



**12<sup>th</sup> World Bamboo Congress**

**Taiwan, 18-22 April, 2024**

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## **Solid bamboo pole standardization and furniture making**

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### **Abstract**

Design and standardization of bamboo pole is one of the key components required for the bamboo furniture sector development in India. Solid bamboo species have better potential to be used in making bamboo furniture. There are various solid bamboo species in India used for furniture making. *Dendrocalamus stocksii*, *Thyrsostachys oliveri* and *Dendrocalamus strictus* are some of the commonly used bamboo species found in India which are solid in most of the cases. These three are growing in various regions in India, cultivated by farmers and is available in good quantities. However, the furniture making process is still limited to hand made and is not able to satisfy the market. Looking at this potential I have explored the design application of these species especially for making furniture. In the process of designing and experimenting, I have developed possibilities of material standardization, various standard formats of joints, standard process of making, finishing, combination with other materials etc. which can create wide range of furniture. This approach can help in bringing the quality of standard and sustainability aspect looking at the market. The process can be followed by both industrial and semi-industrial furniture manufacturing sectors in the country. In the process various furniture samples are being created with the standardized solid bamboo poles and a clear-cut process is followed to maintain the quality aspects. This method can help in production with a flat pack concept suitable for the consumer market. This approach can change the bamboo furniture making scenario in India and can establish a good economic model ‘from plantation to the consumer’.

**Keywords** Solid bamboo; Standardization; furniture

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## 1. Introduction

Bamboo is one of the best natural materials available for various uses from small products to furniture and the construction of houses. It is truly a sustainable – eco-friendly - renewable natural resource and one of the fastest growing plants. Various species of bamboos found at different parts of Indian sub-continent are used locally for various purposes. Most of these uses are in the form of baskets, houses, bridges, and various products for local needs. In the contemporary context, the last two decades bamboo-based activities have been shown tremendous growth, in terms of its availability and the usages. The utility of bamboo products by the consumers has also been increased with innovation of new applications, introduced by various institutions, designers, entrepreneurs etc. Various efforts, such as plantation, design training, technological intervention etc., are introduced to uplift the bamboo clusters in India, looking at the market potential of this material.

The bamboo furniture making sector in India, we can observe there are various approaches are followed. It is based on various kinds of bamboo material, like hollow type, solid type, or using various composites. Traditionally, for many years artisans are following method of making hollow bamboo furniture which are very strong, heavy, and non-dismantlable type. These are difficult in transport and in handling. Another approach found which is using solid bamboo is established around two decades back. Even though it is fixed type, comparatively this is lighter weight and easy to handle. However, the packaging and transportation issues are still there. Both the above cases the scalability is an issue, and this cannot meet the market demand. Some of the industries in India have been trying to establish in making furniture using bamboo composites. However, this method is still needed to establish addressing the demand and supply. The Indian furniture market is very huge, and the bamboo furniture can find a good place in it if we address the potential areas in a strategic manner. We need to look at the species, design approach and the technology aspect to scale up the production.

As a furniture designer I have been investigating and experimenting many approaches in making solid bamboo furniture for about last two decades. Some of these has been introduced to the artisans in the filed through various training programmes. This experience and the feedback from industrial sectors have encouraged me to think about a new system that can help in scaling up the bamboo furniture production with a standardised method to address larger potential of the market.

## 2. Materials and Methods

### 2.1. Bamboo

Bamboo is one of the fastest growing plants, whether to be called green gold, giant grass, or woody grass, it is one of the amazing raw materials to explore in various ways and means for all kinds of applications. Conversion of bamboo to various sizes of splits and its pliability to weave and construct structure etc. makes this material very special among other natural materials. Similarly, many of the special properties of bamboo help to create various products for day-to-day life. It is the most sustainable – eco-friendly - renewable natural resource used for various purposes. India has got good tradition in utilization of bamboo as a raw material for various usages especially in basket making. The North-East part of India has demonstrated the utilization pattern of bamboo through many applications with various species and its properties. When we look at the applications for the modern lifestyle market, furniture is one of the most important products that can be built using bamboo and can replace many materials like wood, steel, and plastic. We can make bamboo furniture in many ways such as using hollow bamboo, bamboo splits, bamboo boards, bamboo timber etc. However, using solid or partially solid type of bamboos for making furniture have a great potential in Indian sub-continent.

