

Hands-on

Chinese Style Bamboo Furniture

Manual on bamboo furniture making

Acknowledgement

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Most of the photographs included in this manual were taken by the authors during the workshop. Exceptions are the photographs on page 11; page 12 (storage and drying); p. 13; p.14; p.15; p.16 (steeping) and p. 17, which were copied from the Bamboo Preservation Compendium, by W. Liese and S. Kumar.

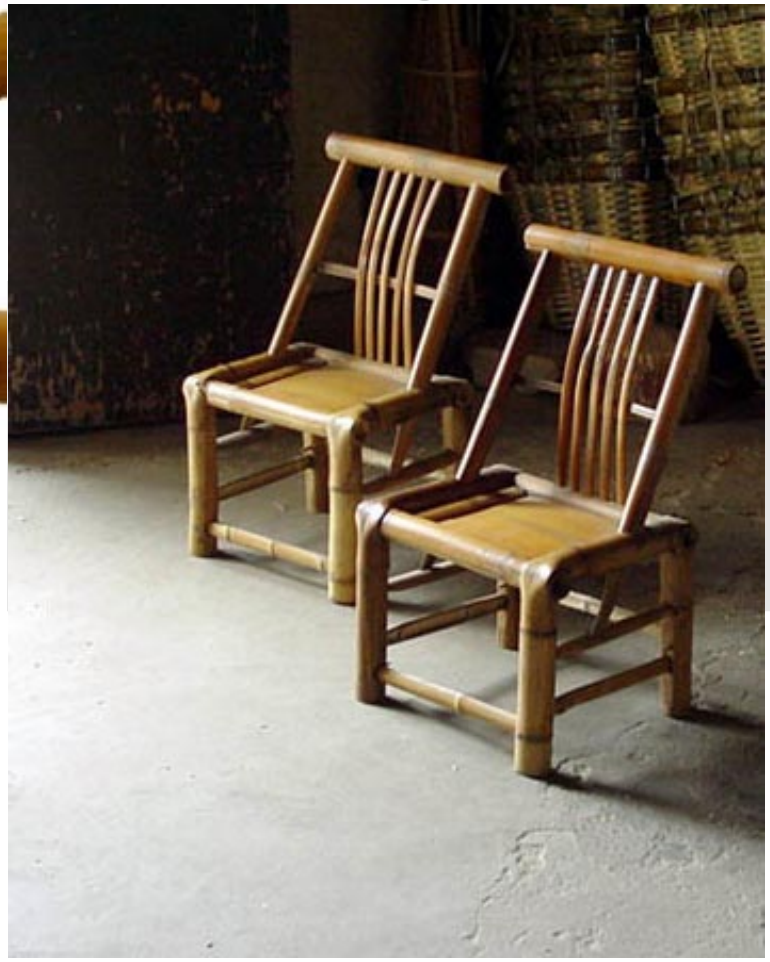
The authors.

Traditional Chinese Furniture Making



The basic technique of traditional furniture making in China is called "YU".

This technique involves making a *bent mortise* which ties the different components together and forms a strong framework.



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Introduction

Bamboo is ...

'The poor man's timber' in INDIA

'The friend of the people' in CHINA

'The brother' in VIETNAM

Bamboo has a long history as material in furniture making. It is widely available in the developing countries as a strong, cheap and eco-friendly material. Bamboo furniture is elegant, light-weight and has a natural look.



The following chapters describe the sequence of the activities involved in furniture making :

1. **Raw material selection**
2. **Preservation methods**
3. **Drying**
4. **Durability measures**
5. **Processing culms**
6. **Making components**
7. **Assembling & Finishing**
8. **Additional design features**

Raw material selection

Bamboo culms used for furniture making are selected according to the specific design requirements of the furniture products. In general, middle or small sized bamboo culms are used, that are straight and upright, with not so protruding nodes and without failures such as lesions or insect holes.

Selection of material further occurs in accordance with required properties like strenght or flexibility that vary with different furniture components. Accordingly we distinguish three different component groups:

1



- **Structural components**
- **Surface slath applications**
- **Weaving**



For each of these the required properties of bamboo culms are described hereafter.

1

Structural components



Properties: Thick-walled culms of medium diameter. Thick walls provide strength and a higher tolerance for nailing and drilling.

Suitable species:
Arundinaria amabilis; Bambusa balcooa; Dendrocalamus bambusoides; Dendrocalamus latiflorus; Phyllostachys pubescens; Thyrsostachys siamensis

Required culm age: Mature culms, 3 to 4 year old, are most appropriate as they combine strenght with low moisture content and low shrinkage.

Surface slath applications

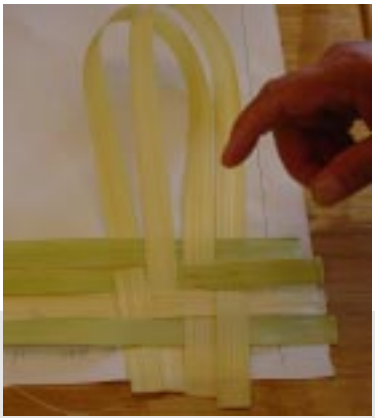


Properties: Bamboos with longer internodes, that give longer slaths. Such bamboos usually have thinner walls.

