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PERFORMANCE OF BAMBOO REINFORCED CONCRETE BEAM

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Abstract: To reduce the cost of construction so that houses may be made affordable to common man of the society, in the present research work bamboo sticks had been provided as reinforcement in concrete beams in place of steel bars. Different shapes of cross section of bamboo stick such as circular, square and triangular were used as reinforcement. As the work was experimental in nature concrete beams reinforced with bamboo sticks as well steel bars were cost and tested under to concentrated load with the help of hydraulic jack. Steel reinforced concrete beam were tested to compare the result obtained for the bamboo reinforced concrete beam.

Keywords: Bamboo, Reinforcement, Concrete Beam, Tensile Strength, Dial Gauge, Hydraulic Jack, Deflection and Crack Pattern.

1. Introduction

In present study tensile strength and elongation corresponding to the yielding of bamboo sticks with and without nodes were determined experimentally with the help of Universal Testing Machine (UTM), in order to check the feasibility to use bamboo sticks as reinforcement in place of steel bars for low cost housing option.

Since the present study was experimental in nature therefore twelve beams each of size 150x150x700 *mm* (supported length 600 *mm* with 50 *mm* overhang on each side to avoid overturning during testing) were cast, out of which nine beams were reinforced with bamboo sticks and remaining three beams were reinforced with steel bars. Out of nine bamboo reinforced beams, every three beams were provided with bamboo stick of triangular, circular and square cross section. In each case spacing as well as number of steel bars/bamboo sticks was suitably provided based on the design as per IS-456:2000 as given in Table 1. In all the beams shear reinforcement was provided in the form of steel stirrups of diameter 6 *mm* at an spacing of 95 *mm* centre to centre as shown in Fig. 1. 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.

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Table 1: Reinforcement Details in Beams

Type of Reinforcement	Cross –Section of Reinforcement (mm)	Total Area (mm^2)	Number of Reinforcement
Circular Mild Steel	10	314	4
Circular Bamboo	10	471	6
Square Bamboo	10	500	5
Triangular Bamboo	10×10	500	10

Fig. 1: Bamboo reinforcement with steel stirrups

2. Literature Review

An exhaustive survey of the available literature was conducted to assess the present status of the work carried out on bamboo reinforced concrete elements. Some of the researches carried out by the past researchers are given below:

H.Y Fang *et al.* [1] 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 [2] 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 [3] studied the bamboo as construction material for the construction of low-cost 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.* [4] 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.

3. Experimental Programme

Properties of Materials 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. M_{20} grade concrete was used for casting of Beams. Bamboo sticks were tested under UTM and yield strength as well as modulus of elasticity was found to be 132 and 52000 *MPa* respectively.

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.2. 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.

Fig. 2: Testing of beam under two concentrated loads

4. Results and Discussion

On the basis of test results obtained by testing of twelve beams it was observed that among the bamboo reinforced beams load at first crack and ultimate load and corresponding deflection was higher in the case of beam with square bamboo reinforcement. Flexural and

shear strength was also higher for square section. In most of the cases beam failed under flexure but in some cases combined flexural and shear failure too place. Average value of different properties is given in Table 2, 3 and 4.

Table 2: Load and deflection at first crack

S. No.	♣Beam Designation	Load at first crack (*kN*)	Deflection at first crack (*mm*)
1	BBT	20	0.61
2	BBC	24	0.74
3	BBS	32	0.92
4	BSC	70	1.31

Table 3: Ultimate load and deflection at ultimate load

S. No.	♣Beam Designation	Ultimate load (*kN*)	Deflection at ultimate load (*mm*)
1	BBT	24	0.98
2	BBC	30	1.12
3	BBS	38	1.22
4	BSC	80	1.74

Table 4: Flexural and shear strength

S.No.	♣Beam Designation	Flexural strength (*MPa*)	Shear strength (*MPa*)
1	BBT	4.65	0.93
2	BBC	6.48	1.31
3	BBS	7.64	1.50
4	BSC	15.46	2.92

♣BBT: Bamboo reinforced beam with triangular cross section, BBC: Bamboo reinforced beam with circular cross section

BBS: Bamboo reinforced beam with square cross section, BSC: Steel reinforced beam with circular cross section

5. Conclusions

On the basis of test results, the following conclusions have been drawn:

1. From test result it was found that tensile strength of bamboo is approximately one half that of mild steel and modulus of elasticity is approximately one third that of mild steel.

2. The load carrying capacity of the bamboo reinforced beam using square cross-section was higher than bamboo reinforced beams with triangular and circular cross sections. From test result it was found that load at first crack and ultimate load in bamboo reinforced beam with square cross section was 53% less than that of mild steel concrete beam.
3. Deflection of bamboo reinforced beam with square cross section was also higher than bamboo reinforced beams with triangular and circular cross sections. From test result it was found that at first crack and ultimate load, deflection in bamboo reinforced beam with square cross section was 30% less than that of mild steel concrete beam.
4. Flexural and shear strength was higher in bamboo reinforced beam with square cross section as compared to triangular and circular bamboo sections. These were about 50% less than steel reinforced concrete beam.
5. 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.

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