# Low Cost Housing: Technology for alternative materials, review and recommendations

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**Abstract:** The provision of low cost housing is a continuous struggle for government as well as for the individuals. In the past many attempts were undertaken to address this issue. One can find numerous examples of realized low cost housing projects worldwide. However, the ideas and projects that were not taken forward and materialized. It is of interest to analyze the existing low cost housing technologies and to draw lessons from them for the future. No single approach and solution is available which will be acceptable in the whole country. The technique has to select on the basis of local climate condition and on the availability of local natural building materials and resources. This publication discusses the use of alternative building materials technology and proposed a new light weight structural composite.

**Keywords:** Low cost housing, sustainable materials, light weight composites, structural panels

## Introduction

Traditional building techniques often consume a lot of wood and the massive reconstruction needs risk to further accelerate the environmental degradation. There is an urgent need to develop new building materials and technologies for low cost housing in rural areas because of (a) increasing population (b) more consumer of energy in construction industry (c) to tackle with natural calamities such as earthquake and tsunami (d) Expensive & scarce building materials and components (e) Severe problem of management of agro industrial waste in developing countries (f) Demand for energy efficiency buildings. There is a need to promote awareness of appropriate construction technologies in civil society and the private sector. Appropriate technologies refer to materials, methods and/or practices which help protect the natural environment, make use of local resources, and contribute to local economic development.

This publication discusses the use of alternative building materials technology such as Interlocking Stabilised Soil Blocks (ISSB) within the context of Indian conditions, as an alternative to burned bricks, use of bamboo as construction material, ferro-cement technology, use of vegetable fibres in cement composite materials and other most affordable options for the construction of houses in rural areas.

Idea of writing this report is to promote the perfect utilization of the locally sourced materials which help in reducing the housing costs.

Table 1-2 shows the break up of cost material, element of buildings, labour and service wise. It appears from the table that maximum cost is occurring for the building materials and floors and roof components of the buildings. These figures prompt us to cut down the cost on the expensive building materials and demanding for low cost floors and panel components. [BMPTC]

Table 1 Break up of Cost - material and element wise

| Material Wise Break up | | Element Wise Break Up | |
|---|---|---|---|
| Cost of Materials | 73% | Foundation | 10% |
| Cement | 18% | wall | 30% |
| Iron and Steel | 10% | Roof | 25% |
| Bricks | 17% | Door and Windows | 15% |
| Timber | 13% | Flooring | 10% |
| Sand | 7% | Finishing | 10% |
| Aggregates | 8% | - | - |

Table 2 Break up of Cost – labour and service wise

| Labour | | Services | |
|---|---|---|---|
| Cost of Labour | 27% | Sanitary Service | 12 to 18% |
| Masons | 12% | Water Supply | 10 to 15% |
| Carpenters | 10% | Electric | 6 to 8% |
| Unskilled Labour | 5% | Painting, White Washing etc. | 2 to 5% |

Table 3 shows the various rates for building materials. Among other building materials, bamboo is the most affordable materials for low cost housing. The use of bamboo and its components is discussed later in this report.

Table 3 Rates of various building materials

| Rates of Various Building Materials | Unit | Rate per unit in Rs. |
|---|---|---|
| Cement | 50 Kg bag | 250 |
| Sand | Per Tonne | 300 |
| Aggregate | Per Tonne | 950 |
| Brick | Per Brick | 5 |
| Steel Bars | Per Tonne | 30000 |
| Tin Sheets | Per Sq m | 90 |
| Bamboo Mesh | Per Sq m | 80 |
| Timber | Per m3 | 2600 |

**Existing Technologies**

Existing technology for low cost housing includes Compressed Stabilized Earth Block (CSEB), use of Bamboo as building materials, ferro – cement, adobe construction, coir fibres, cork floor and panels, fly ash based building components etc. Compressed Stabilized Earth Blocks (CSEB) are manufactured by compacting raw earth mixed with stabilised such as cement or lime under a pressure of 20-40 kg/cm$^2$ using a manual or mechanised soil press. A number of manual and hydraulic machines are available in India. [Fig. 1 (a)] This is very good technique which can be used for affordable housing projects in India. The input of soil stabilization has made it possible to build higher with thinner walls, which have a much better compressive strength and water resistance.

In many part of rural areas, conventional construction materials such as steel are not only expensive but also difficult to obtain. In such situations, the application of abundant locally available materials such as bamboo is ideal as construction material. In addition to this, dead load of the structure will decrease as bamboo is also lightweight material.

