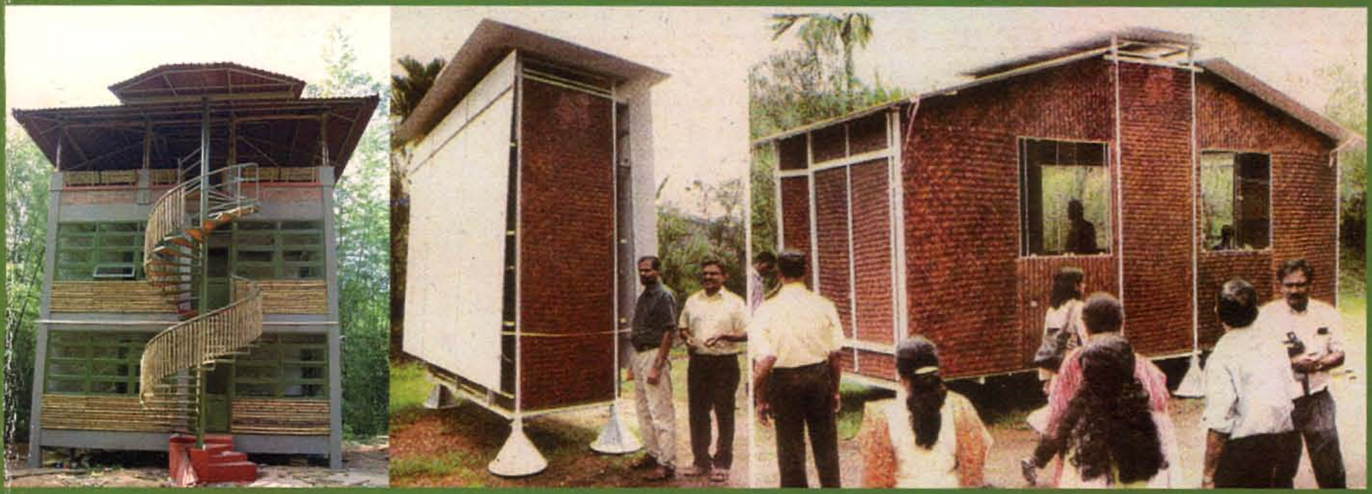
KFRI Research Report No. 393

ISSN: 0970 - 8103

BAMBOO FOR AFFORDABLE SHELTER

DEMONSTRATION OF APPROPRIATE CONSTRUCTION PRACTICE AND CONSTRUCTION OF DURABLE MODEL BAMBOO HOUSE



T K Dhamodaran
R Gnanaharan

Wood Science and Technology Division
Kerala Forest Research Institute
Peechi – 680 653, Kerala, India

April 2011

OUTLINE OF THE PROJECT PROPOSAL

1	Project Number	KFRI 484/'05
2	Title of Project	Bamboo for affordable shelter: Demonstration of appropriate construction practices and construction of durable model bamboo house
3	Principal Investigator	Dr. T. K. Dhamodaran, (Wood Science & Technology)
4	Associate Investigator	Dr. R. Gnanaharan, Research Coordinator (Wood Science & Technology)
5	Objectives	(i) Develop appropriate designs for durable and cost effective bamboo houses suitable for Kerala conditions and construct model houses for demonstration of the building technology (ii) Develop appropriate design for portable expandable modular house with bamboo ply board and construct model house suitable to ecologically sensitive forest areas, pilgrim centres, calamity affected areas, eco-tourism, resorts etc. (iii) Publish a handbook on the design, joinery and structural aspects of bamboo houses suitable for Kerala conditions
6	Funding Agency	
7	Budget Outlay	Rs. 21,32,000/-
8	Duration	3 Years

CONTENTS

ACKNOWLEDGEMENTS

Our sincere thanks are due to Mr. G. Jaigopal and Mrs. Latha Jaigopal, Partners, and Ms. N. M. Shobha, Supervising Engineer of M/s. INSPIRATION, Architects, Kochi for successfully undertaking the construction work. Financial support from the plan funds of KFRI, without which this project could not have been taken up, is sincerely acknowledged. Sincere thanks are due to Dr. J. K. Sharma, former Director and Dr. K. V. Sankaran, Director, KFRI for their keen interest in the study and constant encouragement. Services of the Engineering Division of the KFRI are sincerely acknowledged. The service of Mr. S. Babu and Engr. K. N. Arun Raj, Senior Project Fellows; Mr. P. Sijo, Technical Assistant, Wood Science & Technology Division, KFRI is sincerely acknowledged. We thankfully acknowledge the editorial service rendered by Dr. K.V. Bhat, Dr.V.V.Sudhindrakumar and Dr. K.Seethalakshmi, Scientists of KFRI.

ABSTRACT

Bamboo has been traditionally used as a construction material for the middle and poor class houses in India, especially in the northeast states of the country. Realizing its potential as a renewable low-energy embodied partial substitute for the conventional high-energy embodied building materials, an attempt has been made to improve the traditional indigenous knowledge on bamboo housing by incorporating modern concepts of architecture and civil engineering technologies coupled with cost effectiveness and aesthetics. The project envisages designing bamboo houses appropriate to Kerala conditions and demonstrating the best construction practices for using bamboo for affordable housing. Preservative treated bamboo was used for the construction of floor, wall (plastered bamboo grid wall), and roof. Standardized lengths of round and half-split bamboos were pressure treated with copper – chrome arsenic (CCB) preservative so as to achieve the dry salt retention recommendations of the Indian Standards, air dried and utilized. Columns were built in the traditional way, thin ferro-cement beams were used wherever necessary; doors and windows were made with hardwood. Country bricks were used wherever unavoidable. A bamboo house structure was designed appropriate to the Kerala conditions, constructed and demonstrated. The house having a ground plus one floor and an attic floor, each with 31.83 m^2 (342.5 ft^2) area, totaling to around 95. 5 m^2 (1030 ft^2) was constructed for demonstration of the best construction practices at the KFRI Sub-Centre campus in Nilambur, Malappuram District, Kerala. The attic floor of the house demonstrates the use of bamboo for trusses, rafters, purlins and joists and their jointing methods. Being the maiden attempt for demonstration, the cost of construction came almost equal to a brick-cement construction. However, experiences from the present attempt will definitely help to reduce the cost in future constructions.

The potential of bamboo ply boards for developing portable modular houses especially suitable for ecologically sensitive forest areas, pilgrim centers, calamity affected areas, eco-tourism, resorts, etc, is also investigated. A bamboo-ply based steel framed modular structure in which the sections were hinged together so as to facilitate easy folding, packing and transportation was fabricated and installed at the KFRI campus in Peechi, Thrissur, Kerala. The entire structure with 15.8 m^2 (170 ft^2) area was possible to pack up into a rectangular box with the component sections itself for facilitating easy and quick transportation. The structure also permits jointing of two or more units together. Experiences gained from the present work strengthened the scope for achieving further enhanced portability by reducing the weight and cost reduction at mass production.

The present attempt is expected to create a positive awareness and impact on the promotion of bamboo for affordable green housing which can resist natural calamities like earthquakes.

Key words: Bamboo house, preservative treatment of bamboo, bamboo grid wall, bamboo joinery for attic roofs.

INTRODUCTION

Housing is an undeniable need of all classes of the society. In views of affordability and eco-friendliness, bamboo has emerged as a promising housing material. Scarcity and price factors of traditional woods and constraints with the use of non-wood materials have focused attention on the use of bamboo as a building material. Use of bamboo in building construction has its long history in different parts of the world. In India, the northeastern states have the rich culture in affordable bamboo housing. Apart from the aesthetic value, it is the most suitable structural material for housing to earthquake-prone areas, as the dead weight of bamboo houses is low. The use of bamboo as timber substitute offers ecological security in terms of conservation of forests, efficient carbon sequestration and as an alternative material to non-biodegradable and high-embodied energy materials like plastics and metals.

It has been proved that bamboo has the strong potential for its use in housing. The 'common man's timber has been traditionally used for the construction of shelters (huts) and other temporary structures. Its use in very difficult construction sites like steep hills, earthquake-prone areas or swampy costal areas is well known in India. Utilizing traditional indigenous knowledge and blending it with modern building technology and demonstrating the best construction practices for bamboo houses are the need of the hour as far as for bamboo utilization for housing in Kerala is concerned. A study conducted by the Kerala Forest Research (KFRI) in Kerala, Karnataka and Orissa showed that bamboo houses are economically viable, as assessed in terms of availability, acceptability, affinity, affordability, adaptability and cost of construction (Murleedharan and Anitha, 2000). Methods to overcome the poor durability of bamboo have also been evolved (Gnanaharan, 2000) and bamboo-based building systems are already available with the Indian Plywood Industries Research and Training Institute (IPIRTI, Bangalore) (Reddy *et al.,* 2001). It is with this objective, the present project was planned for developing appropriate design and construction techniques suitable to Kerala conditions for setting up of durable bamboo houses.

The potential of bamboo ply boards for modular houses especially suitable for ecologically sensitive forest areas, pilgrim centers, calamity affected areas, eco-tourism, resorts, etc was also chosen for testing by developing a suitable design and fabricating and installing the same.

In general, the project envisaged to demonstrate appropriate construction practices by putting up a model bamboo house (permanent type) in the premises of the Teak Museum at the KFRI Sub-Centre campus at Nilambur, Malappuram District, Kerala and to develop, fabricate and install a model modular portable bamboo house (made with bamboo ply board). As "seeing is believing" and as at present there is no model bamboo house available anywhere in Kerala, the proposed attempt is expected to create a positive awareness on affordable bamboo housing technologies.

REVIEW OF LITERATURE

Housing is one of the priority items in the National agenda. Meeting a target of adding 7 lakh urban housing units and 13 lakh rural housing units per year for the country involves the management of material resources efficiently to reduce the gap in housing shortage. As the country is already in short of high-energy consuming materials like cement, steel and bricks as well as primary timber resources, there is an urgent need for looking into the possibilities of utilizing low-energy embodied materials at the maximum. Scarcity and high price of traditional woods and environmental constraints with the use of non-wood and synthetic materials like plastics have focused attention on the search for alternative affordable and eco-friendly building materials.

The concept of 'green' building materials derived from renewable materials, consuming less energy and less polluting, and environmentally sustainable is gaining global importance. Optimization of the use of non-renewable building materials like steel and cement needs to be achieved through the rational utilization of composite or re-constituted materials from renewable fibre materials including agricultural residues. The diminishing wood resource and restrictions imposed on felling of natural forests and certification issues related to tropical plantation timbers have focused world attention on the need to identify suitable substitute materials which should be renewable, environmentally friendly and widely available.

The INBAR global bamboo housing programme emerged due to the pressing need for affordable and sustainable building materials to provide homes to the millions of people who are either homeless or live in temporary hovels. UN habitat has reported that 1.1 billion people live in inadequate housing conditions in urban areas alone and an estimated 100 million people are homeless around the world, with increasing proportions of women and children. To improve housing conditions to acceptable levels some 95,000 new urban housing units have to be constructed each day in developing countries.

Why bamboo?

