



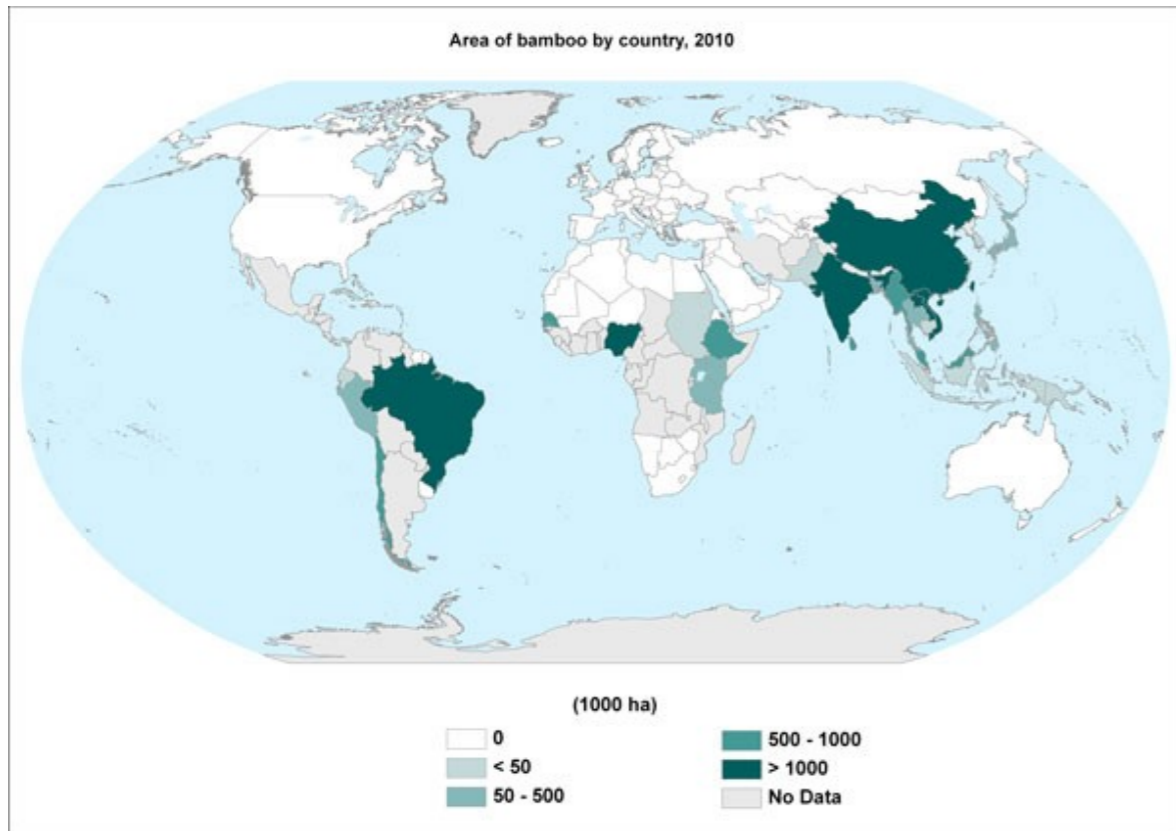
**PHILIPPINE WOOD PRODUCERS ASSOCIATION**



***Making Bamboo Work  
for  
Your Sustainable Designs and Structures***

MA. LOURDES “JOY” MARTINEZ ONOZAWA . APEC ARCH’T, UAP , ENP,REB  
[joy@environmentdesign.ph](mailto:joy@environmentdesign.ph), [joymonozawa@gmail.com](mailto:joymonozawa@gmail.com)

# The World of Bamboo

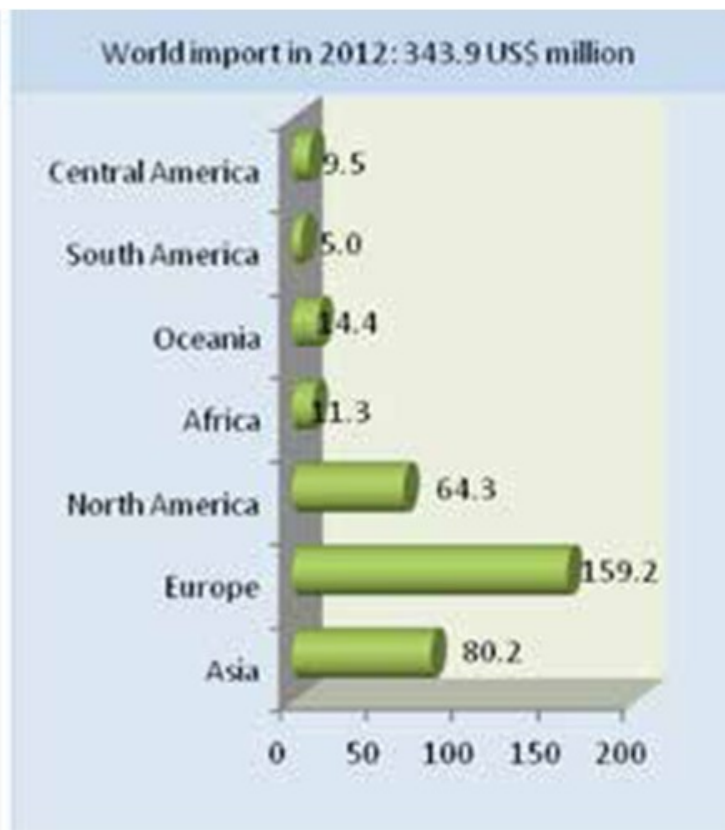
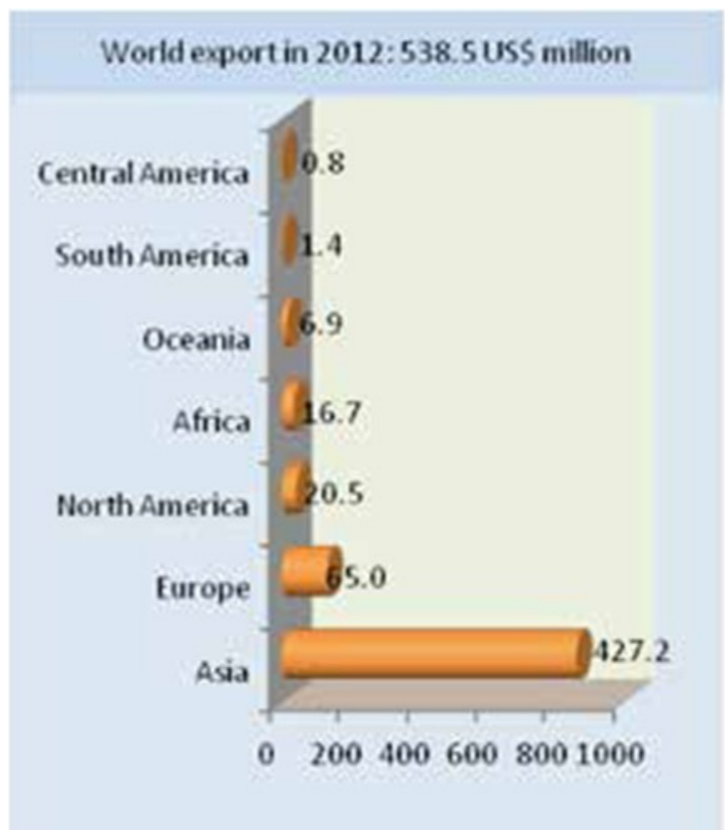


China, India, Brazil, Ethiopia, Vietnam lead.  
Bamboo is grown in various ecosystems

source: International Network for Bamboo and Rattan, 2015

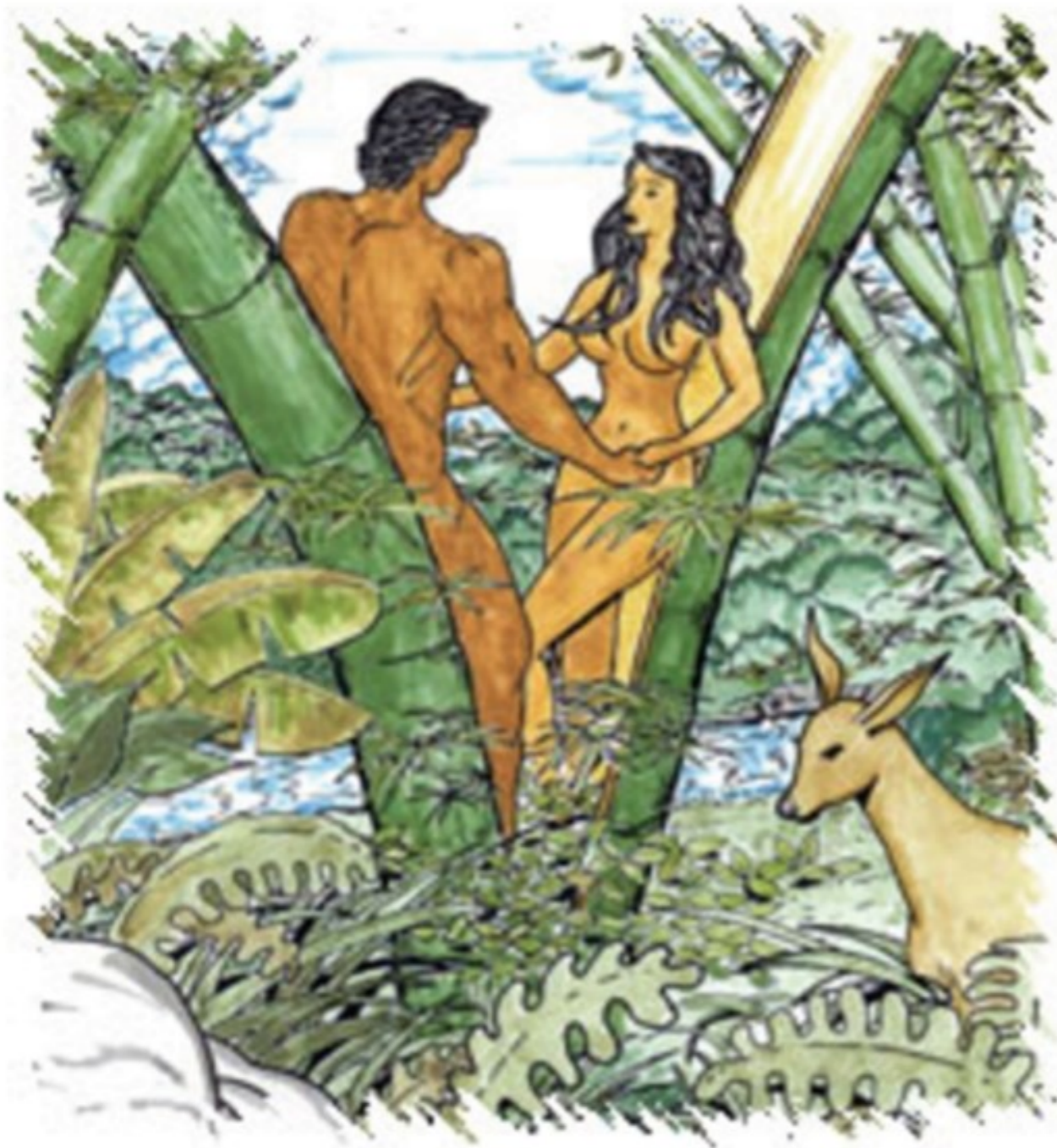


Raw material trading



Industrialized bamboo products trading

# FACTS ABOUT BAMBOO IN THE PHILIPPINES



- 62 species of bamboos recorded in the country
- 21 of those are endemic to the Philippines
- Quick growing..may grow from 1 foot to 3 feet in a day
- Bamboo species can be divided into clumpers and runners. .... *FAO*
- Has 2x the compression strength of concrete and roughly the same strength-to-weight ratio of mild steel.
- The hollow tube shape gives a strength factor of 1.9 times more than an equivalent solid wood beam.
- For structural purposes, poles must be at least 3 1/2 " diameter and 3/4 " thickness

