

Bamboo as a Building Material

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Abstract: Bamboo is one of the oldest traditional building materials used by mankind. They are the largest members of the grass family and are the fastest-growing in the world. In fact, within a 24 hour period, bamboo can grow four feet. Bamboos are of notable economic and cultural significance in South Asia, Southeast Asia and East Asia, being used for building materials, as a food source, and as a versatile raw product. Bamboo has a higher compressive strength than wood, brick or concrete and a tensile strength that rivals steel.

This is a substitute building material, which is renewable, environment friendly and widely available, as the wood resources are diminishing and restrictions are imposed on felling the natural forests. Due to its rapid growth, its adaptability to most climatic conditions and due its properties, bamboo emerges as a very suitable alternative.

Timber demand is increasing worldwide at a rapid rate but the timber supply is depleting. Due to its properties 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 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.

This article deals with why and how bamboo is used as a building material, some of the main properties, construction details and the major uses of bamboo etc.

Also to inspire all for saving nature and to suggest them to use eco-friendly materials and techniques, which are cost-effective and grown abundantly and focuses on sustainable buildings to fit into natural surroundings. **Key words: Bamboo, Renewable, Environment, Cost-Effective, Economical, Building Material**

1. INTRODUCTION

Bamboo is a traditional building material throughout the world's tropical and sub-tropical regions. Bamboo is a renewable and versatile resource, with high strength and low weight. That's why it is widely used in different forms of construction, particularly for housing in rural areas. It can also

be used to make traps, cages, tools, weapons, bridges, rafts, towers, fences, water wheels, irrigation pipe, and thousands of other items. 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 of bamboo. Most of them grow in Asia, Africa and Latin America.

The world's fastest growing woody grass is Bamboo. 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. Species of bamboo which are commercially used 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 is also good in biomass production. 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.

2. WHY BAMBOO IS USED AS A BUILDING MATERIAL?

Housing is a basic need for human being, and is now becoming a burden for low and medium income group. Thus, we need cost effective housing and bamboo is the best building material, result for that as:

- 2.1 It is fastest-growing renewable natural building material.
- 2.2 The material is easily available & Eco friendly.
- 2.3 Bamboo is a viable (if not better!) alternative for steel, concrete and masonry as an independent building material.
- 2.4 It is cost effective and easy to work.
- 2.5 It can be easily bend, give desired shape and can provide joints to suit the construction.
- 2.6 Its enormous elasticity makes it a very useful building material in areas with very high risks of earthquakes.
- 2.7 Local available material to some areas, which tries to carry the local tradition & vernacular Architecture of that place.



Fig 1: Bamboo campus

3. BAMBOO IS USEFUL FOR DIFFERENT PURPOSES AT DIFFERENT AGES AS:

- <30 days it is good for eating.
- 6-9 months for baskets.
- 2-3 years for bamboo boards or laminations.
- 3-6 years for construction.
- >6 years bamboo gradually loses strength up to 12 years old.

4. MAIN PROPERTIES OF BAMBOO

As discussed before that Bamboo is a viable alternative for steel, concrete and masonry, it is so because of its properties which are clearly mention below.

4.1 TENSILE STRENGTH

Bamboo is able to resist more tension than compression. The fibers of bamboo run axially are of highly elastic vascular bundle that has 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/mm² can be found. As a comparison, extremely strong wood fibers can resist a tension up to 50 N/mm².

4.2 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 fibers.

4.3 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.

4.4 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.

4.5 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.

4.6 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.

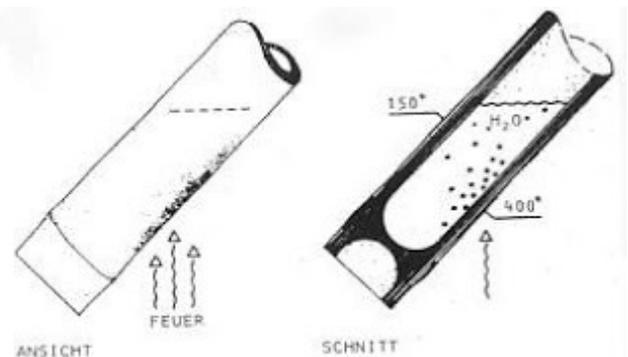


Fig 3: Fire resistance of bamboo cane when filled with water

5. BAMBOO AS A BUILDING MATERIAL

Bamboo is a versatile material because of its high strength-to-weight ratio, easy workability and availability. Bamboo needs to be chemically treated due to their low natural durability. It can be used in different ways for roof structure as purlins,

rafters and reapers, for flooring, doors and windows, walling, ceiling, man-hole covers etc.

5.2 Bamboo Trusses: The bamboo has strength comparable to that of Teak and Sal. A frame is made using bamboo rafters, purlins etc for fixing the roof.



Fig 4: Example of Bamboo truss



Fig5 : Example of Bamboo house

5.3 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.



