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Possible Use of Bamboo as a Sustainable Building Material

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***Abstract*—With growing economy and associated development in housing and infrastructure, the virgin construction materials are consumed in large amounts. Mass production of cement poses a threat to the limestone reserve. It also threatens the depletion of ozone layer due to the proportionate emission of green house gas such as CO_2. The indiscriminate produce and use of OPC cement cannot lead to development strategy that is sustainable. There is a need to conserve the raw materials like limestone and reduce the production of cement. Bamboo serves as a versatile and sustainable natural material, as the bamboo trees re-grow very fast. Further, for properly treated bamboo, the tensile strength of its fibres can be up to three times stronger than structural steel. This paper presents a review of the research across the globe in possible use of bamboo as a sustainable green building material.**

***Index Terms*— Sustainability, Green building materials, Bamboo, Mechanical properties.**

I. INTRODUCTION

In our modern growing civilization resources are decreasing day by day. In industrial aspects bamboo is considered as green steel. Bamboo is a renewable versatile resource. Bamboo is used from ancient period as traditional building material. Bamboo is used for scaffolding works, flooring, walling, trusses & bridges and formwork supporting stands [1]. It has also been used in construction of a two-storey house [2]. It is light weight and economical. There are 1450 species of bamboo found across the world. Most of bamboo grows in Asian countries, Africa and Latin America. Not all types of bamboo are used in construction. Bamboo observes carbon dioxide (CO_2) and converts it into oxygen 35% more than regular trees. There are mainly 20 best bamboo species in the world. This paper presents the various parameters to be considered in using bamboo as a construction material. These include selection criteria, pre-treatment methods, regular treatment methods, material characteristics, mechanical properties and durability aspects of bamboo [3], [7], [8].

II. SELECTION OF BAMBOO

Bamboo which is 3-6 years old is used for construction. Fresh and untreated bamboo culms has green colour and has poor material properties to be used in construction. The bamboo which contains higher moisture contents are also generally neglected. The bamboo after sufficient aging turns brown in colour, and in such a state it is advised to select the largest culms available. It is recommended that the cutting of bamboo be avoided in early summer [3], [7], [8].

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A.Pretreatment of Bamboo

Sizing: The bamboo is natural material with its own shape and structure. Design of bamboo is not possible. Cutting and splitting bamboo is based on the structure.

Splitting: It is recommended to cut or split the larger culms into smaller sections of diameter of about 0.75 inch. And those sections or culms which have less than 0.75 inch diameter can be used as they are. The recommended dimensions are used while splitting of bamboo.

B.Treatment of Bamboo

Firing: Initially bamboo is cleaned and then leaves are to be cut. The smooth bamboo is straightened by firing method. This method keeps bamboo away from pesticides and insects.

Boric acid preservation treatment: Holes are drilled into the bamboo up to the center with small diameter bits based on the actual diameter of the bamboo culms. This drilled bamboo is soaked in borax acid solution for about 2 days. This allows the mineral to percolate into deeper regions and all nodes. The bamboo is then removed the borax acid solution pool. In order for the solution to be drained and be reused again, it is stacked vertically. The bamboo is then exposed to the sun for some time and then placed and to dry gradually in a dry and cool place. Preservation treatment costs a minimum charge of INR 40-50 per pole.

Neem Seed Oil: To improve the water resistance it has been observed that the high temperature neem seed oil treatment of bamboo is very useful. When the bamboo is soaked at 600 ^{o}C in hot neem seed oil for 4 hours, then it shows improved water resistance and dimensional stability as compared to those soaked in oil at room temperature for 24 hours.

C. Untreated Bamboo

The life span of untreated bamboo is reduces in accordance with the conditions that it is exposed to. The following are the life spans of bamboo in different conditions. In exposure to soil and atmosphere the age is 1.3 years, when the bamboo is under cover it is 4.7 years. When there are very favorable conditions, the life span is 10-15 years. The species of bamboo also determines its age and not just the external environment.

D. Significance of Bamboo

In reinforced concrete construction which is most widely used in buildings and infrastructure, various grades of steel are extensively used. However, such heavy usage of steel at the current rate will exhaust the iron ore in 28 years. Bamboo is an alternate material, which is found abundantly and which can regenerate itself very fast after being cut and durable if properly treated. The hollow tabular structure has high resistance against wind forces. These properties of bamboo helps in using it as an alternative to steel in some circumstances.

