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Bamboo in Construction Technology

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Abstract

Ecosystems are largely affected by today's construction activities which uses energy extensively from its very beginning to its completion and even after for its maintenance in many forms. Alone construction sector has been accounted to consume 40% of total energy consumption directly or indirectly. Availability of construction material in a near vicinity and use of locally produced material saves a lot on construction cost and also in terms of energy. Bamboo is one such material which has extensive potential in building industry if used with proper treatment and trained workers. The housing sector in India is growing rapidly but with increased cost it is getting out of reach of people. We in India have 20-30 million families who have next to nothing to live under or no form of shelter at all.

The present paper deals with the utilization of bamboo as a construction /structural element in various building components such as floor, roof, beam, wall-panels, columns etc. Bamboo reinforcement as replacement of steel reinforcement is gaining immense importance today, mainly on account of the improvement in the economical aspect combined with ecological benefits.

Bamboo is an endogenous tree and is found in abundant in most part of the country. Though it is vulnerable to environmental degradation and attacks by insects and moulds, its durability can be enhanced with preservation condition, treatment and curing thus increasing its service life greatly. An engineered Bamboo can substitute steel in making tensile stresses of RCC members and also reduces the consumption of cement in building. Both cement & steel are the most dominant & energy intensive materials used in construction.

Bamboo has a proven testimony as one of the oldest construction material through out the world. It provides a good thermal insulation

and has an advantage of being renewable and fast growing, contributes to higher carbon credit. With proper engineering, use of Bamboo in building can aid in the growth of alternative & sustainable development meeting the challenges of construction industry and growing housing sector.

Keywords: Ecosystem, Bamboo reinforcement, building material, endogenous tree.

1. Introduction

Power is the basic necessity for the economic development of a country in the present day civilization. Development of all kind of industries including construction, agriculture, transportation, etc totally depend on generation of electrical energy. The present power generation which is consuming the resources on earth rapidly is still inadequate to meet the demand. The increasing demand for building materials combined with the higher costs of urban land is marginalizing huge numbers of poor people. This is primarily because we are not able to harness the renewable resources of energy through sustainable technologies, though these resources exist abundantly through out.

The 'Building Sector' is the major source of demand for energy and materials that also produce by-product green house gases (GHG). However, a low-cost and renewable resource for permanent construction could be based on 'Bamboo'. In tropical regions, construction size bamboo reaches full strength already after 3-4 years. Growing on hill sides and along roads and fields it does not encroach on agricultural land either. On the contrary, bamboo can prevent erosion and even revitalize devastated rain forest soil. Local economy can be promoted at all steps in the supply chain. Bamboo can even help the whole world by its remarkable CO2 sequestrating capacity. Bamboo has historically been used as a building material due to its inherent properties, being regenerating, biodegradable, with high tensile strength, and light weight. However, despite its innumerable qualities one does not get to see bamboo as popular building material.

2. Method

The use of bamboo as reinforcement in portland cement concrete has been studied extensively through out the world. Bamboo as a construction material is in use for centuries, but its application as reinforcement in concrete had received little attention.

Unlike in wood, simply nailing and bolting in case of bamboo would be technically improper. Therefore a proven joinery methodology is necessary to develop whereby the stress is distributed evenly and channeled to a fixture that easily can be bolted to another.

With the right structural design columns, beams and floors made of bamboo as reinforcement instead of steel could replace steel reinforced concrete and steel

structures to a large extent. Bamboo reinforcement is used in two ways. Firstly like usual steel reinforcement embedded within concrete. Bond between bamboo and concrete is to be dealt separately. For this the surface of bamboo has to be roughened with the application of tar and sand. Secondly bamboo is used as an externally attached reinforcement. Joinery is the key concern while using bamboo as externally attached reinforcement. Proper methods of fastenings with nut-bolt etc are to be developed to place a bomboo in position. In case of externally attached bamboo reinforcement, there is an advantage of a lever-arm, which being more reduces the overall depth of beam. Externally attached bamboo may also be used for aesthetical purpose providing good looking architectural façade.