..*Bamboo Living Homes*

# Beneficial Uses of Bamboo

The usage of bamboo is grouped into 3 categories.

## A. In its natural form

1. Air Temperature Cooling
2. Air /Quality Enhancement
3. Odor, Sound. Air Pollution Control
3. Sewage treatment
4. Soil Erosion



## B. In its harvested form

1. Construction- housing building materials , bridges, boats,scaffolding
2. Crafts - household fixtures, baskets, musical instruments
3. Food - Bamboo shoot recipes, food wrappings , barbecue sticks
4. Fermented drinks - beer, wine
5. Art - Carvings and sculptures, Bamboo root art
6. Play equipment - Bow and Arrow , Skateboard, Surf Boards



## C. In its processed form ( powder, fiber)

1. Fiber - clothing, towels, bedsheets money
2. Wood Products - veneers, planks,
3. Powder - Incense, Plates, Cups, Tea,

**Kolitong** Ethnic group: Kalingga  
Location: North Luzon, Cordillera  
**Classification**  
Chordophone, idiochord tube zither

**Description**  
Bamboo tube, closed at both end by a node. In both nodes a star shaped opening is cut. Five strings are cut loose from the skin, and lifted and tuned with small pieces of wood. The tube is cracked and slightly opened to improve resonance.  
Dimensions: length: 80 cm. diameter: 11,5 cm.

The strings are cut loose from the skin and lifted by wooden bridges

The star shaped opening in the node

A photograph of a Kolitong instrument, which is a bamboo tube with a star-shaped opening at one end. The instrument is shown in its natural, unprocessed state.

# Philippine Bamboo Statistics

62 native and introduced species, only 11 species have high economic value  
52,000 hectares of bamboo plantations nationwide  
40 M poles (supply) and 60 M poles (demand) = 20 M poles supply deficit annually  
40% of bamboo raw materials are used by the furniture and handicraft,  
25% for fish pens and housing construction,  
10% for the agriculture and 25% for other purposes

## Challenges faced by the bamboo industry in the Philippines

1. Lack of supply of bamboo poles as raw material for finished products
2. Lack of coordinated action in ensuring a steady supply of bamboo poles
3. Lack of high tech facilities/ machineries in processing
4. Lack of market information
5. Substandard quality of products due to
  - low quality of raw material
  - lack of appropriate machinery
  - Lack of highly skilled technicians
  - Poor product designs
6. Transport of Bamboo needs certification , whereas bamboo plantations are very far from Cenro offices



-- (Philippines Department of Environment and Natural Resources Ecosystems Research)

The Bamboo Industry Development Roadmap of the Board of Investments (BOI) is an impetus and game changer needed to bring actors together and energize the bamboo industry .

The estimated number of bamboo culms (poles) required in the BOI-inspired bamboo industry roadmap is 107 million each year.

There are 204 bamboo clumps/ha producing on the average 5 culms/clump year.

One hectare of bamboo = 1,000 culms per year.

The hectarage projection is 107,000 hectares .

The current estimated total bamboo production is 10 million culms. Thus, we need to scale up bamboo pole production by a factor of 10 times between now and 2040, the time frame of the BOI roadmap.



THE BAMBOO INDUSTRY  
ENCOURAGES SUSTAINABLE  
ECONOMIES MOST ESPECIALLY  
GEARED FOR RURAL LIVELIHOOD

# Benefits of Bamboo



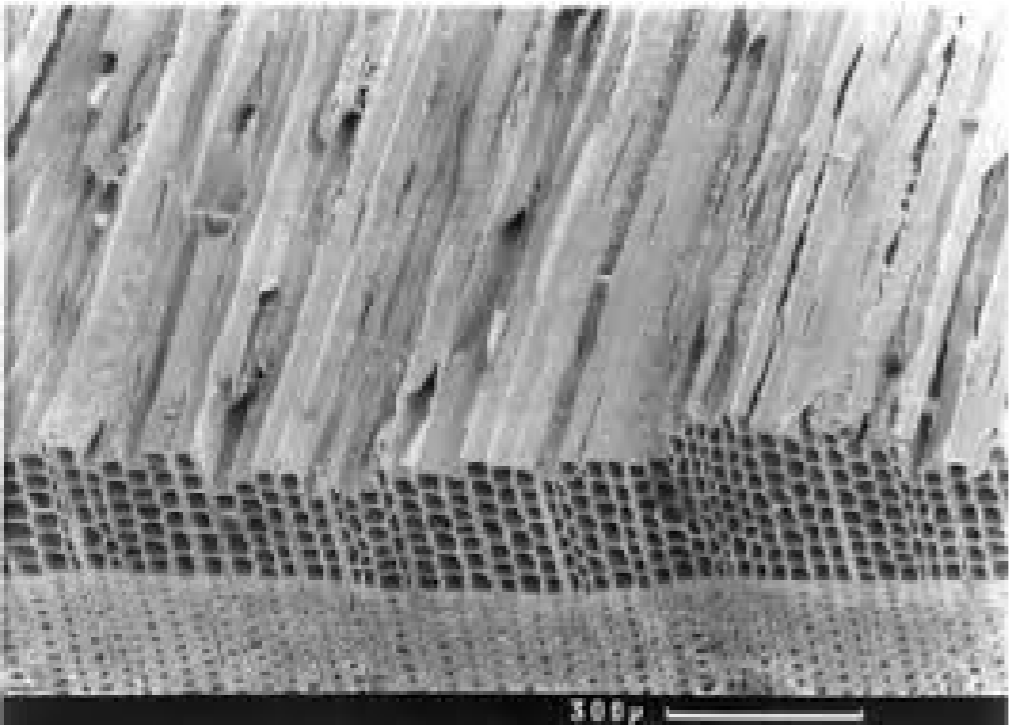
1. Sequesters 21.10 tons of CO<sub>2</sub> a year and is never released even after harvest.
2. Purifies air - gives off 35% more oxygen than any other flora in the world
3. Forest canopy prevents the evaporation of streams.
4. Allows dispersion of raindrops thus mitigating soil erosion
5. Has a high water storage capacity, able to release water onto dry streams and its surrounding plants during the dry season..
6. Organic – Has natural anti-bacterial agents that allow it to be grown without pesticides or chemical fertilizers
7. Sustainable - Regenerates itself from the roots, replacing crops naturally without the need for re-planting or crop rotation
- 8 . Renewable – One of the fastest-growing plants on the planet, growing up to 1.0 meter a day

	<b>BAMBOO</b>	<b>WOOD</b>
<b>STRENGTH</b>	As strong as mild steel with the compression strength of concrete. An inch of bamboo can hold 7.5 tons of weight	University studies show that soft woods cannot match bamboo's compression and tensile strength
<b>Harvest Time</b>	Reaches its full strength in 3 - 5 years. Grows 2 inches/ hour	Softwoods - 10 to 20 yrs Hardwoods - 20 - 25 yrs
<b>Earthquakes</b>	Bamboo bends and sways. Built properly, they can stand up to 7.5 intensity ( NBF, Costa Rica)	The same level of intensity leveled homes made of wood
<b>Indoor Air Quality</b>	Bamboo can be treated with natural solutions. Growing bamboo near the home enhances indoor air quality by 30%	New construction often uses particle boards with chemical adhesives
<b>Growth Locations</b>	1500 species that can be grown in various ecosystems both temperate and tropical with terrains from sea level up to 12,000 ft in elevation	Species are ecosystem dependent

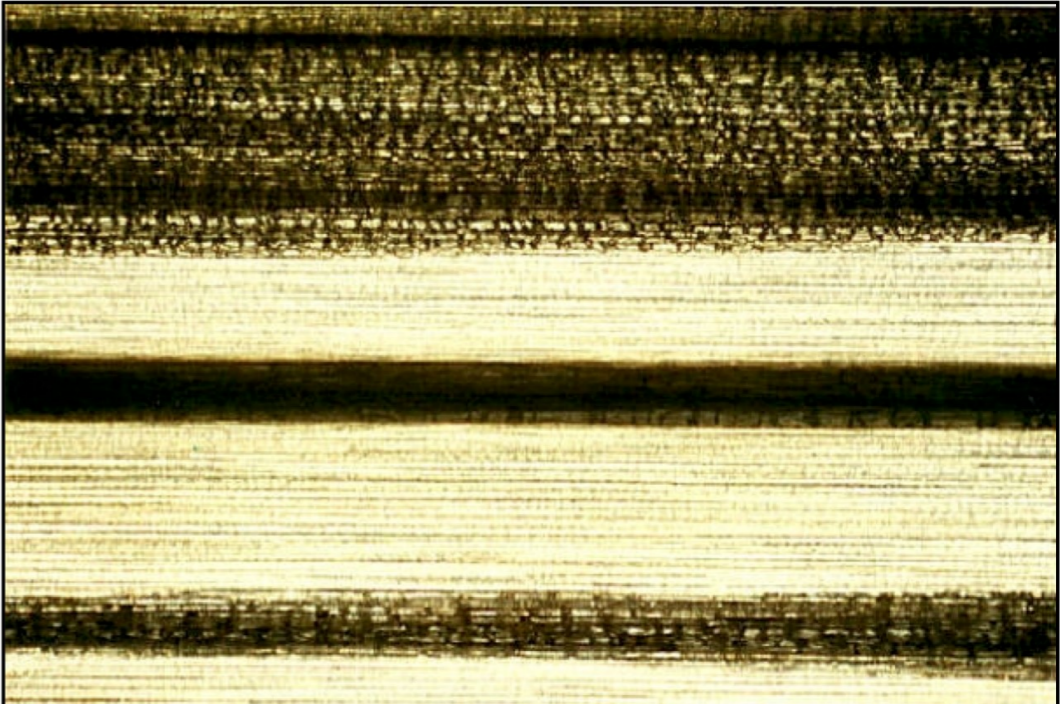
- tensile strength superior to mild steel ( up to 52,000 Pounds of pressure psi)
- weight-to-strength ratio surpassing that of graphite