Bamboo is one of the fastest growing plants (7.5-16 cm per day in height; exceeding most fast growing woods) grown on the earth, suitable for the use as building material. It belongs to the grass family *Poaceae* and sub family *Bambusoidae*. There are 75 genera with 1250 known species, out of which about 136 species occur in India. The country is the second richest habitat in the world next to China in bamboo resources. After the northeast states, Kerala has abundant bamboo resources. *Bambusa bambos* and *Dendrocalamus strictus* are the two major naturally occurring species in Kerala suitable for structural applications. It is one of the oldest and most versatile building materials with many applications in the field of construction. Traditionally bamboo has been put under use for shelter in the bamboo rich north-eastern states of India for hundreds of years. It has been proved that bamboo has the strong potential for use in housing. The 'common man's timber' has been traditionally used for the construction of shelters (huts) and as temporary residences to be replaced later. Its use in very difficult construction sites like steep hills, earthquake-prone areas or swampy costal areas is well known in India. Millions of people still depend on bamboo for their livelihood, and for household and agricultural uses. They are also important in the context of disaster mitigation and post-disaster rehabilitation. Its use through industrial processing has shown a high potential for production of composite materials and components which are cost-effective and can be successfully utilized for structural and non-structural applications in construction. The main characteristic features, which make bamboo a potential building material, are its high tensile strength and very good weight to strength ratio. It can withstand up to 3656 kg/cm^2 of pressure. It can be easily worked with simple tools and machines. The strength-weight ratio of bamboo also supports its use in situations of high velocity winds and earthquakes. Construction techniques developed recently by the Indian Plywood Industries' Research and Training Institute (IPIRTI) and Building Materials Technology Promotion Council (BMTPC) for using bamboo as main material for housing were tested in the Earthquake Engineering and Vibration Research Centre of the Central Power Research Institute, Bangalore and have been found highly suitable for earthquake resistant housing. Impact and racking strength tests conducted as per Indian Standards have shown that the bamboo grid wall infill panels are sufficiently strong. Load tests on bamboo mat corrugated sheets (BMCS) roof covering and bamboo roof truss as per Indian Standards assured the required performance. Thus, if properly preservative treated and industrially processed, components made by bamboo can have a reasonable life of around 50 years and is a potential eco-friendly alternative for modern houses and buildings. With the rising need of housing, advancements in bamboo technology offer several cost-effective and environment-friendly options for its utilization in housing.

Importance of bamboo for housing

Raising bamboo plantation or cultivating a few bamboo clumps requires only low inputs compared to raising traditional hardwood trees or plantations for timber and the fact that it can be harvested within a few years makes it possible for one to prepare a short-term plan for cultivating a few bamboo clumps for his own housing requirements; suitable bamboo house plans can be made for the "do – it – yourselves" model bamboo houses, where one can construct small and beautiful shelters by their own hands. Further, it is an ideal low energy embodied material for substituting a significant quantity of high energy embodied high-priced traditional construction materials like steel, cement, bricks, plastics, etc. All these makes it an environmentally and economically suitable affordable housing material.

Traditional methods

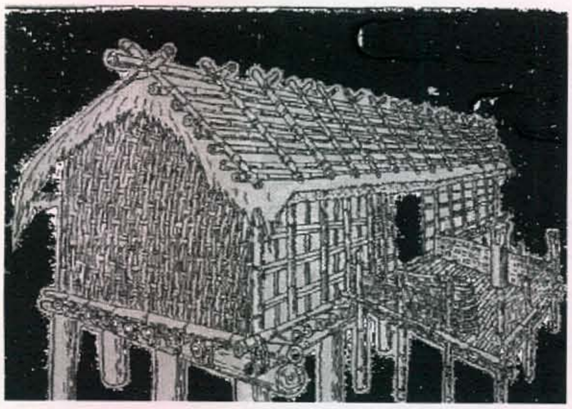
Overseas Scenario

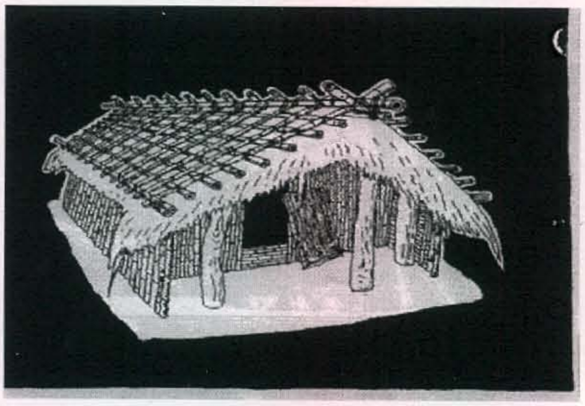
Bamboo has been extensively under use for housing and for commercial buildings in Latin American countries, Costa Rica, etc. Indigenous bamboo housing technology has been updated with modern engineering concepts. Some examples from the Columbian bamboo housing architecture given below will convince the potential of bamboo for engineered multi-storied commercial and residential buildings as well as buildings specially designed for the wealthy class.

In Columbia and Ecuador, a large area that has been an authentic bamboo culture with a strong tradition of bamboo housing has houses 50-100 years old, and most of the houses are built on very steep hills, earthquake-prone or swampy coastal areas. The structural adequacy of these houses was studied by Guiterrez (2000). The traditional bamboo hollow *bahareque* houses and buildings were found to possess a level of excellence that provides them extended durability in humid environments and resistance to earthquakes that are frequent in the region. The weight of the exposed bamboo structures (without mortar) was found to be less than 10% of the weight of similar masonry houses. Even hollow *bahareque* houses with cement mortar weigh only one-third of a similar masonry house. The significant reduction in the mass of the structure is very effective to get protected against earthquakes as the gravitational vertical loads and the horizontal seismic loads are found directly proportional in these houses. Care needs to be taken in regions prone to extreme winds, bare bamboo walls should be avoided and special structural details needs to be worked out to provide resistance to the tensional forces that may be produced by the wind's uplifting effects. The hollow *bahareque* walls plastered with cement mortar are found to form effective structural wall elements with very high strength and stiffness.

The Indian Scenario – Conventional bamboo houses

Some of the typical north-eastern bamboo hut structures prevalent in Assam region are depicted below:





A 41-year-old Architecture Masters' course dissertation published by the Cane and Bamboo Technology Centre (CBTC) (2001) reports about the attempt of Engr. Bipul Kumar Das for finding out a system of building construction with bamboo as the principal material. This work includes an exhaustive sketching of the then Assamese traditional bamboo housing system, followed by the experience with the construction of an experimental residential building with extensive use of bamboo constructed in 1973 where the author lived for 25 years; the aftermath of success in this project is the use of bamboo roof – cum – floor system in RCC framed structure again for self occupation done in 2000. The dismantling of portion of the old structure for renovation showed that the bamboo inside concrete remains safe.

Engineering interventions in traditional bamboo housing system

The salient technical aspects of building with bamboo – such as mechanical properties, modeling and related calculations, and jointing techniques – as well as some economic facets of bamboo – such as plantation economics and job creation potential are described by Jules Janssen (2000); this consolidation provides a comprehensive view on bamboo's place in the world of design and construction. Application of bamboo in construction is detailed by Jayanetti and Follett (1998).

Some of the results of civil engineering interventions in the traditional bamboo housing structures of the northeast are depicted below:

Round bamboo has been used as columns or pillars and beams; round/half-split bamboo has been used as rafters and purlins. Asbestos – cement or tin corrugated sheets were used for roofing. Plastered bamboo infill grid wall panels retain the common look of the house. Sometimes crushed bamboo sheets were used as wall panels.

The National Institute of Design (NID), Ahemadabad has developed various designs for bamboo furniture; Indian Institute of Technology (IIT) Mumbai and Guwahati had done considerable work on improving bamboo joinery and tools and small machinery for handicrafts. As per a study conducted by KFRI in Kerala, Karnataka and Orissa showed that bamboo houses are economically viable, as assessed in terms of availability, acceptability, affinity, affordability, adaptability and cost of construction (Murleedharan and Anitha, 2000). Methods to overcome the poor durability of bamboo have also been evolved by various workers (Gnanaharan, 2000; Kumar *et al.*, 1994; Liese and Kumar, 2003). Engineered bamboo-based building systems are already available with the Indian Plywood Industries Research and Training Institute (IPIRTI) (IPIRTI, 2001). Bamboo cultivation, propagation and plantation technologies are available with KFRI. International Network for bamboo and Rattan (INBAR) at Beijing, China is another international agency working exclusively on bamboo and rattan (cane) utilization and creating awareness and networking on a global level. Training for farmers, planters, industrial entrepreneurs and house builders is also offered in many of the above institutions. The Bureau of Indian Standards (BSI) has various standards for testing bamboo and bamboo products. Recently bamboo has been included in the National Building Code.

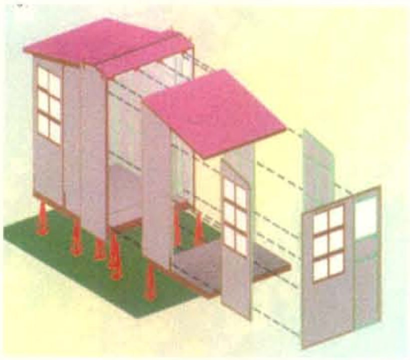
Walling and roofing are two crucial elements in housing and several R & D institutions have been engaged in developing innovative, alternative materials for the purpose. The technology for manufacturing Bamboo Mat Corrugated (BMC) Sheets for roofing has been jointly developed by IPIRTI and Bamboo Technology Promotion Council (BMTPC). The Bamboo Board Factory of the Kerala State Bamboo Corporation (KSBC) at Angamaly, Eranakulam District, Kerala is engaged with commercial production of woven mat based Bamboo Ply Boards, which can be used for the purpose of panel boards. Bamboo Mat Veneer Composite (BMVC) is another product developed by IPIRTI that have already attracted entrepreneurs and gained user acceptance as alternative to wood. Recently production of bamboo – jute composite corrugated roofing sheets has also been initiated in the north-east.

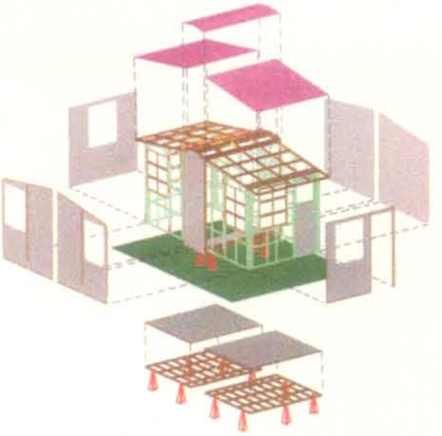
IPIRTI has developed a building system using round bamboo for columns, split bamboo for chicken mesh reinforced cement plastered wall grids, BMCS for roofing, Bamboo Ply Boards for paneling, door and window shutters (IPIRTI, n. d.). The system is based on 1.2 m module with preservative treated bamboo posts and sliver reinforced cement mortar wall panels of 5 cm thickness. The experience on this bamboo housing system has shown that the system is cost effective, attractive and is expected to withstand normal weather and wind conditions. Being light it can be suitably utilized by adopting appropriate design for earthquake prone regions. The prototypes already constructed have shown high potential for wider propagation, particularly in northeastern and other bamboo growing regions where traditional building practices already exist but need to be improved for longevity of buildings. Experiences have also shown that durable bamboo houses of good aesthetic quality can be built with comparable cost with the traditional construction costs. Prototype demonstration houses are built at the IPIRTI campus and in the Energy Park campus at Bangalore. The houses are put to use as watchmen cabins, staff quarters, staff recreation club, resort, etc. All the houses are found to be strong as far as safety is concerned. Houses are tested up to 7 years. IPIRTI and BMTPC are also conducting training courses on bamboo housing systems and encourage and facilitate visitors to bamboo houses. Some of the IPIRTI bamboo housing system is depicted below:

Portable modular Bamboo Housing System

No work has been reported on the fabrication of a portable type modular house made with bamboo or reconstituted bamboo products; but the general article by Soriano (1997) on the successful fabrication of a portable house made with wood-wool based modular components gave an insight into how such a concept can be developed for designing a portable house made with modular reconstituted bamboo components such as bamboo ply board with steel section frames and hinges for folding for making it convenient for packing with self-sections.

