

A Study on Affordable Housing Methods for Rural India

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Abstract—Adequate shelter for all people is one of the pressing challenges faced by the developing countries. India is currently facing a shortage of about 17.6 million houses. Hence, it has become a necessity to adopt cost effective, innovative and environment-friendly housing technologies and methods for the construction of houses and buildings to enable the common people to construct houses at an affordable cost. The study consists of the brief introduction of affordable housing and presents a brief account of various cost-effective construction methods or techniques used to reduce the construction costs and to achieve a sustainable housing model. The affordable housing methods, viz. GFRG wall panels, Ferro-cement wall panels and Bamboo reinforced wall panels have been compared with the conventional method of construction against the comparative parameters of cost effectiveness, resource utilization and project duration. The duration of the construction period is reduced by 32 percent by using GFRG panels as compared to the conventional method of construction. The cost effectiveness of the Bamboo reinforced panels construction method is 40 percent as compared to the conventional method of construction. Thus, there is a need to promote the construction of GFRG and Bamboo reinforced panels as an affordable housing construction method to fasten the housing construction sector in India.

Introduction

A large number of around the world live in slums, lacking the facilities of housing, availability of water and proper sanitation. In the near future a significant portion of the world's population is going to face the problems due to lack of proper housing, sanitation and drinking water facilities. This is mainly due to poor housing policies, poor land use and lack of use of affordable housing methods for the construction of houses. The use of affordable construction methods will not only reduce the cost and duration of the construction but will also help in achieving sustainable construction. There are a lot of obstacles in the utilization of the affordable housing methods, one of which is the public acceptance. In order to achieve greater public acceptance, greater public awareness is required. This study aims at promoting public awareness of the affordable housing methods like GFRG panels, Ferro-cement panels, Bamboo reinforced panels, etc. by highlighting the time and cost effectiveness of these methods.

Literature review

Lal (1991) carried out the detail analysis of various low-cost technologies particularly use of precast techniques. The various precast building components describes in the study in the study includes precast RC roofing's/flooring elements, precast thin RC lintels, Precast RC doors and windows frames. The precast roofing system has shown a saving of about 20 to 30% of the cost of roof construction. The precast channel units save about 20% cost as compare to traditional RC slab. Similarly, all the other precast components depict savings in the range of 20 to 30% as compared to conventional method of construction [1].

A study on the "cost effectiveness of using low cost technologies in construction" was conducted by Tam (2011) using case studies in India. The study points out that low-cost does not imply the mere reduction in the cost while compromising the quality, safety and security of the structure. The comparison of the construction cost for traditional and low-cost housing technologies has been worked out after evaluating the cost of the different elements of the building. The low-cost techniques used in the study include arch foundation, rat trap bond technology for walls, filler slab roofing systems, terracotta tile flooring, avoiding plastering on the walls, omission of door and window frames. The results of the study depict the savings of about 26.11% for walling and 22.68% for roofing with the use of the low-cost housing techniques [2].

Nair et al. (1997) has conducted a study to review the present position of the ongoing research on sustainable-affordable housing for rural areas. A theoretical framework for sustainable and affordable habitat is developed. The framework is a combination of two equally important phases, first phase enlists the requirements and analysis the housing issue, the second phase deals with strategies for sustainable-affordable housing to assist in formulating policy. They study briefly defined the public housing schemes of Kerala and analyse the sustainability in the scheme using two method of analysis: perspective of government and

perspective of beneficiaries. The study has also evaluated the present building process in Kerala using various factors like: socio-cultural factors, economic considerations, technological requirement, and environmental considerations. The study also advocates use of simple technology for sustainable housing technology like using of straw bale and rice husk ash in the building process [3].

Stone et al. (2006) conducted a study on affordable housing to make a case for residual income approach as an effective measurement of affordability. The study presents an analysis of various approaches defining affordability. The study has presented residual income as appropriate indicator of housing affordability. The study has emphasized on the need for answering the certain questions objectively regarding affordable housing, like: Affordable to whom, on what standard of affordability and for how long. The study disapproves affordability as the characteristic of housing and presents it as a relationship between people and housing. The study holds the fact that affordability is an individual measure but also emphasis on the need to develop an indicator for collective determination of affordability [4].

Methodology

The construction techniques and housing affordability parameters were derived from the literature review. Research data related to the parameters have been collected from CPWD, industrial contacts and government surveys. The data collected include the information about various potential housing affordability techniques used or developed, alternate materials that can be used to reduce the cost and carbon footprint on the environment. Data acquired have been evaluated and analyzed to work out cost analysis to determine various incurred costs viz production cost, construction cost, logistic cost and installation cost. Comparison with the traditional methods of construction have been done.

