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The Flexural Behavior of Bamboo Reinforced Concrete Beam

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FLEXURAL BEHAVIOR OF BAMBOO REINFORCED CONCRETE BEAM

Abstract: In this paper our main focus is on finding an environment friendly substitute of steel which is an important material in construction. Steel has an adverse impact on our environment from its complete process of mining to final use in construction. To minimize carbon footprints in environment we studied the flexural properties of Bamboo reinforced concrete to be able to use it as a successful replacement of steel bars. To study the flexural behavior, we kept the total reinforcement constant and partially replaced steel with bamboo as 0%, 25%, 50%, 75% & 100%. The beams prepared were placed under UTM (Universal Testing Machine) with one point loading frame. From our tests results, we recommend that beams reinforced with 25% bamboo can be safely used in structural members.

Keywords: Bamboo Reinforced Concrete, Flexural behavior, UTM

I. INTRODUCTION

In modern world the construction industry consumes a major amount of materials produced. Concrete is made up of materials like cement, coarse aggregate, fine aggregate, steel and admixtures. The complete process of mining, treatment of materials, transport of materials and installation on site, leaves heavy carbon footprints on the environment, which leads to global warming. It is a known fact that construction industry is responsible for total 39% of all carbon emissions in the world. Of which, steel constitutes about 7%-9% emissions. To counter this problem we have tried to establish Bamboo as a successful replacement of steel. In this paper, our effort is to find out the flexural behavior of Bamboo Reinforced Concrete. [1] conveys that concrete has good strength in compression zone but it is weak in tensile zone, hence the steel reinforcement is to be provided. [2] says that in developing countries it is quite difficult to obtain steel due to its high cost. But its alternative, bamboo can be easily available in rural areas and it is very cheap. [6] has conducted experiments with bamboo culms and wax on the surface. It resulted that on seasoning the strength of bamboo was found to be increased. [3] studied that bamboo as a material can be used in walls made of mud. It results in high strength and least harmful to the environment. [7] made an attempt to evaluate and compare the concrete reinforced with bamboo to concrete reinforced with steel bars for flexural behavior & deflection curve. [4] investigates that whether bamboo can be used as reinforcement in concrete without treatment and stirrups. It concludes it can be done as mentioned. [5] conducted an experiment to study the bond strength of bamboo and concrete. Over 20 different treatments were done and it was found that treated bamboo performs better than untreated. [9] experimented with bamboo as a element in mats and was put under loading condition to

study differential settlement in foundations. And its results showed that it has high resistance. [8] performed experiments on different columns of steel, bamboo and plain concrete by applying axial compression and transverse loading to determine the load carrying capacity, lateral deflection pattern and failure pattern. It was concluded by this experiment that bamboo can be safely used in columns. [10] experiment reveals that members which are reinforced with bamboo splints along horizontal axis have higher ultimate load bearing capacity than that of samples without any reinforcement.

In our research we are focused to determine the strength and flexural behavior of concrete beams which are reinforced with bamboo partially (with steel). The beam has 700mm length and steel stirrups spaced at 150mm gap. The tests are conducted after the 28 days of curing. Central/ one point load testing under UTM is performed for all the beams prepared.

II. MATERIALS & TESTS

The concrete is a heterogeneous mixture which requires different high strength materials. The material requirements of this project were cement, coarse aggregates, fine aggregates, sand, bamboo & steel. For many of these materials, testing was required to use high quality material and obtain good strength.

Cement

OPC (Ordinary Portland Cement) of grade 53 was used and tested according to the Indian Standard IS 4031 (part 2: fineness test; part 3: soundness test; part 4: consistency test).

Aggregates

Crushed angular aggregates were chosen and test according to Indian Standard code IS 2386 – 1963 (part 1, 2 & 4). [14,15,16]

Steel

The steel bars used in reinforcement and stirrups selected were of grade Fe 415 according to Indian Standard code IS 1786.

Table 1: Material test results for cement, coarse aggregate and fine aggregate

S.N	Material Test	Cement	C.A	F.A
1	Crushing Strength	-	-	6.3%
2	Consistency	33%	-	-
3	Fineness	7%	-	-
4	Fineness Modulus	-	6.2	2.69
5	Impact Strength	-	-	30%
6	Setting Time A) Initial B) Final	 30 min 6 hrs	 - -	 - -
7	Soundness	2mm	-	-
8	Specific Gravity	3.15	2.6	2.75
9	Water Absorption	-	0.2%	2%

Bamboo

For partial replacement of steel, a good quality of bamboo was required. We selected raw bamboo (untreated) and testing were done according to Indian Standard code IS 6874 (2008). The bamboo was tested for its physical and chemical properties. It was observed that bamboo has much greater mechanical strength than any other timber. Also it was found that bamboo is significantly stronger parallel to its fiber formation but weak in perpendicular direction to grains and fibers.

Table 2: Physical and Mechanical properties of bamboo

S. No.	Properties of Bamboo	Value
1	Density	600 kg/m³
2	Moisture content	5%
3	Shrinkage	0.66mm
4	Static Bending strength	11.6 kN/cm²
5	Shear strength	2.0 kN/cm²
6	Compressive strength	175 N/mm^2
7	Tensile strength	315 N/mm^2

III. METHODOLOGY

In this experiment, we keep the total reinforcement constant at 2% of total beam. This included both steel bars & bamboo combined with variation in percentage of bamboo for different beams. The cement grade used here is OPC (ordinary Portland cement) of grade 53. We prepared M25 mix design according to Indian Standard code IS: 102-2009 [13]. The provided beam length is 700mm where bamboo length is 650mm with clear cover. The beam moulds used were of dimensions 150x150x700mm. Five types of beams were casted with different bamboo variation i.e. 0%, 25%, 50%, 75% & 100%. Total 15 beams were casted, three for each type of bamboo percentage. The curing was done for 28 days. After that tests on each beam were performed under UTM. One point loading frame is used which apply load at L/2 distance from both sides.