Fig 6: Bamboo roofing

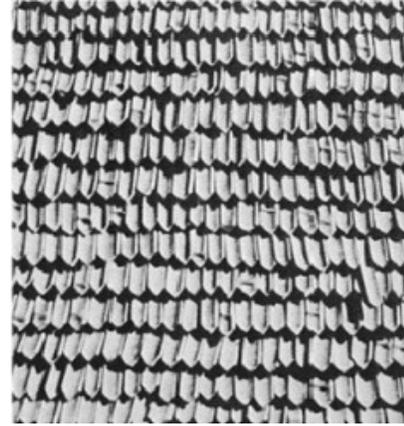


Fig 7: Bamboo shingles

5.4 Bamboo walling/ceiling: As the bamboo material is light in weight it is beneficial for earthquake prone areas as its chances of falling are very less due to flexibility 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 ways like

- Whole stem halved or strips of bamboo can be 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.



Fig 8: Bamboo walling/ceiling



Fig 9: Bamboo mat wall

5.4 Bamboo Doors and Windows: Bamboo frames can replace timber frames appropriate to function. Bamboo mat shutters fixed to bamboo frame or a panel of bamboo board fixed to the frame which is hinged to the wall can be used as door. Small framed openings hinged to the top in the wall can serve as windows.

5.5 Bamboo Flooring: Bamboo can be used as flooring material due to its better wear and tear resistance and its resilience properties. Whole culms act as frame work and the floor covering is done using split bamboo, bamboo boards, mats etc by means of wire lashing these to the frame.

5.6 Reed Boards: Reed boards are made by flat pressing the reed at high temperatures. These reed boards are used in elements like flooring, walls, ceiling and roofing. They can also be used for partitions, doors, windows etc.



Fig 10: Bamboo board

5.7 Scaffolding: Bamboo poles lashed together have been used as scaffolding in high rise structures due to their strength and resilience. The timber planks can be replaced with bamboo culms and these can be lashed to the vertical culms.



Fig 11: Bamboo scaffolding

5.8 Foundations: For use as foundation, the bamboo poles are directly driven into the ground. They have to, however, be pre-treated for protection from rot and fungi. This prolongs the life of the foundation beyond that of an untreated bamboo pole.

6. CONSTRUCTION DETAILS IN BAMBOO

The construction from bamboo is only possible if the joints are strong. They are made strong by using different types of details as follows to be used in construction:

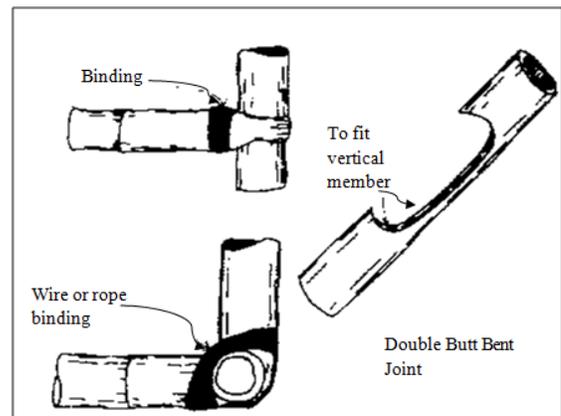


Figure #1- Double butt bent joint

Fig12: Double Butt Bent Joint



Figure #3 – Connection with bamboo strips

Fig13: Friction-tight Rope Connection

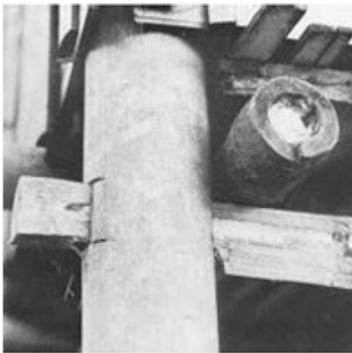


Figure #7 – Bracket interlocking stud

Fig14: Plug-in/Bolt Connection



Figure #10 – positive fitting connection combined with lashing technique

Fig15: Positive Fitting Connection



Figure #11 – interlocking connection with metal anchor technique

Fig16: Interlocking Connection

7. ADVANTAGES & DISADVANTAGES OF BAMBOO.

7.1 ADVANTAGES OF BAMBOO: The various advantages of bamboo are as follows:

- It is Light, strong and versatile.
- It is Environment friendly.
- Easily Accessible to the poor.
- Self renewing resource of nature.
- Speedily growing
- Highly productive.
- Low Cost Material

7.2 DISADVANTAGES OF BAMBOO: The major disadvantages of bamboo are as follows:

- It 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.
- Prone to catch fire very fast by the friction among the culms during wind, and is seen to cause forest fires.

8. CONCLUSION

Bamboo 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 and the transformation of

rural environments, in all regions of the developing world where it grows.

While our natural forests are protected, wood is becoming increasingly scarce. The realization that bamboo is the most potentially important non-timber resource and fast-growing woody biomass, which has evoked keen interest in the processing, preservation, utilization and the promotion of bamboo as an alternative to wood. The top grade building material properties 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.

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