Affordable housing methods

Affordable housing methods consist of the use of affordable and sustainable housing materials and the cost saving methods of construction. In addition to the conventionally used materials, there are various alternative technologies and materials developed by various research organizations, innovators and manufacturers that are beneficial in the housing construction. The three affordable housing methods under consideration for this study are Glass fibre reinforced gypsum (GFRG) wall panels, Ferro-cement wall panels and Bamboo reinforced wall panels.

Glass fibre reinforced gypsum (GFRG) walls are prefabricated large gypsum panels with hollow cores. GFRG walls are hollow machined panels made of modified gypsum plaster and reinforced with glass fibre and is known in the industry as Rapid-wall. The product is not only eco-friendly or green, but also resistant to water and fire. GFRG wall panels are used both architecturally and structurally as walls and slabs, with no columns and beams required. GFRG panels are the composite material consisting of gypsum plaster and glass fibres. GFRG wall panels are currently manufactured to a thickness of 124 mm, a length of 12 m and a height of 3 m, under carefully controlled conditions. It have been found that GFRG panels, suitably filled with reinforced concrete, possess substantial strength to act not only as loadbearing elements, but also as shear walls, capable of resisting lateral loads due to earthquake and wind. The GFRG panels can withstand 1000 degree for 4 hours. The GFRG wall panels are considered to have a life span of 60 years.

Ferro-cement is a construction method using a composite mortar sandwiched around a reinforced wire or steel mesh to form panels. Using Ferro-cement is another affordable construction method, which brings in substantial properties in the construction. Ferro-cement panels are resistant to cracks and impact. The closely spaced and uniform dispersion of reinforcement imparts toughness to the wall panels. Ferro-cement have been increasingly used in developing countries as an affordable housing material. Ferro-cement panels can be constructed with unskilled labours and thus is suitable for areas with labour shortage. The ferro-cement construction provides better fire and earthquake resistance than the traditional methods.

Bamboo reinforced wall panels are casted using bamboo mesh sandwiched between composite mortar. The bamboo reinforced wall panels provide a cost effective material for wall construction. Bamboo reinforced wall panels possess very good tensile strength, which makes it resistant to fast winds. The bamboo reinforced wall panels are under extensive research to analyse the various properties, which can be amplified to make it an ideal building material. Bamboo reinforced wall panels offer a vast range properties which makes it sustainable and cost effective method of construction. Using bamboo reinforced wall panels we can reduce the dead load of the building, thus increasing its earthquake resistance. The issue with the bamboo-reinforced construction is the potential of fungal attack, which can be countered by pre-treating the bamboo strips with anti-fungal solution.

Data analysis

For this study three different housing models were selected for different income groups. The plot coverage details of the selected housing plans is given in Table 1.

Table 1: Plot coverage details of the selected housings plans

House Model	LIG	MIG	HIG
Plot area (Sq. Ft.)	827	1452	2324
Plinth area (Sq. Ft.)	381	643	722
Plot coverage (%)	46	44	31

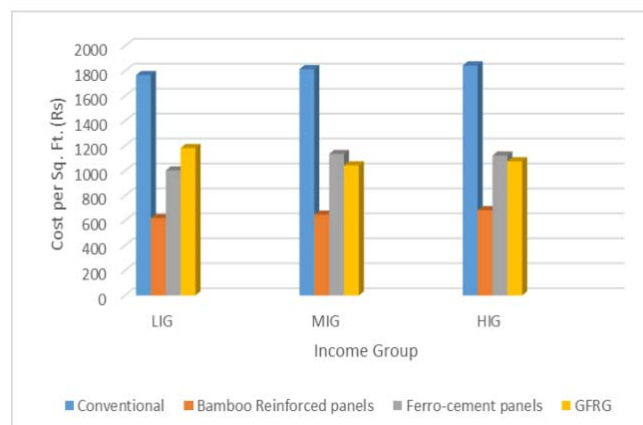
The data analysis includes the cost analysis of the construction process, resource utilisation and project scheduling of all the three housing models. The cost analysis is done by developing an approximate cost estimate of the construction works. Resource utilisation and project duration have been worked out in MS project to depict the resource utilisation and duration of the projects. After the preparation of the cost estimates, resource utilisation charts and project schedule for all the three models using GFRG Panels, Ferro-cement wall panels and Bamboo reinforced wall panels as affordable construction methods, the models were compared with the conventional model and the comparative analysis was done to arrive at a most economic model.

Result and discussion

Table 2 gives the cost comparative cost details of the various methods of construction used for affordable housing along with per square feet cost. Figure 1 is the graphical representation of the comparison of cost per square feet for different methods of construction. From the Table 2 and Figure 1, it is clear that construction method using Bamboo Reinforced Panels is showing the lowest cost per square feet of construction.

