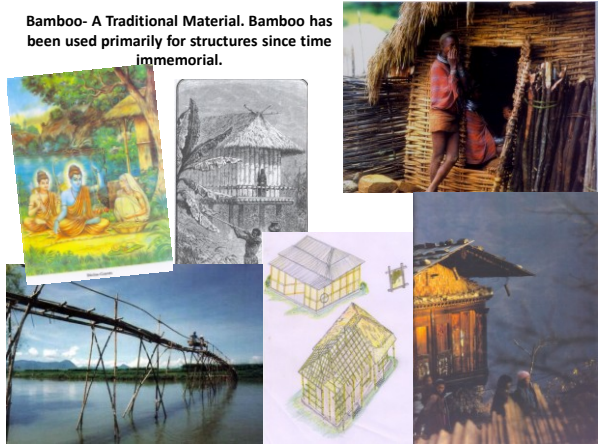


BAMBOO – The Global Material- Tradition and Technology“

Ar. Neelam Manjunath
 Mansaram Architects, Bangalore,
mansarch@gmail.com
 Center for Green Building Materials and
 Technology, Bangalore, cgbmtblr@gmail.com

Alumni meet

Bamboo- A Traditional Material. Bamboo has been used primarily for structures since time immemorial.



BAMBOO- THE MATERIAL

- Bamboo is a woody grass, grows very fast (some giant culms can grow upto 1.22 meters in 24 hrs)
- Hence it is a highly resource efficient material.



11/28/2013

CGBMT.S

Bamboo – locally available

- It is widely and easily available across the world except in europe(lately many varieties have been introduced there as well).
- Hence energy required for transportation can be saved.



11/28/2013

CGBMT.A



Bamboo- The vegetable steel

- It is stronger than wood or timber in tension and compression. The tensile strength of the fibres of a vascular bundle could be upto 12,000 kgs/sq cm, almost twice that of the steel.
- Hence much less material is need to be used for the same strength.

langalore



Bamboo- ever ready for use

- In spite of the strength and hardness of the bamboo culm wall, it can be cut very easily for use , with even a stone axe.
- Hence, very simple tools are required for its processing.

langalore

Bamboo- Light and flexible

- It is light and hollow , stiffened at the nodes making it highly flexible.



CGBMT, S

Energy balance of various building materials in MJ/m³ or N/mm²

• Concrete	240
• Steel	1500
• Wood	80
• Bamboo	30

From J.A.Janseen [Bamboo research at the Eindhoven University of Technology Eindhoven 1990 p.15]

(Energy balance is the energy required to produce a unit of building material with a certain level of load-bearing capacity)

Hence bamboo is SUSTAINABLE and Green !!!

11/28/2013

11/28/2013

CGBMT, Bangalore

Physical properties of Bamboo

- Density-specific gravity (an index of the mechanical strength of the material)-varies between 0.5-0.9 g/cm³ depending mainly on the species and the type of rizome. It increases from the innermost layer to the peripheral layer and along the culm from the bottom to the top. The nodes have a higher sp. Gravity than the internodes.
- Splitting-unlike wood bamboo does not have radial cells to increase its shear strength parallel to the axis. This is the reason why bamboo culms split easily. This could be a disadvantage for nailing bamboo, but it makes it very easy to split bamboo into strips for other purposes like laminated bamboo, woven mat boards etc.
- Thermal conductivity-It has excellent insulation property, and its thermal conductivity is slightly higher than even wood.
- Hardness -The cortex or the outer wall of the culm consists of two epithermal cell layers with a high silica content which strengthens the epidermal layer. It is covered by a cutinized layer or glossy surface with a wax coating on top. This imparts an extraordinary hardness to the outer surface of the culm, forming a protective shield against insects, wearing out and even for improving the acoustical quality of the sound field in a bamboo forest.



