

Bamboo: A Sustainable Building Material

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Abstract—The diminishing wood resource and restrictions imposed on felling in natural forests, have concentrated world attention on the need to identify a substitute building material that should be renewable, eco-friendly and widely available. Bamboo, a common grass which can be harder to pull apart than steel, promises to revolutionize building construction throughout the world. In view of its rapid growth, and property to readily adapt to most climatic conditions, superior to most juvenile rapidly growing wood, bamboo comes out as a very promising substitute. It is widely recognized as one of the most important non-timber forest resources due to the high socio-economic benefits from bamboo based creations. Bamboo is the world's fastest growing woody plant and has over 1600 species of bamboo grows on the globe. Bamboo grows three times faster than most other species. The attributes that makes bamboo a considerable building material include its Renewability, Strength, Sturdiness, Flexibility and Resistance to pests etc. Bamboo as a building material is used as Walls, Roofs, Support structures, Houses, Flooring, Bridges, Room dividers etc. Building with bamboo seems to be the wave of the future. From consumers ardent about the environment, to designers looking for something contemporary and stylish, all kinds of people are seeking interest in bamboo building materials. This renewable resource is gradually coming out of ancient texts and becoming the modern ideal for building materials. This paper will be explaining several possibilities of using Bamboo as a structural material in a building and also provides a detailed study on properties, usage, advantages, disadvantages, preservation and working of Bamboo.

1. INTRODUCTION

Bamboo, a traditional building material all around the world's tropical and sub-tropical regions. Bamboo is a renewable and adaptable resource, with very high strength and less weight. That is why it is extensively used in various forms of construction, especially for housing in rural areas. It can also be used to make cages, traps, tools, weapons, bridges, rafts, towers, water wheels, irrigation pipe, fences, and thousands of other items. It is also widely recognized as one of the most important non-timber forest resource due to its high socioeconomic benefits from bamboo based products. It is estimated that there are more than 1200 species of bamboo growing mostly in Asia, Africa and Latin America.

2. BAMBOO AS A BUILDING MATERIAL

Housing is one of the basic need for human being, and is becoming a burden for lower and middle income group. We

need cost efficient housing and bamboo is among the best building material, as:

- Fastest-growing renewable natural building material.
- Easily available & Eco friendly.
- Bamboo is a feasible alternative for steel, masonry and concrete as an independent building material.
- Cost effective and easy to work with.
- Can be easily bend, transformed into desired shape and can provide joints to meet the construction.
- Its enormous elasticity makes it a useful building material in areas with very high risks of tremors and earthquakes.
- Locally available material to some areas, which tries to carry the local tradition & vernacular Architecture of that place.



Fig. 1: A Bamboo Campus

3. PROPERTIES OF BAMBOO

- **Tensile Strength** - Bamboo resists more tension than compression. The fibres in bamboo run axial. The outer zone is highly elastic vascular bundle that have a high tensile strength. The tensile strength of these fibres 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 silicated outer skin, axial parallel elastical fibers with a tensile strength upto 400 N/mm^2 can be found. As a comparison, extremely strong wood fibers can resist a tension upto 50 N/mm^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 lining 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 fibers.
- **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.
- **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.
- **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.
- **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.

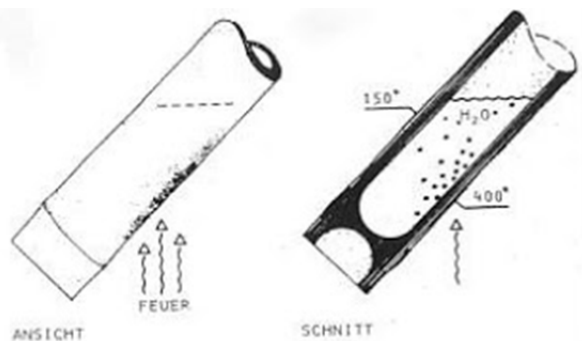
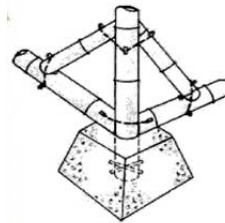


Fig. 2: Fire resistance of bamboo cane when filled with water.

