Bamboo Species Suitable For Building Construction through Case Study

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Abstract*—Bamboo a species of plant in the grass family possessing good strength and flexibility can be used as a building material. However due to emergence of better building materials, bamboo is use limited to certain applications only. Besides the extensive use of steel and other building materials for the construction in the present trend bamboo can replace wood and steel in many applications like roof covering, reinforcement, scaffolding, foot bridge, bamboo houses etc which accounts for low cost construction.*

Keywords—bamboo harvesting and preservation, bamboo properties, bamboo quality poles.

I. INTRODUCTION

Bamboo has along and well-established tradition as a building material throughout the worlds tropical and sub tropical regions. It is widely used for many forms of construction, in particular for housing in rural areas. Bamboo is a renewable and versatile resource, characterized by high strength and low weight, and is easily worked using simple tools. It is widely recognized as one of the most important non timber forest resources due to the high socio-economic benefits from bamboo based products.

Bamboo is the world's fastest growing woody plant. It grows approximately 7.5 to 40 cm a day with world record being 1.2 in 24hours in Japan. Bamboo grows three times faster than most other species.Commercialy important species of bamboo usually mature in four or five years time after which multiple harvests are possible every second year, for up to 120 years in some species and indefinitely in other.

As global population grows and resources stretch, bamboo holds the potential to benefits the poor, its vast spectrum of utilization, ranging from organically poor to mineral rich and moisture levels from those of drought to flooding which it valuable for reclaiming degraded lands. Bamboo, it shelters top soil from the onslaught of topical downpours, preserves many exposed areas, providing micro-climate for forest regeneration and watershed protection. It is often introduced into the banks or streams or in other vulnerable area, for rapid control of soil erosion, one bamboo plants closely matted roots can blind up to six cubic meters of soil.

II. BAMBOO HARVESTING

Bamboo should be harvested during the dry season in the tropics. This reduces beetle attacks, since insects are less active during dry season. Bamboo should be harvested in autumn and winter in subtropical areas. The branches should be carefully removed from the bamboo culms so that the outer skin is not damaged. After harvesting the canes can be stored vertically or horizontally. In the latter case the canes should be frequently supported in order to avoid bending out of shape. Canes should be protected from direct sun, soil moisture and rain. There are two ways for drying the bamboo canes. The bamboo poles can be dried for about 6-12 weeks, by allowing good air circulation while being stored under a shed. Faster alternative is using kilns for drying the canes. In this way bamboo canes are dried for 2-3 weeks. Workability of the canes is ideal when they are dry.

III. BAMBOO PRESERVATION

Bamboo is subject to attack by micro organisms and insects in almost construction applications. The decay and biodegradation of bamboo culms during outdoor storage can be checked to a great extend by adopting a good storage yard practices. Culms should be stacked horizontally over raised wall to facilitate water drainage and air circulation. For reed bamboos, vertical stacking results in a small gain in pulp yield over horizontal stacking because the former suffers less fungal damage. The services life of bamboo is therefore, mainly determined by the rate of attack a variety of methods to improve the durability of bamboo have however been developed If left untreated, bamboo poles may not survive more than two years. The following are the methods for treating bamboo poles.

A. Immersion

Freshly cut bamboo poles are immersed in water for period of 4-12 weeks. During this time the nourishment for insects the poles is removed. Streams or ponds are suitable. Ponds should allow circulation of water immersion in soft water is not a suitable technique.

B. Impregnating Coatings

Bamboo culms and bamboo mats for housing construction are often painted with slaked lime. This is carried out mainly to enhance the appearance but there is also an expectation that the process will prolong the life of the bamboo structure by preventing moisture entering the culms. It is possible that the water or moisture absorption is delayed or in some cases prevented which will provide a higher resistance to fungal attack

C. Heating

This method consist of heating the canes, for a short time in kilns to150^{o} C alternatively the canes can be placed into a large container and boiled for 25 minutes. In Japan a method of boiling the bamboo in caustic ash solution has been used.

IV. CHECKLIST FOR OBTANING CONSTRUCTION QUALITY BAMBOO POLES

- Depending on the species, 3 to 5 year old bamboo is best for construction purposes.
- The bamboo should be harvested in dry season in order to avoid fungus attack and excess pole moisture.
- Use the appropriate species for the particular application.
- Do not expose the bamboo poles to direct sun, moisture and rain .
- Use only straight portions from the bamboo culms for construction poles.
- Poles should be treated against insects and fungus.