Suitable species: *Bambusa chungii; Bambusa nutans; Bambusa textilis; Bambusa tulda; Dendrocalamus giganteus; D. hamiltonii; Melocanna baccifera; Neosinocalamus affinis*

Required culm age: Mature culms, 3 to 4 year old, are most appropriate as they combine strenght with low moisture content and low shrinkage.

Weaving



Properties: Young freshly cut culms with medium to long internodes.

Suitable species: *Bambusa chungii; B. textilis; Dendrocalamus giganteus; Neosinocalamus affinis; Melocanna baccifera; Phyllostachys bambusoides*

Required culm age: Young, up to 1 year old culms are required as they contain a high moisture content for easy slivering.

Durability measures

Compared to timber, bamboo has a low natural durability. When used indoor as furniture, it may last 4 to 7 years. Factors that reduce bamboo quality are cracks, splits and attacks by fungi and insects.

The durability of bamboo against these factors much depends on environmental conditions and its treatment from harvest onward.

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The durability of bamboo can be enhanced by taking measures in the following stages:

- **Species selection**
- **Harvesting**
- **Storage**
- **Drying**
- **Manufacturing**

Species selection

Generally, species with a high starch content are more susceptible to attack by fungi and insects.

Thick walled species are less likely to split or crack when nailing or other fastening techniques are applied, which reduces the risk of fungal or insect attack.



Harvesting

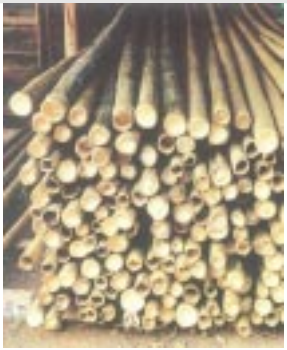
Harvesting culms during the rainy season and after shooting may reduce the risk of fungal or insect attacks, as the culms have a lower starch content.



2

Storage and drying

Culms should be stacked horizontally over raised walls and off the ground, to facilitate water drainage and air circulation. Preferably under a shed to prevent exposure to sunlight which may cause cracks. The latter often develop when bamboo is dried too quickly.



Manufacturing

Nailing without pre-boring frequently results in splitting. Moreover, nails tend to become loose with time and may also corrode. Both increase the risk of fungal attack.



Preservation methods

The durability of bamboo culms can be significantly improved by using preservation methods. The preservation requirements vary from species to species and depend on the climatic conditions of the place where the product is made and used.

3



There are two types of preservation methods:

- **Traditional or non-chemical methods**

These methods are cheap and safe and can be carried without any special equipment. However, not much is known yet about their effectiveness.

- **Chemical methods**

Chemical methods are more effective than traditional methods, but not necessarily economical or feasible. Moreover, their application may be hazardous to the user's health and the environment. In this section only some low-cost and relatively safe methods are described.

Traditional preservation methods

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	Principle	Process
Clump curing	Through leaf transpiration, the moisture and starch content of the culm is brought down to minimize its susceptibility to insect and fungal attack.	The culms are cut at the base and left leaning against neighbouring ones for a few days until the crown has turned yellow-brown . The culms are placed off the ground.
Smoking	On exposure to smoke the moisture content is reduced, and a protective layer of tar is formed on the outer surface of the bamboo. Smoking also reduces splitting. All these together reduce biological attacks.	The culms are exposed to smoke by placing them over fire or by placing them in a smoking chamber for a suitable duration.





Smoke darkened culms



Smoking chamber

	Principle	Process
Soaking	Water leaches out the starch content of the culm, making it less attractive to certain organisms. At the same time the culm is effectively sealed off from these.	Freshly cut culms with ruptured nodal walls are submerged in either stagnant or running water for 2 to 3 months and then air-dried. In some regions culms are submerged in salt water or mud.
Lime washing	Culms are painted with slaked lime that is transformed into calcium carbonate that inhibits water absorption. The surface becomes alkaline which wards off fungal attack.	Culms can also be painted with a mixture of tar and sand, or plaster, cow dung and lime, to prevent fungal and insect attack.



Soaking in water



Plastered walls in Costa Rica



Plastered walls in CostaRica

Chemical preservation

	Principle	Process
Sulphur smoking	Exposure to sulphur smoke kills fungi and insects. *Care must be taken not to inhale the sulphur smoke when opening the bag.*	Bamboo culms are placed in a sealed plastic bag with burning sulphur for 24 hours. The culms turn a little whitish during the process.
Steeping	The sap is replaced by the chemical preservative solution through diffusion.	Culms of desired length, with branches removed, are immediately after harvest placed upright in a container of concentrated water-borne preservative solution for diffusion. Up to 25% of the butt-end is kept immersed for 7-14 days depending on culm lengths.



Sulphur smoking



Butt end treatment

Use a 10 to 15 % solution of boric acid and borax (50:50). This is a clean, odourless and cost-effective water-borne preservative, effective against fungi, termites and insect borers while posing little threat to health and environment.

