

Experimental Study on the use of Bamboo as Structural Reinforcements in RCC Structures

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Abstract—Bamboo is a natural material obtain from plants family. It is fast growing, light weighted, renewable and environment friendly. Bamboo material is very interesting topic in construction for research. Bamboo has good tensile strength; from a study it is found that tensile strength specific weight ratio of bamboo is twenty times more than that of steel.

An experimental investigation of bamboo characteristics and bamboo as reinforcement in concrete study is carried out in this paper. Here we have focused on to identify water absorption in bamboo during curing period and flexure strength of bamboo reinforce beam, cracking pattern and other experimental value to step more towards bamboo as alternative to steel.

Keywords—Bamboo, Reinforcement, flexure, compression, tension, naturally available construction material.

I. INTRODUCTION

In recent year, many researchers around the world have already begun to explore the use of low cost and low energy substitute construction materials. [1]

Among the many possibilities for such substitutions Bamboo, which is one of the fastest growing plants, has great potential. [2] [4]

Bamboo has been used in construction of bridges and houses for thousands of years in Asia. Bamboo takes less energy to harvest and transport. [3]

Bamboo is hygroscopic material that's why it also absorbs moisture from surrounding hence determination of properties, improve over moisture absorption and bamboo reinforcement in concrete beam has been investigated by the authors in the lab and results are presented. [5] [6]

II. EXPERIMENTAL PROCEDURE

A mix design of M25 concrete was used to conduct experiment. Bamboo used were collected from Local Market, Lalganj, Azamgarh Uttar Pradesh (India). The age of bamboo used was four and half year. Several tests were conducted to calculate different strength properties which are necessary to find such as compressive strength test, tensile strength test and water absorption test of bamboo specimen in laboratory.

TEST NO. 01

Compressive Strength Test for Bamboo Specimen

In this test we have calculated how much compressive load can a bamboo specimen bear. This test helped out finding either bamboo is suitable as reinforcement in RCC construction or not. For this test we have selected 6 specimen of length 100mm, 3 (AW1, AW2, AW3) are with node and other (AN1, AN2, AN3) are without node.

TABLE 2.1: Compressive Strength of Specimens (without Nodes)

SPECIMEN	C.S.AREA (mm ²)	COMP. LOAD (KN)	COMP. STRENGTH (N/mm ²)	DEFLECTION (mm)
AN1	2971.168	140	47.11	7
AN2	2909.907	133.4	45.843	4
AN3	2657.794	129.7	48.799	6

TABLE 2.2: Compressive Strength of Specimens (without Nodes)

SPECIMEN	C.S.AREA (mm ²)	COMP. LOAD (KN)	COMP. STRENGTH (N/mm ²)	DEFLECTION (mm)
AW1	2510.14	128.1	51.03	5
AW2	2563.53	120	46.81	6
AW3	2565.90	126.7	49.378	6

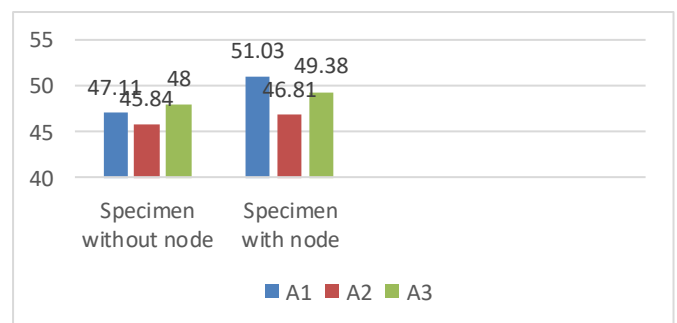


Fig 2.1: Comp. Strength of Bamboo Specimens in MPa



Fig 2.2: Compressive test Specimen with node, Source: Material Testing Lab, REC Azamgarh

TEST NO. 02

Tensile Strength Test for Bamboo Specimen

The tensile test was carried out on bamboo splints to determine the ultimate tensile strength of bamboo. The ultimate tensile strength of bamboo is importance to calculate the maximum allowable tensile stress in bamboo, when bamboo is being used as reinforcement in concrete elements to take the tensile loads. We have taken 5 test specimens namely, A1, A2, A3, A4, A5.



