ENERGY EFFICIENT BAMBOO STRUCTURED BUILDINGS

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NECESSITY OF ENERGY EFFICIENT BUILDINGS

- Boom in Construction and civil engineering activities due to rapid improvements in procurement of building materials.
- This has posed many challenges due to some unsustainable aspects of the highly polluting and exhaustive nature of building materials.
- It has also significantly created opportunities for innovative and unconventional resources to emerge
- Buildings account for 40 percent of the total energy consumption globally.

NECESSITY OF ENERGY EFFICIENT BUILDINGS

- Energy efficient technologies could reduce consumption by up to 60 %.
- In India, the building sector accounts for about 35 % of the nation's total energy consumption and is growing @ 8% rate each year.
- Hence there is a need for energy efficient and economical methods of construction.

INITIATIVE TAKEN BY IPIRTI

Indian Plywood Industries Research and Training Institute (IPIRTI) had developed cost-effective, eco-friendly and energy efficient building materials and housing technologies from Bamboo, Bamboo Composite, Rice Husk Particle Board, Coconut Husk Coir Composite, Bagasse Particle Board that are cultivated on a large scale in Indian farms.

Why Bamboo has been taken as Raw Material ?

From the growing interest among Engineers and Architects in recent times in using Bamboo as a Building and Structural Material due influence of certain factors for recognition as a building material :

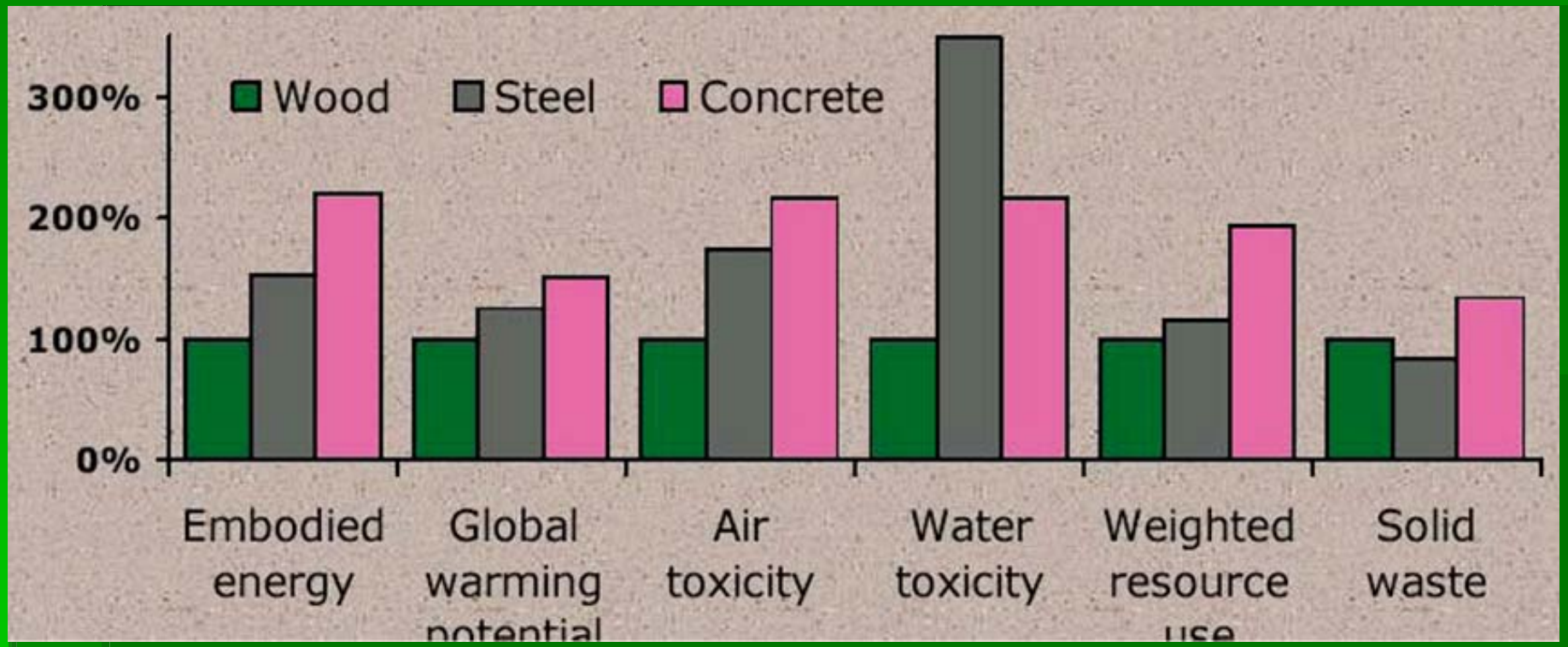
- ✓ **HIGH TENSILE STRENGTH COMPARED TO MILD STEEL**
- ✓ **EASY AVAILABILITY**
- ✓ **LOW COST**
- ✓ **HIGH STRENGTH WEIGHT RATIO**
- ✓ **CAPACITY TO ABSORB MORE CO2**
- ✓ **RENEWABLE RESOURCE**
- ✓ **CONTRIBUTE TO REDUCTION IN GREN HOUSE EFFECT**