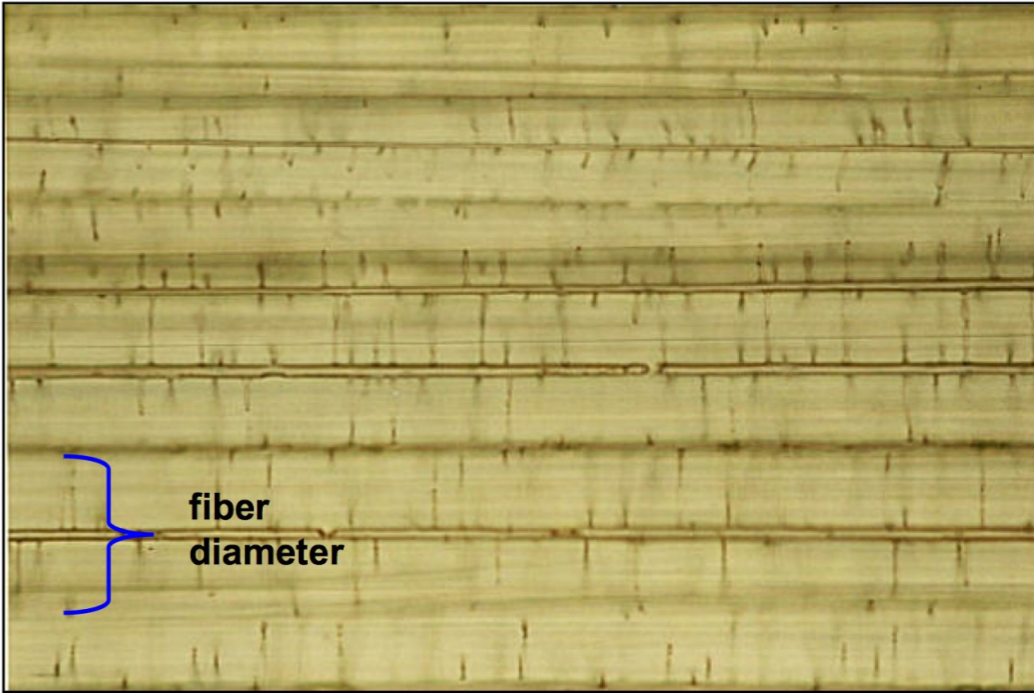
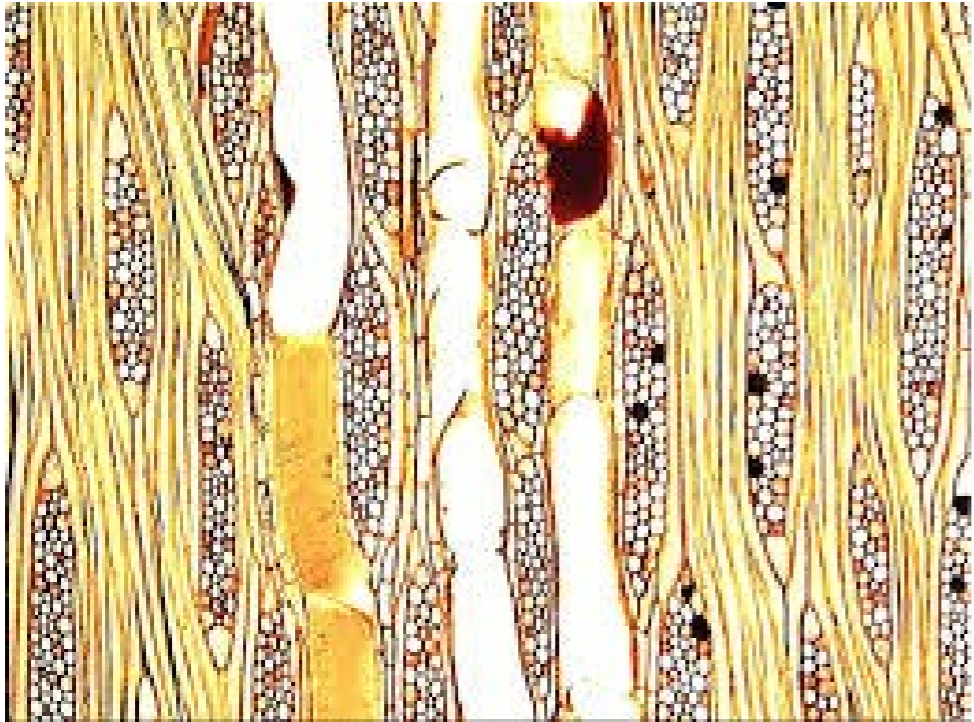
Bamboo fibers, are typically longer than the fibers found in wood (thus the incredible tensile strength of bamboo).