Some Properties which make bamboo suitable building materials are

High tensile strength
Light Weight ( Compared to steel)
Environmental friendly
Shock absorbing and thus earthquake resistant
It uses less fossil fuel to manufacture

Ferrocement is a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small diameter wire mesh; the mesh may be made of metallic or other suitable materials. Mixture of Portland cement and sand reinforced with layers of woven or expanded steel mesh and closely-spaced small-diameter steel rods rebar.

Standard cement, usually mixed with plaster sand. The standard cement is reinforced with more steel or fiber at a closer spacing than traditional construction. Reduced spacing yields uniform force dispersion and increases strength. It can be used to form relatively thin, compound curved sheets to make hulls for boats, shell roofs, water tanks, etc. It has been used in a wide range of other applications including prefabricated building components. The economic advantage of Ferro concrete structures is that they are stronger and more durable than some traditional building methods. In India, Ferro concrete is used often because the constructions made from it are more resistant to earthquakes

Adobe or sun-dried mud blocks are a common method of construction in the rural areas and are also used in camps for displaced people. They are environmentally friendly.

Natural fibres, such as coir fibres are becoming an attractive alternative over synthetics fibers due to their advantages such as recyclability, biodegradability, renewability, low cost, light weight, high specific mechanical properties and low density. Nowadays, applications of natural fibers reinforced polymeric composites can be found in housing construction material, industrial and automotive parts. From a mechanical point of view, natural fibres are good candidates for polymeric composites, i.e. low density, high strength, high flexural modulus, and high impact strength

Cork is another source of renewable natural materials just like bamboo. They look like wood, but bamboo is a kind of grass and the cork is tree bark. Their qualities make them suitable for use in floors, and they are easier than ever to find, buy, and install. Once harvested, cork is durable yet light and non-flammable. The cells of the bark are filled with air; they can withstand high pressures without rupturing, and will return to their previous shape. Cork is composed of suberin, a hydrophobic substance, and because of its impermeability, buoyancy, elasticity, and fire resistance.

Fly ash is used as a replacement for some of the Portland cement content of concrete.

Concrete is a mixture of cement and water with fine and coarse materials, such as gravel and sand. Fly ash, a by-product of combustion in a coal-burning power plant, has the same properties as cement when used in concrete. It’s often less expensive, and its use helps keep waste products out of landfills.

**General Remarks**

Taking clue from the above, there is an urgent need to develop the precast panels for walls and floors using low cost materials, so that the faster construction is achieved.

Bamboo is one of the good alternatives in the replacement of steel, as it can achieve same strength as mild steel yet light weight material. Because of light weight material, dead load of the structure is much more reduced yet stronger material. Compared to RCC, ferrocement is almost 50% times lighter than the RCC, which is another good alternative material. Because the reinforcement mesh is denser, there is no water penetration and it can be a good to resist load under seismic loads. CSEB is a good replacement and alternative source for constructing the walls in the replacement of bricks, bricks are more energy consumption. There is more need to develop light weight composites yet durable.

**Ferrocement Bamboo composite sandwich panels:Modelling**

(1) simply supported (SS) plate is analysed under transverse loading conditions, for the sake of saving computational time, only one quarter of the whole plate is analysed. A complete detail of the model is shown in Fig. 10, 11. Material properties used for various materials in the model are also given. (2) Adding steel reinforcement wire mesh to the ferrocement sheet decreases the mid span deflection from 100 mm to 97 mm (Fig. 14). That is not much significant; the reason is wire mesh spacing is 50 mm is taken for the purpose of less computational action. In reality, it (spacing) can be further reduced and further reduction in deflection is achieved. (3) Maximum mid span deflection of 3 m x 3 m square panel is 100 mm (Fig. 13) incase of ferrocement sheet alone, this is for the benchmark purpose and this is compared with available in the literature. Maximum central deflection of a square plate under transverse pressure is given by $w_{max}=0.00416 \times q0 \times a^4/Eh^3$ ( Where h is the thickness of the plate, a = width of the plate, q0 = intensity of the load) gives us deflection of 114 mm). (4) Adding foam in the bamboo does not contribute to any additional strength to the whole structure, only it serves the integrity purpose. (5) Sandwich composite made out of bamboo and ferrocement sheet gives deflection much less about 1.49 mm. (Fig. 12) . (6) Ferrocment section cannot have thickness more than 25 mm. This excludes them for their use in building walls and roofing. Adding bamboo in it will increase the overall thickness of the structure and make it adequate use in building panels.

