

Study of Alternative Low Cost Construction Materials and Techniques for Housing in India: A Review

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Abstract— This paper reviews the various low cost construction materials and techniques in construction of housing for low-income group (LIG), and below poverty level (BPL). It comprises the important study, analysis and results from the experiments and literature of many authors. India is facing a great housing shortage in LIG and BPL sectors. Building materials like bricks, concrete, steel, cement, wood etc and the technologies are proving unsuitable regarding their cost effectiveness. The houses constructed by using these materials and technologies are unaffordable to LIG and BPL. In this paper review of many researches is taken about low cost materials and techniques for housing. Low cost housing concept deals with use of materials, and techniques which help in reducing the overall cost of construction the materials and methods described in these researches are alternatives to conventional materials and methods of construction. The paper tried to briefly discuss the motives of the researchers, their suggestions and results.

Keywords: BPL, Conventional, Housing, LIG, Low cost

I. INTRODUCTION

After food and clothing, shelter is the next important need of every human being. A major constraint in meeting this demand is the ever-increasing prices of land, materials and labor in construction of housing. This has made the dream of a safe livable house to go beyond the capacity of people from LIG and BPL.

Conventional modern construction materials like cement, steel, aluminum, plastic, concrete, timber, glass, etc., are leading to increase in construction cost. This fact is prominently observed in all the developing cities in India, where increasing demand for housing and shortage of land has led to a continuous increase in land cost over past few years. Land cost and construction cost are the two major factors, which determines the overall cost of housing. The people from low-income group(LIG) and below poverty level(BPL) are construction labors, artisans, industrial labour, hospitality staff, medical staff, hawkers' etc. Their per capita income does not allow them to construct a house with conventional materials and methods due to high cost of construction. Therefore, reduction in housing construction costs by using low cost construction materials and techniques is a challenge in front of the architects, engineers and construction professionals .This will directly benefit the people in LIG and BPL.

II. LITERATURE REVIEW

Many authors have studied the low cost materials and techniques of construction with respect to their properties, availability and their cost effectiveness. They also derived conclusions based on their study. Many papers have been published on Low Cost Housing materials and techniques, some of them are:

1) P. P. Bhangale, Ajay K. Mahajan carried research on Low cost housing construction technologies. The methodology used by the authors is based on literature and field survey. The field study was divided in three parts like on site observation ,Finding new construction techniques ,and study of low cost construction materials and according to them 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 of locally available material. The authors examined the cost effectiveness of using low cost housing technologies for walling and roofing in comparison with the traditional construction methods. They studied following low cost housing techniques.

- 1) Non Erodible Mud Plaster
- 2) Fly –Ash sand lime bricks
- 3) Solid concrete and stone blocks
- 4) Prefabricated brick panel roofing system

They 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 traditional construction methods for walling and roofing respectively.

The authors derived a conclusion that the conventional methods used for housing must be analysed and replaced by new developed construction techniques based on technical experiments and analysis. They say, The methodology for low cost housing has to be of intermediate type- less sophisticated involving less capital investment.(1).

2) Ramachandran K.V., carried out study on, demand for low-cost building materials in Kerala. His study is based on both primary and secondary data. He says shelter must be seen in the context of basic needs as critical to living, as food and clothing & housing is one of the pressing needs of any country's population. He also says that In India, the building need is very high. Therefore, to find a shelter for each one at a low-cost is the greatest challenge of all times. The author observes that the pace of housing construction in India has been extremely slow because of the speculative increase in land price and rising cost of construction and achievement of housing is decreasing whereas the need for housing go on increasing year after year thus bringing about an imbalance between both the demand for and supply of housing. He feel that the predominant use of conventional construction materials like steel, cement, burnt clay bricks and timber clearly shows an increasing trend in the construction costs over the years.as a result cost of construction is increasing by 13-15 percent each year. For doing a micro- level study, the total 14 districts of Kerala were divided in five zones. To determine the household's demand for low-cost

housing total 150 households have been selected as samples from which 75 households which opted low cost technology and 75 households which opted conventional technology. He further studied relative cost differences between the conventional and cost effective technologies. He analyzes the trend and pattern of the demand for low-cost houses built by Nirmithi and COSTFORD in the Kerala state. In the conclusion they say that Cost-effective technology, no doubt, can be opted as a permanent remedy to overcome the severe housing inadequacy in the country. The author recommends that it is better to construct houses according to the income-affordability of each. By selecting cost effective technology we can definitely construct houses based on our budget line.(2).