Table 2: Cost analysis using different methods of construction

Construction Method	LIG		MIG		HIG	
	Cost of construction (Rs)	Cost per Sq. ft. (Rs)	Cost of construction (Rs)	Cost per Sq. ft. (Rs)	Cost of construction (Rs)	Cost per Sq. ft. (Rs)
Conventional	673867	1768	1167347	1815	1332283	1845
Bamboo Reinforced panels	236220	620	417456	648	493873	684
Ferro-cement panels	382326	1003	730482	1135	810210	1122
GFRG	450224	1182	671176	1043	776473	1076

**Figure 1: Cost comparison using various methods of construction**

Duration of a construction project is an important factor in determining the economy of the project. In this project the construction activities for all the three income group (LIG, MIG, and HIG) housing models using each GFRG wall panels, Ferrocement wall panels and Bamboo reinforced wall panels as wall construction methods were plotted in work breakdown structure (WBS) using MS Project. Each activity was allotted a suitable number of days for its completion based on the standard productivity of the resources. Table 3 gives the project duration using different construction methods

Table 3: Project duration using different construction methods

Construction Method	Project Duration (Days)		
	LIG	MIG	HIG
Conventional	181	234	297
Bamboo Reinforced panels	154	186	231
Ferro-cement panels	165	203	264
GFRG	134	159	186

Figure 2 is the graphical representation of the project duration details. From Table 3 and Figure 2, it is evident that GFRG panel construction is least project duration. Thus, GFRG panel construction can be suggested for time effective construction. GFRG panel construction can be used to complete construction in shorter span of time, thus reducing the duration, which in turn increases the economy of the construction.

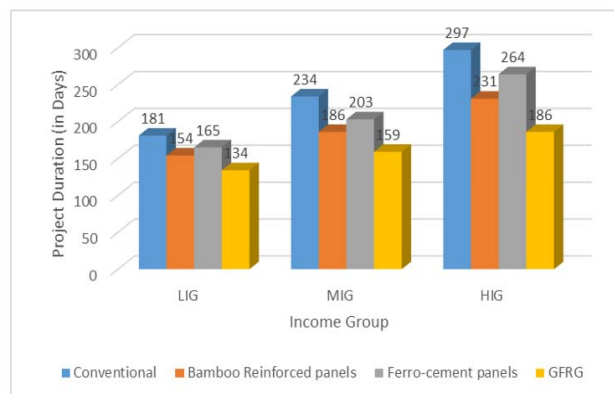


Figure 2: Project duration comparison of various construction methods

Table 4 gives details of the GFRG Panel method of construction as the most time saving method of construction. The study showed that by using GFRG Panel method of construction, the duration of the project can be reduced up to 32 percent.

Table 4. GFRG Panels as Time Effective Method

		Conventional Method (Days)	GFRG Panels (Days)	Reduced Duration (Days)	Average Reduced duration (Days)	Percentage Reduction (%)
Duration	LIG	181	134	47	77	32
	HIG	234	159	75		
	MIG	297	186	111		

Table 5. Bamboo Reinforced Panels as Cost Effective Method

		Conventional Method (Rs)	Bamboo Reinforced Panels (Rs)	Reduced cost (Rs)	Average Reduction in cost (Rs)	Percentage Reduction (%)
Cost per Sq. ft. (Rs)	LIG	1768	980	526	659	40
	HIG	1815	648	529		
	MIG	1845	684	468		

Table 5 gives details of the Bamboo Reinforced Panel method of construction as the most cost saving method of construction. From the analysis, it is found that by using Bamboo Reinforced Panel method of construction, the cost of the project can be reduced up to 40 percent.

From the study, it is clear that GFRG panel construction is the faster construction method. The construction duration has reduced by 30 percent of conventional method. Bamboo reinforced panels is showing the most promising results to be used as a potential affordable housing construction method on the basis of construction cost. The cost effectiveness of the construction method is 40 percent as compared to the conventional method of construction. Thus, there is a need to promote the construction of GFRF and Bamboo reinforced Panels as an affordable housing construction method to fasten the housing construction sector in India.

Conclusion

From the study, it can be concluded that GFRG is showing the most promising results to be used as a potential affordable housing construction method. The duration of the construction period is reduced by 32 percent by using GFRG panels. The cost effectiveness of the Bamboo reinforced panels construction method is 40 percent as compared to the conventional method of construction. Thus, there is a need to promote the construction of GFRF and Bamboo reinforced panels as an affordable housing construction method to fasten the housing construction sector in India.

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