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Sustainable Low-Cost Housing using Cost Effective Construction Technology "Rat Trap Bond Masonry" and "Filler Roof Slab" in Bihar

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Abstract

India is the developing country having only 20% population of higher income group. Low cost housing can be considered affordable for low- and moderate-income earner if household can acquire a housing unit for an amount up to 30%of its household income. The low-income group in developing country are generally unable to access the housing market. Low cost housing is a relative concept and has more to do with budgeting and seeks to reduces construction cost through better management, appropriate use of local materials, skills and technology without sacrificing strength and life of structure. The methodology "Rat Trap Bond and Filler Slab" can be used in housing project to achieve cost effectiveness as well as sustainability of the structure without compromising the strength and durability of the scheme. It was analyzed in this case study of Bihiya in Bhojpur district of Bihar, that was about 26.11% and 22.68% of the construction cost, including material and labor cost, can be saved by using Rat trap bond Masonry and Filler Slab respectively. The Rat Trap Bond Masonry creates heat insulation due to presence of air in cavity and inner side of the houses are warmer in winter and cooler in summer season as compared to external atmosphere. The methodology "Rat Trap Bond and Filler Slab" reduces the dead load of the structure and suitable for soils of low bearing capacity. In this methodology the locally available materials like earthen pottery, earthen tiles etc. which is conveniently available. The use of these methodologies gives the ornamental and architectural view of buildings which is looking attractive as compared to conventional methodology.

Keywords: Rat trap bond, Filler roof slab, Low cost housing, Sustainable

INTRODUCTION

Low cost housing construction technologies aim to cut down construction cost by using alternatives to conventional methods and input. "It is effective budgeting and technique which help in reducing cost of construction through use locally available material along with improve skills and technology without sacrificing the strength, performance and life of structure. 'Low cost housing' merely satisfies the most bottom and fundamental human needs for shelter and neglects other needs that people aspire home including psychological, social, and aesthetic needs and ultimately, need for self-actualization. All we need where families can have a comfortable living and work in a sustainable environment. It is found that cost-effective and alternative construction technologies, which apart from reducing construction cost by the reduction of quantity of building materials through improved and innovative techniques, can play a great role in providing better housing methods and protecting the environment. This paper examined the cost effectiveness of using low cost housing technologies in comparison with the traditional construction methods. It was analyzed in this case study of Bihiya in Bhojpur district of Bihar, that about 26.11% and 22.68% of the construction cost, including material and labor cost, can be saved by using the low-cost housing technologies by using Rat trap bond Masonry and Filler Slab respectively if we compare it with traditional construction methods for walling and roofing respectively.

CASE STUDY AND DATA COLLECTION

The case study done for the Bihiya. It is in district Bhojpur in the state of Bihar. The longitude and latitude of Bihiya is 25.5607° N, 84.45935° E. In Bihar State, cost effective technologies are adopted by Department of Education, Govt. of Bihar since 1995 under world bank assisted project Bihar Education Project. Lateron, District Primary Education Programme (DPEP)-III is introduced from 1995 to 2002. After that a Project name Sarva Shiksha Abhiyan is started by Ministry of Human Resource Development, Govt of India which is continued till now.

In this project school infrastructure development is a major component in which many educational buildings are constructed in schools and other administration places in Bihar to empower the educational system. These school buildings, Cluster Resources Centers, Block Resources Centers etc. are constructed in many villages /Panchayats/ Blocks of the Bihar covering almost entire districts of Bihar in different Phases. This construction makes awareness between communities to adopt the technology in their private houses to minimize the construction cost. To construct more units in the limited budget the cost-effective technologies like Stub Foundation, Rat trap

Bond Masonry, Filler Roof Slab, Inclined Roof (to reduce bending moment), were used which is continuing till now. In this study Rat trap bond masonry and filler roof slab used for the Bihiya block.

LITERATURE REVIEW

R.R.Sorate et.al. 2014, "Slum Rehabilitation with Fast Track Techniques", Slum is an area with heavy population living in substandard housing which lacks basic and civics amenities. Urbanization, growing population and migration pressurizes cities leading to overflowing infrastructure, increase in urban poverty and haphazard development of cities. Thus, rehabilitation of slum is necessary to provide fair and affordable houses to slum dwellers.

