Low Cost Affordable Quality Housing-The Factors of Concern

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Abstract: Low cost affordable housing, especially in Indian perspective, requires a humane and responsible approval in addition to the big bite of technology. The present common approach of Low Cost Affordable Housing has only single emphasis on cost. The maximum possible space in affordable cost, user responsiveness and sustainability are the new dimensions of housing in present scenario. The vital question is, how to use materials, components and technology replacing conventional to keep the cost of housing units within affordability of the people of LIG and EWS category? Apart from the problems related to cost, we cannot ignore the socio cultural, emotional and humanitarian aspects, which are related to its acceptability by people and makes it a home from a house. There is also a growing concern for sustainability and reduction of carbon footprint. There is very good scope of achieving it by energy saving in housing sector; and especially in EWS and LIG housing. This paper discusses the ways in which one can accomplish objectives of Low Cost Affordable Quality Housing while making it user responsive, co-friendly and sustainable which aims at improving the quality of living of its users ,saves energy for sustainability and reduces environmental hazard.

Index Terms: Low cost housing, affordable housing, incremental housing, sustainability, user responsiveness, low embodied energy materials.

I. INTRODUCTION

It is a proven fact that urbanization plays a crucial role for economic development of any nation of the world, and India is no exception. As stated by, the census of India in 2001, about 72% of the population lived in rural areas, and 28% in urban areas. But by 2011, these figures have changed to 69% rural population and 31% urban population. [1] .

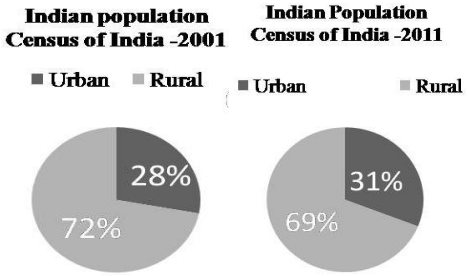


Figure 2: Pie chart – Indian population-Comparison of Urban and Rural population in 2001 and 2011 Census of India

Urbanization reflects the migration of rural population to urban areas [2].

In 2020, nearly 40 % of India's population will be living in cities and urban areas and it is predicted that by 2051 the population of India would be almost equal in urban and rural areas thus aggravating demand for urban housing (MoHUPA 2009) [3]. According to the report of the technical group on Urban housing shortage in India (2012-17),India needs 18.3 million housing units in cities alone, out of which more than 95 % are in the EWS/LIG categories[4].

According to the 'White paper –Indian Housing Industry',by research and consultancy firm R.N.C.O.S.,it is expected that the urban shortage will reach to 34.1 million units by 2022.It further mentioned that the total urban housing shortage is mostly exhibited by the Economically Weaker Sections(E.W.S.)and Lower Income Group(L.I.G.)segments.The report also highlights the importance of environment friendly 'green buildings' in urban areas [5]. A mission on Housing For All (Pradhan Mantri Awas Yojana) aims with constructing 20 million housing units for the urban poor and slum households [6].

These facts ascertain the demand for low cost affordable housing in urban areas. How the Indian city would be able to accommodate the migrated population with a decent living with all the basic facilities and infrastructure at an affordable cost is the mammoth task.

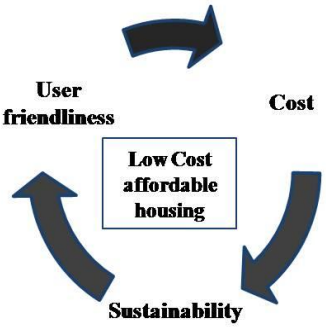


Figure 1- Quality factors of Low Cost Affordable Housing

But the real challenge is to make it user friendly and sustainable. The various parameters of these challenges are discussed here.

II. UNDERSTANDING THE FACTORS OF LOW COST AFFORDABLE HOUSING:

Affordable housing refers to housing units that are affordable by that section of society whose income is below the average household income irrespective of the quality of housing [7].Some of the factors which are considered vital by the authors in present scenario but are often given least attention ,are discussed here.