CGBMT, Bangalore

Structure of Bamboo



11/28/2013

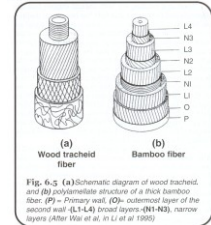


Fig. 6-5. (a) Schematic diagram of wood tracheid, and (b) polyamellate structure of a thick bamboo fiber. (P) - Primary wall, (Q) - outermost layer of the second wall (L1-L4) broad layers (N1-N3), narrow layers (after Mohr et al., in Li et al. 1995).

Difference between wood and bamboo

CGBMT, Bangalore

Mechanical properties of some woods and bamboo

Woods	Strength [MPa]	Mod. Elasticity [GPa]	Density [g/cm ³]
Ceder	29.3-48.5	4.4-9.8	0.29-0.46
Fir	30.7-33.8	5.9-6.7	0.31-0.34
Pine	34.0-41.6	6.5-8.8	0.36-0.42
Spruce	31.0-41.6	7.3-8.5	0.38
Hickory	62.5-81.0	8.9-11.4	0.56-0.67
Oak	47.7-74.9	7.9-12.4	0.53-0.61
Bamboo [fibre]	610	46	1.16
Bamboo [matrix]	50	2	0.67
Bamboo [composite]	140-230	11-17	0.6-1.1

Source: [Bodig & Jaine, 1993] in Amada et al [1996]

11/28/2013

CGBMT, Bangalore

Chemical properties of wood and bamboo

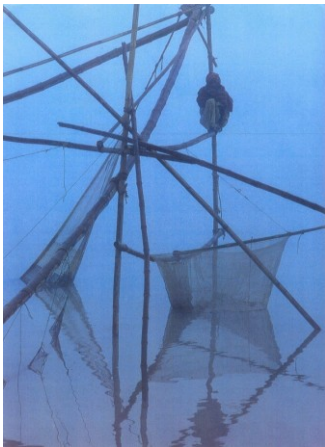
Components	Wood	Bamboo
Cellulose [%]	40-50	45.3
Hemi-cellulose [%]	20-35	--
Legnin [%]	15-35	25.5
Olyoses [%]	---	24.3
Extractive [%]	< 10	2.6
Tensile strength [MPa]	34-220	150-520

Source: Li, Zeng, Xiao, Fu, Zhou [1995]

