BAMBOO
For the 21th Century
By Martin Tam

Speaker:
Mr. Martin T. F. Tam

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Mr. Martin Tam is an experienced architect who has worked in this field for over 40 years. His expertise includes development management and construction management in a variety of building types such as residential, commercial, industrial, public and private institutions, hospitals, schools and universities.

Mr. Tam has a high degree of sensitivity to the society and advocates zero carbon emissions and sustainable development. As he concerns about the ecology of the earth as well as the indoor air quality, he strongly promotes the use of the innovative materials, bamboo products.

Contents

Prologue

1. What is Bamboo?
2. Geography & Distribution
3. Bamboo & the Environment
4. Bamboo Architecture
   - Why use Bamboo?
5. Interior Design
6. Others Products
   - Textiles, food, etc.
7. Bamboo Industrial Development

Epilogue

BAMBOO

PROLOGUE

Fresh * Natural * Peaceful

The Universe is derived from nature's law

Between Universe and Earth there goes our building structures

Father: Space & Time

Conform to Universe and Earth

Mother: Earth

Universe

Human

Earth

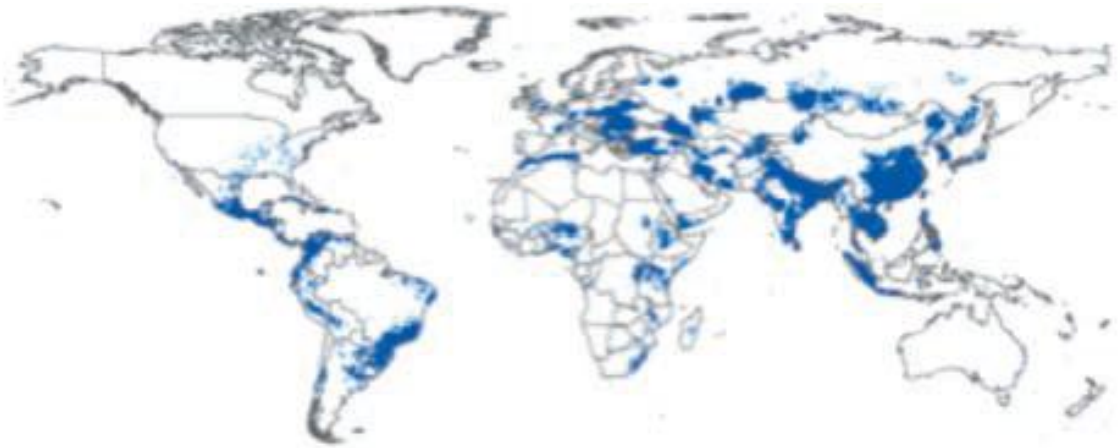
It's a sin for human to damage our Mother (Earth) in the presence of Father (Space & Time).

Morality is the key to success.

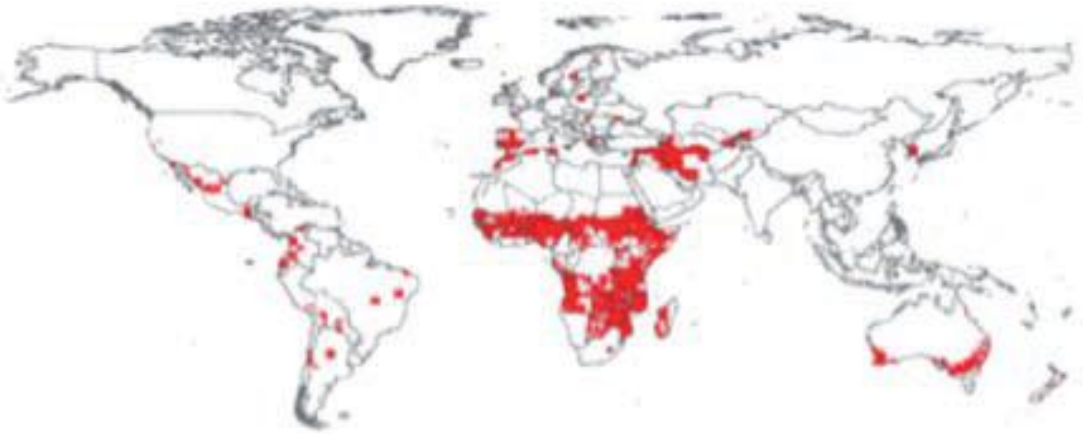
或問勝天下之道，曰：「在德。」何從勝德？曰：「大德勝小德，小德勝無德；大德勝大力，小德敵大力。力生敵，德生力；力生於德，天下無敵。故力者勝，一時者也，德愈久而愈勝者也。夫力非吾力也，人各力其力也，惟大德為能得群力，是故德不可窮，而力可困。」

（《德勝》節錄《鬱離子》）

Areas most affected by flooding

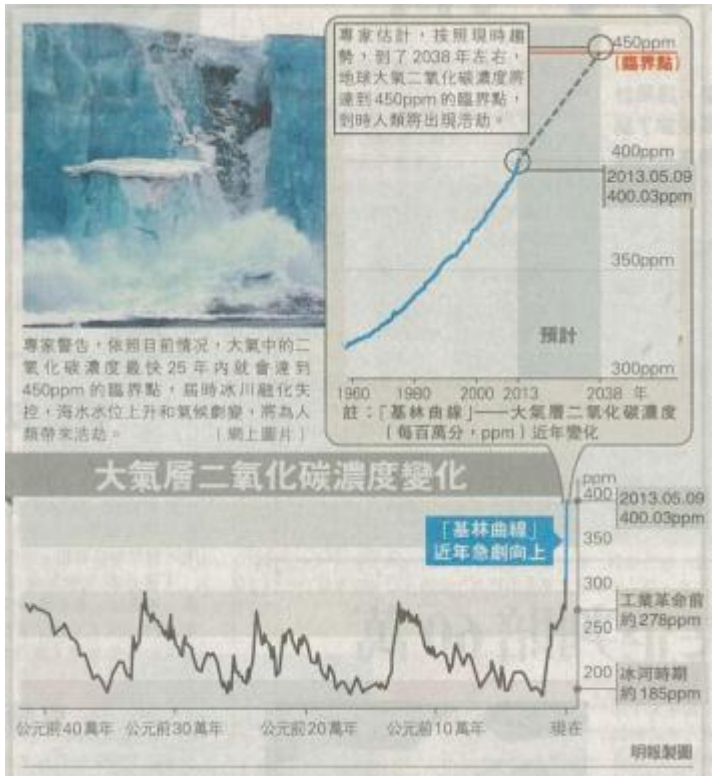


Areas most affected by drought



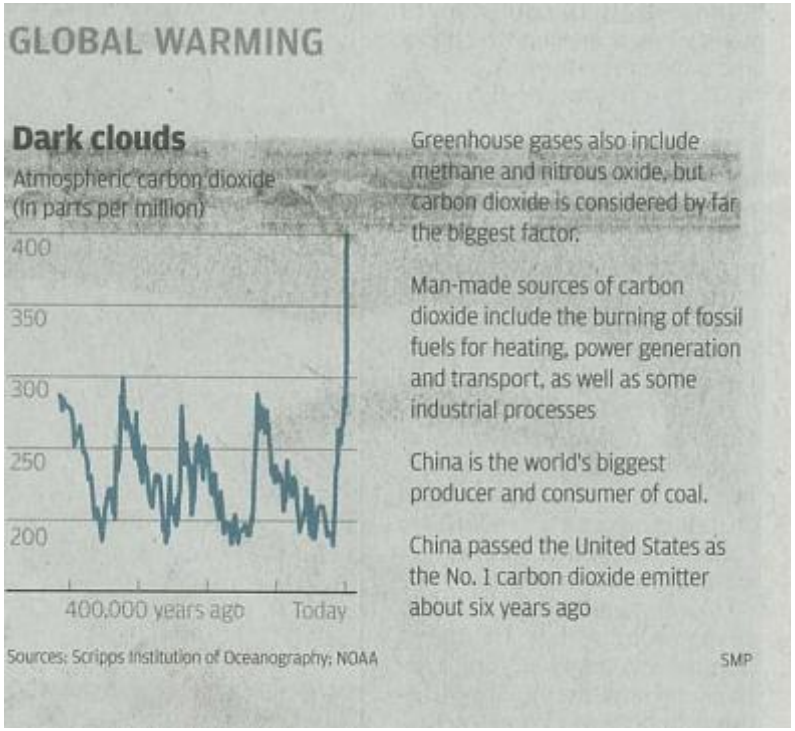
Source: 10CIFOR. 2012. Adapting forests and people to climate change – Conserving ecosystem services that reduce risk to the world's poorest. A framework proposal

Green House Gas – CO_2



Source: Ming Pao, 12-5-2013

Carbon dioxide level at new record high in 25 years for the pass 3 million years



Source: SCMP, 12-5-2013

Carbon dioxide level passes grim milestone

Global warming !!!!

Natural ecological crisis!!!

Extreme weather!!!!

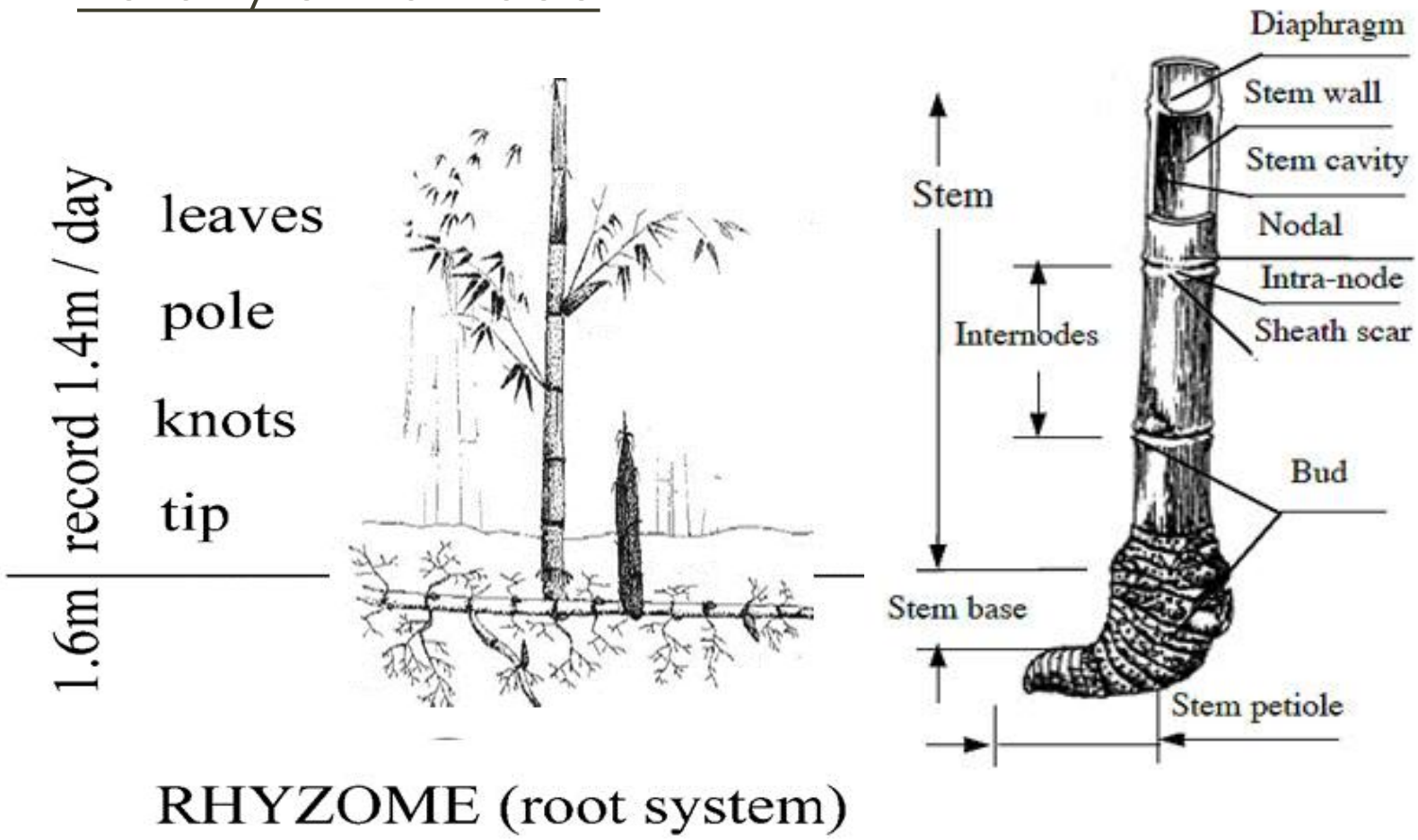
BAMBOO

WHAT IS BAMBOO?

What is bamboo?

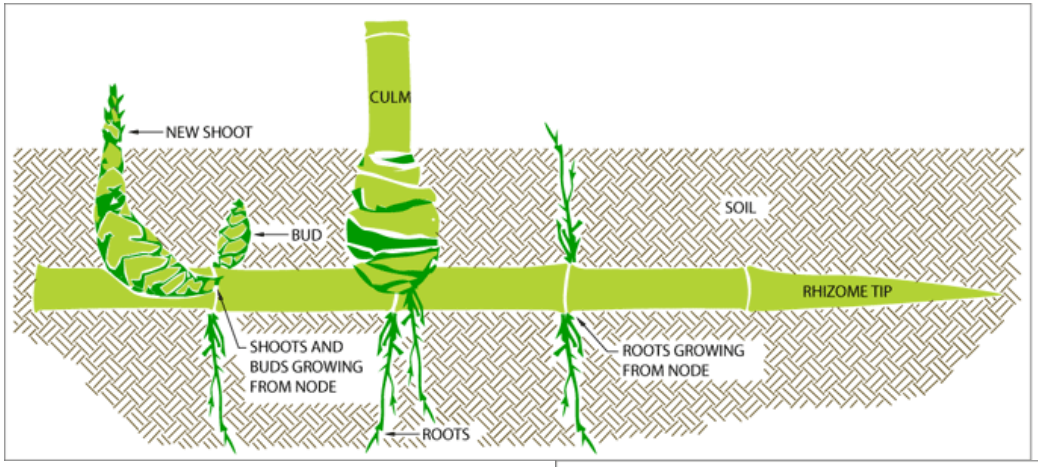
- Arborescent (treelike) **GRASS!**
- Flowering perennial evergreen plant
- family *Poaceae*, subfamily *Bambusoideae*

Botany of Bamboo



Around 50 genera and over **1200** species

- Sorted according to root system (Zhang et al., 2002)

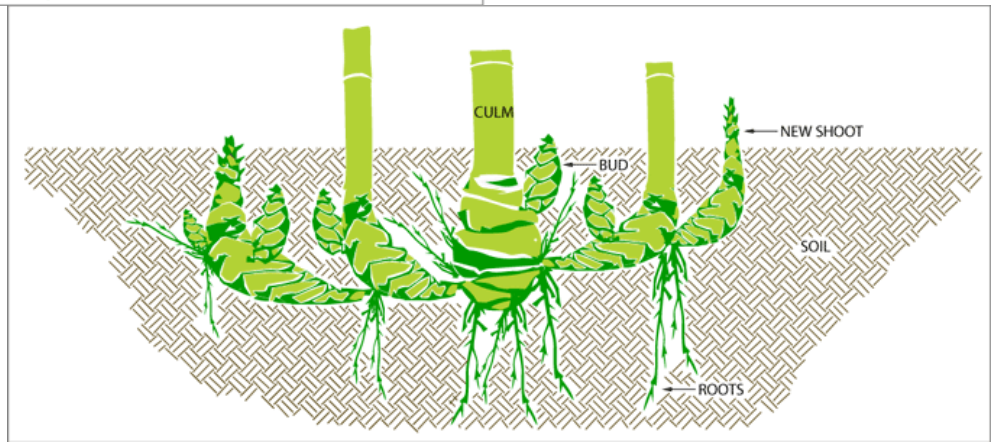


Monopodial

- Send out a number of long heavily rooter underground rhizomes each year

Sympodial

- produce only a single culm, a vertical growing shoot, from each new rhizome



Bamboo Characteristics

One of the **fastest** growing plants in the world

- Grows 1030 mm per day and reaches its full height in 4-6 months (Aminuddin, & Abd. Latif, 1991)
  - Unique rhizome-dependent system
- Root system can extend up to 100km/ha and live for a hundred years

Fast Growing Bamboo (BBC)

BAMBOO

GEOGRAPHY & DISTRIBUTION

Geography and Distribution

- About **36** million hectares worldwide
  - 3.2% of the total forest area
- Commonly found in Asia, Africa and Latin America

(Lobovikov, Paudel, Piazza, Ren, & Wu, 2007)

Distribution in China

The bamboos in China are distributed near Yellow River –Yangtze bamboo area and Yangtze River –Nanling bamboo area and at South China bamboo area and Southwest alpine bamboo area.

World Bamboo Resources

Asia and Oceania

- 65% of total world bamboo resources
- Approximately 24 million hectares
- 900 species and about 40-50 genera
  - 80% of bamboo species in the world (Jiang, 2007)

China

- Highest biodiversity with 39 genera and over 500 species
- Up to 2010, 6.73 million ha forest area is bamboo in the 16 main bamboo provinces
- From 2008-2010, rapidly increasing of about 1.35 million ha/year

(《全國竹產業發展規劃（2013 - 2020年）》,2013)

Top 10 Bamboo Provinces in China

（1）Anji County, Zhejiang Province
（2）Linan County, Zhejiang Province
（3）JianOu County, Fujian Province
（4）Shunchang County, Fujian Province
（5）Yifeng County, Jianxi Province
（6）Chongyi County, Jiangxi Province
（7）Taojiang County, Hunan Province
（8）Guangning County, Guangdong Province
（9）Guangde County, Anhui Province
（10）Zhishui City, Guizhou Province

Bamboo species in HK

Landscape Architect, please note

Phyllostachys bambusoides
f. lacrima-deae
桂竹,亦称斑竹

Bambusa ventricosa
佛肚竹

Phyllostachys
iridescins
红竹,亦称红哺鸡竹

Bambusa multiplex cv 琴丝竹

Bambusa vulgaris 金丝竹

P. Nigra Munro 毛金竹

D.barbatus 叶龙竹

BAMBOO

& THE ENVIRONMENT

Bamboo & Biodiversity

What is biodiversity?

- The variation of life forms within a given species, ecosystem, biome or planet

Why is it significant?