- 3) Vivek Kumar, Vidit Gupta, Shivam Sagar, Sushant Singh, Mohd. Haroon, had taken review of the various research papers by different authors about alternate construction materials and techniques for building design in the field of civil engineering. They say that there is a general exodus of rural population to the cities with the rapid industrialization in developing countries. Shortages of conventional building materials and abundantly available industrial wastes have promoted the development of new building materials. The rapid increase in the capacity of thermal power generation in India has resulted in the production of a huge quantity of fly ash. Fly ash, lime and gypsum are available in mutual proximity in many regions. An economical alternative to conventional burnt clay bricks will be available, if these materials can be used to make bricks and hollow blocks of adequate strength. The authors did experimental work on fly ash bricks with different mix and proportions. Combinations were made: (i) fly ash, clay, sand and (ii) fly ash, cement, stone dust and (iii) fly ash, Lime, sand and Gypsum.

From their study, they derived following conclusions about these materials.

- 1) Fly ash is an industrial waste from the power stations; there rise a big problem of utilization of fly ash.
- 2) Fly ash can be used for different purposes as it shows the cementing properties when mixed with water.
- 3) The fly ash bricks can be manufactured easily and show sufficient strength.
- 4) Cost of the fly ash brick is very low as compared to conventional clay brick.
- 5) Conventional clay bricks can be replaced with the Fly ash brick. In the conclusion, they found that Fly ash brick is a good building material and can be used as an affordable building material to replace conventional clay brick. Use of fly ash brick as a building material for the construction of walls is not only viable alternative to conventional clay brick but

also a solution to a difficult an expensive waste disposal problem.

The authors reviewed by Vivek Kumar, Vidit Gupta, Shivam Sagar, Sushant Singh, and Mohd. Haroon, in their experimental work used following materials for the manufacturing of fly ash bricks and their constitution, is as shown in table below.

Material	Percentage
Fly ash	60
Sand/ stone dust	30
O.P.C.(lime + gypsum)	10

Table 1:

- 4) Satish S. Deshmukh and Mittal C. Mohite, carried out study on alternative low cost materials and techniques and presented work on low-cost and sustainable alternative building materials having on areas such as India, where concrete or steel housing is expensive.

According to the authors in India managing the response to the ever-increasing housing needs population expanding by 1.3% every year, results a problem for government. Providing affordable housing remains a major concern of the government, as 37% of its population remains below the International poverty line. The maximum affordability of household was defined to be 5.1 times the household's total gross income as compared to the developed countries (In US it is 0.3 times or less of a household's gross annual income). In this paper In India there is the use of natural materials like straw, bamboo, fibres (jute, coir), earth etc. is a centuries' old practice. These materials apart from being locally available have easy workability and speedy construction hence reducing costs. Also industrial wastes like fly ash and rice husk possess pozzoloanic properties which can act as excellent substitute material.

This paper aims to bring together the studies of these materials keeping in mind their affordability. In this paper authors studied various natural and man made low cost alternate building materials like Bamboo, earth, compressed earth block, no erodible mud plaster, straw, Bagasse, Jute –coir composites, manmade materials like – Ferro cement, Rice husk, concrete hollow locks etc.

In this study, alternate construction materials were studied and the potential of these materials to be used as al-ternate building materials is brought out. Depending on the availability of the materials in a particular region, these materials can be selected as transportation consists of approximately 30% of total construction budget. These materials if studied and developed properly hold the key to address the current housing needs. (4).

Satish S. Deshmukh and Mittal C. Mohite, studied the alternative low cost building materials with respect to their availability and properties as shown in tables below.

Item	Source	Application in building material
Rice husk	Rice mills	As fuel, for manufacturing building materials and products for production of rice husk binder, fibrous building panels, bricks, acid proof cement
Banana leaves/stalk	Banana plants	In the manufacturing of building boards, fire resistance fibre board

Coconut husk	Coir fiber industry	In the manufacture of building boards, roofing sheets, insulation boards, building panels, as alightweight aggregate, coir fibre reinforced composite boards
Groundnut shell	Groundnut oil mills	In the manufacture of buildings panels, building blocks, for making chip boards, roofing sheets,particle boards
Jute fiber	Jute industry	For making chip boards, roofing sheets, door shutter
Rice/wheat straw	Agricultural farm	Manufacture of roofing units and walls panels/boards
Saw mill waste	Saw mills/wood	Manufacture of cement bonded wood chips, blocks, boards, particle boards, insulation boards,briquettes
Sisal fibres	Sisal plantation	For plastering of walls and for making roofing sheets, composite board with rice husk,cement roofing sheet, roofing tiles, manufacturing of paper and pulp
Cotton stalk	Cotton plantation	Fiber boards, panel, door shutters, roofing sheets, autoclaved cement composite, paper, plastering of walls