1) COST REDUCTION

Without the cost factor, the goal of achieving affordability in housing cannot be attained. Among many parameters related to this issue, an architect can certainly aim at:

Reducing the cost through various aspects of his design:

- Including layout, clustering, materials, technology and component design.
- Hence, it is necessary to devise a technology and invent materials, which can substitute the conventional and reduce the cost by giving more importance to performance demands than appearance.
- Optimization of space and materials through design innovation could also give tangible results in improving space and cost efficiency.
- The authors have proposed design of wall, roof and window components by use of waste and eco-friendly materials with industrialized building system as one of the significant parameters of cost reduction, while saving energy to achieve sustainability.

According to Deane Evans, (2014) a Good-quality design is too often considered as an expensive amenity, rather than a necessity and is usually one of the first components to reduce the cost of a dwelling unit. [16]. In the research paper titled "The architecture of affordable housing", Sam Davis says that seventy percent of the cost of a new dwelling is affected by the planning and design. [9]. Thus the first step to by one can achieve the goal of cost effective dwelling unit is proper planning and design.

The authors have proposed Stabilized Waste Panel Masonry (SWPM) which consists of precast composite panel using building debris as a major ingredient. When compared with the commonly used brick masonry in low cost housing, this masonry would give almost 75 % reduction in cost. The major factor leading to cost reduction is cheap and easy availability of its principal ingredient i.e. waste; and elimination of external as well as internal plaster due to the type of finish provided. Hence it becomes a more economical option for walls with additional advantage of embodied energy saving which makes it sustainable.

The floor substitute i.e. Stabilized Waste Panel Slab (SWPS) to conventional R.C.C. slab proposed by the authors is precast panel 80 mm thick uses 50 % less steel and cement as compared to conventional slab. The cost of centering is also reduced to 75% ,and plaster is eliminated. This brings down its cost by over 70% and proves to be a suitable substitute for floor with double benefit of cost and sustainability value as shown in Table no. 1.

Table 1: Comparison of the cost of Dwelling unit (EWS) using conventional technology with the proposed Low Cost Sustainable technology.

COMPARATIVE ITEMWISE ANALYSIS OF CONVENTIONAL TECHNOLOGY WITH PROPOSED LOW COST SUSTAINABLE TECHNOLOGY			
CONVENTIONAL TECHNOLOGY		**PROPOSED LOW COST TECHNOLOGY**	
RCC SLAB		**STABILISED WASTE PANEL SLAB**	
Material	Item cost in Rs.	Material	Item cost in Rs.
• Concrete • Chajjas	30130.80 1578.281	• Debris (50%) • Cement (15%) • Fly ash (12.5%) • Sand (12.5%) • Aggregate (10%) • RCC joists	262.50 1860.00 1114.36 1114.36 900 2030.00
• Steel	8646.00	• Steel	2161.50
• Tiles	40440.00	• IPS flooring	8400.00
• Plaster	4710.00	• Plaster	Not Required
• Screed	3907.20	• Screed	Not Required
• Scaffolding	9000.00	• Shuttering (joist)	2412.00
Total Cost in Rs.	**98412.00**	**Total Cost in Rs.**	**20254.72**
Total difference in cost = (98412.00 – 20254.2) = 78157.28 **Reduction of cost in proposed Low Cost Sustainable Technology = 79.41 %**			
BRICK MASONRY		**STABILISED WASTE PANEL MASONRY**	
Material	Total cost in Rs.	Material	Total cost in Rs.
• Brickwork	64760.04	• Debris • Cement • Fly ash • Sand	1555.75 2700.00 4762.81 4762.81
• Reinforcement	Not Required	• Bamboo	2667.00
• Plaster(internal)	50879.50	• Plaster (internal)	Not Required
• Plaster(external)	27877.50	• Plaster (external)	Not Required
• Patli with steel	783.00	• Patli with steel	Not Required
Total cost	**144300.00**	**Total cost in Rs.**	**16448.37**
Total difference in cost = (144300.00 – 16448.37) = 127851.67 **Reduction in proposed Low Cost Sustainable Technology = 88.60 %**			
CONVENTIONAL WINDOW		**ECO -FRIENDLY WINDOW**	
Material	Total cost in Rs.	Material	Total cost in Rs.
• Aluminium • Steel • Wood	2200.00 2308.00 2540.00	• Eco–friendly Panel available in market	1350.00
Total cost in Rs.	**19975.00**	**Total cost in Rs.**	**11475.00**
Total difference in cost = (19975.00 – 11475.00) = 8500.00 **Reduction of cost in proposed Low Cost Sustainable Technology = 42.50 %**			

NOTE : Above quantities are based on a typical EWS unit with – 30.00 SQ.M. Carpet area. The conventional RCC slab and Brick masonry rates are as per prevailing CSR rates of Nagpur 2015 -2016 .

