Bamboo as Reinforcing Material for Low Cost Housing

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Shelter Hazards

• In the aftermath of cyclones and flash floods many families are rendered homeless

• Houses made up of mud-brick wall are washed away

• Dire need for a construction; cheap and is structurally stable enough to last floods
Lessons from Past
At Kaikhali

At Pataspur
At Pingla
Near the bank of River Matla
Need of Low Cost Houses

• **Demand for houses is increasing due to the following factors**
  – Increase of population
  – Change of Joint family to Nuclear family
  – Change in living style influencing room requirement
  – Large populations get displaced every year due to natural calamities like floods and cyclones.

• **Modern Building can provide all the above needs, but is not affordable for a large section of people**

• **Price is also increasing as the available natural materials are getting exhausted**

• **High Cost of Steel**

• **Housing- a basic need for human being, is now becoming a burden for low and medium income group.**—Thus, we need cost-effective housing
House Construction Methods and Standards

• A home is the largest investment that most families ever make – it therefore needs to be a structure that will last for decades without major expense.

• The risk of flooding need to be considered.

• Attention has to be given about home security issues.

• Modern standards of hygiene dictate that running water, proper waste water treatment, electrical power etc must always be provided.
House Construction Methods and Standards (Contd..)

• Maximize the life cycle of the building frame
• Maximize the use of readily locally available materials
• At the end of the economic life of the module all components can be re-cycled with little or no waste
• The basic unit can be easily enhanced and/or upgraded as the financial stability of the occupants improves
Magical Bamboo

- Bamboo Generates almost 35% more Oxygen in comparison of trees
- Estimated Bamboo Market By 2015------ 26,000 Crores
- A Single bamboo Culm Can Spread 15 Km ------- Lifetime

- Giant Grasses; 1400 Species---- 130 in India
- 13% of Forested Area Of India-----96000 Sq Km
- Bamboo Culm -------Cylindrical Shell
- Bamboo------Composite & Functionally Graded material(FGM)
- Fibres Concentrated At The Outer Skin
BAMBOO INCREDIBLE ADVANTAGES

WOOD
- Global Warming
- Erosion
- Harvest once every ten years
- Irregular employment
- Irregular income

BAMBOO
- Annual crop
- Labor intensive
- Regular income

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**BAMBOO USES**

Upper Culm (Leaves & Branches):
- Arts & Crafts
- Medicinal
- CO2

Mid-Culm:
- Houses
- Furniture

Base:
- Construction
- Charcoal
- Furniture

Root Systems:
- Food
- Water Shed
- Erosion control
- Toxic Cleanup
- Charcoal
- Medicinal
Bamboo Environmental Blessing

- CO2 sequestration
- Oxygen generation
- Water retaining
Bamboo Applications

Bamboo Trusses
Bamboo Door Shutters

Bamboo Floor Laminates

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Bamboo Corrugated Sheets

Bamboo Board
Bamboo Scaffolding

Bamboo Mat Wall
Bamboo Bridge
Advantages

• High strength to weight ratio and high specific load bearing capacity than other wooden products.
• Requires less energy for production compared to material like steel, plastics, aluminum etc.
• 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.
Advantages

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

➢ It uses less fossil fuel to manufacture

➢ Available in almost all Tropical – Sub Tropical Regions

• Bamboo along with fast grown plantation species is very efficient in sequestering CO₂ and contributes to the reduction of greenhouse effect.
Advantages

• Its surface is smooth, clean and hard, enabling easy use for specific purposes without much processing and consequently avoiding wastage.

• Even workers with a low level of skill can split culms (stem) easily into strips with simple tools.

• Bamboo can prevent pollution by absorbing large amounts of nitrogen from waste water and reducing the amount of carbon dioxide in the air.
Bamboo with respect to low Cost housing

- High tensile strength
- Light weight (compared to steel)
- Environment friendly
- Shock absorbing and thus earthquake resistant
- Because of its lightness, bamboo house suffers very little damage from earthquake. Temporary and quick construction in disaster-prone areas is possible in cases of emergency.
Drawbacks of using bamboo

• Bamboo is not cylindrical throughout, but tapered.
• The hollow form makes jointing difficult.
• It needs preservative treatment to obtain a reasonable life-span.
• When compared with wood, it has low resistance to splitting. It is a living organism which is subject to fungi and insect attacks. Bamboo is more prone to insect attack than other trees and grasses because of its high content of nutrients.
• Low strength along fibres (it tends to separate and crack along cleavage)
NON UNIFORM FIBRE DISTRIBUTION (Cross Section)
BAMBOO CROSS SECTION

Parenchyma  Fibre  Vein
Drawbacks of using bamboo

- It is not that uniform \( i.e., \) large varieties of bamboo are found having different tensile strength.
- It has great tendency to absorb water and also to release water on drying.
- Due to its low modulus of elasticity, bamboo can crack and deflect more than steel reinforcement under the same conditions.
- It is susceptible to catch fire as compared to its counterpart steel.
Durability of bamboo as an engineering material:

• Just like timber, bamboo is vulnerable to environmental degradation and attacks by insects and moulds. Its durability varies with the type of species, age, conservation condition, treatment and curing. Curing should be initiated when bamboo is being cut in the bamboo grove.

