Promotion of bamboo Housing system & Recent Developments

Shri K.Shyamasundar and Jagadish Vengala

Abstract

The Bamboo Housing system differs significantly from other established bamboo construction practices in many ways viz. – (a) Use of round bamboo columns and trussed rafters as main load bearing element, (b) Use of split bamboo grids/chicken mesh and plastered with cement mortar to act as shear walls for transmitting wind loads and to provide overall stability to the structure, (c) Application of appropriate preservative treatment of bamboo depending on the degree of hazard and service conditions, (d) Use of BMB gussets in combination with mild steel bolts for load bearing joints in roofing structure, and (e) Use of BMCS as roof claddings.

The technology evolved 'can be effectively adopted for construction of low-cost (single storied) houses with cost ranging from Rs. 300 to 500 per square feet depend upon the design of the house and nature of interior finish, and also upon the local conditions. To promote this technology, IPIRTI had put several demonstrate structures throughout India during the last few years. The details of the above structures and an innovative idea of pre-fab housing and its conceptual are discussed in brief.

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Introduction

Bamboo – A green Gold: Bamboo is rightly called the green gold as it qualifies under many of the categories listed for green building materials.

Globally, there is a resurgence of interest in Bamboo in this age of information revolution and environmental consciousness. Bamboo is being currently looked upon as an alternate low cost material for the enormous housing problem faced by several developing countries. To increase the self sufficiency of developing countries indigenous materials must be exploited to the full. Bamboo is one such material with a long history of usefulness. Several countries in Asia and Latin America still depend on bamboo as an important source of building material not only for construction of rural houses but also for pucca houses and public buildings in towns and cities.

Bamboo a potential environmental friendly material for housing and construction

Fast growing nature of bamboo to provide sustainable supply to meet the demands of the building industry and many positive aspects of modern engineering materials found in bamboo has renewed interest of engineers and architects to use bamboo as an engineering material. Some of the advantages of bamboo are:

i. High tensile strength compared to that of mild steel – can be used for reinforcement in place of mild steel

ii. High strength to weight ratio and high specific load bearing capacity

iii. Requires less energy for production compared to material like steel, plastics, aluminium etc.

iv. Physical-mechanical properties of bamboo which grows to maturity in 4 to 5 years compares favorably with that of hardwood which requires 40 to 50 years to attain maturity.

v. Service life of bamboo can be enhanced considerably by providing suitable preservative treatment.

vi. Studies as in China, India has further established its versatility to be converted into panel and composite material possessing enhanced strength properties suitable for structural applications.

vii. Like wood bamboo also possesses high residual strength to absorb shocks and impacts–this makes it highly suitable material for construction of houses to resist seismic and high wind forces.

viii. Bamboo along with fast grown plantation species is very efficient in sequestering carbon and contributes to the reduction of green house effect.

Potential applications of bamboo in housing/construction

Bamboo trusses

Traditionally timber trusses or rafter-purlins have been in vogue for sloping roofs from time immemorial. Bamboo trusses offer a good substitute for supporting roof loads and transmitting them to the foundation through columns. Bamboo trusses are fabricated using culms having an outer diameter of 75-100 mm. When the top and bottom chords and strut members are properly jointed by suitable fastening devices, a truss can resist compressive and tensile forces conglomerately and as such act as a stronger supporting component even in earthquakes compared to rafter-purlin system

Bamboo truisses

Bamboo roofs skeleton:

Consists of bamboo truss or rafters over which solid bamboo purlins are laid and lashed to the rafter or top chord of the truss by means of G.I wire, cane, grass, sutli or bamboo leaves but not the nails for fear of splits in the bamboo. A mesh or grid made of halved bamboo is laid and lashed to the purlins and roof covered.