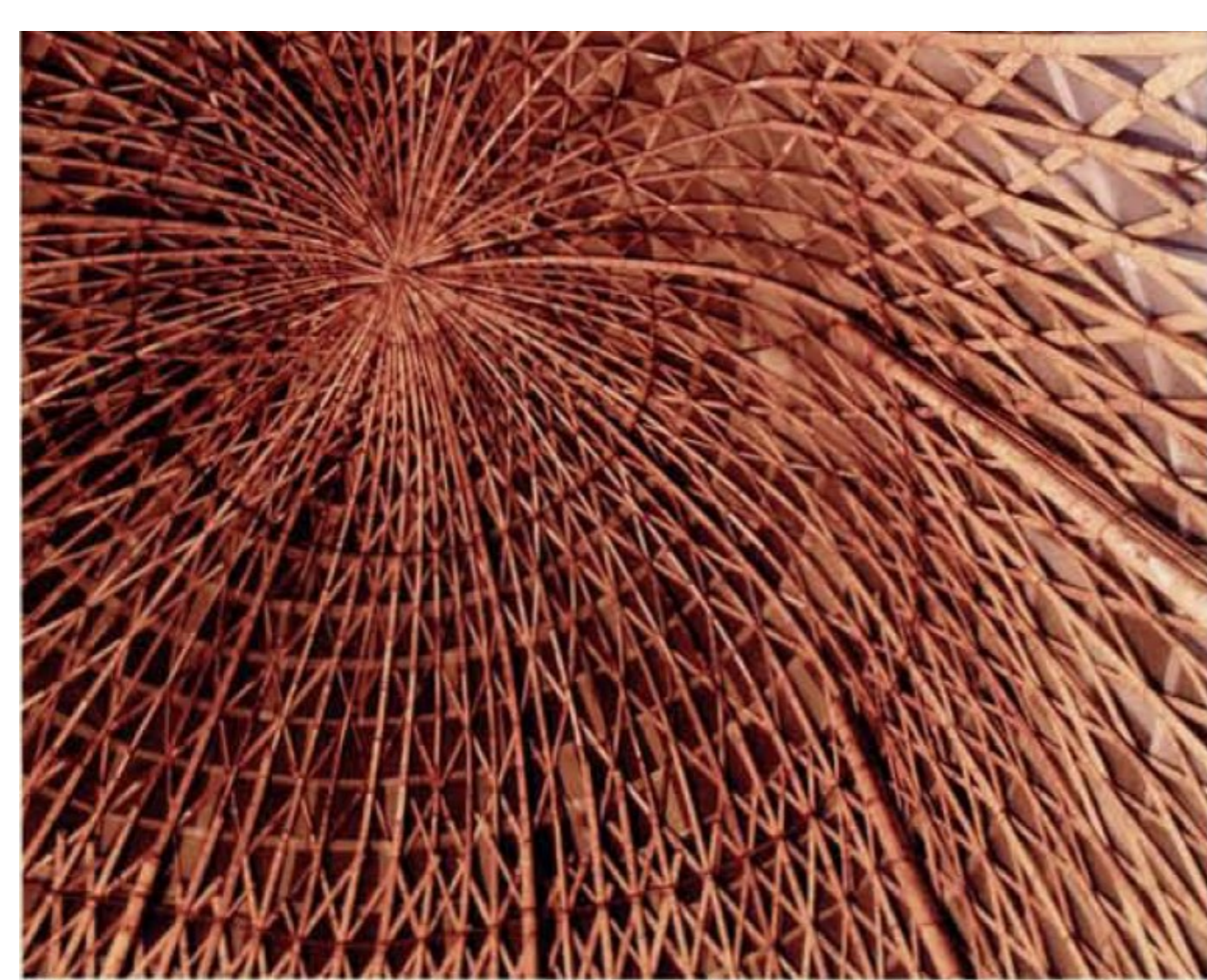


Longitudinal Section of Wood



Longitudinal Section of bamboo





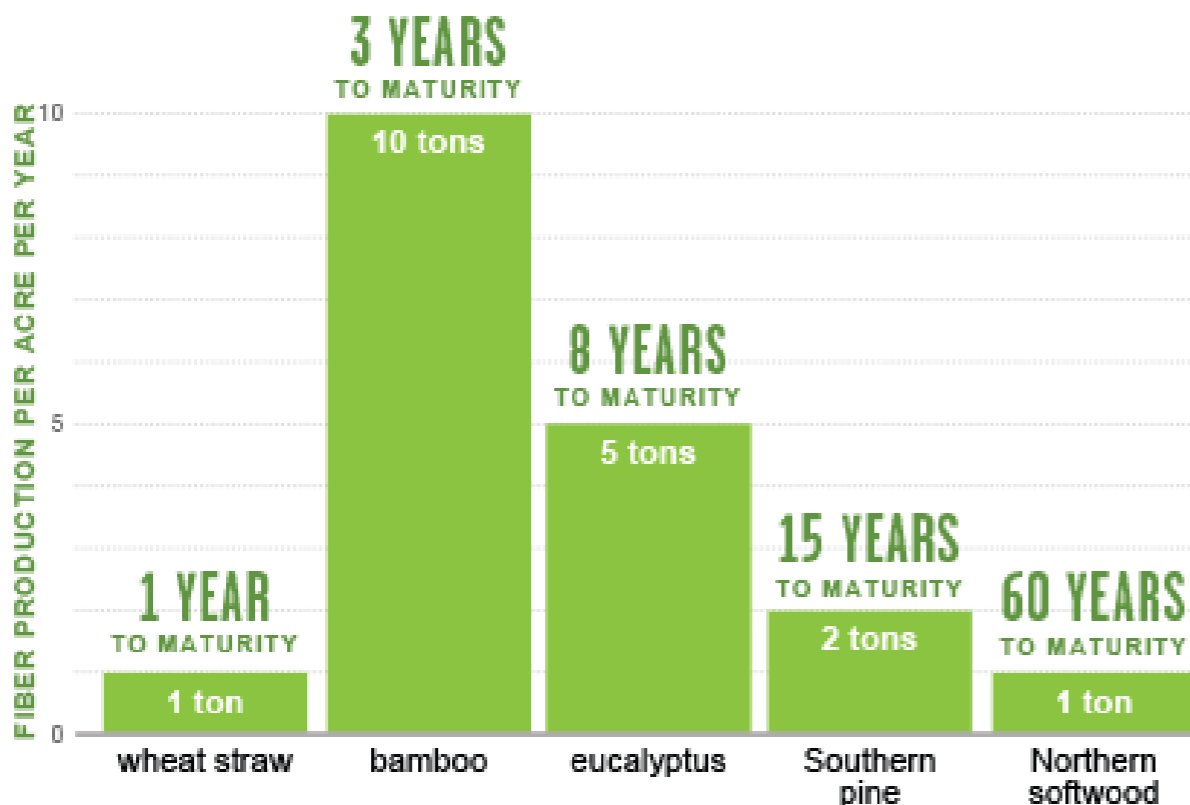
Bamboo fibers have a tensile strength of up to 3,200 kg/cm , surpassing that of timber and mild steel



## COMPARISON BETWEEN BAMBOO & STEEL

<b>Property</b>	<b>Bamboo (kN/sq. cm)</b>	<b>Steel (kN/sq. cm)</b>
<b>Modulus of Elasticity</b>	<b>2000</b>	<b>21000</b>
<b>Compressive Strength</b>	<b>6.2 – 9.3</b>	<b>14</b>
<b>Tension Strength</b>	<b>14.8 – 38.4</b>	<b>16</b>
<b>Bending Strength</b>	<b>7.6 – 27.6</b>	<b>14</b>
<b>Shear Strength</b>	<b>2.0</b>	<b>9.2</b>

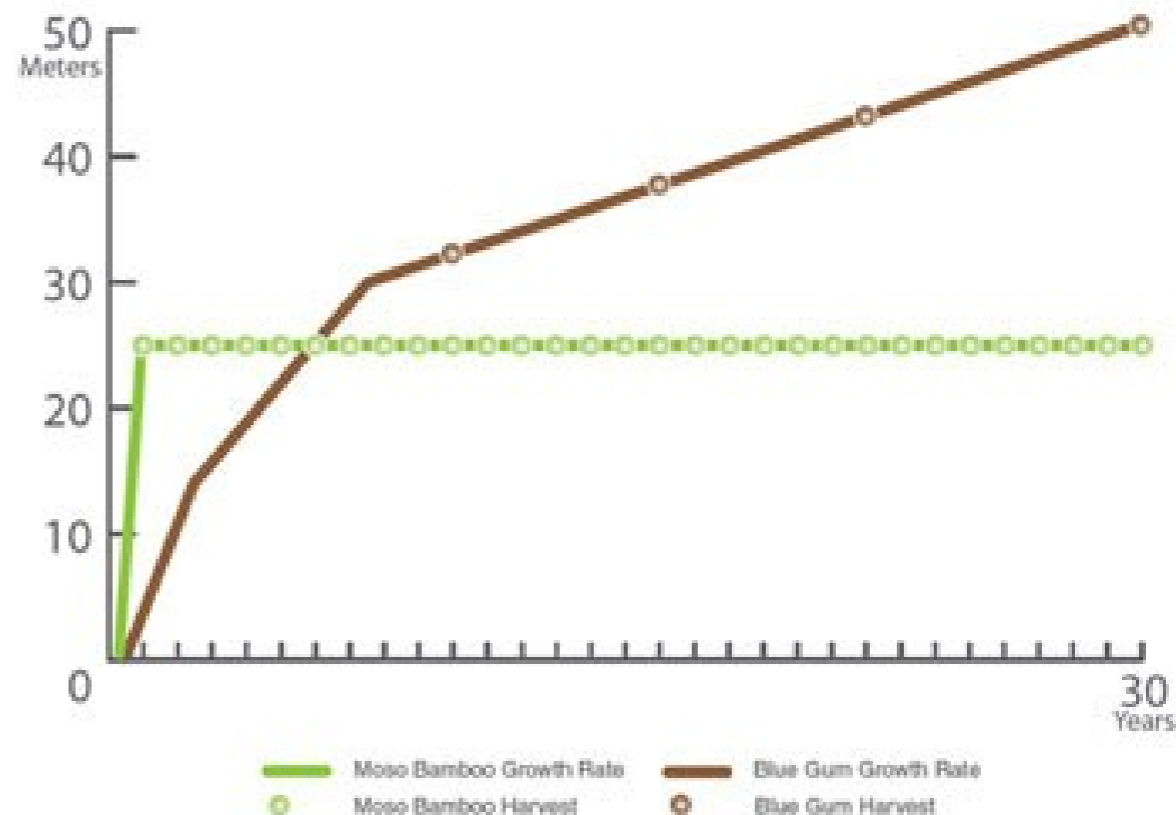
## Growth Rates and Productivity



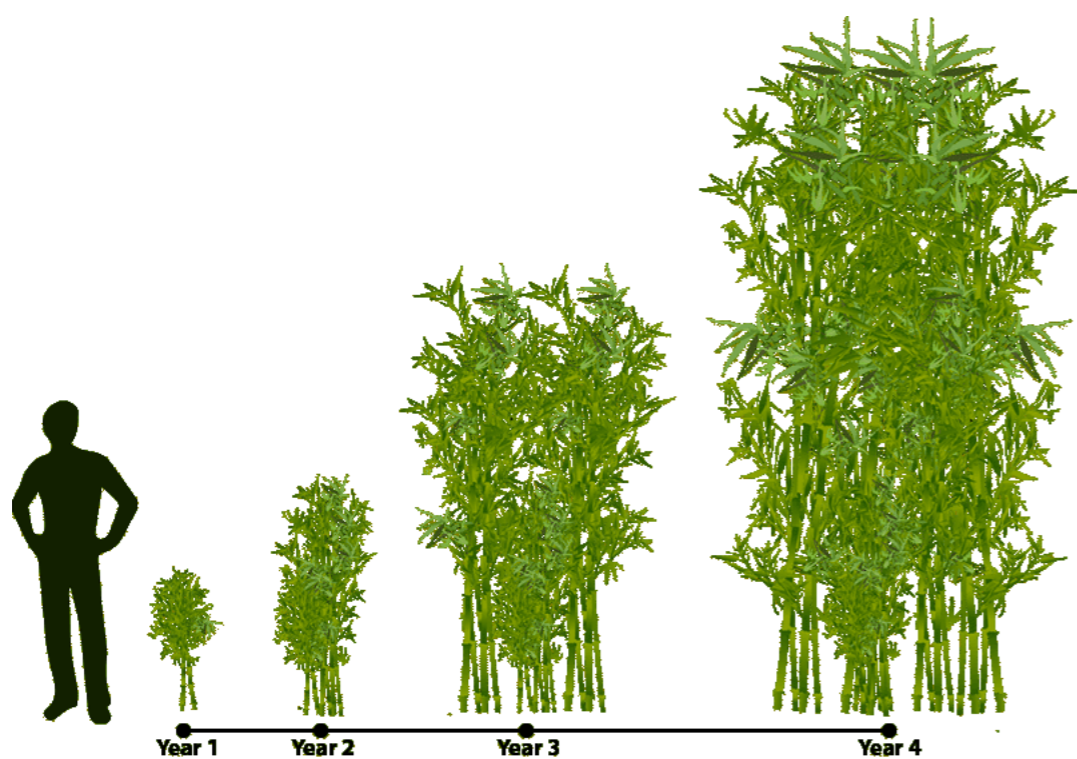
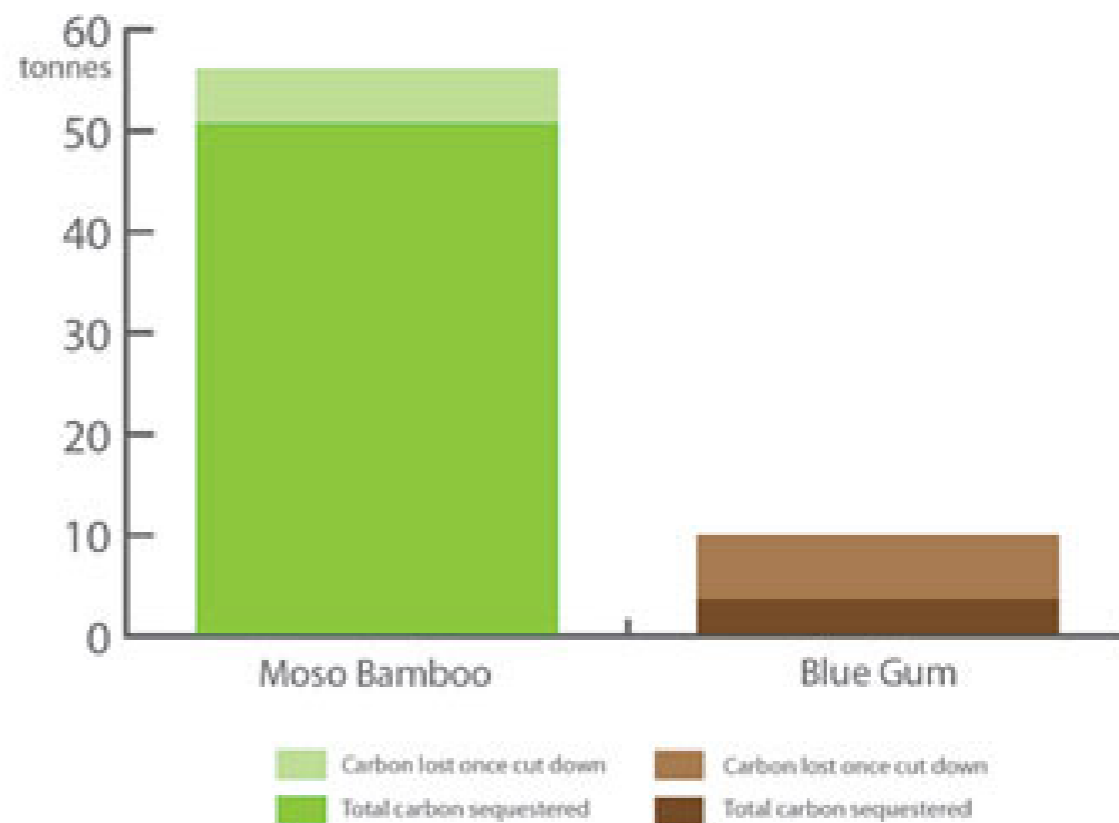
Source: Beyond Forest Brochure

Non-tree alternatives mature significantly faster than traditional fiber sources or yield significantly more fiber than traditional sources.