4. USE OF BAMBOO AS BUILDING MATERIAL

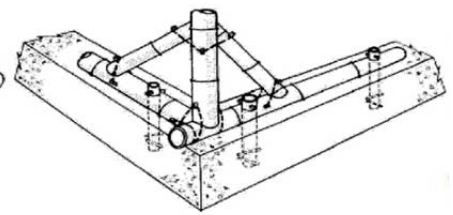
Bamboo is used as a building material in several below mentioned ways -

- **Bamboo Footings** - For use as foundation, bamboo poles are directly driven/inserted into the ground. They have to, however, be pre-treated for protection and prevention from rot and fungi.



Single Post Footing

Fig. 3



Strip Footing

Fig. 4

- **Bamboo Trusses** - For the spanning of larger distances in public utility buildings such as schools, storage areas, commercial buildings, bamboo is used as a truss member. Bamboo has a high strength /weight ratio and hence is a good alternative for roof framing.



Fig. 5

- **Bamboo Scaffolding** - Since time im-memorable, bamboo poles have been tied together and used as scaffolding. These properties of bamboo such as resilience, shape and strength make it an ideal material for the purpose. The climbing and working platforms for masons can also be built of bamboo.



Fig. 6

- **Bamboo Tile Roofing** - Bamboo Tiling is the simplest form of bamboo roofing. The culms are split into halves, the diaphragms then scooped out and these run full length from eave to ridge. The first layer of bamboo splits are layed concave side up and the second layer interlock over the first with convex side up. Though a very simple method, it can be made completely watertight.



Fig. 7

- **Bamboo Walls** - Bamboo walls are constructed by tying and nailing a thin bamboo mat to either sides of a braced timber or bamboo frame.



Fig. 8

- **Bamboo Reinforcement** - Besides the use of bamboo as a building material, there have been a lot more proposals to use bamboo as reinforcement in RC columns, beams and slabs.



Fig. 9

5. PRESERVING BAMBOO

- **Smoking:** Another possibility to preserve the bamboo is smoking it in its own resin. The smoke makes the rind unpalatable to insects which therefore decline the bamboo.
- **Immersion:** Freshly cut canes are immersed deep in water for 4-12 weeks. The nourishment for insects (starch and sugar) is then removed. Streams are more suitable than stagnant ponds. Saltwater is not suitable, because the salt will stay in the bamboo and can bring moisture and fungi into the canes.
- **Impregnating coatings:** Coatings with borax are ecological and are widely used. In addition, lime slurries, slurries from lime or cow dung or rangoo oil are also used. Using insecticides is ecological not acceptable. These are kerosene, PCP, DDT and others.
- **Heating:** The canes are heated in kilns to 150°C for a short time, so the structure of the outer zone changes and becomes more resistant against insects. The poles can crack up easily. When you cook bamboo, the starch and nutrient content is reduced. The Problem is to find a container that is big enough to cook the canes in it.

6. ADVANTAGES

- Light, strong and versatile.
- Accessible to the poor.
- Self-renewing resource.
- Fast growing.
- Environment friendly.
- Highly productive.
- It can be transported and worked easily.
- The use of cranes is mostly unnecessary.
- It is a very flexible plant.
- Grows back very rapidly once harvested.
- Raw material for paper making.
- Bamboo has a higher tensile strength.
- Usage of bamboos will reduce deforestation.
- Composite material.

7. DISADVANTAGES

- **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.
- Requires preservation.
- Shaped by nature.
- Prone to catch fire very fast by the friction among the culms during wind, and is seen to cause forest fires.
- Lack of design guidance and codes.

8. CONCLUSION

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.

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