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ALTERNATE CONSTRUCTION TECHNOLOGIES FOR MASS HOUSING: CHALLENGES TO ADOPTION IN INDIA

Ayush Khare, Debarpita Roy, Triveni Prasad Nanda

Key Highlights

- Alternate technologies compared to conventional in-situ construction have the potential to improve speed and quality of construction and reduce environmental impact. In the current Indian scenario, they are relevant for large scale mass housing projects or multiple small scale housing projects in close vicinity.
- The technologies require high initial investment for set up and a project of large scale to remain financially viable. Government can intervene in the initial years of the technologies' uptake to improve financial viability.
- Construction firms will need to reorient planning and design and manage a skill transition to adopt alternate technologies.
- Home-buyers are sceptical of purchasing houses built with alternate technologies and more research and communication efforts are needed to convince them.
- Significant ambiguities remain surrounding the technologies in post-occupancy experience, lifecycle cost estimates, overall carbon footprint, etc. Participative exercises in technology assessment are needed to answer these questions and improve uptake of the technologies.

EXECUTIVE SUMMARY

BACKGROUND

Urban India suffers from a massive shortage of adequate housing. The demand for adequate and affordable housing is expected to grow further in the decades to come as India urbanises rapidly. Mass housing projects will gain importance to supply housing to the lower- and middle-income segments in Indian cities. This paper discusses the scope for alternate construction technologies to build mass housing.

The conventional process of constructing mass housing is time-consuming, produces large quantities of construction waste, and is of poor quality and durability. Alternate construction technologies offer an improvement over conventional construction by mechanising parts of the construction process. Alternate construction technologies can be classified under four broad categories – alternate formwork systems, prefabricated sandwich panel systems, steel structural systems, and precast concrete construction. Most often, alternate construction technologies take a part of the construction process to a factory location where the building components are manufactured at a rapid pace in a controlled environment. This reduces construction time, improves construction quality, reduces water consumption and optimises resource utilisation.

There has been a decisive effort by the Government of India to build the case for alternate technologies in the residential construction industry over the last few years. The Global Housing Technology Challenge (GHTC) programme was launched under the Technology Sub-mission of Pradhan Mantri Awas Yojana – Urban (2015) in 2019. A key initiative of the GHTC programme is the launch of six 'Lighthouse Projects'[1] to build residential complexes of about 1,000 low-cost houses each using alternate construction technologies in six cities – Agartala, Chennai, Indore, Lucknow, Rajkot and Ranchi. The projects are meant to create awareness, encourage evaluation and documentation, and help mainstream the use of these technologies. The Government of India has also been organising expositions, setting up start-up

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accelerators, and providing grants to increase the adoption of alternate construction technologies.

CHALLENGES TO ADOPTION IN INDIA

The central government's push to expedite the adoption of alternate construction technologies for mass housing is forward-looking but the transition from conventional to technology-intensive construction processes may not be smooth. Based on semi-structured interviews with 40 experts and practitioners and a literature review, we find six major challenges that have prevented the diffusion of alternate construction technologies in the residential construction industry.

High initial investment

Initial investment required for the use of alternate construction technologies is high. It includes the costs involved in the purchase of factory land, machinery, storage infrastructure, transportation vehicles, and other pre-production costs. For construction technologies such as engineered formworks that may not require a factory set up, the capital cost of purchasing the formworks is high. Factory land can constitute as much as 40 per cent of the total initial investment of setting up a factory. Machinery used in the factory usually has to be imported, adding to the cost. In the industry's initial years of development, government may provide some financial incentives to make the initial factory investment more viable for private sector construction firms.

Achieving optimal scale required for commercial viability

The scale of housing units at which the use of alternate construction technologies becomes financially viable and comparable in cost to conventional construction is rather large. For monolithic concrete construction systems using engineered formwork, at least 500 housing units may be required and, for precast, the required scale may be as high as 5000 housing units. The high scale requirement of using alternate construction technologies implies that they are relevant only for large-scale mass housing projects. One way to fulfil the high scale requirement for factory-based construction technologies is for the factory to supply to multiple mass housing projects in its vicinity. Alternatively, a model for factory planning is to have several geographically dispersed sub-contracted factories that are called into production when there is excess demand.