## Growth Rate & Harvest



## Carbon Sequestration Annually



# SIGNIFICANT BAMBOO SPECIES in the PHILIPPINES



**Kauayan Tinik**  
**Bambusa Blumeana**



**Machiku ( Botong in Davao)**  
**Dendrocalamus Latiflorus**  
**Guada bamboo**



**Giant Bamboo**  
**Dendrocalamus Asper**

# SIGNIFICANT BAMBOO SPECIES IN THE PHILIPPINES



**Bayog**  
**Dendrocalamus Merrillianus**



**Kaychi**  
**Gigantochloa Atter**



**Bolo or Botong Patong**  
**Gigantochloa Levis**

# SIGNIFICANT BAMBOO SPECIES IN THE PHILIPPINES



**Anos, Bagakai**  
**Schizostachyum Lumampao**



**Anos / Golden Bagacay**  
**Schizostachyum Lima**  
**(Lime bamboo)**



**Kauayan Kiling , Yellow Bamboo**  
**Bambusa Vulgaris Vittata**

# SIGNIFICANT BAMBOO SPECIES IN THE PHILIPPINES



**Laak**  
**Bambusa Philippinensis gamble**



**Bulo Padi , Golden buho**  
**Schizostachyum**  
**Brachycladum Kurz**

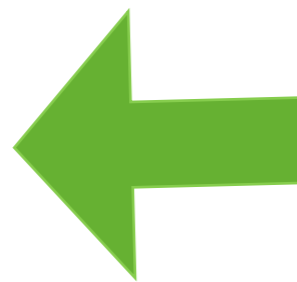
**Moroku-Chiku**  
**Bambusa oldhami**  
**(Munroe) Me Clure**



# Bamboo in Architecture/ Urban Design

- windbreaks, noise control
- odor and pollution control - converts 35% more CO<sub>2</sub> into oxygen than a regular tree
- soil erosion - controls landslides and prevents washouts
- soil /water remediation - absorbs heavy metals and sewage effluent

- HIGHWAYS  
- POLLUTION  
- NOISE  
- ODOR



# Environment Temperature Cooling and Quality oxygen



Bamboo gives off 35% more oxygen than any other flora in the world!! Bamboo is a natural portable air filter. It also sequesters 12 tons of CO<sub>2</sub> / hectare.

When air quality is good, the air we breathe alkalizes our bodies.



#5 Bamboo House

# Barometers of Good Quality Oxygen



Lichens



“Bamboos, growing thick, standing single—put all your roots together and all is well in the mountains and rivers.” Sengai, 19th century Japanese Zen Master.



Binds 80% of soil.  
Bamboo mulch reduces runoff and remediates poor soils.  
Soil underneath bamboo is excellent for growing seeds and fingerlings



Water runoff from agricultural fields with fertilizers are cleaned up by bamboo before reaching the rivers.



High Nitrogen and heavy metal uptake useful in waste water treatment. Bamboo charcoal is also effective.

# EFFLUENT SPREADING

**CULM OR CANE**  
Main organ of element assimilation

**EVERGREEN**  
=  
EVAPOTRANSPIRATION  
THROUGHOUT  
THE YEAR

**METABOLISM  
AND/OR STORAGE**

GROUND/SOIL

**UPTAKE**

Organic and mineral pollution

Mineralisation of organic pollution by microorganisms

MINERALISED ELEMENTS

**CREeping RHIZOME**  
Continuous growth and colonisation of space

Very dense, intricate root system that encourages the activity of micro-flora in the soil: rhizosphere effect. The root system provides an excellent support for bacteria (fixed culture)



## BAMBOO/SOIL/CLIMATE INTERACTIONS

# Bamboo Charcoal



- GREAT FOR FUEL
- PURIFIES DEODORIZES WATER,
- CAN BE PULVERIZED FOR MANY OTHER USES



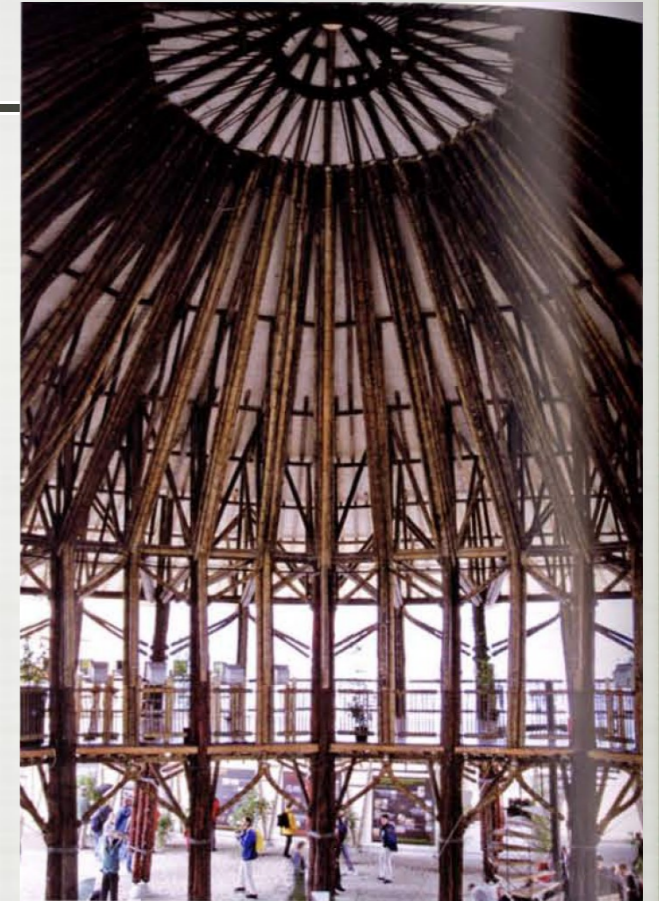
Can be utilized for lightweight construction



Emergency shelter

by USC Cebu

High bending strength makes ideal material for seismic-resistant construction

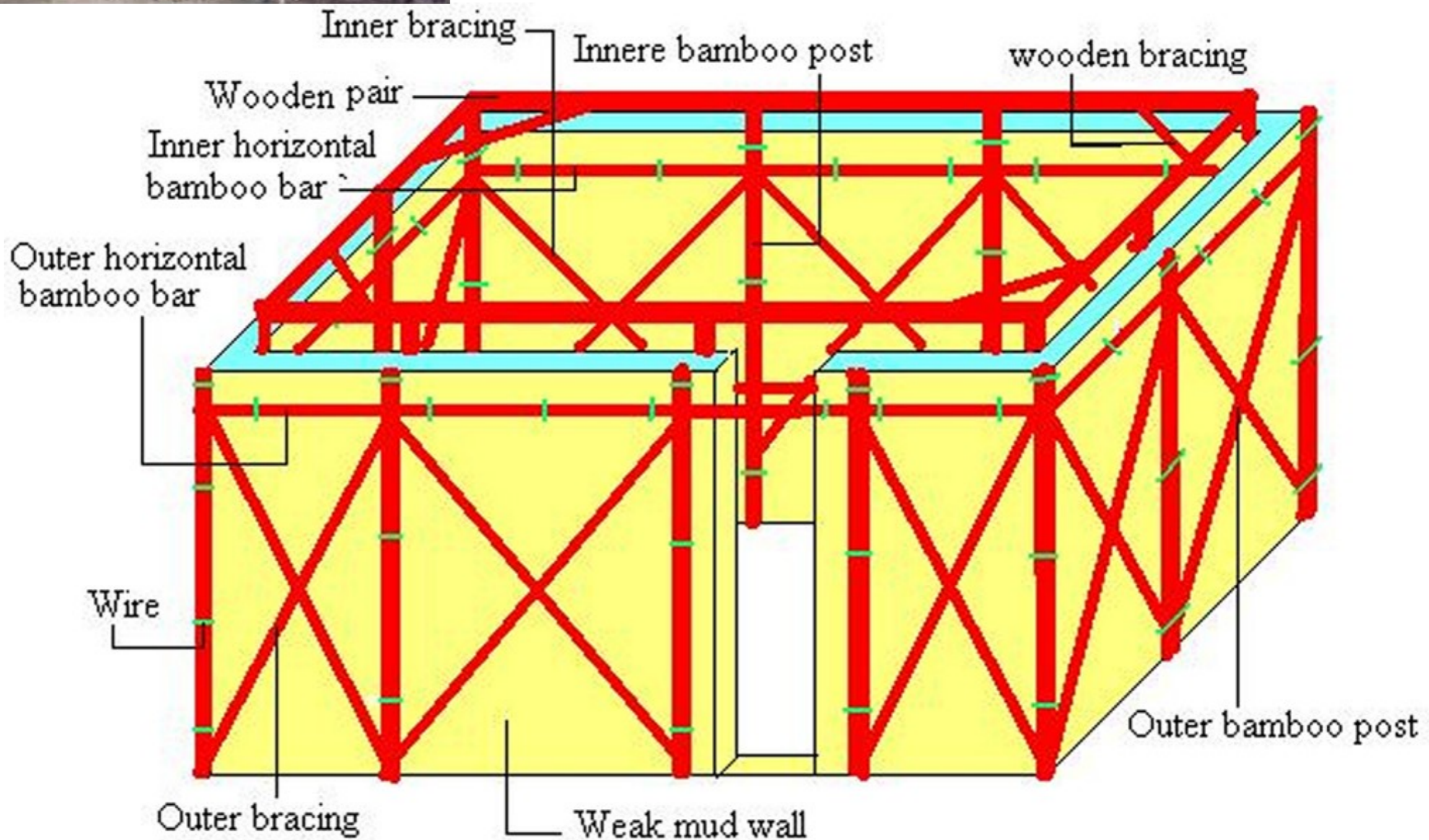


ZERI PAVILION , WORLD EXPO 2000



# KUCHA HOUSES IN BANGLADESH

## EARTHQUAKE RESISTANT DESIGN





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## BEAUTIFUL BRIDGES





Before  
( was destroyed in a typhoon)