Fig 2.3: Bamboo Specimen for tensile test, Source: Material Testing Lab, IIT BHU

TABLE 2.3: Bamboo splints tensile test

Specimen	Crosssectional Area (Mm ²)	Tensile Load (Kn)	Tensile Strength (N/Mm ²)
A1	202	33.50	164.8515
A2	190	29.5	154.2105
A3	186	26.80	139.7849
A4	262	47.04	179.542
A5	224	39.24	176.428

TABLE 2.4: Bamboo splints tensile test

SPECIMEN	Elongation (mm)	Strain	Cracking Load (KN)
A1	8.50	0.0168	28.5
A2	8.00	0.0158	26.5
A3	8.00	0.0158	22.5
A4	9.32	0.0170	37.9
A5	8.75	0.0164	36.7

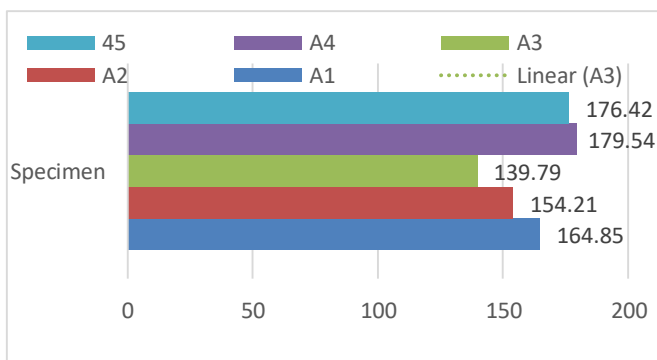


Fig 2.4: Tensile Strength of Bamboo Specimens (MPa)

TEST NO. 03

Water Absorption Test for Bamboo Specimen

Since Bamboo is a hygroscopic material having tending to absorb moisture from air and surroundings. In green concrete bamboo splints absorb moisture and swells, when the concrete becomes dry the bamboo splints contracts and creates spaces between the contacts, the bamboo-concrete bond strength decreases and member fails in bond. Hence water absorption is one of the main drawbacks of bamboo, when it is used as reinforcement in concrete so our main aim is to perform this test to find out percentage of water absorb by bamboo and percentage of volume increase.

We have taken six (WA1, WA2, WA3, W1, W2, W3) sample of bamboo specimen of 50*50mm² and let it dry for 24hrs in an oven. After that the specimen was allowed to cool for 30 minute. 3 Specimen painted with water proof coating (W1, W2, W3) but remaining three were not. Calculation of dimension, weight was made initially. Then all the 6 samples were allowed to soak in water at normal temperature pressure. Reading for changes in dimension and weight was made at every 24-hour interval for next 28 days.



Fig 2.5: Bamboo Specimen into Water, Source: REC Azamgarh Lab

TABLE 2.5: Water absorption of bamboo sample without paint

DAY	WA1(g)	%GAIN	WA2(g)	%GAIN	WA3(g)	%GAIN	AVG % GAIN
1	4.273	00.0%	4.638	00.0%	4.404	00.0%	0%
2	6.671	56.12%	7.61	64.08%	7.215	63.82%	61.34%
3	7.429	73.85%	8.329	79.58%	7.956	80.65%	78.03%
4	7.584	77.49%	8.304	79.04%	7.923	79.91%	78.81%
5	7.700	80.20%	8.289	78.71%	7.945	80.42%	79.78%
6	7.783	82.15%	8.352	80.77%	7.852	78.29%	80.40%
9	8.3661	95.67%	8.920	92.15%	8.577	94.75%	94.19%
11	8.493	98.75%	8.952	93.14%	8.617	95.66%	95.85%
14	9.491	122.2%	10.228	120.5%	9.778	122.3%	121.67%
28	10.209	138.92%	11.647	151.00%	11.007	164.46%	151.46%

TABLE 2.6: Water absorption of bamboo sample with paint

DAY	W1(g)	%GAIN	W2(g)	%GAIN	W3(g)	%GAIN	AVG % GAIN
1	5.878	00.0%	4.549	00.0%	4.557	00.0%	0%
2	8.405	42.69%	7.127	56.67%	6.856	50.44%	49.93%
3	9.194	61.36%	7.815	73.77%	7.616	67.12%	67.42%
4	9.572	62.84%	8.079	77.59%	7.825	71.71%	70.71%
5	9.836	67.33%	8.240	81.38%	7.989	75.32%	74.68%
6	10.154	72.74%	8.428	85.27%	8.046	76.56%	78.19%
9	10.940	91.54%	9.182	101.8%	8.507	86.67	93.34%
11	11.306	92.34%	9.558	110.8%	8.823	95.83%	99.66%
14	11.689	98.86%	10.114	122.3%	9.286	103.7%	108.29%
28	12.533	113.22%	10.684	134.86%	11.209	145.97%	131.35%