Swaptik Chowdhury, Sangeeta Roy,2013, "Prospects of Low-Cost Housing in India", The paper presents work on low-cost and sustainable alternative building materials having advantages on areas such as India where concrete or steel housing is expensive. The project addresses the challenges and stereotypes of using these materials as a structural component for low-cost housing and their same capacity for adaptation to the broad spectrum of factors—physical, ecological, social, economic and technical—through different products developed which can be the production of the construction environment.

A. K. Jain, M. C. Paliwal,2012, "Adoption of Appropriate and Cost-Effective Technologies in Housing: Indian Experience "There is a need to adopt cost-effective construction methods either by up-gradation of traditional technologies using local resources or applying modern construction materials and techniques with efficient inputs leading to economic solutions. This has become the most relevant aspect in the context of the large volume of housing to be constructed in both rural and urban areas and the consideration of limitations in the availability of resources such as building materials and finance.

Vivian W. Y. Tam et.al., 2011 "Cost Effectiveness of using Low Cost Technologies in Construction Housing" Case studies in India are used for the investigation. Construction methods of foundation, walling, roofing and lintel are compared. Strength and durability of the structure, stability, safety and mental satisfaction are factors that assume top priority during cost reduction. This proves that using low cost housing technologies is a cost-effective construction approach for the industry.

RESEARCH METHODOLOGY

This study is based on literature and field survey. The focus of the study is to find out issues resulted from low cost house construction projects that affect the construction activities.

Rat trap bond masonry: The rat trap bond is a masonry technique, where the bricks are used in such a way which creates a cavity within the wall, while maintaining the same wall thickness as for a conventional brick masonry wall. While in a conventional English bond or Flemish bond, bricks are laid flat, in a Rat trap bond, they are placed on edge forming the inner and outer face of the wall, with cross bricks bridging the two faces. The main advantage of Rat-trap bond is reduction in the number of bricks and mortar required as compared to English/ Flemish bond because of the cavity formed in the wall. It can be seen in the fig.1.

Filler roof slab: Filler slab is a variation of conventional reinforced cement concrete slab in which part of the concrete is replaced with a filler material which can be a waste material to ensure economical advantage over an RCC slab. The basic principle in a filler slab is that, considering an RCC slab of a given thickness, the concrete in the bottom half of the slab is simply dead weight and does not play a role in taking up compressive load, which is normally taken up by concrete in an RCC slab. So, this concrete can be replaced by a suitable lightweight filler material which can be accommodated in the bottom half of the slab. The design of the filler slab is based on the same procedures which are adopted for design of conventional reinforced concrete slabs. The underlying principle of the filler slab is that for roofs which are simply supported, the upper part of the slab – above the neutral axis - is subjected to compressive. The section and plan is shown in Fig.2 and Fig.3 respectively.