11/28/2013

CGBMT, Bangalore

Joints in Bamboo- can take all kinds of joints



Bamboo in Structures



Bamboo scaffolding

Bamboo bridges



Modern Bamboo Bridges



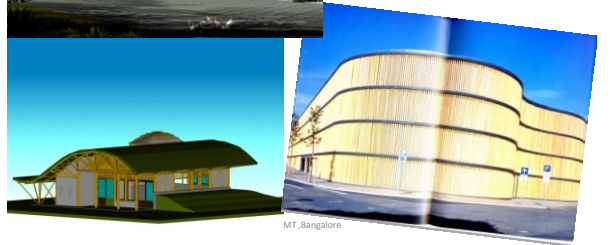
CGBMT, Bangalore

Traditional Bamboo houses



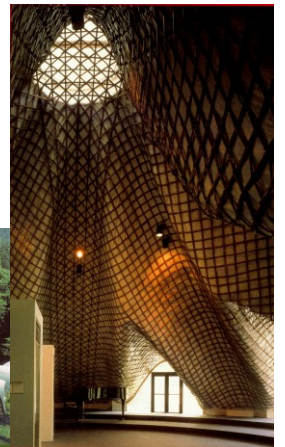
Modern Bamboo Buildings



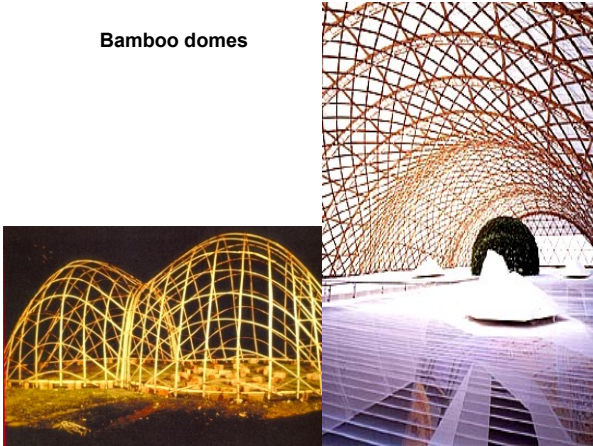


Bamboo for Geodesic domes

Bamboo for grid matrices



Bamboo domes



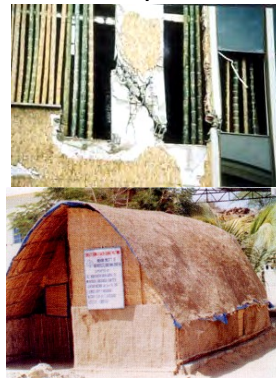
Bamboo for tensegrity structures



Bamboo tension structures



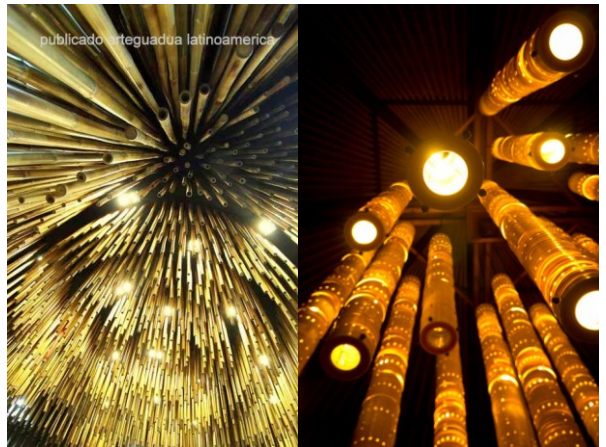
Bamboo's behavior in earthquake



Houses in the Malabar project after 15 years: (a-above), well-maintained (b-below) ill-maintained









BVT, Bangalore



Carlos M.



Carlos M.



WWW.PROJECTORAMBU.COM



WWW.PROJECTORAMBU.COM



Globally Local- Glocal Architecture

11/28/2013

CGBMT, Bangalore



11/28/2013

CGBMT, Bangalore



Zeri pavilion, Hanover, Expo 2000-Simon Velez

ZERI PAVILION DETAILS



11/28/2013

GCA Alumni meet



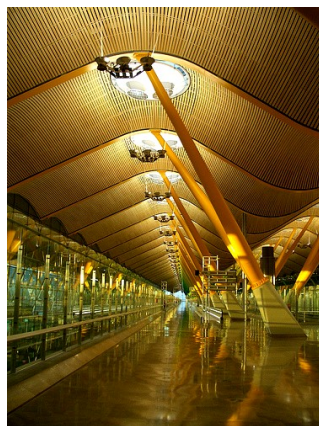
11/28/2013

CGBMT, Bangalore

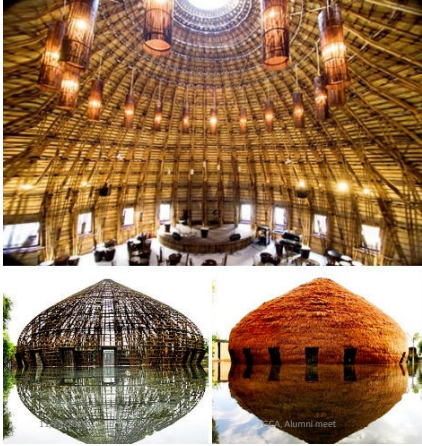


11/28/2013

CGBMT, Bangalore



ore



Wind and Water Cafe

Made almost entirely of bamboo without the use of a single nail, the Water and Wind Cafe in the Binh Duong province of Vietnam is just one example of incredible bamboo structures designed by architecture firm Vo Trong Nghia. The domed structure, dripping with lights, features a dazzling skylight, with the end result resembling a natural cathedral. The bamboo was woven together using traditional Vietnamese bamboo weaving techniques and covered in a local bush plant.



