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Properties of Bamboo Strip Reinforced Concrete

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***Abstract*—Study was made in laboratory on concrete beam reinforced with bamboo strips. Bamboo strips was coated with resin and fine particles of sand were attached to bamboo strips, steel chicken mesh was wound around each bamboo strip. Such strips were used as reinforcing material in concrete beam. Such beam were cast in laboratory and tested under four point flexural test and results were presented in this paper.**

Keywords- Bamboo strips, steel chicken mesh, flexural strength.

I. INTRODUCTION

Bamboo having properties cheap, easily available and easy to handle has attracted many research workers, to find mechanical properties of bamboo. Bamboo strip properties as reported by many investigators forced to use it as reinforcing material in concrete structural members.

II. PREPARATION OF A BAMBOO STRIP

Splitting the Bamboo was done by separating the base with a sharp knife and then pulling a dulled blade through the Culm. Two/Four/eight pieces made from a single Bamboo.Waterproof Coatings was applied on strip.

1. Firstly a chicken mesh around the Bamboo Strip was provided.
2. Applied a resin on the surface of a Bamboo Strip with the help of brush and kept it for drying for 2 hours.
3. After 2 hours, secondcoat of resin was applied.
4. Applied a coat of fine sandparticles (below 600 µ) on it and kept it for drying for 2 hours.

Figure 1: Application of Resin, drying strips, sand application, chicken wounding around strip, and final drying of Bamboo Strip

III. MATERIALS USED FOR PREPARING SPECIMENS

OPC, 20 mm gravel aggregate, 12 mm gravel aggregate, natural sand and potable water was used to manufacture concrete in laboratory of grade M20. Hydroclear glossy transparent acrylic weatherproof water proofer of Krishna concare pvt.ltd Ahmadabad was used for applying as resin coat on bamboo strips. Nominal mix method as per is 456 -2000 was used to find mix proportion.

IV Preparations of Concrete Specimen

Concrete specimen using cube moulds and beam mould were cast. Concrete was manufactured nominal concrete mix of grade 20.

A. Nominal Mix Concrete

Nominal mix concrete may be used for concrete of M20. The proportion of materials for nominal mix concrete shall be in accordance with Table 9, as per IS 456-2000.

(a) Estimated quantities of material per cubic meters of concrete.

1. Cement = 50 kg
2. F.A = 83.3 kg
3. C.A = 166.67 kg
4. Water = 30 kg

(b) Proportion

C : F.A : C.A : Water
1 : 1.66 : 3.330 : 0.5

B. Preparation of Concrete Specimens

Total test specimens of plain concrete were casted based on mix design. For each design, specimens were prepared which were of size 150×*150×150* mm and 4 beams cast of size 150×150×700 mm. The cubical moulds of size 15cm×15cm×15 cm confirming to IS 10086 were used.

(a) Mixing of Concrete

Materials were weighing batched using weigh balance. To batch coarse and fine aggregates weigh balance with accuracy of 50 gm was used and for batching cement weigh balance of capacity 10 kg with accuracy of 2 gm was used. Also for measuring materials, standard pans were used. For measurements of water, cans of capacity 2 liters and measuring cylinder of 1 liter with accuracy of 10 ml was used.

Details of concrete cubes were given in following table (table 1).

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Table 1: Details of Concrete Cube Specimen

Cube	Size of cube (mm)	Weight of cube specimen(kg)	Density (kN/m^3)	Average Density kN/m^3
C1	150×150×150	8.95	26.51	25.63
C2		9.15	27.11	
C3		8.60	25.48	
C4		8.41	24.91	
C5		8.24	24.41	
C6		8.56	25.36	

Table1 represent the size, weight & density of the 6 Concrete Cube Specimens

(c) Preparation of Concrete Beams for Flexural Test

Four beam specimens were caste of size 150×150×700 mm.

1. Concrete Beam + 6 Bamboo(figure 2)
2. Concrete Beam + 4 Bamboo(figure 3)
3. Plain Concrete Beam
4. Concrete Beam - Single12 mm TMT Rod(figure 4)

Each mould was filled with fresh concrete to one third of its height and vibrated on table vibrator until the specified condition was attained.

Specimens were then removed from vibrating table to casting room floor for initial curing. After 24 hours concrete specimens were remolded and relocated into the curing tanks for proper curing until the specified test (Flexural Strength)was performed at specified curing periods (7 and 28days).Bamboo reinforcement placed less than 25 mm from the face of the concrete surface and 25 mm from bottom .

Figure 2 Shows that Bamboo Strips placed in two layers with the 25 mm cover and spacing of 25 mm between the two layers this ensures a fairly uniform cross section of the bamboo throughout the length of the member.

