

Bamboo: A Green Building Material

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Abstract

This paper addresses about the concerns of affordable housing, green construction material and talks about the efforts to develop bamboo as a modern sustainable green building material for construction. With increasing population and decreasing resources there is a need to adopt cost effective and eco-friendly building materials. This paper addresses the potential of bamboo and projects the possibilities of usage of bamboo in the construction field, green Architecture using bamboo. To understand the holistic usage of bamboo, local artisans, bamboo growers and bamboo scientists were interviewed. Housing is one of the priorities of the present times. Understanding the current shortage of the housing, other than construction materials already in practice, bamboo seems to be the most promising building material. Bamboo building construction is characterized by a structural frame approach similar to that applied in traditional timber frame construction. Bamboo can replace 70% of steel and wood used in the construction and reduce the cost by 40%. Its high valued utilization not only promotes the economic development, but also saves forest resources to protect our ecological environment as a wood substitute. Bamboo is a truly sustainable material, with the compressive strength of concrete and the tensile strength of steel (experiments done by Colombia University). It is also flexible, making it ideal for earthquakes. Growth of every ton of bamboo consumes nearly a ton of carbon dioxide^a (sequester carbon) besides releasing 35% more fresh oxygen into the atmosphere than any other tree species. It can have reasonable life of 30 to 40 years after proper treatment (studies carried by CBTC).

Keywords: Bamboo, Green Architecture, Sustainable green construction material, tensile strength, compressive strength, Sequester carbon: A process in which CO₂ is removed from atmosphere and stored in the soil carbon pool.

Introduction

Bamboo has been used traditionally as a building material. Among the natural building materials bamboo is unique due to its negative carbon foot print, quality construction material and its very short maturity time (3-5 years). It is very effective functionally to be used as tubular structure as well as in its engineered forms.

The population of the world is growing and shelter being a basic requirement, providing affordable housing solutions is a key concern. Bamboo can be used in construction but should be treated to resist insects and pests before bringing into usage. Commonly treatment is done with mixture of borax and boric acid or boiling, cutting bamboo to remove the starches that attract pests. Bamboo used in construction after treatment gives a life span of 35 to 40 years to houses made out of bamboo and bamboo building products. Bamboo can be used as green building construction material in its natural form and by-products made out of bamboo like, bamboo flooring, bamboo corrugated roof sheets, bamboo ply and boards, bamboo prefabricated walls, bamboo door and window frames, railing, handrails etc.

Characteristics of bamboo

To establish the holistic usage of bamboo as a green building material it is necessary to understand the some properties of bamboo that makes it suitable as building construction material.

Tensile strength: The fibers of bamboo run axially, the outer core of bamboo is highly elastic vascular bundle having high tensile strength. The tensile strength of these fibers is higher than that of steel (as conducted by IIT Delhi).

Fire resistance: Because of the presence of high contents of silicate acid the fire resistance of bamboo is very good. If filled with water it can withstand the temperature of 400 degree Celsius while water will boil inside. Traditionally rice is been cooked by stuffing inside bamboo in parts of south East Asia.

Earthquake resistant material: Its high elasticity and low weight makes it most suitable for design of earthquake resistant structures.

Suitable for fabrication of engineered woods: The latest technology in practice for manufacturing of engineered woods, bamboo is regarded as most suitable material because of its easy cultivation, high tensile, compressive strength and short maturity period. Engineered woods fabricated out of bamboo are very strong compared to other raw materials. This has resulted in new innovations like roof corrugated sheets, ply boards, prefabricated wall panels, flooring, handrails, door window frames and wooden posts.

Bamboo in structural framework:

Bamboo has high tensile strength and good mechanical properties. Traditionally bamboo was used as primary building construction material using traditional construction techniques, which has transferred to new modern prefabricated bamboo housing. In modern times engineered bamboo is used to make prefabricated bamboo houses with the help of bamboo based logs, door/window frames, panels, veneers, laminated boards and corrugated roof sheets. The new technology evolved can be used for low cost two storied houses. New developments has taken place to improve technology, techniques, preservation and protection of bamboo as well as jointing techniques that can be used to make bamboo suitable as construction material. Advanced structural engineering and development of engineered bamboo woods has opened the new options for house construction with eco friendly green building construction material.

Use of bamboo in Foundations:

The usage of bamboo for foundation is very restricted because when it comes in direct contact with damp ground, it decays very fast unless it is treated with some effective preservatives. Still bamboo is been extensively used in rural sector.

Bamboo with direct contact to ground: Bamboo is placed either on the surface or buried underground. For strength and stability, large diameter and thick walled sections of bamboo with closely spaced nodes are used. Bamboo used shall be properly treated with preservatives.

Bamboo on rock beds or concrete footings: To protect the bamboo from dampness and decay the bamboo is placed out of ground with contact on footings of either rock or concrete. The largest and strongest sections of bamboo should be used.

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.

Bamboo piles: it is used to stabilize soft soils and reduce building settlement. The treated split bamboo piles are filled with coconut coir strands wrapped with jute. The sections are then tied with wire. After installation of the piles the area is covered with sand.

