An Experimental Study On Bamboo As A Reinforcing Material In Concrete

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Abstract- *This research paper critically examines the role of bamboo as a reinforcement material in concrete structures, synthesizing existing research findings and insights without conducting new experiments. Through an extensive analysis of published literature and case studies, this research highlights bamboo's remarkable strength-to-weight ratio and flexibility, making it a promising alternative to conventional steel reinforcement. The sustainability aspect of bamboo reinforcement is a central theme, focusing on its renewable nature, minimal environmental footprint, and carbon sequestration potential. This eco-friendly profile aligns with the growing demand for sustainable building materials and practices.Practical considerations are thoroughly examined, including challenges related to standardization, building codes, and the long-term performance of bamboo-reinforced concrete in different environmental conditions. The researchalso identifies gaps in current research and suggests avenues for future investigation to advance the use of bamboo as a viable reinforcement material. Flexural strength test of the bamboo stick reinforced beam, laminated bamboo reinforced beam and steel reinforced beam with the size of 150 mm x 150 mm x 700 mm has been undertaken to determine the performance of bamboo as reinforcement. From the test, it has resulted that bamboo give good potential as an alternative material in concrete reinforcement for low-cost housing industry.*

Keywords- Bamboo, Concrete, Beam, Flexure Strength

I. INTRODUCTION

A study of the feasibility of using bamboo as the reinforcing material in precast concrete elements was conducted at the U. S. Army Engineer Waterways Experiment Station in 1964. Ultimate strength design procedures, modified to take into account the characteristics of the bamboo reinforcement were used to estimate the ultimate load carrying capacity of the precast concrete elements with bamboo reinforcing. This study has been taken as a reference in the study conducted henceforth.

The investigation of the use of bamboo as a complimentary material with steel in RCC construction has been shown in this study with the economy, safety, convenience and durability of application of the particular idea. Since the use of bamboo in the ancient times for housing purposes, it has been diminishing in our world in the form of a building material in despite its rich properties, strength and economic advantages. There are several methods presented and deduced by universities and the U.S navy and has proven the validity of the use of bamboo in structural members such as columns and girders. Hence in this report, the methods are presented by the members of this group for the better strength and more applicable methods with the least compromise in strength. Methods that have been put forth in this report are not guaranteed to have the best outcomes or with any assurance of the maximum strength of a structure, the designs being presented are those which have been tested on software simulation for safe working load and failure analysis. This could be very helpful and have a very good breakthrough in the field of concrete designing with prominent economical benefits over steel (being used with it) and its benefits related to the reduction of carbon emission in the atmosphere, if methods like these are applied extensively and studies for the development of a code pertaining to concrete design with bamboo reinforcements can be brought forward for a better future of economical and eco-friendly RCC construction.

Concrete is an extensively used construction material for its various advantages such as low cost, availability, fire resistance etc. But it cannot be used alone everywhere because of its low tensile strength. The plain concrete possesses a very low tensile strength, limited ductility, and little resistance to cracking. So, generally, steel is used to reinforce the concrete because steel has a hightensile strength to complement the low tensile strength of concrete. In construction, the use of steel is very costly and caused so much energy-consuming in its manufacturing process. Thus, a suitable material must be used to substitute steel in construction. The material must provide availability with a low cost, environmentally friendly and also less energy-consuming. Addressing all these problems, bamboo is one of the suitable replacements of reinforcing bar in concrete for low-cost constructions. Bamboo is easily

accessible as it is available in almost every tropical and subtropical region. One of the characteristics that would make bamboo an excellent substitute to steel in reinforced concrete is its strength. The strength of bamboo is greater than many advantageous timber products, but it is quite less than the tensile strength of steel. Bamboo is natural, cheap, widely available and most importantly strong in both tension and compression. The tensile strength of bamboo is relatively high and can attain 370 Mpa [3], which makes bamboo an attractive substitute to steel in tensile loading applications. This material can reduce the cost of construction and increases the strength of the buildings that would otherwise be unreinforced. This paper aims to study the characteristic of the bamboos for concrete reinforcement performance, investigate the characteristic yields stress of the bamboo and to compare the bamboo and steel reinforcement for low-cost housing industry.

II. LITERATURE REVIEW

H.Y Fang et al. [2018] Department of Civil Engineering, Lehigh University, Bethlehem submitted thier paper which presents the basic factors for selecting bamboo, the mechanism of bamboo-water-concrete interaction, and the sulfur-sand treatment of the bamboo used for reinforcement in structural concrete.

Youngsi Jung [2019] at University of Texas, Arlington studied the use of bamboo as reinforcement in concrete as a substitute steel. His study was focused on the tensile strength of bamboo and its pullout characteristics in concrete.