Kontum Indochina Café

- Kontum Indochina Café Kontum Indochina Café is designed as a part of a hotel complex along Dakbla River in Kontum City, Middle Vietnam. Adjacent to Dakbla Bridge, a gateway to Kontum City, the cafeteria serves as a breakfast, dinner and tea venue for hotel guests. It also functions as a semi-outdoor banquet hall for wedding ceremonies. Located on a corner plot, the Café is composed of two major elements: a main building with a big horizontal roof made of bamboo structure and an annex kitchen made of concrete frames and stones.



Bird-Like Amphitheater, Hanoi, Vietnam

- Also by Vo Trong Nghia is "Bird Wing", an avian-like bamboo building used for fashion shows, live music, conferences and other public activities. Set beside a pond, the wing-inspired design of the amphitheater paired with the organic, eco-friendly qualities of the chosen material is a fitting tribute to the natural beauty of the setting. It's made only from bamboo and rope, with no metal or other types of wood used in the construction.



Green School , Bali

Have you ever seen a school made entirely out of bamboo? The Green School in Bali is unusual in a number of ways, from its sustainable curriculum to the degree of freedom enjoyed by the students, but it is the structures themselves that are often the center of attention for visitors. The Green School chose bamboo because it's green, renewable and very plentiful in Bali. "Frankly, it is hard to talk to students about sustainability while they are using the last piece of rainforest for their chair and their table. It is the painful truth that they are going to have to stretch to get enough rain forest timber to build their homes," says co-founder, architect John Hardy.



Bamboo House by Benjamin Garcia Saxe, Costa Rica

Architect Benjamin Garcia Saxe created this intricate, light-filled, open-air bamboo home for his mother in Costa Rica. Being open to the air allows the house to catch every breeze that comes through, but the bamboo and roof are angled to protect against rain. Inside, a cone-shaped dome gives Saxe's mother a view of the sun and moon, with the space protected by an umbrella-like second roof.







Solar powered Bamboo House

'Sunshine Inn', a solar-powered bamboo house, was made by the Chinese team from Tongli University as their official entry into the first European Solar Decathlon in Madrid. Bamboo was chosen as the main material because, as a highly renewable resource that fixes carbon into the soil, it minimizes CO2 emissions throughout the whole production phase. This beautiful structure features two curved solar panel-clad roofs and a solar-facing wall covered which is also covered in photovoltaic panels.



Mason Lane Farm, Goshen, Indiana

- This geometric bamboo structure is not located in Asia or in the tropics, but in the rather unexpected locale of Goshen, Indiana. American architecture practice De Leon & Primmer created the Mason Lane Farm Operations Facility as their entry into the 2010 World Architecture Festival. It houses farm equipment, hay and other stored goods. The bamboo stalks were laid out in a lattice grid fashion and assembled using galvanized rebar wire ties, providing perforated walls that let the wind dry the hay.



Bamboo Forest House, Taiwan

- This vacation house for an extended family in eastern Taiwan is connected on two sides to neighboring structures, but its two street-facing facades were given an eye-catching bamboo treatment that lets in light and air. This screen also provides privacy and security, and gives the feel of being in a bamboo forest when gazing out the windows from inside.



Origami-Inspired Bamboo Folding House Concept

- Designed for use as temporary shelters in the aftermath of an earthquake, these origami-inspired bamboo folding houses might just be the most elegant and artistic example of **disaster housing** ever produced. After a 2007 earthquake in China killed 69,000, Ming Tang was driven to create a shelter that was inexpensive, environmentally friendly and easy to produce. The pre-fabricated structures can be quickly assembled on-site and are then covered in post- and pre-consumer recycled paper for protection from the sun.