Mon Floating Bridge in Sangkhlaburi,  
Thailand



After  
rebuilt with sustainable design

# Structural forms



**GEODESIC STRUCTURE USING  
DOME MARQUEE**

# geodesic dome

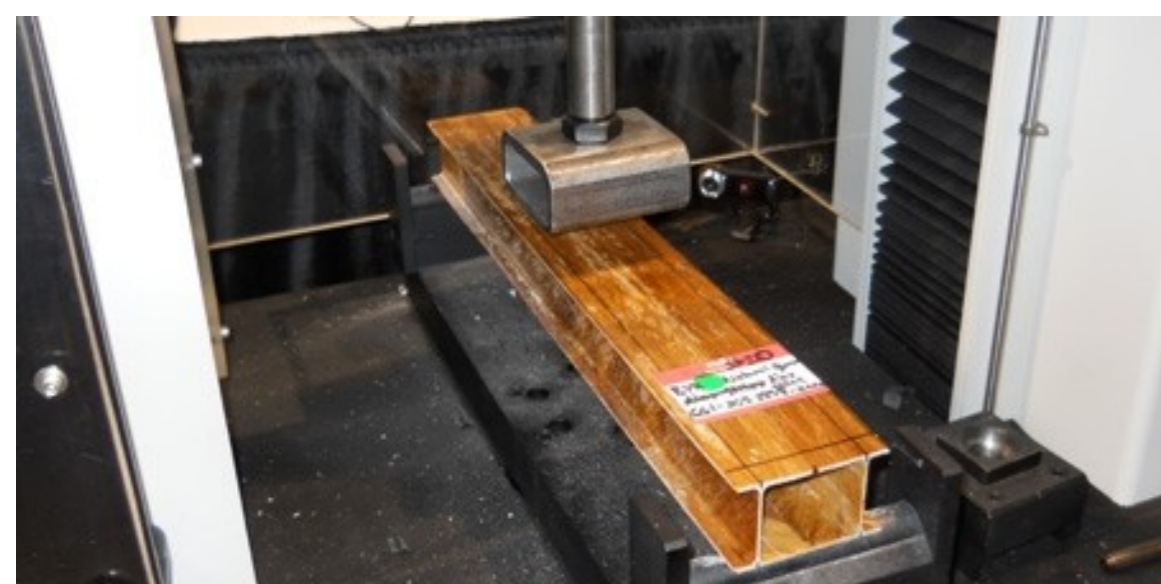
- RESILIENT TO EARTHQUAKES  
AND TYPHOON





# Bamboo Pavilion, Shanghai



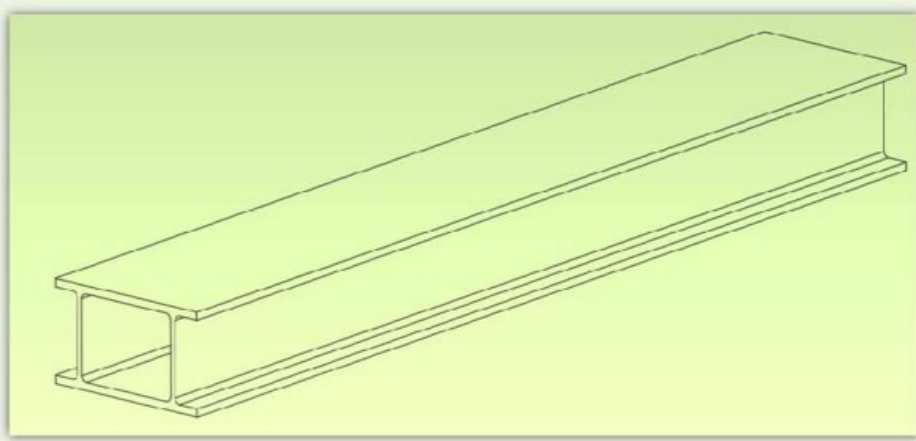


# Bamboo Fiber Double I-Beam

Brigham Young University  
 ALEX STILES\*, STEVEN GARDNER, ROGER SMITH  
 \*e-mail: astiles@byu.edu

**Background:**

*This bridge is the first natural fiber bridge ever submitted by Brigham Young University. It was built as part of a larger research project, whose goal is to develop a low cost fiber separation technique that will allow bamboo farmers in less developed nations to produce bamboo fibers strong enough to compete with fiberglass*



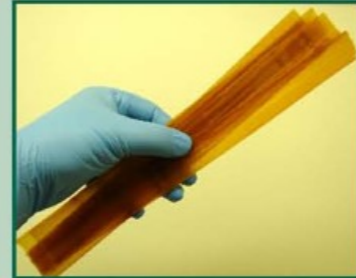
Our bridge design features 45 degree plies on the webs to counteract shear forces present along the neutral axis and 0 degree plies on the flanges to resist tensile and compressive forces. Two webs are used to help resist torsion.



## Bamboo Fiber Processing:



**1. Cut Bamboo Into Strips**  
 Bamboo strips are cheap to produce and thin enough for chemical treatments to penetrate the fibers. Our strips came from woven mat provided by Cali Bamboo.



**2. Treat Strips With Lye**  
 Sodium Hydroxide (Lye) is a low cost chemical common to paper manufacturing. In solution, it breaks down the softer lignin surrounding and holding together bamboo's strong cellulose fibers



**3. Roll & Clean Fibers**  
 The treated strips are machine rolled to separate cellulose fiber bundles from the partially dissolved lignin. Washing removes this lignin and further separates the fibers.

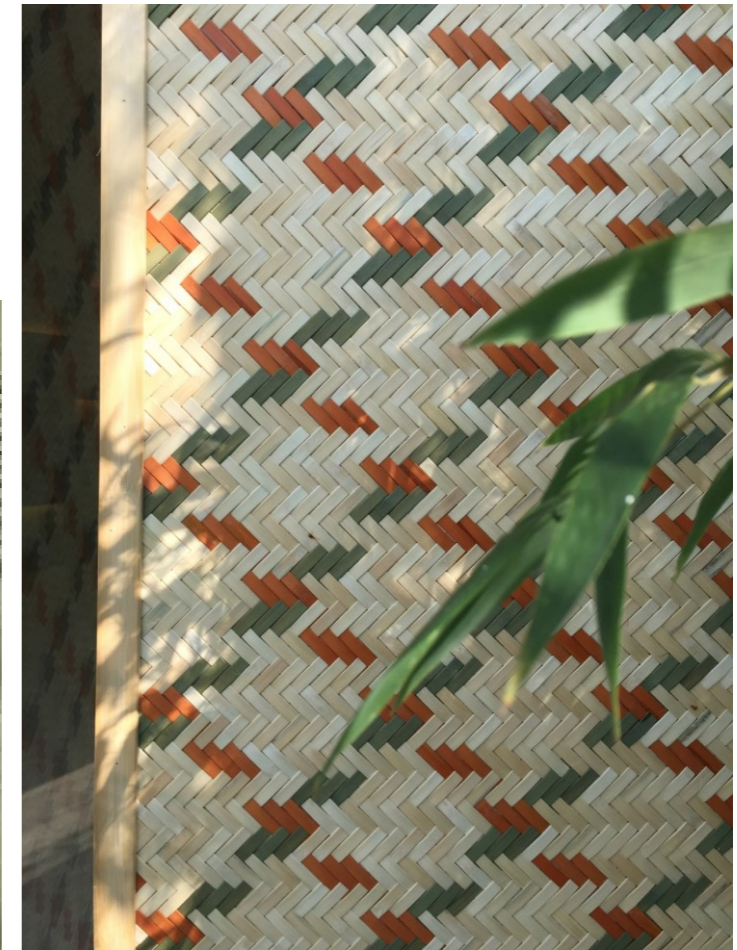


**4. Lay Fibers Into Mats & Dry**  
 Separated fibers are difficult to use unless rolled into a mat. Our bridge uses a delicate hand laid unidirectional mat for greatest strength, but bamboo fibers seem best suited for use in chopped strand mat

# Bamboo Walls



Download from [Dreamstime.com](https://www.dreamstime.com)







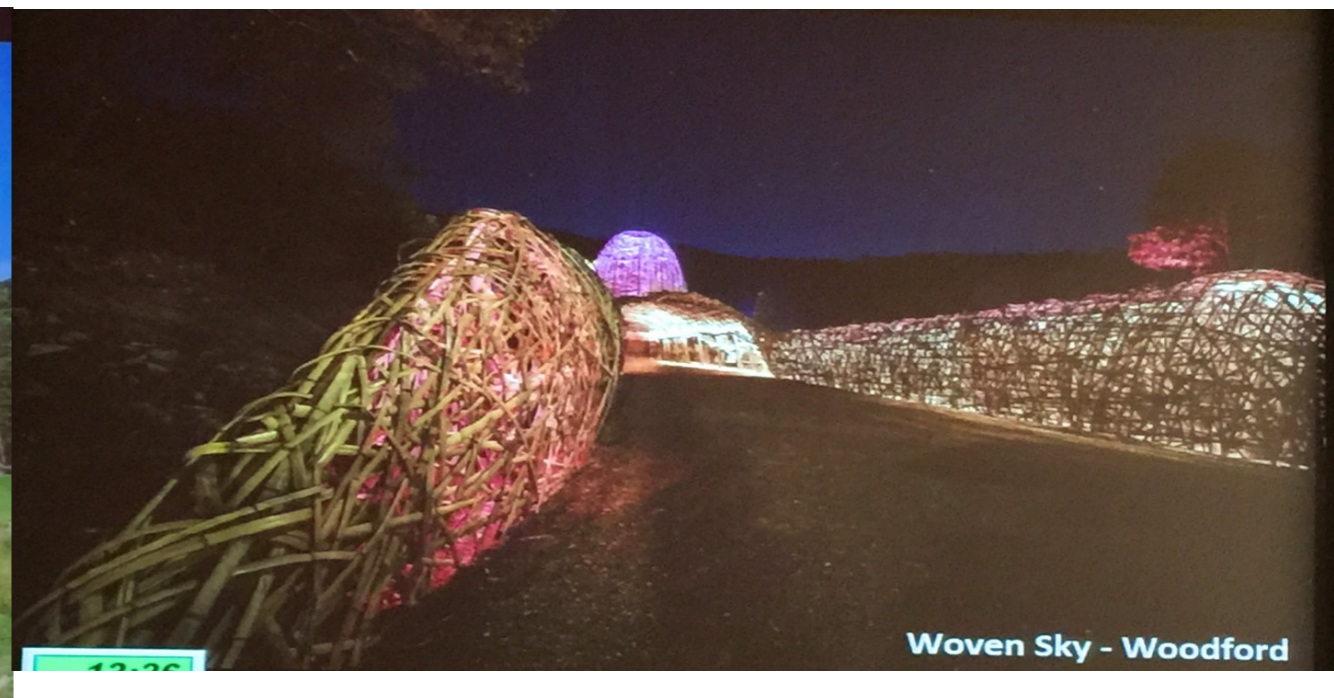
## INTERIOR CREATIVITY





## Bamboo Splitting Machines





## Visitor Entrance Facility



# BAMBOO ROOFING



Ichibanya Restaurant by DSA Architects. [www.archdaily.com](http://www.archdaily.com)