Wall Infill Panel: The non-load bearing infill wall comprises of treated split bamboo grid 19 x 9 mm wired together at 150 mm spacing. The grid is tied to MS dowels passing through the columns and to the wall plate using nails and binding wires. Chicken mesh is fixed to the outside face of the grid. A 3:1 mix cement mortar is applied over the grid to a finished thickness of 50mm. When the cement mortar is applied to the walls, they become very strong, but retain the lightness and resilience. These characteristics make the construction inherently resistant to dynamic forces and are therefore beneficial in the earthquake prone areas. Walls are required to resist both static and dynamic forces. Static forces such as self weight and roof loads can be dealt with by calculation. Dynamic force will include impacts, wind and earthquake forces. Tests were carried out both for impact and racking strength based on Indian standard specifications for doors.

Potential applications of bamboo composites in housing/construction

Bamboo Mat board partition wall/ceiling

At IPIRTI BMB has been successfully used as a roof cladding material. BMB being very light, rigid and relatively strong requires very nominal structural frame work of wood or bamboo. Three ply boards, thickness 3 mm have been earlier used in experimental demonstration houses, after treating them with CCB preservatives. 3 mm thick BMB were secured to 5cm x 2.5cm sections hardwood battens at 30 cm spacing with the help of 2 cm long wire nails at 8 cm spacing with vertical and horizontal overlap of 8 to 10 cm. Joints were supported with wooden battens/stiffness.

BMB roofing can be cost effective as compared to conventional tile and sheet roofing, mainly due to saving in the supporting frame work and low cost of BMB in the thickness range, 3 to 6 mm. It is amenable to situation requiring large span where dead load could be critical

Door and window shutters

It is easy to make low cost paneled door and window shutters by laminating panels of bamboo mat boards and stiles and rails of thin sections of wood with either gluing or nail-gluing. A 7-ply 5mm thick board is adequate in a single panel shutter whereas 3-ply, 2.5mm thick board can safely be used in a double door shutter having a maximum panel width of 30 cm. Thin bamboo mat board of 2-ply and 3-ply make excellent skin for hollow core flush doors due to high modulus of rigidity and good impact resistance of the

board. A few experimental doors of this type used under exterior conditions are still in good condition after 12 years.

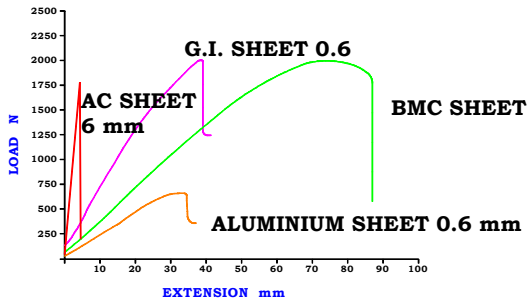
Bamboo laminates for floor

These laminates are finding wider applications for flooring, wall paneling in door and window frames, furniture, etc. as alternate for wood and wood based products. The boards have a natural elegant pattern with beautiful colors. The panels are treated with anti-insects and anti – decay chemicals and bonded with urea or phenolic resin adhesives depending upon end use application.

Bamboo Mat Corrugated Sheet (BMCS):

Bamboo mat corrugated sheet [BMCS]: Roofing materials such as asbestos cement corrugated sheet(ACCS), corrugated fiber reinforced plastics(CFRP), Corrugated aluminium sheet(CAS) Corrugated galvanized iron sheet(CGIS)which have been established for more than several decades, are being subjected to scientific scrutiny on several counts, including their impact on workers health and environment., their energy requirement for their manufacture, and sustainable supply of raw materials. Of late priority is being given, and rightly so to green building materials, based on renewable resources. BMCS is one such material. It is made of four or more bamboo mats bonded with an adhesive and pressed in a specially designed sinusoidal platen dies. They have very high potential as eco-friendly roofing material. The load deflection curves of various corrugated roofing materials indicate the comparative advantage of BMCS over other corrugated materials. The load bearing capacity of BMCS is comparable to that of ACCS and CGI sheets and much superior to ACS. BMCS being light in weight possess high resilience. BMCS is water proof and resistant to decay, termites/insects and fire. The thermal conductivity of BMCS(0.1928

Kcal/m°c) is lower compared ACCS.(0.3422 Kcals/ m°c) and provides better thermal comforts compared to houses having ACCS or CGIS as roofs.



