**A REVIEW PAPER ON BAMBOO AS REINFORCEMENT MATERIAL IN CONCRETE STRUCTURES**

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**Abstract:** Iron ore reserves all around the world are predicted to completely exhaust by 2070. With constantly increasing demand and depleting resources, there is a need to adopt cost effective and eco-friendly materials in construction industry. This paper studies the use of bamboo as an effective solution. Bamboo is an ancient solution and its use in construction industry is the (re)discovery of a Sustainable Material with Endless Possibilities. The physical and mechanical properties of bamboo proved to be appropriate to replace steel as reinforcement material in members. It has good tensile and compression strength. The tensile strength of bamboo and steel falls in the same range. Using bamboo may reduce the cost of construction upto 40%. Bamboo is light in weight, easily available renewable resource. This paper studies the mechanical and physical properties of bamboo, measures to make bamboo more suitable as a reinforcement material. Test results on bamboo reinforced beams are reviewed.

1. **INTRODUCTION**

Steel and concrete are the primary materials used in construction as they have extraordinary properties, including strength, availability. Production of this material requires high consumption of energy and natural resources causing high environmental contamination.

With researches going worldwide to explore the cost effective and eco-friendly substitute’s an insight of material already been used for decades to build structures such as rural houses flashed- an ancient solution for present day problem- BAMBOO.

Bamboo is primarily a type of giant grass with woody stems located mainly in America, Asia and Africa. There are approximately 90 genera and 1100 species of bamboo. It is fast growing resource which can be harvested in a short time which is 3-5 years. A single bamboo clump can produce upto 15km. of usable pole with upto 30cm in diameter in its lifetime. 1m3 of bamboo substituting steel saves 3 tons of CO2

Bamboo has a good tensile strength and light weight. Bamboo has low manufacturing cost compared with steel. Bamboo is able to resist more tension than compression. The fire resistance is very good because of the high content of silicate acid.

Experiments conducted on bamboo over years prove that the tensile strength of bamboo is comparable to that of mild steel and compressive strength of bamboo is slightly less than that of steel. The physical and mechanical properties of bamboo have been studied and compared with steel which describes its suitability as a replacement to steel reinforcement. Bamboo reinforced concrete follows same mix design as used for steel reinforcement.

A review of using bamboo as a structural material is presented here by studying research papers over the years and also the latest development in this field.

1. **LITERATURE REVIEW**

 Ghavami, K. (1995) [2] studied the physical and mechanical properties of seven different bamboo, water repellent treatment of bamboo and bond strength between bamboo and light weight concrete. The research was conducted in Brazil where conventional materials such as steel are expensive as well as scarce. In such situation locally available material Bamboo is ideal as construction material. This study shows that for bamboo reinforced lightweight concrete beams, the ultimate applied load increased by 400% compared to un-reinforced concrete beams. The research showed that there was lower bonding between bamboo and concrete as compared with steel. Use of locally available negolin sand wire treatment improved the bonding by 90%. Further work in treatment of bamboo and analysis of bamboo reinforced beams is required for development of a simple design code.

 Ghavami, K. (2005) [3] presents the results of studies of microstructure of bamboo as a functionally gradient material helpful in establishing bamboo’s composite behaviour through the rule of mix. It summarizes bamboo reinforced beams, permanent shutter concrete slabs and columns. This paper studies on the basic characteristic’s, durability of bamboo, effect of water absorption and bonding strength of bamboo in concrete. To improve the bond strength, three factors of impermeability treatments were used to bamboo- Adhesion properties of the substance applied to bamboo and concrete, water repellent property, topography of bamboo and concrete interface. The most effective treatment- water treatment with a thin layer of epoxy is an expensive treatment. Therefore 20 products were studied in pull-out tests from which Negrolin on bamboo shows a 90% increase in shearing bond strength. In recent studies Sikadur 32-Gel increases the bonding strength by 5.29 times. Based on this research and others carried out in Brazilian Universities norms were created and later evaluated by ICBO to be included in ISO norms, Results proved that bamboo can substitute steel and is suitable for use in many constructions. Furthermore there is a need to establish the characteristic strength of bamboo based on a statistical analysis.

 M.R. Wakchaure, S.Y. Kute (2012) [4] presents results of experimental investigations for mechanical and physical properties of the bamboo species. The research is done on Manvel (Dendrocalamus strictus) for one, six and twelve month’s period at top, middle and bottom locations of bamboo. Moisture content, specific gravity, water absorption, dimensional changes, tensile and compressive strength are worked out. Moisture content governs the mechanical properties and plays a vital role in deciding the life of bamboo. Drying bamboo is important for its conservation and bamboo are seasoned by air drying. Specific gravity remained almost same based on oven dried mass. Specific Gravity is higher for top portions. Water absorption was at faster rate for initial 72 hours and declines after that. It was inversely proportional to the moisture content. Dimensional changes were proportional to the water absorption and vary with seasoning. The water absorption was less at one month seasoning than at six and twelve months. The percentage of dimensional change, at seventh day of water absorption, for thickness was more at levels of seasoning- 7.59% for one month seasoning which reduces to 5.55%, at 12 months of seasoning. The percentage change in cross section is 15% at one month seasoning against 10 % that for six and twelve months. The percentage change in cross sectional area ranged 0.28 to 0.23%.The tensile strength of middle portion was larger than that of top and bottom whereas the compressive strength of top portion always remained larger than top and bottom.

 Nathan Schneider1, Weichiang Pang2, Mengzhe Gu3 (2014) [5] acknowledged the work done by other researchers Yu et al. (2008), Cao and Wu (2008), Ghavami (2005), Khare (2005), Amada (1997), and Kankam and Perry (1989) in general properties of bamboo. The study aimed to confirm the mechanical properties of Moso bamboo to be used as reinforcement in concrete beams. Tensile strength, modulus of elasticity and bond strength tests were worked out. Results for tensile tests indicated the average tensile strength of bamboo around 18ksi and modulus of elasticity around 1149ksi.The results confirmed the benefit of diaphragms on bond strength. Test specimen with one diaphragm had bond strength of 106psi whereas one without diaphragm had bond strength of 59psi. Bamboo cages were successfully constructed in a unique closed stirrup design.

1. **CONCLUSION**
2. Utilisation of bamboo as a structural material should be emphasized as non-renewable materials being primarily used are on the verge of extinction.
3. Bamboo can be harvested in 3-5 years of short span and is available easily.
4. Bamboo has maximum compressive strength in the range of 45- 60 N/mm2
5. Tensile strength of bamboo is suitable and can be used as reinforcement material.
6. Moisture content of bamboo for different species varies which affects the strength of the material.
7. Water absorption of bamboo is high. Some locally available cheap material may be used to treat bamboo without hampering its bond strength with concrete.
8. **REFRENCES**
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