ENERGY REQUIRED FOR CONSTRUCTION MATERIALS

MATERIAL	ENERGY for Production (MJ/Kg)	Weight per volume (Kg/m3)	Energy for production MJ/m3	Stress when in use N/mm2	Ratio energy per unit stress
Concrete	0.8	2400	1920	8	240
Steel	30	7800	234000	160	1500
Wood	1	600	600	7.5	80
Bamboo	0.5	600	300	10	30

Source : Bamboo in building structures by Jules Janessen, 1981, Eindhoven University

ENVIRONMENTAL IMPACT RELATIVE TO TYPICAL WOOD FRAMED HOUSE



CARBON (CO_2) RELAESED & STORED IN BUILDING MATERIALS

MATERIAL	CARBON (DIOXIDE) RELEASED Kg/t	Kg/m³	CARBON (DIOXIDE) STORED Kg/m³
ROUGH SAWN TIMBER	30 (110)	15 (55)	250 (917)
STEEL	700 (2567)	5320 (19510)	0.00
CONCRETE	50 (183)	120 (440)	0.00
ALUMINIUM	8700 (31903)	22000 (80675)	0.00
BAMBOO	29(106)		350(1283)

- OLDER PLANTS HAVE LOWER CO_2 UTILIZATION CAPABILITY COMPARED TO GROWING ONES
- BAMBOO BEING FASTEST GROWING PLANT IS MOST FAVOURED
- USE OF TIMBER FOR DURABLE PRODUCTS ENSURES FIXATION OF CO_2 FOR LONG PERIODS
- IN THE MANUFACTURE OF 'Fe' & 'Al', OTHER TOXIC GASES LIKE CO, SO_2, NITROGEN OXIDES TOTALLING ABOUT 40 Kg/ton OF STEEL RELEASED. APART, ABOUT 150,000 LITRES OF CONTAMINATED WATER CONTAINING TOXIC GASES, METALS, OILS, ETC., THEREBY POLLUTING AIR AND WATER.

WHY BAMBOO BASED COMPOSITES?

- They absorb and reduce seismic energy and are able to withstand wind forces, energy efficient
- Conventional heavy and brittle building materials such as stones, bricks, mortar, granite etc. do not absorb shock waves but they amplify them, causing more destruction
- In contrast, lightweight bamboo composite based housing system are more flexible allowing lateral movements of the structures

BAMBOO SPECIES STUDIED FOR MANUFACTURING COMPOSITES

IPIRTI had 10 no Bamboo Species

- D. strictus
- D. hamiltonii
- D. brandisii
- M. baccifera
- O. travencorica
- B. nutans
- B. bambose
- B. balcoa
- B. tulda
- Schizostachyam dullooa

BAMBOO MAT BOARD

- HIGH MODULUS OF RIGIDITY COMPARED TO PLYWOOD
- HIGH IN–PLANE RIGIDITY
- MORE FLEXIBLE THAN EQUILAVENT PLYWOOD
- ECONOMICAL COMPARED TO PLYWOOD
- BMB CAN BE UTILIZED FOR SHEATHING MATERIAL IN STRUCTURAL AND SEMI STRUCTURAL PURPOSES SUCH AS WALL PANELING, PARTITIONS, ROOF SHEATHING, DOOR SKINS, BUILT UP HOLLOW BEAMS & GUSSETS

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BAMBOO MAT CORRUGATED SHEET(BMCS)