Figure 2: Beam with 6 Bamboo Strips ($1/4^{th}$)

Figure 3: Beam with 4 Bamboo Strips ($1/4^{th}$ c/s)

Figure 4:Beam with a Single TMT Steel Rod

3. Curing of Concrete Specimens

The test specimens were stored in laboratory on a place free from vibration at room temperature for 24 hours from the time of addition of water to the dry ingredients. After this period, specimens were removed and marked. The specimens were placed in water in curing tank at atmospheric temperature for

Curing for periods of 7 and 28 days .For each mix, out of 6specimens, 3 specimens were cured for7 days, another 3 for 28 days.

IV. EXPERIMENTAL PROGRAM

Experimental programme was made to first cast cubes and four beams. After 28 days curing test cubes and beam under compression and flexure respectively.

V. OUTLINE OF TEST

A. Outline of Test

To study the feasibility of the Bamboo as reinforcement in the cement concrete flexural element that is beam the following test were performed,

a) Compression Test on cement concrete cube

b) Flexural test on the Bamboo reinforced cement concrete beam.

B. Compression Test on Cement Concrete Cube

To check the compressive strength of the M20 grade concrete the compression test on the cement concrete cubes was conducted.

The cubes were of dimension150×150×150 mm. Three cubes were tested at the age of 7 days and three cubes at the age of 28 days after curing. The average compressive strength at 7 days and 28 days were 14.96 and 32.74 N/mm^2 respectively.

Table 2: Compression Test on Concrete Cubes

Cube	Weight (kg)	Density (kg/m^3)	Curing Days	Strength N/mm^2	Average Strength (N/mm^2)
C1	9.000	26.51	7	11.29	14.96
C2	9.200	27.11	7	15.11	
C3	9.150	25.48	7	14.22	
C4	8.41	24.91	28	37.77	32.74
C5	8.24	24.41	28	24.44	
C6	8.56	25.36	28	36.00	

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C. Flexural Strength of Concrete Beam

To check and compare the flexural strength of concrete beam reinforced with Bamboo Strips, steel and plain concrete beam the flexural test was carried out. Two beams were reinforced with Bamboo Strips, 1 with steel reinforcement and 1 beam without any reinforcement.

A mould of size 150×150×700 mm was taken. One beam was reinforced with six Bamboo Strips in two layers were placed with cover of 25 mm from bottom and side covers with 25 mm was left from both sides. A cover in the form of cement block with thickness of 25 mm was attached from bottom. One beam reinforced with four Bamboo Strips in two layers was caste with same covers. One beam with steel reinforcement was caste with same bottom and side covers as for Bamboo Strips.

Testing Procedure:

After casting of all the beams they are kept for curing in the water tank for 28 days and on 29th day they are taken for flexural testing under UTM. Beam was placed on roller support and four point loads was applied as shown in figure with reference taken as markings. Also beams are covered with coating of lime as shown in figure 3 so that crack should be clearly visible.

Load is increase slowly and a dial gauge is attached to machine as the load increases deflection on dial gauge is simultaneously recorded. The readings of first crack and breaking of Bamboo Strips wererecorded and after beam gets fully cracked or once the noise of breaking of Bamboo Strips was heard, stopped test.

Figure 5 Shows that beam specimens loaded by Four Point loading produced by a hydraulic jack supported on a rigid steel frame. Spreader beam transfer the load symmetrically to ensure pure bending in the mid-span of the beams. A dial gauge reading to 0.01mm was used to record the central deflection of the beams.

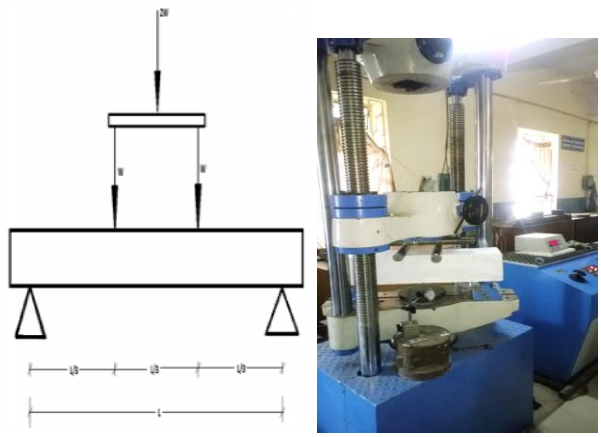
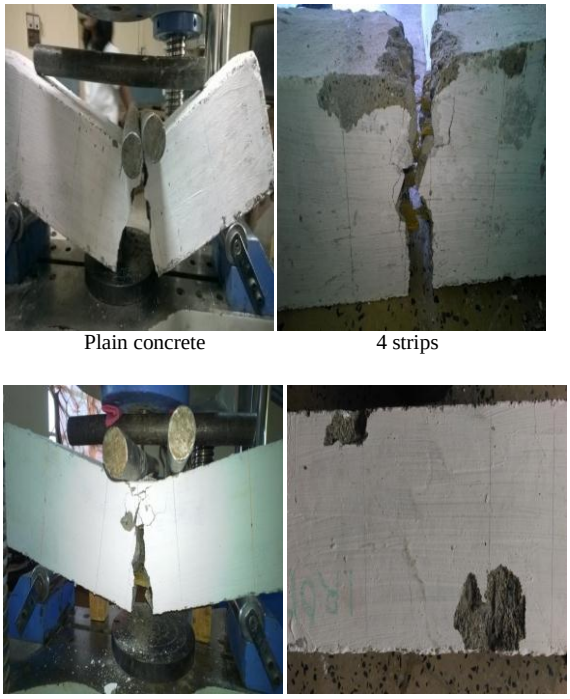