2) USER RESPONSIVE DESIGN

After assuring the affordablity aspect of the dwelling unit which include providing optimum space,optimized volume,modest basic amenities with effective cost specifications. The humane aspect i.e. user satisfaction should also be researched upon.From the point of view of the users well being physically and psychologically healthy environment is the priority for better response of different user group .This would include :

- Adequate space for different activities with appropriate location and adjacencies.
- Excellent condition of light and ventilation.
- Conducive private open space for family
- Incremental Housing

- Flexibility to adapt to activity needs in different phases of a day.

This humane aspect is seen neglected and dealt very shallowly while understanding affordable housing.

Low cost housing is presumed to be merely a synthesis of low cost building materials and techniques coupled with prefabrication techniques e.t.c.In a quest to achieve low cost housing,the user responsive architecture remains sidelined. Does low cost housing mean replication of the design which concentrates only on the cost parameters without giving prominence to the user ?is a fitting question to a universal low cost unit design.If this approach continues then the living units shall be only match box units which can be replicated with out any attention to users life style,culture,social and behavioral needs.The misconception that housing is a mass produced commodity should be curbed instantaneously. Housing cannot be produced in a single location and distributed throughout the nation (Sam Davis) [9].Housing should comply to the physical context,local needs,customs , traditions and climate.

The important parameters of user response are discussed herewith.

a) Socio Economic, Cultural and Behavioral needs.

The increasing concentration of economic and commercial activities rapid economic growth and influx of population in urban areas is a scenario, which has resulted in acute shortage of affordable housing. Especially the pressure on delivery of such housing for economically weaker section (E.W.S.) is mounting. The proliferation of slums is directly related to this situation. In most cities in India, over 30 per cent of the population live in Slum like conditions [10]. Slums are the consequence of lack of proper affordable housing options for the urban poor in the Indian Cities. [19]. It has been also experienced that majority of low cost or affordable housing developed by government and semi government agencies have not satisfied the householder due to lack of understanding of their socio economic cultural and behavioral needs . We have many such examples of low cost or affordable housing which are comparable with concrete slums as they fail to create responses with neither physical nor psychological needs of various user groups. The affordable housing shall thus be sustainable economically by giving ample opportunities for the residents to be financially sufficient. The house should be a place for generating income .People should be able to open up small scale industries, and create a job opportunity thus making them self sufficient.

It can also be seen that most of the affordable or low cost housing provided by the government and even many private agencies does not ensure healthy environment from the point of view of physical as well as psychological or mental health. In a report by National Resource Centre SPA, New Delhi, Prof. Kiran Wadhya points out that, "provision for small sized high-density units is similar to one replacing one types of slum with other type of slums". He further points out that , 'Poor housing conditions impacts directly on the resident's health and well being which in turn affects their productivity and consequently low productivity of the citizens has direct impact on the G.D.P. of nation.' [11]. People require good social spaces for healthy interactions, cultural activities and festivities, which are mandatory for the mental well-being. Ministry of Housing and Urban Poverty Alleviation, GoI (MoHUPA) and Dept.of Housing,SPA Delhi suggests that affordable housing design should also give equal importance to open spaces, public spaces, parks and playgrounds to ensure proper societal development of the inhabitants. Thus, a habitant should feel a sense of pride while living in an affordable housing.

b)Health – Physical and Mental

A research paper titled Dwelling disparities :How poor housing leads to poor health states that housing is the ultimate nexus between the built environment and health disparities [12]. Thus, any low cost housing should have proper ventilation,daylighting , water supply and sanitation.Energy efficiency in buildings can also be achieved by increasing levels of provision of natural ventilation and daylighting to all homes .This ensures less dependency on mechanical means of cooling /heating and reduction on dependency on artificial lighting.