### 2.2. Solid Bamboo

There are various solid or partially solid bamboo species are found in India. The partially solid portion of the bamboo with very thick walls are also suitable for utilizing in the making of furniture. *Dendrocalamus stocksii*, *Thyrsostachys oliveri* and *Dendrocalamus strictus* are some of the commonly used bamboo species found in India which are solid in most of the cases. After experimenting with available solid bamboo species from various regions by making furniture products, the raw material that I have used is *Dendrocalamus stocksii* (Figure 1) which is naturally distributed in Central Western Ghats of India. It has medium sized, and strong culms. Though the natural distribution of this species is in humid tropics with lateritic soil type this species has a wide adaptability and comes up well in tropical humid, sub humid and semi-arid conditions under black and red soils as well.



**Figure 1. Clumps**  
*Dendrocalamus stocksii*

It is the most preferred species by the farmers in Peninsular India. *D. stocksii* is considered as an important agroforestry species, ideal for plantations in watershed and coastal regions. It is planted as a component of home gardens or as pure block plantations. This is an extremely manageable species with great economic and ecological importance as well as large scale utilization potential. This species is preferred among bamboo users because of its non-thorny nature, loosely spaced culms which facilitate easy management. Because of its inherent properties as a solid bamboo, it can be bent to form a curve/arc by applying heat and pressure on the poles. This is one of the important properties when we consider it for making furniture products. Similarly, since it is solid in nature joining it with various joints like timber is also an added advantage. Sometimes the above portion of the culms will be hollow which also can be utilized for various applications. The raw material from various regions appears in change in the diameter which also helps in using various components of furniture. This can be one of the species that can be used on a larger scale as an industrial raw material for furniture making.

### **2.3. The Design Approach**

The approach is derived from observing the market needs and the potential of solid bamboo species which is not yet explored at its best possible ways. The Indian bamboo furniture sector is lacking the approach of component-based production system and knockdown joints that define the scalability in an industrial scenario. The current systems of bamboo furniture manufacturing by using hand tools and semi-mechanized method does not support scalability in terms of numbers. This is due to the current approach in design and construction method that has been practiced so far. We require the knockdown and flat pack systems, which are the

market trends, that helps in easy production, transport, and handling for both retailers and customers. So, the challenge here is establishing a proper standardized method of raw material processing, joinery systems that can be adaptable for both small scale and large-scale furniture making sector. This approach can be partially adapted by the handmade sector, semi-mechanized sector, and the industrial sector.

#### 2.4. Standardisation of poles

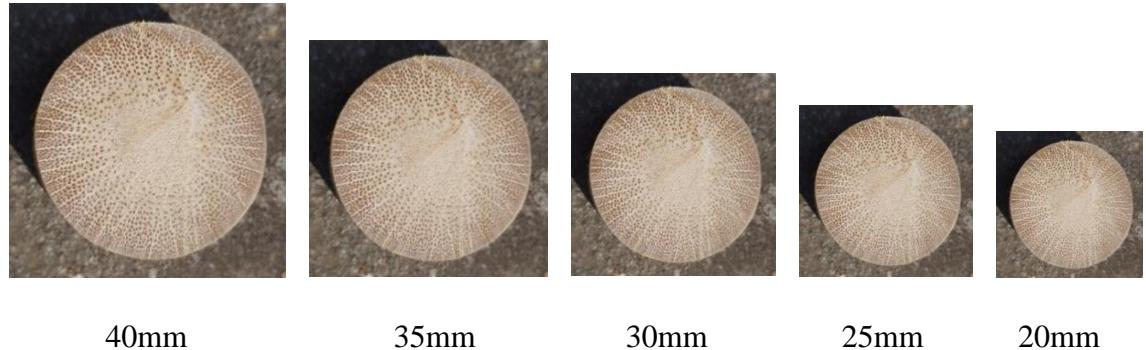
Currently large-scale furniture manufacturers are utilizing only standardized raw materials for their production of furniture. However, Solid bamboo comes in various sizes, diameter etc. in its natural form. So, creating standardized raw material of solid bamboo in its natural form is the key challenge. Standardizing certain length, diameter etc., according to the availability can create a system in utilizing this raw material for methodical production. This study is done on bamboo from various locations where it has been cultivated, which established the dimension of this species can be standardized for furniture making.