- It is the resource upon which communities, nations and future generations depend on
- Web of life: link between all organisms on earth , binding each interdependently
- Biodiversity underpins the health of the plant and has a direct impact on all our lives

Bamboo & Biodiversity

Planting of bamboo as priority action

(Clause no.4, Biodiversity Strategy and Action Plan 2013, Environment Bureau, HKSAR)

Bamboo forests are important for biodiversity

- Rhizome systems are intermixed with tree shrub and herbaceous layer of vegetation
- Habitats for insects, birds and other animals
- food for mammals and birds (ex. Giant Pandas and Mountain Gorillas)

Bamboo & Biodiversity

- A mix of plant species is important
- intermixed of bamboo with broad leaved trees exhibited higher amounts of desirable soil qualities
  - Porosity, aeration, and bulk density
  - Maintaining high levels of nutrients in the soil
  - increase the resilience to adverse weather conditions

Soil & Water Conservation

- No special irrigation required
- Its water-use efficiency is twice that of trees
- roots remain in place after harvesting
  - prevent erosion
  - help retain nutrients for the next crop

INBAR rehabilitation project in India

Soil & Water Conservation

- High capacity landslide prevention, protection of riverbanks, and windbreak and shelterbelt potential
- Recommended to consider for civil engineering applications

River bank stabilization

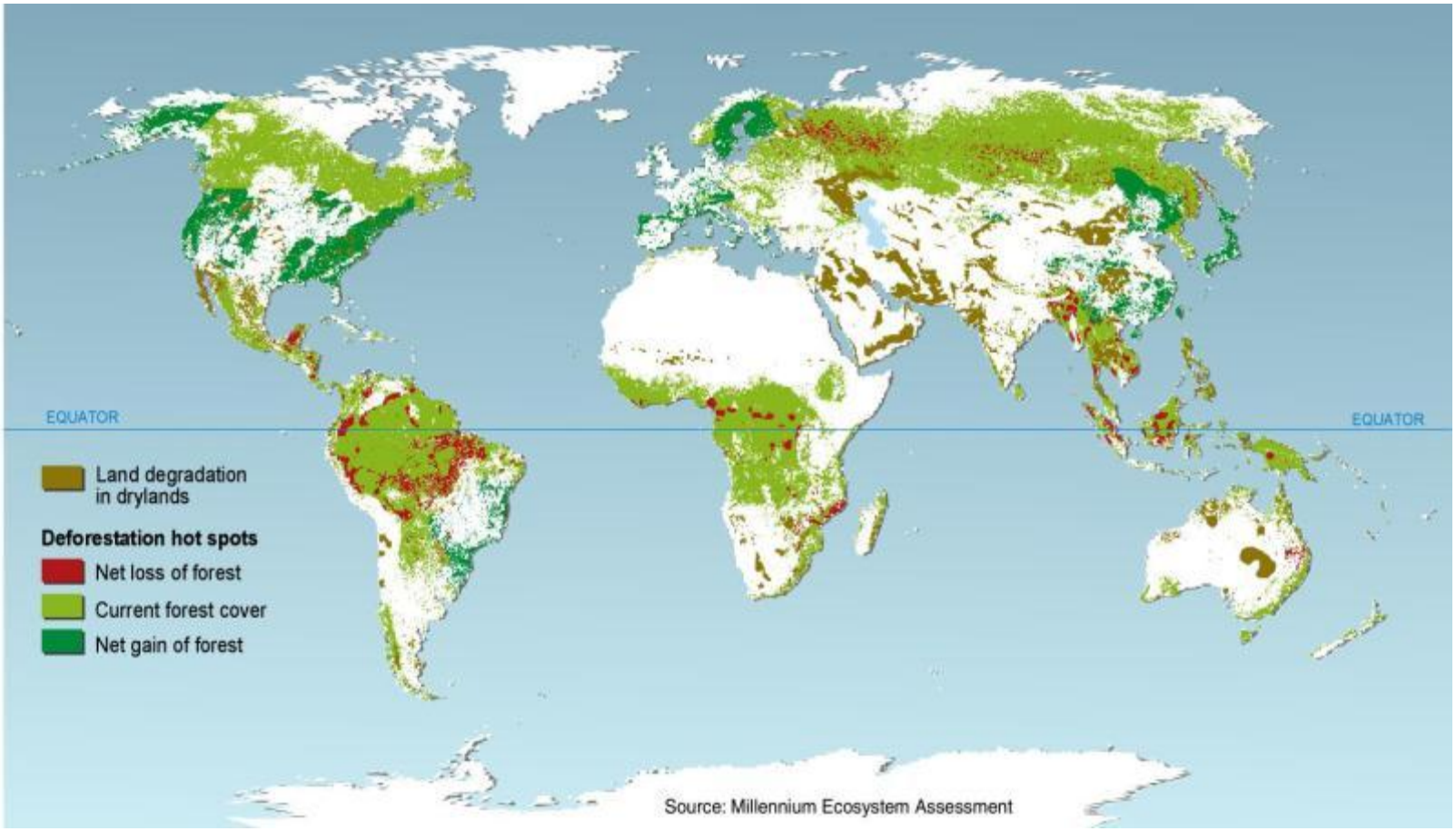
Reduce 90% soil erosion

Soil & Water Conservation

Researches and studies

- In China, more than 90% of bamboo forests are found in the source regions of major rivers and lakes and along riverbanks, where they play an important role in regulating water flows, protecting water sources, and reducing water erosion (Xiao, 2001)
- The water conservation function in Moso bamboo is about 30% to 45% more than that in the Chinese fir forest (Huang et al., 2010)

Deforestation



Deforestation

- Bamboo grows quickly
  - can take pressure off other forest resources

Reduce 90% Soil Erosion

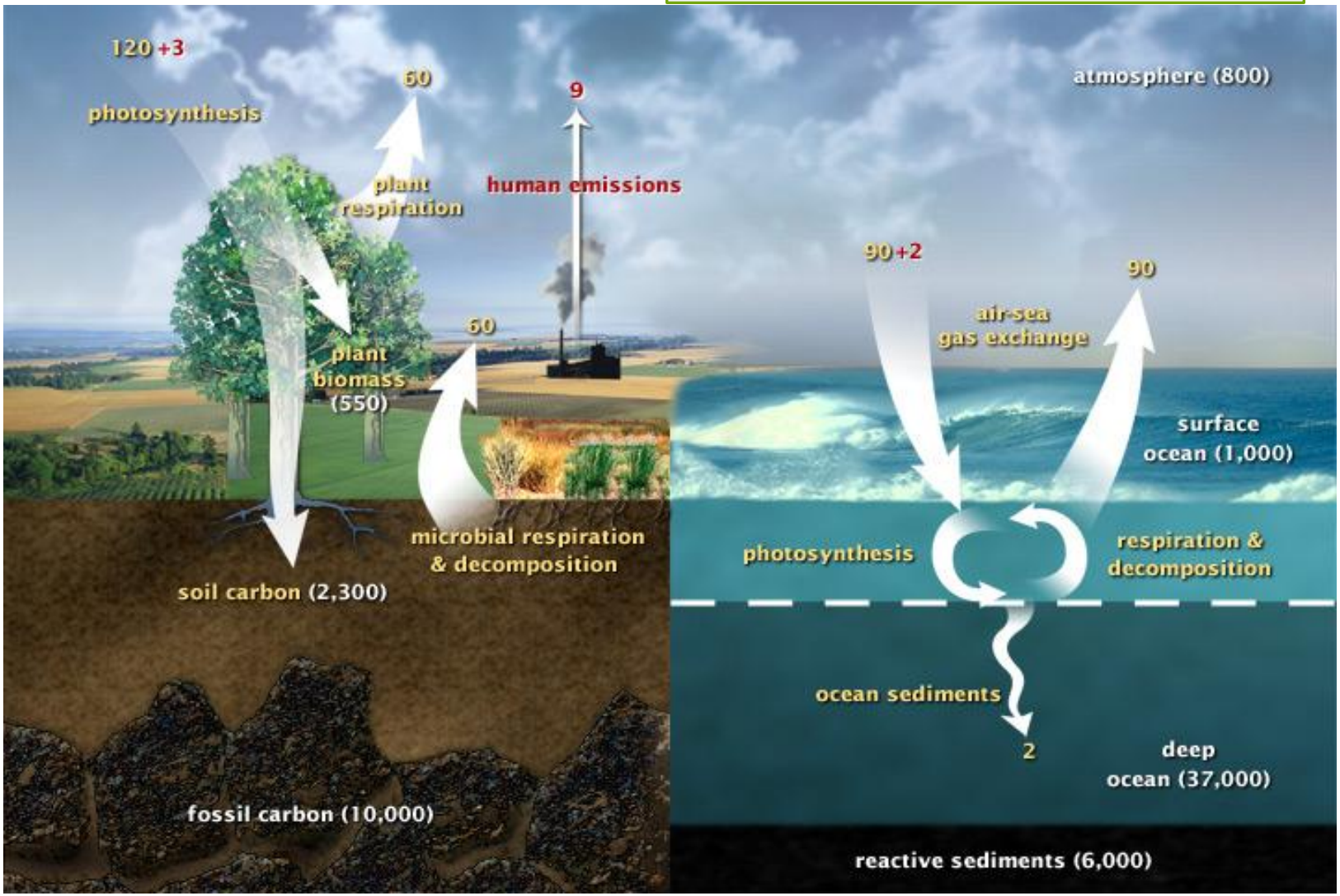
River bank stabilization

Example: INBAR conservation project in China

- Other uses of Bamboo against deforestation
  - use of bamboo charcoal and firewood as an alternative source of energy in Africa
  - coffins of bamboo in northeastern India, an eco-friendly method of burial for the state's Christians

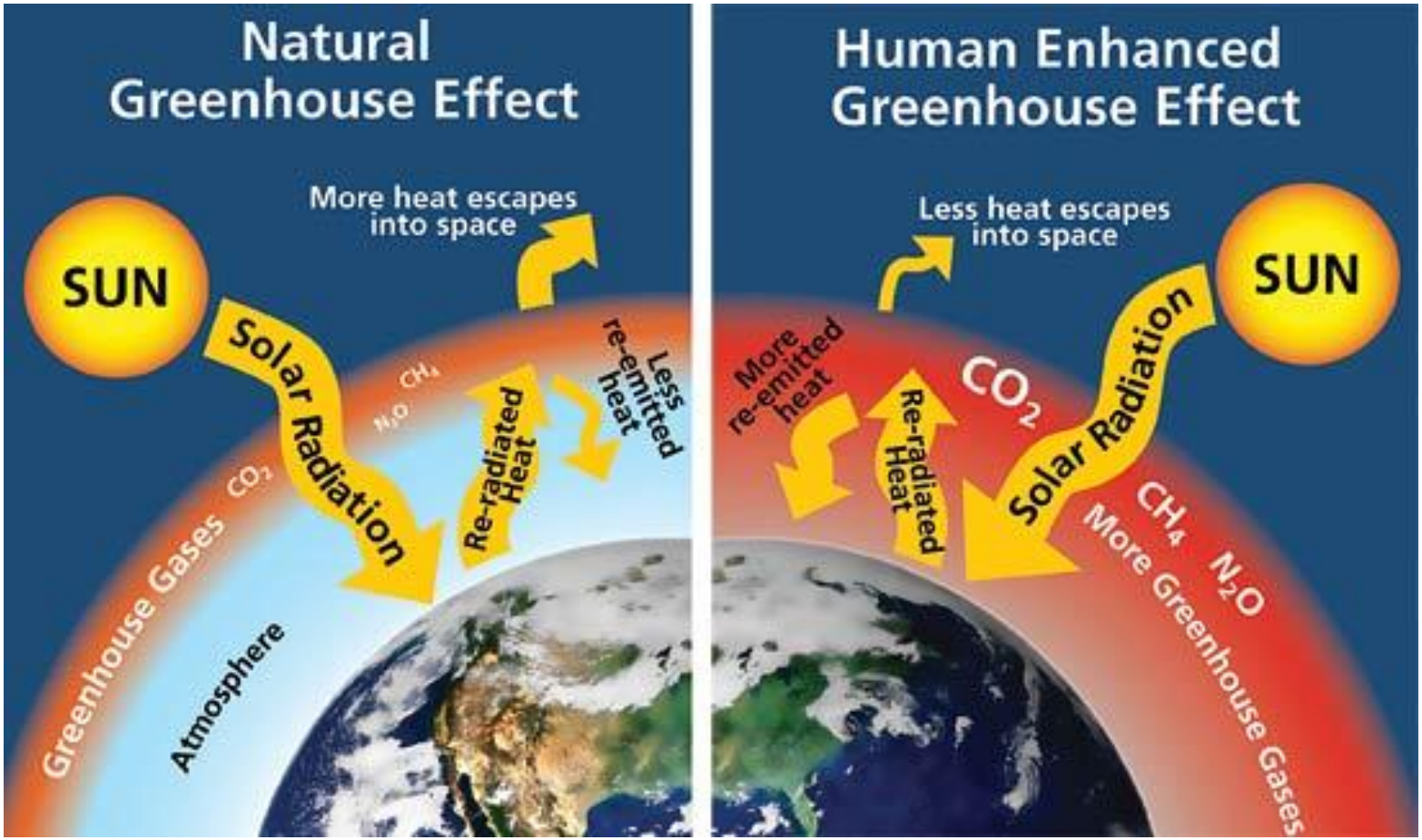
(UCA News, 2013)

The Atmosphere



Movement of carbon between land, atmosphere, and oceans in billions of tons of carbon per year

Global Warming



Greenhouse gas effect due to increased CO2

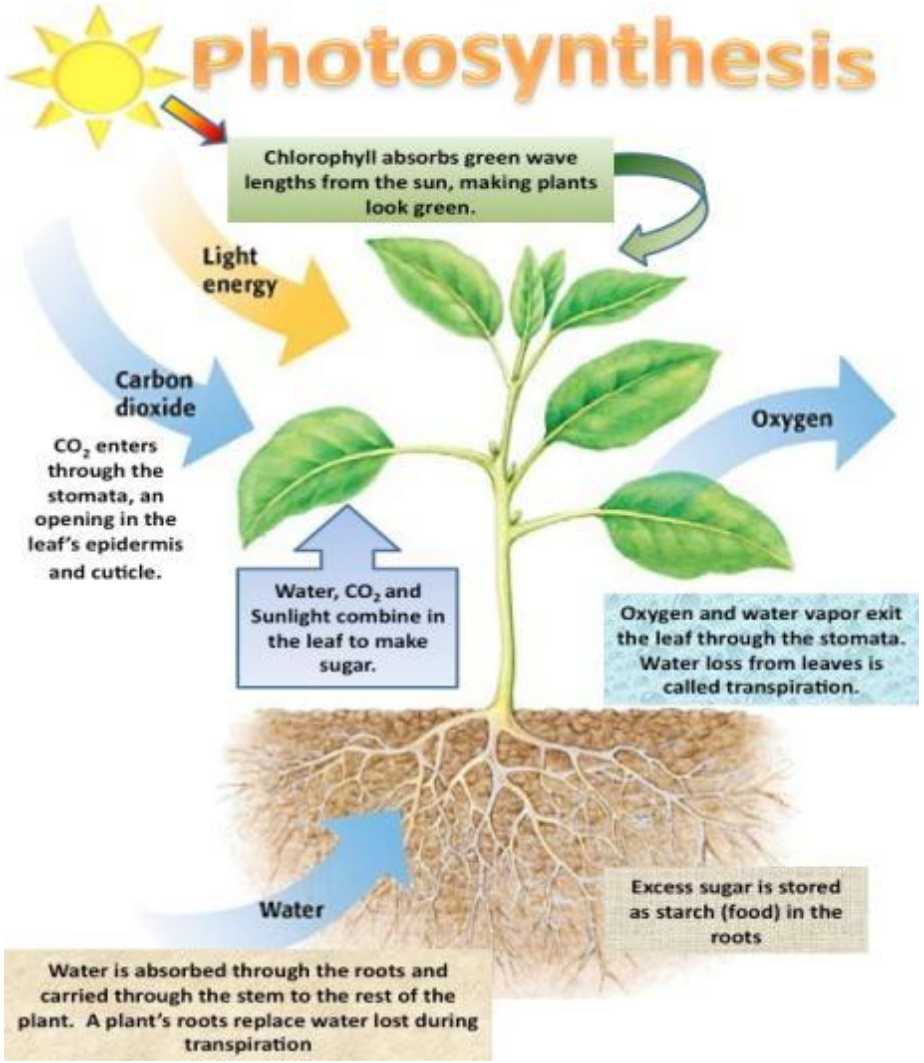
Reduction of Greenhouse Gases

Bamboo helps indirectly reduce the emission of green house gases by:

- Producing bamboo products usually requires less energy than comparable fossil-fuel based produce
- selectively harvested and provides woody biomass each year
- transformed into durable products with long life spans increases the terrestrial carbon sink

Carbon Sink

Abosrbing carbon from the atmosphere and transform into biomass



Bamboo

- **absorbs relatively more CO_2 than trees, thereby**
- **releases relatively more O_2 than trees**
- great **natural** carbon sink → Fast biomass generation
- Fast re-growth even after regular harvesting

Carbon Sequestration

Researches and studies

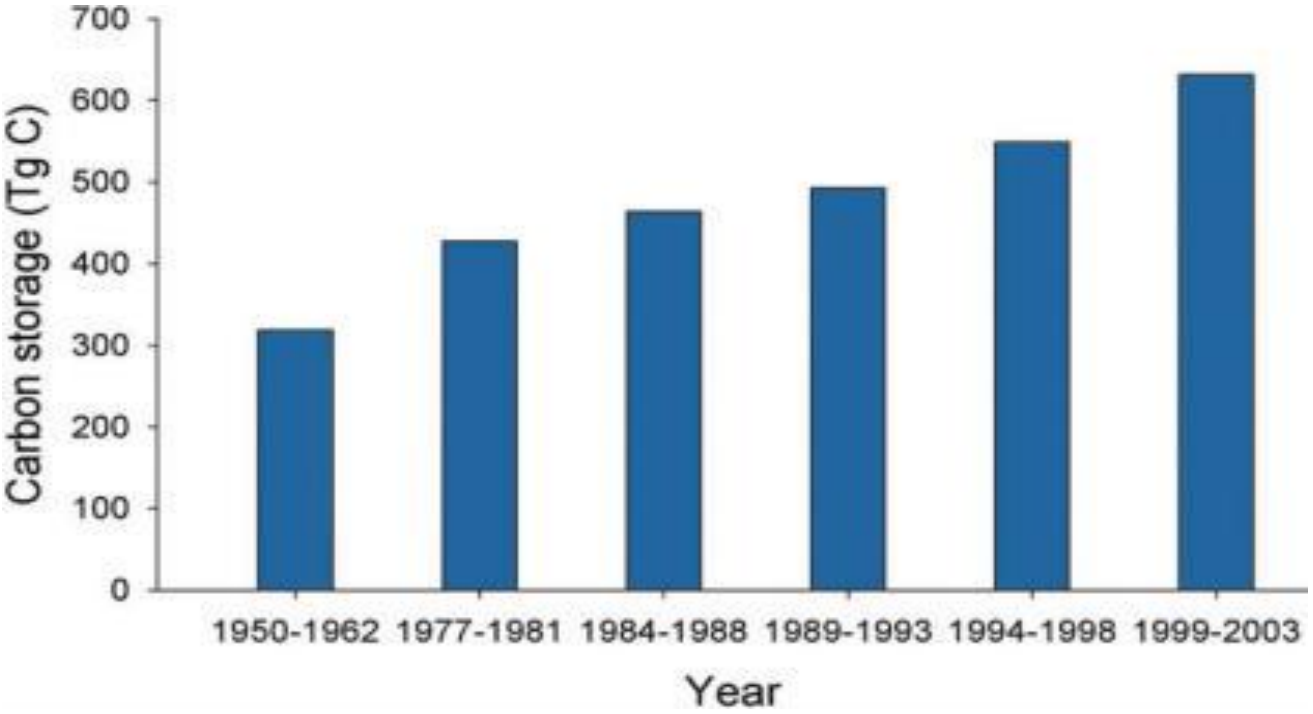
- **Annual carbon fixation** of the tree layer in a Moso bamboo forest was 5.10 t/ha
  - 1.33 times the value for a tropical mountain rainforest
  - 1.41 times the value for Chinese fir *Cunninghamia lanceolata* at 5 years old (Zhou and Jiang 2004)