Exhaustive evidence of research has shown that various aspects of built environment can have profound, directly measurable effects on both physical and mental outcomes, adding to the burden of illness among the low income communities.The research also states that the lack of social open spaces and recreational areas discourages physical activities [12].This affirms that the design of proper open spaces ,playgrounds is a must in low cost affordable housing schemes. Designed cluster layouts with internal courtyards and open spaces shall be encouraged which ensures appropriate light, ventilation ,daylighting and proper hierarchy of open spaces for social activities or recreation . They are directly related to resident's physical, mental health and well-being.

Hence, the quality of life in affordable housing is a major challenge, which is not taken seriously in the present approach especially by the government and semi government agencies primary due to the bureaucratic set up and lack of perception of the related issues.

The affordable housing should thus have ample light and ventilation, adequate privacy, conducive private open space for family which is essential for good mental health. Community Solar kitchens, public toilets, community taps, community worship places, maidans should be lined up in affordable housing schemes which shall cater to the social and economic aspect of the inhabitants.

c) Incremental Housing

The factor of incremental housing which allows for pacing, addition and extensions of construction as per the user's convenience and needs is pointed out in the Model state affordable housing policy for Urban areas drafted by GoI, Ministry of Housing and Urban Poverty Allevation [8]. This factor is often neglected in most of the low cost affordable housing scheme.

Alejandro Aravena, a Chilean architect from Santiago who won the Pritzker Architecture Prize in 2016 mentions in his website that, seeing the magnitude of the housing shortage, one won't be able to solve the problem without the addition of people's own resources in government's building capacity and market. He came up with a thought of open system, which channelizes all the players of housing, leading to people's participation in the housing solution. He has proposed a principle of incremental housing. He has identified five design conditions as the prerequisites of incremental housing. They are: 1) Good location with dense housing projects enough to pay for the expensive well located sites.2) Harmonious growth in time which includes building of necessary basic amenities like bathroom, kitchen, staircase ,roof leaving the rest for customization by the inhabitants. 3) Urban layout with introduction in private and public space which are necessary for social interaction . 4) Plan for final scenario i.e. for middle class society, which includes more space than the present. 5) In the fifth point he says that the housing should strike a balance between low rise and high density, without overcrowding and with a possibility of expansion. [13].

D) Flexibility

Flexibility refers to idea of accommodating change over time. During, the day time spaces are used for daily activities. (Steven Groak)[24]. defines flexibility as capability of "different physical arrangements" are adaptability as capability of adjustments and changes for "different social uses". The same spaces can be converted for sleeping in night. This can be facilitated by design of furniture adaptable to change in activity as well as space could be temporality partitioned to meet requirement of privacy etc. needed to night.

The commonly provided EWS housing do not offer this flexibility, which is necessary due to constraint of available space. This is an important factor related to quantity living of inhabitants.

3) Sustainability

In the present scenario of global warming and carbon footprint reduction, sustainability is one of the important means to deal with it. Considering the enormous quantity of construction materials required for EWS and LIG housing, it is prudent to look into aspect of sustainability and eco-friendliness by following the practice of reduce, reuse and recycle .This will save embodied energy, reduce carbon footprint and environmental hazard.

Thus, one needs to address to the following questions while designing a low cost affordable housing.

- How much sustainable is our design for housing?
- What options we have to reduce, reuse and recycle materials in design of low cost affordable housing to save energy and environment?, as construction of abundant low cost affordable housings shall have a great impact to save energy and environment.

Blending sustainability and environmental friendliness along with housing helps tremendously to low cost housing .The building debris can be well reused in the building construction which has negligible embodied energy. Model state affordable housing policy for Urban areas drafted by GoI, Ministry of Housing and Urban Poverty Alleviation suggests that, the State shall encourage:

1) the use of vernacular styles of architecture for housing stock,

2) promote innovative technology and building materials for low cost and mass housing ,

3) encourage pre-fabrication techniques, green housing,

4) low energy consuming building materials, rain water harvesting and water conservation techniques and other latest techniques [8].

All these policies are aimed at achieving sustainability and pollution free environment.