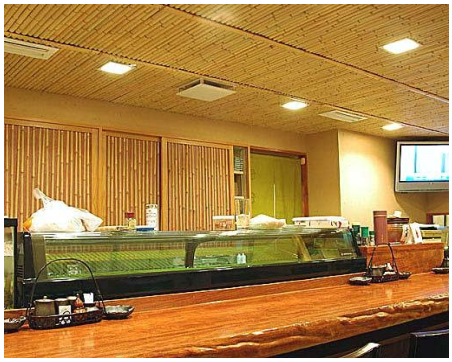

Fig 1: Bamboo interior

V. PROPERTIES OF BAMBOO

To evaluate and compare the material conditions of bamboo of the descent, the age the moisture content and the diameter of the tube are of immense importance.

A. Compressive Strength

Compared to the bigger tubes, slimmer ones have got, in relation to their cross-section a higher compressive strength valve. The slimmer tubes posse's better material properties due to the fact that bigger tubes have got a minor part of the outer skin, which is very resistant in tension.

The portion of lignin inside the culms affects compressive strength where as the high portion of cellulose influence the buckling and the tensile strength as it represent the building substance of the bamboo fibers.

Diameter (mm)	60	32
Compressive strength	63.6	86.3

B. Tensile strength

Bamboo is able to resist more tension than compression. The fibers of bamboo run axial. In the outer zone are highly elastic vascular bundles, which have a high tensile strength. Slimmer tubes are superior in this aspect too. Inside the silicate outer skin, axial parallel elastically fibers with a tensile strength up to 400N/mm^2 can be found. As a comparison extremely strong wood fibers can resist a tension up to 50N/mm^2.

Diameter (mm)		80	30
Tensile strength,	min	162.7	232.5
	max	215.1	275.8

C. Elastic Field

The accumulation of highly strong fibers in the outer parts of the tube wall also work positive in connection with the elastic modulus like it does for the tension, shear and bending strength. The higher is the quantity of the bamboo. Enormous elasticity makes it a very useful building material in area with very high risks of risk of earthquakes.

Diameter (mm)	90	80
Elastic modulus	1700	17900

Bamboo is an anisotropic material. Properties in the longitudinal direction are completely different from those in the transversal direction. There are cellulose fibers in the longitudinal direction which is strong and stiff and in the longitudinal direction there is lignin, which is soft and brittle, although the approximate recommended values are required, it is safer to take the lower values. Even then bamboo still guarantees a perfect utilization of an unusual building material.

Approximate recommended values of Bamboo

Properties of Bamboo	Approximate values Recommended (N/mm^2)
Elastic modulus	18000
Tensile strength	150
Compressive	39

Bending strength	7.6

Since bamboo is being used widely as a substitute for timber, table shows a compression between the commonly used timbers and one of the bamboo species in India. The specimens were selected taking into consideration their moisture contents.

VI. ADVANTAGES

- Light, strong, versatile.
- Environment friendly.
- Accessible to the poor.
- Self renewing resource.
- Fast growing.
- Highly productive

VII. DISADVANTAGES

- Requires preservation.
- Shaped by nature
- Durability: - bamboo is subjected to attack by fungi, insects for this reason untreated bamboo structures are viewed as temporary with an expected life of not more than 5 years.
- Jointing: - although many jointing techniques exist their structural efficiency is low.
- Lack of design guidance and codes.

Based upon these advantages the general use of bamboo can list as;

- Soil stabilization, wind break, urban waste water treatment and reduction of nitrates contamination.
- Creating a fire line in traditional forests due to the content of silica.
- Removing atmospheric carbon-bamboo can rupture 17metric tons of carbon per hectare per year, i.e., effectively than any other species.
- The shoots are edible.
- Building and construction.
- Small scale and cottage industries for handicrafts and other products.
- New generation products as wood substitutes.
- Industrial products.
- Transportation industry – truck bodies, railway carriages etc.
- Boards and furniture.
- Medicine paper and pulp industry.
- Longtime source of biomass for industry

VIII. A BAMBOO HOUSE CASE STUDY

Construction in bamboo has come a long way, where people have explored and exploited its properties, intuitively and scientifically. Bamboo based construction materials have tended to replace the initially simple methods by cost effective technologies. The programme was to build a house for a family with multifunctional space, kitchenette and a toilet. The planning was develop on a which measured.4x4ft based on the structural efficiency of the material.

