BAMBOO AS A CONSTRUCTION MATERIAL

Mr. Nitin Kumar[1], Mr. Utkarsh Mathur[2], Mr. Bharat Phulwari[3],Mr. Amit Choudhary [4]

[1] *PG Scholar, Department of Civil Engineering, Bhagwant University ,Rajasthan, India*
[2] *PG Scholar, Department of Civil Engineering, Bhagwant University ,Rajasthan, India*
[3] *Assistant Prof, Department of Civil Engineering, Bhagwant University ,Rajasthan, India*
[4] *Assistant Prof, Department of Civil Engineering, Bhagwant University ,Rajasthan, India*

ABSTRACT

The diminishing wood resource and restrictions imposed on felling in natural forests, particularly in the tropics, have focused world attention on the need to identify a substitute building material that should be renewable, environment friendly and widely available. In view of its rapid growth, a ready adaptability to most climatic conditions and properties, superior to most juvenile fast growing plant, bamboo emerges as a very suitable alternative. This report deals with some of the main properties and the major uses of bamboo and its culms. It also recommends on the various preservation techniques to be adopted in order to enhance the durability.

The world timber demand is increasing at a rapid rate but the timber supply is depleting. It's been found through research that bamboo can suitably replace timber and other materials in construction and other works. Industrially treated bamboo has shown great potential for production of composite materials and components which are cost-effective and can be successfully utilized for structural and non-structural applications in construction. Bamboo is one of the oldest traditional building materials used by mankind. The bamboo Column, or stem, has been made into an extended diversity of products ranging from domestic household products to industrial applications. Examples of bamboo products are food containers, handicrafts, toys, furniture, flooring, pulp and paper, boats, charcoal, musical instruments and weapons. Bamboo is quite common for bridges, scaffolding and housing, but it is usually used as a temporary exterior structural material. In many overly populated regions of the tropics, certain bamboos supply the one suitable material that is sufficiently cheap and plentiful to meet the extensive need for economical housing. It has been used in bicycles, windmills, scales etc. Its uses are broad and plentiful. With the advancement of science and technology and the tight supply of timber, new methods are needed for the processing of bamboo to make it more durable and more usable in terms of building materials. Studies have been carried out on the basic properties and on processing of bamboo into various kinds of composite products. Bamboo has several unique advantages like ability to grow fast with a high yield and also it matures quickly. Additionally bamboo can be grown abundantly and that too at a lower cost which makes it more economical.

Keyword : - *Building Material , Bamboo, Timber Demand, and Bamboo Column .*

1. Introduction

Bamboo has a long and well-established tradition as a building material throughout the world's 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. It is estimated that there are 1200 species growing in about 14.5 million hectares area. Most of them grow in Asia, Africa and Latin America.

Bamboo is the world's fastest growing woody plant. It grows approximately 7.5 to 40cm a day, with world record being 1.2m in 24 hours in Japan. Bamboo grows three times faster than most other species. Commercially 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 others. Bamboo also excels in biomass production, giving 40 tons or more per hectare annually in managed stands. It accounts for around one-quarter of biomass produced in tropical regions and one-fifth in subtropical regions.

It has been used successfully to rehabilitate soil ravage by brick making in India, and abandoned tin-mine sites in Malaysia. It shelters top soil from the onslaught of tropical 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 areas, for rapid control of soil erosion; one bamboo plants closely matted roots can bind up to six cubic meters of soil.

GENERAL USES

1.1 Bamboo Trusses:

The bamboo has strength comparable to that of teak and sal. An experiment with the construction and testing of a 4m span truss made of round bamboo and different jointing techniques for web-chord connections gave results that were matching with the strength of timber.

1.2 Bamboo Roofs Skeleton:

It consists of bamboo truss or rafters over which solid bamboo purlins are laid and lashed to the rafter by means of G.I.wire. A mesh of halved bamboo is made and is lashed to the purlins to cover the roof.

