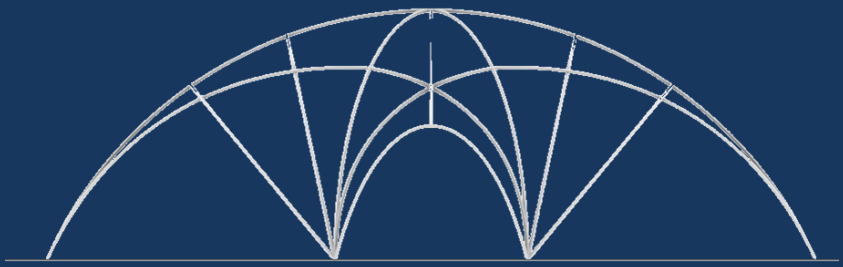
Capacity Building in Built Environment Sustainability Research (CAPABLE)

HANDS-ON WORKSHOP

# BAMBOO PAVILION

(23 - 25TH DECEMBER 2024)



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# INTRODUCTION

**Importance of Bamboo in Construction in Relation to the Circular Economy.**

The concept of a "circular economy" has been gaining momentum in recent years as an innovative approach to sustainable growth. This model focuses on creating products, services, and supply chains that are regenerative, relying on renewable energy and resources. In this type of system waste is eradicated, resources and products are reused endlessly, and economic, environmental and social well-being are intentionally cultivated [5].Bamboo could play a significant role in the transition towards a more sustainable, circular economy if the right policy measures and industry adaptations are taken.

The decline in forest wood resources and concerns over conservation emphasize the necessity of finding alternatives to traditional timber. It is in this context that bamboo assumes special significance. Bamboo is a versatile, strong, renewable and environment-friendly material. It is a member of the grass family, the fastest growing woody plant on the planet. Most bamboo species produce mature fibre in 3 year, sooner than any tree species. Some bamboos grow up to 1 metre a day, with many reaching culm lengths of 25 metres or more. Bamboo can be grown quickly and easily, and sustainably harvested in 3 to 5-year cycles [6].

Durable, flexible, low-carbon and self-renewing, bamboo poles are some of the most sustainable building materials available, with a cradle-to-gate carbon footprint.

**Bamboo is well placed to address four major global challenges**:

**Shelter security**, through the provision of safe, secure, durable and affordable housing and community building.

**Livelihood security**, through generation of employment in planting, primary and secondary processing, construction, craft and the manufacture of value-added products.

**Ecological security**, by conservation of forests through timber substitution, as an efficient carbon sink, and as an alternative to non biodegradable and high-embodied energy material such as plastics and metals. Sustainable food security through bamboo-based agro-forestry systems, by maintaining the fertility of adjoining agricultural lands, and as a direct food source – example, bamboo shoots [6].

## Geographical distribution, climatic and soil conditions

The main area of distribution are the tropics, in particular, South-East-Asia. Bamboo grow at sea level and can be found at altitudes of up to 3800 m. Some 1250 species of bamboo have been identified worldwide. India has around 130 bamboo species [1].

Fig 1: Geographical distribution

# BAMBOO SPECIES

Most widely used and distributed species are Bambusa bambos and Dendrocalamus strictus, are both well suited to construction. There are many other common species too that can be used in construction, including Bambusa balcooa, Bambusa tulda, Dendrocalamus asper and dendrocalamus hamiltonii [6].

Fig 2: Dendrocalamus strictus

Fig 3: Bambusa bambos

Fig 4: Bamboo Clump

## ANATOMY OF BAMBOO [11]

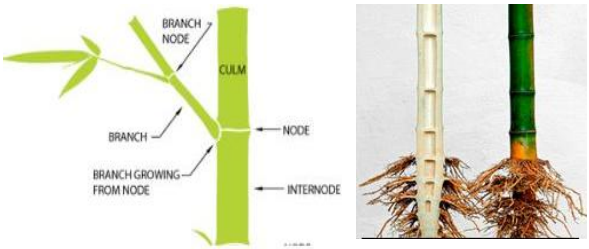


Fig 5: Parts of Bamboo Plant

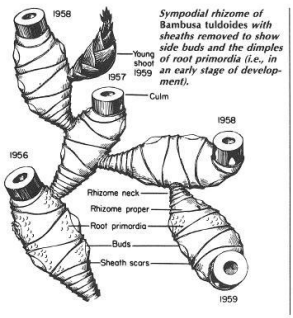


Fig 6: Sympodial /'Clumper'

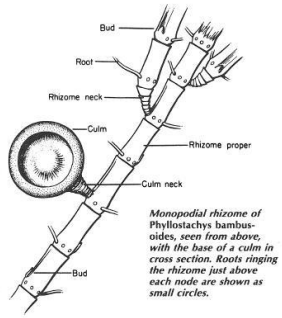


Fig 7: Monopodial /'Runner'