- one of the most efficient types of forest vegetation for carbon fixation

- Estimates of the total carbon storage in Chinese bamboo forests from 1999 to 2003 ranging from 605.5 to 1425 Tg C

(Lou et al. 2010)

Carbon Sequestration

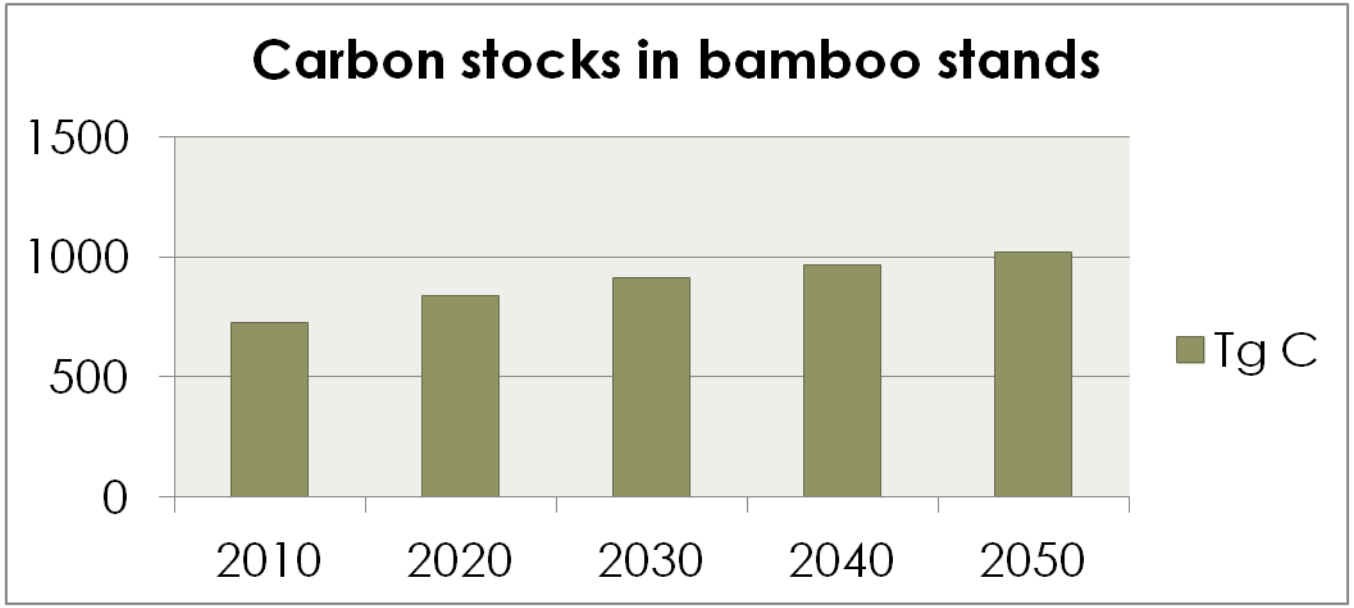


Changes in carbon storage by bamboo forests in China since 1950

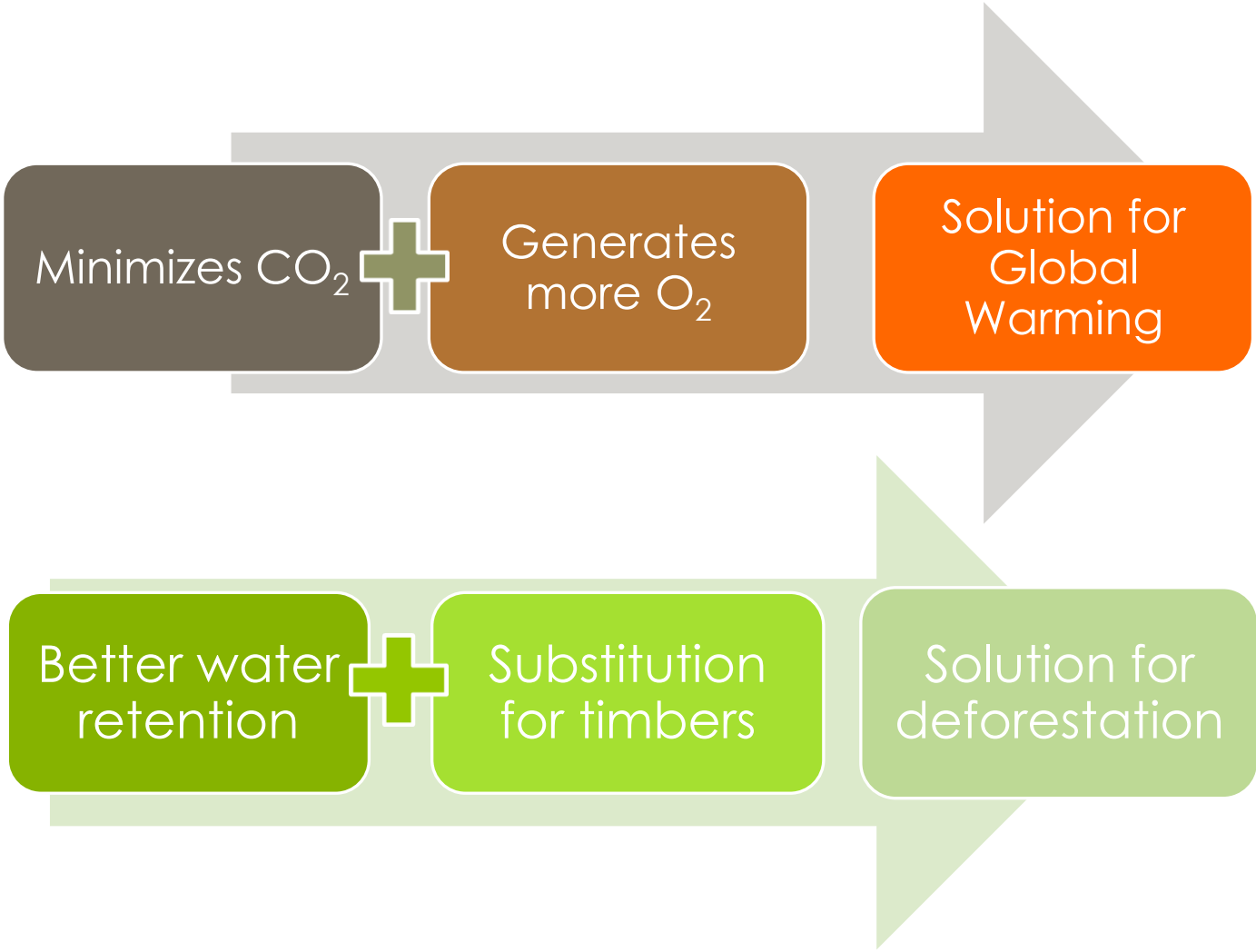
(Chen et al. 2009)

Carbon Sequestration

- carbon stocks in bamboo stands for 2020, 2030, 2040, and 2050 are expected to increase to 839.16 Tg C, 914.43 Tg C, 966.80 Tg C, and 1017.64 Tg C respectively in China



(Chen, X. G., Zhang, X. Q., Zhang Y. P., et al., 2009)


Minimizes CO_2
Generates more O_2
Solution for Global Warming
Better water retention
Substitution for timbers
Solution for deforestation

Benefits of Using Bamboo

- Reduces the adverse impacts on natural environment and human health
- Uses renewable resources more efficiently and wisely
- Reducing the pace of deforestation
- Relieving global warming and natural ecological crisis

Bamboo is a **GREEN** material

Other Benefits of Bamboo

- "natural oxygen bars"
- 2 times negative oxygen ions concentration comparing to evergreen broad-leaved forest (ChaShanZhuHai National Forest Park in Chongqing city)
- Bamboo leaf can capture 4 to 8 g/m of dust
- bamboo belt reduce noise (10 to 15 dB by 40m wide belt)

Source: Li, R., Zhang, J., and Zhang, Z.E. 2003. Values of bamboo biodiversity and its protection in China. J. Bamboo Res. 22: 7–13.

BAMBOO

ARCHITECTURE

bamboo Industrialization

Bamboo Seed

Bamboo Resources

Bamboo Industrialization

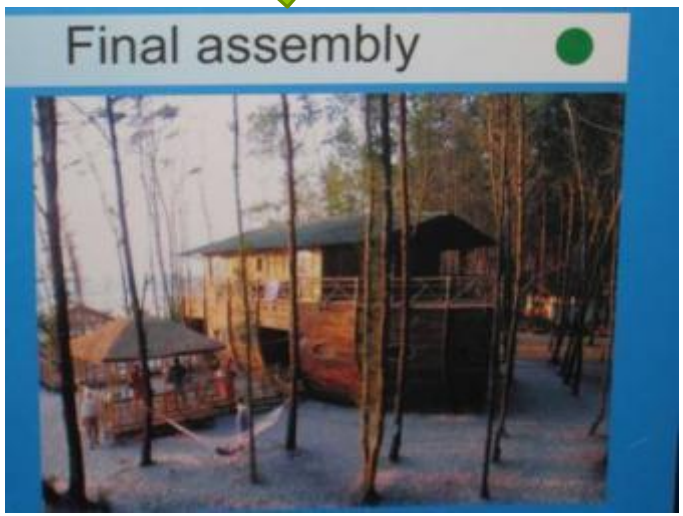
Different products

Bamboo architecture

Low carbon

Harmony with nature

bamboo Industrialization



As a Building Material

- Often referred to as the poor man's timber,
- becoming increasingly popular among Western architects and engineers
- a major building material in many countries, particularly in Asia, Africa and South America
- Well Known for its strong characteristics, light weight and flexible properties
- can be used for almost all parts of houses, including posts, roofs, walls, floors, beams, and trusses

Mechanical Properties

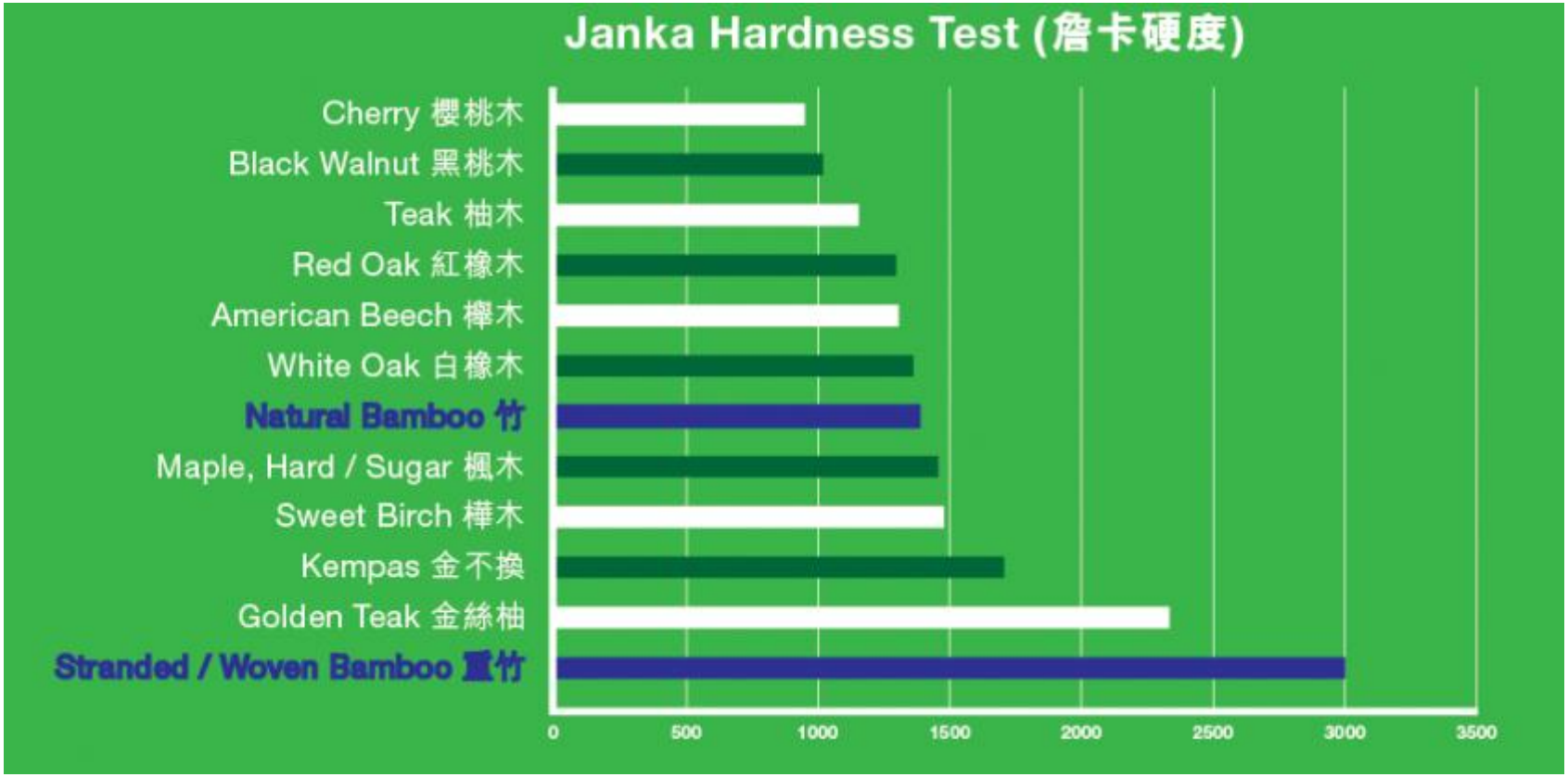
Compression Strength

→ the capacity of a material or structure to withstand loads tending to reduce size

Material	MPa
Bambusa blumeana	24.0
Bambusa vulgaris	25.3
Gigantochloa scortechinii	27.0
Red Oak	46.5
Douglas Fir	49.8
White Pine	33.0
Western Cedar	31.5

Liese (1985)

Mechanical Properties



Mechanical Properties

Ultimate Tensile Strength

- the maximum stress that a material can withstand while being pulled before breaking

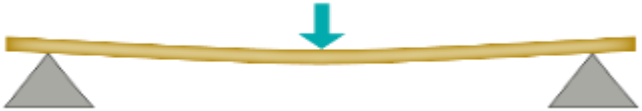
Material	MPa
Bamboo	350 – 500
Red Oak	48 – 63
Pine	21-32
Concrete	3
Structural Steel A36	400
Silicon	7000

(David W. Green et al., 2008)

Mechanical Properties

Flexural Strength (Modulus of Rupture)

→ the highest stress experienced within the material at its moment of rupture



Material	MPa
Bambusa blumeana	99.8
Bambusa vulgaris	62.3
Gigantochloa scortechinii	52.4
Red Oak	98.5
Douglas Fir	85.5
White Pine	59.3
Western Cedar	51.7

Liese (1985)

Mechanical Properties

Modulus of Elasticity

- An object's tendency to be deformed (non-permanently) when a force is applied to it
- A measurement of stiffness

Material	MPa
Bambusa blumeana	4,100
Bambusa vulgaris	6,100
Gigantochloa scortechinii	4,800
Pine (along grain)	9,000
Oak (along grain)	11,000
Douglas Fir	13,000
Steel	200,000

Liese (1985)

Mechanical Properties

- In general, bamboo is stronger than wood in bending strength, compression strength parallel to grain and is similar in shear strength parallel to grain
- The strength of bamboo in grain direction is extremely high, especially MOR and MOE. It might be suitable as the raw material for such products as oriented structural boards which bears unidirectional load (Febrianto et al., 2012)
- Bamboos have low shear strength parallel to grain. The bamboo veneers can be peeled from straight culms of a thick-walled bamboo species

Why use bamboo?

