Original Research Paper

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FEASIBILITY STUDY ON LOCALLY AVAILABLE BAMBOO AS REINFORCEMENT IN CONVENTIONAL RCC STRUCTURAL MEMBER

Engineering

KEYWORDS: Reinforcement material, Bamboo, Seismic, CO2 emission, Energy consumption, construction material.

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ABSTRACT

Globally, iron and steel sectors are the second largest industrial user of energy, consuming 616 million tons of oil in 2007, and largest industrial source of (CO2) emissions with 2.3 Giga ton in 2007. There is an urgent need for using naturally occurring products as construction material to reduce the growth of energy consumption. One of the possible solution is to replace steel with bamboo. Bamboo is widely recognized as one of the most important non-timber forest resources because of its high tensile strength and socioeconomic benefits with bamboo based products. This experimental research is focused on the use of bamboo as reinforcing material in beam and comparing it with conventional steel reinforced beams. It's a seismic resisting material for sustainable environment development as it absorbs nitrogen and carbon dioxide from the atmosphere during its growth.

1. INTRODUCTION

In most countries, concrete is widely used as the foundation for the infrastructure. Concrete is used largely because it is economical, readily available and has suitable building properties such as its ability to support large compressive loads. However, the use of concrete is limited because it has low tensile strength. For this reason, it is reinforced, and one of the most popular reinforcing bars (rebar) is steel. It is available and affordable in most developed countries but unfortunately not all parts of the world and steel reinforcements at some point may no longer be available. Even today there exists a need for more economical and readily available substitute reinforcements for concrete. In some parts of the world many buildings are still constructed with concrete or mud-bricks. This is dangerous in case of seismic activity. These buildings have little hope of standing in case of an earthquake. Steel reinforcement would be an ideal solution, but the cost is a problem. The idea of using bamboo as possible reinforcement has started gaining popularity.

BAMBOO CHARACTERSTICS

Bamboo is not a tree but giant grass. Bamboo culms are cylindrical shell divided by solid transversal diaphragms at nodes and have some intriguing properties such as high strength in the direction parallel to the fibers, which run longitudinally along the length of the culm, and low strength in a direction perpendicular to the fibers. The density of fibers in cross-section of a bamboo shell varies with thickness as well as height. Fiber distribution is more uniform at the base than at the top or the middle. This is because bamboo is subjected to maximum bending stress due to wind at the top portion of the culm [1].

Bamboo is a natural functionally[2]. It is a composite with hierarchical structure. The strength of bamboo is greater than most timber products.

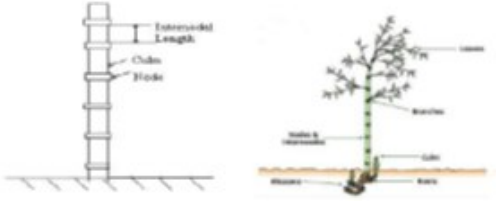

Fig1. Whole Bamboo Culms and Structure of Bamboo Plant

The mechanical properties of bamboo vary with height and age. Research findings indicate that the bamboo strength increases with age. The optimum strength is achieved between 2.5 and 4 years. The strength decreases there after[3]. The function of nodes is to prevent buckling and arrest axial crack.

One of the amazing aspects of bamboo is the way it interacts with the environment. It has been discovered that bamboo can prevent pollution by absorbing large amounts of nitrogen from waste water and reducing the amount of carbon dioxide in the air [3].

COMPARISONS OF BAMBOO AND STEEL

One of the properties that make bamboo a good substitute to steel in reinforced concrete is its strength. The strength of bamboo is approximately halfthetensilestrengthofsteel and greater than most timber products. Bamboo is easily accessibleasitgrowsinal most-everytropical and subtropical region. This lowers the cost of construction and increases the strength of the buildings compared to unreinforced ones.

One major problem with bamboo is that it is a living organism which is prone to fungi and insect attacks because of its high content of nutrients. In order to combat this problem, it becomes necessary to treat the bamboo to protect it from the environment. Steel does not have this problem but it also needs to be coated in order to protect from rusting. Bamboo is lighter in weight compared to steel. Due to its lowmodulusofelasticity, bamboo can crack and deflect more than steel reinforcement under the same conditions. These properties, when combined, suggest that bamboo will make a fine addition to the current selection of materials, but it is necessary that people in general be made more familiar with its strengths and weaknesses.

GOALS AND OBJECTIVES

The goal of this research is to determine the feasibility of using bamboo reinforcement in concrete beams and comparing the same with steel reinforced concrete beams i.e. to provide a preliminary contribution toward the collection of the mechanical properties and behaviors of Bamboo reinforced beams.