	Principle	Process
Soaking	The sap is replaced by a chemical preservative solution through diffusion.	Freshly cut branchless culms with punctured nodal walls are weighed down in a container prior to adding a water borne preservative solution. The method takes at least 14 days for round culms.
Sap-replacement	The sap is replaced by a chemical preservative solution under pressure.	With a bicycle pump a preservative solution is forced under pressure through a freshly cut culm. Usually, when the outflow has reached 10% of the culm's volume (which is equal to the vessel volume of the culm), the treatment has been accomplished.



Soaking in Boric acid solution



Sap replacement method



Dripping preservation solution

In Costa Rica, a boron-based preservative (Menorel) has been successfully used, that also serves as a fertilizer.

Drying

In this process the content of both starch and moisture is reduced. The method of drying varies with the market requirements. If the product is used in a moist environment, the moisture content of the bamboo should be lower.

If dried too quickly, bamboo will split and shrink around its solid nodes. Cracks and splits will develop and lead to subsequent deterioration by fungi and insects.

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There are two basic methods for drying:

- **Traditional Drying**
- **Commercial Drying**

Traditional Drying

Drying by exposing the culms to natural air, preferrably under a shed, is traditionally practised in many countries. This is the most economical method. Drying depends on prevailing temperature, relative humidity, and natural movement of atmospheric air to which it is exposed. For local markets traditional drying may suffice.



Commercial Drying

In this method drying occurs in a closed chamber or a building where the drying conditions (temperature, humidity, air circulation and ventilation) can be controlled and maintained at desired level. The drying time is influenced by the species, culm wall thickness, initial moisture content and portion of the culm. Grading of the culms before drying is therefore very important. Drying is hastened by scraping the outer skin.



4

Processing culms

As a raw material, bamboo culms have to undergo a series of treatments before their actual application in furniture making. These collective treatments we call processing.

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These are the processing treatments:

- **Checking for straightness**
- **Straightening bamboo**
- **Scraping skin**
- **Removing outer nodes**
- **Node punching**
- **Sand filling**
- **Heat bending**
- **Cross cutting**

	When applied	How applied	
Checking for straightness	To check whether bending has to be done for straightening the culm.	Bring the culm end to the eye for alignment, to check for straightness. *Roll the culm on a plane surface to detect posssible irregularities.*	
Straightening	To ensure straight and uniform lines and curves in the furniture components.	Apply heat with a blow torch, uniformily across the whole section to be straightened.	
Scraping skin	In case the bamboo does not have a clear skin, removing a thin layer of the culm skin makes it look nice and uniform.	Apply the knife to remove a thin layer of the culm skin. Use use the knife back and forth for a uniform removal of outer skin.	

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	When applied	How applied	
Removing outer nodes	Outer nodes are shaved off in order to get a uniform diameter all along the culm length.	Apply a hand plane along the circumference of the culm node, making back and forth movements while turning the culm with the other hand, to remove the protruding portion of the node.	
5		Keep the marked part of the hand plane as well as the blade edge against the node, perpendicular to the culm length.	
Node punching	In order to fill the whole culm with sand, drilling through the inner nodal walls is required.	Puncture the inner nodal walls with a long drill bit fixed on a drilling machine.	

	When applied	How applied
Sand filling	Culms are filled with sand before heat bending is applied, to prevent cracking and splitting of the culm.	Plug one side of the culm. Then fill the culm with sand while tapping on the floor to close the voids.





Hole in the culm node

Plugging one end of the culm



Cross cutting	Prior to making funiture components the culms are cut to the desired lengths.	Cut the culms to desired lengths using a saw. *The handsaw blade should always be right angled to the culm length while cutting*



5

Heat bending



When applied

Heat bending is done for transformation of straight bamboo culms into desired curves.

How applied

1. Apply heat using a blow torch, in proximity to the portion to be bent.

2. Move the blow torch back and forth, so as not to crack the bamboo culm. Single point heating should be avoided.

3. Bend the culm by applying force on opposite ends.

4. Cool the bend of the culm with water to fix the fibers, in order to maintain its position. Cooling also serves to prevent scorching.

5. Continue to apply heating and cooling till the desired curve has been obtained.









Making furniture components

After processing, the culms are used for making furniture components. All components used in Chinese style furniture are listed hereafter.



- **Leg poles**
- **Stool leg supports**
- **Mortise frame**
- **Bamboo or wooden plugs**
- **Surface supporting batterns**
- **Bamboo nails**
- **Surface strips**
- **Concealing belt**
- **Flattened Bamboo surface**

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Leg poles

Leg poles are important components, as they support the entire furniture piece.

1. Cut the required number of legs out of a single culm. Ensure that each leg pole has a node at one end for strength reasons.



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2. Check if all the pieces are vertically upright and equal in length. Make both the cut ends perpenndicular to the culm length.



Stool leg supports

For this component culms need to be sand-filled so they can be subjected to heat bending. Leg supports are added to the leg poles for extra strenght. They are applied in between the leg poles.

Apply heat bending* to the culms and check constantly for the right fit.