Cocoon Houses, Bali

- They may not resemble any houses you've ever seen, but these vertical bamboo structures could offer inexpensive housing in hard-hit places like Haiti. The design, by Saint Val Architect, marries low-tech and high-tech, using bamboo poles and x-shaped metal joints to form the 'exoskeleton' of each home. A circular staircase wrapping around the central support beam brings occupants to each successive floor, and canvas seals the home from the elements.



Giant Bamboo Umbrellas at a Japanese Restaurant, Jakarta, Indonesia

- The form of an umbrella served as the basis of inspiration for the bamboo structures that make up the Outdoor Japanese Noodle Restaurant in Jakarta. Designed to be temporary and simple to disassemble, the bamboo umbrellas overlap each other to become one big roof, protecting guests from sun, wind and rain. Rainwater is diverted through bamboo 'gutters', poured into the ground through a pipe in the middle of the structure.

Could you guess the sea creature that inspired the shape of this bamboo building, even if it weren't in the name? seeming to soar through the sky just as a manta ray gently floats beneath the surface of the sea, the Children's Activity and Learning Center at the 6-star Soneva Kiri resort in Thailand fits in beautifully with its lush tropical surroundings.



Bamboo Manta Ray Dome, Thailand

- Spain's capital city Madrid has given a glimpse of its highly ecological exhibition for the Urban Best Practices Area at World Expo 2010 Shanghai -- a bamboo building and an eco-boulevard, the two most outstanding architectural designs in the city. Madrid's display is entitled "New Horizons for Public Housing". The idea of the 18-meter building of bamboo, which will help control temperatures and reduce noise originated from a residential block in southern Madrid. It will be rebuilt in the Expo site to demonstrate its original efficiency.



Madrid reveals its Expo eco contribution



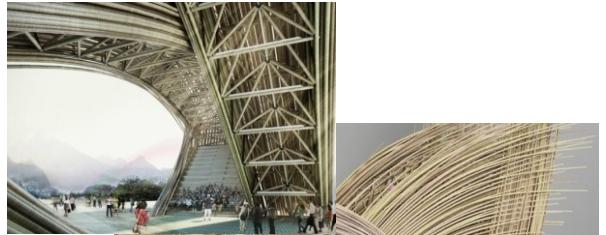
Integer Bamboo House

- Although the project looks luxurious, the idea was to show what the material was capable of.
- [The World's First Multi-Story Laminated Bamboo House Integer Bamboo House, The Oval Partnership.](#) With a growth cycle of four years, bamboo is a quick growing material that can be raised almost anywhere, making it one of the more natural and eco-friendly building materials -- assuming it is harvested sustainably. The Oval Partnership chose to explore this material in more detail to come up with better solutions that can withstand earthquakes. The entire house is built from bamboo including the furniture, doors, the structure, external and interior walls.
- The Kunming INTEGER Bamboo House is based on 4 glass-reinforced and sandwith panels that provide a very high thermal insulation value. The laminated bamboo technology has the potential to be an affordable and ecological way of building for the new townships and villages in China.
- The Oval Partnership teamed up with scientists and engineers from local academic institutions, including the Kunming University of Science and Technology, for this project.

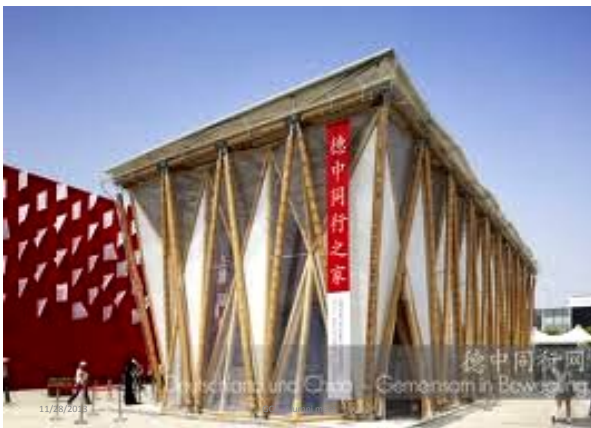
Read more: [Integer Bamboo House: The World's First Multi-Story Laminated Bamboo House Integer Bamboo House, The Oval Partnership](#), [Gallery Page 1 - Inhabitat Sustainable Design Innovation, Eco-Architecture, Green Building](#)