- bamboo can be harvested within 5-7 years
- extraordinary physical characteristics
  - suitable for all types of structures and constructions
- Light building material for easy transportation & storage

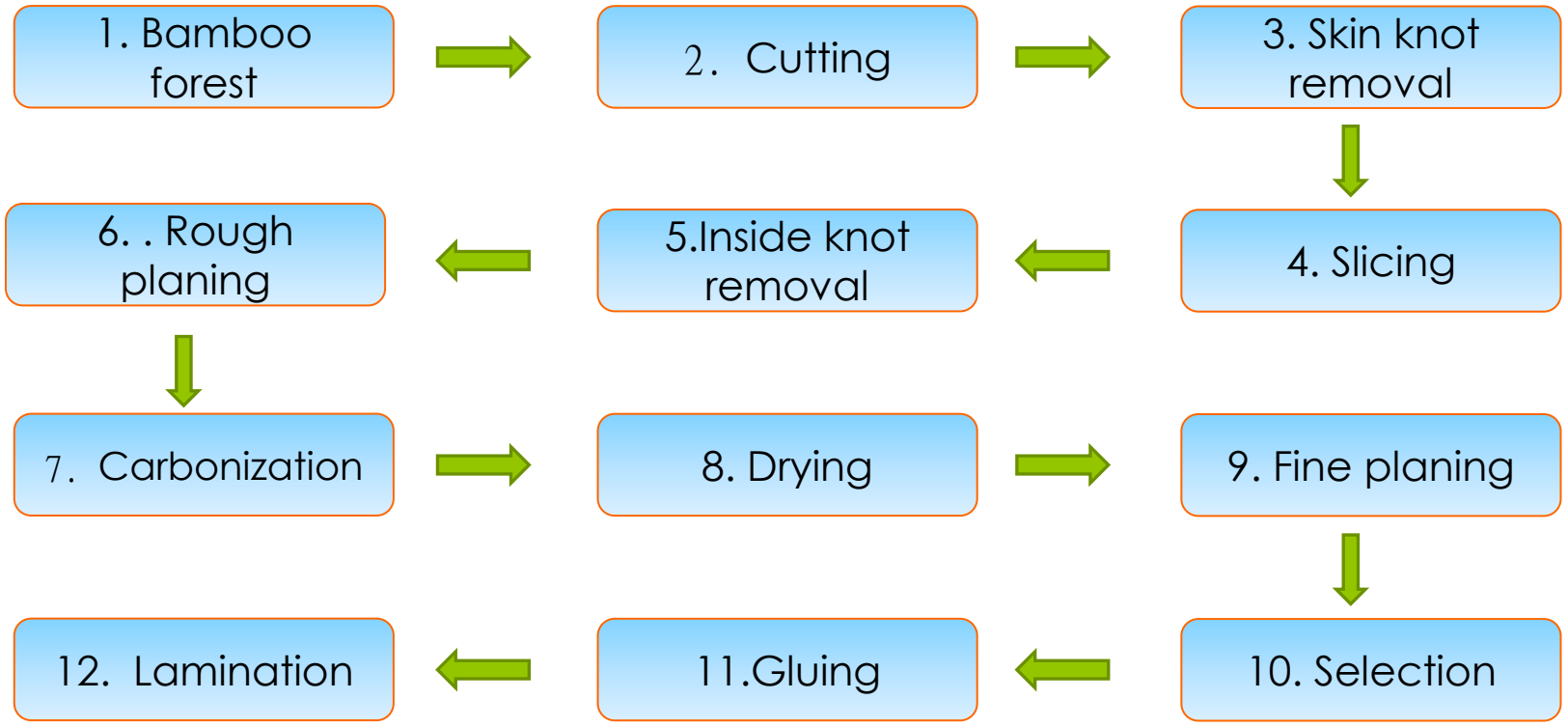
Why use Bamboo?

- Superior earthquake-resistance
  - Nodes of bamboo has a dividing or transverse wall allows bending
- Cutting and processing with simple manual tools
  - Easily be cut length-wise or cross cut in pieces of any length
- Attractive color
  - does not require painting, scraping or polishing

Facts to be noted

- Are processed and compressed with chemical-based glue
  - formaldehyde out-gassing, esp bamboo product made with low quality glue
- Durability
  - bamboo flooring last 30–50 years (while some solid hardwood last 125 years or longer)

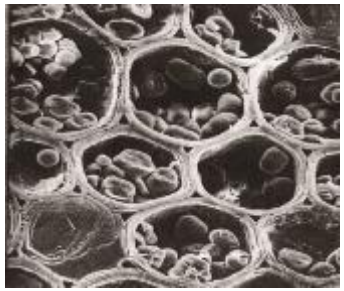
Bamboo Slat Manufacturing Process

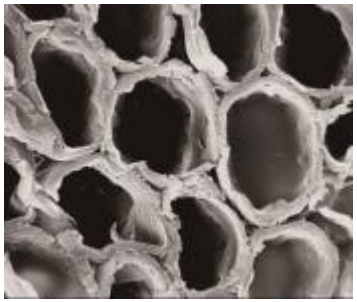


When not handled correctly

- starchy interior is attractive to insects and pests
  - Proper immunization techniques and drying processes will prevent this from occurring

Before Treatment





After Treatment

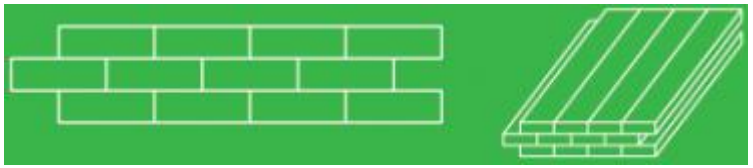
- diameter of the bamboo diminishes when drying
  - dried in advance of construction

- special techniques for joints and terminals
  - nails into bamboo can result in splitting
  - Variation in thickness of the internal walls

Structure & Colour

Vertical: Bamboo strips are stood vertically on their narrowest edge and then laminated from side to side. The effect is a lined, almost uniform look to the surface of the finished floor plank.

Horizontal: Bamboo slats are arranged in a horizontal direction, on their widest edge, and then joined side by side with adjacent pieces using a high-pressure laminate system. The characteristic nodes of the bamboo are visible on the finished horizontal surface.



Strand Woven: Bamboo strips are thrashed into thing strips and then being compressed under high pressure

Structure & Colour

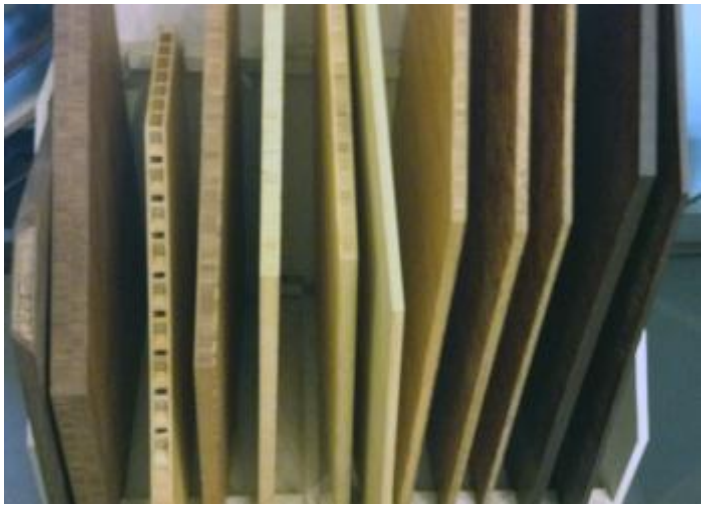
Horizontal
Natural

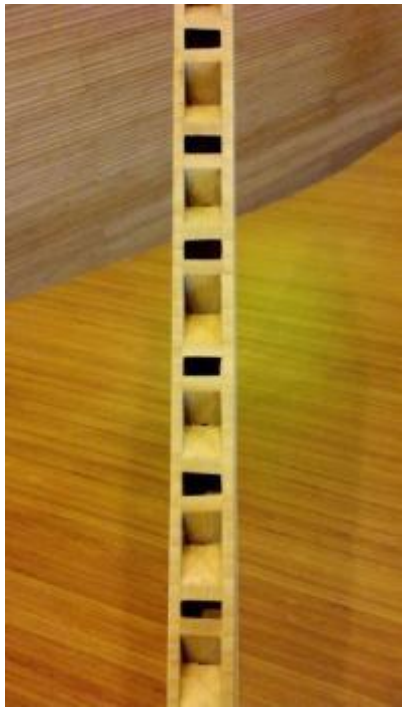
Horizontal
Carbonized

Vertical
Natural

Vertical
Carbonized

With proper management and building techniques, bamboo can be a **better** alternative to wood



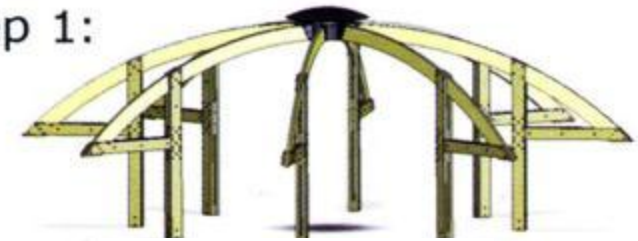


Bamboo Scaffolding

Low income bamboo housing

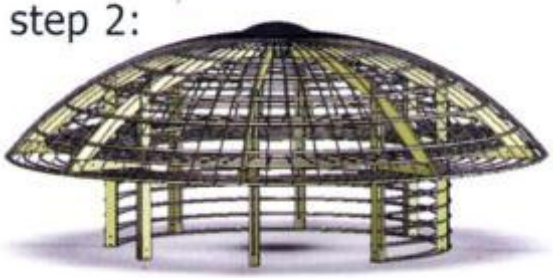
Affordable Housing

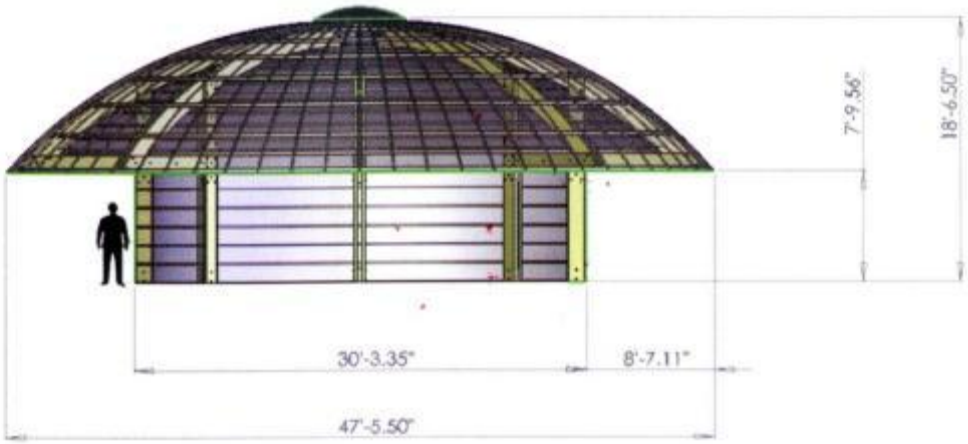
step 1:



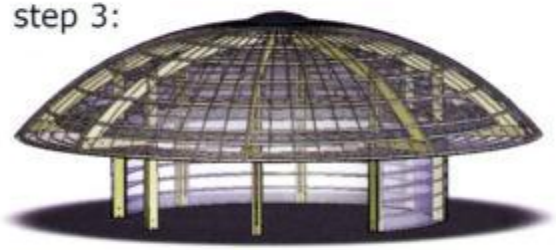
step 4:

step 2:





step 3:

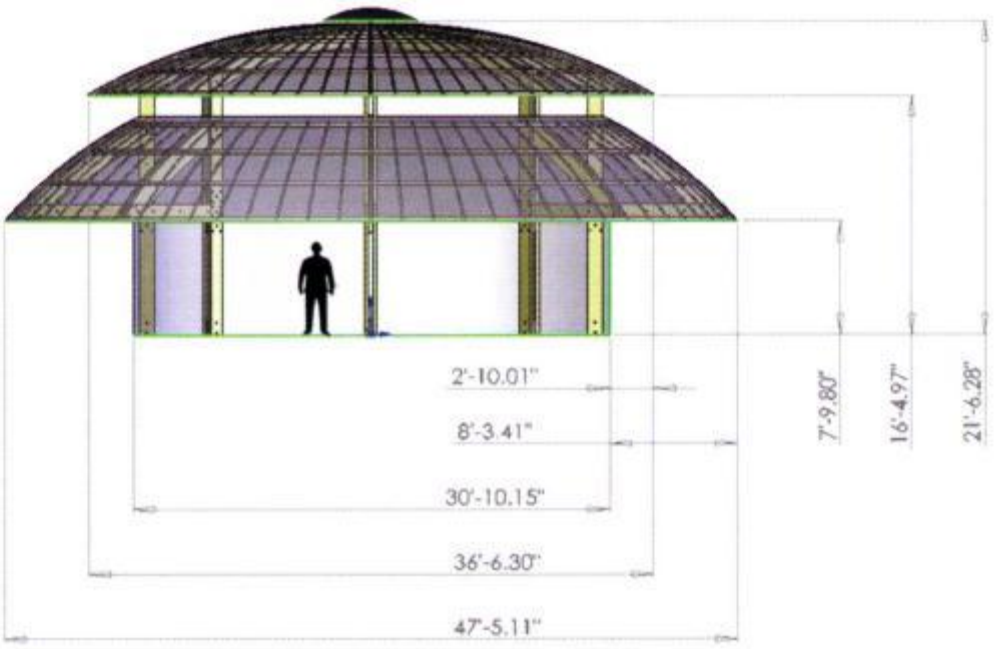


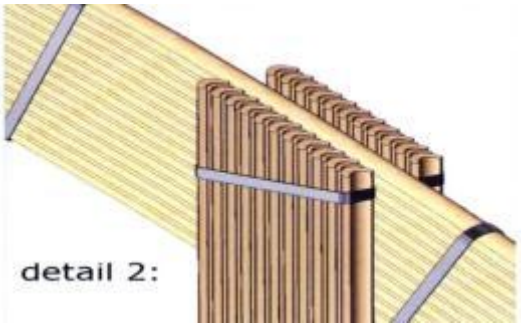
"We come spinning out of nothingness, scattering stars...
the stars form a circle, and in the center we dance."

-Rumi

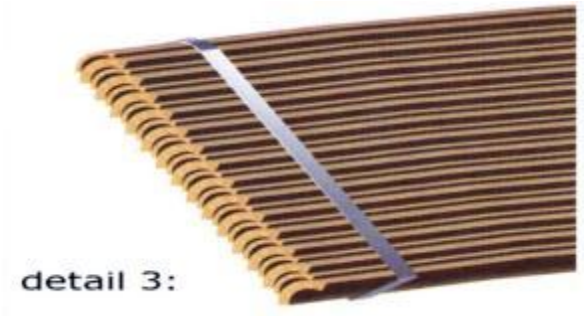
Affordable Housing

detail 1:



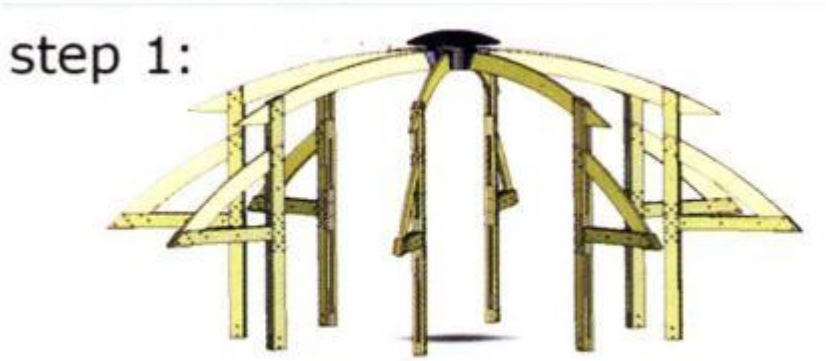


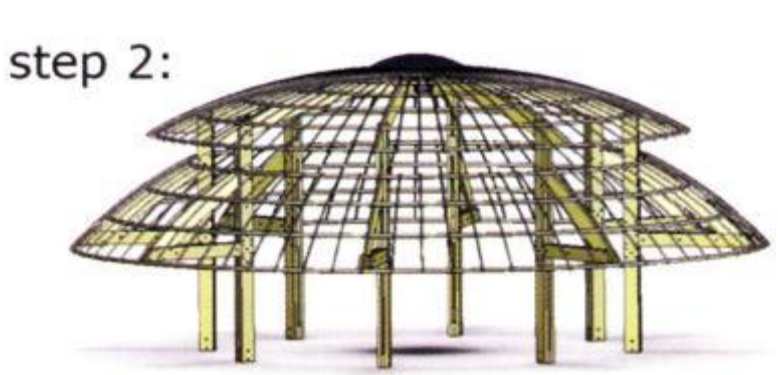
detail 2:

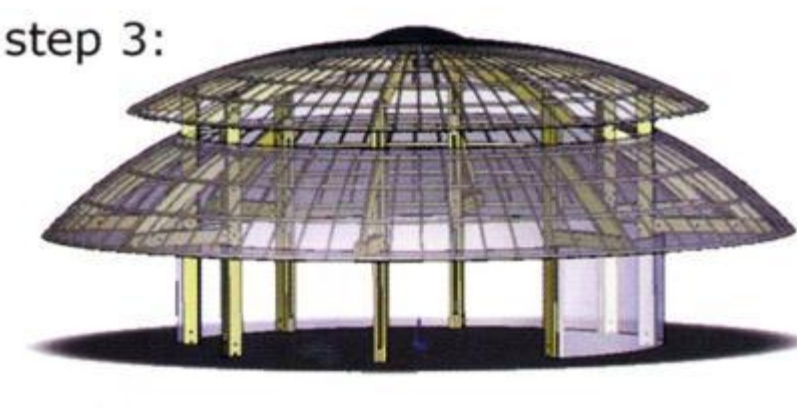


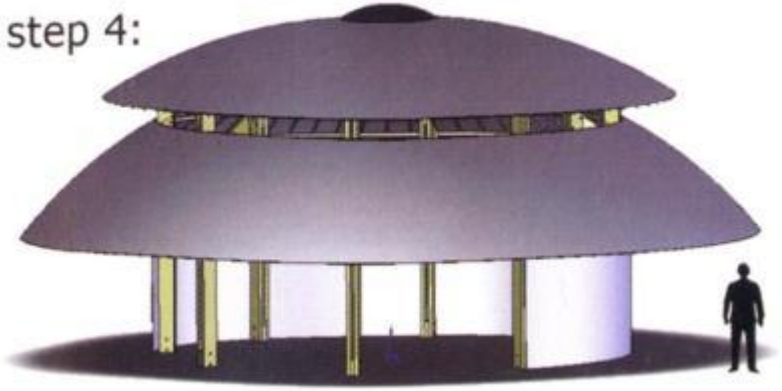
detail 3:

Affordable Housing



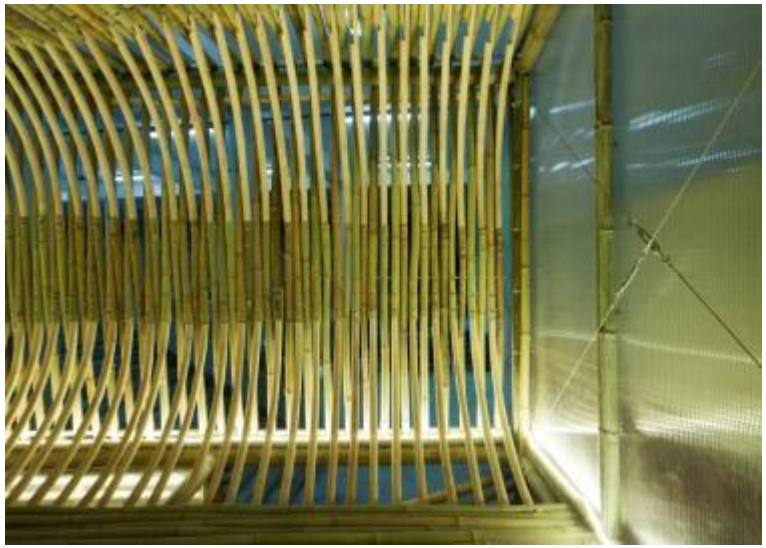






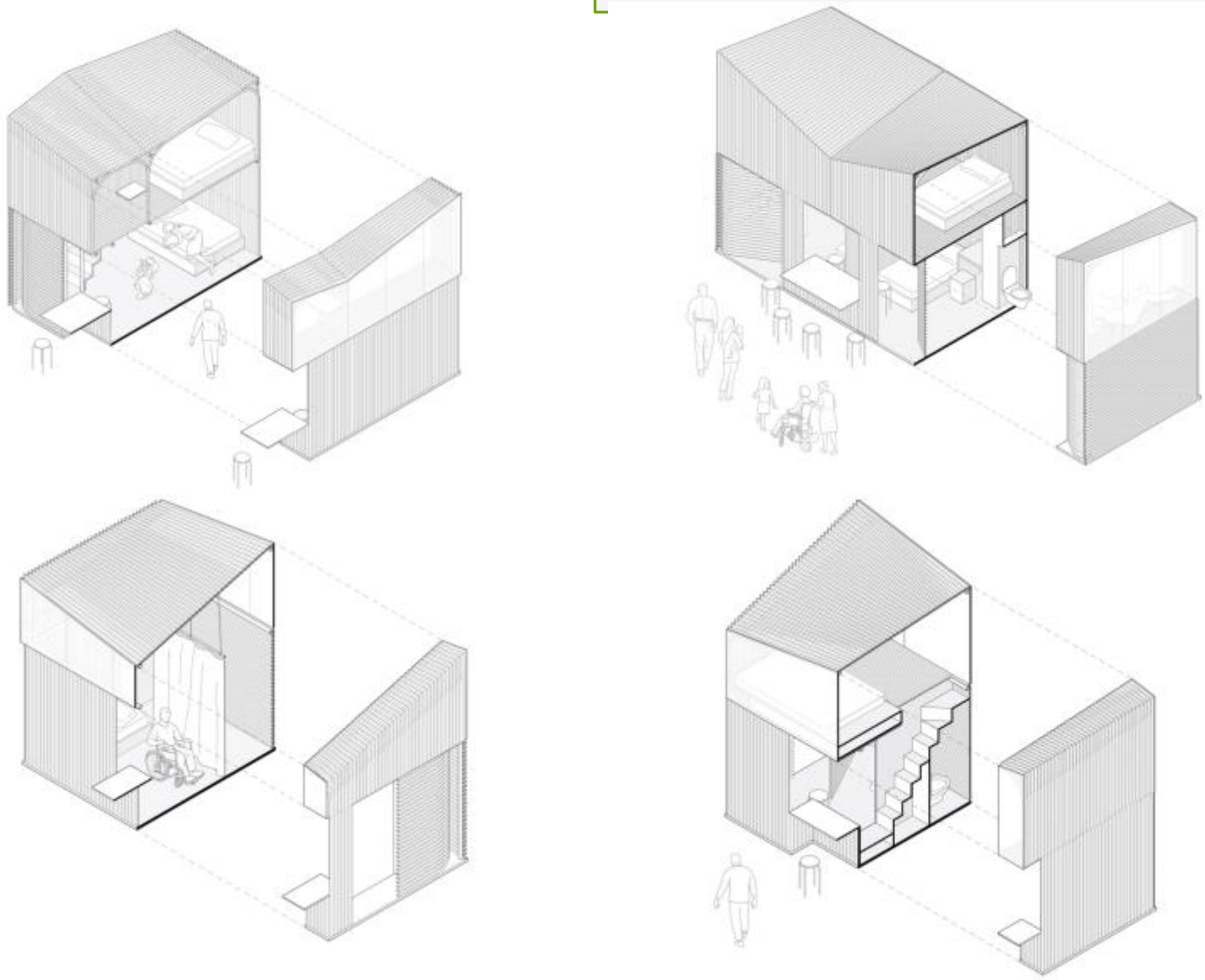
1420/affordable housing

Team: Joshua Doolittle, Glenn Schmierer, Zak Rosser, Garth Goldstein, Tony Birkholz

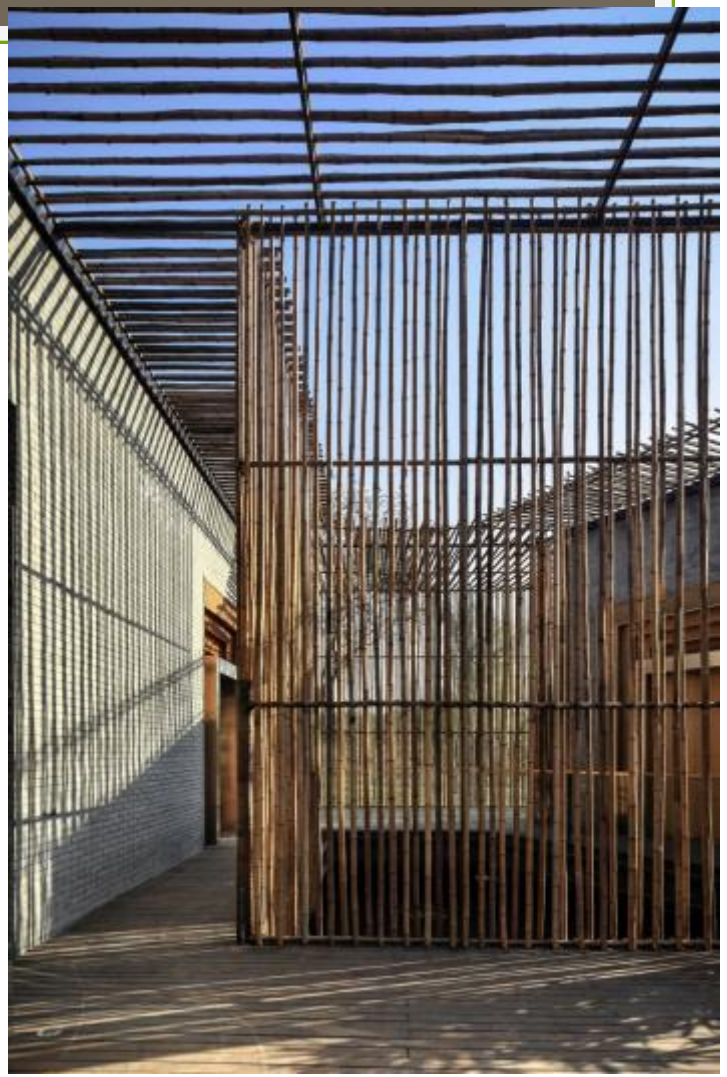


Bamboo Micro Housing Proposal, Hong Kong

Bamboo Micro Housing Proposal, Hong Kong

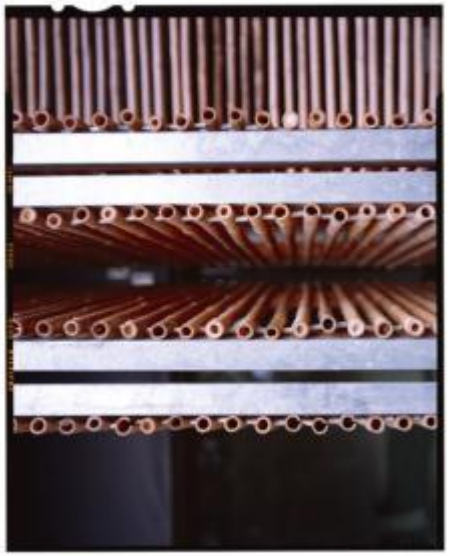


Bamboo Micro Housing Proposal, Hong Kong

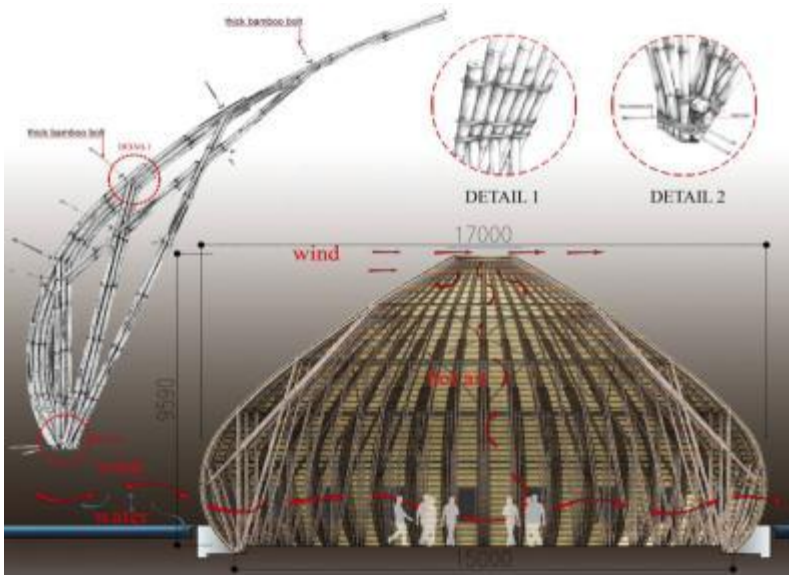


Bamboo Courtyard Teahouse, Yangzhou, China

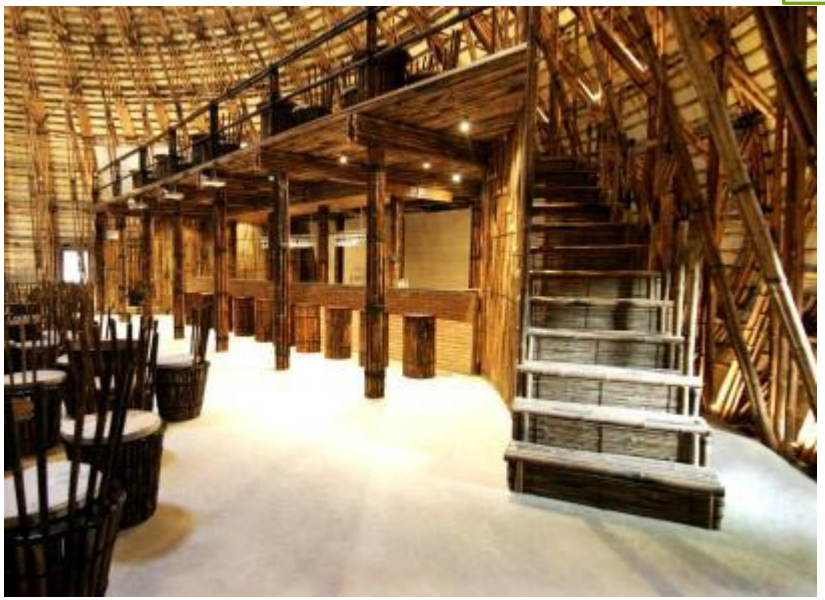
Bamboo Courtyard Teahouse, Yangzhou, China