The positive outcome of the grid planning is flexibility, where additions and subtractions based on the contextual requirements are easily possible. The methodology also paves way for a prefabricated system of construction in the case of large scale demand. Stress was on efficient planning of space with quality lighting and ventilation. The structure is essentially very light owing to the property of a material like bamboo and the foundation less elaborate and the walls considerably thin. Since the bamboo is attack by several insects and pests, treatment of round/split bamboo used as such in housing through appropriate method is very essential.

A. Foundation

As the building system is very light compared to the brick/stone masonry structures, excessive foundation works are not necessary. Bamboo culms were erected and a footing with a dimension of 400x400x600mm was used and was secured by means of pouring concrete. Strip foundation of 300mm width supports the partition and external walls. The time and costs are brought to minimum in this process.

B. Columns

Treated bamboo culms of 80-100mm diameter and wall thickness of 10-12mm spaced at an interval of 12mm and set in concrete footing provide the base load bearing fame work for the building. The wall plate made of the columns by screwing into the wooden inserts. The wall plate ties the columns at top and distributes dead loads trusses purlins and sheet roofing.

C. Walls

The wall structures was made of bamboo strip grids measuring 19x19mm which were the secured to mild steel rods fixed to the culms ti form 150x150mm grid. Chicken wire mesh is fixed to the outside face of the grid a 1:3 mix cement mortar is applied on both sides of the grid to a finished thickness comes to be 5cm only. Inclined posts are introduced in the front to create more space and a windows seat within and also a study of the formal possibilities within a system like this.

D. Doors and windows

The doors and shelves are made of bamboo while the door and window frame are of silver oak.

E. Miscellaneous

Electrical conduits are provided within the 5cm wall with points at strategic locations to illuminate the place. Water lines are provided from a common source to outlet in the toilets and kitchen.

This type of construction provides good shelter from and humidity. It is strong and very economical. The area of the building is 30sq.m and costs about Rs.80000.On comparison with the common construction technique adopted using concrete as the main material it is estimated to cost about Rs.1,50,000 to build a house of the same area.

IX. CONSTRUCTION STEPS

The planning of the proposed housing as well as the layout of structural members are presented below. Follow the sequence of images to view the construction process in progression.