3. Selection & Characteristics

While selecting the bamboo culms (whole plants) for use as reinforcement in concrete structures, the following factors should be considered:

1. Use only bamboo showing a pronounced brown color. This will insure that the plant is at least three years old.
2. Select the longest large diameter culms available.
3. Do not use whole culms of green, unseasoned bamboo.
4. Avoid bamboo cut in spring or early summer. These culms are generally weaker due to increased fibre moisture content.

Some specific properties of Bamboo are given below:

- Specific gravity - 0.575 to 0.655
- Average weight - 0.625kg/m
- Modulus of rupture - 610 to 1600kg/cm2
- Modulus of Elasticity - 1.5 to 2.0 x105kg/cm2
- Ultimate compressive stress- 794 to 864kg/cm2
- Safe working stress in compression - 105kg/cm2

Bamboo is the fastest growing woody plant on the planet belonging to the grass family. It can be harvested every year from a mature bush without effecting the existence of the bush. A bamboo shoot barely takes about three years to attain its maturity. In fact, 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.

4. Case Study

The building has been built for a Trust in adivasi area at Bhopoli on western express highway near Manor. Constructed in 2007-08. , it was to be used as an office and hall. Author was also the part of its execution team. The building constitutes of conventional RCC column structure with spread footing & plinth beams in the substructure and RCC column and floor beams in the superstructure.

Fig. 1

Fig. 2

The wall and slab components are made up of externally attached bamboo reinforced panels casted on site. These panels consists of composite of cement & polypropylene material molded in the form of corrugated sheets of @ 2.7 m. x 0.9 m in dimension. Split bamboo were attached to the ridge portion of the corrugated sheet with the help of fixtures (nut-bolts). They were then placed across the span supporting on the beam. For longitudinal reinforcement whole bamboo are used fitted with nut-bolt to the transverse bamboo reinforcement (Fig.2). When all the panels are laid down, a desired thickness of concrete mix(as per structural design) was spread over it. Thus bamboo is completely designed to act in the tension zone and concrete in the compression zone. The form-work needed for the slab has also been eliminated thereby reducing the cost of formwork. (Detailed methodology is not the part of this paper)

The walls used in the building are of two types. The panels used for slabs were used for walls also, placing it horizontally between the columns (Fig.3). In some part of wall, bamboo are placed side by side with appropriate joinery creating a full bamboo façade on the external face (Fig.1). Both types of wall are plastered from inside with cement mortar to get smooth surface, which is easy to paint. All bamboo used in the structure are treated one making it less likely to be damaged and improving its life span. Door panel too is made up with bamboo (Fig.4) Not only the structure is capable of withstanding the loads as prescribed in the codes of practice, its cost is several times less than the so called “modern structures” constructed using concrete and steel. It is earthquake resistant too.

Fig. 3

Fig. 4

5. Conclusion

Bamboo reinforced Concrete for the key structural elements like slab, walls, columns and beams, of a modest dwelling unit can be successfully utilized for structural and non-structural applications in construction. A sustainable building , or green building, or green Architecture was fundamentally seen in so many ancient civilizations and traditional architectures. So it is no more a new trend except that in the present it is viewed through a new perspective and a with proper technological support.

Main characteristic features which makes bamboo as a potential building material, are its high tensile strength and very good weight to strength ratio. It can withstand upto 3656 kg/cm2 of pressure. It can be easily worked out by simple tools and machines. Above all bamboo is renewable raw material resource from agro-forestry. Properly treated and industrially processed, components made by bamboo not only are cost-effective, it can have reasonable life of 30 to 40 years. Construction techniques using as main material have been found very suitable for earthquake resistant housing. It is an environment- friendly, energy-efficient and cost-effective construction material. Bamboo is one of the oldest traditional building materials used by mankind. Bamboo is one of the oldest traditional building materials used by mankind. Imaginative design and the use of other locally available materials within the cultural context can make the bamboo building desirable rather than just acceptable.

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