In concrete, reinforcement is provided for tensile strength, a property that concrete lacks. Therefore, if Bamboo is to be used as concrete reinforcement, it is necessary to understand how Bamboo

behaves under tension. This study will consider well-seasoned bamboo, cut into thin strips, and tested without waterproofing agents. Once all the data is collected, a series of stress vs. strain graphs areplotted and analyzed to determine the tensile properties of Bamboo.

Single point load tests of Bamboo reinforced concrete beams are conducted to examine the behavior of Bamboo in concrete. Well dried bamboo, cut into 19mm wide 2.36m long strips is used for the tests. The beams used will be 8ft. (2.44m) long, 200mm wide and 500mm deep. The percentage of reinforcement is as per the literature [4] i.e. 3%. When the tests are completed, the results will be compared with steel reinforced balanced section and plain concrete beams to compare their performances.

2. EXPERIMENTAL PROGRAM
MATERIALS CONSIDERED FOR THE STUDY.

CONVENTIONALCONCRETE(M 35).

The concrete used for the beams was made using Ordinary Portland cement 53 grade, sand as fine aggregate, coarse aggregate with a maximum size of 20mm.A typical beam has the dimensions of 2.44m x 500mm x 200mm and the volume of 0.25m3 for a compressive strength of 35 MPa. Single beams concrete mix proportion has been arrived from the mix design using IS10262-2009,as shown in table below.

LOCALLY AVAILABLE NATURAL DRIED BAMBOO

For the present study naturally dried bamboo collected from Bamboo Bazar Mysore is used. It is known from literature that the finest width of the Bamboo strips of 19mm [5], provides maximum area with the least amount of curvature. Since the beam was 8ft. (2.44m) long, it was determined that the Bamboo culms needed to be cut 8ft. (2.44m) long and19mm wide without adjusting their thickness, as this could reduce the strength of the strips.

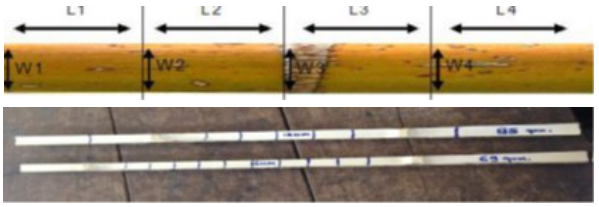

Fig2.Locally Available natural dried Bamboo (2X12MM, 2X19MM)

TENSILE STRENGTH OF LOCALLY AVAILABLE NATURAL DRY BAMBOO

The tensile test is conducted on different samples of bamboo to find a pattern of behavior based on the structure of bamboo as a plant. These tests are performed on several specimens with and without nodes. The results suggested two vague patterns. The first pattern observed is that if a node is present, the failure often occurred at thenodeasshowninFigures2.3.1and2.3.2,whichshowsfourdifferentte st specimens after failure at the nodes. The second pattern observedis that specimens without nodes of ten heldalarger load before reaching failure in contrast to those with a node. Test results of different samples are given below: Assume factor of safety as 2 [4].

Table1.Concrete mix details for the water/cement ratio 0.5.

Cement	Coarse aggregate	Fine aggregate	compressive strength in MPa
386.94	1161.39	851.67	38.5
1	3.0	2.2	

Table 3.Specification and test results of Tensile strength of Bamboo.

Sl.no	Test Results	Without	With node (S2)
1	Width (cm)	1.82	1.34
2	Depth (cm)	1.14	1.08
3	Length (cm)	33	40
4	Weight (gm)	81	53
5	Gauge length (cm)	9	7
6	Area (cm2)	2.075	1.45
7	Young's modulus (GPa)	14.01	12.23
8	Ultimate tensile strength in (MPa)	83.2	94.7
9	Allowable tensile strength (MPa)	41.6	47.35

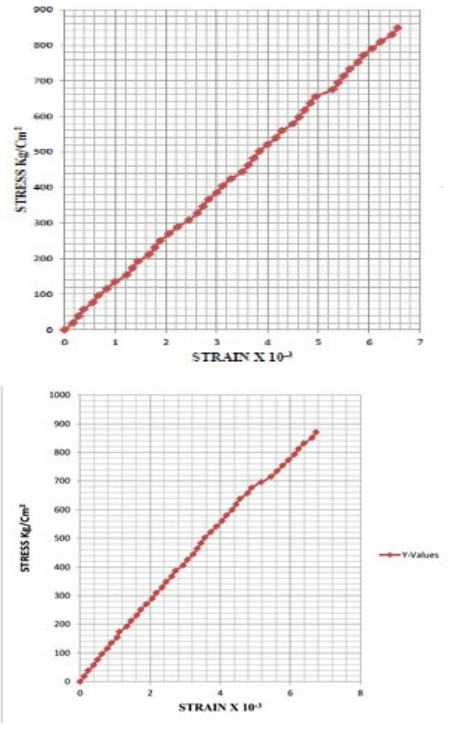

Fig 3. Stress strain relationship for both the specimen (S1 and S2)