- BMCS IS A GREEN ROOFING MATERIAL COMPARED TO OTHER ROOFING MATERIALS IN THE MARKET SUCH AS ACCS, CFRP, CAS, CGIS
- THE MANUFACTURE OF BMCS DOES NOT AFFECT THE HEALTH OF WORKERS AND ENVIRONMENT
- ENERGY REQUIREMENT IS LOW
- HAS IMMENSE POTENTIAL AS AN ECO-FRIENDLY ROOFING MATERIAL
- IS HIGHLY RESILIENT, LOW WEIGHT, LOW THERMAL CONDUCTIVITY, GOOD AESTHETIC APPEARANCE

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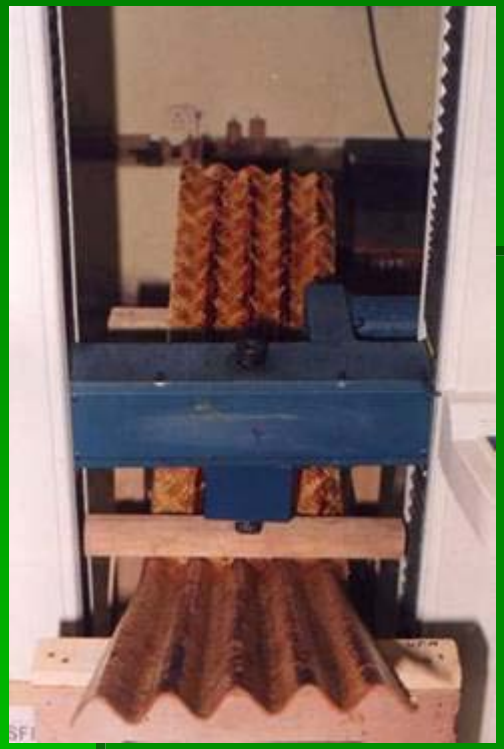
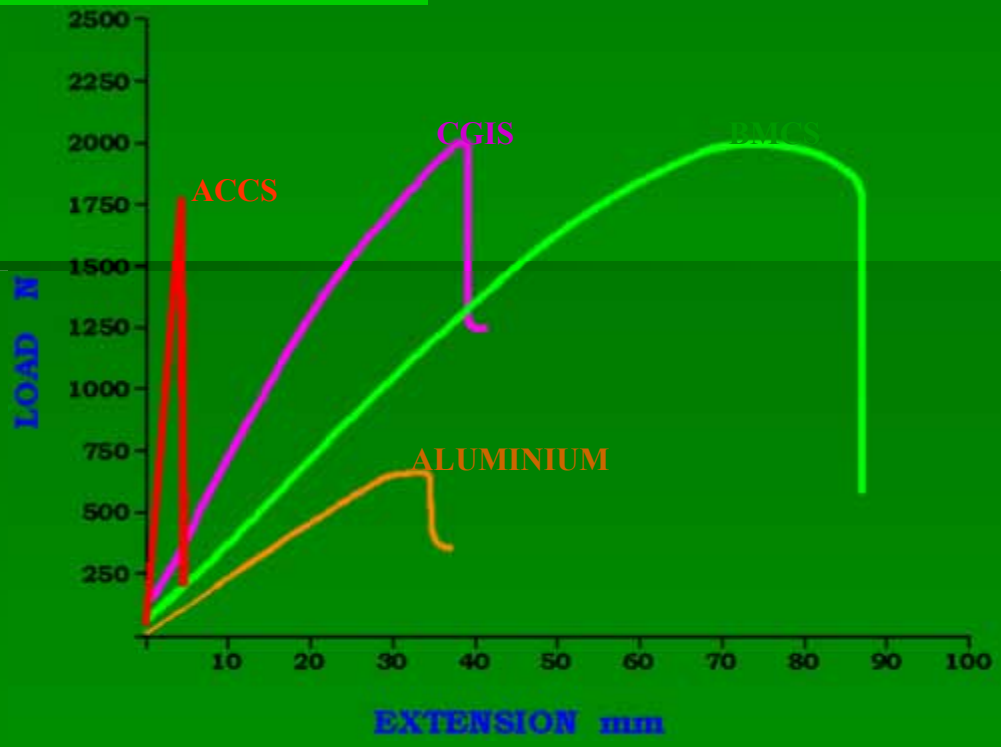
LOAD BEARING STRENGTH OF BMCS