**Figure 2.** Raw material, *D. stocksii*, of various diameter from 60 to 20 mm (approx.) in natural form

Based on the experiments, several *D. stocksii* samples were collected from various regions in South and Western part of India, to check the available diameter and finalize the standardized rods (Figure 2). It is found that various geographical factors influence the growth and that allows get the variations in the diameter. It is found that the maximum diameter at the bottom of the pole available is 60mm (+/-) approx. which are mostly solid. Then the variation up to around 20 mm. – Figure 3 presents the different diameter class of *D. stocksii* available. Based on these following dimensions are finalized as the standard diameter rods that are suitable for

making various furniture, in combinations. The diameter can be standardised to 20mm, 25 mm, 30mm, 35mm and 40 mm in its diameter (Figure 3 & 4).



**Figure 3.** Various standard diameter achievable from *D. stocksii*



**Figure 4.** Samples of standardised poles prepared as part of experiment.

Initially these standard poles were made using a wooden lathe and then for faster production a CNC lathe can be used. However, this is not feasible in larger scale production in an industrial set up. There is another mechanical process that is suitable and can be used in such a scenario. The cutting blades can be standardized according to the diameter requirement. This method of standardization is experimented with to establish the viability of it. This will ease the production of natural bamboo furniture making it easier like other standardized materials used in furniture making.

## 2.5. Standardisation of Joints

The second part of the challenge is the development of standardized joints for fixed and knockdown furniture making. After doing the research of existing joints and testing I have established several bamboos to bamboo joining methods for the previously mentioned standardized solid bamboo poles using currently available equipment. This can be refined, and a new set of machines could be introduced for an appropriate production method. According to the various standard diameter of poles various combinations need to be developed to ensure

the maximum strength. The selected round tenon and mortise joints were experimented on these materials. Along with connectors this will be helpful for creating any types of furniture structure using the standardized poles of solid bamboo. This can be achieved with a simple mechanized process existing in the furniture manufacturing sector with necessary modifications. Based on this number of test joints were created to understand the viability of it with fitting to each other with various diameter of poles (Figure 5). Based on this a size versus joinery proportions was created as a reference point for designers and manufacturers (Figure 6).



**Figure 5.** Sample joints made as part of the experiments with various sizes of poles.

Combination of Bamboo to Bamboo Joints of varius Diameter					
	20 mm	25 mm	30 mm	35 mm	40 mm
20 mm	20 x 20	20 x 25	20 x 30	20 x 35	20 x 40
25 mm	25 x 20	25 x 25	25 x 30	25 x 35	25 x 40
30 mm	30 x 20	30 x 25	30 x 30	30 x 35	30 x 40
35 mm	35 x 20	35 x 25	35 x 30	35 x 35	35 x 40
40 mm	40 x 20	40 x 25	40 x 30	40 x 35	40 x 40

**Figure 6.** Size Reference Chart describing the various possible combinations of standardized solid bamboo rods.

This chart will help the designers and furniture producers to decide the usage of standard poles with a proper strong joint without any technical failures. Various shapes of neck and shoulder of round tenon will help in bringing various aesthetics to the joints and will define a style.

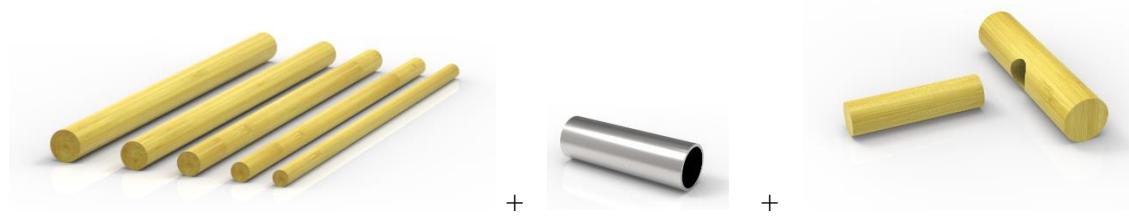
## 2.6. Metal Connectors

Along with these bamboo-to-bamboo joints I was also looking into developing a few standardized steel connectors (Figure 7) to enable the production and assembly much faster as well as stronger. We can create many furniture using only bamboo to bamboo joints; however, this limits the further possible design direction to expand the collections.



