research, and publications	(Din et al., 2012), (Y. Gao & Tian, 2020), (Z. Wu et al., 2021),
Supportive Policies	SP	Directive is the same as mandatory policies. Supportive refers to various forms from economic to assistance.	(Y. Gao & Tian, 2020)
Incentives- Economic & Non-Economic	IE/INE	Covers all the formats from subsidies/ tax benefits, and penalties to assistance, transportation, guidance, sanction process, and contract process among others.	(Z. Wu et al., 2021)

INTERVENTIONS TO PROMOTE PREFABRICATION IN CONSTRUCTION

Developing countries initiated several reform-based incentive policies/schemes to give impetus to the application of offsite construction technologies. Precast construction technology (PCT) is considered one of the most suitable technologies that meet the requirements of the housing sector. (Zhou et al., 2019).

SINGAPORE- In Singapore, the Government agency, Housing Development Board, is the main supplier of housing in the country. Construction Industry Development Board (CIDB) later Building and Construction Authority (BCA) is the custodian body managing the construction activities/ policies in Singapore (S. Gao et al., 2018). The government initiated the prefabrication in 1963 & then in 1972 but was not successful as local contractors were not able to manage it and foreign contractors were not able to adapt to the local conditions (Park et al., 2011). Singapore launched three major road maps - First Construction Productivity Roadmap to increase the construction productivity and standardization of components in the year 2011, the Second Construction Productivity Roadmap to increase DfMA (design for manufacturing assembly) in 2015, and Research and Development Road map wherein 35 technologies were identified in the year 2016 (Release, 2016).

Increased housing demand for housing and heavy reliance on foreign workers/laborers made it an absolute necessity to employ the industrialized building components for the housing projects. HDB tried to revamp the use of prefab technologies for the buildings in the year 1981. It's initiative in the form of interest-free loans to the contractors employing prefabrication in their projects. It also purchased prefabrication manufacturing units. Also, negative construction productivity growth enabled HDB to reinforce the use of prefabrication in the private sector. It introduced Buildability Score Regulations in the year 2001 or Buildable Design Score (Park et al., 2011), this score also encouraged the use of prefabricated toilets, PPV units, and other such repetitive components. The majority of the Landbank in the country is with Government and private developers purchase it through a bidding process. Any project on these lands is known as Project on Government Land Sales (GLS) sites. As per (BCA, 2017), (Release, 2016), the adoption of DfMA was made compulsory for projects on these sites in the year 2014. Incentives in terms of interest-free loans, and relaxation of the gross floor area. Prefabricated Prefinished Volumetric Construction (PPVC) has become very popular in Singapore because of the modularity, significant reduction in time, government incentives, and assistance (Xu et al., 2020).

MALAYSIA The government of Malaysia is encouraging the use of Industrialized Building System (IBS) construction technology through

various government interventions like the inclusion of this technology in the 5-year plan of Malaysia through various budget announcements. Industrialized Building System (IBS) is used in the country to cover all the prefabrication technologies and automation processes. In one of the very important announcements in budget 2004, a road map for the use of IBS technology in government projects was introduced wherein a minimum of 50% IBS components were required in these projects. As per the construction industry Development Board (CIDB), the Malaysia IBS core manual was developed to calculate IBS components in any building. (DBS Group Research, 2017) (Ismail et al., 2012). A detailed study of the Malaysian context is undertaken to enable a stronger interpretation in Table 2.