The above F- House developed by the Forest Products Research and Development Institute (FPRDI), Philippines serve as the basic model which can be further developed and appropriated to suit our environment (Soriano, 1997). Pictures given below show the fully erected F – House (2.4 x 4.8 m) with its enlarged view. All the components and joints in the F – House are shop assembled, packed into a casing with dimensions 1.0 x 2.4 x 2.6 m appropriate to local road conditions (Fig .3 B) and transited and erected at site within an hour. Figs. 3 C & D show an exploded view of the F – House. Bamboo ply boards could be an ideal substitute for the cement-bonded wood-wool boards used for the original fabrication of the Philippine modular house. This will reduce the weight and add more rigidity to the product. Adoption and modification of the above mentioned modular housing system to make it suitable to the local conditions and requirements needs transfer of technology and further research efforts. The potential of bamboo ply board for modular housing will open up new avenues of its utilization in ecologically sensitive forest areas, pilgrim centers, calamity affected areas, eco-tourism, resorts, etc. This ultimately benefits the poor mat weaving community as well as modern eco-tourism industry.





Assuming a 10% substitution of timber with bamboo and bamboo-based products for housing in the country, it has been calculated that in housing alone bamboo will have a share of Rs. 435 crores per year at the current price level. Similarly the other types of buildings for community centers, schools, health care, tourism, etc would also offer a large share for bamboo which definitely improves the livelihood opportunity as well as ecology and environment.

MATERIALS AND METHODS

The site plan of the bamboo house constructed at the KFRI Sub-Centre campus at Nilambur, Malappuram District, Kerala is given in Fig. 1.

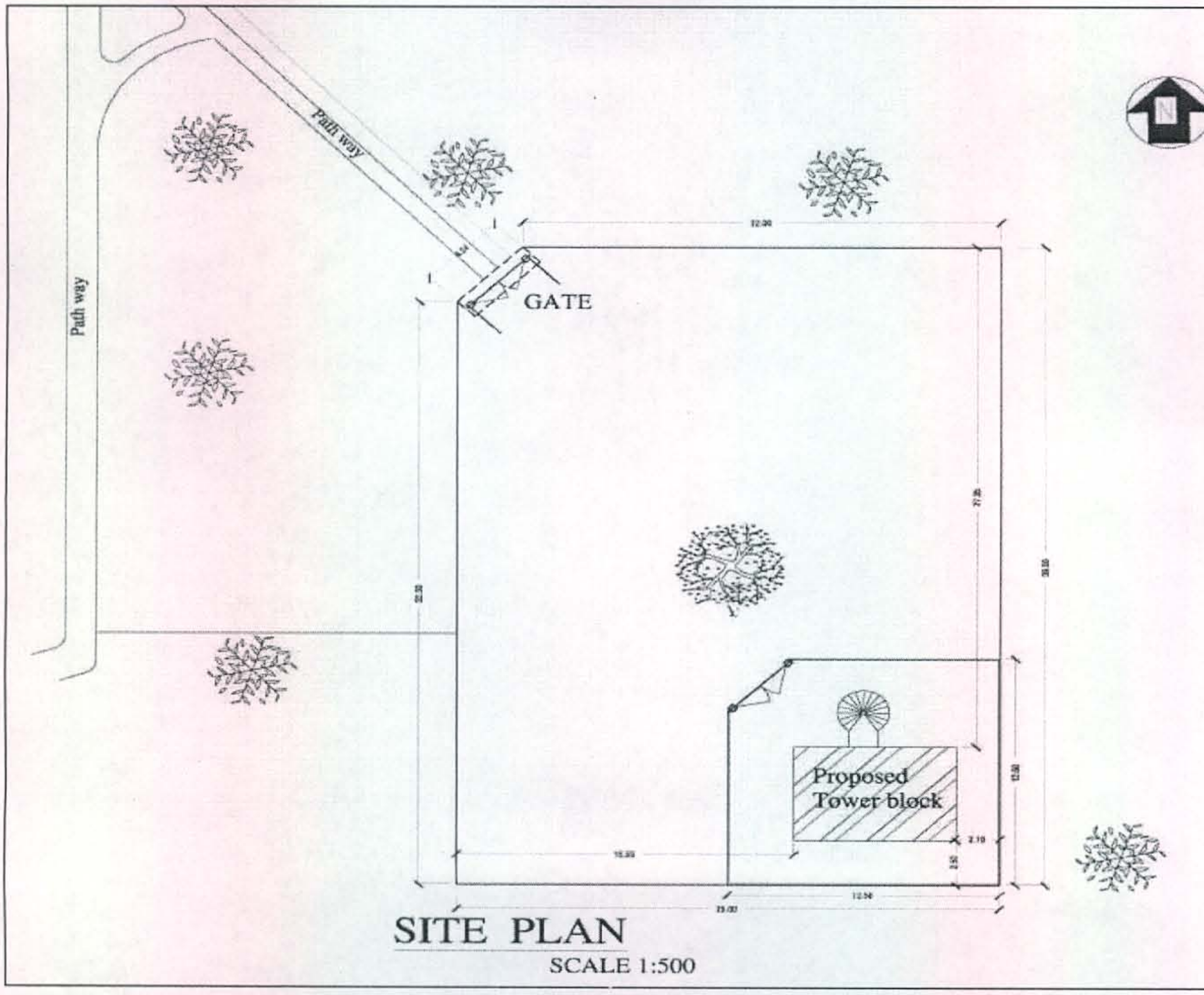


Fig. 1 Site plan of the bamboo house.

The floor plan is given in Fig. 2. The floor area was 7.5 m x 5.15 m; the entire building is built on 9 columns equidistantly placed. To facilitate the laying of bamboo for floor casting, between two columns, 2 numbers of pre-cast beams in the length side and one pre-cast beam in the width side are given; totally 4 pre-cast beams in the lengthier side and 2 numbers along the width and 4 in the central line.

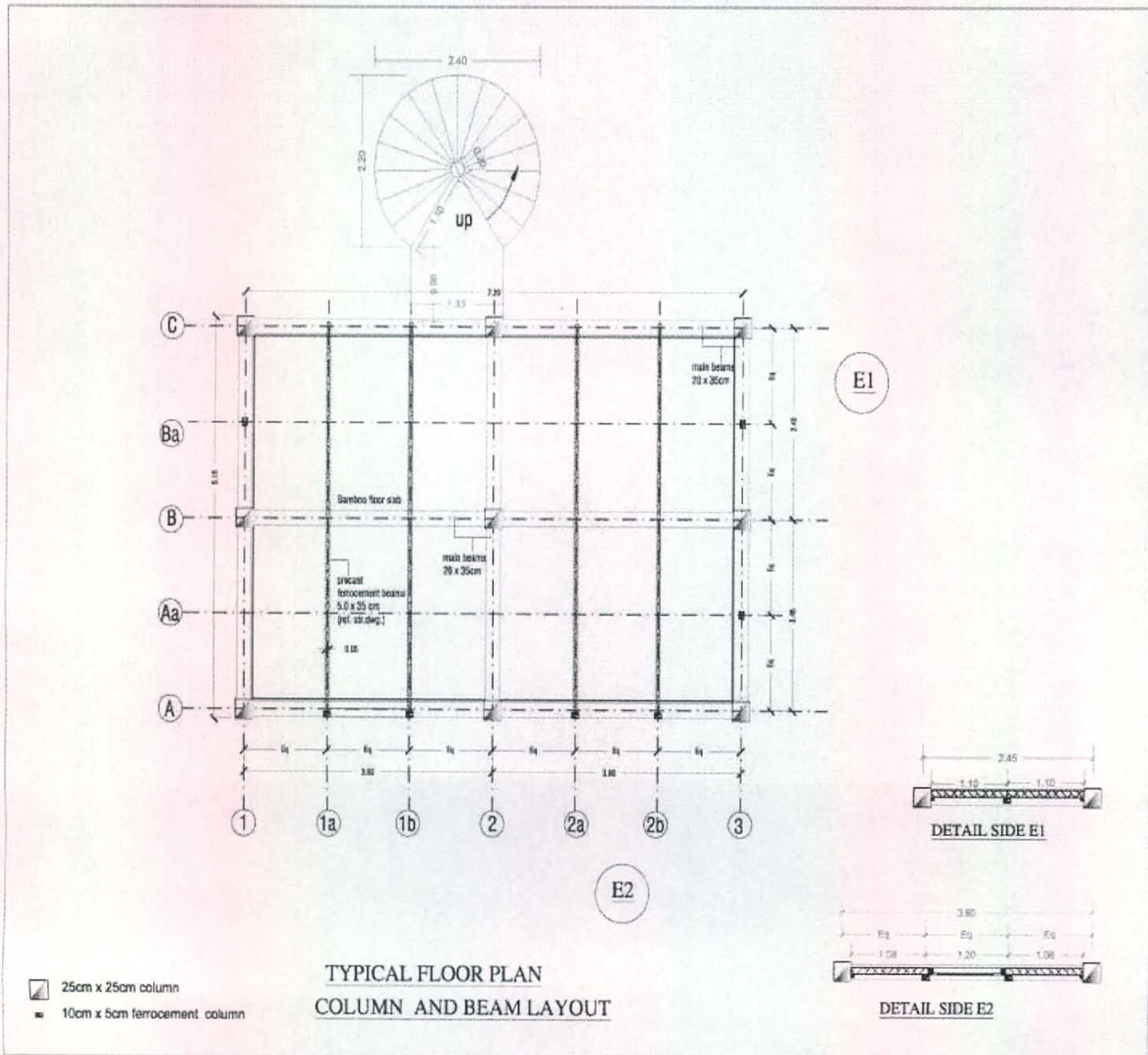


Fig. 2. Floor plan and column and beam layout of the bamboo house.

Fig. 3 shows the detailed plan of the ground floor and the repetition in the first floor. The structure consists of a direct landing entry (height 2 feet from the ground) to a living area of 3.53 m x 2.46 m adjoined by a bed room of 3.35 m x 2.28 m area. Entry to the bed room is from the living area. A dressing area of 2.2 m x 2. 46 m with entry from the bed room, followed by a toilet of 1.08 m x 2.46 m area adjoining with the dressing area. Entry to toilet is from the dressing area only. A kitchen of area 3.53 m x 2.28 m is adjoining with the living area, with entry from the living area.