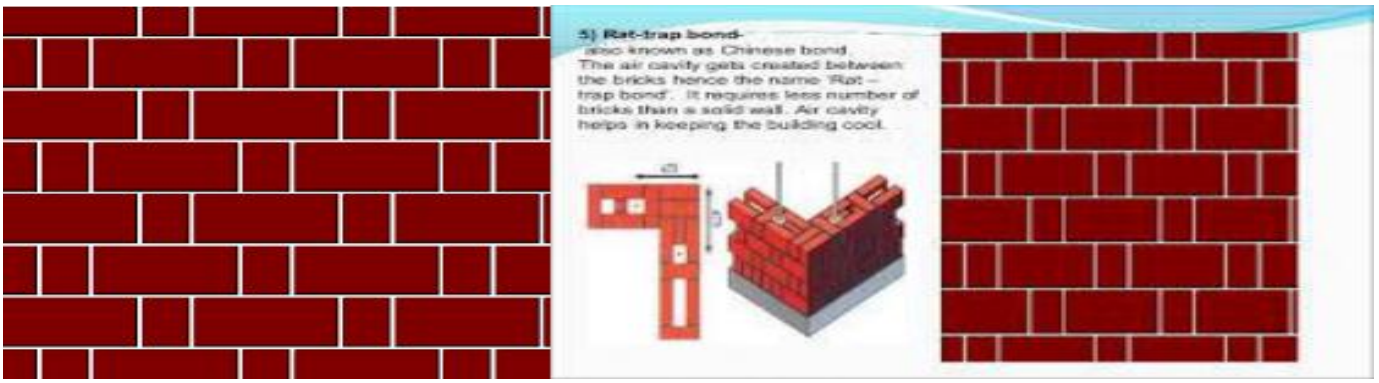

Fig.1: The Elevation and bonding structure of Rat Trap bond Masonry

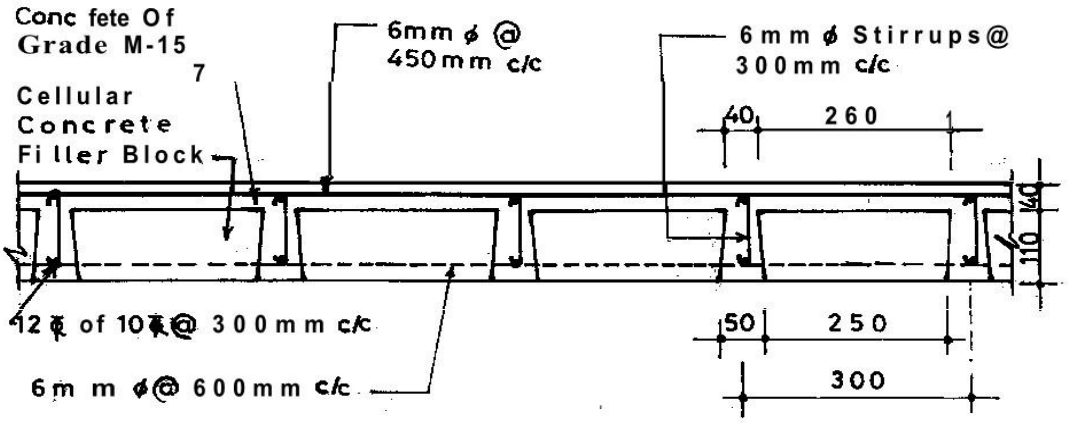

Fig. 2: RCC Filler Slab (Section)

Fig. 3: RCC Filler Slab (Plan)

In Fig.4 and Fig.5 shown the rat trap bond brick masonry work and filler slab of the Block Resources Centre, Bihiya District-Bhojpur, Bihar. The use of cost effective technology in this mega project saves lots of money to construct more number of buildings as compared to conventional technology. Rat-trap bond is a special type of masonry construction which is economical when compared to conventional masonry. It consists of construction of headers and stretchers where bricks are used to lay vertically in the edge of the masonry wall, so as to form a cavity inside the wall as in Fig. 1 The Rat- trap bond is also thermally efficient and intuitively appears to be stronger, since the number of bed joints in a wall is lesser that that of the wall constructed with other bonds (Anon., 1997)

Fig. 4: Rat Trap Bond masonry of Block Resources Centre, Bihiya District-Bhojpur, Bihar

Fig.5: The use of filler slab in study area Block Resources Centre, Bihiya

To check the sustainability of the structure some of the test has to perform for compering the strength of with the conventional methods. Various test performed for the rat trap bond masonry and the filler roof slab as mentioned here for rat trap bond masonry Development of Shock Table, Preparation of Scaled Bricks, Construction of Scaled Building Models and Base Impact Test. For filler roof slab Deflection recovery test, Failure load test, Impact load test, Thermal Performance, Sound absorption, Leak proofness and Economy.

RESULTS AND DISCUSSION

A filler slab roofing system is used which based on the principle that for roofs which are simply supported, the upper part of the slab is subjected to compressive forces and the lower part of the slab experience tensile forces. Concrete is very good in withstanding compressive forces and steel bears the load due to tensile forces. Thus, the low tensile region of the slab doesn't need any concrete except for holding steel reinforcement together. It has been observed that adoption of filler slab in place of conventional RC slab, the saving of about 17 to 26 percent in total cost results. In addition, the saving of 16 to 33 percent in cement and about 45 percent in steel. Rat trap bond technology has been used in this case study. It is an alternative brick bonding system for English and Flemish Bond. The reduced number of joints can reduce mortar consumption. No

plastering of the outside face is required and the wall usually is quite aesthetically pleasing and airgaps created within the wall help making the house thermally comfortable. In summer, the temperature inside the house is usually at least 5 degrees lower that the outside ambient temperature and vice versa in winter.