Table 2: Malaysian Government Interventions and their impact on promoting prefabrication/ IBS

Type	Incentives/Initiatives/Policy Intervention	Impact
SI	Proactive Initiative of Malaysian Government- In 1964, the government introduced a pilot housing project of 17 floors and 3000+ units to encourage this technology. (Din et al., 2012)	Early Introduction of the technology. No support from other stakeholders.
SI	Partnership with other countries - The government launched its project with the British agency for the low-cost housing, BRECAST.	Contractors raised concern about the use of IBS in Malaysian climate and transportation. The government received very little positive response.
SI	In 1994, Construction Industry Development Board (CIDB), a custodian for the construction sector was constituted. After 1994 use of hybrid IBS technology was predominantly seen in large projects like Kuala Lumpur convention centre, Kuala Lumpur International Airport, and Petronas towers among others (Din et al., 2012), (Powell, 2016).	Promotion activities and publications spread the knowledge. Improved image for IBS in the country and to the world as well due to these reputed projects.
GA	In 1997, Akademi Binaan Malaysia (Malaysian Construction Academy-ABM) was established.	Training programmes, career guidance initiatives, and accreditation programmes widespread the awareness of IBS in the country.
SI	1999- first IBS Strategic Plan was announced to promote IBS in the country.	Till 2003 as per a survey by Govt, the share of IBS in country's construction was 15%. (Act et al., 2021)
SI	1st IBS Roadmap (2003- 2010)	
GA/ MP	2004/5- IBS Score Manual developed by CIDB(CIDB, 2018)	Manual of IBS score calculation was given by CIDB. Mandatory employment of 50% of IBS in government buildings
GA/SI	Construction Industry Master Plan (CIMP) 2006 – 2015, Construction Research Institute of Malaysia (CREAM 2004), National Construction Cost Centre (N3C), Quality Assessment System in Construction (QLASSIC), Labs among others	Improvement in quality of construction Increased adoption of IBS R&D setup enabled cost-effective and quality-oriented construction techniques
SI	In 2005's budget, the government promised to construct 100,000 affordable housing units in IBS	
MR	2008's Mandate – Minimum 70% of IBS content to be used in government projects costing more than RM10 million. (Earlier it was 50%)	The impetus to IBS in government large-scale projects.
SI	As per the mid review of IBS adoption, only 10% of the completed projects used IBS in 2006; however, the target was 50%. 2nd IBS roadmap (2011-2015)	IBS employed projects worth RM10 billion were completed by the year 2010 (Powell, 2016) with 331 projects being constructed/ awarded in IBS. Cost was the major concern with IBS; however, mandatory use of IBS resulted in a significant reduction in the cost of construction employing this technology.
IE	As per (Powell, 2016), Tax incentives were given to the firms using IBS in their projects.	
MP	Dependency on the foreign labours/ work force remained a concern for Malaysia since the early 90s. The local workforce accounts for only 10%; to decrease this dependency IBS duty levied on foreign workers in construction and manufacturing was doubled to RM2,500.	An increase in the cost of hiring foreign workers encouraged the use of IBS. The government aims to limit the foreign workers up to 15%.
MP	Penalties were imposed on the abandoned projects when the developer delayed/stalled continuously for six months beyond the completion date as per the legal agreement.	Many projects were delayed due to the use of conventional construction technology. A very little shift was witnessed towards IBS despite fines.
IE	2016's budget sought to provide RM500 million in loans to developers and contractors for using IBS.	IBS employment is still not as per the expected estimate. Estimation of 42% of public projects and 70% of private projects. (Powell, 2016)
IE	As per (Act et al., 2021), IBS manufacturing companies were eligible for tax exemption for up to 100% of their income for five years.	The impetus to green initiatives
MP	In 2017, it was made mandatory for all the construction projects (public and private) worth RM50 million or more to use IBS methods with a minimum IBS score of 50(Act et al., 2021).	Due to Covid 19 fewer projects of this scale were launched.

