IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

INNOVATIVE HOUSING TECHNOLOGIES FOR A BETTER URBAN FUTURE

[1]Charve Jain

[1]Urban Planner, Vardhman Plazas, New Delhi, India

Abstract: With increasing urbanization, the need for adequate affordable shelter also increases. Housing shortage is one of the major challenges faced in developing countries like India. It is imperative to provide housing that caters to all income groups with special focus on the low and middle income groups. In order to provide low cost housing, it is essential to adopt innovative sustainable technologies which are affordable, fast track, cost effective, durable as well as environment friendly. This paper discusses emerging innovative technologies that can be adopted in the country to lower housing construction cost and help in provision of mass affordable housing. Some of the technologies discussed are Tunnel form, Sismo building technology, Light Gauge Steel Framed Structural technology, Precast Sandwich Panel technology etc. These technologies are reviewed on various parameters like local availability, affordability, energy efficiency, structural stability, quality, speed, cost effectiveness, eco-friendliness and suitability for high rise construction. The advantages and limitations of the technologies are also mentioned. The paper highlights the potential barriers for adoption of these technologies in the Indian urban scenario and methods which can be employed to overcome those barriers in order to provide affordable housing for the low and middle income groups.

Index Terms - ***Low Cost, Innovative Technology, Mass Affordable Housing, Cost Effective***

I. INTRODUCTION

Shelter is one of the basic human needs and it is inadequate in India as estimated by the Ministry of Housing and Urban Poverty Alleviation, Government of India. This problem of housing is exacerbated with increase in population and need for residential accommodation. The Indian urban population is expected to increase to 600 million by 2030 from 377 million in 2011. The pressure of growing concentration of people in urban areas can be realized in land and housing shortages. The Ministry of Housing estimated a housing shortage of 18.78 million during the 12th five year plan (2012-2017) with 95 percent of the population belonging to the lower income groups (Ministry of Housing & Poverty Alleviation, 2013). Provision of adequate housing for all sections of society especially the low and middle income groups is one of the most daunting challenges faced by the government. The Government of India envisages provision of 20 million affordable houses to its urban population by 2022 under the "Housing for All" Scheme (Ministry of Housing & Urban Poverty Alleviation, 2016).

Some of the challenges associated with provision for housing for all are extremely high cost of housing construction technologies and materials, limited availability of land, high land prices, increasing urban population and limited financial and economic capability. All these challenges for providing housing for all can be solved by application of low cost, energy efficient, cost effective, environment friendly, durable, good quality technology which would consume local resources rationally. In order to achieve cost effective and timely implementation of housing delivery, it is essential to adopt innovative sustainable technologies in the housing industry. Hence, there is a need to review alternate technologies for housing which can be easily adopted in the country and reduce the housing cost significantly. Such technologies will help to make housing affordable for the low and middle income groups.

Ministry of Housing and Urban Affairs (MoHUA) of the Government of India has set up a technology sub-mission under the Pradhan Mantri Awas Yojana – Housing for All (Urban) to facilitate adoption of innovative and sustainable technologies for fast track and good quality housing construction. It advocates identification of solutions and design pertaining to local conditions and requirements. It promotes identification and transplanting global best practices which adapt to the local conditions and environment. The sub-mission encourages setting up of mechanisms for testing and accepting materials in the construction technology (MoHUPA, 2017). Many conventional technologies used in construction of housing are time taking as well as expensive and they fail to meet the present requirements of housing shortage. This creates a need to adopt new construction housing technologies which are affordable, cost effective, fast track, give structurally stability and good quality of housing

II. INNOVATIVE TECHNOLOGIES FOR HOUSING

The key innovative technologies for housing that can be adopted in the country are 3D Monolithic Precast Construction Technology, Tunnel form Technology, Sismo Building Technology, Precast Sandwich Panel Technology, Glass Fibre Reinforced Gypsum (GFRG) Panel Technology, Light Gauge Steel Framed Structural Technology, Speed Floor System Technology and Structural Stay-in-Place Formwork Technology. These technologies are discussed along with their advantages and limitations. Affordable construction technologies which cater to high rise developments are also mentioned. The technologies are reviewed on various parameters of whether they are locally available, cost effective, fast track, affordable, energy efficient, durable, good quality and provide structural stability.