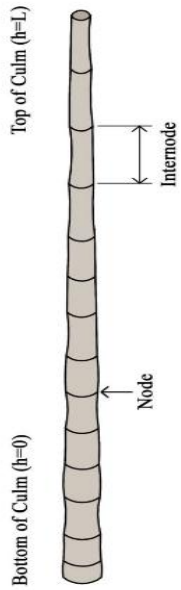


Fig 8: Bamboo Pole

# PROPERTIES OF BAMBOO

- Bamboo structure is similar to wood, but Bamboo has hardly any knots compared to wood and its culm is hollow and has built up of sections.
- Bamboo is a natural material, that *varies in diameters, length and quality* according to the climate.
- The straight grained sections are internodes which are separated from each other by a diaphragm at the lower and upper end, this diaphragm has an outgrowth called node.

Fig 9: Bamboo poles

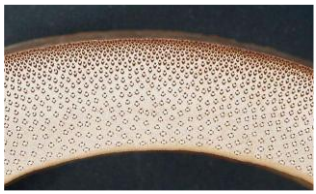

Fig 10: Bamboo cross section

Fig 11: Direction of Fiber

- Bamboo fibers only grow in the *longitudinal* direction.
- The inside cavity is called a lacuna, which is present in almost all bamboos, although there are some which have solid internodes.

Fig 12: Split Bamboo

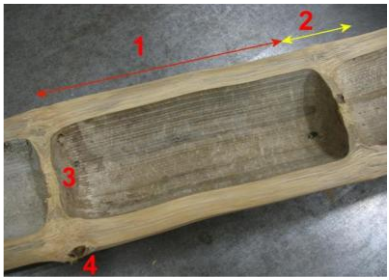


Fig 13: Nodes and Internodes

Fig 14: Surface

- The outside of the culm wall is formed by a thin cortex which has a high silica content an important barrier against water and degrading organisms and is covered by a thin layer of wax.

## PARAMETERS FOR SELECTION

Basis of selection of bamboo for real world application.

- Do not use green, fresh cut bamboo.
- Bamboo has to be completely **dry** before using it in construction (preferable air dried).
- Only use mature bamboo of **3-5 years**.
- Do not use bamboo infected by insects (powder beetle for example).
- Bamboo has to be properly **cured.**
- Do not use bamboo that has **flourished.**
- Do not use bamboo poles with profound vertical **cracks**
- Use appropriate **cuts and joints** when building with bamboo.
- Use bamboo with the right **diameter and wall thickness** for your project.

## METHODS OF HARVESTING AND STACKING

- New shoots of bamboo grow in rainy season.
- The best season for harvesting is after the winter.
- Cut bamboo that is 3-5 years old, as it is matured and naturally seasoned.
- Bamboo older than 3-5 years is harder and if it is not harvested it will start drying resulting in the cracks and breakage of culms in the stand.

Fig 15: Harvesting

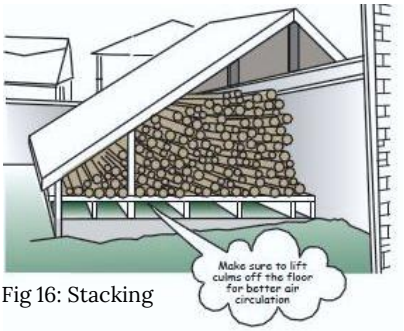

Fig 16: Stacking

- Store the bamboo horizontally or vertically in the shade to slowly dry.
- Hot sun splits Bamboo and cracks are developed on the surface, in these cracks moisture will get accumulated resulting in fungus formation and decay of bamboo.
- Bamboo should be protected from rain as excessive rain will lead to decay of Bamboo [9]

# METHODS OF PRESERVATION

## 1.Natural Method

Fig 17: Water Treatment

Fig 18: Heavy Rainwater treatment

Fig 19:Heating

Fig 20: Smoking-Kiln Seasoning

## 2.Chemical Method

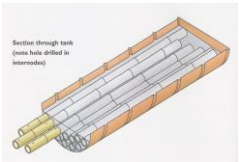


Fig 21:Dip diffusion method

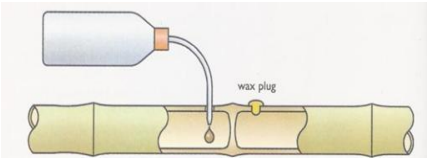


Fig 22: Internodal injection method

## 3. By Design

Protection by design involves three basic principles:

1. Keeping the bamboo dry

2. Keeping the bamboo out of ground contact

3. Ensuring good air circulation.

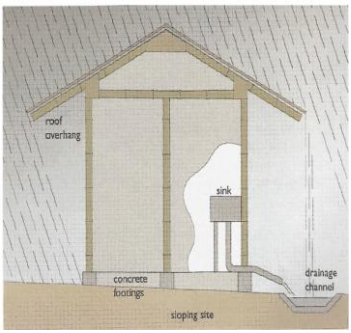


Fig 23: Protection by design

# TOOLS USED FOR BAMBOO CONSTRUCTION

The basic kit of tools necessary for construction using the bamboo-based building system as described in this manual is listed below [6].