Bamboo Placement in Beams

We all are aware that plain concrete is weak in tension zone and might lead to breakage on application of load. We placed bamboo in both compression and tension zones provided given percentage and rest with steel. Also steel stirrups were placed at the gap of 150mm

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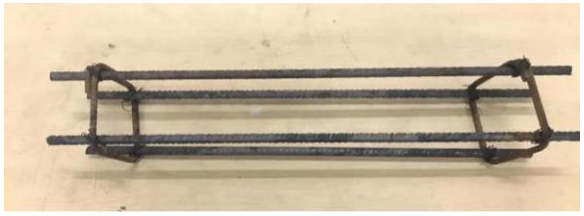

Figure 1: 0% Bamboo reinforcement

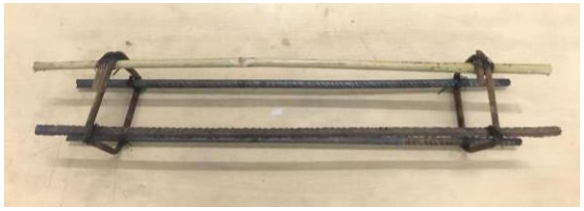

Figure 2: 25% Bamboo reinforcement

Figure 3: 50% Bamboo reinforcement

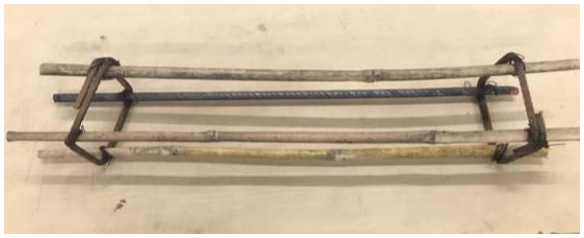

Figure 4: 75% Bamboo reinforcement

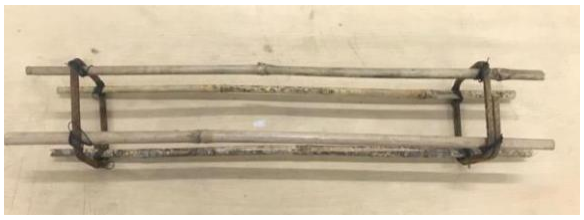

Figure 5: 100% Bamboo reinforcement

IV. RESULT & ANALYSIS

To determine the flexural strength we conducted flexure tests on prepared beams

in our university's concrete technology laboratory. After curing for 28 days, all 15 beams were removed from moulds and cleaned properly with a dry cloth.

Figure 6: de molded beams

We performed tests according to methods of test for concrete from Indian Standard code IS 516 (1959). One by one each beam was placed under UTM. The load was applied gradually using one/ central point loading frame. The load was increased until the failure of beam. When beam reached its ultimate strength, crack pattern on surface was observed.

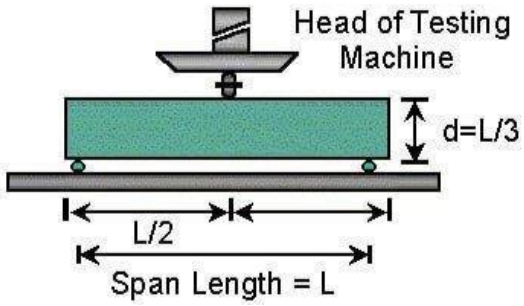

Figure 7: One point loading frame

The readings were taken of the load applied and the point of failure of beam. The process was repeated for each beam. And the data was recorded on a bar chart given below.

Table 3: Flexural strength of BRC samples

Bamboo	0%	25%	50%	75%	100%
Flexural Strength (N/mm^2)	14.87	12.64	10.27	7.74	5.06

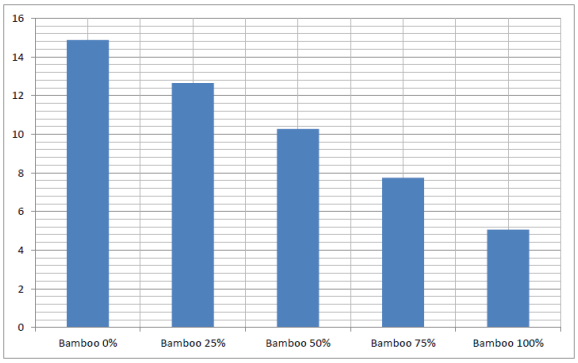

Figure 6: Flexure strength results

V. CONCLUSION

Following conclusions can be drawn from this research:

i) We can safely use bamboo in structural members as reinforcement.

ii) It greatly increased the strength properties when compared to conventional concrete.

iii) The cost of the project is efficiently reduced with use of bamboo.

iv) For obtaining greater strength bamboo must be seasoned properly.

v) It was observed that 25% bamboo beam attain higher strength than other beams of percentages such as 50%, 75% & 100%.

vi) The optimum percentage of bamboo which can be used safely is 25%.

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