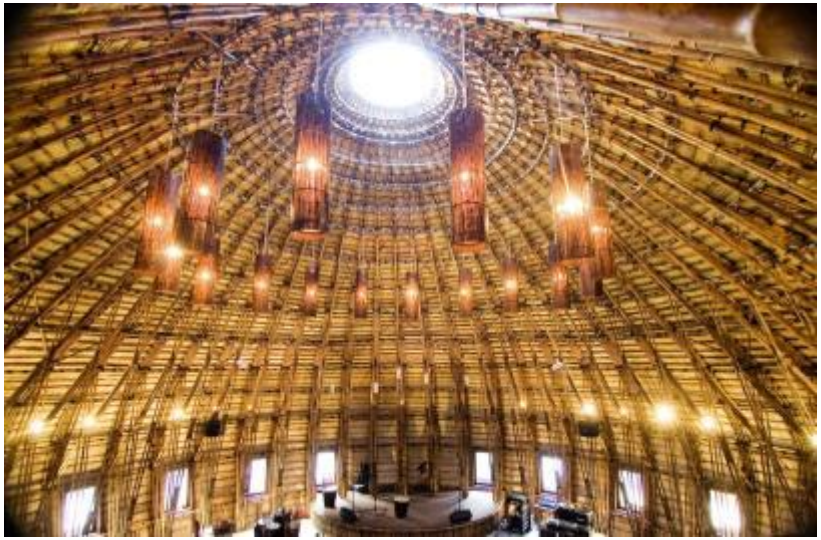


Passive House, France



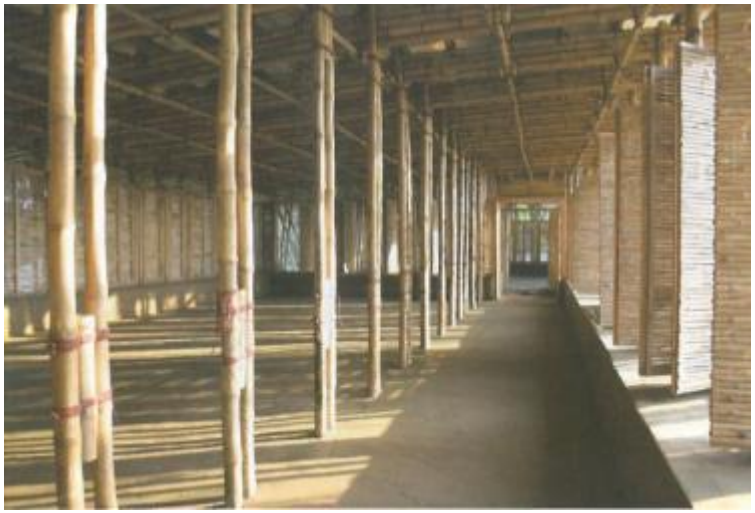
Nw Bar, Vietnam



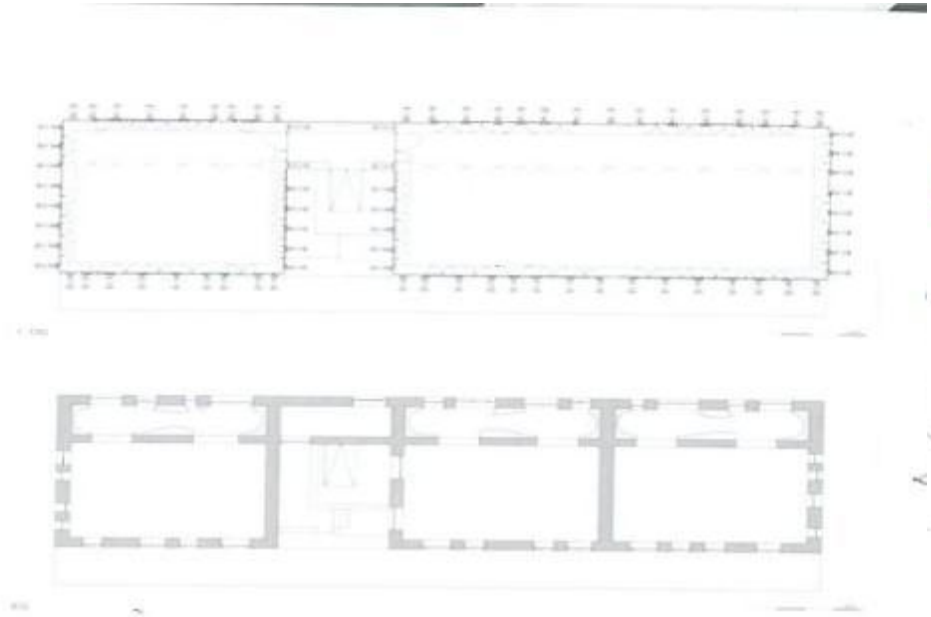


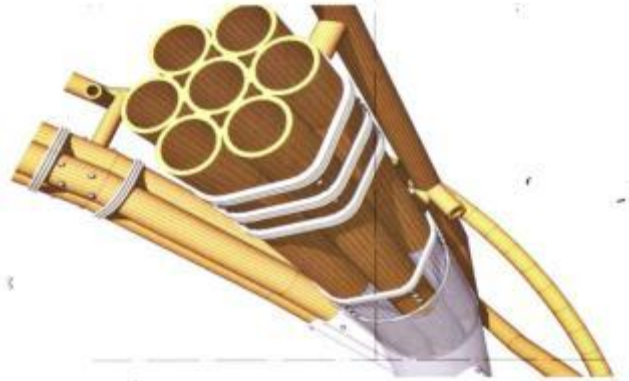
Nw Bar, Vietnam

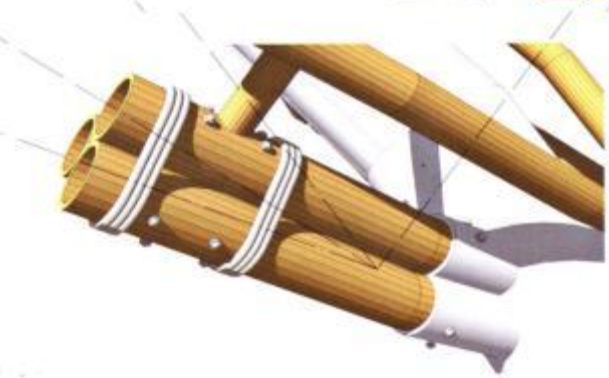
Low Energy Bamboo House, Belgium

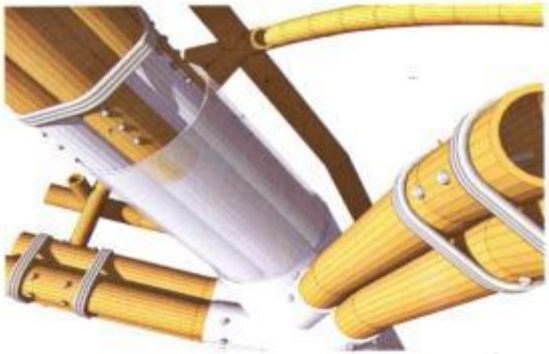


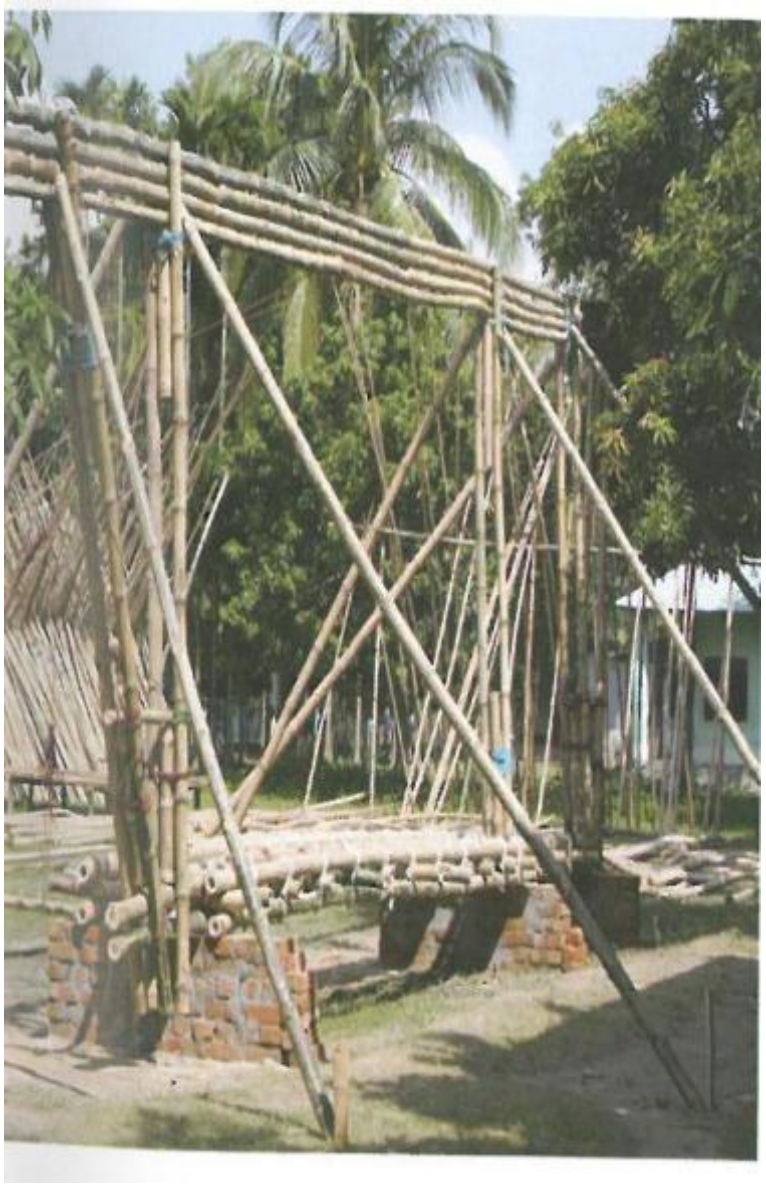
Handmade School
Bangladesh









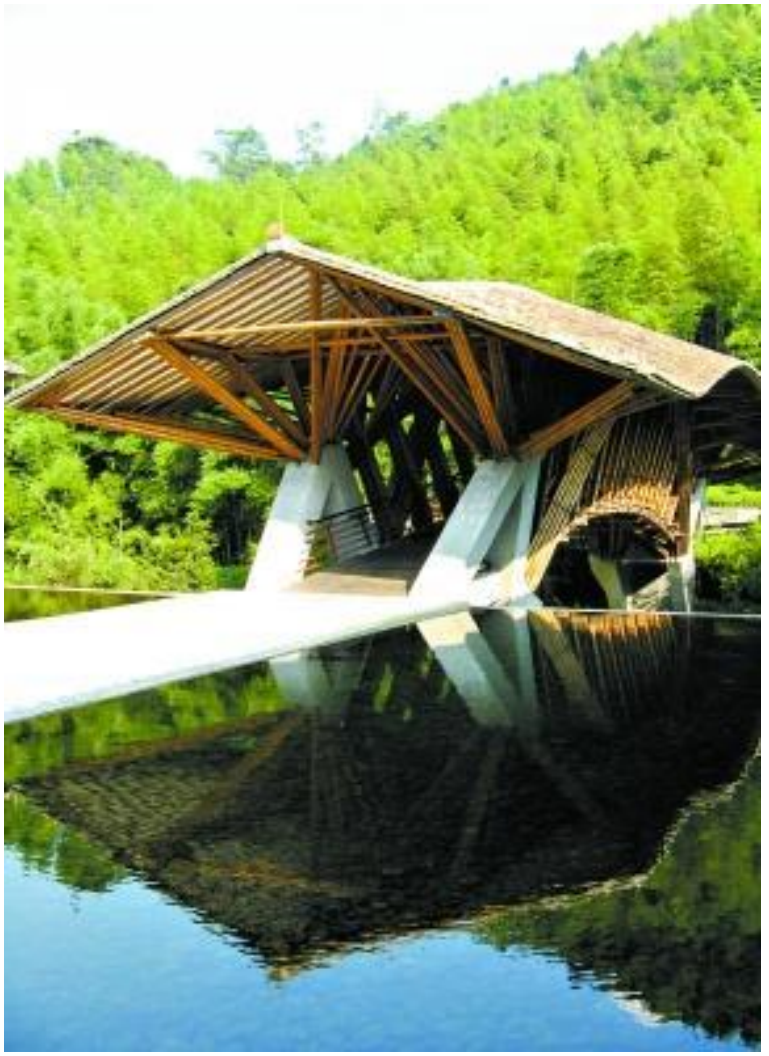


Timarai Bamboo Beach Resort Costa Rica
1st place in the 2005 National Architectural Contest

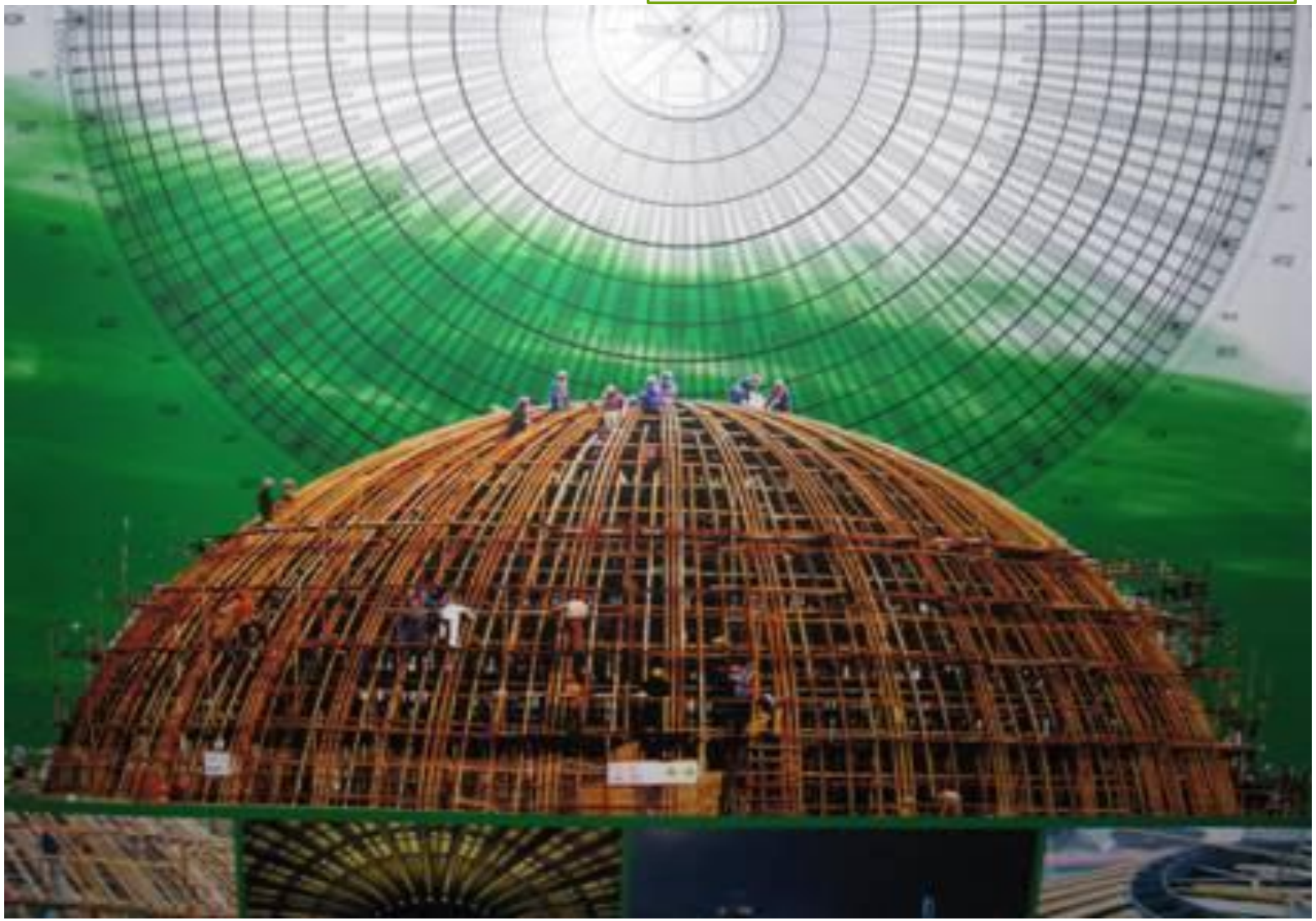
Bamboo Vacation Home Casa Atrevida
Earthquake and flood resistant

Bamboo House in Costa Rica
Designed and build by Martin Coto

Guadua Bamboo House
It took 12 people to built this bamboo project from scratch



Crosswaters Ecology & Spa
Nankun, Guangzhou, China



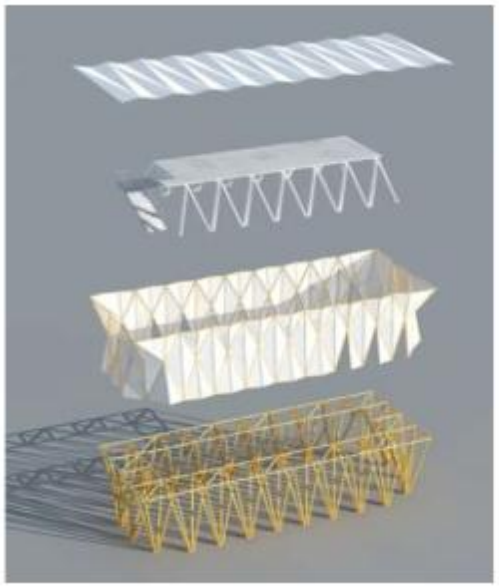
Indian Pavillion at 2010 Shanghai World Expo
World's largest bamboo dome

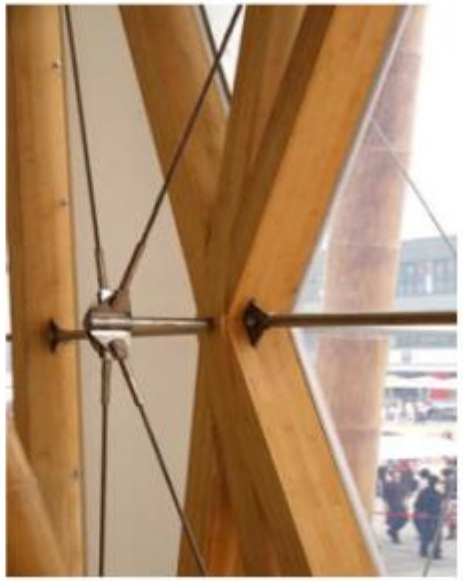
Indian Pavillion at 2010 Shanghai World Expo
World's largest bamboo dome

Spain Pavillion at 2010 Shanghai World Expo

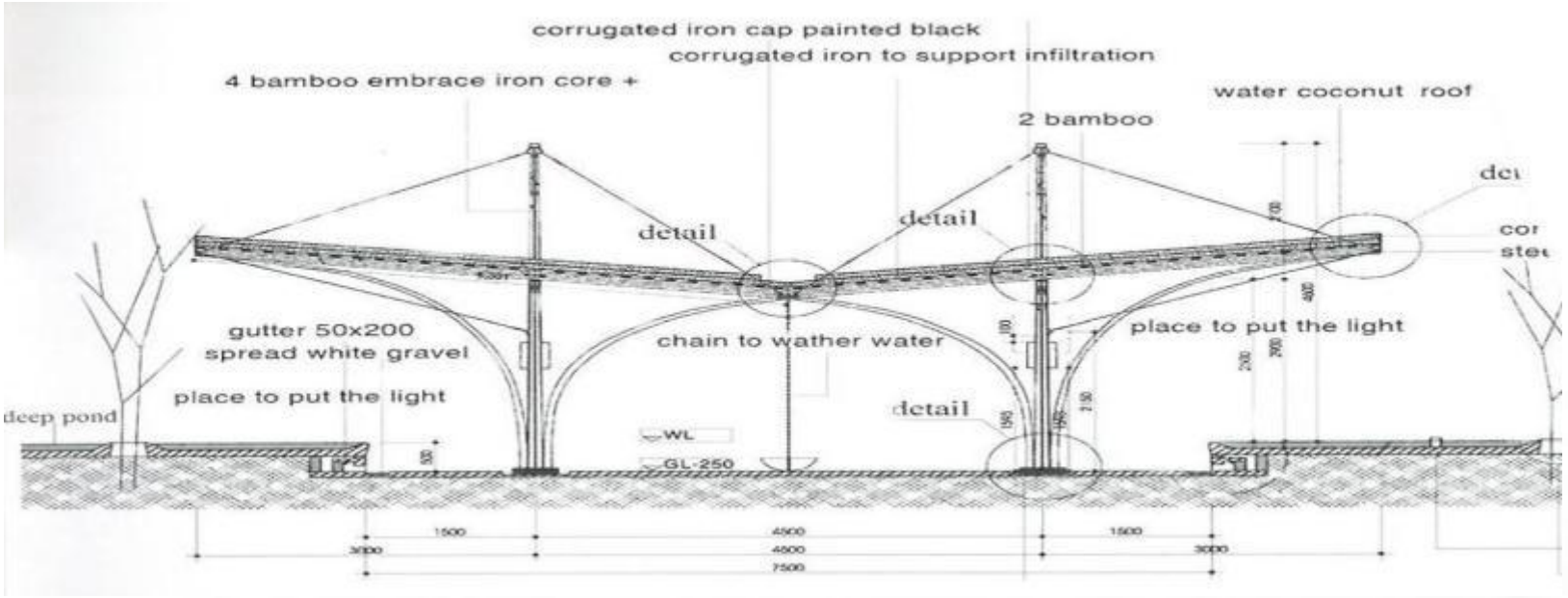
Vietnam Pavillion at 2010 Shanghai World Expo

德國館(German Roving Trade Show)



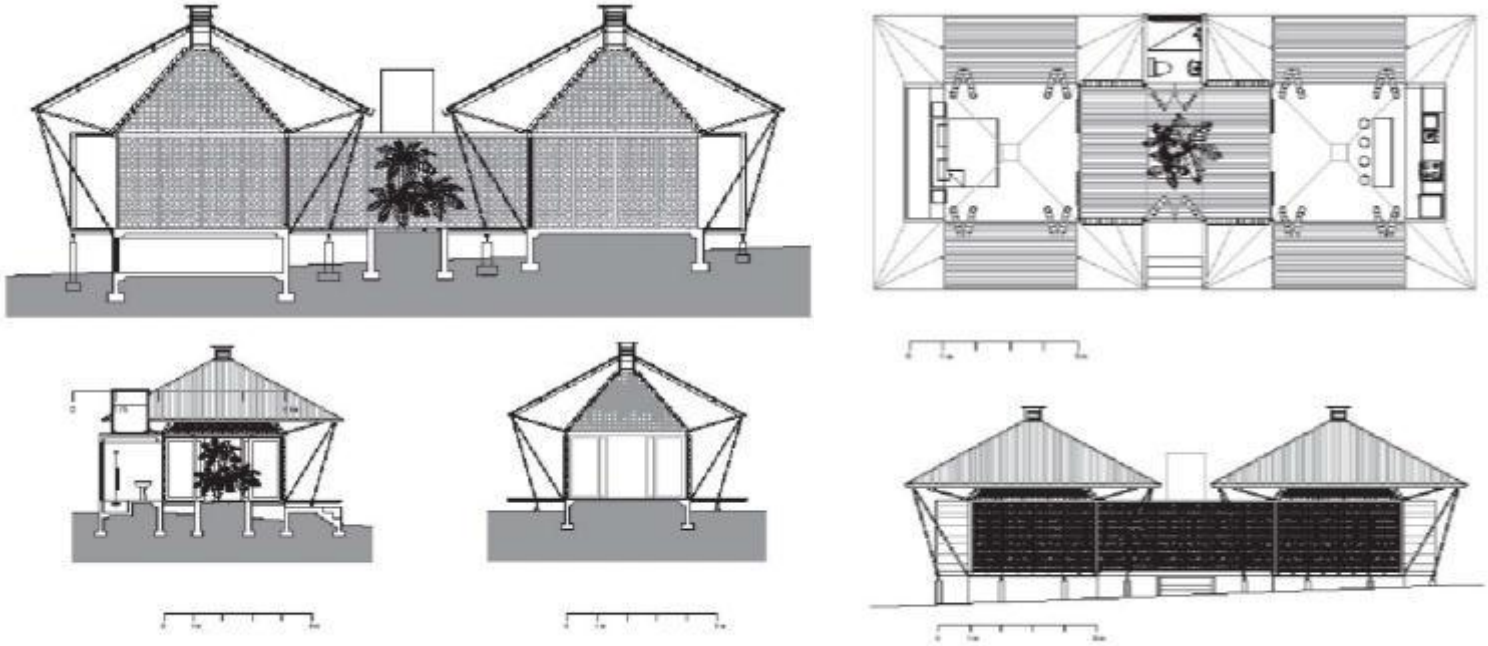


越南　河内　鳥狀競技場

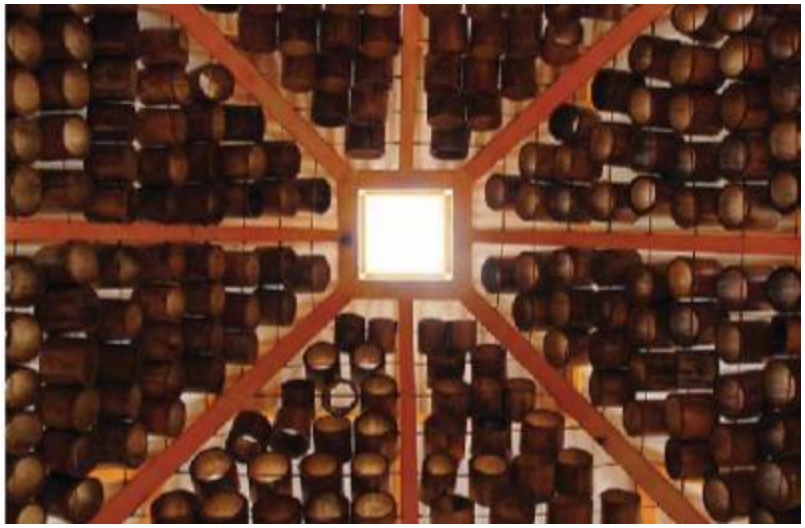

corrugated iron cap painted black
corrugated iron to support infiltration
4 bamboo embrace iron core +
water coconut roof
2 bamboo
detail
detail
detail
gutter 50x200
spread white gravel
chain to wather water
place to put the light
place to put the light
deep pond
WL
GL-250
1500
4500
1500
3000
4600
3000
7500