1.3 Bamboo walling/ceiling:

As the bamboo material is light in weight it is more advantageous in earthquake prone areas as its chances of falling are very less and even if it falls it can be re-erected easily with less human and property loss with least efforts and minimum cost. Bamboo walls can be constructed in different modes like Whole stem, halved or strips of bamboo can nailed to one or both the sides of the bamboo frame Split bamboo mats can be fastened to the bamboo posts or mats can be woven, mud can also be applied to both sides of such mats. Bamboo strips nailed to bamboo frame or posts for interior walling. Cement or lime plastering can be done on the mud covering for better appearance and hygiene. It has been found that the bamboo in the vertical position is more durable than in horizontal direction. For partition walls only single layer of bamboo strips are used.

2. PROPERTIES

2.1 TENSILE STRENGTH

Bamboo is able to resist more tension than compression. The fiber of bamboo run axial. In the outer zone are highly elastic vascular bundle, that have a high tensile strength. The tensile strength of these fibers is higher than that of steel, but it's not possible to construct connections that can transfer this 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 400 N/mm^2 can be found. As a comparison, extremely strong wood fibers can resist a tension up to 50 N/mm^2.

2.2 COMPRESSIVE STRENGTH

Compared to the bigger tubes, slimmer ones have got, in relation to their cross-section, a higher compressive strength value. The slimmer tubes possess 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, whereas the high portion of cellulose influences the buckling and the tensile strength as it represents the building substance of the bamboo fabrics.

2.3 ELASTIC MODULUS

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 the elastic modulus, the higher is the quality of the bamboo. Enormous elasticity makes it a very useful building material in areas with very high risks of earthquakes.

2.4 ANISOTROPIC PROPERTIES

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 transverse direction there is lignin, which is soft and brittle.

2.5 SHRINKAGE

Bamboo shrinks more than wood when it loses water. The canes can tear apart at the nodes. Bamboo shrinks in a cross section of 10-16 % and a wall thickness of 15-17 %. Therefore it is necessary to take necessary measures to prevent water loss when used as a building material.

2.6 FIRE RESISTANCE

The fire resistance is very good because of the high content of silicate acid. Filled up with water, it can stand a temperature of 400° C while the water cooks inside.

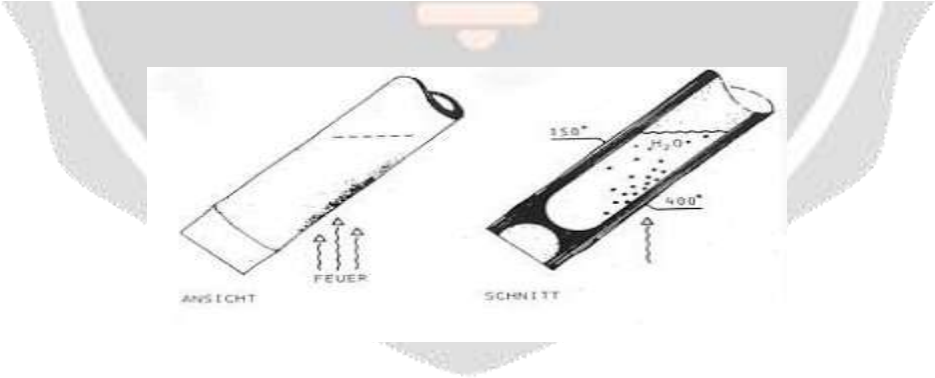

Fig -1: Fire resistance of bamboo cane when filled with water

3. BAMBOO HOUSING

The majority of bamboo construction relates to the rural community needs in developing countries. As such domestic housing predominates and in accordance with their rural origins, these buildings are often simple in design and construction relying on a living tradition of local skills and methods. Other common types of construction include farm and school building s and bridges. Further applications of bamboo relevant to construction include its use as scaffolding, water piping and as shuttering and reinforcement for concrete. In addition, the potential number of construction applications has been increased by the recent development of a variety of bamboo-based panels.