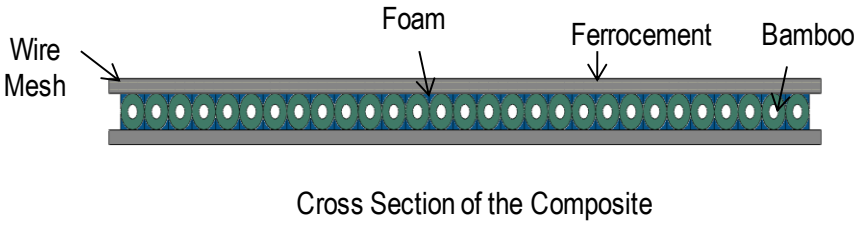
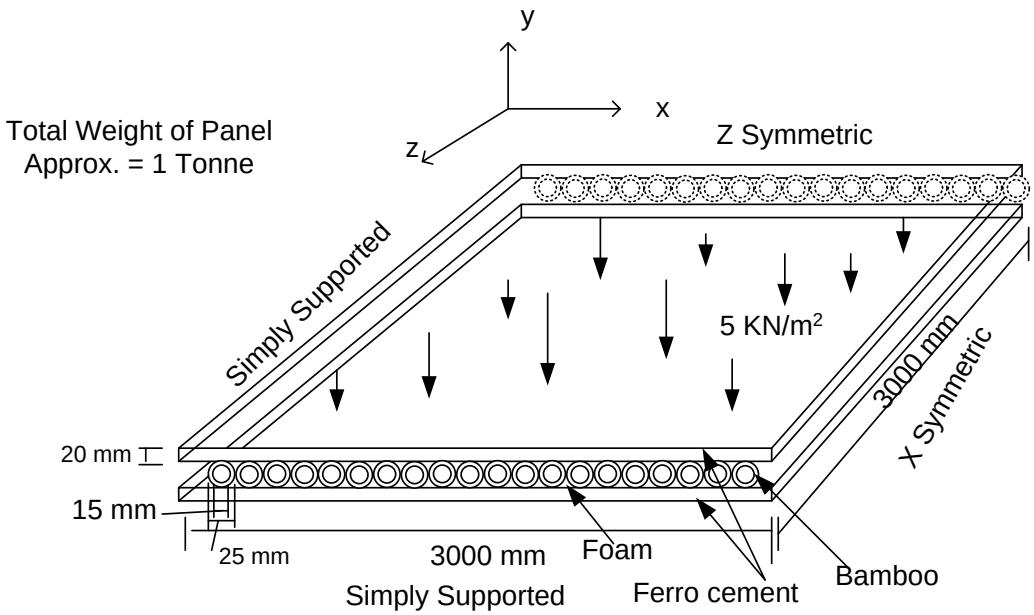



Fig. 10 Cross section of the model




Bamboo Properties

Density of bamboo = $7.5\times10^{-12}$ Ton/mm$^3$,Elastic Young's Modulus of Bamboo = 20000 MPa

Poisson's Ratio of bamboo = 0.3,Coefficient of Thermal Expansion = $0.65\times10^{-5}1/^{o}C$

Foam Properties

Density of Foam = $4\times10^{-11}$ Ton/mm$^3$,Elastic Young's Modulus = 20MPa

Poisson's Ratio = 0.001,Coefficient of Thermal Expansion = $7\times10^{-5}1/^{o}C$

Cement Properties

Density = $2.4\times10^{-9}$ Ton/mm$^3$,Elastic Young's Modulus = 22500 MPa

Poisson's Ratio = 0.18,Coefficient of Thermal Expansion= $1.1\times10^{-5}1/^{o}C$