越南 河内 鳥狀競技場

Bamboo Design Competition 2010

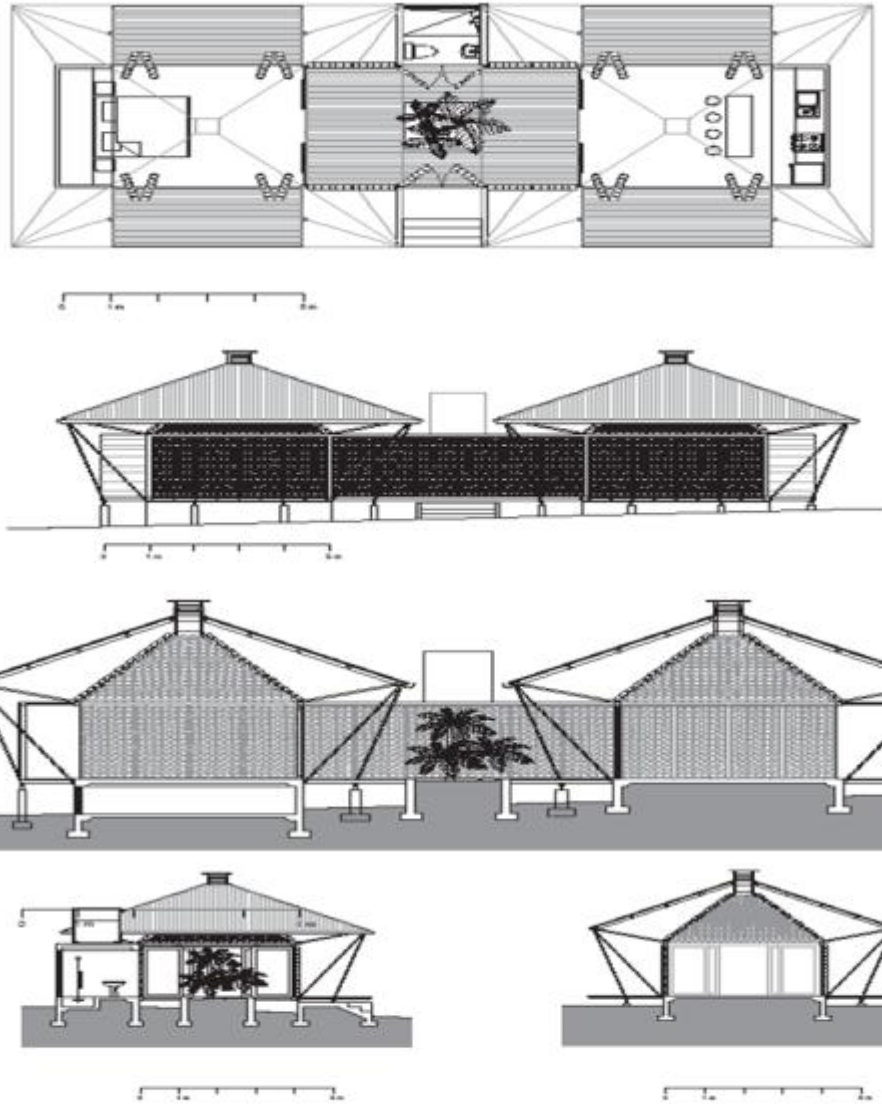


Bamboo Design Competition 2010

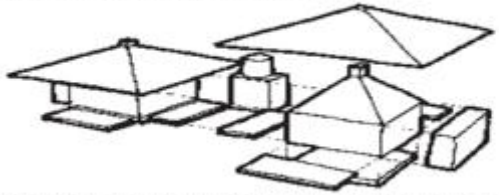


Bamboo Design Competition 2010

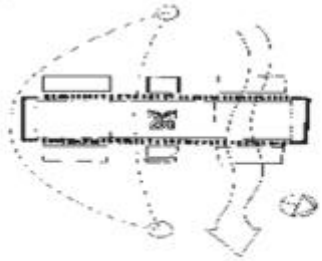
Bamboo Design Competition 2010

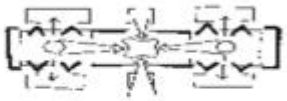


The house inverts the role of the forest by bringing it inside thus providing an internal patio where functions rotate about.

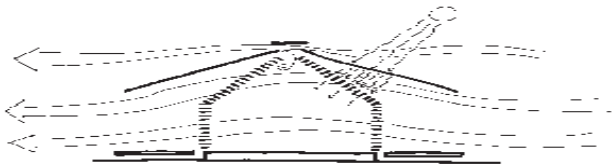


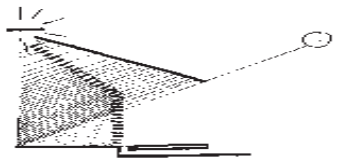
The house is then divided into two living modules, one private (bedroom) and one public(Kitchen/Living area) which in turn are weaved together by this internal patio.



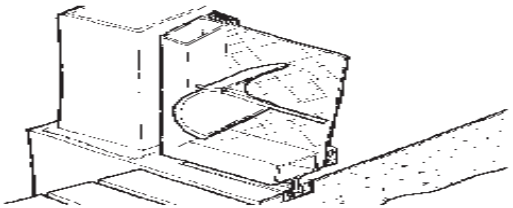


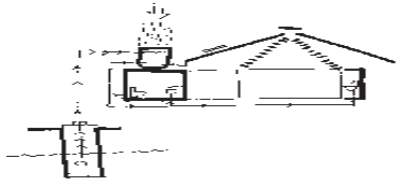
Both modules are composed of a bamboo cone structure that opens up to the sky under an "umbrela" roof that provides a large shadow.

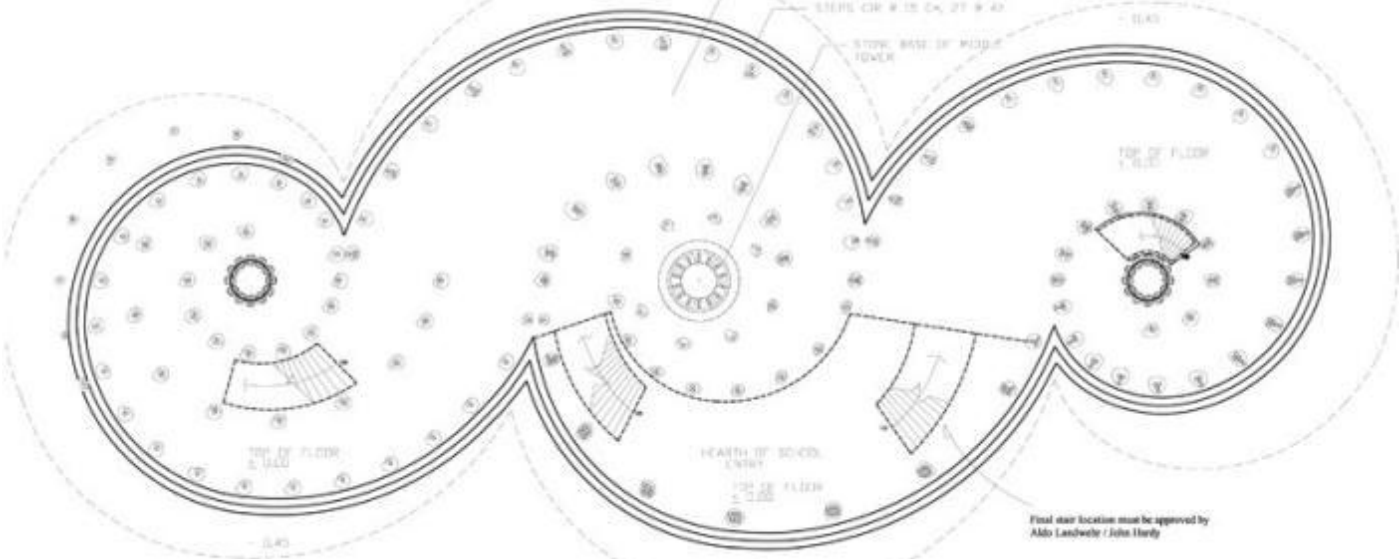




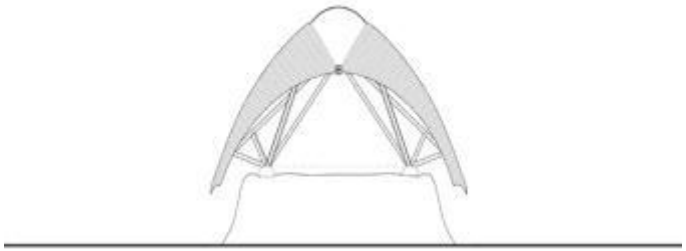
Due to its orientation, The sun travels around the house traversing the patio thoughout the day. This then makes the shadows from the bamboo to be cast inside the bedroom in the morning and to move around the house until they reach the Living module where the sun sets.



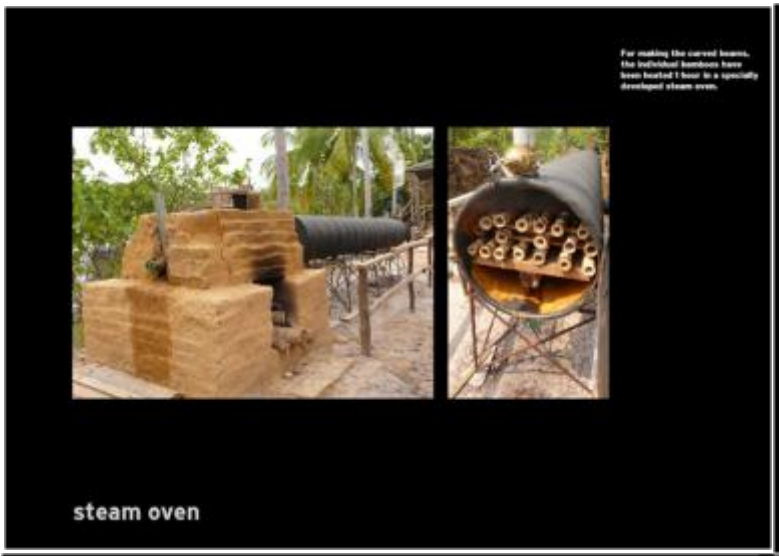


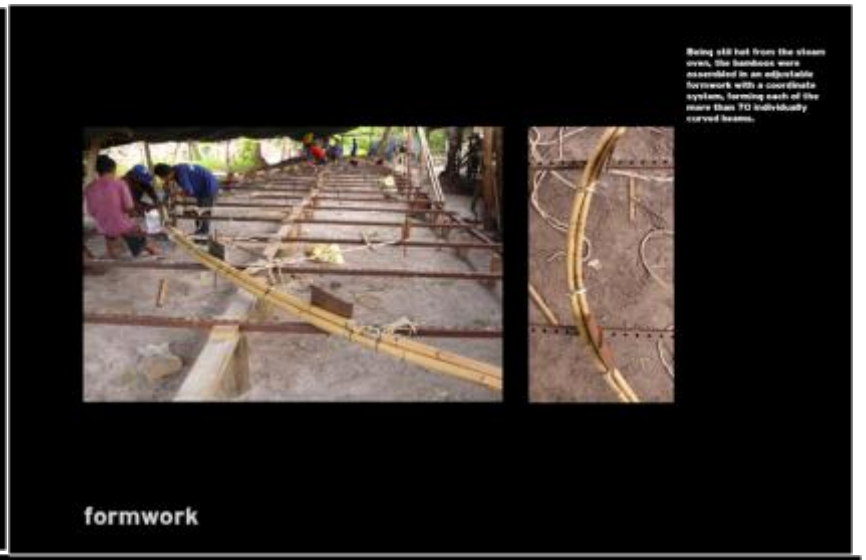


"Green School" in Bali



UNIV OF CUBAO BALI FIELD SCHOOL


steam oven


formwork

roof beams

columns

The roof consists of a cellu split bamboo with a waterp membrane on top, covered w bamboo shingles.

roof

The 4 rooms in the interior are the 'organs' inside the animal. Local rattan was used to construct these organically shaped volumes and plantation river red gum wood was used for the floor.

In the front, a balcony provides an amazing view over the resort's bay.

In the centre, the circular steps of the stairs form a small theatre or cinema with a rattan chill balcony above, shaped like a blowfish.
For the children's safety, all doors and windows are made from acrylic.

interior

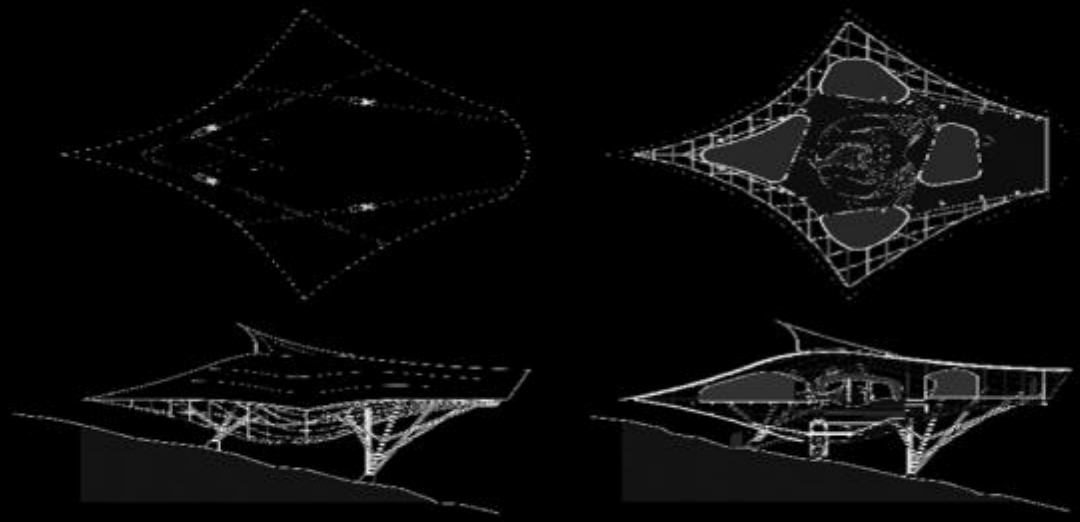
interior

The walls of rooms are made from mosquito netting, clad with bamboo sawdust, red soil, white sand or wood chippings, giving each room it's own atmosphere and identity.
On the inside, the Music Room is insulated with cellulose insulation and clad with nata mesh.

The building was built by team of bamboo specialists from the Karen hill tribe from the Mae Chaem district in Chiang Mai, supervised by the project architect.

By having a mix of young and old, the bamboo knowledge could be passed on from the experienced older men to the younger generation.

In addition, there was a knowledge exchange in the team of modern and traditional bamboo construction techniques, which could revitalize and stimulate the use of bamboo in Thailand, reducing the carbon footprint of the local construction industry.



The Den is located at a rocky slope close to the sea. With its Manta-ray inspired bamboo dome, perched in an elevated position so as to offer magnificent views, it seems to launch itself into the bay.

The design adopts all bioclimatic aspects to suits its humid tropical environment. The open design with the setback floors and elevated rooftop provide natural cross-ventilation.

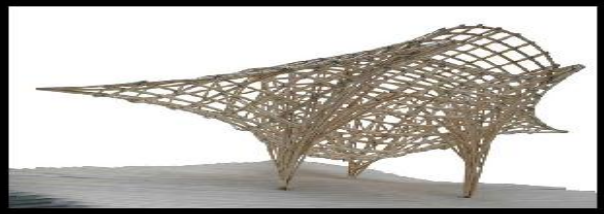
Similar to traditional Thai houses, the the structure is elevated for a better cross-ventilation.

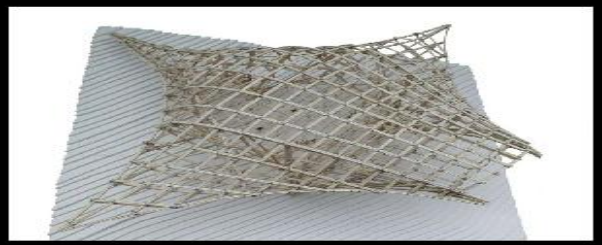
In addition, it's footprint in the natural surroundings is minimized.

The roof cantilevers up to 8m acting like a big umbrella providing shade and protection from the heavy rains.

The translucent elevated rooftop in the centre of the building allows natural daylight in the building, limiting the energy consumption.

design





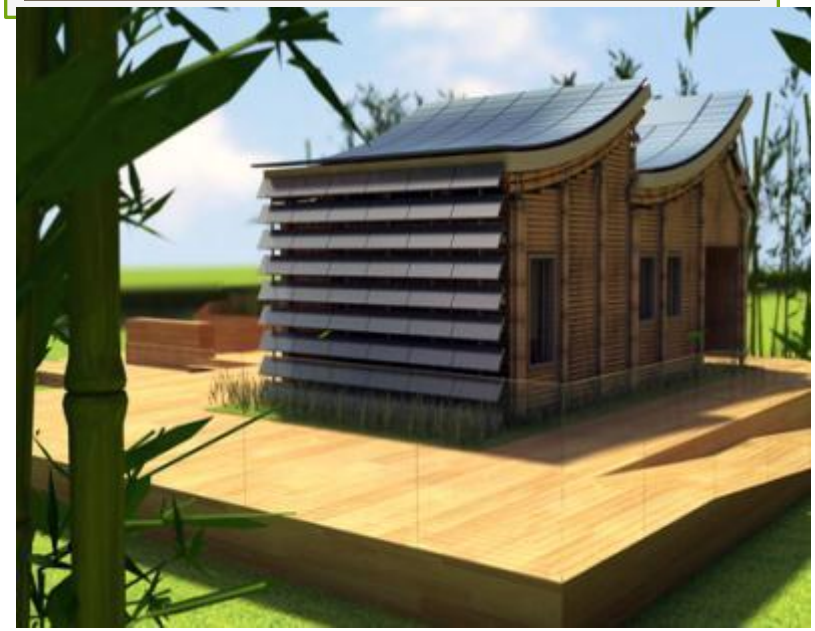
The main challenge of the project was to make a contemporary design with a traditional material. Therefor, material and design research had to be made and experts had to be consulted duringthe design process.