Bamboo Courtyard House by
Harmony World Consulting Design



11/28/2013







11/28/2013

CGMT, Bangalore



CGMT



11/28/2013

CGMT, Bangalore

87



11/28/2013

CGMT, Bangalore

88





STATE LEVEL ENERGY PARK, IGMF



11/28/2013









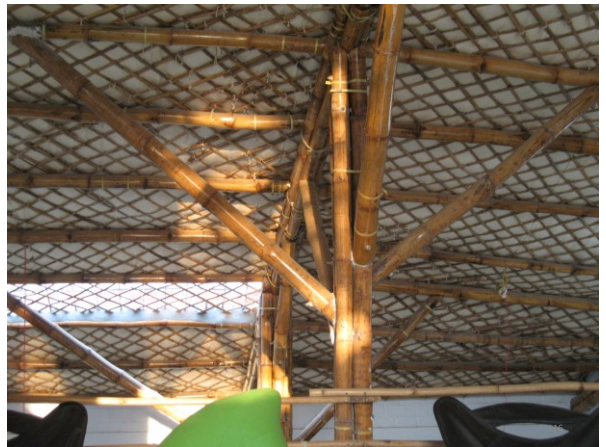
107





HOUSE OF FIVE ELEMENTS, Bangalore;

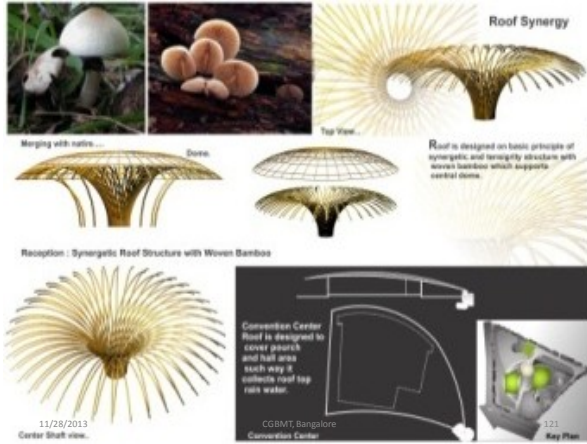






118

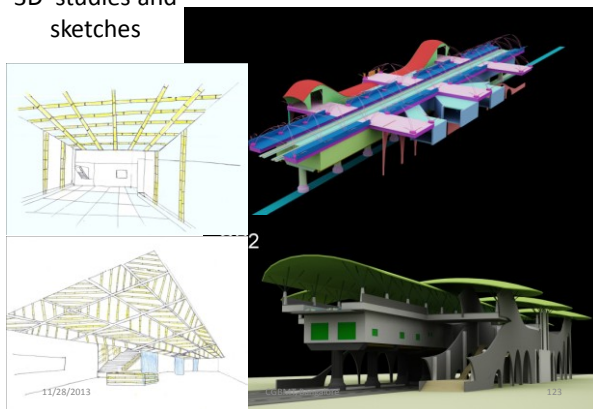
120



Metro Stations with Bamboo!