# bamboo bathroom fixtures



# BATHROOM AMENITIES



# Strong Scaffoldings





# MADRID BARAJAS AIRPORT

by: Rogers Stirk Harbour



VO TRONG NGHIA

MOre....



SIMON VELEZ



ARATA ISOZAKI

# Bamboo School - Camarines Sur



BY: EILEENA JAMIL

# Plantation BAY, Cebu



# Plantation B'ay, Cebu

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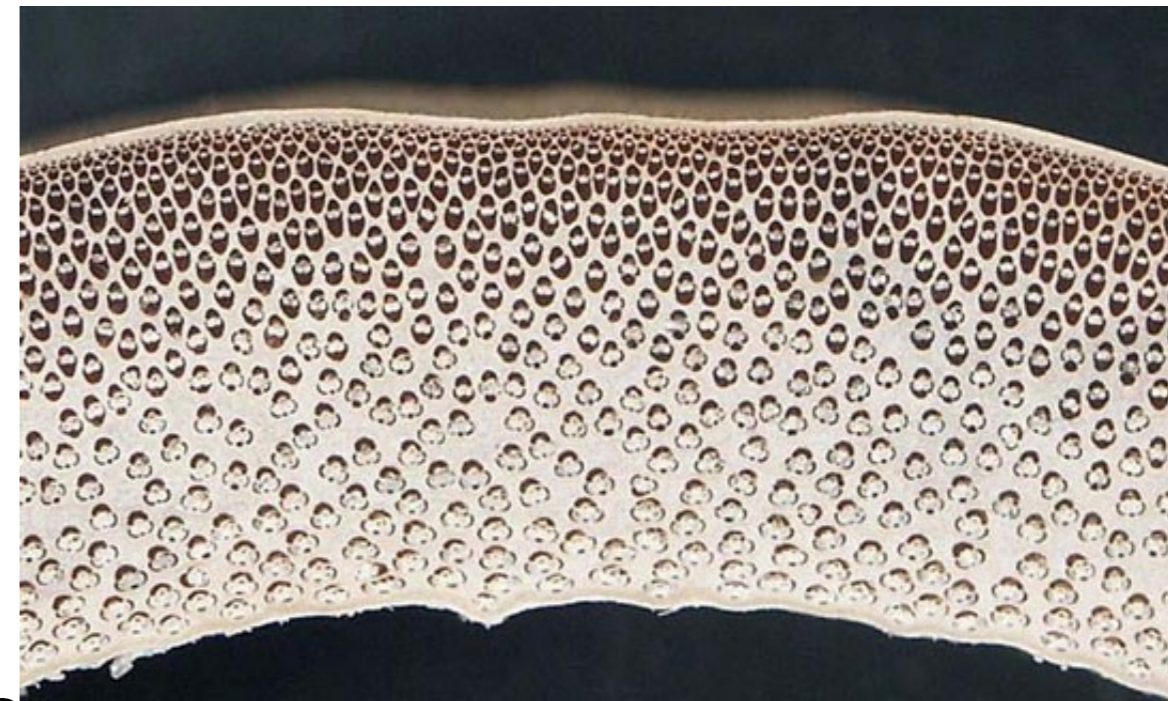
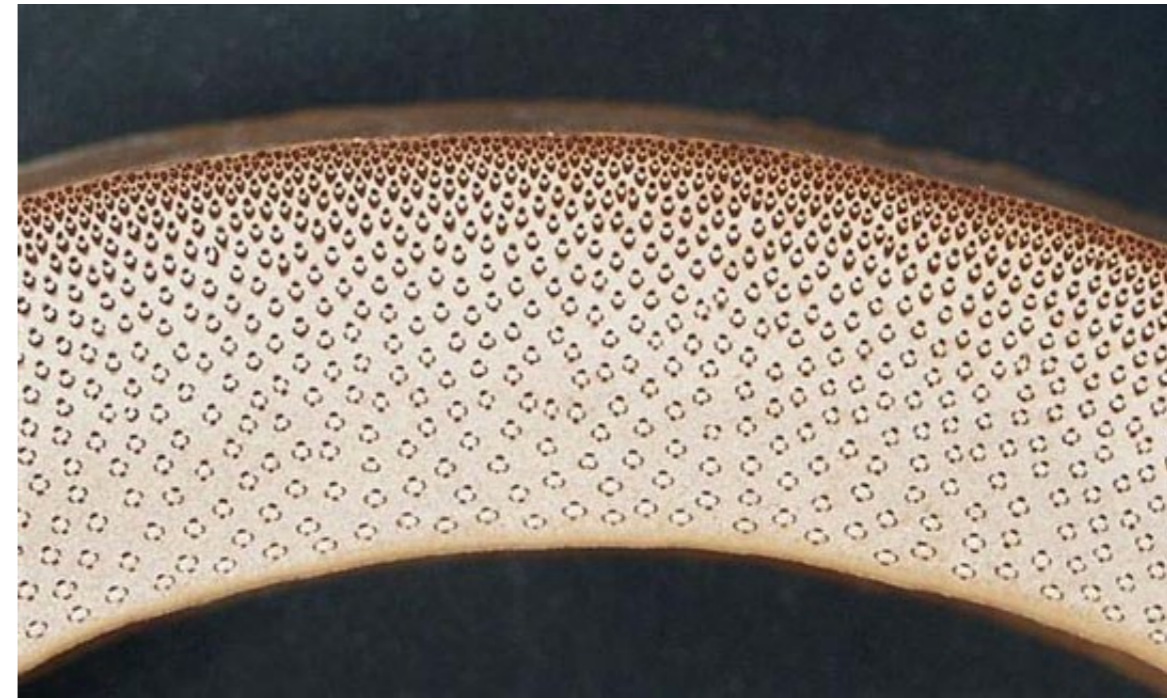