Fig 4. Tensile Test Specimen with Node



Fig 5. Tensile Test Specimen without Node

Beam Design (bamboo reinforced)

Since it is the purpose of this research to determine the feasibility of the use of Bamboo as reinforcement in concrete, it is necessary to compare its behaviors to steel, the traditional reinforcement. Therefore beam designs in accordance with IS standards and specifications are used. The width of bamboo bars of 19mm, as suggested by reference [4] concerning bamboo reinforced concrete. The clear cover (shown in Figure 2.4) is between 35mm and 50mm for steel reinforced concrete, and the clear spacing between reinforcement should be the greater of 25mm or 1.33 times the maximum aggregate size, with a minimum of 25mm. Both the clear cover and the spacing were chosen as 40mm, usingthese dimensions and reference U.S. Naval Civil Engineering Laboratory 1966, 2000, a width of 200mm and a depth of 500mm were chosen for the test beam The

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next step is to determine the length of the beam. Evaluating the lab conditions and desired test set-up in accordance to literature, the beam length of 8ft (2.43m) is chosen. Figure 4 shows the final dimensions of the test beam. The loads were placed 1.22m (1220mm) from each edge of the beam.

Table 4. Beam Detailing consider for the present experimental work

Sl.no	Test Results	Without node (S1)	With node (S2)
1	Width (cm)	1.82	1.34
2	Depth (cm)	1.14	1.08
3	Length (cm)	33	40
4	Weight (gm)	81	53
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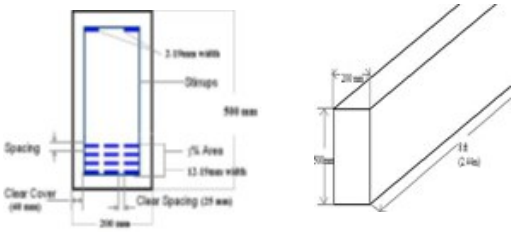

Reinforcement Preparation

Choosing the best method to attach the Bamboo strips together requires careful consideration. Different ideas considered are using thin string or fishing line to tie the strips together, but would not support bamboo bars well enough for the reinforcement to stay in the desired shape. The method eventually preferred for tying the Bamboo bars together was binding wires.

After much difficulty, it is decided to tie each layer separately, and then tie the layers together. For the design of 3% reinforcement, four layers of reinforcement are provided. This is determined by measuring the cross-sectional area of each strip of Bamboo, calculating the average area and then calculating how many strips at that given cross-sectional area would provide 3% cross-sectional area of the entire beam. Before tying the strips together, they were cut to the exact needed length. Generally with steel reinforced concrete beams, a hook length, as shown in Figure 6, is employed at the ends of the beam to enhance the bond between the reinforcement and the concrete. Due to the nature of Bamboo, it is impossible to provide this hook length. Therefore, the Bamboo strips of about 8ft. (2.44m) longare cut to 7ft. 9in (2.36m), to provide 40mm cover on either side of reinforcement as shown in Figure 2.5. Another component of the reinforcement is the stirrup, which provides shear reinforcement. Figure 2.6 shows the two most common methods of providing stirrups.Typical steel stirrups constructed are either open loop or closed loop stirrups, as shown in Figure 2.7. Young Bamboo is chosen because of its flexible nature. Young Bamboo culms are split vertically with a knife, then bent into shape and secured with steel wire. This proved to be very difficult to manufacture. The closed loop type shown in Figure 2.10 is impossible to construct for the same reasons as providing the development length is impossible. Therefore, it is decided to make the U-shape without curving the ends or single strips open stirrups as shown in the figure 6.



Fig 6. Casting and poring of concrete for Bamboo reinforced concrete.

Test on Bamboo reinforced beam

The Bamboo reinforced beam test is done with 3% reinforcement. The load is applied at the center and the deflection is recorded after every 15kN until 240kN is reached. After 240kN load is applied, the load is applied with no readings until ultimate failure at 295kN. Crack initiation and propagation are recorded throughout the testing. The first crack initiated in vertical direction, the front center of the beam at 105kN fig6. These are flexure crack and are followed by second crack extending from it at 135kN. The third crack occurs on right side of the beam at 150kN followed by fourth crack mirrored on left side of the beam at 165kN, both in vertical direction. The sound of Bamboo cracking is heard at 280kN, and the beam fails at the load of 295kN as shown in fig 7.