INDIA- In India, prefabrication was introduced as early as 1948 with the establishment of Hindustan Prefab Limited (HPL) to facilitate and execute prefabrication projects. In 1952, HPL constructed Delhi Development Authority's (DDA) flats with the prefab components. In 1964-65, a 100% prefabricated four-floor building at Vikas Bhawan was constructed in Delhi. A decade later in 1973, 27 storeyed prefabricated high-rise housing building at Petit Hall Mumbai was constructed by a private developer. Excluding the three lower floors, the rest 24 floors were 100% prefabricated with a large panel system. In 1972, BG Shirke Group introduced 3S technology (Safetly, Strength & Speed) to resolve the problem of Mass Housing and has approximately delivered 2 million housing in five decades. However, the use of precast was very limited and there was only a handful of building projects across the country despite successful implementation. There were barriers like lack of expertise, a limited number of manufacturing units, increased cost, heavy reliance on skilled labors and high-end machinery among others that impeded the use of precast in buildings. Use of precast increased in infrastructure projects since the 90s.

In 2011-12, DDA announced the construction of 50,000 houses for EWS & LIG with precast technology; this gave the desired impetus to the precast industry. Private developers in South and West parts of the country started employing precast in various projects ranging from housing, hospitality, commercial to industrial. With the liberalization in the foreign policies, overseas companies started supplying equipment for the manufacturing of precast components. Companies from Finland, Spain, Germany, Netherlands, Italy, and New Zealand among others were the major players.

The Indian government acknowledged the immediate need to use innovative construction technologies in the housing sector to achieve the Housing for All goal as per PMAY (U). As a part of this, "the Government of India emphasized the need to accelerate the adoption of new construction technologies to fast track and improve quality of construction under the PMAY (U)–Housing For All Mission (PMAY_HFAU)". MoHUA successfully conducted a Global Housing Technology Challenge - India (GHTC- India) to identify the innovative housing technologies from across the globe which are cost-effective, speedier, sustainable, and disaster-resilient and ensure a higher quality of construction of houses, meeting diverse geo-climatic conditions and desired functional needs. (*BMTPC Handbook*, 2020).

A set of 54 new/advanced proven and innovative technologies were identified under GHTC-India through Building Materials and Technology Promotion Council (BMTPC). To give impetus to these technologies, the Government of India through BMTPC initiated the construction of Demonstration Housing in the name of Light House Projects (LHPs) to showcase the field application of these technologies. These LHPs are acting as live laboratories for stakeholders involved in the housing projects to see and learn the execution of these technologies on site. Also, under this vertical, the government is trying to develop and nurture future technologies through "Affordable Sustainable Housing Accelerator (ASHA) – India". Under the PMAY-HFAU, it is estimated that 11.2 million houses will be constructed by 2022 in the 75th year of independence. Out of aboutmillion houses that have been constructed/under construction to date; around 1.5 million are using these new innovative technologies. (*BMTPC Handbook*, 2020).

To promote this technology many government agencies like BMTPC, National Buildings Construction Corporation Ltd. (NBCC), Central Public Works Department (CPWD), National Building Code (NBC), and Bureau of Indian Standards (BIS) among others have included it in their codes or demonstrated housing project using it. NBC 2016 has also added a separate section (7A under Part 6) providing recommendations on the sizes, design considerations, erection, transportation, and usage of prefabricated concrete elements in synchronization with the recommendations for mass housing given by BMTPC (*NBC 2016*, 2016). All these policy frameworks, schemes, and incentives show the efforts of the government of India in making PCT a widespread technology for housing projects; but the application is still very limited.

Few significant government projects include DDA housing Project (Delhi), BDA Housing project (Bangalore), CIDCO mass housing project (Navi Mumbai), SRA slum re-development (Mumbai) etc. Tata Peenya (Bangalore), Commune-1(Bangalore), Lakeside (Chennai), IT SEZ (Hyderabad), MLCP (Mumbai), OP Jindal University, Novotel Ibis Como Hotel (Chennai), Supertech Eco Village (G. Noida), Amrapali Dream Valley (G. NOIDA), EWS Central Park (Gurugram) etc are few of the known precast projects of the country. However, the number of projects in precast is still less than approx. 1% of the total building projects.