3.1 DOMESTIC HOUSING AND SMALL BUILDINGS

There is a long-standing tradition of bamboo construction, dating back to many hundreds of years. Different cultures have found in this material an economical system of building, offering sound yet light and easily replaceable forms of shelter. The methods, activities and tools are often simple, straightforward, accessible even to the young and unskilled. Despite human exploitation and unfavorable treatment, trees maintain its contributively role towards the dwelling of mankind. Man has for centuries enjoyed the benefits of the free gift of nature.

Housing is one of the priority items and sensing the current shortage of the dwelling units, the present administrative leaders around the world find tough to hit upon a solution for. The search for an efficient economical and replicable housing solution based on the contextual needs is the need of the hour. Apart from the other substances already in practice, bamboo appears to be the most promising material. Bamboo building construction is characterized by a structural frame approach similar to that applied in traditional timber frame design and construction. In this case, the floor, the wall, the roof elements are all interconnected and often one dependent on the other for overall stability.

Bamboo culms are used in building. The thicker culms or strands made up of several culms are employed for load bearing materials such as girder, purlin, post or rafter. Bamboo based materials are widely used too. In its natural condition as solid culms, halved culms or as longitudinally split strips, bamboo has been used in almost all parts of house construction except for the fireplace and the chimneys. These are described in detail below:

3.2 Foundation

The use of bamboo for foundation is rather restricted. This is mainly due to the fact that like timber when in contact with damp ground, they deteriorate and decay very quickly unless treated with some very effective preservatives. However, in spite of their short life considerable use of bamboos is made as foundation or supporting posts in case of houses built on raised platforms. The types of bamboo foundations identified are:

(a) Bamboo in direct ground contact: Bamboo is placed either on the surface or buried. For strength and stability, large diameter and thick walled sections of bamboo with closely spaced nodes should be used. Where these are not available, smaller sections can be tied together. It can decay within six months to two years, and hence preservative treatment is recommended.

(b) Bamboo on rock or preformed concrete footings: where bamboo is being used for bearings, it should be placed out of ground contact on footings of either rock or preformed concrete. The largest and stiffest sections of bamboo should be used.

(c) Bamboo incorporated in to concrete footings: the poles are directly fit into concrete footing. It can take the forms of single posts or strip footings.

(d) Composite bamboo/concrete columns: a concrete extension is given to a bamboo post using a plastic tube of the same diameter. The result is a bamboo post with an integral durable foundation.

(e) Bamboo piles: it is used to stabilize soft soils and reduce building settlement. The treated split bamboo piles were filled with coconut coir strands wrapped with jute. The sections were then tied with wire. After installation of the piles the area was covered with a sandy material.

3.3 Flooring

The floors may be at ground level, and therefore consists only of compacted earth, with or without a covering of bamboo matting. The preferred solution is to raise the floor above the ground creating a stilt type of construction. This improves comfort and hygiene and can provide a covered storage area below the floor. The surface of earth floor is sometimes made more stable by paving it with crude bamboo boards made by opening and flattening whole culms. The various types used are:

(a) Small bamboo culms: they are directly tied and nailed together.

(b) Split bamboo: culms are split along their length into strips, several centimeters wide.

(c) Flattened bamboo: formed by splitting green bamboo culms removing the diaphragms, then rolling and flattening them. The resulting board is laid across the joists and fixed by nailing or tying. They are screeded with cement mortar for reasons of hygiene and comfort as they are uneven and difficult to clean.

(d) Bamboo mats: thin strips varying in size from 5-6mm or 10-15mm and thickness of 0.6-1.2mm. These slivers are then woven into mats of different sizes according to the available hot-press plates and user's demands. After drying the mats to 6-10% moisture content, sufficient glue is applied to ensure enough bonding between the overlapped areas. In construction using bamboo mats, phenolic resins are employed.

(e) Bamboo plastic composites: it is an innovative technology in which bamboo fiber is the raw material and compounded with plastic as the core material of the flooring. This has higher water resistance and dimensional stability properties than those of normal floorings.