The dream of owning a house particularly for low-income and middle-income families is becoming a difficult reality. It is necessary to adopt cost effective, innovative and environment-friendly housing technologies for the construction. This paper examined the cost effectiveness of using low cost housing technologies in comparison with the traditional construction methods. Two case studies were conducted. It was found that about 26.11% and 22.68% of the construction cost, including material and labor cost, can be saved by using the low-cost housing technologies in comparison with the traditional construction methods for walling and roofing respectively. It is shown in Table 1 and Table 2 respectively. This proves the benefits and the trends for implementing low cost housing technologies in the industry.

Table 1: Cost analysis of the traditional construction methods and the low-cost housing technologies used in the case studies for 1 m^3 of walling (work departments 2002)

No.	Item	unit	Rate	conventional brickwork		Rat-trap bonded brickwork	
				Quantity	Amount	Quantity	Amount
Materials							
1	Bricks	No	0.02	350	7	284	5.68
2	Sand	m^3	0.32	0.28	0.09	0.17	0.05
3	Cement(10kg bag)	No	6.17	0.67	4.13	0.4	2.47
Labor							
1	Mason (highly skilled)	No	1.7	0.35	0.6	0.35	0.6
2	Mason (2nd class)	No	1.49	1.05	1.56	0.8	1.19
3	Unskilled Labor	No	1.06	2.96	3.14	1.96	2.08
Add 2% tools and plant charges					0.34		0.25
	Add for scaffolding- superstructure: 0.42/m^3				0.42		0.42
	Total (per m^3)				17.71		13.08
	savings			26.11%			

Table 2: Cost analysis of the traditional construction methods and the low-cost housing technologies used in the case studies for 1 m^3 of roofing (works department,2002)

No	Item	Unit	Rate	Conventional Slab		Filler slab	
				Quantity	Amount	Quantity	Amount
				Materials			
1	Concrete, including labor	m^3	38.6	1	38.6	0.8	30.88
2	Reinforcement	ton	36.12	0.8	28.89	0.38	13.72
3	Steel cutting, bending	ton	3.87	0.8	3.09	0.38	1.47
4	Mangalore tiles	No	0.06	N/A	N/A	65	4.14
				Labor			
1	Mason (2nd class)	No	1.49	N/A	N/A	0.2	0.3
2	Unskilled labor	No	1.06	N/A	N/A	0.8	0.85
	Add 2% tools and plant charges				0.11		0.11
	Total (per m^3)				84.32		65.2
	Savings			22.68%			

CONCLUSION

It is found that cost-effective and alternative construction technologies, which apart from reducing construction cost by the reduction of quantity of building materials through improved and innovative techniques, can play a great role in providing better housing methods and protecting the environment. The methodology "Rat Trap Bond and Filler Slab" can be used in housing project to achieve cost effectiveness as well as sustainability of the structure without compromising the strength and durability of the scheme. It was analyzed in this case study that about 26.11% and 22.68% of the construction cost, including material and labor cost, can be saved by using Rat trap bond Masonry and Filler Slab respectively. It was found that about 17% to 26% of the construction cost, including material and labor cost, can be saved by using the low-cost housing technologies in comparison with traditional construction methods for walling and roofing. Cost-effective construction technologies do not compromise with safety and security of the buildings and mostly follow the prevailing building codes. The Rat Trap Bond Masonry creates heat insulation due to presence of air in cavity and inner side of the houses are warmer in winter and cooler in summer season as compared to external atmosphere. Use of these technologies along with many other invented cost-effective technologies we can solve the housing problem of common people ensuring economy and sustainability. The methodology "Rat Trap Bond and Filler Slab" reduces the dead load of the structure and suitable for soils of low bearing capacity. In this methodology we use locally available materials like earthen pottery, earthen tiles etc. which is conveniently available. The use of these methodologies gives the ornamental and architectural view of buildings which is looking attractive as compared to conventional methodology.

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