Prefab construction technology can be used to as an effective technology to satisfy housing needs in urban cites which involves off-site fabrication of building components to higher degree of finish and then the components are assembled on site. Prefab construction improves construction efficiency by improving quality of housing along with workers safety. Prefab materials are known to be durable and have good quality. Prior to the construction, Building Information Modeling (BIM) techniques are used for planning for the construction process. It is an innovative technique capable of addressing the issues of mass housing. This technique is able to reduce the wastage involved in the construction process. Cost, wastage of materials, time taken for construction, labor requirement is significantly lower than traditional methods of construction. This technology has the great potential to make a difference in Indian housing industry due to its economic, social and environmental benefits. It is important to reap the benefits of this innovation to achieve the goal for housing for all economic sections of the society (Shetty and Dash, 2018).

Precast technology is another technology used in housing construction. In this technology, concrete is casted in a reusable mould or form which is then treated in a controlled environment where it is transported to the construction site and then assembled on site. The factory is usually developed near the site to provide an economical solution for storage and transportation. This technology involves various precast elements such as beams, slabs, columns, walls, staircase and other elements which provide structural stability and durability to the building. Precast housing construction involves the designing, planning, lifting, handling and transportation of pre-cast elements. This technology is extremely suitable for high-rise building construction since it is able to resist seismic loads. The frame of the building is planned in such a way that maximum number of repetitions of the mould can be obtained. There are two types of pre cast concrete elements, which are precast reinforced concrete elements and precast pre-stressed concrete elements respectively. The advantage of using this technology is that it provides good quality, fast track construction and cost effectiveness. The product provides good value for money. This technology can also contribute to sustainable design since it is versatile and durable (BMTPC, 2019). However, the cost of construction of this technology is marginally higher than the conventional methods. It involves fast track construction with best quality without any wastage, so it amounts to the same amount of investment as conventional methods.

3D Monolithic Precast Construction Technology is an Australian patented innovative technology which allows production of automated and hydraulically driven modules. This unique technology produces five panels in a single pour. 3D Monolithic volumetric precast construction technology involves production of three dimensional modular units in a controlled factory environment and then the modules are transported to the site for assembly. The modules can be customized during its design process. Doors, windows, piping, conduits and insulation can be designed in the mould. This technology reduces project time and cost significantly. The 3D monolithic modules produced can be fitted and stacked on top of each other or even side by side. This technology allows construction of self supporting structures up to 10 storeys. Concrete also offers high energy saving over the lifetime of the building. The advantages of using this technology are that it provides long term strength and durability. It is fire, earthquake and termite roof. This is a fast track construction technology and incurs lower cost than traditional methods. The structure produced has longevity for more than 50 years and requires low operating and maintenance costs. This technology provides great flexibility in design as the wall openings, windows and stairwells can be remolded into each module. This technology offers superior finish with controlled manufacturing process such that the concrete can be left in its natural state without being painted or covered. It allows a safe working environment and it is non-hazardous for the laborers. Traditional building methods are labor and cost intensive which utilize precious raw materials. In comparison, this technology produces environment, energy, acoustically and structurally efficient structures and is suitable for construction of affordable housing. This technology is also wastage free; it permits easy reuse and recycling of the leftovers (Hommission, 2017).

Outinard pioneered Tunnel Form construction technology from 1959. In this technology, the slab and the wall are cast monolithically in one operation and the components are made up of steel. It is a fast track method of construction. It is an economical, time saving and good quality housing construction technology. This technology enables easy alignment, de-shuttering, hot air curing and also improves labour productivity. The form is manufactured from steel and the tunnel provides stability, rigidity and high quality smooth finish to the concrete. A tunnel is formed when two half tunnels are combined together, the tunnel sections is of varying length, 1.25 meters and 2.5 meters respectively. The tunnel sections are combined together to produce a tunnel length appropriate for the building sections. Tunnel form technology incurs lower manpower, lower labor cost and lower materials cost than conventional methods of construction. This technology enables fast track construction and is suitable for high rise building construction. Good quality of house is constructed due to use of high quality steel formworks and it also offers adequate structural stability. However, this technology involves high initial investment, accurate form fabrication and detailed accuracy during assembling (Chavan, 2016).

Sismo Building Technology enables insulating shuttering kit for the whole building based on three dimensional lattice made up of galvanized steel wire. The lattice is composed of many materials which serve as formwork. The basic structure of the building includes steel wire lattice. This technology was developed in Belgium. Infill panels are inserted at the exterior sides of the lattice which transforms the lattice into a closed structure. The closed structure can be filled with concrete. This technology is suitable for high rise construction. It offers structural stability and durability with good quality control (BMTPC, 2017). This technology

is energy efficient, durable, cost effective, earthquake resistant, fire resistant, hurricane proof and environment friendly. Sismo technology shortens the construction time and lowers pre-financing costs for the developer. This technology creates large economies of scale, particularly in large projects. Hence, it is suitable for construction of mass housing (Sismo India, 2017).