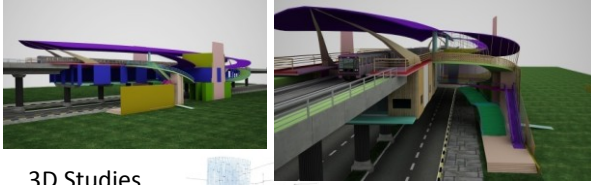


3D studies and sketches

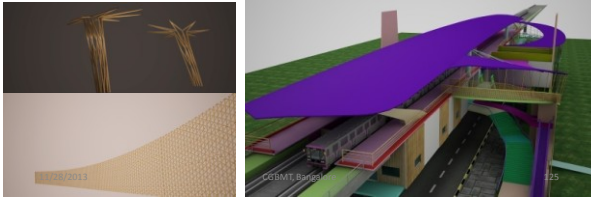


View of all the floor levels





3D Studies and sketches



View towards the tracks

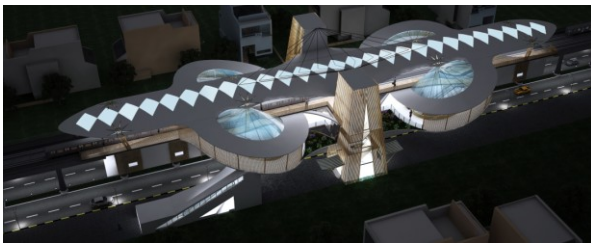


11/28/2013

CGBMT, Bangalore

126

Eagle's view at Night



11/28/2013

CGBMT, Bangalore

127

Interior view of Concourse Level



11/28/2013

CGBMT, Bangalore

128



11/28/2013

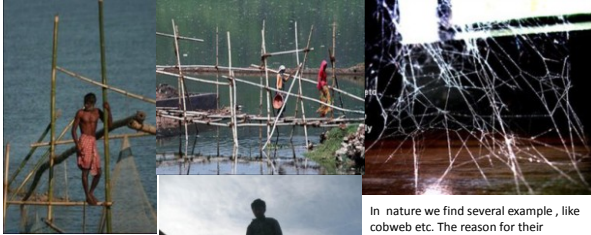


11/28/2013



CGBMT, Bangalore

132



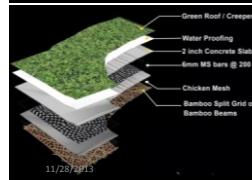
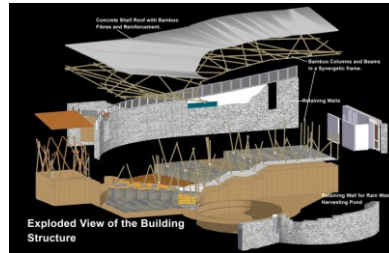
Ancient local wisdom
Our traditional fishing Platforms and Bridges are excellent examples of Synergetic structural systems—simple technology, high science

In nature we find several example , like cobweb etc. The reason for their efficiency is homogenous load distribution, which efficiently leads to **global Synchronization**. Interestingly, the tensile strength of spider silk is greater than the same weight of steel and has much greater elasticity , just like Bamboo.

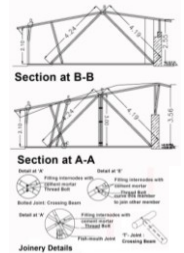
11/28/2013

CGGMT, Bangalore

133

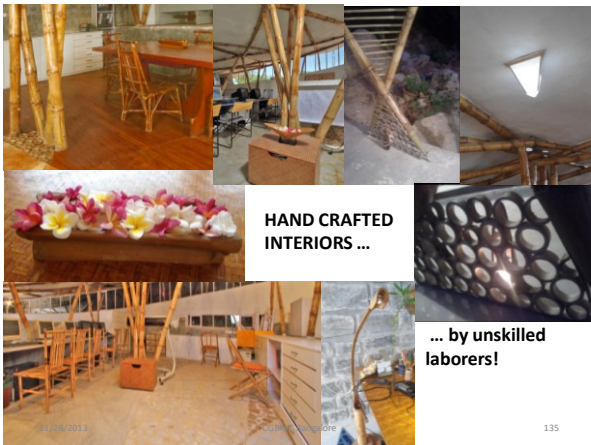


The STRUCTURE of the building is its most unique feature. It is based on the model of SYNERGETIC structures. It was physically tested before concreting the roof. These types of structures are being made across the world with modern materials with high energy balance. Bamboo is the only Natural building material with lowest energy balance that can be used for these structures. The columns in BAMBOO SYMPHONY THOUGH LOOK HAPHAZARDLY PLACED HAVE DEFINITE POSITION, SIZE AND INCLINATIONS, I.E. ARE STRUCTURALLY RELEVANT, just like the highly evolved TECHNOLOGICAL LOGIC WE FIND IN NATURE!!!



