AN EXPERIMENTAL STUDY ON REINFORCED CONCRETE BEAM USING BAMBOO-STEEL

Latha M S¹, Naveen Kumar B M², Revanasiddappa Madihalli³

¹Associate Professor, ²,³Assistant Professor,
Department of Civil Engineering,
Sri Venkateshwara College of Engineering,
Bangalore, India.
lathamsm@yahoo.co.in

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Abstract

At present, concrete and steel are the most widely used construction materials in the world. The concrete has high compressive strength but low tensile strength. Therefore, steel is used to reinforce the concrete. Steel has a very high tensile strength as compared to concrete, but there are certain problems associated with it. Some of these problems are high production cost, large energy consumption during its production; it is a non-renewable resource and large amount of carbon emission during its production. The urge to overcome these problems without the tensile capacity of reinforced concrete being compromised, has prompted numerous scientists and engineers to seek out locally sourced materials as a replacement for conventional steel reinforcement. Specifically bamboo is one of the most suitable materials that may be used as reinforcing bar in concrete. This project work assessed the suitability of bamboo as reinforcement in concrete. Concrete mix for M-20 grade concrete has been found as per design requirement of the IS code 10262-2009. In this project, size of beams
selected is 230x 300 x 2000 mm. treated bamboo reinforced concrete (TBRC) beam and steel reinforced concrete (SRC) beam was casted for each size of beam and they were tested on loading frame machine. The flexural test results shows that steel reinforced concrete beam has the highest flexural strength compared to others. However, bamboo reinforced concrete beams (treated) shows a significant improvement in their flexural strength as compared to steel reinforcement concrete beam. The compare of the results for the bamboo reinforced beam and steel reinforced beam shows that the load was varying from the percentage of bamboo and steel. For example steel is 90 percentage and bamboo is 10 percentage. These varying percentages of beam absorbed and minimum 30. Hence, it can be recommended to use optimum bamboo reinforced concrete beam for light load bearing structures like beam, plinth beam and slab for small panel. Also, it may be used for temporary structure.

Keywords: Bamboo-Steel, Reinforced Concrete, Deflection, Ultimate Load

1 INTRODUCTION

In recent times, there is a scarcity for steel in construction industry due to which the cost of steel has increased in the developing countries. In these days, the usage of metal is restricted in development industry. The research has found that the construction of the building with the steel has seen drastic reduction because of over consumption of the mineral fuel which made difficult for the production of the steel in recent times. Even though the use mineral assets are limited in the manufacturing of substances like cement, steel, glass, plastic and aluminium it has major contribution towards the ecosystem deterioration. Bamboo is quickly developing and further more eco-accommodating material for structural applications. Usage of bamboo has major advantages especially in developing countries. Bamboo culms are tube shaped shells, at nodes they are divided by solid diaphragms, for example low quality towards a path opposite to the strands and high quality towards the path parallel to the filaments along the length of the Culms, which ran longitudinally. The thickness of bamboo fibre in cross-segment of a bamboo shell shifts with thickness and in addition tallness. Since bamboo has
high content of vitamins and minerals it attracts the living organisms such as bugs and fungi and therefore it is highly vulnerable to fungi. To overcome this problem we need to preserve the bamboo from the living organisms by some treatment. Bamboo forest are found throughout tropic and sub tropic zones between latitudes of about 40° south, i.e. areas which has annual temperatures from 20° C to 30° C. The physical and mechanical attributes both differs considering distance across, length, age, sort, position along culms and dampness substance of bamboo. Performance of Bamboo varies depending on the specie and maturity. At the age of three to four years plants gets total maturity. Due to all these good features of bamboo which was observed during the experiments done in the previous years, it was said that bamboo is one of the best substitute material for reinforcement. Bamboo is predicted to have great contributions to seismic resistant construction and building retrofit technology in the evolving countries.

2 RESEARCH SIGNIFICANCE

The literature review of bamboo is to appreciate the prior research on the mechanical behaviors of bamboo. The following research paper deals with all of the characteristics and mechanical properties of Bamboo. I K Khan (2014)suggested that, the construction cost in building the houses can be reduced so that it could be provided to the society, by using the bamboo sticks as a substitute material in the concrete beams instead of iron bars. The cross shape element of the bamboo culms like round, rectangular, trilateral has been used as a substitute material in reinforcement. Concrete beams become strengthened with the bamboo sticks as a good metal bar. These are casted and tested by two concentrated loads with the aid of hydraulic jack. The rectangular cross section was compared with the circular and trilateral bamboo. The cross section was high due to the shear strength and flexural properties of bamboo.

Anurag Nayak and Bajaj (2013) tried to make use of bamboo as a replacement of metal in concrete, based on the bodily and mechanical features of bamboo. The two forms with the moso models are considered. The first form had contained a node at the middle. The second form had nodes with the 1/4th of length from both end.
The compressive tests, shear checks, tensile tests and bond checks of the bamboo are conducted in the Universal testing machine and the Compression testing machine. The obtained valuable graphs are compared with the steel. The normal tensile force of most bamboo obtained was 125N/mm². This was half of the force used in mild steel.