Reorientation of planning and design

Alternate construction technologies require a significant shift in the approach to planning and design compared to that used in conventional construction. A construction intent is devised that documents the plan for manufacture, delivery and installation of building components. Enhanced co-ordination is necessary with all stakeholders of the supply chain. Since the building components have to be stored, transported and assembled at the construction site, the principles of design for manufacture and assembly (DFMA) must be applied. Unlike conventional in-situ construction, late modifications in design are difficult to accommodate and can be prohibitively expensive. Building information modelling (BIM), in particular, complements the use of alternate construction technologies by optimising the sequence of construction processes, improving material yields, simulating the assembly of building components, and reducing the risk of accidents. While conventional construction requires supplies restricted to the current project, alternate construction processes require a continuous and long-term supply of raw materials at the factory. Alternate construction technologies need standardisation so machines may be able to produce set lengths, widths and assemblies. Standardisation ultimately improves compatibility and interchangeability of products and efficiency of processes. Optimal standardisation in the use of alternate construction processes can help unlock economies of scale in the mass housing industry.

Transportation of building components

Factory-based technologies involve the additional step of transporting building components from the factory to the construction site. For technologies such as stay-in-place formworks and steel structural systems, whose size and weight are low, transportation is relatively cheap but for precast slabs and modules, the size and weight, and consequently, the transportation costs are high. The distance between the factory and the construction site is another key factor that determines the costs and ease of transportation. The quality and density of India's road network is adequate and minimal handling losses occur due to bad roads although the last few miles leading to the project location may be of poor quality.

Lack of skilled professionals

Substantial changes in skill requirements may be expected with the adoption of alternate construction technologies. In

Diagram 1: Conventional construction

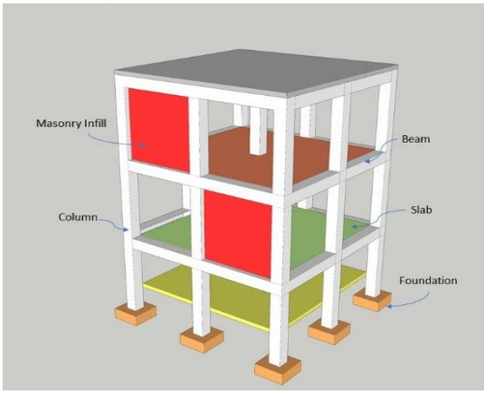

Diagram 2: Engineered formwork system made of aluminium

Diagram 3: Light gauge steel framed structure

Diagram 4: Precast wall panel

some vocational jobs, such as carpentry and plastering, the skill requirement may not change but the context in which they are applied will change. In high skill professions, such as architects and construction managers, enhanced knowledge of all parts of the construction lifecycle, design for manufacture and assembly, planning across the supply chain of building components and the use of information technology will be necessary. Government intervention may be necessary to bridge the skills gap. Construction firms will also need to invest in re-skilling their employees for the shift in responsibilities.

Consumer scepticism and questions on liveability

Consumer scepticism about the quality and performance of buildings constructed using alternate technologies is rooted in two factors. First, precast houses built in the post-war decades were poorly built and suffered from water seepage, poor thermal comfort, and early deterioration. These early precast buildings contributed to a negative perception of alternate construction technologies among homebuyers. Second, wall panels used in some precast and steel structural system technologies are much lighter in weight compared to concrete-filled walls and give the homebuyers the impression of being fragile and of low quality. While the quality of buildings constructed using alternate technologies is generally superior to conventional buildings, there is some ambiguity on waterproofing issues and thermal comfort that requires deeper investigations into the post-occupancy experience of homebuyers.