Some Important Properties of BMCS

Size : 1.05m X 1.8 m X 3.5 mm

Weight : 6.5 – 7.90 kg/sheet
(app. half that of ACCS)

Load Bearing Capacity : 4.8 N/mm width

Deflection at Breaking Point : 85 mm

Thermal Conductivity : 0.1928 k cal/m OC (app. half that of ACCS)

Fire Resistance : Confirms to flammability test for FR plywood

Energy Requirement : Highly Energy Efficient

BAMBOO MAT RIDGE CAP(BMRC)

- BMRC IS COMPATIBLE FOR ROOFING WITH BAMBOO MAT CORRUGATED SHEETS
- SUITABLE FOR WIDE RANGE OF ROOF ANGLES
- REPLACEMENT FOR THE PRESENT PRACTICE OF USING THIN FLAT BOARDS WHICH CAUSES PERFORATIONS DUE TO WEATHERING.
- DIMENSIONALLY STABLE, NON PERMEABLE , ANTI-TERMITE AND WEATHER RESISTANT
- READY & EASY TO FIX FOR ROOFING PURPOSE

Bamboo Mat Ridge Cap

ENERGY EFFICIENT

AND

ECO FRIENDLY BAMBOO

HOUSING SYSTEM

WHY BAMBOO HOUSING ?

Affordability:

- Foundations are minimised, wall panels are non-load-bearing and can be reduced in thickness, basic components are standardized.

Sustainability and environmental impact:

Bamboo is available in commercial quantities using the established supply system. It is a renewable resource with a short rotation period and can be grown on degraded land. The bamboo is treated using environmentally friendly preservatives. The use of high energy embodied materials (cement, steel) is minimised.

Flexibility:

It allows greater flexibility in designing and construction. One of the important advantages of bamboo housing is that it can be maintained regularly by replacing deteriorated parts.

WHY BAMBOO HOUSING ?

Durability and safety:

All bamboo components including composites are treated with safe preservatives to give extended life, the structure is engineered to resist wind and earthquake forces and other imposed loads.

Control of De-Forestation:

During disasters, the general tendency is that affected people build temporary shelters nearby forest by cutting trees, which is environmentally and economically not a viable alternative. Bamboo based housing system could make viable substitute to control indiscriminate cutting of trees and to protect environment.

Quick to construct:

Bamboo house takes very short time for assembling. Such efficiency makes it very important for disaster management and quick relief to victims or affected population to rehabilitate their family life.

IPIRTI – TRADA BAMBOO HOUSING SYSTEM

Wall in fill: Non-load-bearing, comprising a grid of split bamboo covered in wire mesh and cement mortar

Roof structure: Bamboo rafters or trusses supporting bamboo purlin

IPIRTI – TRADA BAMBOO HOUSING SYSTEM

To date, a prototype building system has been developed comprising

Foundations: individual column footings

Columns: bamboo culms set in (or on) concrete footings

Floor: raised by two or three brick courses, filled with rubble and secreeded

IPIRTI – TRADA BAMBOO HOUSING SYSTEM

Treatment

1.Rafters & Purlins
Dip diffusion

2.Grid
Dip diffusion

3.Columns

Internodal injection or Boucherie Process

IPIRTI – TRADA BAMBOO HOUSING SYSTEM

PLASTERING

FLOORING

FIXING OF TRUSS

FIXING OF PURLINS

IPIRTI – TRADA BAMBOO HOUSING SYSTEM

FIXING OF BMCS

INNER VIEW OF HOUSE

FINISHED HOUSE

TESTING

WALL TEST

BENDING TEST FOR BMCS

FLAME TEST FOR BMCS

ROOF TRUSS TESTING

TESTING

Successfully tested on shake table at CPRI, Bangalore. Withstood zone 5 (NBC 83) earthquake intensity of 7.0 Richter Scale