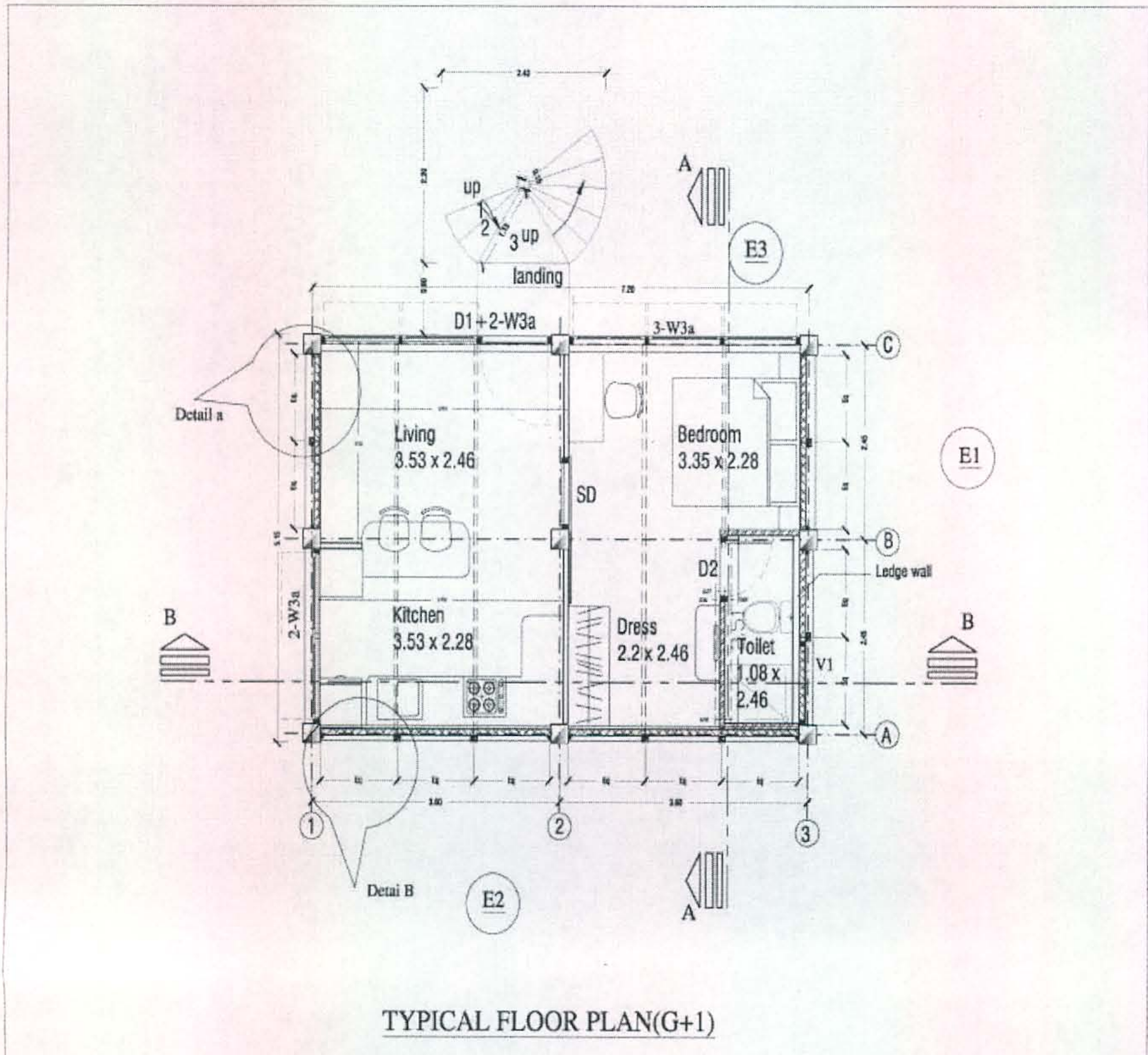


Fig. 3. Detailed plan of the Ground floor and the first floor (repetition).

The G+ 1 attic floor structure is given in Figs. 4 and 5. This has got an open area of 6.6 m x 4.5 m; bordered by parapet of Kerala style "*charupadi*" made with round bamboo. The attic floor is roofed with jute-bamboo composite corrugated sheets. Roof truss structure is supported by bamboo columns. Each column consists of two numbers of round bamboo pillars joined mutually on the top end by means of ms sleeves from the 2" ms pipe ridge placed over ten columns as shown in Fig. 5. Purlins are made of bamboo.

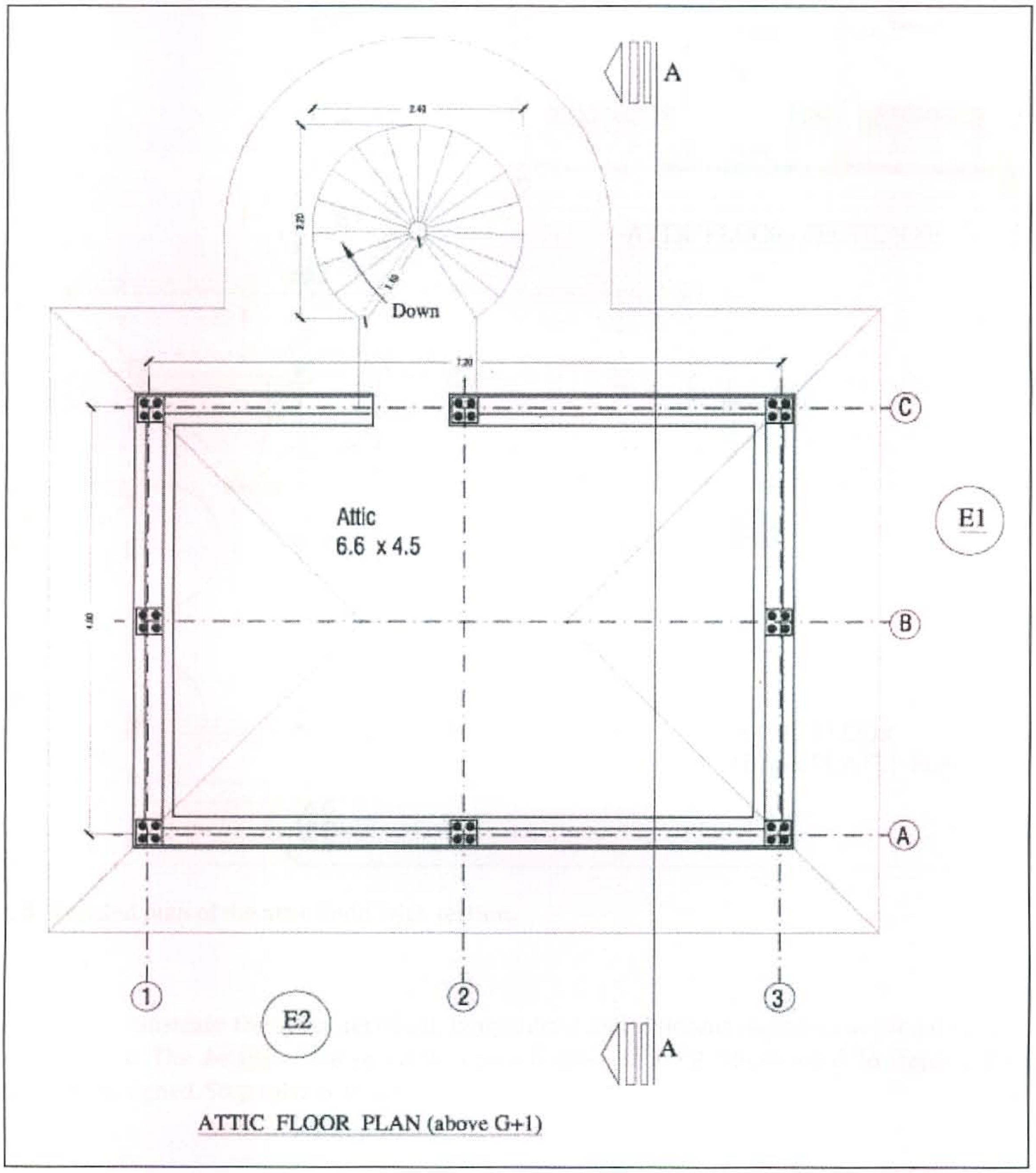


Fig. 4. Plan of the attic floor.

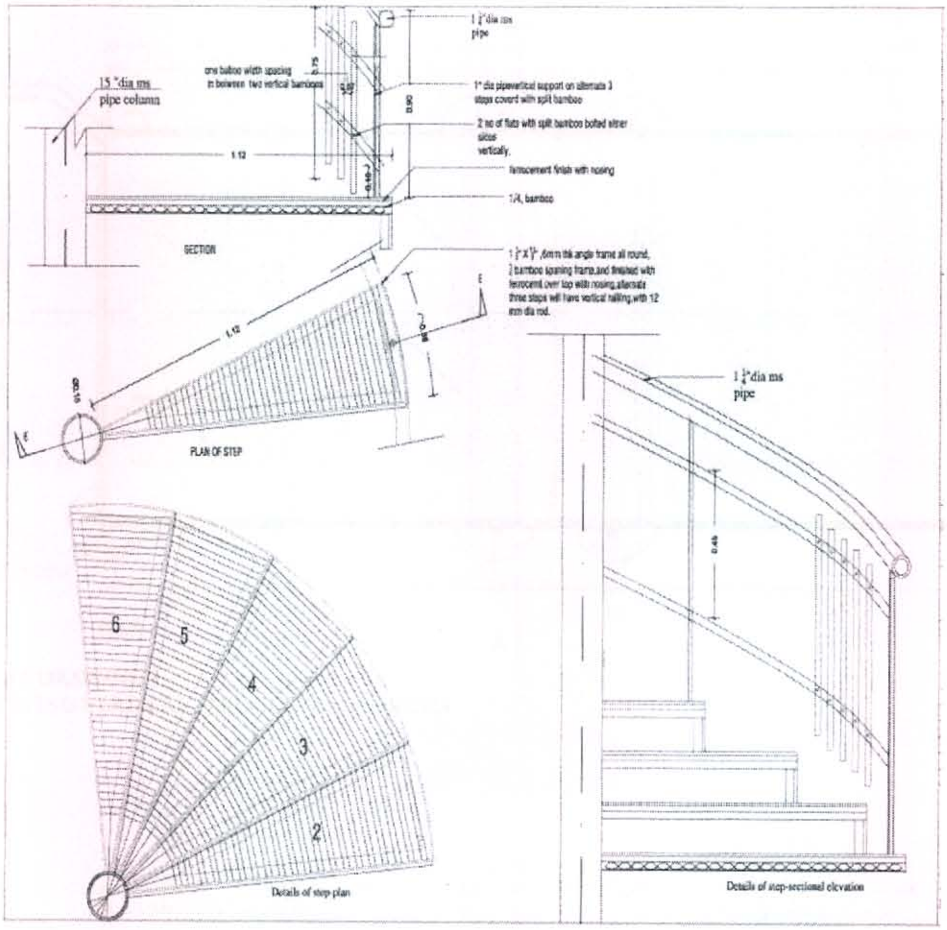


Fig. 8. Details of step plan.

Portable house made with bamboo ply based modular components

The portable bamboo house was having an area of 170 ft^2, made with bamboo ply board frames, framed with 25 x 25 mm ms squares hinged together so as to enable the whole structure to be packed into a rectangular block of 1.05 m x 2.95 m x 2.35 m (Figs. 9 and 10). The entire structure is supported with 8 numbers of 2" ms pipes of height varying from 2.95 m to 2.30 m, depending upon the slope. All the pipes are footed inside ms sections of diameter 50 cms. The floor and roof sheets are made with bamboo ply board frame sections, which can be easily folded to the rectangular pack-up structure mentioned earlier.