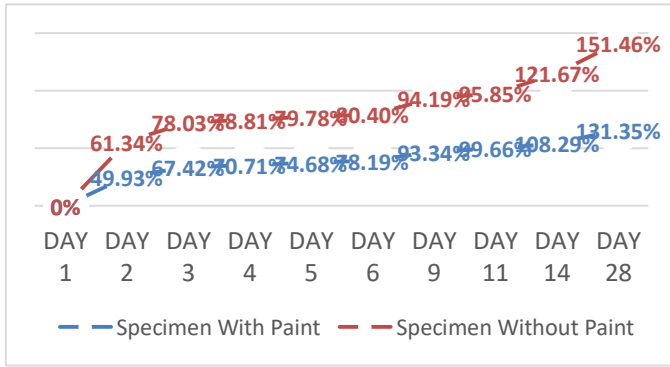


Fig 2.6: Water absorption vs time graph of bamboo specimens.

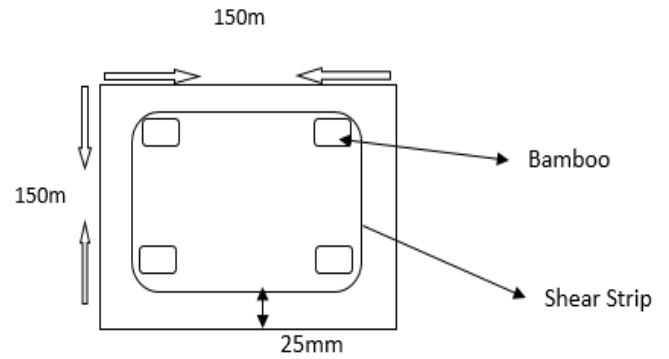


Fig 2.8: Cross sectional detailing of Beam for Flexure

TABLE 2.7: Calculation of c/s area change due to moisture

Sample	Area before test (Without painted in mm ²)	Area After test (Without painted in mm ²)	% change in area (mm ²)	Area before test (Painted in mm ²)	Area After test (Painted in mm ²)	% change in area (mm ²)
A1	225	239	0.062	225	230	0.022
A2	225	232	0.031	225	229	0.017
A3	225	236	0.048	225	232	0.031

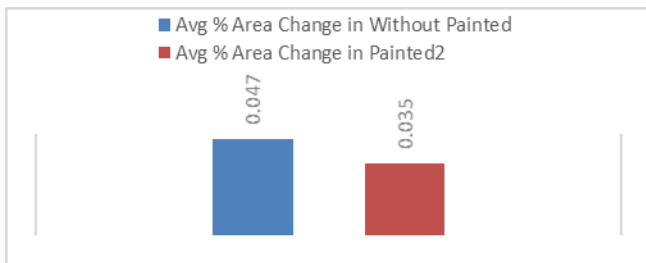


Fig 2.7: % change in c/s area of bamboo sample



Fig 2.9: Bamboo frame for reinforcement, Source: Material Testing Lab, REC Azamgarh

TEST NO. 04

Flexural Strength Test for Bamboo Specimen

Bamboo splints of 12*12mm² were used as reinforcement. Bamboo splints were tied in frame of 55cm length and within 10*10cm². Binding bar is use to tie. Since bamboo absorbs water so a moisture resistance paint was applied over bamboo splints. Bamboo reinforced concrete beam of 150*150*600mm³ were casted with clear cover of 25mm. For casting beam, we have used mix designed concrete grade of M25. After 28 days of curing, beams were subjected to standard Flexure test and the flexural strength was calculated.

TABLE 2.8: Design mix Grade of M25 concrete ratio.