JK Sevalia et al (2013) used bamboo as support material with no treatment. In this paper tended to that the correlation of modulus of elasticity for singly and doubly reinforcement beams. Young s modulus of doubly strengthened shaft is higher than single reinforcing cement beams. Modulus of elasticity of singly reinforced beam is 3762.94 N/mm², Young s modulus of doubly RC beams is 14597.70 N/mm². The load carrying strength is increased 29.3

SUMMARY OF LITERATURE SURVEY
1. Bamboo is an attractive replacement to steel in ductile strength capacities. The strength of bamboo RC concrete in tensile is fairly much more and might reach as much as 40Mpa.
2. Even though the steel is utilized as RC concrete. By considering the amount and availability option of steel with each other appropriate substance on reinforcement is a main primary issue.
3. Bamboo reinforcement concrete beams with shear connections are produced by using substances. The materials viewed have been bamboo, rattan cane and steel. New exploring methods of making the usage of bamboo RC concrete beams are easy, productive cost robust for the rural buildings.
4. The execution of bamboo reinforced concrete beams are upgraded by using the steel stirrups.
5. The vital problem in bamboo culms is the water absorption. By the correct treatment of water the strength of the bamboo culms are reduced. Due to the presence of powder like substances at nodes, the water absorption properties of bamboo increases with increase in nodes.

3 OBJECTIVE SCOPE OF WORK
The objective of this research is to determine the feasibility making use of Bamboo and Steel Reinforcement as a composite reinforcement material for Concrete beams and trying out the same in
loading frame equipment. Steel stirrups are used in beams. The mechanical properties of bamboo are determined in order to model. 1. Mechanical properties of Bamboo are studied. 2. Bamboo culms are coated with epoxy resin and sand is sprinkled on the bamboo culms. 3. The maximum load carrying capacity of solid bamboo reinforced cement concrete beams using steel stirrups as shear RC are evaluated. 4. Optimum reinforced bamboo and conventional beam are studied on comparison and its cost effective.

4 METHODOLOGY

To arrive at the objectives, the methodology included basic test on materials, casting of beams, curing and testing, and comparison of results.

4.1 Basic tests for bamboo

i) Water absorption test—naturally bamboo came with broaden nodes. Due to this the water absorption capacities of bamboo increases. Sample of bamboo preferably dry sample was taken in natural and coated form. One of coating was applied i.e. coal tar creoptrate coating both natural and coated and coated types are immediately immersed in water for a period of 7 days and their weights were noted. This dry in weights is experimented as the percentage of water absorption for natural form and coated form, referred as per code IS 2383-part 3

ii) Tensile test for bamboo—The bamboo was utilized as to take tensile load in the prolongation or flexural, component of the ductile test was carried on the bamboo, and bamboo strip was of the 520 mm length and 10 mm thickness used and the sample was readied. The finish of the specimens was roughed at the both ends to have a superior hold in UTM. Tensile test was done by using UTM. To obtain tight holding on the Bamboo in the Machine of iron hold was used and the position of the Bamboo strip in UTM.

A. Dimension of Beams

Experimental investigations were carrying out on eight simply supported reinforced concrete beams to study the behavior of flex-
ural strength in beams. By considering two different material one steel and other one bamboo. The both series of beams as same dimension 230mm wide, 300mm depth and 2000mm long on a simply supported span of 1800mm, for both the beams are shown in figure.

Figure 1: Bamboo reinforced beam details

Figure 2: Steel reinforced beam

4.2 Reinforcement Details

Bamboo reinforced beams of 3 numbers of solid bamboo reinforced is casted with M20 grade of concrete and also casted 3 numbers of steel reinforced concrete beams. the dimension of beam is 230X300X2000 for the conventional beam details only steel reinforce provided 16 mm dia bar at 3 number tension zone, 2 number of compression zone mm and shear reinforcement 2 legged 8 mm dia bars at 220 mm centre to centre. the beam design for a maximum load 250kN. for fully bamboo reinforced beam provided in main bar are in bamboo material and shear reinforced bar steel bars is 20 mm solid bamboo 3 number of tension zone, 2 number of compression zone and the stirrups at 2 legged 8 mm dia, bar at 220 mm center to center as shown Figure 4 as per design IS 456-2000.

4.3 Preparation of Bamboo Reinforcement Beam

Solid Bamboo of length 1800mm length and dia of 20mm was taken as a replacement for reinforcement in beams. After the treatment
process of Bamboo culms, the Bamboo culms were dried for a period of 2-3 days. Then the Bamboo is tied upon the reinforcement with the help of binding wire to hold the bar onto the solid bamboo culms. The spacing of stirrups was 6 inches, Bamboo culms was securely tied to the vertical steel stirrups. Equal intervals of stirrups were marked in order to maintain the spacing of the stirrup.