1. **Saw:** cutting timber, bamboo and mat board to size
2. **Splitting knife:** for cutting bamboo strips
3. **Chisel:** for fine splitting, general carpentry
4. **Hammer:** for use with splitting knife and chisel and nailing
5. **Tape measure:** for setting out and general measurements
6. **Pliers:** for cutting and fixing chicken mesh and wire
7. **Hacksaw:** for cutting steel dowels and small bamboo
8. **Drill and drill bits:** for drilling bamboo for dowels and bolts **Spanner:** for tightening bolts
9. **Plastering trowel:** for floor and wall plastering
10. **Bricklaying trowel**: for plinth construction
11. **Square:** for general use
12. **Spirit level:** for ensuring plumb and level .

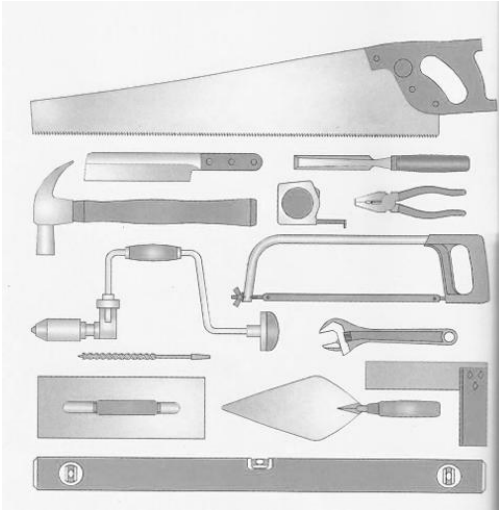

Fig 24: Protection by design

**Bamboo processing** refers to the series of steps and techniques used to transform raw bamboo into various usable products for construction [1].