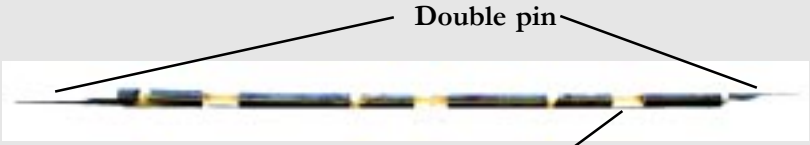
* Refer to page 24

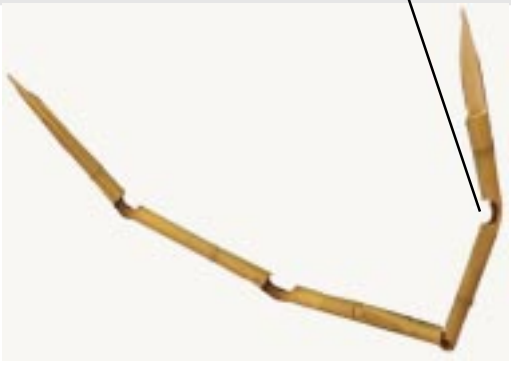




Bent Mortise

A *bent mortise* is the basic element in chinese style furniture making which ties the other components together and forms a strong framework.





Steps to make the bent mortise:

- **Determine the mortise groove length**
- **Mark refernce lines on the culm**
- **Make a template stick**
- **Mark the culm**
- **Cut the mortise grooves**
- **Make the double pins**
- **Apply heat bending to bend the mortise**

6

Determine the mortise groove length

An essential part of making the *bent mortise* is determining the length and position of the grooves to allow perfect positioning of the leg poles in these grooves. Apart from the circumference of the leg poles, the length of the groove depends on the number of leg poles. Accordingly we distinguish 3 different types of *bent mortise*:

- **Triangular** (3 legs)
- **Square** (4 legs)
- **Pentagonal** (5 legs)

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The groove length in each case can be determined using the paper technique. Starting point of this technique is to make a paper strip that is equal in length to the circumference of the leg pole. This is done in two stages:

1. Cut a paper strip (1-2 cm wide) and fold it around the leg pole with overlap.

2. Make a cut parallel to the culm length on the overlap. The length of the obtained strip corresponds with the circumference of the leg pole.



Cut on the overlap



Strip matches circumference

Step by step we will now adjust the length of the strip to the groove length, for each of the three types of bent mortise.

Triangular bent mortise

The following steps are required:

Step 1
Fold the strip into half to make foldline 1.

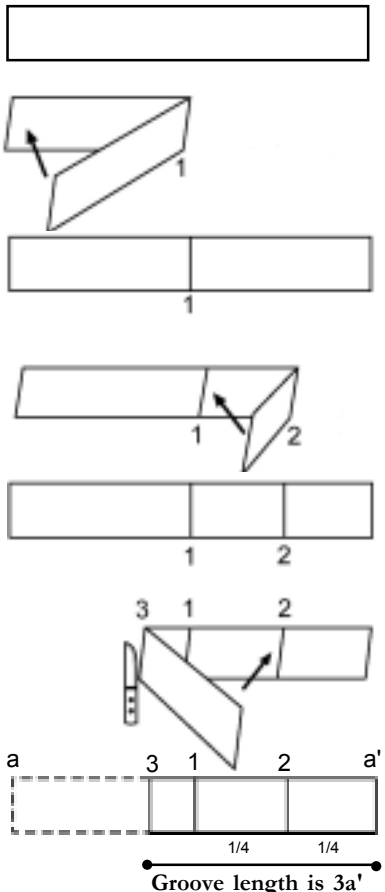
Step 2
Fold the right half into two quarters to make foldline 2.

Step 3
Make the left end meet fold line 2 and cut through the new fold line 3.

Result
The longer part of the strip corresponds to the correct groove length of a triangular mortise.



Triangular bent mortise with leg poles



Calculations:
1(**aa'**) - 1/4(**2a'**) = 3/4 (**a2**)
3/4(**a2**) : 2 = 3/8 (**a3**)
1/2(**a1**) - 3/8(**a3**) = 1/8 (**31**)
1/8(**31**) + 1/4(**12**) + 1/4(**2a'**) = 5/8(**3a'**)

Inference: the required length of the strip is 5/8 th of the original strip.

Square bent mortise

The following steps are required:

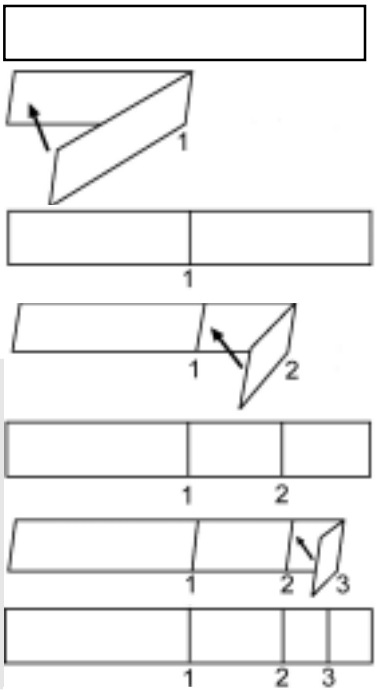
Step 1
Fold the strip into half to make foldline 1

Step 2
Fold the right half into two quarters to make foldline 2

Step 3
Fold the right quarter into two eighth to make foldline 3

Step 4
Make the left end meet fold line 3 cut through the new foldline 4

Result
The longer part of the strip corresponds to the correct groove length to make a square mortise.