The ratio of plastic should be over 30% for higher water resistance and dimensional stability. Polypropylene is recommended, and if recycled plastic is used it is ideal to reduce the cost of production. The density of substrate should be higher than 1gm/cm3 to ensure best mechanical properties. It prevents the floor from swelling and cracking, which is the disadvantage of other timber based flooring materials.

3.4 Walls: The most extensive use of bamboo in construction is for the walls and partitions. The major elements, the posts and beams, generally constitute part or structural framework. They are to carry the self-weight of building and loads imposed by the occupants and the weather. An infill between framing members is required to complete the wall. The purpose of the infill is to protect against rain, wind and animals, to offer privacy and to provide in plane bracing to ensure the overall stability of the overall structure when subjected to horizontal forces.

3.5 Roofing

The roof offers protection against extremes of weather including rain, sun and wind, and to provide shelter, clear and usable space beneath the canopy. Above all it must be strong enough to resist the considerable forces generated by wind and roof coverings. In this respect, bamboo is ideal as a roofing material- it is strong, resilient and light weighted. The bamboo structure of a roof can comprise of purlins, rafters and trusses.

(a) The simplest form consists of a bamboo purlin and beams, supported on perimeter posts. Halved culms are then laid convex side down, edge-to-edge, spanning from the ridge to the eaves. A second layer, convex side up, is then laid to cover the joints.

(b) Corrugated sheets made out of bamboo are also used commonly as roof covering. The bamboo mats are dipped in resin, dried and heat pressed under pressure in a specially made platen, to give strong, reliable sheets of bamboo, which is lightweight. It has good insulation properties too.

(c) A layer of bitumen is sandwiched between two mats of bamboo forming a semi rigid panel. The mats can be fixed to rafters at 200-250mm center to center. A bituminous or rubberized weatherproof coating is then applied to the finished roof.

(d) Plastered bamboo: A cement plaster, with or without the addition of organic fibres, is traditionally applied to bamboo roofs, to get stronger roof coverings. Various forms of trusses are also adopted using bamboo culms of diameter ranging from 40mm-100mm. The king post trusses are the most common and the simplest.