Markos Alito [2020] studied the bamboo as construction material for the construction of lowcost houses in Ethiopia. He identified an alternative method for low-cost construction for areas where steel is costly. Based on his research findings he suggested theta bamboo might replace steel in light constructions in the tensile elements.

Lakkad et al. [2021] studied mechanical properties of bamboo, mild steel, polyester resin and glass reinforced plastic. The mechanical properties of bamboo were found to be better than those for other reinforcing materials.

Dr. Ashok Kumar Gupta, Dr. Rajiv Ganguly, Ankit Singh Mehra [2015], the density of bamboo is very low which makes it very light material. Water absorption capacity is increase as increase in node. Tensile stress increase as increases in number node**.**

Sanjeev Gill, Dr. Rajiv Kumar[2016], bamboo can use as reinforcement. Bamboo is cheap substitute for steel because bamboo grows much faster and is renewable source after 5-6 years. Water absorption in bamboo is directly affect the strength of bamboo. Tensile strength of bamboo is good so it can be use as a reinforcement. The behavior of bamboo as a reinforcement is same as plain steel bar.

Pritesh Kumar Singh, Aashish Jodhani, Abhay Pratap Singh[2016] , it is been found that bamboo in the vertical position is more durable than in horizontal. Bending of bamboo can be permanently bent if heat, either dry or applied the pressure. The type of coating will depend on the seasoning material is used. A brush coat or dip coat of emulsion is useful for treatment of bamboo. Bamboo reinforced concrete beam design is similar to steel reinforcing design.

Ajinkya Kaware, Prof. U. R. Awari, Prof. M. R. Wakchaure[2018], bamboo weak at node, maximum failure occur at node of the bamboo. Bamboo is weak in bond stress hence it should be treat with epoxy coating to get bond stress. Bamboo is weak in shear so it cannot used as a shear reinforcement. Tensile strength of bamboo is good so it can be used as a reinforcement in R.C.C structure for low cost housing. The behaviour of bamboo is same as the steel bar. Moisture of content of bamboo is varies according to topography.

III. METHODOLOGY

Bamboo material:

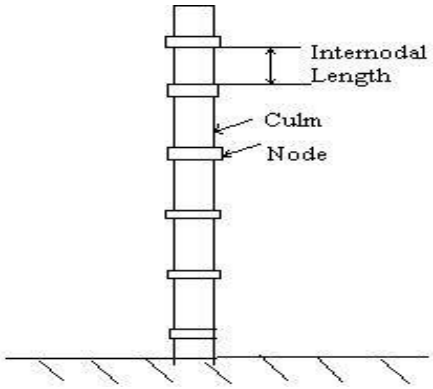
Belowarethematerialsthathavebeenusedinthisstudy:

Selection and preparation of bamboo:

For the sample selection of bamboo, the brown colour of bamboo with longer and great diameter culms has been selected. Bamboo culms are cylindrical shells as shown in Figure, and are divided by nodes as solid transversal diaphragms. The strength distribution is more uniform at the bottom of bamboo than at the top or at the middle of it since it is subjected to maximum bending stress due to wind at the top portion of the culms. Based on the previous studies, the following criteria have been measured in this research for the selection of bamboo culm for use as a reinforcement in the concrete structures:

- The bamboo showing a brown colour with at least three years old is selected.
- The accessible biggest diameter of the culm is being selected.
- The whole culm of green bamboo is not being used.

- Avoid cutting the bamboo in spring or early summer because the bamboo is weaker due to increase in fibre and moisture content.



Preparation of Mould:

The mould used in this study measures 150 mm in width, 150 mm in height, and 700 mm in length. This specific size was selected to accommodate the testing requirements and ensure the consistency of the samples produced.

Figure 1. Mould

Bamboo stick reinforced beam specimen peparation:

Two beams each of size 150x150x700 mm (supported length 600 mm with 50 mm overhang on each side to avoid overturning during testing) were cast.

Figure 2. Bamboo stick placement

spacing as well as number of bamboo sticks was suitably provided based on the design as per IS-456:2000 . In all the beams shear reinforcement was provided in the form of steel stirrups of diameter 8 mm at an spacing of 95 mm centre to centre as shown in Fig.2. Beams were tested in flexure under two equal concentrated loads each applied at the one third point of the beam with the help of hydraulic jack.[6]

Figure 3. Casting of beam

Laminated bamboo reinforced beam specimen peparation:

Two beams each of size 150x150x700 mm (supported length 600 mm with 50 mm overhang on each side to avoid overturning during testing) were cast.