## Splitting

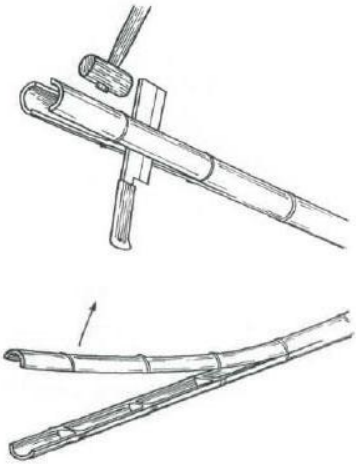

Fig 25: Process of splitting using splitting knife

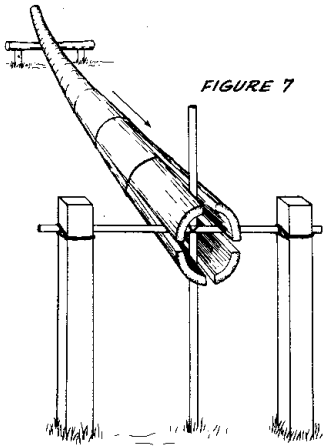


Fig 26: Process of splitting using fixed splitter

## Knot Removing, Width sizing & Plaining

Fig 27 : Knot Removing

Fig 28 : Knot width sizing

Fig 29: Matt Making

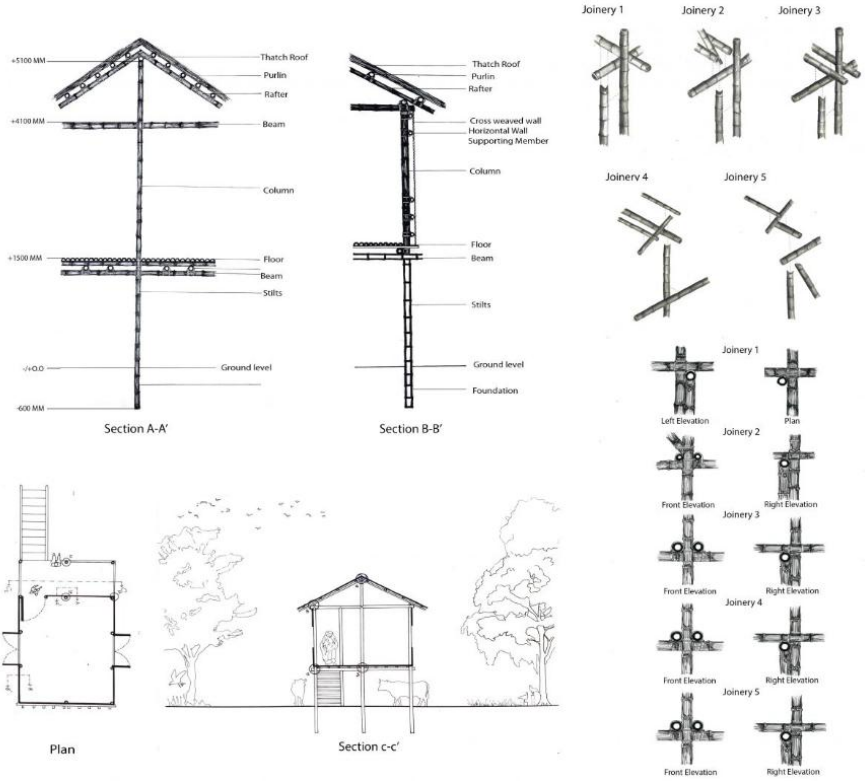


Fig 30: This drawing describes a building system in which bamboo fulfils the main structural role [8].

The following types of joints are used in Bamboo construction to suit the different purposes:

- Lengthening Joints
- Bearing Joints.
- Framing Joints.
- Angle or Corner Joints.
- Oblique Shouldered Joints [10]

**Bamboo cuts for joining**

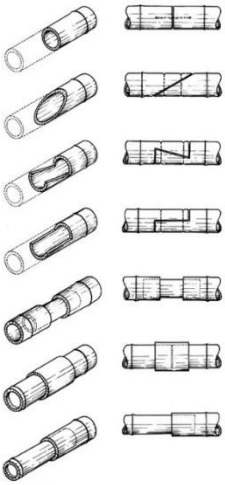

Fig 31 : Bamboo Cuts

## Bamboo joining techniques

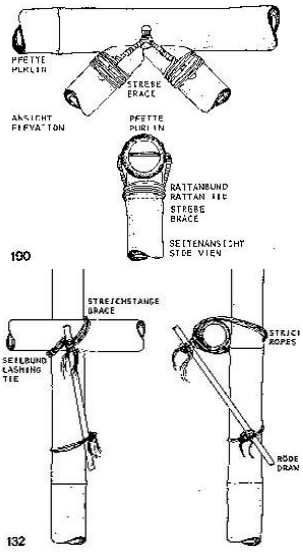


Fig 32: Joinery by thread

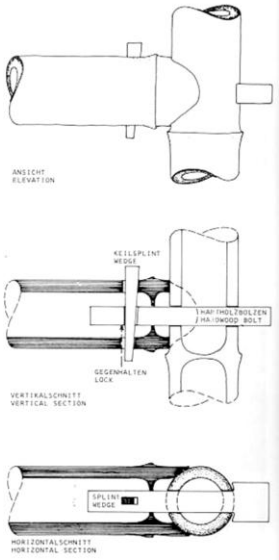


Fig 33: Joinery by bamboo pin

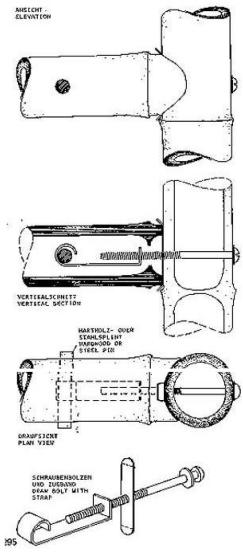


Fig 34:Joinery by nut and bolt

Fig 35: Green School, Bali

Fig 36: Meti School, Rudrapur, Bangladesh

Fig 37: 80' Bamboo Bridge, Pyramid Valley, Bangalore India

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# NOTES

## Resource Persons

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*Assistant Professor | Practicing Architect | Sustainable Design Enthusiast*
Sayali Andhare, is an accomplished **architect** with over **19 years of professional experience** in architecture and more than **14 years as an Assistant Professor at BNCA, Pune**. A graduate with **First Class Honours** from **Visvesvaraya National Institute of Technology, Nagpur**, and masters from Dr.B.N.College of Architecture in Environmental architecture,Sayali specializes in **sustainable architecture, green material usage**, and **innovative, ecosystem-conscious design**.
As Principal Architect of *Studio Shoonya*, Pune, she has spearheaded several eco-friendly projects, including earth-based and bamboo constructions, prioritizing energy efficiency and context-sensitive design.
An avid learner and nature enthusiast, Sayali combines her passion for **teaching, research**, and hands-on building to foster a **holistic architectural approach**.

**Rajendra Sapkal**
Bamboo Artisan

*Bamboo Artisan | Sustainable Crafts Specialist*
Rajendra Sapkal is a skilled bamboo artisan renowned for his expertise in crafting sustainable and eco-friendly bamboo products. With years of experience, he blends traditional techniques with innovative designs, creating functional and artistic pieces. Passionate about promoting bamboo as a renewable material, Rajendra actively engages in workshops and community initiatives to empower artisans and encourage sustainable living.

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