**Figure 7.** The exploration of metal connectors in various forms and junctions

The combination of these joints and connectors will be helpful for creating any types of furniture structure using the standardized poles of solid bamboo. Altogether this will enhance the capacity of production, flat pack and transportation and easy assembly and dismantling. The concept also enables a customer to use their basic skills to assemble and dismantle the furniture without any technical support. This basic construction method was derived to experiment the viability of this method. The construction of a simple frame structure is described with the 3D images below here (Figure 8) to understand the basic method. This defines a particular way of processing raw material to components and to assembly method. This can be a scalable method to be used in a larger bamboo-based unit and will also make the cost of production more affordable to the customers.





**Figure 8.** Basic frame construction using the joint & connector with solid bamboo pole.

The above example is a demonstration of a semi assembled component-based furniture structure that can be made. Here the bamboo-to-bamboo joints will be fixed permanently using adhesive and the location with metal connectors will be dismantlable. Like the above, other various shaped metal connectors can be used for preparing more complex structures for furniture making. This has been established through making various furniture forms and testing with the designers and furniture makers in various design experimental workshops.

### 3. Result and Discussion

#### 3.1. Examples of Furniture

I have been associated with the Centre for Bamboo Initiatives of the National Institute of Design for the past 24 years. During this period, I designed many solid bamboo furniture as part of various projects and developments. Initially most of this furniture was fixed type rather than knockdown.



**Figure 9.** A test prototype of centre table, created using the standardised method of construction.

Gradually the concepts of knockdown joints were tried out using various bamboo to bamboo joints and metal connectors along with hardware. Now with the new approach of standardized solid bamboo poles and joints I have tried making various combinations for prototyping furniture (Figure 9).



**Figure 10a.** Prototype of an office table using the bamboo structure with steel connector and bamboo laminated board for the top surface.

**Figure 10b.** Various prefabricated components of the office able constructed as per the standardised systems created as part of the research.



This demonstrates the potential direction for generating more designs for all categories of residential, office, partition, school furniture etc. This approach is mostly to create the furniture structure. However, various other materials like bamboo boards, glass, canvas, upholsteries, etc. (Figure 10a & 10b), can be used appropriately along with this for adding the surfaces.