• There is a strong relation between insect attacks and the levels of starch plus humidity content of bamboo culm. In order to reduce the starch content, bamboo receives a variety of treatments including curing on the spot, immersion, heating or smoke. Drying bamboo is fundamental to its conservation for various reasons.
Durability of bamboo as an engineering material:

• Bamboo with low humidity is less prone to mould attacks especially when humidity content is less than 15%. Physical and mechanical properties of bamboo increase with a decrease in its humidity content.

• Bamboo can be dried in air, oven or by fire. The preservative can be applied using simple systems such as immersion.

• Concrete is very alkaline in nature and will attack the bamboo reinforcement (long term performance). In addition, cracking can allow water ingress, which will cause further deterioration.
Measures to Curtail Drawbacks

- Use of coating with waterproof material like Bitumen

- To avoid swelling of bamboo culms, a thin coating of adhesive such as asphalt, araldite, Tapecrete, Sikdar 32 GEL

- Use of Sand-To enhance bond between concrete and bamboo
BOND STRENGTH

- Main Factors Affecting The Bond Strength
- Swelling & Shrinkage Of Bamboo
- Water Repellant Treatment

UNTREATED BAMBOO SEGMENT AS REINFORCEMENT
Bamboo Treatment

• Four Stages ---- Water soakage; Application of lime; Application of Adhesive & Application of Sand layer.
BAMBOO TREATMENT

ADHESIVE APPLICATION

SAND LAYER
Bamboo Reinforced Concrete Elements

- Beams
- Columns
- Slabs/Roofs
- Walls
Bamboo Reinforced Beams
BAMBOO REINFORCED COLUMNS
BAMBOO REINFORCED COLUMNS
Bamboo Reinforced Slabs
Bamboo - Concrete Mesh Panels

• Total thickness of the bamboo panel is made as 70 mm

(50 mm concrete + 6mm × 2 plaster on both sides + 8mm thick bamboo panel mat after treatment)

Concrete Mix used in Panels

- Mix proportions of 1:3:6 of cement: fine aggregate: course aggregate
- Water to cement (43 grade OPC) ratio of 0.55, all measured by weight
Steps to Prepare Bamboo Concrete Mesh

Bamboo Mesh
1 m X 1 m

Bamboo mesh after bitumen Coating

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Finished Bamboo Concrete panel
CASTING OF BAMBOO REINFORCED SLABS

• Frame work of bamboo strips was constructed which was consisting of bamboo strips varying from 94 to 96 cm in length.

• Concrete used was 1:2:4 by weight. The concrete is reinforced by bamboo frame work to produce a reinforced slab of 1mX1m.

• The finished thickness of the slab is 70 mm.
CASTING OF BAMBOO REINFORCED SLABS

- The bamboo frame was first soaked in water for 24 hrs & then it was painted with 1:1 by weight cement & water.

- In a frame work of (1*1) m at first 1 inch thick concrete was added, then the treated bamboo frame was laid on it. Then 1 inch layer of concrete was added on the top of that. The whole thing was compacted & then it was smoothly finished with cement, sand & water mix. After 24 hr it was demoulded & cured for 28 days.
Plan of Dwelling Units

Plan of one bedroom dwelling unit
(5m×5m)

Plan of two bedroom dwelling unit
(6m×6m)
Side view of one bedroom dwelling unit
## Cost analysis

### Table 2 Comparison of cost of one bedroom dwelling unit

<table>
<thead>
<tr>
<th>S.No</th>
<th>Type of construction</th>
<th>Total Cost of Dwelling unit</th>
<th>Cost of dwelling unit in per sq ft</th>
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<tbody>
<tr>
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<td>with mud wall</td>
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<tr>
<td>2.</td>
<td>with brick wall</td>
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<td>272</td>
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<td>3.</td>
<td>with bamboo concrete panels</td>
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### Table 3 Comparison of cost of two bedroom dwelling unit

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<td>2.</td>
<td>with brick wall</td>
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<td>3.</td>
<td>with bamboo concrete panels</td>
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Rates per square m

- Mud wall 80
- bamboo concrete mesh wall 285
- brick wall 430

Cost Analysis; With RCC ------ 30-40% Reduction
Outcomes

- Strength of bamboo concrete panels - much higher than the mud wall
- Bamboo concrete panels - much more durable
- The initial cost of the bamboo-concrete panels higher but the maintenance cost - lower as compared to mud walls
- Coating on the bamboo mat and sand spraying increases the bond between concrete and bamboo
- Construction of bamboo panels does not require much skill and can be easily done
- Mud walls get washed in case of floods which do not happen in case of bamboo reinforced concrete walls
Low cost housing in flood prone area

Timber or bamboo floor
Prefabricated RCC / Timber / Bamboo column as required
Bamboo-concrete / Metal wall cladding

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Bamboo-concrete / Timber wall cladding

Monday, February 28, 2011
Thanks