Figure 4. Laminated bamboo reinforcement

spacing as well as number of laminated bamboo was suitably provided based on the design as per IS-456:2000 . In all the beams shear reinforcement was provided in the form of steel stirrups of diameter 8 mm at an spacing of 95 mm centre to centre as shown in Fig. 4. Beams were tested in flexure under two equal concentrated loads each applied at the one third point of the beam with the help of hydraulic jack.[6]

Figure 5. Casting of beam

Steel reinforced beam specimen peparation:

Two beams each of size 150x150x700 mm (supported length 600 mm with 50 mm overhang on each side to avoid overturning during testing) were cast.

Figure 6. Steel reinforcement

spacing as well as number of steel was suitably provided based on the design as per IS-456:2000. In all the beams shear reinforcement was provided in the form of steel stirrups of diameter 8 mm at an spacing of 95 mm centre to centre as shown in Fig.6. Beams were tested in flexure under two equal concentrated loads each applied at the one third point of the beam with the help of hydraulic jack.[6]

Properties of material used

43 grade Ordinary Portland cement of normal consistency 27%, initial setting time 28 min., final setting time 560 min. and compressive strength at 28 days as 40 MPa was used throughout the test. Locally available Badarpur sand was used as fine aggregate having specific gravity and fineness modulus as 2.60 and 2.65 respectively. Crushed stone of nominal size 10 mm was used as coarse aggregate having specific gravity and fineness modulus as 2.68 and 3.58 respectively. M20 grade concrete was used for casting of Beams[6].

Flexural testing of Beams

All the beams were tested under two concentrated load each applied at one third point of the beam with the help of hydraulic jack as shown in the Fig 7. Loads were gradually increased and corresponding deflections were recorded at three different locations viz. under the two loads and at the centre of the beam with the help of three dial gauges. In each case in each case beam was tested up to failure.

Figure 7. Experimental setup

Figure 8. UTM

In this research, flexural test has been conducted for three type beam specimens i.e. Steel reinforced beam (S), bamboo stick reinforced beam (B1) and laminated bamboo reinforced beam (B2). Three type of specimens have shown the different value of strength. Steel reinforcement (SR) has shown the highest value of strength with the ultimate load of 82.4 kN (for 28 days) compared to bamboo. of strength with the ultimate load of 82.4 kN (for 28 days)) compared to bamboo stick reinforcement and laminated bamboo reinforcement.For the steel reinforcement beam (S), the failure pattern of the beam specimen showed a ductile failure. The firsts crack started at the central of the beam.

The shear crack developed at the bottom ofthe beam element and transmitted towards the central portion of the beam.The crack widened with the increase of the load from the flexural test.The failure pattern of the S beam reinforced can be seen in Figure 9.For B1 beam, crack also started at the central of the beam. The crack developed at the bottom in tension zone of the beam element.The crack propagated vertically toward the top of the beam. This proved that the beam was able to undertake shear load but weak to undertake the flexural load. The crushing of the concrete also took place at the top of the beam. The beam failed in ductile failure. The failures pattern of the beam is shown in Figure 10.B2 beam also failed in ductile failure similar with S beam. The shear crack generated at the bottom of the beam element and propagated towards the central portion of the beam as can be seen in Figure 11. The crack widened with the increase of the load from the flexural test.

Figure 9. Failure of S beam

Figure 10. Failure of B1 beam

Figure 11. Failure of B2 beam

III. RESULT AND DISCUSSION

In this research, flexural test has been conducted for three type beam specimens i.e. Steel reinforced beam (S), bamboo stick reinforced beam (B1) and laminated bamboo reinforced beam (B2).Three type of specimes have shown the different value of strength.

Table 1: Load at first crack

S.NO.	Beam Designation	Load at first crack(kN)
1	S	79.5
2	S	85.3
Average		82.4

S.NO.	Beam Designation	Load at first crack(kN)
1	B1	56.6
2	B1	53.7
Average		55.2

S.NO.	Beam Designation	Load at first crack(kN)
1	B2	58.4
2	B2	63.3
Average		60

Table 2: Ultimate Load

S.NO.	Beam Designation	Ultimate Load (kN)
1	S	88.2
2	S	93
Average		90.6

S.NO.	Beam Designation	Ultimate Load (kN)
1	B1	61
2	B1	58.2
Average		59.6

S.NO.	Beam Designation	Ultimate Load (kN)
1	B2	64.1
2	B2	68.9
Average		66.5

Table 3. Flexural strength

S.NO.	Beam Designation	Flexural strength (MPa)
1	S	16.10
2	B1	10.59
3	B2	11.82

IV. CONCLUSION

Based on the limited number of test conducted, it was concluded that Bamboo may be used as substitute of steel reinforcement in beams. However, for regions of the world where availability of steel is limited and plain concrete members are commonly being used.

The load carrying capacity of the steel reinforced beam using square cross-section was higher than bamboo reinforced beams. From test result it was found that load at first crack and ultimate load in bamboo reinforced beam with square cross section was 33% less than that of hysd steel concrete beam.

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