Precast sandwich Panel Systems Technology comprises of Expanded Polystyrene (EPS) Core Panel System which are completed on site by spraying concrete and a dry wall system where the inner and outer boards are made up of fibre cement with infill core of lightweight concrete with Fly ash and EPS beads. The panels are made in a controlled factory condition. This technology involves very less time in construction as compared to conventional brick and mortar walling construction. Since no plastering is required on the walls, manual work is reduced on the site. The materials used in this technology bring thermal efficiency and thus this technology is sustainable and energy efficient. Use of natural resources is reduced since Fly ash and EPS are used in this technology. It is suitable for affordable housing construction and offers efficient thermal and acoustic insulation. It provides good structural stability as well as durability. However, this technology can only be used in high rise construction when it is coupled with steel frame, otherwise it is suitable for construction of medium rise buildings (MoHUA, 2019).

Glass Fibre Reinforced Gypsum (GFRG) panel technology is an innovative technology which can be used to build low cost housing. In this, gypsum which is produced as waste by the fertilizer industry is re-processed by calcining into gypsum plaster. This forms the raw materials for gypsum panels. This technology allows structural stability as it is capable of resisting high lateral loads and winds. The walls, roofs, sunshade along with the boundary walls can be made using GFRG panels. The panels are cut using computerized machinery in the factory and are transported to the site. High rise buildings can be also built by using gypsum panels. The advantages of using this technology are that it allows quicker construction and incurs lower cost as compared to conventional methods. These panels can keep the building cooler by 4 degrees in comparison to conventional building materials. It is earthquake and water resistant. This technology is eco-friendly, energy efficient, cost effective and durable which makes it very suitable for building affordable mass housing. However, extreme care should we taken while handling the panels and specific machinery is needed for movements of the panels. These panels cannot be used for wall with circular curvature (Goutham, 2013).

Light Gauge Steel Framed Structure technology involves galvanized light gauge cold formed steel structural components manufactured in the factory and are assembled as panels at the site. This technology provides fast track construction. It generates less waste by using the resources efficiently and steel used can be recycled as per requirement. Light Gauge Steel Framed Structure with Infill Concrete Panels (LGSFS-ICP) is a patented technology which uses Light Gauge Steel Framed Structure (LGSFS). The infill wall comprises of factory made precast panels which is filled with light weight concrete at site. This technology provides good structural stability. For high rise construction, composite structural system consisting of LGSF and hot rolled steel need to be provided. This technology is suitable for construction only up to 4 storeys (BMTPC, 2017).

Speed Floor Technology is a patented technology which allows suspended concrete flooring with the help of a hot rolled steel joist combined together to make concrete and steel composite floor. The system involves a hybrid of concrete and steel beam in one direction and an integrated continuous slab in other direction. The joists are manufactured from pre-galvanized high tensile steel. This technology involves cost saving, time saving, good quality and sustainable construction where the raw materials can be easily recycled. It provides good structural stability, ensures durability and is suitable for high rise construction. However, it doesn't provide insulation against heat and sound (Aggarwal, 2017).

Waffle crate building technology comprises of large structurally ripped panels made up of reinforced precast concrete combined together using a bolt. The joints between the panels are caulked to form the floors, walls and roofs of buildings. The floors are manufactured using precast reinforced concrete floor panels which are supported by precast concrete grade beams. The window and door frames are integrated in the wall panels during casting. In this technology, precast wall floor panels are made from steel and concrete. This technology is suitable for construction from low to mid rise mass affordable housing structures. It offers structural integrity, durability, high resistance against earthquakes, wind and fire. Waffle Crate technology reduces low material cost, low labor cost, less construction time as compared to conventional methods of housing construction. This technology is not suitable for high rise construction (BMTPC, 2017).