Cement	F.A	C.A	Water
435.409 Kg/ m ³	653.384 Kg/ m ³	1173.782 Kg/ m ³	216.49 Kg/ m ³
1	1.5	2.696	0.497

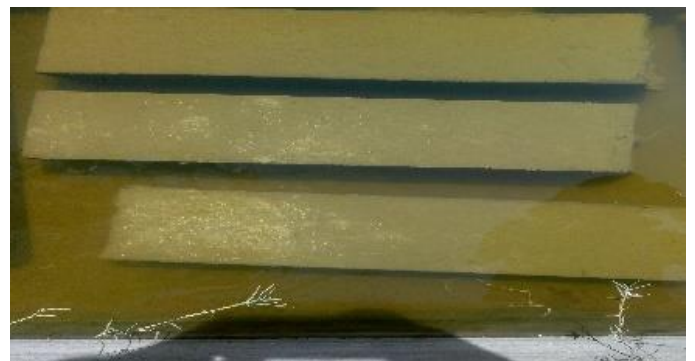


Fig 2.10: Beam during curing, Source: Material Testing Lab, REC Azamgarh



Fig 2.11: Bamboo reinforced Concrete Beam during test

TABLE 2.9: Flexural strength of BRC beam after 28 days

Sr. No	Test Sample	FLEXURAL STRENGTH (N/mm ²)
1	B1	56.36
2	B2	46.01
3	B3	49.83

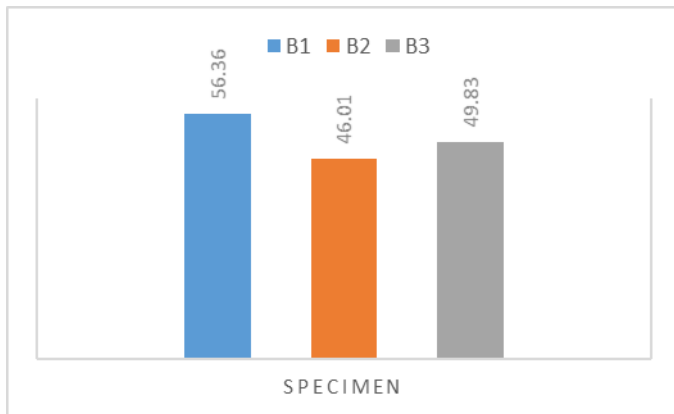


Fig 2.12: Flexural Strength of Test beams in MPa

III. RESULT AND DISCUSSION

We have obtained compressive strength of bamboo was good for short building but on application of heavy load, it can fail along the longitudinal direction in form of buckling.

1. Avg Compressive strength with node = 49.07 MPa.
2. Avg Compressive strength without node = 47.25 MPa.

By tensile test, it was found out that bamboo follow brittle failure.

1. Average tensile strength of bamboo specimen = 162.96 MPa.

By water absorption experiment results it was found out that water absorption and change in area volume due to absorbed water, both are decreased when coated with moisture resistant paint. That is positive result and helping in maintaining strength of bamboo.

1. Avg % Area Change (Paint) = 0.047%
2. Avg % Area Change (Non-Paint) = 0.035%
3. % by weight of max water absorbed in Painted = 131.55%

4. % by weight of max water absorbed in Non-Painted = 151.46%

In our flexural strength test, failure in beam is occurs at the mid of beam hence this was flexural type of failure.

1. Avg Flex. strength of Bamboo = 50.73 MPa

IV. CONCLUSION

The experimental analysis is done for compressive strength of bamboo specimen. And it was found that compressive strength of bamboo specimen with node has greater strength than that of specimens without node this could be because of additional cross-sectional area at nodes and due to the dense mass present at nodes. Some of the specimen showed an ideal failure by cracking longitudinally but most of them showed a mixed mode of failure where in the specimen cracked as well as got crushed and buckled along length.

As per result an average ultimate tensile strength of bamboo splints is 160 MPa which is comparatively lower than the yield strength of structural steel i.e. 250MPa. But bamboo splints can resist sufficient tensile loads in a concrete flexure element. All the bamboo specimens shown brittle failure.

The water absorption value is decreased by using moisture resistant paint and can help in maintain strength and shrinkage and swelling problem.

Bamboo Reinforced Concrete Beam follows same pattern those in steel reinforcement elements. The ultimate moment is 50.733MPa i.e. good result for short building. After testing, cracks are developed at the mid span in beam i.e. flexural type failure.

V. REFERENCES

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