Comparative load-deflection curves

Table 1
Strength properties of BMCS in comparison with other roofing sheets

	Thickness, mm	Width in mm	Max Load, N	Load bearing capacity in N/mm	Weight of sheet(2.44m x 1.05m) in kgs
BMCS(4LAYERS)	3.7	400	1907	4.77	9.78
GI SHEET	0.6	400	1937	4.84	10.43
ALUMINIUM SHEET	0.6	405	669	1.67	3.92
ACCS	6	330	1800	5.45	21.5

These sheets have been already used as roofing material in demonstration houses built by using Bamboo based housing technology

Affordable housing technology developed at IPIRTI using bamboo and bamboo composites [IPIRTI-TRADA]

Engineering and material properties have been studied exhaustively to utilize the full

potential of bamboo as an engineering material in housing. Bamboo housing technology developed at IPIRTI in collaboration with TRADA, U.K. clearly demonstrates the engineering application of bamboo in housing. All load bearing and semi load bearing elements have been made either of round or split bamboo in the form of slivers in combination with bamboo based composites like BMB and BMCS for roofing with minimal use of timber and high energy consuming materials like iron, steel and cement.

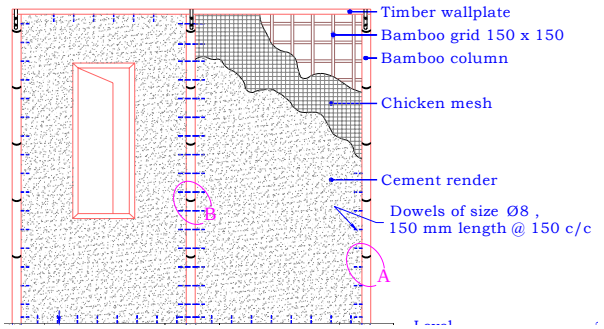


Fig. 1: ***Infill Wall***

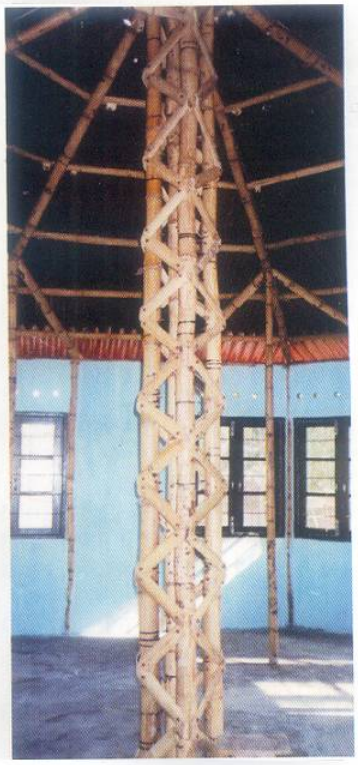
The IPIRTI -TRADA Bamboo Housing system differs significantly from other established bamboo construction practices in many ways viz.,

(a) Use of round bamboo columns and trussed rafters as main load bearing element,
(b) Use of split bamboo grids/chicken mesh and plastered with cement mortar to act as shear walls for transmitting wind loads and to provide overall stability to the structure,
(c) Application of appropriate preservative treatment of bamboo de-pending on the degree of hazard and service conditions,
(d) Use of BMB gussets in combination with mild steel bolts for load bearing joints in roofing structure, and
(e) Use of BMCS as roof claddings.

The low mass of the bamboo based building is an advantage under earthquake condition as compared to masonry structures. The buildings constructed in bamboo using this method are able to withstand the highest levels of earthquake loading likely to be experienced in India. The test building of 2.7m^2 resisted seven repetitions of a typical Zone 5 earthquake, the highest in India and equivalent to 7 on the Richter scale, as well as a replication of the notorious Japanese Kobe earthquake (Richter 7.8), without any damage whatsoever.