Calculations:

1(**aa'**) - 1/8(**3a'**) = 7/8 (**a3**)
7/8(**a3**) : 2 = 7/16 (**a4**)
1/2(**a1**) - 7/16(**a4**) = 1/16 (**41**)
1/16(**41**) + 1/4(**12**) + 1/8(**23**) + 1/8(**3a'**) = 9/16 (**4a'**)

Inference: the required length of the strip is 9/16 th of the original strip.



Square bent mortise

Pentagon bent mortise

The following steps are required:

Step 1
Fold the strip into half to make foldline 1.

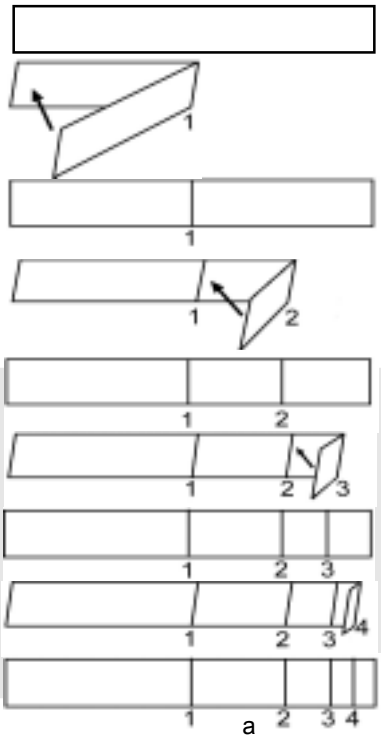
Step 2
Fold the right half into two quarters to make foldline 2.

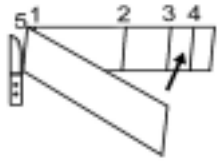
Step 3
Fold the right quarter into one eighth to make foldline 3.

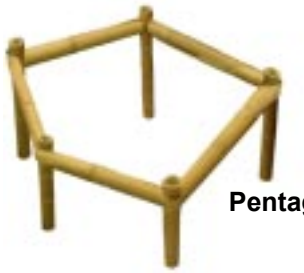
Step4
Fold the right eighth part into one sixteenth parts.

Step 5
Make the left end meet fold line 4 and cut through the new foldline 5

Result
The longer part of the strip corresponds to the correct groove length to make a pentagon mortise.

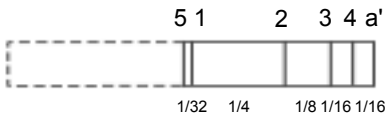






Pentagonal bent mortise

Result

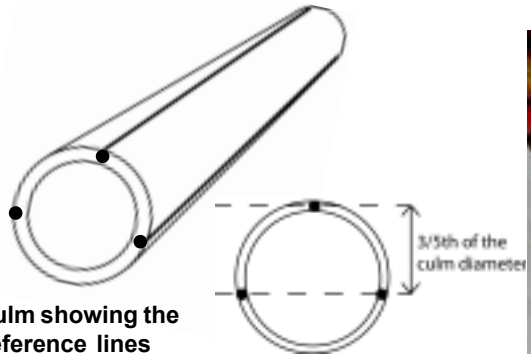


Calculations:

1(**aa'**)- 1/16(**4a'**) = 15/16 (**a4**)
15/16(**a4**) : 2 = 15/32 (**a5**)
1/2 -15/32(**a5**) = 1/32 (**51**)
1/32(**51**) + 1/4(**12**) + 1/8(**23**) + 1/16(**34**) + 1/16(**4a'**) = 29/32(**5a'**)
Inference: the required length of the strip is 29/32 th of the original strip.

Mark reference lines

Mark a reference line by scraping a straight line along the culm length. On either side of it, two parallel lines are marked, at a distance of two thirds of the culm diameter from the first one.



culm showing the reference lines



6

Make a template stick

Mark the groove length on a bamboo strip using the paper strip. The length of this template stick should be equal to the length of the groove plus the distance in-between two grooves.

Template stick





Marked grooves on the culm (triangular mortise)



Mark the culm

Using this template stick, mark the culm along the central reference line. Make sure the mortise grooves do not lie on a node. The distance between two grooves should be marked on both ends of the culm.



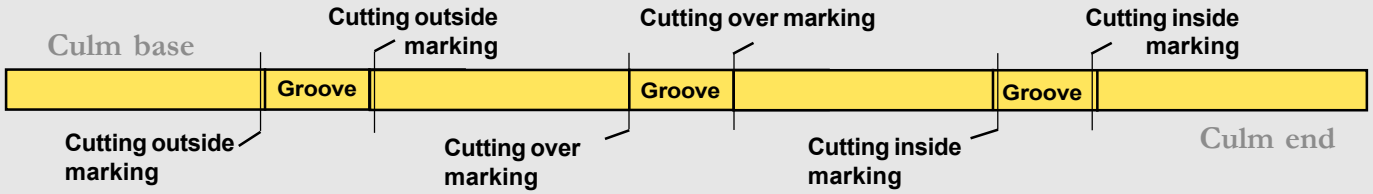
Cut the grooves

1. Make a cut half the culm diameter on the groove markings. Cut just outside the marking at the culm base, cut just inside the marking at the culm end and cut exactly over the groove markings in the middle of the culm. This is done to neutralize the differences in wall thickness.