BAMBOO HOUSES CONSTRUCTED AT IPIRTI BANGALORE CAMPUS

Prefabricated BMB Wood Shelter

Demonstration house

Security Cabin

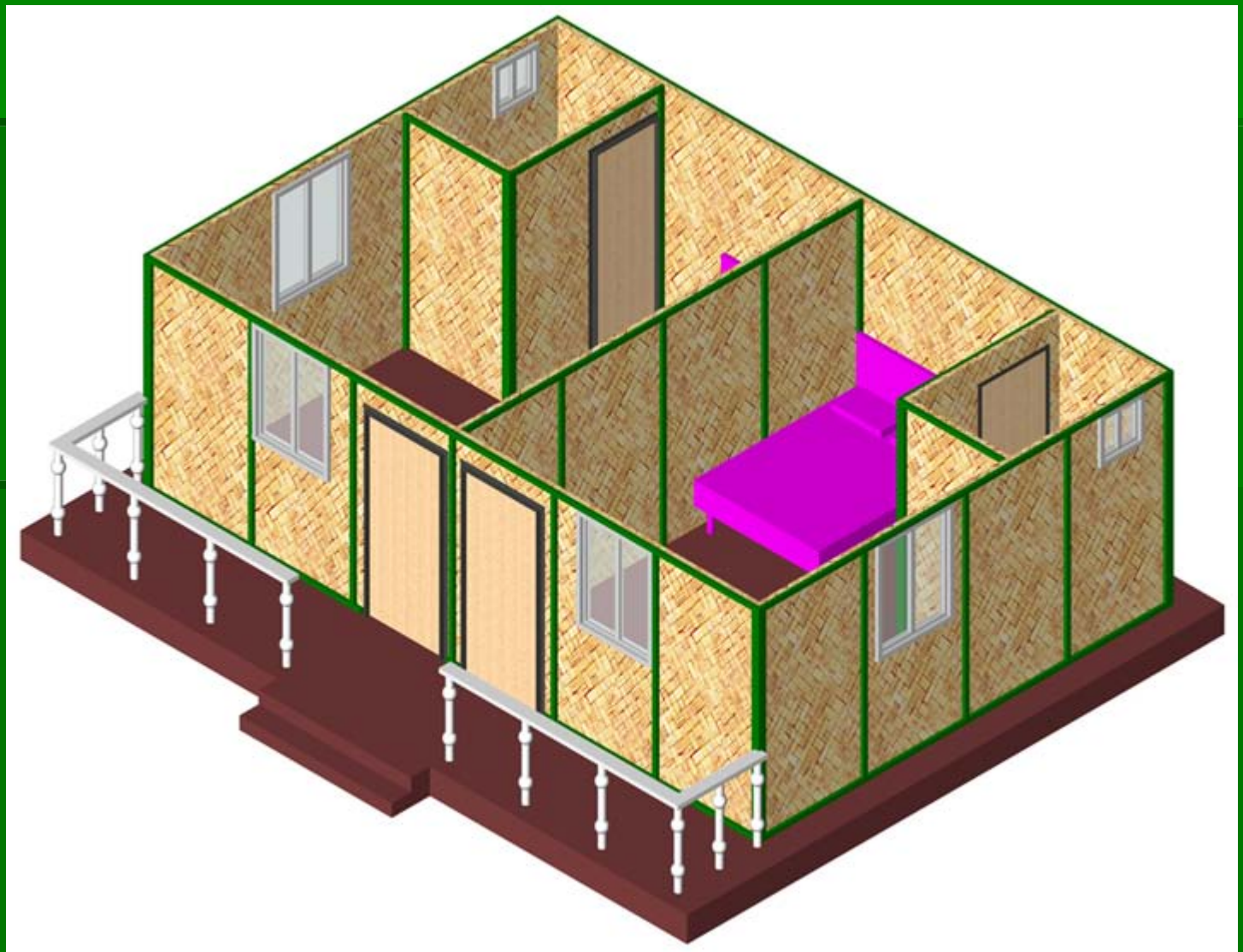
Two bedroom Guest House

BAMBOO HOUSES CONSTRUCTED AT DIFFERENT PLACES IN INDIA

BAMBOO HOUSE
BUILT AT AGARTALA

BAMBOO HOUSE
BUILT AT CHENNAI

PORTABLE PREFABRICATED MODULAR HOUSES



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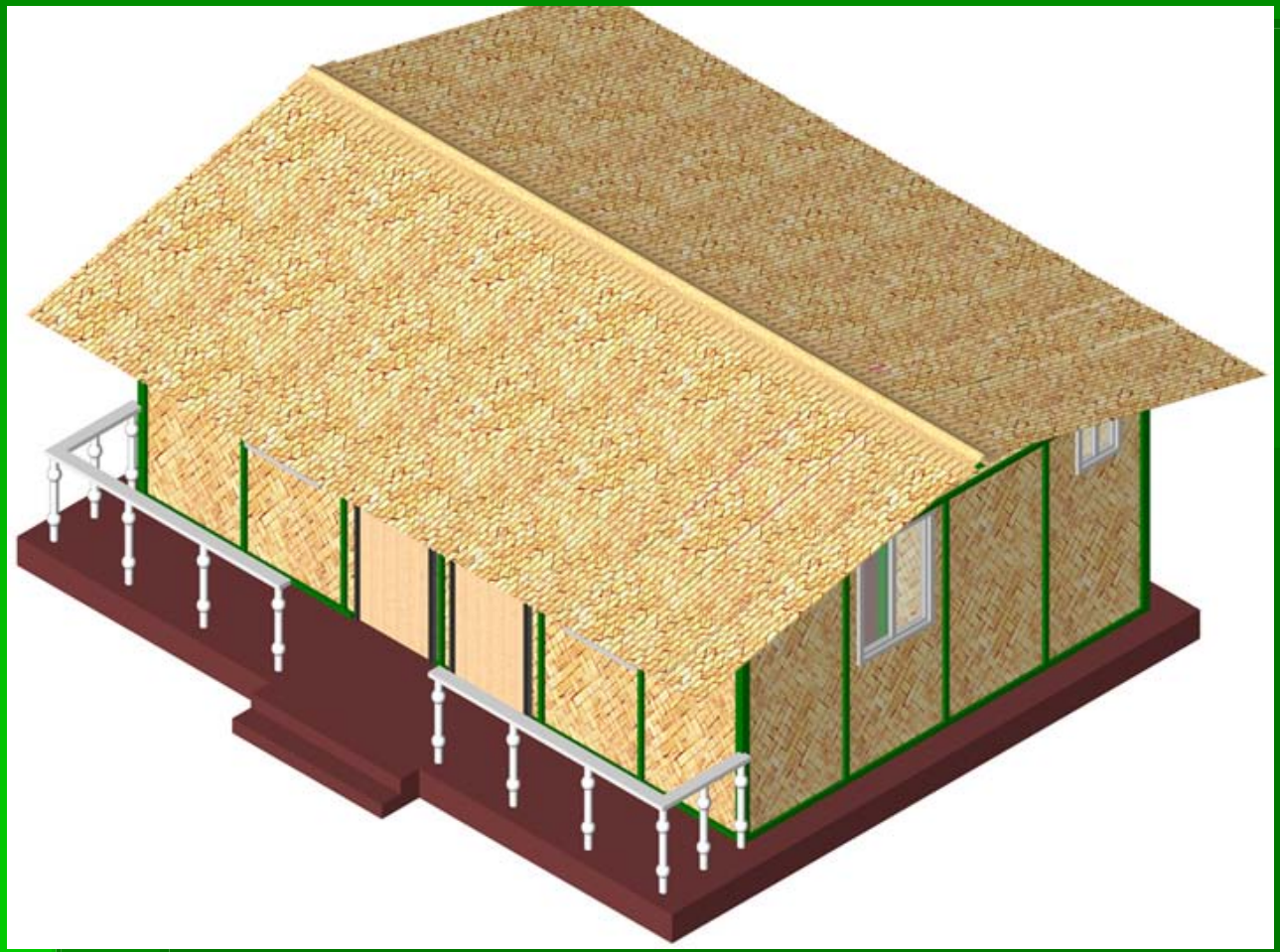

PHASES OF PRE-FAB SINGLE WALLED HOUSE CONSTRUCTION

BAMBOO HOUSING TRAINING PROGRAMME

A ten days Training Programme on Bamboo based housing system for trainees was conducted during the month February, 2016 by IPIRTI organised SIRD, Meghalaya

- **A Total of 24 participants have attended the programme**
- **During the 10 day course only five one hour theory classes were taken by resource persons and rest of the time trainees were engaged in hand's on training to build a 8'x8' full scale bamboo model house.**

CONCLUSION

Bamboo Houses developed by IPIRTI consumed 7.1 times less energy that a conventional house of similar dimensions.

Hence it is common sense and common knowledge that we should all need to conserve energy but actually making the changes in our lifestyles and in the buildings that we reside in.

THANK YOU

For information, please visit

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E-mail: ipirtikolkata@ipirti.gov.in