CGGMT, Bangalore

134



11/28/2013

CGGMT, Bangalore

135



CGGMT, Bangalore

136







11/28/2013

CGMT, Bangalore

145



11/28/2013

CGMT, Bangalore

146



147



11/28/2013

CGMT, Bangalore

148



11/28/2013

CGIMT, Bangalore



11/28/2013

CGIMT, Bangalore

150



11/28/2013

CGIMT, Bangalore

151



11/28/2013

CGIMT, Bangalore

152



11/28/2013

CGBMT, Bangalore

154



11/28/2013

CGBMT, Bangalore

155



11/28/2013

CGBMT, Bangalore

155



11/28/2013

CGBMT, Bangalore

156



11/28/2013

CGMT, Bangalore

157



11/28/2013

CGMT, Bangalore

158



11/28/2013

CGMT, Bangalore



11/28/2013

CGMT, Bangalore

160





11/28/2013

CG&MT, Bangalore

165



11/28/2013

166



11/28/2013

CG&MT, Bangalore

167



11/28/2013

CG&MT, Bangalore

168



11/28/2013

CGMT, Bangalore

169



11/28/2013

CGMT, Bangalore

170



11/28/2013

CGMT, Bangalore

171



11/28/2013

CGMT, Bangalore

172



11/28/2013

CGIMT, Bangalore

173



11/28/2013

CGIMT, Bangalore

174



11/28/2013

CGIMT, Bangalore

175



11/28/2013

CGIMT, Bangalore

176







11/28/2013

CGBMT, Bangalore

185



11/28/2013

CGBMT, Bangalore

186



11/28/2013

CGBMT, Bangalore

187



11/28/2013

CGBMT, Bangalore

188



11/28/2013

CGBMT, Bangalore

189



11/28/2013

CGBMT, Bangalore

190



11/28/2013

CGBMT, Bangalore

191



11/28/2013

CGBMT, Bangalore

192



11/28/2013

CGIMT, Bangalore

193



11/28/2013

CGIMT, Bangalore

194



11/28/2013

CGIMT, Bangalore

195



11/28/2013

196



11/28/2013

CGMT, Bangalore

197



11/28/2013

198



11/28/2013

CGMT, Bangalore

199



11/28/2013

CGMT, Bangalore

200



11/28/2013

CGMT, Bangalore

201



11/28/2013

CGMT, Bangalore

202



11/28/2013

CGMT, Bangalore

203



11/28/2013

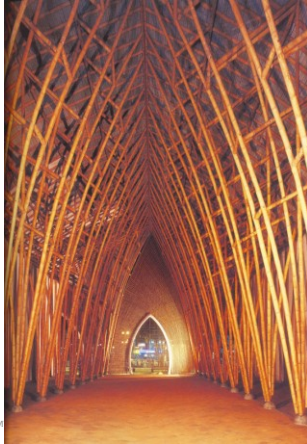
CGMT, Bangalore

204

epilogue

THE TECHNOLOGY OF
CONSTRUCTION WITH BAMBOO
COULD BE ONE OF
THE GREATEST
CONTRIBUTION THAT THE SOUTH
AND THE EASTERN WORLD CAN
GIVE TO SUSTAINABLE
DEVELOPMENT.

ONLY NORTH-SOUTH AND EAST-
WEST COMPLEMENTARITY
WILL BE REALISTIC TO DEVELOP
A FAIR AND GLOBAL PRACTICE
OF SUSTAINABLE DEVELOPMENT
AND AN APT AND REASONABLE
REDEFINITION OF OUR FUTURE.



11/28/2013

CGBM