Make sure the blade of the saw is perpendicular to the culm and the central reference line.



Cutting adjustments (view from above)



2. Insert a pointed knife in between the lower ends of both cuts and twist the blade slightly to break the culm open.



3. Make the groove corners round, meeting the 3/5th of the culm diameter, using the reference lines as guidelines.





6



a.

4. Remove material from the mortise grooves in two stages:

a. **Perpendicular to groove length on either ends**

b. **Along the culm length**



b.





Make the joint pins

In order to make the joint for the *bent mortise,* at both culm ends a pin is made in three steps:

1. Make a cut at half the distance to the groove on one extreme of the *bent mortise*. The cut must be made perpendicular to the plane of the groove, three-fifth of the culm diameter deep. Repeat this for the other culm end, but in opposite direction.



2. Remove the upper 3/5th of the culm section by splitting it perpendicular to the previous cut.





Opposite ends of the bent mortise

3. Taper both ends to make a pin.





Bamboo or wooden plugs

Chisel a plug from either a thick walled bamboo or a piece of wood, that tightly fits in the cavity of the leg poles on hammering.





6



Surface supporting batterns

Take a culm of approximately 8-10 mm wall thickness and cut strips of desired length and width.





Bamboo nails

Split a thin-walled culm into square sections of which the size depends on the application. Chisel and taper to get a nearly pointed end.





Surface strips

Make incisions at equal intervals in the culm end so as to get strips of required width. Tear the strips apart as shown in the image.



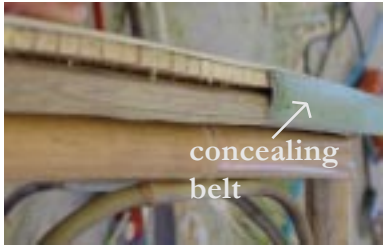




Concealing belt

Split a thin-walled culm to make a long strip of bamboo. Remove the white material to make it more flexible.

The purpose of a concealing belt is to cover any unattractive parts of the furniture piece.





Crushed bamboo surface

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1. Split the culm in 2 halves. Remove the inner nodes and put the halves on the ground with the opened side down. Make multiple slits using an axe, starting from one end of the culm. While crushing, move towards the middle of the culm. Then start at other end, making sure that the starting point of the slit is not in line with the slits made from the other side.







2. After making the bamboo flat, glue it to a veneer ply.





3. Cut the crushed bamboo surface into desired shape and size for their application.



Assembling & Finishing

In this section a stool is assembled that incorporates all basic skills and techniques of Chinese style furniture making.

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- **Fix the leg poles**
- **Fix the supporting legs**
- **Fix the supporting batterns**
- **Place the surface strips**
- **Frame the seat surface**
- **Apply the concealing belt**
- **Quality check & finishing**

Fix the leg poles

1. Apply heat from the inner side of the groove till it becomes bendable. Position the leg pole in the groove and bend the mortise around it. Maintain the position by applying water to cool and to fix that position. Repeat this for the remaining leg poles.





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2. Now position all the leg poles in the bent grooves one by one. Bring the two opposite ends of the culm together to close the mortise frame.





3. See if the frame allows the joint to be fixed and check the geometry. Make adjustments if required by sawing, to relax tension between mortise and leg poles.

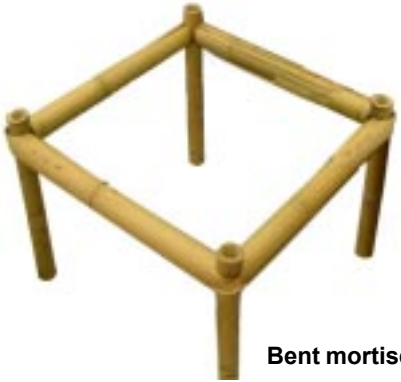




4. Mark and drill a hole in both rear legs to match the joint pins. Make sure not to drill through the whole culm, but only through one wall.







Bent mortise with leg poles

5. Insert the pins and adjust the frame position to suit the required geometry.

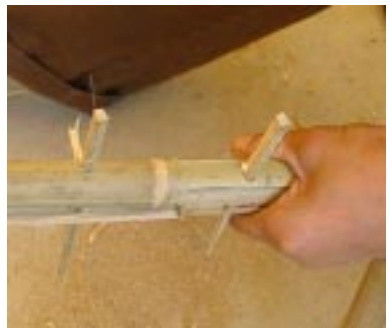




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6. Drill one or two holes through the pin joint in order to fix them with bamboo nails.
Chop off the nail parts that are sticking out.





7. After ensuring that a perfect geometry (with right angles) has been achieved, a bamboo plug is inserted and hammered into the cavity of each leg pole. The extra portion is cut with a saw blade.





7



Fix the supporting poles

1. Apply heat bending to fit all 4 supporting poles on each side of the stool, as shown in the image.





2. Position the support pole between two leg poles and then drill a hole through both of them exactly in the middle. Fix them by applying a bamboo nail.
Then, nail both sides of the supporting pole to the corresponding leg pole, also from the middle.