THE WAY FORWARD

Improving financial viability

Under current conditions, the use of these alternate construction technologies is more relevant for large-scale mass housing projects or several small-scale housing projects in close vicinity. For large-scale mass housing projects that are developed by national/state/local governments, imposing conditions such as reduced construction time and high environmental and quality standards in public procurement can help implicitly favour alternate construction processes. For large-scale mass housing projects developed by the private sector, mild policy nudges such as simplification of regulations and information, and outreach programmes can increase private developers' interest in the new technologies. To encourage several small-scale housing projects in close vicinity to use alternate construction technologies, the government will need to develop the ecosystem for these technologies at an urban centre. The state industrial policy or city development plans may encourage investments in structural components, formwork systems, and building materials that are used in alternate construction processes to reduce the initial investment costs. Government can also share risk with private manufacturers to cushion the burden of high initial investment in building with alternate construction technologies. Access to cheaper capital for manufacturing building components such as precast slabs and steel sections or to purchase alternate formwork systems can help in easing the burden of high initial investment for using alternate construction technologies.

Improving operational viability

The transition from conventional construction to the use of alternate construction technologies will be a slow and phased process for any construction firm. Construction firms will need to incorporate principles of DFMA, digitise building design, and execute with detailed planning and close monitoring. Hiring high-skilled managers with experience in executing projects using alternate construction technologies can make the transition easier. The pool of talent available for high-skill roles must expand by increasing the emphasis on new technologies in the academic curricula of civil engineers and architects and by increasing opportunities for on-the-job training at construction firms. There is also a need to train vocational workers such as electricians and plumbers to the new environments in which they will apply their skills. Public/private certificate courses, training and apprenticeship programmes for vocational workers can help improve the quality standards of workmanship.

Improving uptake among home-buyers

As adoption of alternate construction technologies spreads, scepticism among homebuyers about the quality of houses built using them can be expected to decrease. Until that point is reached, the industry, government and individual firms will have to continue to educate potential buyers. Collecting post-occupancy data for apartments

constructed using alternate construction technologies is an important research agenda for the coming decade.

Technology assessment through a participative approach

The Global Housing Technology Challenge programme and the six 'Lighthouse Projects' to demonstrate the functioning of six different alternate construction technologies are welcome steps by the Government of India. The next step must be a participative exercise in the assessment of alternate construction technologies. While the benefits and challenges of these technologies have become more evident, there are ambiguities in post-occupancy experience, lifecycle cost estimates, overall carbon footprint, adequacy of building codes and other decisive factors.

There is need for continuous assessment and discussion on existing and new alternate technologies and their relevance for Indian conditions. The gaps in existing knowledge need to be filled with openly available information, wider consultations across all stakeholders in the industry, and deeper examination of structures built using these technologies. Such participative exercises in technology assessments will increase awareness of the unforeseen effects of alternate construction technologies, help prioritise important areas for policy action, bring to the fore the complex effects in the industry of any policy that favours alternate construction processes, and increase homebuyer's confidence in purchasing apartments built with new technologies.

The long-term benefits of a move towards increased mechanisation of house building can be substantial. As the need to deliver affordable housing of better quality at a faster pace grows over the next decade, this is a critical time for government and industry to examine the bottlenecks that have prevented the wider adoption of these technologies and take concrete steps towards solving them.

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1. *'Lighthouse Projects' are demonstration projects meant to demonstrate the speed, economy and better quality of housing that can be built using alternate technologies compared to conventional in-situ RCC construction*

ABOUT AUTHORS

Ayush Khare is External Consultant, Indian Council for Research on International Economic Relations (ICRIER), and Research Associate, Centre for Social and Economic Progress (CSEP). Email: ayushkhar@gmail.com

Debarpita Roy is Fellow, Indian Council for Research on International Economic Relations (ICRIER). Email: debarpitaroy@gmail.com

Triveni Prasad Nanda is External Consultant, ICRIER, and Assistant Professor, School of Construction, RICS School of Built Environment, Amity University NOIDA Uttar Pradesh. Email: triveninanda@hotmail.com

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Our Offices:

4th Floor, Core 6A, India Habitat Centre, Lodhi Road, New Delhi-110003

Plot No. 16-17, Pushp Vihar, Institutional Area, Sector 6, New Delhi-110017

O: +91 11 43112400 | **F**: +91 11 24620180 | **W:** www.icrier.org

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