RESULTS AND DISCUSSIONS

In Malaysia, prefabrication practices are primarily adopted by the government sector while the private sector is lagging despite a series of government interventions. However, Singapore has made many advancements in employing this technology due to the land crunch and huge demand for housing in the country coupled with incentive measures and mandatory regulations. It is also identified that in China despite a series of governmental initiatives, prefabrication technology has not received the desired acceptance due to reasons like cost, skilled labors availability, manufacturing units availability, transportation, restrictive design, safety, apprehensions of job loss, installation, machinery, huge investment, structure safety among others.

Table 3 : Comparative summary of measures/promotional activities/ regulations for IBS/ Precast/ Prefab in three countries

DETAILS/ MEASURES	SINGAPORE	MALAYSIA	INDIA	GAPS IN CONTEXT TO INDIA
Economic Incentives	Yes	Yes	No	No Economic Incentives are the main force to attract private agencies
Tax Exemptions	Yes	Yes	No	No rebates; private agencies are not opting due to high capital cost
Mandatory use in Govt. projects	DfMA/PPVC on GLS sites	70%	No	Countries were able to increase the technological use in the Govt. projects. India is lagging due to the unavailability of such mandatory policies.
Mandatory use of IBS - Private projects	DfMA/PPVC on GLS sites	No	No	Singapore's mandate for private developers on Govt. lands substantially increased the use of PPVC.
Inclusion in Codes	Yes	Yes	Partly Yes (NBC 2016)	With the inclusion in codes, many developers in India have also found the echnology more reliable.
Standardization Codes	Yes	Yes	No	Cost benefits can be achieved through standardization; India doesn't have any.
Rating/Scoring System	Yes (Buildability Score)	Yes (IBS Score)	No	Rating systems gave a huge impetus to this technology in Singapore and Malaysia. This is required to be incorporated in India as well on the lines similar to Green Building Rating Systems.
Identified Emerging Technologies	35	12	54	India has done significantly appreciable work in this area but it took decades in doing the same.
Demonstration Projects by Govt.	Pilot Projects (1980-90)	Pilot Projects in 1964	6 light house projects (2019)	India is the first country which is constructing large-scale housing projects in various parts of the country through demonstration projects. It is allowing architects, and engineers to become a "Technogrihi" and learn through liveapplication.
Educational Programs	Many	Many	Only few	For the last two years, BMTPC is organizing several workshops, certificationprograms and webinars to share the knowledge.

DfMA- design for manufacturing assembly, PPVC- Prefabricated Prefinished Volumetric Construction, GLS- Government Land Sales, GHTC- Global Housing Technology Challenge (detailed comparative table 3 as appendix-1)

In the Indian context, there is an unavailability of comprehensive data showcasing a number of precast projects in the country is one major gap identified. A need is visible for an agency to maintain the record of such projects along with the details of all the manufacturing companies. This data will help in statistically comprehending the employment of the technology and will also help in mapping the government plans and actual progression at the grass-root level.

Singapore's policy to promote prefab is significantly effective; however, considering the huge housing demand, a need is established to focus on the barriers like manufacturing units, lower taxes on transportation, economic incentives to reduce the cost, and interest rates on loans among others. Also, a government agency can be made responsible to regulate, promote and assist the precast projects. As each building project is required to be sanctioned by the competent authority; likewise there is an urgent need for a custodian body that can register prefab projects. Government should provide some scoring system concerning the percentage of precast employed in the projects like the buildability score in Singapore. This score should get benefits/tax rebates/ reduced taxes in the transportation of the precast components.

To summarize, India is paving its path effectively in the use of prefabrication technology through awareness programmes and live project to demonstrate the technology. Through various interventions, it is observed that mandatory regulations helped in increasing the adoption rate for this technology but are not able to clear the apprehensions associated with prefabrication. Thus, continuous training/skill development/awareness programs reinforce the need and benefits of the technology in any ecosystem. Economic incentives like tax rebates, interest-free loans, relaxation in GFA etc help in encouraging the use of technology provided the required manufacturing, transportation, and other support is available.

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