Fig. 11 Detail of the ferrocement bamboo sandwich composite

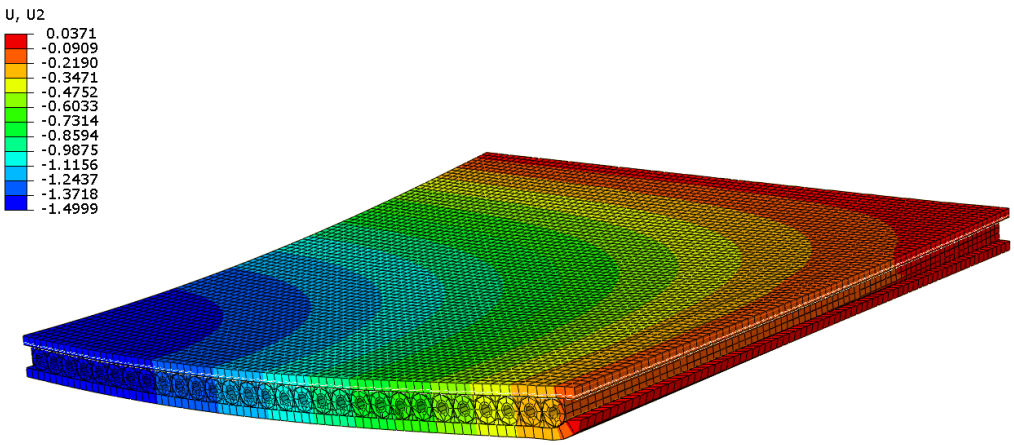



Fig. 12 Ferrocement bamboo sandwich composite under transverse loading

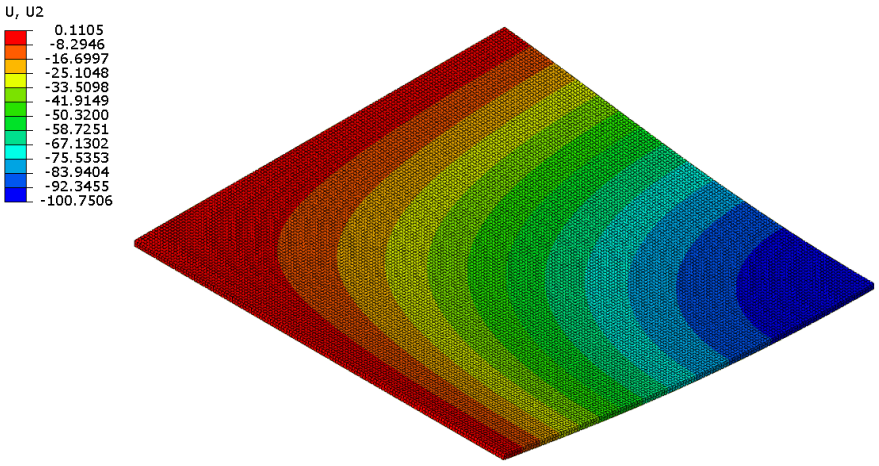



Fig. 13 Ferrocement sheet under transverse loading

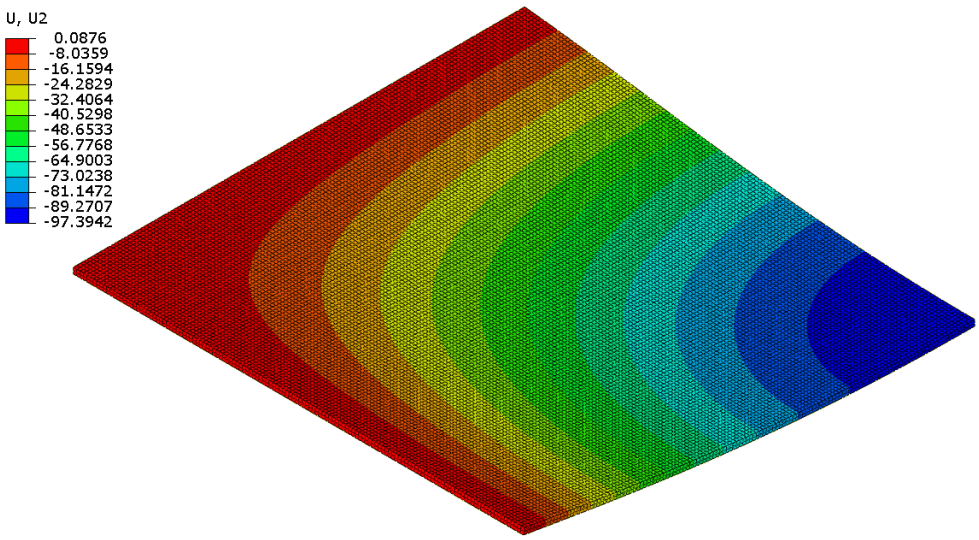



Fig. 14 Ferrocement sheet with 2 layer bamboo wire mesh

## Conclusion

The current practices were identified for low cost housing including low cost building materials as well as construction technologies. Based on the current practice, a model for better quality construction for affordable housing is proposed. A new potential light weight structural composite, that is an integration of ferro cement sheet reinforced with bamboo woven mesh composite is recommended for modern modular housing and building system such as wall/floor and roofing elements. A computational model was generated by analysing these panels for its use in the housing system.

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