Fig. 9 depicts the plan details of the modular portable bamboo house made with bamboo ply board. The elavational view details of the modular portable bamboo house are given in Fig. 10. Fig. 11 shows the schematic diagram of the folding/packing up of the modular portable bamboo house. The frames are made in steel; flooring and wall panel sections are made with bamboo ply boards, hinged together for convenient folding and unfolding for packing

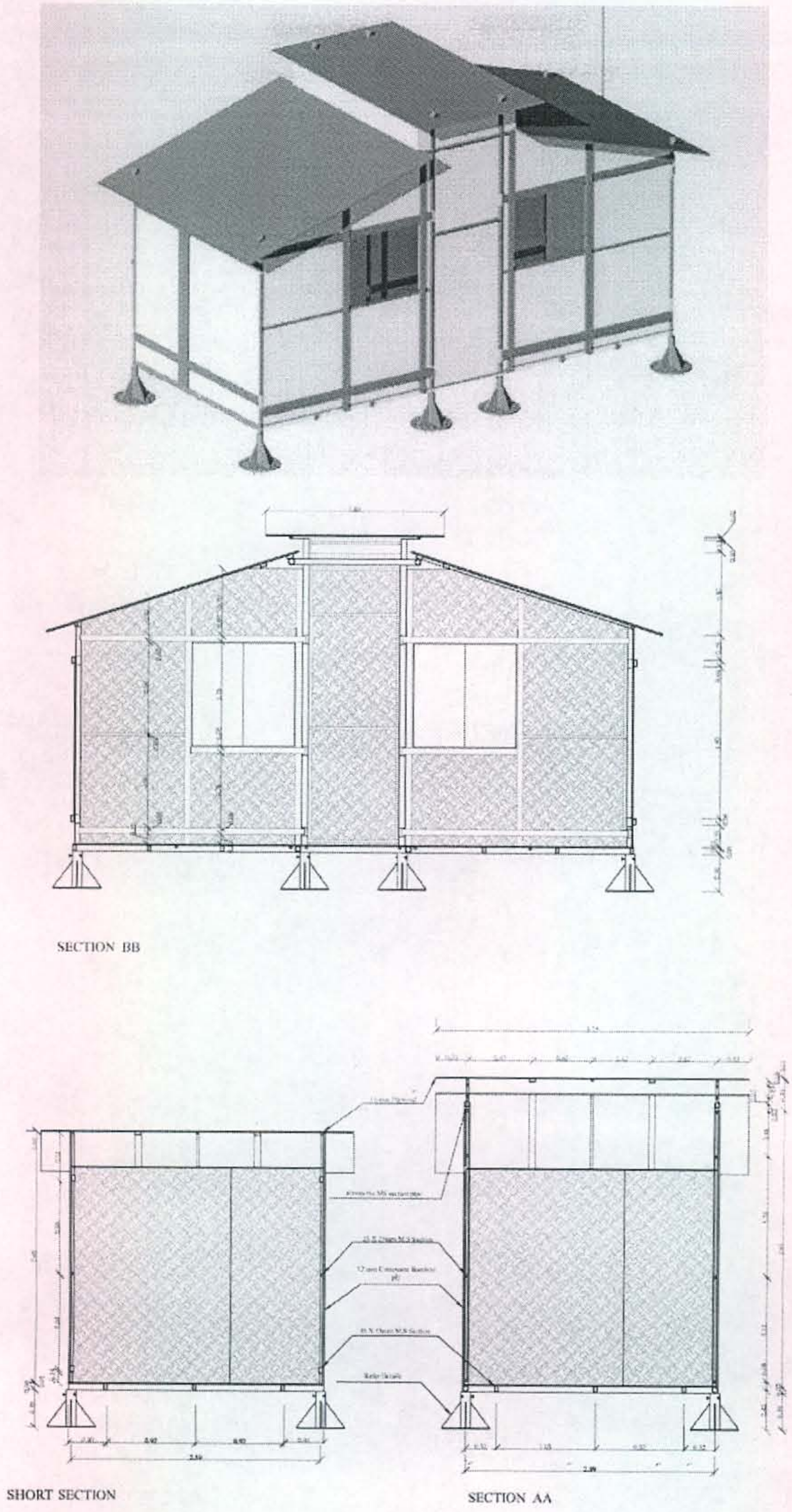


Fig. 10. Elevational view details of the modular portable bamboo house made with bamboo ply board.

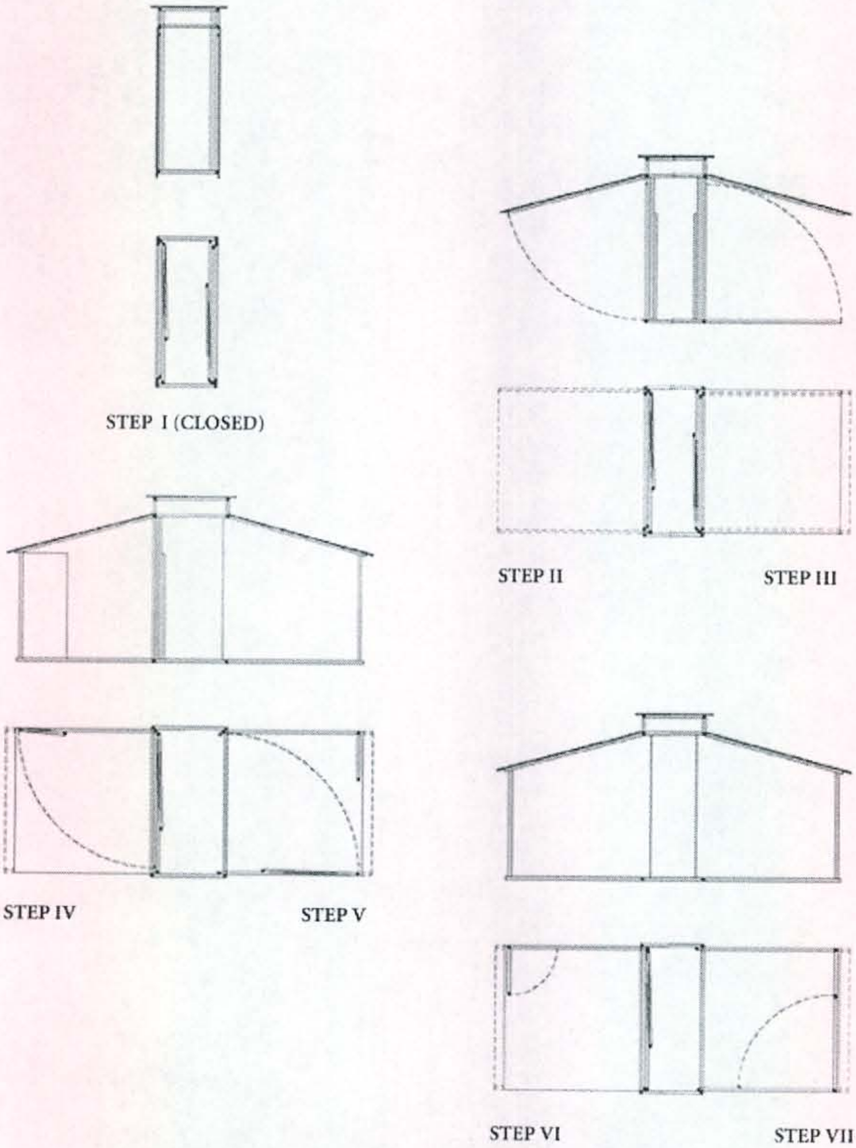


Fig. 11. Schematic diagram of the folding/packing up of the modular portable bamboo house.

The folding or packing up stages of the modular house is indicated in Fig. 11. The opening up or installation of the entire unit is illustrated in Fig. 12. Fig 13 illustrates how a unit can be used, how a unit can be attached with a toilet, and how two such units can be combined.

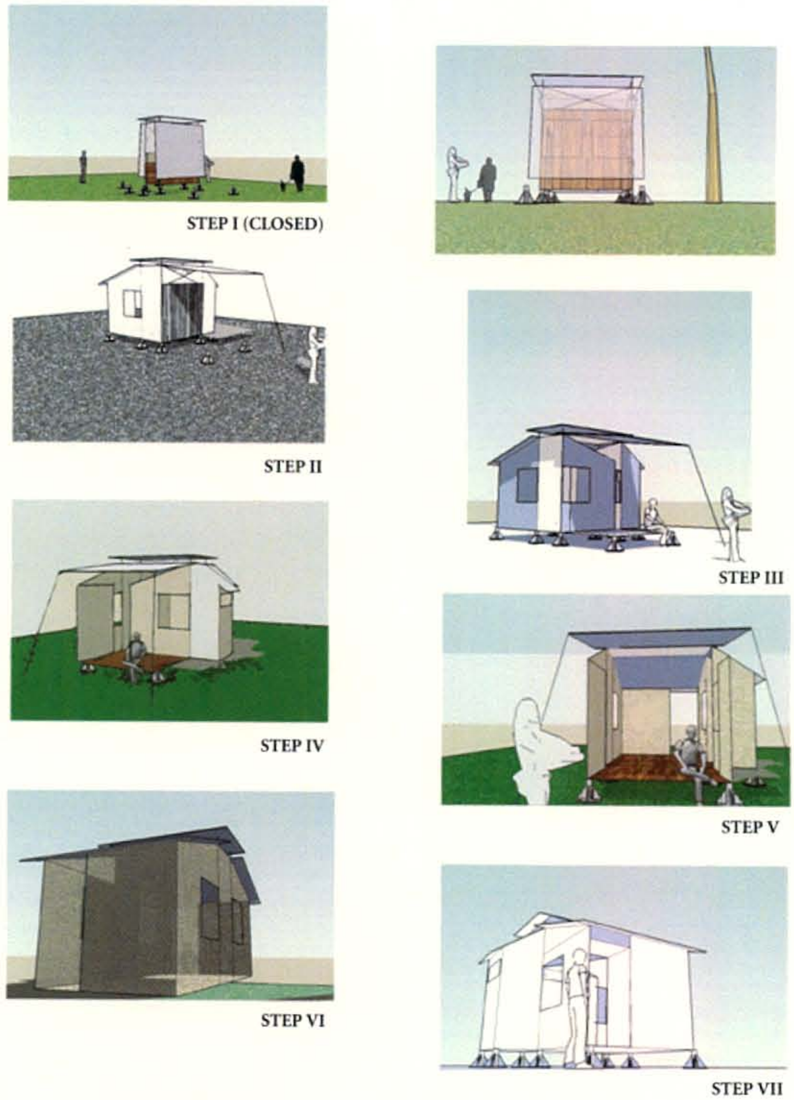


Fig. 12. Illustration of the installation of the modular portable bamboo house.