Structural Stay-in-Place Formwork technology or Coffor technology consist of Expanded Polystyrene (EPS) blocks or panels which are known as insulated concrete forms, steel cage filled with concrete or lightweight concrete known as structural forms, Panels, PVC formworks etc. These stay in place formworks act as a guide for fast construction of walls and slab. This is a cost effective technology. These components are manufactured in the factory and have good quality. The formworks system uses EPS as outer core, alleviate concrete with EPS bead is as infill which is responsible for thermal as well as resource efficiency. This technology can be used to build low cost housing and it also offers structural stability (MoHUA 2019). This technology can be used for building construction of only up to 5 storeys. In case of construction above 5 storeys, extra steel in the walls will be required (BMTPC, 2017).

Apart from the above construction technologies, one of the fastest growing digital technology in the world is 3D printing which is environmental friendly, less time taking and less expensive as compared to traditional techniques of building construction. This technology is yet to be adopted in India in housing industry. It provides flexibility to implement complex geometric designs as well. Initially when the 3D printing technology was introduced in 2014, it was an expensive technology but over the years this technology is commonly used in all kinds of industry fields and its cost has also reduced. This technology can be used in the housing industry by printing the building components as prefabricated elements and then they can be assembled at the site. The printer extrudes the mortar via nozzle layer by layer. The components can be printed in the factory and then they can be transported to the building site where they are assembled and construction would be completed. There are many advantages associated with this technology such as lower costs, environment friendly construction process and time saving. The potential injuries will be minimized as the printers will be responsible for carrying out most hazardous works (Hager et al, 2016). A

sustainable durable building material can be selected for 3D printing. The structural stability, quality and durability of the house constructed will depend on the building material used in 3D printing technology. However, this technology can only be used to construct low rise buildings.

.

III. BARRIERS FOR ADOPTION OF TECHNOLOGY AND WAYS TO OVERCOME THEM

Numerous barriers are associated with adoption of innovative housing technologies and the need of the hour is to overcome these barriers to enable widespread usage and awareness among the people. The barriers faced by new technologies at various stages of development and commercialization can potentially thwart the ability of the technology to succeed in the marketplace. Many successful innovative construction techniques remain confined in their regions and are unable to get replicated in other regions of the country due to limited outreach, inadequate knowledge dissemination, restricted technology transfer, inadequate manufacturing facilities and lack of regulatory environment. Lack of awareness and understanding about the possible technology options by practicing professionals and artisans who deal with housing construction restrict movement of innovative technologies into the mainstream practice (MoHUA, 2020). Absence of a readily trained work force to execute the implementation of such technologies is another challenge. Need arises to train the manpower such as architects, structural engineers, artisans and construction workers for use of these technologies. Inadequate enabling institutional mechanisms pose another challenge; local governments due to inadequate knowledge dissemination do not have the capacity to evaluate projects with innovative housing technologies.

The focus needs to be on technology transfer, where sufficient aid is provided to the housing industry to use its human, physical and capital resources more effectively by proper knowledge dissemination, providing guidance and assistance wherever it is needed. This will improve the facilities and methods of manufacturing by promotion of use of innovation technologies. People need to be educated about the benefits of adopting these innovative technologies at pan India level. There is a need for proper research and evaluation, cost-benefit and return on investment analysis will highlight the financial gains that will be achieved by implementing such technologies. In order to facilitate use of successful technologies and their diffusion in the housing industry, development may be incentivized by providing subsidies or tax rebates. This will encourage the developers in the field towards voluntary behavior awareness on innovative technologies adoption. There is a need for a proper enabling regulatory environment and institutional mechanism. The laws and regulations also need to improve to ensure adoption of the innovative low cost housing technologies to provide affordable housing, provide technical support and education to improve the developer's capacity. This will provide a better understanding for the developers and facilitate promotion of innovative housing technologies in the country.

IV. CONCLUSION

Adoption of appropriate innovative technologies for overcoming housing shortage needs to be promoted in order to realize the vision of providing Housing for All by the year 2022. The adoption of innovative housing technologies will aid in enabling cost effectiveness, energy efficiency and sustainability in construction of mass affordable housing. It is essential to promote these technologies pertaining to the local conditions and environment. The technology should be selected based on the easy availability of the material and the components without causing additional stress on transportation cost and the environment. Efforts need to be made to strengthen the supply side to facilitate adoption of innovative technologies. The workers, artisans, engineers and architects need to be provided training to use these technologies. There needs to be sensitization as well as proper dissemination of the benefits of using these technologies at pan India level. Proper capacity building, awareness creation and skill development is required for successful implementation of these technologies. The need of the hour is to mainstream such innovative technologies into the housing industry. All these efforts can be undertaken in order to overcome the issues associated with housing shortage in the country and help to create a better urban future.