Table 2: Availability of natural fibre in India and its applications in building materials

Sr. No.	Properties	Bamboo	Concrete Blocks	Ferrocement and Aerocon panels	Fiber-cement composites	Fly ash bricks	Mud blocks (compressed)	Rice husk	Straw bale (with bricks)
1.	Structural	Works better with moisture in shear forces; have high flexibility than steel and lower young's modulus.	Can be given strengths Per required; less mortar joint as size bigger which increases stability	Lightweight and requires no wet plastering (aerocon); high strength ,low density and high crack resistance of mortar (Fero cement)	The light weight, high strength to weight ratio, corrosion resistance, crack resistance, flexibility, lightness	Reduce pollution, save energy, reduce mercury pollution and cost 20% less than traditional clay Brick manufacturing, high strength, lower water penetration,	Economic and energy efficient	Pozzoloanic, economical, corrosion resistance increases, light weight final product	Stable and high load bearing power
2.	Thermal	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Moderate	Moderate
3.	Temperature and water resistance	Moderate	Excellent	Excellent	Moderate	Excellent	Excellent	Depends on composition as it is used as admixture	Also depends on brick composition as it is mixed with the brick and withmud
4.	Durability	Depends on thickness	Excellent	Excellent	Excellent	Excellent	Excellent	Moderate	Moderate
5.	Cost (In Rs/square meter)	(1*)	31.25	Depend on thickness	Depends on fiber	62.66	15.625	NA	NA

Table 3: the properties of building materials in consideration

Sr No.	States	Bamboo	Concrete	Ferrocement	Bagasse (Fiber)	Jute (Fiber)	Coir (Fiber)	Fly ash Mud	Rice husk	Straw	Aerocon
1	Madhya Pradesh	√	√	√				√			√
2	Mizoram	√	√	√				√			√
3	Assam	√	√	√		√		√			√
4	Andhra Pradesh	√	√	√		√		√	√	√	√
5	Uttar Pradesh		√	√	√						√
6	Bihar		√	√	√	√		√			√
7	Punjab		√	√	√						√
8	Haryana		√	√	√				√		√
9	Orissa		√	√		√					√
10	Karnataka		√	√			√				√
11	Pondicherry		√	√			√		√		√
12	Lakshadweep		√	√			√				√

13	Andaman and Nicobar Island		√	√			√		√		√
14	Jharkhand		√	√				√			√
15	Chhattisgarh		√	√				√			√
16	Goa		√	√					√	√	√
17	Delhi		√	√					√		√
18	West Bengal		√	√		√		√	√	√	√

Table 4: Availability of different materials in India showing feasibility

- 5) Manjesh Srivastava, VikasKumar carried out study of The methods of using low cost housing techniques in Indian context. In this, paper authors tried to point out the various aspects of predestined building methodologies by highlighting the different available techniques, and the economical advantages achieved by its adoption. He also tried to cover the use of local materials in the different components of building to make them as low cost available solutions for low income groups. They say that to own a house by middle and lower income groups in today's economic trends is very difficult. Therefore, it has now become a necessity to adopt cost effective, innovative and environment-friendly housing technologies for the construction of houses and buildings and availing them at low cost comparatively. This paper compares the construction cost for the traditional and low cost housing technologies, it was observed that with the use of technology, and reuse of waste material as building material the cost of construction can be minimized to an extent. The authors observed that filler slab can be used as an alternative to conventional slab the cost of construction can reduce upto 25%. They tried to identify the reuse of waste material like fly ash, rice husk, etc as building material. After realizing, the true potential of these waste materials as building material in construction industry the cost can be minimized largely. After analyzing the use of various sustainable materials which are environment friendly, cheaper and easily available following conclusions are made -
- 1) Filler slab is much more economical than traditional slab as it saves 16%, 44%, 17% of cement, steel and cost in two way slabs and 33%, 46%, 25% in one way slab respectively.
 - 2) 2 Brick panel saves 19% per m³ and Rs 418 in cement, 19% per m³ and Rs 21 in sand, 19% per m³ and Rs 127 in aggregate, and 38% per m³ and Rs 536 in steel.
- 6) Swaptik Chowdhury, Sangeeta Roy, carried out study on low-cost and sustainable alternative building materials having advantages on areas such as India where concrete or steel housing is expensive. In this paper they have addressed 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 dictate the production of the construction environment. In this research they have studied natural as well as man-made materials .The natural materials include Bamboo, corrugated bamboo

roofing sheet, Thatch roofing, Earth, Straw, Fiber cement composites etc. The man made products included Bagasse- cement boards and panels, Bagasse PVC boards, Coir- CNCL boards, Fly ash, aerocon panels etc. Man-made materials like Ferro-Cement, Cement Concrete Hollow Blocks, Rice Husk, Low Cost Sandcrete Block, etc. With the help of this study the potential of these materials to be used as alternate building materials is brought out. In conclusion the authors say that, These materials if studied and developed properly hold the key to address the current housing needs.