# Plantation B Ay, Cebu

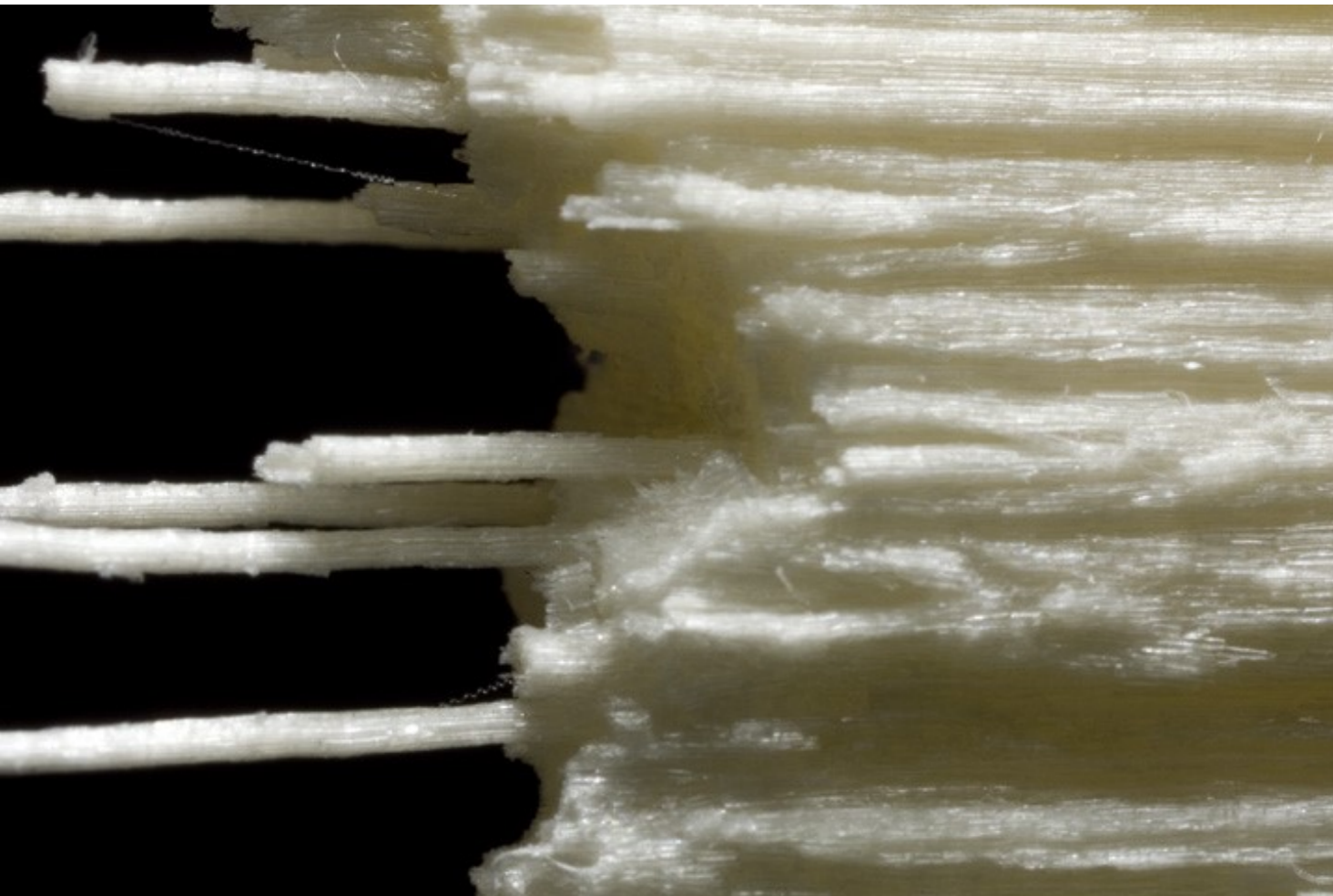


# Moso Bamboo

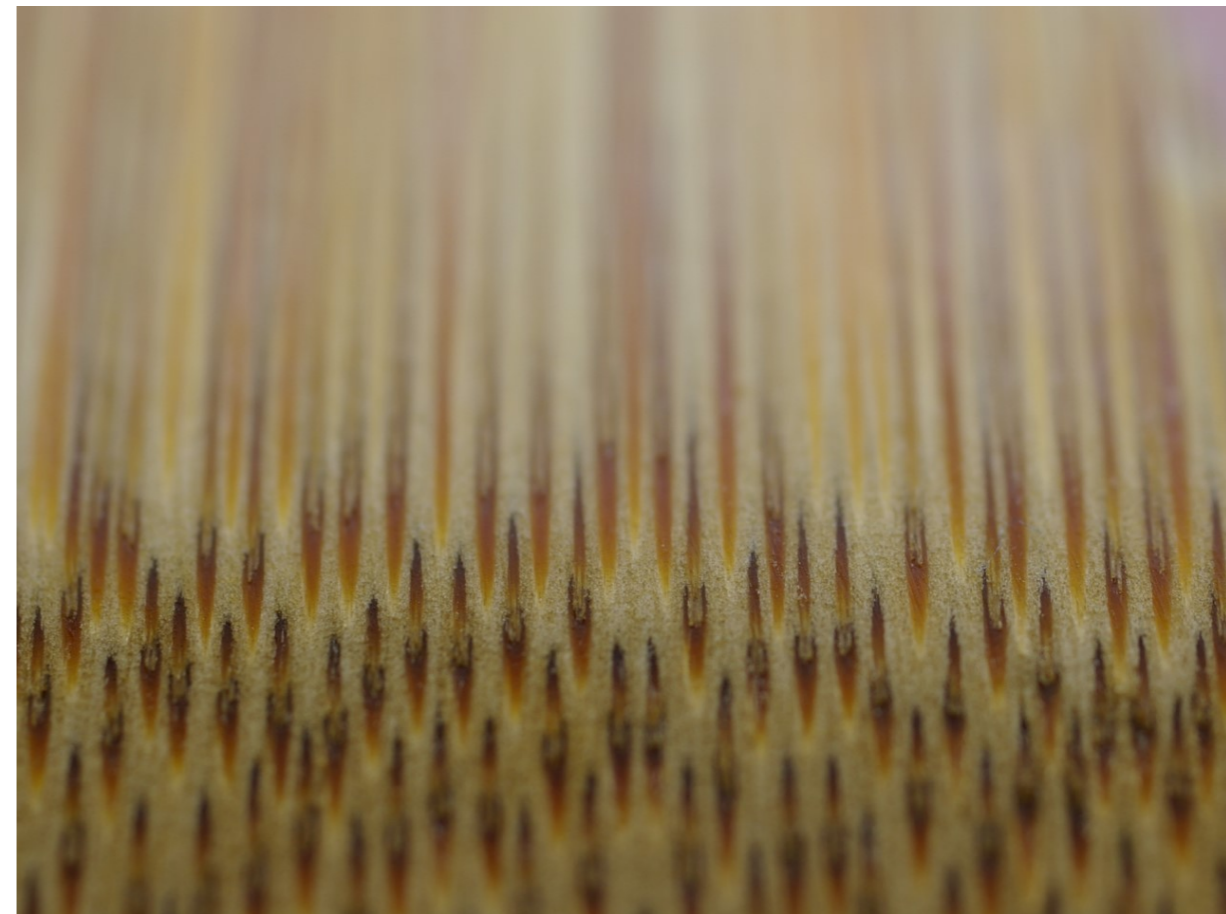
## Microscopic Images of Bamboo



# Guadua Bamboo



Bamboo is made out of thin  
straws bunched together



# Heat Pressed Bamboo

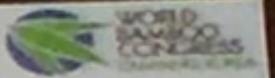
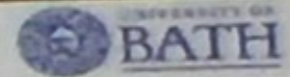
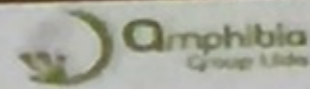
## 4.4 Schematic diagram of the machine for flattening hemi-cylindrical bamboos with nodes



- Temperature of flattening: 150–200 °C
- Flattening speed: 30–100cm/min depending on the thickness, the moisture contained and the age of bamboo



# Heat Pressed Bamboo



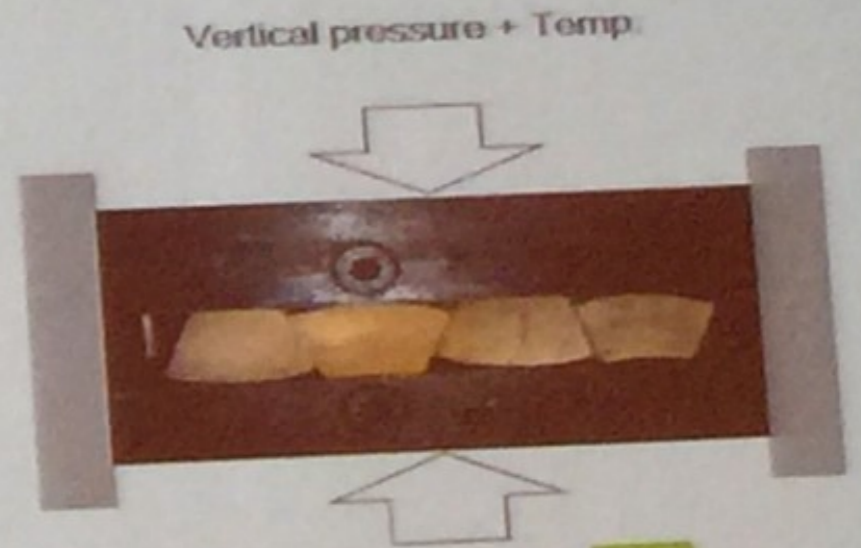
***Straight forward processing by THM***  
*From round Guadua to flat sheets*



Round cane



Cut into strips  
(peeled skins)



Heat pressed

Vertical pressure + Temp.



Flat densified strips



# Quincha - building with bamboo , Peru



TRADITIONAL



IMPROVED



# HOW TO USE BAMBOO

## 1. SELECTION

IDENTIFY THE SPECIE OF BAMBOO THAT YOU NEED FOR A SPECIFIC PURPOSE

## 2.HARVESTING

MUST BE AT LEAST 3 YEARS OLD. HARVEST ONLY AT THE END OF THE RAINY SEASON / BEGINNING OF THE DRY SEASON. STARCH IS LOWEST AT THIS TIME AND MOISTURE IS HIGH.



Young



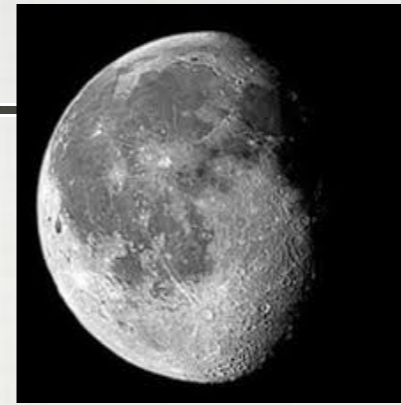
Mature



Old

## 2. HARVESTING -- USING THE MOON PHASE

The starch content is lowest between waning gibbous moon and last quarter moon (between the 6th and 8th day after full moon)



## -- USING PHOTOSYNTHESIS TIME

The starch content is lowest between 12:00 midnight and 6:00 am



# TREATMENT OF BAMBOO

1. Transpiration Treatment Method

2. Direct Immersion Method

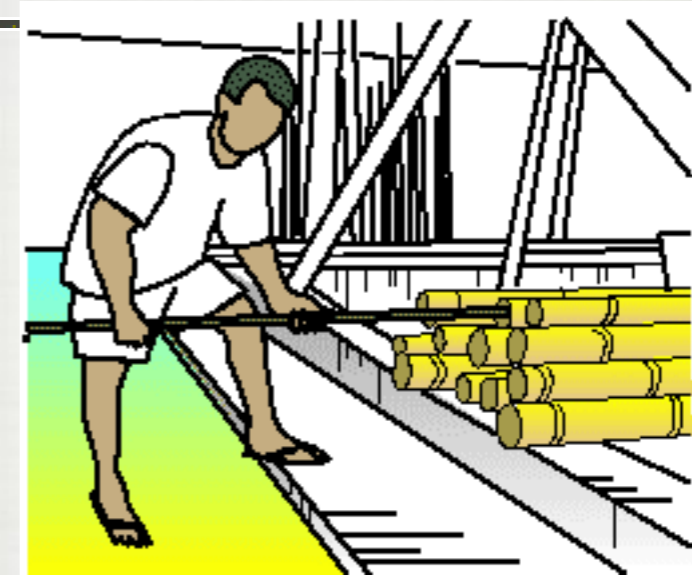
- seawater
- limewater
- Boron/ Borax/Perla Soap, Chili Peppers

3. Immersion with Boiling Solutions

4. Charring Bamboo for (water proofing)



# ALWAYS , ALWAYS PUNCTURE BAMBOO BEFORE TREATMENT



WATER IMMERSION  
( LEACHING )



# IMMERSION WITH BOILING SOLUTIONS

Immerse in a boiling solution of natural soap ( perla) , chili peppers, and garlic, and borax/ boric acid for about 2 - 3 hours . Let the bamboo stay immersed for 3 days then air dry.



# BAMBOO POST TREATMENT

## -- CURING/ STORAGE

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Bamboo is air dried in a roofed structure away from harsh sunlight and rain. Poles must never touch bare ground.





# The World of Bamboo is BIIIIIGGG!



**BAMBUHAY, Salamat Kaayo, Thank you very Much!!**

MA. LOURDES "JOY" MARTINEZ ONOZAWA . APEC ARCH'T, UAP , ENP,REB

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