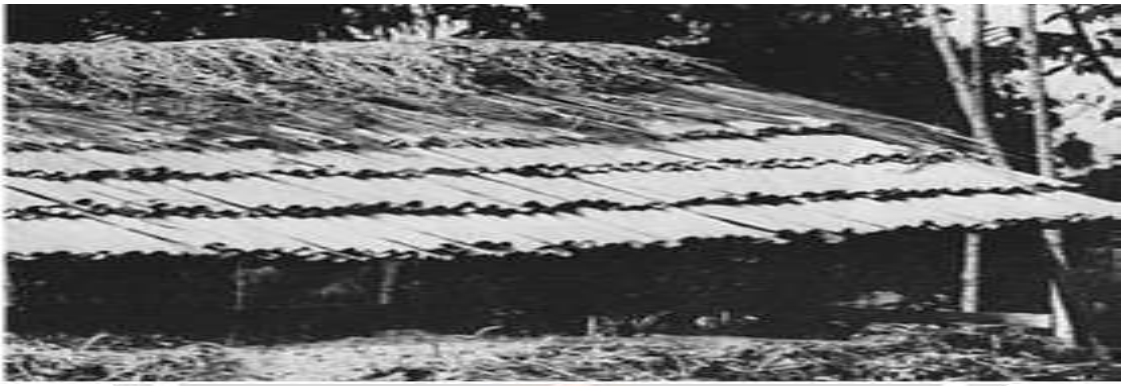

Fig -2: Double layers of bamboo shingles

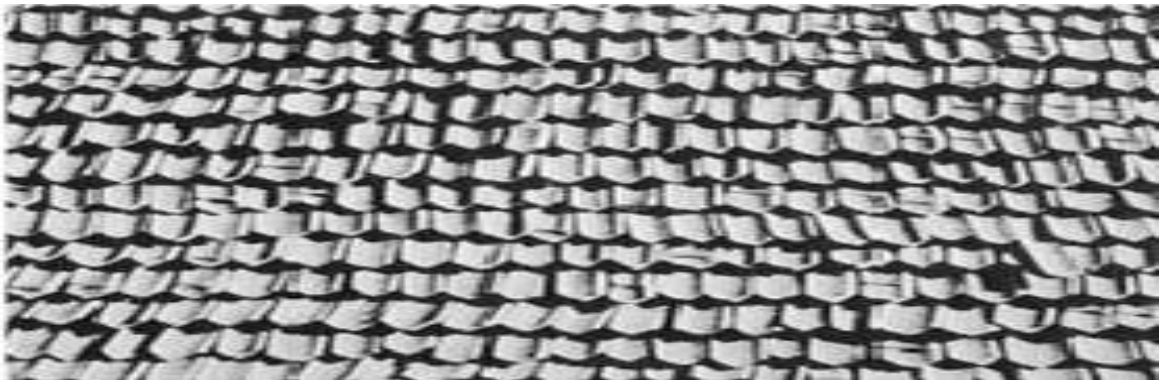

Fig -3: Lancet shingles

3.6 Scaffolding

Because of the favourable relationship between load-bearing capacity and weight, bamboo can be used for the construction of save scaffoldings even for very tall buildings. Even at their connections the canes are not treated in any way. Only lashed joints are used. The cane extension is carried out by lashing the cane ends together with several ties. The ties are arranged in such a way that a force acting vertically downwards wedges the nodes in the

lashing. With larger cane diameters the friction can be increased by tightening the rope between the canes. The vertical and horizontal canes used for scaffolding are almost exclusively joined using soft lashing. This technique has the great advantage that the joints can be re-tensioned to the right degree without difficulty and also quickly released again.

4. CONCLUSIONS

Since time immemorial, bamboo 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. 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 valued utilization not only promotes the economic development, but also saves forest resources to protect our ecological environment as a wood substitute. As an economic building material, bamboo's rate of productivity and cycle of annual harvest outstrips any other naturally growing resource, if today you plant three or four structural bamboo plants, then in four or five years later you will have mature clumps, and in eight years you will have enough mature material to build a comfortable, low cost house.

6. REFERENCES

1. Duggal.S.K Building Materials
2. Kenneth H., Longman, 1972, Building Material
3. Jambal N, Gambhir.M.L., Tata McGraw–Hill Education(2011), Building Materials: Products, properties and Systems 1st Edition
4. Varghese.P.C., Building Materials (Google Book)
5. En.wikipedia.org/wiki/Bamboo
6. Dunkelberg, Klaus: Bamboo as a building material, in: IL31 Bambus, Karl
7. Krämer Verlag Stuttgart 1992 Eberts, Wofgang:www.bambuszentrum-deutschland.de
8. Contributions from the seminar: Design with bamboo, RWTH Aachen SS 2001
9. Patel (June 1981). "Mechanical properties of bamboo, a natural composite". Fibre Science and Technology. 14 (4): 319–322. doi:10.1016/0015-0568(81)90023-3.
10. The Bamboo Solution: Tough as steel, sturdier than concrete, full-size in a year. Mary Roach. Discover Magazine. 1 June 1996. Retrieved 7 December 2013.
11. Mechanical Properties of Bamboo. Evelin Rottke. RWTH Aachen University. Faculty of Architecture. Aachen, North Rhine-Westphalia, Germany. Section 3, page 11 and Section 4, page 11. 27 October 2002. Retrieved 7 December 2013.
12. Farrelly, David (1984). The Book of Bamboo. Sierra Club Books. ISBN 0-87156-825-X.
13. Guinness. "Fastest growing plant". Retrieved 22 August 2014.
14. Landler, Mark (27 March 2002). "Hong Kong Journal; For Raising Skyscrapers, Bamboo Does Nicely". New York Times. Retrieved 12 August 2009.