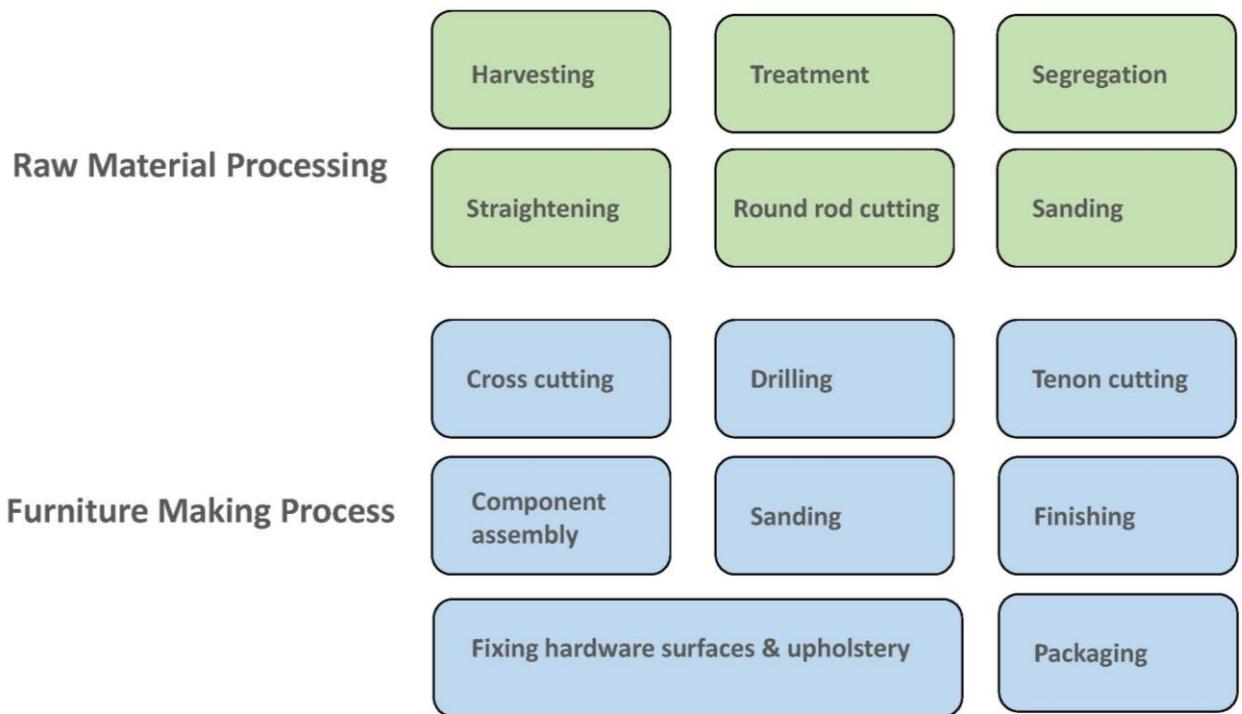


**Figure 11.** The furniture made by participants using same method during the design workshop.

As a result, it is established that the system developed can be adaptable by many people with simple production processes and methods. The above images (Figure 11) are made by the participants in a design workshop by adapting the methodology that has been developed. These are only a few examples of the application of this system, and this can be expanded to many more furniture products with quality in structure, strength and aesthetics.

### 3.2. Standardization of Production Process

Based on the above experiments and findings a system of production method can be created to understand it well to maintain the quality aspects of the furniture (Figure 12). In the system there existing methods and new methods are suggested with available and modified technologies. Some of the process can be completed near the harvesting place itself to make sure the material is transported without much insect attack on it. This will reduce the risk in long-term storing and using the material in an industry or warehouse. Most of the other processes are using the basic machines and tooling that are required to standardise the pole dimension and joints like round tenon and fastener bits etc. Bamboo being a harder and fibrous material it required good hard and sharp tools compare to timber. Even though we are using similar machines used in woodwork it required some modification of tools and fixture that helps working with bamboo. The work process flow chart is given below for the ready reference to understand the standardized methods in various stages.



**Figure12.** Standard process flow chart for making the solid bamboo furniture from raw material to the product packaging. These processes are existing practices in bamboo and wood - based industries, which are systematized for faster production and quality control.

### 3.3. Market Potential

Connecting this development to the market is also very important. Currently domestic and international markets are looking for bamboo furniture for various segments which could be scalable to an industrial level production. The furniture should be affordable to the larger section of the consumers, simple, strong as well as help in easy production and transport. This will open the potential of bamboo furniture market supporting large scale farming of similar species, processing and will create more job opportunity. Several technology developments are required apart from the current technologies to create a smooth production line. However, this will be one of the way Indian furniture sectors can shape up with using local bamboo species. The current manufacturers and entrepreneurs can adapt this method with their current set up adding a few more processes. Large furniture retailers in domestic and international market can look at this as an opportunity to look at India in producing bamboo furniture in large scale.

## **Conclusion**

The above development shows an opportunity for Indian market to scale up for bamboo furniture manufacturing, which is achievable in near future. However, the efforts need to be put in creating an ecosystem from farming to processing to production. These need to be established in specific to the requirement of above methodologies can ease the entire process. I am still in the process of validating my development with a greater number of products and furniture for various uses. Simultaneously my students are also using this method in developing their new furniture systems in various projects. A proper bamboo furniture manufacturing standard can be established through this development which will guide students, entrepreneurs, and manufacturers for the development of furniture.

The system also has an opening to combine the traditional woven baskets and trays for making sustainable furniture for retail space. This will help in reducing the non-eco-friendly material used in a retail environment. I have developed few models for such applications which are scalable and at the same time provide rural employment in villages. Through these we can drive the market to use more sustainable material and replace the other materials.

## **Author Declaration**

I hereby confirm that the manuscript is based on the original research and experiment of the author as part of the PhD with National Institute of Design from 2018 onwards. All the images used here are the original images created by the author. Therefore, there is no conflict with intellectual property rights and there are no impediments to publications.

## **Acknowledgements**

I am extremely thankful to the National Institute of Design (NID) Doctoral Advisory Committee and Dr Shilpa Das for their encouraging feedback during various stages of research and experiment. I am also extremely thankful to my guides Dr. Syam Viswanath, Director, Kerala Forest Research Institute and Prof. Vijai Singh Katiyar, Principal Designer, National Institute of Design, Ahmedabad. I express my gratitude to Mr. Parameswaran Krishna Iyer, Bamboopecker for his constant support in providing raw material for the experiments and providing necessary technical support, and express my thanks to Mr. Ranjit Debbarma, Mr. Shreedhar H., and Mr. Rahul David Sanapala for their support in prototyping the experimental models. Thanks to NID Director and colleagues for their encouragement and support throughout.

## **Conflict of Interest**

The authors declare there is no conflict of interest

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