7



3. Saw the surplus length of the support pole diagonally so as only the leg poles touch the ground.





Fix the batterns

Fix the batterns to the frame using nails, preferrably made of bamboo.





7

Place the surface strips

Place the surface strips across the batterns and fix them with nails or weave them together with fiber. Cut any surplus material.





Frame the seat surface

1. Place four strips outlining the surface seat with crossing ends. Fix each strip to the structure from the center of each side.



2. Cut the corner overlaps diagonally to get a perfect seam.





7



Fix the concealing belt

1. Fix the concealing belt to one side of the stool. Remove some white material from the inner side of the belt to allow bending around the corners.





7

2. Then apply heat and bend the belt along the adjecent side and fix it with nails.



3. Continue the process for all the corners, to end with an overlap. Cut the belt on the overlap in the centre and fix the ends with nails.





Quality check & Finishing

After assembly, the products must be checked for quality and modified if required. After that, finishing is done. These two stages combined, guarantee safety for the user and result in a higher percieved value of the end product.

Quality Check

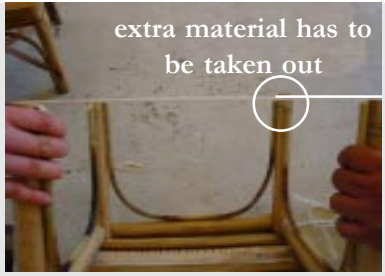
- **Check for any irregularities**

Check for any splinters, protruding nails, cracks and unwanted cavities

- **Check for perfect symmetry**

Check if all the leg poles have the same length, by means of a string, as shown in the images. Also make sure that all angles are equal.





Check the symmetry with a string..

- **Check for solid sound on impact**

Drop the furniture on the floor to hear a single solid sound which indicates the components are well assembled.

- **Check for structural strength**

Apply load on the furniture and check for the strength of all the components.



Apply load to check for strength



Remove surplus material

Finishing

- **Remove surplus material**

Chisel off any protruding material to get a smooth surface.



- **Filling cavities**

Use a mix of sawdust and glue to fill in any cracks or unwanted cavities



- **Sanding**

Use rough sandpaper for removing surplus material and use fine sandpaper for smoothening surfaces.



- **Heat blowing & cleaning**

Using a blow torch, burn and remove all the tiny bamboo hair.



- **Lacquering**

Remove dust or any other impurity before applying the lacquer using a brush.

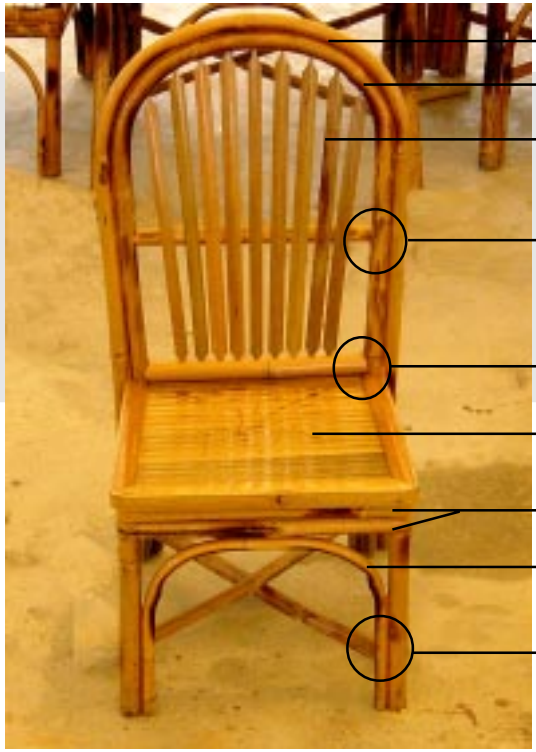




Additional design features

Having covered the basics skills and techniques of Chinese style furniture making, in this section we show some additional applications and design features, based on a chair design.





8

Back rest & back rest support

In this chair design, the back rest continues into the rear leg poles, made of one solid culm piece. This design requires good skills in heat bending, the stages of which are shown hereafter in the right sequence. The same sequence applies for making the back rest support.

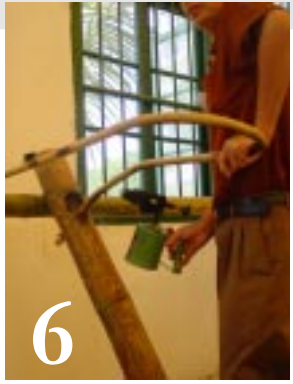
















Joinery

Plugging joint

A plug is inserted in the tube to be jointed and a hole is drilled through it. Then the other part is drilled and the joint is fixed by applying a nail.





Pin joint

Two pins are made on one culm end to fit a rectangular groove on the other culm.





U-cut joint

A deep U- Cut is made at both ends of the culm to be fitted around another culm.

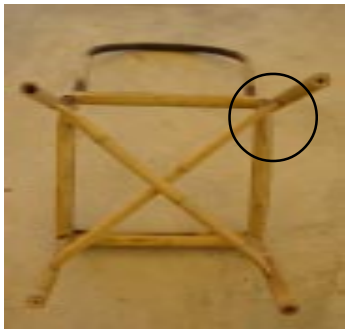




8

C-shaped joints

A culm is sharpened to a point to fit a C-shaped cavity in another culm.