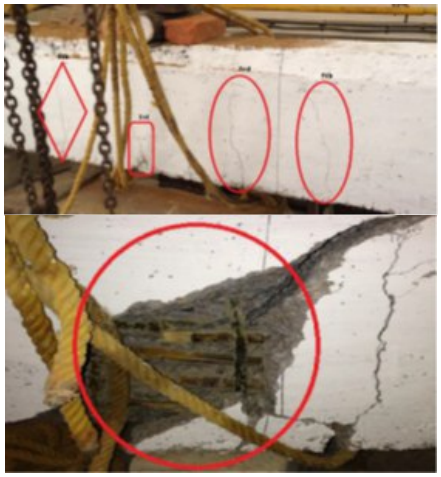

Fig 7. Failure in Bamboo Reinforcement Beam showing In-Tact at failure Crack

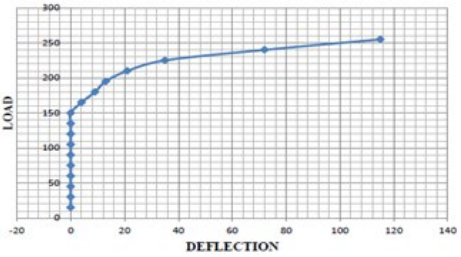

Fig 8 Load v/s Deflection (Bamboo Reinforcement)

3. Test on Steel reinforced beam

Single point load test on a steel reinforced beam is also done. The load is applied at center and its failure load is noted. Crack initiation and propagation are recorded throughout the testing. The first crack is initiated in front at center of the beam at 130kN as shown in fig 8. This is followed by a second crack at 155kN on left side followed by third crack mirrored on right side at 180kN. The sound of cracking is heard at 330kN, and the beam fails at the load of 350kN as shown in fig 9.

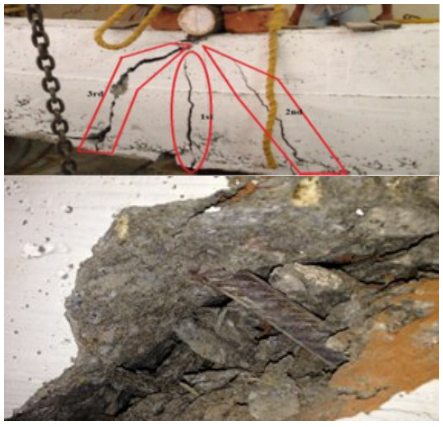

Fig 9. Failure in Steel Reinforcement Beam showing In-Tact at failure Crack

4. CONCLUSION

Based upon the experimental study, the following conclusions are at the forefronts:

1. Tensile tests indicate that the presence of nodes in bamboo specimens affect its behavior

2. The stirrups are made up of flexible young bamboo. 13mm size is selected to obtain flexibility

3. The constitutive relationship of the nodes differs from those of the intermodal region

4. Use of bamboo as reinforcement may lead to economy as compared to structures reinforced with steel; thereby overall cost of construction can be reduced (10-20%)

5. Based on the results of point load test, it is concluded that Bamboo can potentially be used as substitute to steel reinforcement. However, for regions of the world where availability of steel is limited and plain concrete members commonly being used, the use of reinforced bamboo concrete is highly recommended

6. The breaking patterns of the tensile tests inconclusive. However, there is an indication that the fracture points of the tensile specimens containing nodes occurred at the nodes

7. In tensile test the specimens without nodes generally failed at higher loads than those specimens with nodes

8. The failure loads for both beams were almost same, so we can conclude that the theory used for steel reinforced beam can be appliedto bamboo reinforced beam.

5. REFERENCES

1. Ghavami, K. (2004), "Bamboo as Reinforcement in Structural Concrete Elements", Cement & Concrete Composites.
2. Amada, S., Ichikawa, Y., Munekata, T., Nagase, Y. and Shimizu, H. (1997), "Fiber Texture and Mechanical Graded Structure of Bamboo", Composites Part B, Vol. 28B, pp 13-20.
3. INBAR (2002), (International Network for Bamboo and Rattan) "Bamboo Structure at CO: Advantages and Disadvantages", 6 June 2005,
4. U.S. Naval Civil Engineering Laboratory (1966, 2000) "Bamboo Reinforced Concrete Construction",
5. Mardjono (1998), "Bamboo knowledge based building design decision support system".
6. INBAR (2005), (International Network for Bamboo and Rattan) "Bamboo in Construction: An Introduction."
7. ISO (1999), (International Standard Organization), "Laboratory Manual on Testing Methods for Determination of Physical and Mechanical Designing and Building with Bamboo", TC 165 N315.
8. Naveen, C.G., Sunil, N. and Sarangapani, G. (2012), (National Institute of Engineering) "Bamboo Reinforced Concrete".
9. Nirmala, D.B., Raviraj, S. (2015), "Development of optimal self-compacting concrete containing fly-ash and spent foundry sand by Taguchi method", Journal of Concrete Technology, Vol.1, No1, pp. 14-21