Affordable housing MoHUPA and Dept.of Housing,SPA Delhi report says that guidelines are needed to be set for the design of low income housing that respond to local climatic conditions and the socio economic and cultural needs of the people who will live in the projects.It also talks about environment sustainability which include saving of energy by responding to the climatic requirements for comfort in outdoor and indoor spaces,capturing and treating locally storm water ,harvesting rain water,recycling and reusing of waste water,use of local building materials and construction techniques. Few of the following guidelines of Affordable housing MoHUPA and Dept.of Housing,SPA Delhi ,which support the sustainable building practice are :

1) Construction materials should be selected such that a majority of the materials are available within 250 kms of the site.

2) Reuse of previously ised construction materials and building elements.

3) Use materials which have some recycled contentthat can be recycled after use.

4) Reduce the use and depletion of finite raw materials by replacing them with rapidly renewable materials like

bamboo products,corn products,wheat based products ,strawboard products e.t.c[14].

The Cement industry ranks second in the energy consumption among the other industries in India which makes one of the highest emitter of carbon di oxide [15]. As this huge amount of CO2 emissions is a major concern for the enviornmentalist ,the efficient and effective utilization should be a major goal of all the players of the building industry.An architect can thus play a lead role in designing sustainable affordable housing while encorporating eco friendly building materials which have low embodied energy and minimizing the use of cement concrete in building.

Reduction in carbon footprint of a building is possible through minimization of energy consumed for various purposes such as operation and thermal comfort, transportation and production of building materials. The embodied energy of a building can be reduced by following considerations:

1) Minimizing the quantity of materials.

2) Buildings often have a service life that is far less than that of the materials they are made of. Building with deconstruction will enhance the reuse of construction materials .Hence; buildings should be designed for deconstruction, reuse and recovery.

3) Use of alternative materials for certain locations, which has low embodied energy content.

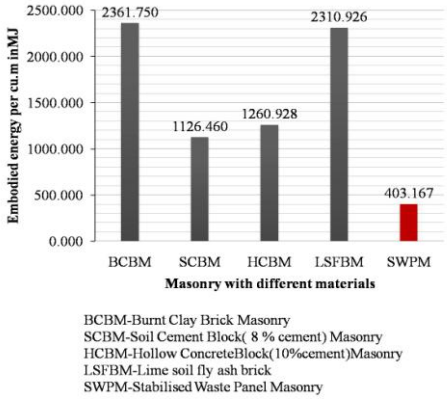
4) Reduce the use of high embodied energy materials.

Considering the vast requirement of E.W.S; L.I.G. housing and the materials consumed for its construction, the significance of reduction in embodied energy for reduction in carbon footprint and pollution cannot be overlooked.

It is estimated that about 30% of all energy consumed throughout the lifetime of a building can be in its embodied energy [17]. Energy consumption produced CO2, which contributes to green house gas emission. Hence, embodied energy is considered as an indicator of the overall environmental impact of building materials and systems [18]. For low cost user friendly and sustainable quality affordable housing, waste material from various sources could be used to produce various components of building such as walls, floors and windows. The Table no 2. given below , explains the percentage of embodied energy saved by the use of low embodied energy materials for different building elements. The proposed Stabilized Waste Panel Masonry (SWPM)offers 83% saving of embodied energy saving as compared to normally used Brick masonry, proving it as highly sustainable materials for walls. In the similar way, proposed Stabilized Waste Composite Panel (SWCP) gives over 60 % saving of embodied energy as compared to conventional R.C.C. slab and justified its use as sustainable material. Both these materials are at least 50 % low in cost compared to commonly used materials i.e. burnt clay bricks for walls and R.C.C. slab. Hence, the choice of material suggested by authors is justified from cost as well as sustainability point of view.