Demonstrate structures constructed at several places in India during the last few years are given below. The details of the same and an innovative idea of pre-fab housing and its conceptual are discussed in brief.

The Ministry of Urban Employment & Poverty Alleviation, INDIA had sanctioned two projects for putting up Demonstration buildings using above technology in Tripura and Mizoram (Northern India). Building Materials and Technology Promotion Council (BMTPC) India, is putting up demonstration buildings using the above technology in Mizoram in order to propagate use of locally available bamboo.



The Roof Detail

Houses at Mizoram, 2005

Rain Shelter for Delhi Zoo at New Delhi, August 2000

Bamboo House built at AGARTALA

Based on the IPIRTI-TRADA technology a few demonstration houses have been built at different parts of Southern India are as shown below

Proto Type House at IPIRTI, Bangalore February 1999

Demonstration House at Chikkabettahalli, Bangalore, October 1999

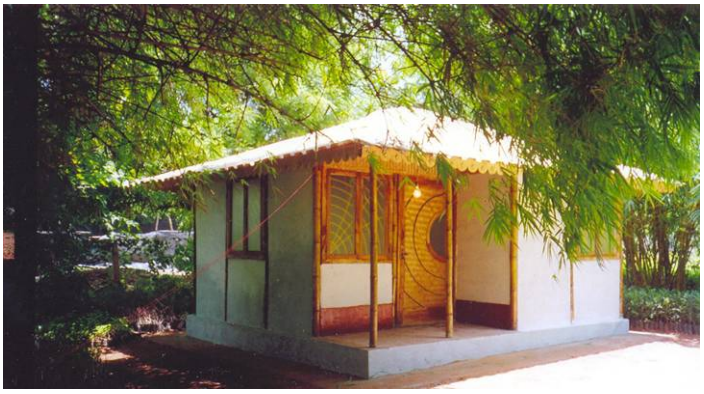
Demonstration two bed room house at IPIRTI – Bangalore, January 2002

Demonstration House at IPIRTI – Bangalore, March, 2001

Recent Photograph

Pantry Building at Raj Bhavan, Bangalore, January 2001

Security House at IPIRTI, Bangalore, 2004



Bamboo House at Rajmundry, Andhra Pradesh, 2004

The Roof Detail

Bamboo House at FRI,
Chennai – Tamil Nadu

Solar Bamboo Hut at
Bangalore – Karnataka, 2005

Recent studies on Bamboo based walling System:

Testing of panels under progress

Recently, A study has been conducted to utilize the fly ash as part replacement of cement in Bamboo walling system. The results shows that utilization of fly ash as part replacement of cement (up to $1/3^{rd}$) in bamboo based walling system provides better bonding with chicken mesh & bamboo strips, improved surface finish and high water retentivity (as observed visually) when compared with the control panel as tested for the purpose. The forces imposed on the test panels were intended to replicate the most severe conditions likely to be experienced during the life of the structure. The test panel with fly ash resisted the forces with minimal deflection and total absence of damage (including superficial cracking) on par with the panel without fly ash and is more than adequate for its intended applications. The study emerges that inclusion of fly ash in mortar does not alter the structural performance of bamboo based walling system.

Prefabricated House: Bamboo construction technique is also amenable to prefabrication either in the form of precut or prefabricated components like trusses, frames, columns, wall panels and beams (BMB and wood Glued components) or as fully prefabricated units which could be transported.

PREFABRICATED BMB WOOD SHELTER

Recently a prefabricated composite house conceptual was made and a computer model was generated. Construction work is about to start. In this concept, the foundation is of stone masonry construction and a composite connection was made between wall system and the foundation. The walling system is of prefabricated frames made using Aluminum/Steel angles & channels and pre fabricated Bamboo Mat Board (BMB) panels of various sizes were fitted into the frames using locking system. BMB gussets in combination with mild steel bolts are used for load bearing joints in roofing structure, and BMCS is used as roofing.

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