8

Flat spokes

Flat spokes are made of flat bamboo strips and pointed at both ends. They are vertically fixed by sticking the points in drill holes. At seat level these drills are made in a tube, with corresponding holes made on the underside of the back rest pole.





Round spokes

Round spokes are made of small-sized culms shaped by applying heat bending. They fit in holes drilled with a hole saw bit on the underside of the backrest pole. With their base, the spokes rest in a long groove made in the spoke support, positioned on the seat surface.











8

Multipe mortises

For furniture pieces that require more stength, two or more mortise bents can be applied. In that case, it is important to keep the joints on alternating sides of the furniture piece.





8

Applications of a multiple mortise bent...









Alternative application of a single mortise bent...





ANNEXURE I
Tools

Hand plane

Use: scraping outer nodes of culms.





V-shaped knife

Use: splitting bamboo culms from the ends.





Pointed knife

Use: inserting culms for precise splitting.





Mallet

Use: scraping material from the inside of the culm.





Wood saw

Use: cutting portions of the culm





Chinese Hacksaw

Use: cross cutting of the culm





Axe

Use: making flattened bamboo by crushing round culms.





Torch

Use: applying heat to the culm to facilitate bending.





Jig

Use: molding culms into desired shape.







Hammer
Use: applying nails.



Plier
Use: extracting nails and staples.



Chisel
Use: removing surplus material from the inside of the culm.

Drill bit
Use: special diamond shaped bit to pierce bamboo culms without splitting.



Brush
Use: applying water during heat bending to fix the bend position and avoid scorching.



Sand container
Use: filling culms with sand prior to heat bending.





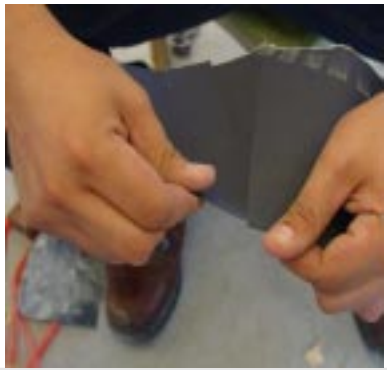
Pencil
Use: marking on the culm where cuts and drills are to be made.

Adhesive
Use: glueing.



Steel Rule
Use: measurement.

Pencil
Use: marking on the culm where cuts and drills are to be made.



Sandpaper
Use: to finish a surface to smoothen.

Staple gun
Use: quick nailing of bamboo parts.







ANNEXURE II

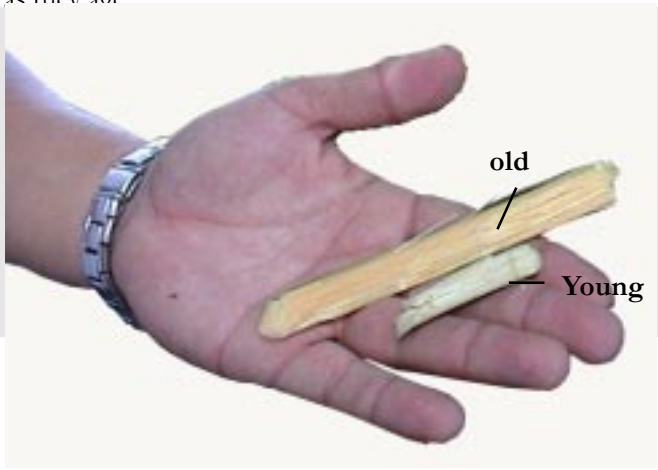
Culm Age

It is impossible to make a presize estimation of the age of a bamboo culm, unless it was marked after appearing as a shoot. There are no indicators with a reliability comparable to that of growth rings in trees.

In the following, six culm characteristics are listed, for three different age categories. The indicated changes over ageing are similar for most species. However, their reliability as age indicator is limited as differences between species can be big. If more characteristics are considered, the age estimation is more reliable.

Bamboo fibre colour

Young bamboo culms have white fibres, indicating a high water content. The fibres become more yellowish as they age.



Culm age < 1 year | **1 - 2 years** | **> 2 years**





Emerald or dark green | Green | Turning into yellow

Internode color

Internode cover

Often covered with tiny white hairs or 'flour' | Flour is falling off | No flour left





Culm age < 1 year | **1 - 2 years** | **> 2 years**

All the pictures were taken in a stand of ***Dendrocalamus latiflorus****. Other species may show differences in characteristics and in their changes over age categories.*

Culm age < 1 year	1 - 2 years	> 2 years
		
None	None	Lichen and epiphytes are found

Internode epiphytes

Culm sheaths

All or almost all sheaths are kept	None are left
	
Culm age < 1 year	> 1 years

Culm age < 1 year



Branching has just begun. Branches feel soft.

1 - 2 years



Secondary branches start growing, they are lightly coloured and not tough

> 2 years



Branches are becoming tougher and colour is turning into yellow-green

Branching

Sheath ring at node

Whole sheath ring or part of it is kept



Remaining part becomes harder



Remaining part falls off



Culm age < 1 year **1 - 2 years** **> 2 years**


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