E. Use of Bamboo as Reinforcement

Bamboo as reinforcement is an alternative idea and many experiments are conducted to check the properties of bamboo [4], [5]. Each species differs in their test results on the characteristics, texture, thickness and strength. Along the fibres bamboo has higher strength than compared to the transverse direction. Bamboo consist cellulose fibres aligned across the length. Bamboo can resist wind forces due to high thick fibres near to the outer length of bamboo.

F. Water Absorption Property of Bamboo

The greater limitation of using bamboo as reinforcement is the property of its water absorption. The water absorption capacity varies according to various species. Water absorption swells the bamboo and in turn puts stress in the internal concrete matrix and may develop cracks. This also makes the bamboo weak. Some of the species such as Dendrocalmusgiganteus (DG) and Bambusa Vulgaris (BVS) have less water absorption. Certain chemical treatments can alter the rate of water absorption. The adhesive property of bamboo, the water repelling property and rough surface on the bamboo are the factors to be consider while treatment.

Durability of Bamboo Material: Durability of bamboo material is mainly based on treatment of bamboo. Its fibers can be three times stronger than steel. When a flexural member is subjected to normal service loads it develop some cracking because of its low modulus of elasticity.

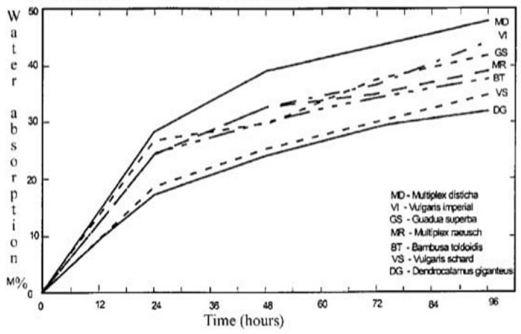

Figure 1.Water absorption rate of different bamboo species [3]

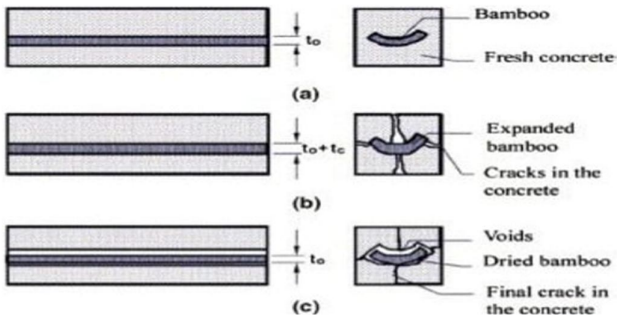

Figure 2.Action of untreated bamboo as reinforcement material[3]

Guadua Angustifolia: Guadua Angustifolia is the one of the best and giant bamboo mostly found in a America and China. There are 20 main bamboo species mostly used for construction. It is also called as king of bamboo and consist of thick walls and strong fibers. It is mostly used for construction in Colombia.

Tests on Bamboo According to ISO: The abbreviation of ISO is international organization for standardization know as ISO .Mechanical properties of bamboo was determined in 2004.Bamboo poles were approved as a building material throughout worldwide. The ISO 22157 standard describes bending, compression, tension, shear strengths and durability. The tensile strength of bamboo show an impressive results which is three times stronger than construction grade timber. The compressive strength for guaduaangustifolia was observed greater at 3-4 years old culms. Guadua offers the most resistance to shear in the middle . It has bending strength nearly around 80 N/mm^2.

III. Conclusions

Bamboo is mainly used in Earthquake prone areas due to its elastic property.It absorbs shock forces and resists high wind forces structural efficiency of bamboo is low.Shrinkage of bamboo is high when compared to other wood.Greater strength is observed in middle part of largest culms.Untreated bamboo has low bonding strength and voids are formed.It resist high buckling loads due to nodes.The authors can conclude on the topic discussed and proposed. The treated bamboo can be used in the construction. Overcoming the limitations of bamboo can serve as partial replacement to structural steel helping in a sustainable technology.

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