REFERENCES

1. Agarwal S. *(2016) Technology transfer - challenges in use of new technology and materials in real estate.* [Online] Available from: https://www.ricssbe.org/what-s-new/expert-talk/challenges-in-use-of-new-technology-in-real-estate/ [Accessed 8 September 2020].
2. *Aggarwal, S.K. (2017) Emerging Construction Systems for Mass Housing, Building* Materials & Technology Promotion Council. Ministry of Housing & Urban Poverty Alleviation, Government of India.
3. Bhatewara, A. (2017) *Tunnel Form Construction Technique at Rohan Abhilasha, Pune.* [Online] Available from:https://www.rohanbuilders.com/blog/tunnel-form-construction-technique-at-rohan-abhilasha-pune.html [Accessed 5 September 2020].
4. Chavan, A.R. (2016) A Review on Fast Track Construction Using Modern Formwork Systems. *In Internal Journal of Advanced Technology in Engineering and Science*, 4, 12.
5. Building Materials & Technology Promotion (BMTPC) (2017) *Annual Report 2016-2017*. Ministry of Housing & Urban Poverty Alleviation, Government of India.
6. BMTPC (2019) *Performance Appraisal Certificate for Precast Construction Technology Issued to M/s Urbanaac Infrastructure Pvt. Ltd*. Ministry of Housing & Urban Poverty Alleviation, Government of India.
7. Building Materials & Technology Promotion Council (2017) *Compendium of Prospective Emerging Technologies for Mass Housing*. Ministry of Housing & Urban Poverty Alleviation, Government of India.
8. Daud, N. M. & Nor, N. M. (2018). Challenges and Technologies for Affordable Housing System. *International Journal of Academic Research in Business and Social Sciences*, 8(6), 1121–1126.
9. Goutham, V. (2013) *IIT Madras Innovates Eco-Friendly Low-Cost Houses.* [Online]Available from: https://www.ecoideaz.com/innovative-green-ideas/iit-madras-innovates-eco-friendly-low-cost-houses[Accessed 5 September 2020].
10. Hager I., Golonka A. & Putanowicz R. (2016) 3D Printing of Buildings and Building Components as the Future of Sustainable Construction? *Procedia Engineering*, 151, 292-299.
11. Hommission (2017) *Manual on 3D Monolithic Precast Construction Technology Solution*. Hommission India.
12. Lojanica, V., Colic-Damjanovic, V.M. & Jankovic, N. (2018) Housing of the Future Housing Design of The Fourth Industrial Revolution. *In: Proceedings of the 2018 5th International Symposium on Environment-Friendly Energies and Applications (EFEA).*
13. Ministry of Housing and Urban Affairs (MoHUA) (*2019) Shortlisting of Proven Technologies for Participation in Bidding for Construction of Light House Projects.* Ministry of Housing and Urban Affairs *Government of India.*
14. Ministry of Housing and Urban Affairs (*2020) Concept Note on New Urban India Promoting Technology & Innovation in Housing Expo-cum-Conference. Ministry of Housing and Urban Affairs Government of India.*
15. Ministry of Housing & Urban Poverty Alleviation (MoHUPA) (2013*). Scheme Guidelines for Affordable Housing in Partnership*. Ministry of Housing & Urban Poverty Alleviation, Government of India.
16. Ministry of Housing & Urban Poverty Alleviation (2016) *Pradhan Mantri Awas Yojana; Housing for All (Urban) Scheme Guideline*. Government of India
17. Ministry of Housing and Urban Poverty Alleviation (2017) *Pradhan Mantri Awas Yojana (Urban) Housing for All Technology Sub-Mission.* Ministry of Housing & Urban Poverty Alleviation, Government of India.
18. Ramli Sulong, N., Mustapa, S. & Abdul Rashid, M. (2019) Application of expanded polystyrene (EPS) in buildings and constructions: A review. *Journal of Applied Polymer Science*, p.47529.
19. Shetty, D. & Dash S.P. (2018) Pre-Fab Construction Technology: An Innovative Approach towards Affordable Mass Housing. *International Journal of Civil Engineering and Technology (IJCIET)*, 9,8, 1255–1265.
20. Sismo India (2017) *Advantages of Sismo Building Technology.* [Online] Available from: http://sismoindia.com/advantages/ [Accessed 8 September 2020].
21. Srivastava, A. (2014) Cost Effective and Innovative Housing Technology. *In: International Journal for Scientific Research and Development*, 2, 6.