Sr.No	Name of brick masonry	Total embodied energy in MJ	Transportation energy	Total embodied energy	Embodied energy of sand (m3)	No of kg.of cement	Total embodied energy of cement	Total embodied energy	Quantity of cement plaster in m3	Total Embodied energy in cement plaster 1:6 MJ/m3	Total embodied energy	Equivalent to brick masonry energy (%)	% Savings in Embodied energy as compared to conventional burnt clay brick masonry
		Brick/Block/Panel			Sand	Cement							
		A	B	A+B				1		2	1+2		
1	Burnt Clay Brick Masonry	1666.67	133.33	1800.00	87.835	80.97	473.65	2361.487	0.00021	0.262	2361.75	100.000	
2	Soil Cement Block(8 % cement) Masonry	662.88	0.00	662.88	87.766	64.18	375.47	1126.110	0.00028	0.350	1126.46	47.696	52.30
3	Hollow Concrete Block (10%cement) Masonry	829.60	66.37	895.97	87.695	47.19	276.05	1259.710	0.00096	1.217	1260.93	53.390	46.61
4	Steam cured block Masonry	1268.94	101.52	1370.45	87.766	64.18	375.47	1833.686	0.00028	0.350	1834.04	77.656	22.34
4	Lime soil fly ash brick(25%lime,5%sand ,70%flyash)	1619.61	129.57	1749.18	87.835	80.97	473.65	2310.664	0.00021	0.262	2310.93	97.848	2.15
5	Stabilized Waste Panel Masonry	42.33	0.00	42.33	87.693	46.69	273.14	403.167	Nil	Nil	403.17	17.071	82.93

Table 2- Embodied Energy of different walling materials per cum.



BCBM-Burnt Clay Brick Masonry
SCBM-Soil Cement Block(8 % cement) Masonry
HCBM-Hollow ConcreteBlock(10%cement)Masonry
LSFBM-Lime soil fly ash brick
SWPM-Stabilised Waste Panel Masonry

Figure 1 – Histogram showing the Embodied Energy of different types of masonry with different materials per cu.m. in MJ.

The factors of quality in low cost affordable housing and their parameters are given in nut shell in the chart below.

<table>
<tr><th colspan="3">DESIGN PARAMETERS FOR LOW COST, USER RESPONSIVE, SUSTAINABLE, AFFORDABLE HOUSING</th></tr>
<tr><th>COST</th><th>USER RESPONSE</th><th>SUSTAINABILITY</th></tr>
<tr><td>Layout and Clustering
Sharing of walls
Optimization of building services</td><td>Open Spaces
Conducive Private Open Spaces
User Friendly Community Spaces
Design suitable for all age groups</td><td>Reduce-reuse-recycle
Use of materials with Low embodied energy
Use of Eco friendly materials
Waste water recycling
Use of Solar energy
Rain water Harvesting</td></tr>
<tr><td>Optimum space design
Space efficiency
Circulation</td><td>Incremental Housing
Provision for expanding the space horizontally or vertically</td><td>Climate responsive design sensitive to local climate</td></tr>
<tr><td>Optimum use of volume
Use of inbuilt storage spaces
Multilevel use of space</td><td>Flexibility
Adaptable to activity needs at different time of day</td><td></td></tr>
<tr><td rowspan="3">Time saving
Prefabrication
Industrialization</td><td>Physical comfort
Adequate protection from elements of climate
Excellent light and ventilation
Adequate activity space</td><td rowspan="3"></td></tr>
<tr><td>Mental comfort
Adequate privacy
Social interaction space</td></tr>
<tr><td>Response to Socio Economic Background
Lifestyle
Activity Pattern
Social Behavior</td></tr>
</table>

III. CONCLUSIONS :

The proposed Stabilized Waste Masonry Panel and Floor Panel can give benefit of cost reduction above 70% percent as compared to conventional burnt brick/fly ash masonry and R.C.C. Slab floor. This technology has also very low embodied energy which is 75% lower tremendously contributing to sustainability and reduction of carbon footprint. Hence, this proves to be more suitable as compared to any other technology with lower cost.

The window design using special composite material made out of wood dust and cement is 43% low in cost. Being eco friendly as compared to commonly used materials like Aluminum, Steel or Wood this also is the best option. The technology using these components offers 40% cost reduction over the conventional and is highly sustainable.

An overall the proposed technology is viable is terms of cost reduction sustainability and has less environmental impact.

The user response envisaged is much higher due to following design considerations i) Provision of conducive private open space accessible from most of the areas and its utility value.

ii) Flexibility in use of living space to meet requirements of nighttime activities with system of converting it into a private space.

iii) Scope for incremental growth can be provided by marginally increasing the floor heights to accommodate sleeping and study space at minimal cost at mezzanine level. This will meet requirement of additional space as per growth of family. Such provisions are mostly not available in commonly designed EWS/LIG housing.

Consideration for these necessities would improve user satisfaction as their physical as well as psychological needs will be fulfilled and the housing for EWS category will be more acceptable and livable.

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