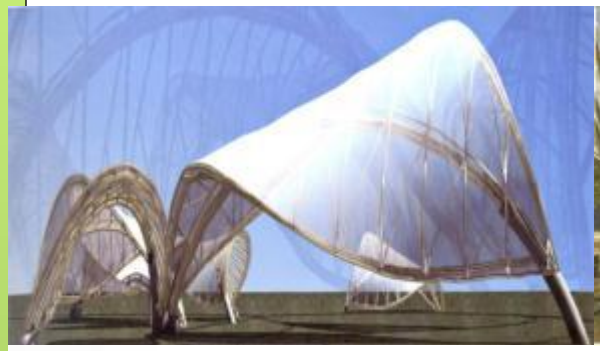
Besides a 3D computer model, a big 1:30 scale model was built helping designing the bamboo structure. This model was tested in the windtunnel of Thammasat University in Bangkok, supervised by the engineering company Ove Arup.

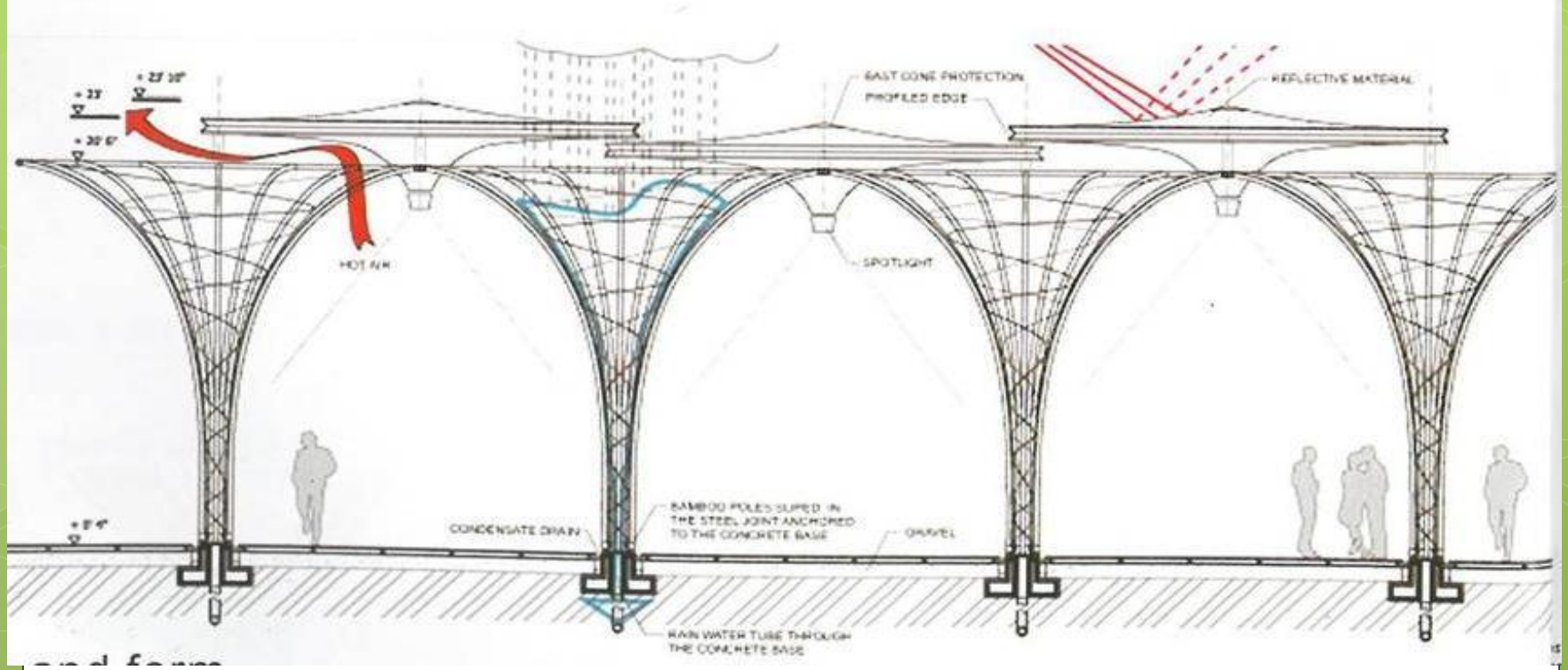
Furthermore, Pai Tong bamboo has been tested on tension, compression, shear and bending in the King Mongkut Institute of Technology in Bangkok.

scale model

Bamboo house equipped with solar engergy system
by students of Tongi University, China

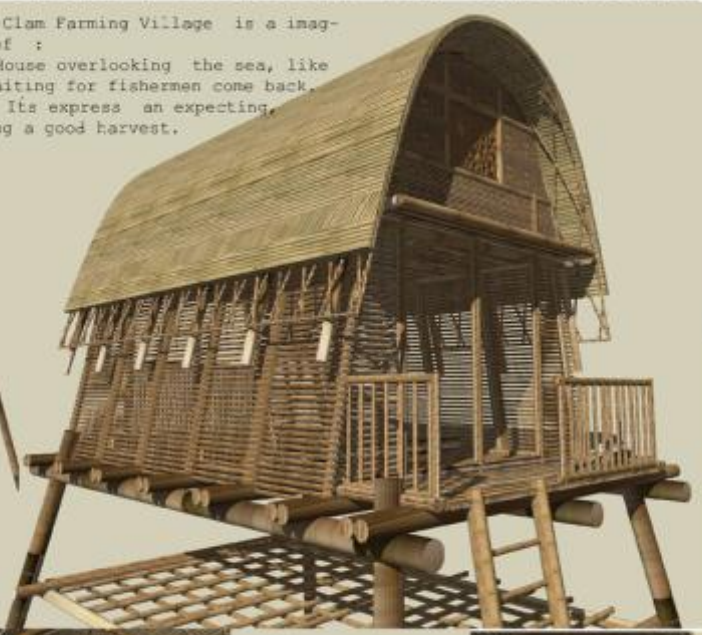




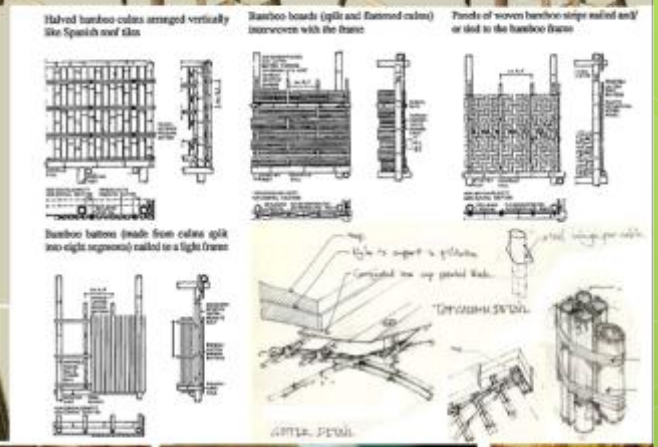

+ 23' 10"
+ 23'
+ 20' 6"
HOT AIR
EAST CONE PROTECTION
PROFILED EDGE
REFLECTIVE MATERIAL
SPOTLIGHT
+ 8' 4"
CONDENSATE DRAIN
BAMBOO POLES SUPED IN THE STEEL JOINT ANCHORED TO THE CONCRETE BASE
GRAVEL
RAIN WATER TUBE THROUGH THE CONCRETE BASE

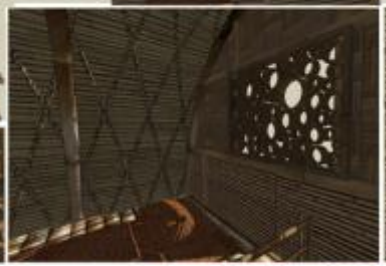
BABY CLAM FARMING HOUSE & STRUCTURE FOR CONSTRUCTION

Baby Clam Farming Village is a imag-
ine of :
+ House overlooking the sea, like
as waiting for fishermen come back.
+ Its express an expecting,
hoping a good harvest.

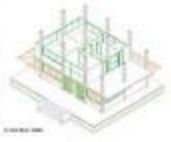


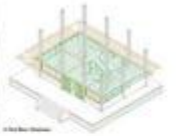
ROOF STRUCTURE





BAMBOO STRUCTURE & INTERIOR



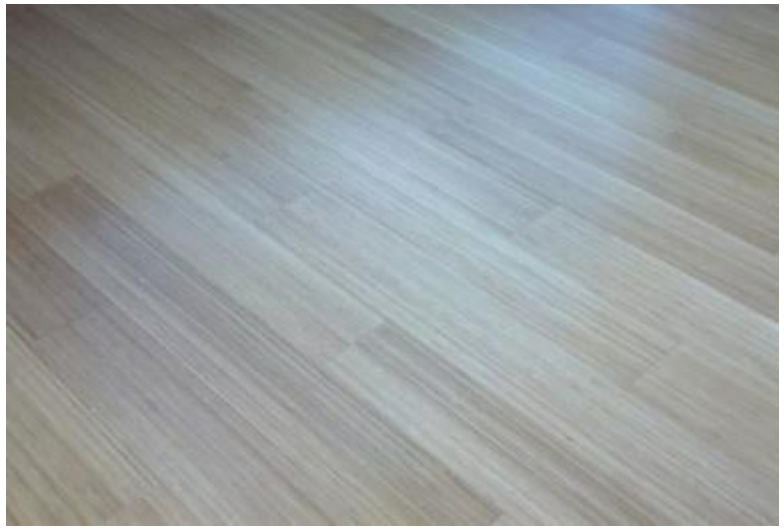


Project: COTTAGE FLIA LÓPEZ. **Area** = 571,31 m².
Activities: Construction, Design and Management.
Date: October 2006/April 2007.
Company: ARME IDEAS EN GUADUA LTD.
Contract: Strategic Alliance.
Inspección San Javier - La Mesa/CUNDINAMARCA, Colombia.

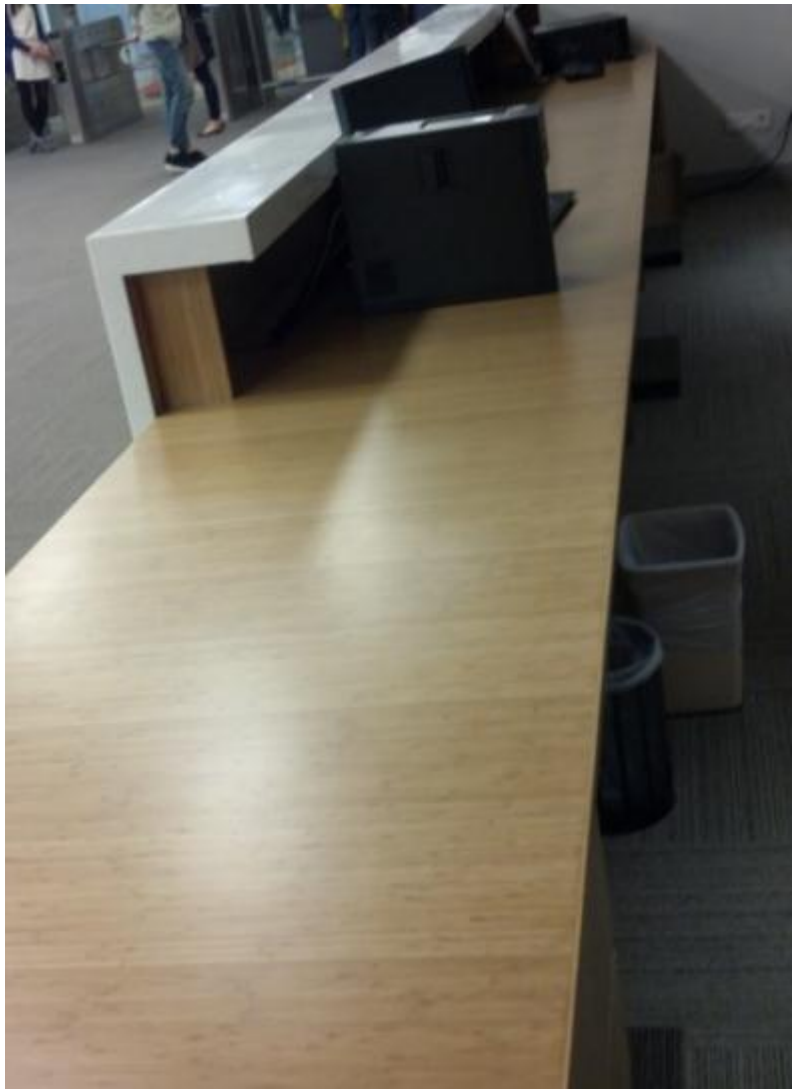
BAMBOO

INTERIOR DESIGN

Federation of Hong Kong Industries



Hang Seng Management College



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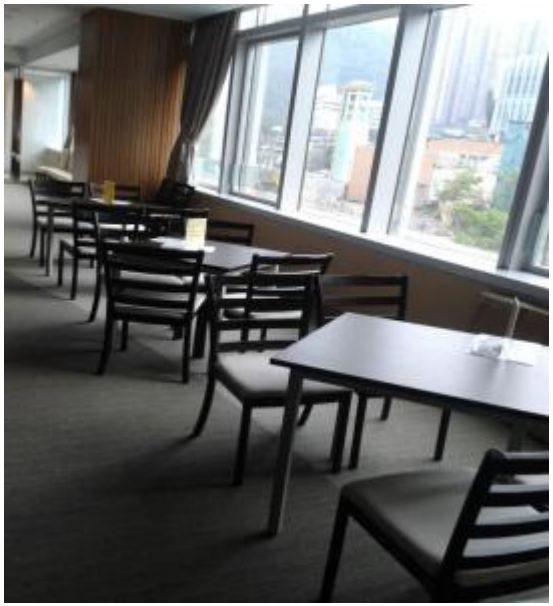

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INBAR

International Network for Bamboo and Rattan

- INBAR is an intergovernmental organization established by treaty deposited with the United Nations.
- Sovereign states become members.
- INBAR works with Governments, Industry partners, Development Partners, NGOs, Universities, etc,
- As of Aug 2012, 38 members:

INBAR

- Carbon Accounting Methodology for Afforestation with Bamboo
  - developed in partnership by INBAR, China Green Carbon Foundation and Zhejiang A&F University in 2012
  - recognizing bamboo as an official carbon offset and a tool for climate change mitigation, thus enabling Chinese companies to buy bamboo carbon credits on the voluntary market
  - contribute to the goal of optimizing the potential for carbon finance through bamboo carbon sinks and bamboo harvested wood products (HWP)

Carbon Trade / Market

- Carbon markets: allow CO_2 to be traded as a commodity

- Carbon offsetting: the purchase of carbon credits from greenhouse gas reduction projects to negate the equivalent of a ton of CO_2 emitted in one area by avoiding the release of a ton of CO_2 or sequestering a ton of CO_2 in another place

BAMBOO

INDUSTRIAL DEVELOPMENT

Bamboo Cultural Development

- To organize various activities for promoting bamboo culture
- To set up bamboo museums, workshops and concept shops, etc.
- To declare the origins of bamboo products as geographical landmarks
- To facilitate international bamboo cultural studies and global bamboo industrial development

(《全國竹產業發展規劃（2013－2020年）》, 2013)

Bamboo Industrial Development in China

Bamboo Shoot Product Processing

- To improve the quality of traditional products and enhance the taste and added value
- To invent new products to meet the diet needs of different people from different countries or regions
- Product Production: 5.3 million tons

Bamboo Pulp and Paper

- To make use of the natural resources of coastal and southwestern provinces and the distribution of the existing enterprises
- To maximize the scale of the existing bamboo industry
- Product Production: 3.04 million tons

(《全國竹產業發展規劃（2013－2020年）》, 2013)

Bamboo Industrial Development in China

Bamboo Material Manufacturing

- To develop the manufacturing of bamboo timber, stranded bamboo materials,, composite bamboo materials ,etc.
- Product Production: 4.3 million tons

Bamboo Flooring

- To encourage the manufacturers, bamboo cultivation bases and farmers to work together
- To invent various of bamboo floorings for brand development
- Product Production: 1.21 million m^3

(《全國竹產業發展規劃（2013－2020年）》, 2013)

Bamboo Industrial Development in China

Bamboo Furniture

- To upgrade the standard of the manufacturing and improve the product creativity and innovation
- To apply the bamboo restructuring and laminating technology to increase the added value of the furniture
- To further promote bamboo to the public for the increase in bamboo furniture consumption
- Product Production: 12.88 million pcs

(《全國竹產業發展規劃（2013－2020年）》, 2013)

Bamboo Industrial Development in China

Bamboo Fiber Products

- To invent new fiber processing technology
- To explore and expand the range of bamboo fiber application
- To standardize the bamboo fiber testing and facilitate the brand building and industrial scale
- Product Production: 380,000 tons

Bamboo Drinks

- To produce various of natural bamboo drinks with extract from different parts of bamboo
- Product Production: 140,000 tons

(《全國竹產業發展規劃（2013－2020年）》, 2013)

Bamboo Industrial Development in China

Bamboo Art and Craft Products

- To develop production bases for bamboo lifestyle products such as chopsticks, mats and etc.
- To focus on special products like carved bamboo products , formed bamboo products and Chinese tea art products
- Product Production: 4.72 million tons

Bamboo Charcoal Products

- To invent bamboo charcoal products and its production chain in order to unleash its benefits
- To establish the big scale corporations by developing bamboo charcoal products for daily life and health use
- Product Production: 360,000 tons

(《全國竹產業發展規劃（2013－2020年）》, 2013)

How to further develop bamboo industry?

- To develop innovative technology platforms to enhance scientific and technological achievements of bamboo industry
- To establish a modern market for bamboo products, such as agents and Economic Cooperation Organization, etc.
- To improve the standards and specifications of bamboo product business to assure the product quality
- To develop electronic business platforms for bamboo industry
- To raise the social awareness about bamboo industry and to promote ecological, natural, low-carbon, environmentally friendly, healthy ideas to improve the market influence of bamboo products so that the public will use bamboo in daily life

(《全國竹產業發展規劃（2013－2020年）》, 2013)

BAMBOO

EPILOGUE

Focuses on Reform in China

- To implement the proactive fiscal policy and prudent monetary policy and improve the policy framework; to ensure that the economy is developing appropriately
- To focus on the economic reform and achieve breakthroughs in important areas of the reform; to build an open economic system and enhance the international competitiveness
- To strengthen the domestic demand; to promote agricultural modernization, rural reform and human-centered urbanization
- To facilitate educational equity and to further medical development
- To improve people's living standard and quality
- To further promote the ecological & environmental protection and pollution prevention and strive to build a beautiful country with ecological civilization

(Discussion on the Draft of "Report on the Work of the Government 2014" , China)

Fast Growing Bamboo (BBC)

*Bamboo **sustains** our **future***
*Bamboo can **save** our **world***

Thank You!