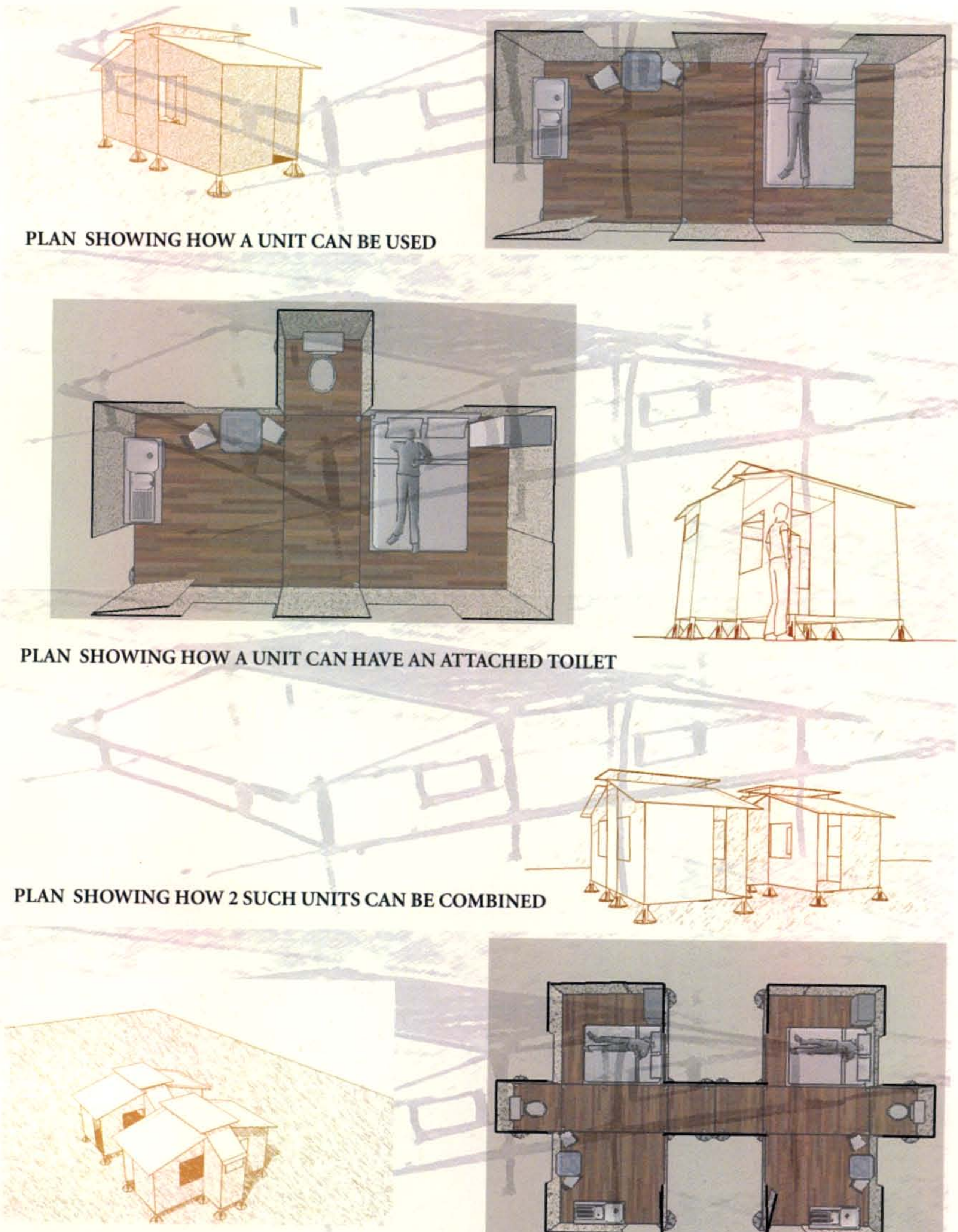


Fig. 13. Illustrations on the multiple uses of the modular portable bamboo house developed.

Construction of the permanent bamboo house at the KFRI Sub-Centre campus in Nilambur

The house construction site (KFRI Sub-Centre campus in Nilambur) was a bamboo growing area. Minimum land required was cleared and the felled bamboos were collected for use.

Preservative treatment of bamboos

Necessary quantity of bamboos in round and split form were preservative treated employing commercial copper - chrome - boron (CCB) preservative formulation as per Indian Standards (BIS 1979). The vacuum - pressure impregnated (VPI) bamboos were dried under shade and stored for further use.

Columns and beams

Pits were dug for casting the columns. M20 grade 1:1.5:3 (cement: sand: 20 mm metal) aggregate concrete is used for column and beam construction. Columns and beams were reinforced with 8 mm steel bars.

Floor/roof details

Copper - chrome - boron treated half-split bamboo pieces were laid closely with their curved external side facing downwards along the network of the main and pre-cast beams. The entire bamboo laying was covered over with 20 mm chicken mesh; 8 mm steel rods used for reinforcement in every 30 cm gap (Fig. 14). The bamboo mesh floor was topped with 1:3 mortar and cured. The floor of the ground (G), G + 1 and the attic levels were constructed in similar way. The exposed side of the bamboo floors were pointed with 1:2.5 cement mortar and polished with glossy polish. All the floor/roof was constructed in similar way. The area of the ground, G+1 and the attic floor were equal, 31.83 m^2; the total area of the house was thus 95.5 m^2. The initial activities of the construction, site clearing, collection of bamboo, earth work, column construction, etc are depicted in Fig. 15.

Fig14. Floor/ roof details

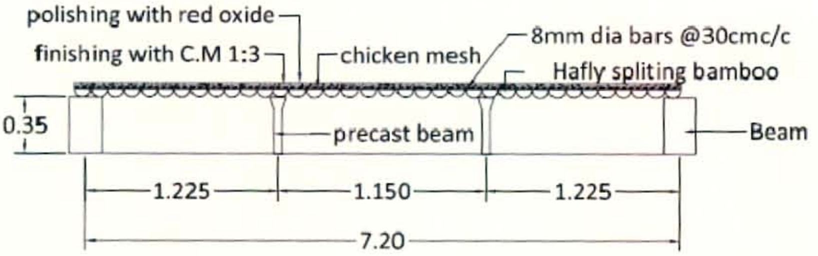


Fig. 15. Construction stages – Initial activities: Site preparation, bamboo collection, earth work, construction of columns, etc

Walling

Wooden support columns (25 mm x 25 mm x 2.5 m) are provided adjacent to the RCC columns and pre-cast columns to nail the treated half-split bamboos paved closely for walling (Fig. 16). The entire wall area is covered with chicken mesh over a coat of 1:3 cement mortar is given for making the walls. The exposed bamboo surface is pointed with 1:2.5 cement mortar and polished with glossy polish. The central inner walls are constructed with 4.5" bricks.

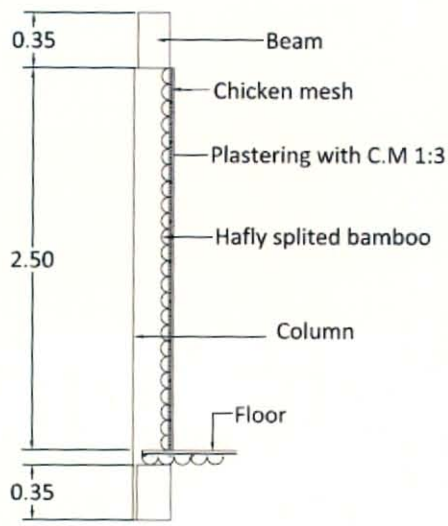


Fig. 16. Wall details of the bamboo house (all dimensions in m).

Stair case details

The details of the spiral staircase made outside the building, in the front side is detailed in Fig. 17a and b. Step raise is 16 cms.

Fig. 17a. Staircase details.

Fig. 17b. Staircase details -Front view.

The Attic Floor roof

The attic floor roofing is made of bamboo – jute composite corrugated sheets supported by bamboo trusses. The attic floor details are given in Fig. 18.

Fig. 18. The attic floor roofing details.

RESULTS AND DISCUSSION

Figs. 20 a & b show the various views of the completed bamboo house constructed at the KFRI Sub-Centre campus in Nilambur, Malappuram District, Kerala. Fig. 20 c gave the view of the attic floor of the house with bamboo *charupadi*. Fig. 20 d. gave the view of the floor and roof details of the completed bamboo house. Fig. 20 e. gave the view of the window details of the completed bamboo house.

Each floor of the house was having a living area of 31.83 m^2 (342.5 ft^2); the total area of the house including the ground, 1st and the attic floor is coming to nearly 95.5 m^2 (around 1030 ft^2).

The Photograph of the completed modular portable bamboo house is shown in Fig. 21a. Fig. 21b shows the photographs of the modular portable bamboo house in the packed form as well as in the installed form. The dimension of the portable house is 5.85 m x 2.70 m, equaling to 15. 8 m^2 (nearly 170 ft^2).

Analysis on construction expenditure

Appendix I. gave the split-up expenditure of the bamboo house construction. It can be seen that the per m^2 construction cost of the bamboo house has come to around Rs. 11,700/- (Rs. 1100/- ft^2); the slightly higher expenditure can be reduced in constructing further houses (as the present construction work was the first of its kind and was involving a lot of unforeseen expenditure for working in the difficult to access place of construction). The construction rate details are given in Tables 1, 2 and 3 for the bamboo floor (bamboo grid wall and 4.5" thick brick walls respectively for the ground, 1st and attic floors (Appendix III).

Appendix II gave the split-up expenditure of the portable modular bamboo house fabrication. The cost of the unit is in the tune of around Rs. 2, 11,200/- unit of area 15.8 m^2 (Rs. 13,367/m^2, or Rs. 1,242/ft^2). The cost can be considerably reduced by further standardization while attempting mass production.

Appendix IV shows the newspaper clippings on the press conference held for demonstrating the bamboo houses for publicity and awareness creation.

Fig. 20a. Front view of the completed bamboo house

Fig. 20 b. Side view of the completed bamboo house.

Fig. 21b. Photographs of the modular portable bamboo house in the packed form as well as in the installed form.

CONCLUSION

A durable model bamboo house was constructed for demonstration of the best construction practices, for the first time of its kind in Kerala. The house was constructed at the KFRI Sub-Centre campus in Nillambur, Malappuram District of Kerala. The bamboo house is open for interested visitors. The house construction makes use bamboo preservative treated as per Indian standards, for the floor, wall and roof components. The objective was to use bamboo to the extent possible retaining the minimum necessary RCC columns and ferro-cement thin beams; the bamboo grid walls are plastered for keeping the common look of ordinary houses. The house demonstrates the use of standardized lengths of solid round and half-split bamboos for construction. The attic floor with its bamboo trusses and joists, roofed with bamboo-jute composite boards demonstrates bamboo joinery for construction along with the potential of bamboo board products for roofing. The entire structure convinces the public about the scope of potential application of bamboo for housing without adversely affecting bank loan and insurance issues. It also spreads the message of saving the high-energy embodied building materials with the probable partial but significant substitution of low-energy embodied natural material like bamboo for building. The experiences gathered during the construction of the present structures will be of immense use for reducing the cost and improving the aesthetics by better designing in future constructions.

A portable modular bamboo house made with bamboo ply board was designed, fabricated and installed at the KFRI campus in Peechi, Thrissur District, Kerala. The 170 ft^2 area structure was designed for framing the bamboo ply floor, wall and roof panels with steel pipes or rectangular sections and the entire sections were hinged together so as to facilitate the packing of the unit as a rectangular box with the component sections itself (without using external packing sections). The structure developed is suitable for application in disaster rehabilitation, housing in ecologically sensitive forest and pilgrim centers where permanent civil construction is undesirable, for eco-tourism, etc. The structure was opened to the public and press; awareness and publicity efforts were made on convincing the potential of bamboo for application in both permanent and temporary housing. The experience gained showed the potential of further reduction in the weight of the portable house for enhanced portability and improving the aesthetics for better marketing by better designing and cost reduction while mass production.

REFERENCES

Building Materials and Technology Promotion Council (BMTPC) (n. d.). Bamboo – A material for cost effective and disaster resistant housing. BMTPC, Government of India. New Delhi. 23 p.