III. RESULTS

Many experimental work and studies have been carried out to find out the following results.

Using low cost housing technologies for walling and roofing, about 26.11 % and 22.68 % of the construction cost, including material and labor cost, can be saved.

By selecting the cost effective technology we can definitely construct houses based on our budget line. Fly ash bricks can be manufactured by different combinations of fly ash, clay, sand , cement, stone dust , Lime, Gypsum and used as an affordable building material to replace conventional clay bricks. Fly ash and rice husk possess pozzoloanic properties, which can act as excellent substitute material. filler slab can be used as an alternative to conventional slab the cost of construction can reduce upto 25%.

Filler slab is much more economical than traditional slab as it saves 16%, 44%, 17% of cement, steel and cost in two-way slabs and 33%, 46%, 25% in one-way slab respectively. Brick panel saves 19% per m³ and Rs 418 in cement, 19% per m³ and Rs 21 in sand, 19% per m³ and Rs 127 in aggregate, and 38% per m³ and Rs 536 in steel.

The natural materials like Bamboo, corrugated bamboo roofing sheet, Thatch roofing, Earth, Straw, Fiber cement composites etc. and The man made products and materials like Biogases- cement boards and panels, Bagasse PVC boards, Coir- CNCL boards, Fly ash, aerocon panels, Ferro-Cement, Cement Concrete Hollow Blocks, Rice Husk, Low Cost Sandcrete Block has a great potential to be used as alternate low cost building materials.

IV. CONCLUSIONS

The investigation has been done shows the following conclusions:

- 1) Alternative methods of walling and roofing can save on construction cost of these items of construction.
- 2) By using cost effective construction materials and technology we can construct houses within our budget line.

- 3) Fly ash is an industrial waste from the power stations, which creates a big problem of utilization of fly ash if not reused. It can be used for different purposes as it shows the cementing properties when mixed with water.
- 4) Fly ash bricks can be used as an affordable building material to replace conventional clay bricks.
- 5) The natural materials like Bamboo and the things made from bamboo, and the man made materials and products from Bagasse & cement, cement & PVC, Coir, Fly ash, aerocon panels, Ferro-Cement has a great potential to be used as alternate low cost building materials.

V. DISCUSSION

From the conclusion we can say that with the use of alternative low cost building materials and technologies the cost of construction of housing can be reduced. Fly ash brick is a good building material and can be used as an affordable building material to replace conventional clay brick. Use of fly ash brick as a building material for the construction of walls is not only viable alternative to conventional clay brick but also a solution to a difficult an expensive waste disposal problem.

REFERENCES

- [1] P. P. Bhargale, Ajay K. Mahajan "Cost Reduction through Cost Effective Construction Techniques", *International Journal of Science and Research (IJSR)*, ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438, <https://www.ijsr.net/search>, Volume 4, Issue 2, February 2015, 2167 – 2169.
- [2] Ramachandran K.V "Demand for low-cost building materials in Kerala", Thesis. Department of Economics, Dr. John Matthai Centre Thrissur, University of Calicut, 2001.
- [3] Vivek Kumar, Vidit Gupta, Shivam Sagar, Sushant Singh, Mohd. Haroon, "A Review Study on Alternate Low Cost Construction Materials & Techniques for Building Design" *International Research Journal of Engineering and Technology (IRJET)* e-ISSN: 2395 - 0056 Volume: 04 Issue: 04 | Apr -2017, www.irjet.net p-ISSN: 2395-0072.
- [4] Prof. Satish S. Deshmukh Department, Mittal C. Mohite. Alternate and Low Cost Construction Material and Technique, *IJSTE - International Journal of Science Technology & Engineering* | Volume 5 | Issue 1 | July 2018 ISSN(online):2349-784X.
- [5] Manjesh Srivastava, Vikas Kumar "The methods of using low cost housing techniques in India" *Journal of Building Engineering*, Volume 15, January 2018, Pages 102-108.
- [6] Swaptik Chowdhury, Sangeeta Roy "A comprehensive review on low cost building systems", *Geomaterials*, 2013, 3, 60-65 <http://dx.doi.org/10.4236/gm.2013.32008> Published Online April 2013