Figure 5: Schematic Beam Testing Set-up (Four Point Loading Set-up)



Plain concrete 4 strips

6-strips TMT bar

Figure 6: Failure of Concrete Beam

Figure 6 shows the failure of beam having 4, 6 Bamboo Strips in this type of the beam the first crack initiated were flexural which developed in the middle third portion of the beam. Then the shear crack generated at the bottom of the beam element near the support, and propagated towards the middle third portion. The crack widened with the increase in the load. The beam showed a ductile failure. The failure patterns of the beams were shear with flexure.

(b) Plain Cement Concrete Beam

In plain cement concrete beam the first crack was observed at the bottom of the beam in the middle third portion. The crack travelled vertically upwards towards the point of load application. The crack widened with the increase in the load. The flexure crack was recorded. The beam suddenly failed at the ultimate load. The beam showed the brittle failure.

(c)Flexure Element Reinforced with Single TMT Steel Rod

The first crack was developed in the beam under the application of load.Ductile failure observed.

D. Observations of First Crack

Following figure 7 shows first crack observed in all beam test specimen-plain concrete beam, 4-bamboo strips reinforced concrete beam, 6-bamboo strips concrete beam and concrete beam reinforced with one 12 mm diameter TMT steel rod.

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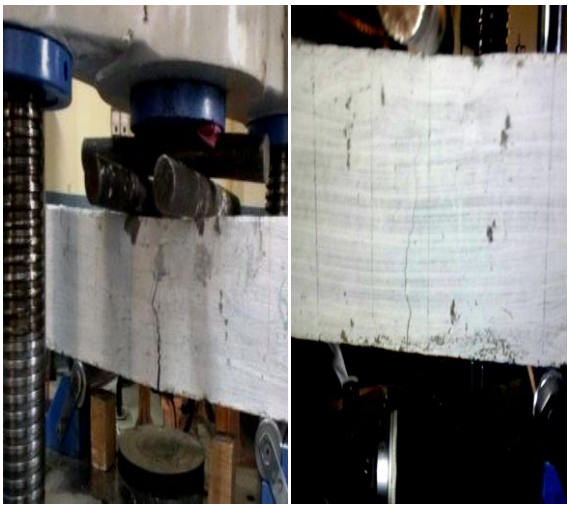
Plain concrete 4 strips



6-strips TMT bar

Figure 7: First Crack in the Beam under the Load.

VI TEST RESULTS

1. Experimentally it was observed that the plain cement concrete beam failed suddenly and showed brittle failure while the bamboo reinforced concrete beam failed gradually and showed ductile failure.

2.It has been found that while conducting the compression test the compressive strength of plain concrete cube was found to be 32.17 N/mm^2 (28 days).

Table 3: Experimental Values load of Beam Specimens

Sr. No.	Identity	Load 'kN'	% increase in load
1	Concrete Beam + 6 Bamboo	21.8	171
2	Concrete Beam + 4 Bamboo	15.273	90.31
3	Plain Concrete Beam	8.025	Reference beam
4	Concrete Beam with Single 12 mmTMT Rod	37.5	367

V. CONCLUSIONS

After testing the specimen in laboratory following conclusion were made

1. Plain Cement Concrete Beam failed suddenly, it has shown brittle failure. Bamboo Strip Reinforced Concrete Beam failed gradually and showed ductile failure.
2. Bamboo Strip is having more flexural strength than plain concrete beam can be used as tension member.
3. Bamboo Strip is cheap and hence it can lead to low cost housing technique in rural areas where the cost of steel is very high.
4. To increase further flexural strength of bamboo strip reinforced beam the waterproofing agent with more bonding should be applied. Bond-enhancing applications should be required to strengthen the bonding between the concrete and the Bamboo Strip.

VI. REFERENCES

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