Bureau of Indian Standards (BIS). 1973. Method of Tests for Round Bamboos. IS: 6874. BIS, New Delhi. 16 p.

Bureau of Indian Standards (BIS) 1976. Method of Tests for Split Bamboos. IS: 8242. BIS, New Delhi. 7 p.

Bureau of Indian Standards (BIS). 1979. Code of Practice for Preservation of Bamboos for Structural Purposes. IS: 9096. BIS, New Delhi. 8 p.

Bureau of Indian Standards (BIS). 1993. Preservation of Bamboo and Cane for Non-Structural Purposes – Code of Practice. IS: 1902. BIS, New Delhi. 4 p.

Cane and Bamboo Technology Centre (CBTC) 2001. Bamboo in the field of construction in northeast India. M. S. Architecture Dissertation by Das, Bipul Kumar. CBTC Technical Paper No. 1. Guwahati, Assam, India. 121 p.

Gnanaharan, R. 2000. Preservative Treatment Methods for Bamboo: A Review. Part II of "Bamboo Shelter – A Demonstration of Best Construction Practice". KFRI Research Report No. 177 (II). Kerala Forest Research Institute, Peechi – 680 653, Kerala, India. 19 p.

Gutierrez Jorge A. 2000. Structural Adequacy of Traditional Bamboo Housing in Latin America. INBAR Technical Report No. 19. International Network for Bamboo and Rattan (INBAR), Beijing, China. 112 p.

Indian Plywood Industries Research and Training Institute (IPIRTI) (n. d). Bamboo Housing Construction Techniques: Do – it – Yourself. IPIRTI, Tumkur Road, Bangalore 560 022, India. 21 p.

Janssen, Jules, J. A. 2000. Designing and Building with Bamboo. INBAR Technical Report No. 19. International Network for Bamboo and Rattan (INBAR), Beijing, China. 208 p.

Jayanetti, D. and Follett, P. R. 1998. Bamboo in Construction – An Introduction. INBAR Technical Report No. 15. International Network for Bamboo and Rattan (INBAR), New Delhi. 120 p.

Jorge Moran Ubidia. 2001. Building with Bamboo – A Doing Yourself Manual. Special Edition for the Workshop in Aizawal, India. 31 p.

Kumar, S., Shulla, K. S., Dev, I. and Dobriyal, P. B. 1994. Bamboo Preservation Techniques. INBAR Technical Paper No. 3. . International Network for Bamboo and Rattan (INBAR), New Delhi & Indian Council of Forestry Research and Education (ICFRE), Dehra Dun, India. 59 p.

Liese, W. and Kumar, S. 2003. Bamboo Preservation Compendium. INBAR Technical Report No. 22. Centre for Indian Bamboo Resources and Technology (CIBART), New Delhi & International Network for Bamboo and Rattan (INBAR), Beijing, China. 230 p.

Murleedharan, P. K. and Anitha, V. 2000. Assessment of economic feasibility and socio-cultural acceptability of bamboo-based architecture: A case study in Kerala, Karnataka and Orissa States. KFRI Research Report No. 177 (1). Kerala Forest Research Institute, Peechi – 680 653, Kerala, India. 55 p.

National Mission on Bamboo Applications (NMBA) 2004. Building with Bamboo – Training Manual. NMBA, New Delhi. 62 p.

Soriano, F. P. 1997. Manufacture, performance tests and marketing of pre-fabricated houses with wood-wool based modular components. ITTO Fellowship Grant Technical Report. International Tropical Timber Organization (ITTO), Yokohama, Japan. 54 p.

APPENDICES

Appendix I

Bamboo house construction expenditure - Split-up statement

Description of items	Unit	Quantity	Rate	Amount
MATERIALS				
Cost of 5 meter long pieces	Nos	50	200	10000.00
Cost of *lathi* bamboo, 1 meter long for stair and *charupaddy*	Nos	96	40	3840.00
Cost of Bamboo purlin, 10 feet long	Nos	35	46	1610.00
Total for Bamboo procurement				**15,450.00**
Treatment charges for the procured bamboos				7000.00
Treatment charges for own bamboos	Cft	497	34.2	16995.00
Total for bamboo treatment charges (including coast of preservative)				**23,995.00**
Bamboo - jute Composite ridge	Nos	20	770	15400.00
Bamboo - jute corrugated composite roofing sheet	Nos	50	2365	118250.00
Total for reconstituted bamboo roofing material procurement				**1,33,650.00**
HARDWARE MATERIALS				
GI Sheet, 8 feet long	Nos	16		
GI Sheet, 6 feet long	Nos	28	Item 1+2	7209.00
Bolts ,Nuts ,washers ,Nails, etc. ,Total Cost				9983.60
MS square pipe, 4" size	Kg	48.50	51.00	2473.5
MS square pipe	m	18	72.20	1299.6
1 1/4" MS pipe	Kg	205.70	53	10902.10
1" MS Pipe	Kg	21	53.5	1123.50
1 1/4 X 1" MS angle	Kg	4.50	50	225.00
Cost of MS flat	Kg	24	51.63	1239.00
MS Flat	Kg	42.50	50.45	2144.00
15" X 25" size MS flat	--	--	--	950.00
MS Flat 32 X 6" size	Kg	72.00	45.94	3308.00
Cost of short bevel, 10nos, and screw 20nos.	--	--	--	665.25
Cost of 1 1/4" MS pipe for spiral stair 10nos and coach 20nos	Kg	54.00	59.30	3202.00
cost of screw for bamboo stair and charupaddy	Nos	250	4.94	1235.00
Aluminium pipe	Nos	10	52.91	529.10
Cost of 6" MS Pipe for stair case	m	12.06	971.25	11713.28
MS flat and MS angle	Kg	445	38.64	17192.60
Lock fix	Nos	4	222	888.00
Plain glass, 4 mm	Sq. ft	3.50	28.57	100.00
plain glass, 5mm	Sq. m	18	45.14	812.50
1/2 X 1/2 size reaper	Bundle	6.50	125	812.50
Electrical accessories				2760.00
Plumping accessories				1020.00
Total for Hardware Materials				**81787.53**
PAINT, WARMISH, OXIDES, ETC.				
Polish thinner epoxy clear	l	4.00	1162	4648.00
Lock fix chemical	Nos	3	240	720.00
Fevicol DDL	Nos	4.00	75.25	301.00
Red oxide	Kg	10.00	75	750.00
Cost of Cem	Kg	20	7	140.00
Enamel painting, green colour	litre	8	329.38	2635.00
Manson polish and water paper				855.00
Petrol for polishing works	litre	5	50	250.00
Plastrocrete, for water proofing	Kg	40	54	2160.00
Brush 4"	Nos	3	32	96.00
White cement	Kg	10	15	150.00
Total for Paint, Warnish, etc.				**12,705**
CEMENT, SAND, ROCK, BRICKS, STEEL, ETC.				
Cement	Bag	356	242.90	86471.40
Sand	Cft	1820	25.14	45750.00
Crushed rock (Metal)	Cft	800	10.00	8000.00
Bricks	Nos	3000	2.55	7650.00
Cost of reinforcement material, ms bars, including winding wire etc.	Kg	1130	30.01	33906.30
Total for cement, sand, metal, bricks, steel, etc..				**1,81,777.7**
STONE SLABE & TILES				
Kadappa slab	Sq. ft	77.55	35.98	2790.00
Shahabad tiles	Nos	35	78	2730.00
Cement tiles, 300X300	Box	4	300	1200.00
Cement tiles, 300X200	Box	16	220	3520.00

Total for Slabs & Tiles				**10,240**
WOOD - DOORS AND WINDOWS				
Hard wood shutter with SS fittings 3 W 3a 3.35 X2.4 meter size	Nos	2	14100	28200.00
Hard wood shutter with SS fittings D1 + 2 W 3a 3.35X2.4 meter size	Nos	2	13700	27400.00
Hard wood shutter with SS fittings 0.90X2.4 meter size	Nos	2	6300	12600.00
Hard wood door shutter with SS fittings 0.80X2.4 meter size	Nos	2	3150	6300.00
Hard wood window shutter with SS fittings 2.20X2.4 meter size	Nos	2	11000	22000.00
Hard wood ventilator shutter with SS fittings 1.05X0.60 meter size	Nos	2	1700	3400.00
Hard wood frame window 3.35X2.40 meter size W3a	Nos	2	10100	20200.00
Hard wood frame window D1+2W3a 3.35X2.40 meter size	Nos	2	9600	19200.00
Hard wood frame sliding door 0.90X2.40 meter size	Nos	2	1300	2600.00
Hard wood frame D2 0.80X2.40 meter size	Nos	2	2800	5600.00
Hard wood frame 3Wa 2.20X2.40 meter size	Nos	2	6850	13700.00
Hard wood frame V1 1.05X0.60 meter size	Nos	2	1650	3300.00
Total for Timber - Doors & Windows				**1,64,500**
LABOUR CHARGES				
Bamboo felling work	Nos	1693	54.43	92149.99
Bamboo cutting charge				550.00
Bamboo panelling work	Sq. m	7.83	350	2740.50
Polishing work				19734.00
Bamboo roof bracket fixing				970.00
Bamboo truss fabrication				15612.00
Bamboo truss fixing				2750.00
Painting bamboo truss				1100.00
Cost of mason for scaffolding, chipping, drilling etc.,				1575.00
Wages paid for welders				1035.00
Spiral step fabrication charge				8500.00
Labour for red oxide flooring, plastering, coping, moulding, edges of tiles, etc.				31288.70
Labour for RCC Works				77783.67
bamboo floor & roof plastering				46201.00
Bamboo panelling work for floor wall				47796.00
Loading charges for treated bamboo				8500.00
Kadappa slab cutting charges				600.00
Labour charge for sheet loading				1510.00
Loading and unloading for composite roofing sheets				500.00
Concrete works for bamboo post of attic floor				2315.00
RCC work of landing slab and steps of attic floor				815.00
Charges paid for semi- glossy polish work on bamboo panel plywood				1877.18
Labour charges for Ground floor door works				5334.55
Labour charges for First floor, toilet door window sliding door works				8130.46
Painting attic floor bamboo, polishing post charupaddy and truss				7012.20
1 1/4" MS Pipe welding charges				3250.00
Labour charge for welding roof members - Stair portion				3200.00
Total labour charges for polishing red oxide first floor, ground floor, attic floor, seat slab concreting work, washing basin fixing, closet and urinal, step polishing brick work plastering tile works				52091.37
Labour charges for PCC below brick step work, plastering outside				3448.00
Labour charges for bamboo panelling work for steps				14378.00
Labour charges for roofing with bamboo-jute composite sheet over bamboo joist and roof truss pipes, etc.				6244.00
Carpentry charges				800.00
Labour charges for ascending spiral stair				22000.00
Labour charges for concreting column footing of spiral stair bottom				2715.00
Labour charges for stair case hand rail fixing				7000.00
Labour charges of semi glossy polishing work				7000.00
Polishing labour charges				6999.00
Labour charges for Pointing brick work on attic floor				5378.00
Labour charges for brick loading and unloading				900.00
Labour charges for loading and unloading for bamboos				10550.00
Labour charges for earth excavation for foundation				7700.00
Labour charges for plumbing and sanitary fittings				6310.00
Electrical work labour				1200.00
Total for Labour charges				**5,47,543.62**
			TOTAL COST OF BUILDING	**11, 16,898.85**
			Rounded to	**11,16,900.00**