Bamboo for flooring:

Split bamboo or bamboo mats are commonly used for flooring. To give it a rich look engineered bamboo tiled flooring can be pasted over the mat surface which is now a day's been used in resorts. Small bamboo culms are also used for flooring. They are directly tied and nailed together. Split bamboo: culms are split along their length into strips, several centimeters wide. Flattened bamboo: formed by splitting green bamboo

culms removing the diaphragms, then rolling and flattening them. The end result is a board laid across the joists and fixed by nailing or tying. They are screened with cement mortar to give it smooth and even surface.

Bamboo mats: thin strips varying in size and thickness woven into mats of different sizes according to the available hot-press plates. After drying the mats moisture content, sufficient glue is applied to ensure enough bonding between the overlapped areas. In construction using bamboo mats, phenolic resins are used. 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.

Bamboo roofing:

Bamboo trusses used for roofing are the most common practice for a long time. Top surface is been constructed with bamboo culms split into two halves. These roofs were considered as low cost practices for budget houses. Latest material invented out of bamboo is bamboo corrugated sheets which are aesthetically good looking and are been used in resorts and villas now. 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. The simplest form consists of a bamboo purlin and beams, supported on outer posts spanning from the ridge to the eaves. A second layer, convex side up, is then laid to cover the joint.

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 machine mould, to give strong, reliable sheets of bamboo, which is lightweight. It has good insulation properties too. A layer of bitumen is sandwiched between two mats of bamboo forming a semi rigid panel. The mats can be fixed to rafters. A bituminous or rubberized weatherproof coating is then applied to the finished roof.

Plastered bamboo: A cement plaster, with or without the addition of organic fibers, 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 used.

Bamboo for construction of walls:

Bamboo can be used for construction of lightweight prefabricated walls. Since light in weight bamboo is most suitable for construction of lightweight earthquake resistant walls. Due to its less weight even if the wall falls it will cause less harm compared to other building materials. 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.

Conclusion

Since ages, bamboo has played an important role in the development of rural housing for humans. Bamboo is been used for many day-to-day purposes, both as construction material and for furniture. The properties as good building material and better availability of bamboo in India makes it appropriate to use bamboo in the field of construction more extensively. Its increased utilization not only promotes the economic development, but also helps in preservation of forest resources to protect our ecology and environment by its usage as a substitute of wood. Bamboo is an economic building material. Bamboo's production rate and annual harvesting cycle makes it most appropriate green building material among the other naturally

growing resources. The bamboo clumps achieves maturity to be used for construction in four to five years, and maximum in eight years you will have enough mature material to build a comfortable, low cost house as well as luxury cottage. India has the largest reserves of bamboo in the world. But most the bamboo produced is used for paper production. The species which has good characteristics to be used as building material is under produced. The usage of bamboo as building material is still limited to rural areas only. Its engineered building material forms are also produced at a very small scale, though it has proved that bamboo is the best replacement of tree wood. Presently it is underutilized and found in abundance. Recently the Government of India has taken a major step for promotion of bamboo production, by including it in central budget. The regulatory restrictions on trade and transits on bamboo have also been removed. India can have 4-5 times better productivity then now and is expected to have an increase in the market size in future if proper management, cultivation and plantation practices are followed with proper market linkages. Thus, bamboo can play an important role in meeting the future human needs of wood used as input for housing and construction.

With increasing demand of raw materials for housing and construction, the demand of wood has increased which has resulted in decreasing forest area. Bamboo based materials can serve as an alternative in reducing the gap of demand and supply. Bamboo is lightweight and easy to replace. Bamboo building is suitable in all type of climates. Bamboo is a truly sustainable unrivalled replacement of wood with high compressive strength and tensile strength.

Bamboo is flexible with good elasticity, which makes it ideal building material for construction earthquake resistant houses, as it will bend and flex long before it breaks. Growth of every ton of bamboo consumes nearly a ton of carbon dioxide besides releasing fresh oxygen into the atmosphere. It is adaptable to most climatic conditions and soil types. It can withstand high pressure, it can have reasonable life of 30 to 40 years.. It is an environment-friendly, energy-efficient and cost-effective construction material. Bamboo when comes in contact with moisture or water its strength will increase time to time.

Soft government laws and norms: The restrictions on trade and transit of bamboo were the biggest hindrances to the bamboo based industry and traders. Irregular supply of bamboo has affected the development of bamboo industry in India. But in recent years Central and some state governments has taken positive steps to promote bamboo industry and restrictions on trade and transit of bamboo has been lifted. Governmental organization can play a strong promotional role which would help generate awareness on bamboo products by running a national campaign and can help to develop the byproduct-market of bamboo based construction materials. It can also encourage private entrepreneurs to enter bamboo sector as the increase in promotion will help in increasing the awareness among the people about the usage of bamboo in construction field. These efforts will definitely help in increasing the demand of bamboo in construction industry.

Emphasis on research in the field of Bamboo as green construction material: It can largely help to develop the bamboo sector to invent good High Yield Variety bamboo and bamboo products and conserve the existing quality species of bamboo. Some institutes like IIT, Bamboo Mission, Cane and Bamboo technology center, Bamboo Technology Park etc, can help in developing new and better technology for primary and secondary processing of bamboo. Institutes can help in promoting researches in bamboo sector regarding data on the usage pattern, bamboo resources, species, etc. Bamboo sector lacks the data base. Regular surveys could be conducted in order to have adequate necessary information for proper planning, management and allocation of bamboo resources.

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