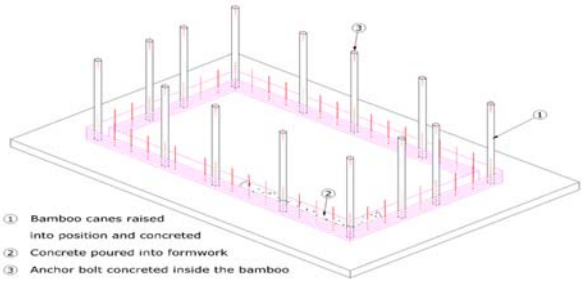

Fig 2:Proposed bamboo house-phase 1

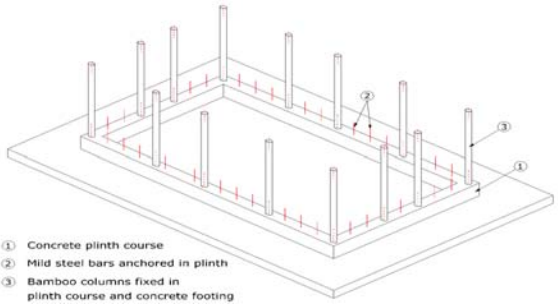

Fig 3:Proposed bamboo house-phase 2

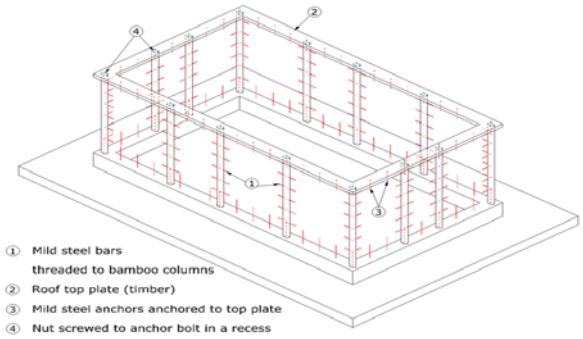

Fig 4:Proposed bamboo house-phase 3

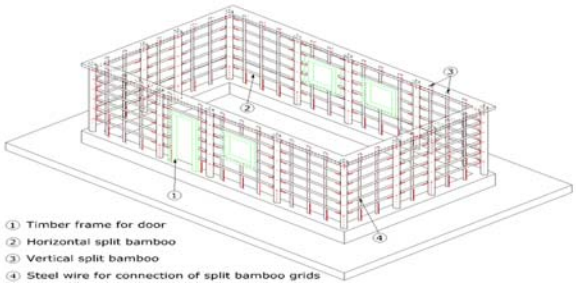

Fig 5:Proposed bamboo house-phase 4

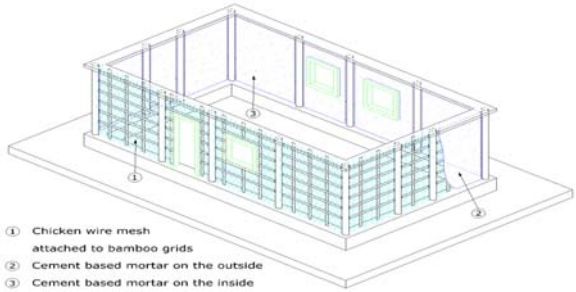

Fig 6:Proposed bamboo house-phase 5

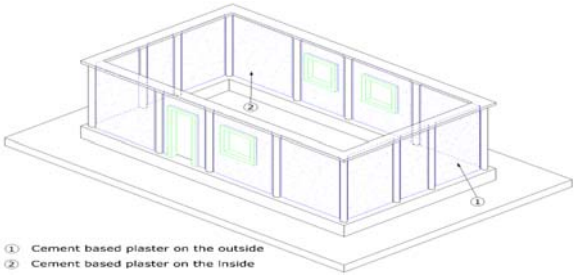

Fig 7:Proposed bamboo house-phase 6

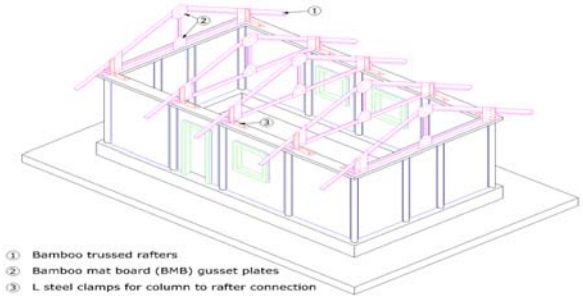

Fig 8:Proposed bamboo house-phase 7

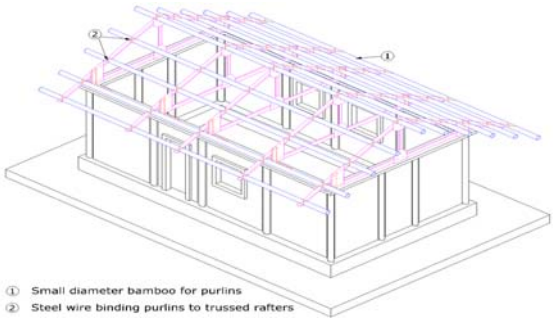

Fig 9:Proposed bamboo house-phase 8

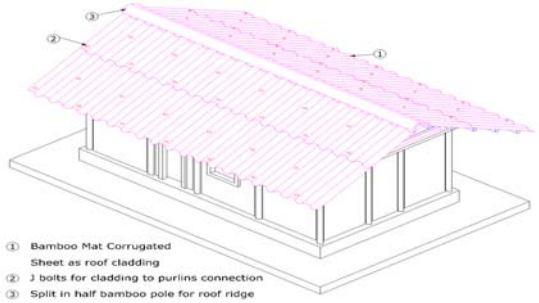

Fig 10:Proposed bamboo house-phase 9

Fig 11:Proposed bamboo house-phase 10

Prototype of a Bamboo house of IPIRTI - Bangalore, India

X. CONCLUSION

Since time immemorial has played an important role in the development of mankind. It is used for a wide range of day-to-day purposes both as a woody material and as food. It has been the backbone of much of the world's rural life and will remain so as the population increases. Bamboo will continue to play an important part in the development of enterprises and the transformation of rural environments in all regions of the developing world where it grows.

On account of the enforcement of our natural forest projection project, wood is becoming increasingly scarce. The realization that bamboo is the most potentially important non-timber resource and fast-growing woody biomass has evoked keen interest in the processing, preservation, utilization and the promotion of bamboo as an alternative to wood .The properties as top grade building material and increased availability of bamboo in our country makes it possible to use, bamboo in the field of construction extensively. Its high utilization not only promotes the economic development but also saves forest resource to protect our ecological environment as a wood substitute

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