Appendix II

Modular portable bamboo house fabrication expenditure – Split-up expenditure

Description of items	Unit	Quantity	Rate	Amount
MATERIAL				
Cost of wood primer and turpentine				10225.00
Cost of Bamboo composite sheets	Nos	12	2000.00	23999.98
Wipe compressed plain boards 2.85x1.22x10mm size	Nos	19	1376	26144.00
Pipe	Mtr	12	125	1500.00
2' x 1" rectangular pipe	Mtr	5	98	490.00
Cost of zinchromate yellow paint	Litre	1	136	136.00
cost of etching solution	Litre	10	73.20	732.00
Cost of rivet screw				489.00
Cost of aluminium pipe, GI bolt, nut, washer etc				2894.00
MS flat 75 x 10 size	Kg	31.8	34.14	1085.65
CR pipe 96 x 48 x 2.65	Mtr	6.75	255	1721.25
CR pipe 88 x 66 x 3.6	Mtr	6.07	217.77	1321.86
CR pipe 25 x 25 x 3.20	Mtr	6.06	93.43	566.19
MS pipe 2" dia.	Mtr	6	255.7	1534.20
MS plate 12 mm	Kg	155.6	46.16	7182.50
MS plate 10 mm	Kg	72.6	46.16	3351.22
MS pipe 80 mm dia.	Mtr	6	408.66	2451.96
MS pipe 50 mm dia.	Mtr	48	254.81	12230.88
CR pipe 66 x 33 x 2.6	Mtr	60.4	166.27	10042.71
MS round 65 mm dia.	Kg	290	35.10	10179.00
Cost of a sand	c. ft	51.04	36	1837.44
Cost of aggregate	c. ft	82.20	17.5	1438.50
Cost of 10 mm dia. tore steel	Kg	196	30.77	6030.92
Cost of RHS tubes 66 x 33 x 3.60mm	Mtr	36.30	199	7223.70
8" aldrope and bolt				686.00
Cost of handle and screw	Nos	1	400	400.00
Enamel paint	Litre	6	153	918.00
Bamboo ply sheet	Sq. ft	398.15	14.00	5575.00
LABOUR CHARGES				
Portable house fabrication charges paid to M/s wheel fabrication				5000.00
Labour charges paid to steel structure work for walls & roof				2650.00
Labour charges paid for sheet laying, plywood fixing floor of modular house				5936.00
Labour charges paid for painting				2475.00
Loading and un loading charges				4094.73
Labour for steel fabrication				10000.00
Fabrication labour charges				10000.00
Labour for painting				5005.00
Roof beading fixing for door shutter fixing				3450.00
Carpentry work				550.00
Labour welder for roof fixing				1200.00
Charges for resetting roof				450.00
Fabrication and fixing slide window with 5mm fibre glass				18000.00
			Total Amount	**2,11,197.68**
			Amount rounded to	**2,11,200**

Appendix IV

Newspaper clippings on the press conference held for demonstrating the bamboo houses.

2008 ജൂലൈ 10 വ്യാഴം

ഒരുലക്ഷം രൂപയുടെ പോർട്ടബിൾ വീടിന്റെ പ്രദർശനം തുടങ്ങി

കൊച്ചി : ഇനി ആവശ്യത്തിന് ചുരുട്ടിമടക്കാവുന്ന പോർട്ടബിൾ വീടും. കേരള ഫോറസ്റ്റ് റിസർച്ച് ഇൻസ്റ്റിറ്റ്യൂട്ട് പ്രശസ്ത ഡിസൈനർ സ്ഥാപനമായ ഇൻസ്പിരേഷൻസിന്റെ സഹകരണത്തോടെ വികസിപ്പിച്ച മുളകൊണ്ടുള്ള പോർട്ടബിൾ വീടിന്റെ പ്രദർശനം ദേശീയപാത ബൈപാസിൽ ഹോട്ടൽ സരോവരത്തിൽ തുടങ്ങി. ഇരുനൂറ് ചതുരശ്രഅടിയുള്ള വീടിന് രണ്ടുമുറികളും ഒരു കുളിമുറിയുമുണ്ട്. മുള കൊണ്ട് നിർമിച്ച് ഇരുമ്പുസ്റ്റാൻഡിൽ ഘടിപ്പിച്ച വീട് ആദ്യഘട്ടത്തിൽ നിർമിക്കാൻ മൂന്നു ലക്ഷംരൂപയായെന്നും എന്നാൽ ഇനിമുതൽ ഒരു ലക്ഷം രൂപ ചെലവിൽ നൽകാൻ കഴിയുമെന്നും ഇൻസ്റ്റിറ്റ്യൂട്ട്ഡയറക്ടർഡോ.കെ.വി. ശങ്കരൻ പറഞ്ഞു. ദുരിതബാധിത മേഖലകളിൽ പുനരധിവാസത്തിന് ഏറെ അനുയോജ്യമായ മോഡലാണിതെന്ന് ഇൻസ്പിരേഷൻസ് മാനജിങ് ഡയറക്ടർ ജയഗോപാൽ, പീച്ചി കേന്ദ്രം മുൻ ഡയറക്ടർ ആർ. ജ്ഞാനഹരൻ എന്നിവർ പറഞ്ഞു.

പോകുന്ന പോക്കിന് വീടും കൊണ്ടുപോകാം

കൊച്ചി: ചുരുങ്ങിയ സമയത്തിനകം അഴിച്ചുമാറ്റാനും ഘടിപ്പിക്കാനും ആവശ്യമുള്ളിടത്തേക്ക് കൊണ്ടുപോകാനും കഴിയുന്ന 'പോർട്ടബിൾ ഹൗസി'ന് കേരള ഫോറസ്റ്റ് റിസർച്ച് ഇൻസ്റ്റിറ്റ്യൂട്ട് രൂപം നൽകി. അഴിച്ചുമാറ്റാവുന്ന ഇത്തരം വീടിന്റെ 90 ശതമാനം ഭാഗവും 'മുള' കൊണ്ടുണ്ടാക്കുന്നതാണെന്ന് കെ.എഫ്.ആർ.ഐ. ഡയറക്ടർ ഡോ. കെ.പി. ശങ്കരൻ പത്രസമ്മേളനത്തിൽ പറഞ്ഞു. ഡിസൈനിങ് രംഗത്ത് പ്രവർത്തിക്കുന്ന 'ഇൻസ്പിരേഷൻ' എന്ന സ്ഥാപനവുമായി ചേർന്നാണ് പുതിയ തരം വീട് രൂപകല്പന ചെയ്തിട്ടുള്ളത്. വീടിന്റെ പ്രദർശനം ഹോട്ടൽ സരോവരത്തിൽ തുടങ്ങി.

പ്രദർശനത്തിനായി തയ്യാറാക്കിയ വീട്

ഓരോ ഭാഗങ്ങളായി അഴിച്ചുമാറ്റിയ ശേഷം വാഹനത്തിൽ കയറ്റി ഇഷ്ടമുള്ളിടത്തേക്ക് കൊണ്ടുപോകാമെന്നതാണ് പ്രത്യേകത. ആവശ്യാനുസരണം മുറികളുടെ നീളവും വീതിയും കൂട്ടാനും കുറയ്ക്കാനും കഴിയും. ഇരുമ്പുകൊണ്ടുണ്ടാക്കിയ സ്റ്റാൻഡിലാണ് വീട് കെട്ടിപ്പൊക്കുന്നത്. മേൽക്കൂരയും തറയും ചണവും മുളയും ചേർത്തുണ്ടാക്കിയ പ്ലൈബോർഡ് കൊണ്ടാണുണ്ടാക്കുന്നത്. 200 ചതുരശ്ര അടിയുടെ ഒരു യൂണിറ്റിൽ രണ്ട് മുറികളും കുളിമുറിയും തയ്യാറാക്കാം. 10 മിനുട്ടിനകം ഭിത്തികളെല്ലാം ചേർത്തു ഘടിപ്പിക്കാൻ കഴിയുമെന്നും അദ്ദേഹം അവകാശപ്പെട്ടു. പ്രദർശനത്തിനായി തയ്യാറാക്കിയ വീടിന് മൂന്നു ലക്ഷത്തോളം രൂപ ചെലവായെങ്കിലും ഒരു ലക്ഷം രൂപ ചെലവിൽ ഒരു വീട് തയ്യാറാക്കുന്നതിനാണ് ലക്ഷ്യമിടുന്നതെന്ന് കെ.എഫ്.ആർ.ഐ. ഗവേഷകൻ കൂടിയായ ഡോ. സി.കെ. ദാമോദരൻ പറഞ്ഞു.

ദുരിതബാധിത സ്ഥലങ്ങളിൽ പുനരധിവാസത്തിനും മറ്റും ഇത്തരത്തിലുള്ള വീടുകൾ അനുയോജ്യമാണെന്നും അദ്ദേഹം പറഞ്ഞു. ഇതിനുപുറമെ ടൂറിസം മേഖലയിലും പോർട്ടബിൾ ഹൗസ് പ്രയോജനപ്പെടുത്താനാകും. കെ.എഫ്.ആർ.ഐ. മുൻ ഡയറക്ടർ ഡോ. ആർ. ജ്ഞാനഹരൻ, ഇൻസ്പിരേഷൻ എം.ഡി. ജയഗോപാൽ, ആർക്കിടെക്ട് ലത ജയഗോപാൽ എന്നിവരും പത്രസമ്മേളനത്തിൽ പങ്കെടുത്തു.


P.K. JEEVAN JOSE

The portable bamboo house which was unfolded in Kochi on Wednesday. This prototype is a joint venture of the Kerala Forest Research Institute (KFRI) and Kochi-based architect firm Inspiration.

NEW INITIATIVE

Portable bamboo house

Express News Service
Kochi, July 9

PORTABLE bamboo shelters could become a boon for many refugees seeking shelter during disasters like floods or tsunami. A prototype of the portable bamboo house was unfolded on Wednesday as part of a joint venture by the Kerala Forest Research Institute (KFRI) and Inspiration, a Kochi-based architectural and designing firm.

The rectangular structure which was installed in 10 minutes opened into a 200-sq ft house with eight supports and steel base. The material used in the construction is bamboo. The roof is wood-free acrylic. There is a ventilation shaft and the whole structure stands 80cm above ground. Ideally, it is a relief structure during disasters. It can be used as a rehabilitation housing for slum dwellers and migrant labourers in urban areas.

"Two or three units can be joined together for bigger families. If industries come forward, we can start the construction," said Jaigopal of the Inspiration.

The firm made the design by using KFRI technology. He said that it could cost around Rs 1 lakh and could be readied in a month in the factory.

The structure uses bamboo mat board as the principal component while the support and joineries are of steel. The entire structure can be packed in a slot of 40 sq ft plinth area. "Housing revolution has started. We can develop this into 'Laksham Veedu'" said Sankaran, director, KFRI.

Speaking about the advantages of bamboo, the fastest growing grass, KFRI scientist Gunaharan said that bamboo's tensile strength was its biggest value. He said that the no-loan risk was taken into consideration by the use of steel, wood and glass in the house.

"Bamboo houses are becoming popular in eco-tourism sector. Resorts and offices have started using bamboo. The KFRI and Inspiration have jointly built a demonstration residential block in Nilambur forest area," he said.