Figure 3: Marking of spacing for vertical stirrups and tying of stirrups to the bamboo culms

4.4 Test Procedure
The casted reinforced concrete beams were taken to test using loading frame (100 tons capacity). Before testing of the beam, the beam should be marked at the center point and two points were marked at a distance of 300 mm away from center on both sides and supports points were marked 100mm away from the edges on both sides. The beam should be placed on the loading frame using hand pumping crane, then the set-up of beam should be done as shown in figure. Both beams are of same size 230mm wide, 300mm depth and 2000mm long on a simply supported span of 1800mm. The applied load on each specimen was 4-point loading, in this loading system beam with rectangular cross-area is set on two parallel roller supports. The load is applied at the middle of the beam through loading cell. The working load for design of all the beams in two series was 250kN. As applying of load start at the center of specimen at very slow rate (2.0kN per second), simultaneously load taken by specimens wererecordedinexcel sheet in system. Deflection of the beam will also record together by means of LVDT
in the system. When testing is completed the crack patterns were marked and measured through scale. The photographs have been taken for ever testing of beam as shown in Figure

Figure 4: Four point load system arrangement

5 RESULTS AND DISCUSSION

The following code provision for M20 grade concrete material tests and also tests for beam bamboo reinforced beam (TBRC) and steel reinforced (SRC) beam has simply supported beam and the four point load tested following the results are drown.

Water Absorption Of Bamboo - The experiment results seen in the water absorption without coating of bamboo is 100% water absorbed and the coated bamboo was absorbed only 20% of water this process is specified in IS 2383 - Part 3.

Tension Test Of Bamboo - Tensile test was carried as the specimen which has nodes towards the end. Nodes are a frail and brittle in resistance to the tensile force. This test shows that with nodes at gauge position point and the primary reasons for existing has to determinate young s modulus of the determined bamboo species material. It has been observed that most of the failure is 37913

Four point load test results

1. Load, deflection of steel RC beam testing -

   The plot in the Figure 5 shows load and deflection curve for steel reinforced beam. The load linearly varying with respect to deflection. The maximum strength of 249.3kN IS obtained for SRC
under the deflection of 13.2 mm. An analysis was carried out to determine an equation for the above plot.

\[ Y = -1.248x^2 + 36.31x - 20.15 \]  

(1)

The regression value of above equation is 0.96. The value of deflection 15.2 mm is within the permissible limits of IS 456-2000, clause 23.1.1

2. Load, deflection of Bamboo RC beam testing-

The plot in the Figure 5 shows load and deflection curve for Bamboo RC beam. The load linearly varying with respect to deflection. The maximum strength of 72.3 KN is obtained for BRC under the deflection of 8.1 mm. An analysis was carried out to determine an equation for the above plot.

\[ Y = -0.315x^2 + 8.560x + 14.77 \]  

(2)

The regression value of above equation is 0.96. The value of deflection 9.55 mm is within the permissible limits of IS 456-2000, clause 23.1.1

3. Percentage varying of Steel and Bamboo in RC beam results

The above results of SRC and BRC, an optimum percentage of steel and bamboo for singly reinforced beam is drawn as 50% bamboo and 50% steel in RC beam with varying the percentage of combination steel and bamboo for example 10% steel and 90% bamboo, 20% steel and 80% bamboo, 30% steel and 70% bamboo, 40% steel and 60% bamboo, 60% steel and 40% bamboo, 70% steel and 30% bamboo, 80% steel and 20% bamboo, 90% steel and 10% bamboo.
6 CONCLUSION

After testing and observations made, following conclusions are drawn,
1. With the use of bamboo as tensile material, percentage of steel can be reduced effectively in beam. 50% of bamboo and steel is selected as datum to study the beam with varying percentage of steel and bamboo. Increase in percentage of bamboo with steel, the maximum load decreased and deflection reduced.
2. The datum line fix and below the datum line percentages of steel and bamboo decrease strength of beam Also it is that with 10% steel and 90% bamboo the maximum load percentage is less than 41.03% whereas for 90% steel and 10% bamboo the maximum load percentage is greater than 47.82%
3. It is found that with 20% steel and 80% bamboo the maximum load percentage is less than 30.09% whereas for 80% steel and 20% bamboo the maximum load percentage is greater than 35.68%.
4. It is observed that with 30% steel and 70% bamboo the maximum load percentage is less than 19.03% whereas for 70% steel and 30% bamboo the maximum load percentage is greater than 25.54% and with 40% steel and 60% bamboo the maximum load percentage is less than 7.88 % whereas for 60% steel and 40% bamboo the maximum load percentage is greater than 13.1.
5. It can be concluded that, percentage of steel can be reduced to minimum of 30% and maximum of 50% in beam, to gain a maximum strength ranging from 124.08kN to 192.37 kN with maximum deflection of 14mm.
References


