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An experimental study on structural behaviours of treated bamboo reinforced concrete beams

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Abstract— **Recently, in the attention in response to global warming issues and sustainable society, the manufacturing using natural materials has become actively. Bamboo, low cost, fast growing, and broad distribution of growth, is expected to contribute significantly to earthquake-resistant construction and seismic retrofit technology in the developing countries. This paper investigates the mechanical properties of bamboo reinforced concrete beams. It compares these experimental results of bamboo reinforced concrete beams with the experimental ones of reinforced concrete beams and the mechanical property of the bamboo reinforced concrete beams is studied. From these experimental works, the possibility of effective using of 'Bamboo' is discussed.**

Keywords: Bamboo Reinforced Beams; Crack pattern; Deflection; Earthquake resistance; Flexibility

1. INTRODUCTION

In recent years, steel prices have soared. For developing countries, steel is difficult to obtain because of expensive prices, and for the construction industry, usage of steel is currently limited heavily. The production of steel has high consumption of fossil fuels. So, the steel discharge in the construction of structures has been presented, showing the possibility of drastic reduction by research institutes. Meanwhile, for developing countries, it is important to make the development of buildings construction; low cost, no requirement of sophisticated technologies and reliable construction methods. Environmental destruction such as pollution of air and water has been occurring in some regions by rapid development and production of materials like iron, steel, glass, cement and aluminium that use limited mineral resources. On the other hand, plants and fibers are annually reproducible clean resources. Bamboo is a unique group of gigantic grasses the culm of which originates in underground rhizomes. It grows naturally in many parts around the world country but some species are artificially planted. Bamboo forests are found across tropic and sub-tropic zones between latitudes of about 40° south, i.e. areas with mean annual temperatures of from 20°C to 30°C. Bamboo suitable for water pipes grows at altitudes from 20 to 3,000meters. The plant is fully mature at an age of three to four years. In recent years, many researches around the world are begun to explore the use of low-cost and low-energy substitute construction materials. Among the many possibilities for such substitutions, bamboo, which is one of the fastest growing plants, has got a great economic potential. Bamboo has been used in constructions of bridges and houses for thousands of years in Asia. Bamboo takes less energy to harvest and transport. Therefore, bamboo has low manufacturing costs compared with steel, bamboo is widely expected to be possible even in countries and regions that have no advanced manufacturing technology and construction techniques.

II. MATERIALS

Bamboo

Bamboo, which is a perennial grass has been procured from nearby market. They were cut into pieces as per the required dimensions for the casting of the trial beams. The bamboo is so treated by applying a thin layer of epoxy solution to the surface and it is followed by the coating of fine sand. The compressive strength of the bamboo ranges from 50 to 100 MPa. The tensile and bending strength of the bamboo ranges from 111 to 219 and 86 to 229 MPa respectively

Fig.1. Different types of bamboo

Fig.2. Bamboo for reinforcement

Epoxy resin

Concresive 1315 is a two-component, low viscosity epoxy resin based crack injection resin system, with long mixed pot life designed for sealing cracks in concrete, increasing the bond strength and restoring its structural integrity. It gives excellent bond strength and restores structural integrity. It yields high elastic modulus and ensures effective transfer of stresses at bond interface.

Fig.3. Epoxy resin

The applications of Concresive Master Inject 1315 include:

- ✓ Stabilized cracks in structural elements.
- ✓ Unfilled voids behind tiles, stone facades.
- ✓ Gap behind the steel plate for epoxy plate bonding.
- ✓ Coating of the concrete reinforcing materials.

Table 1: Properties of concresive 1315

S.No	Components	Properties
1	Aespect	Yellow liqid
2	Mix density	1.05 Kg/litre
3	Mix ratio by weight	77:23
4	Pot life	50 Minutes at 25'C
5	Compressive strength	70 Mpa at 7 days
6	Tensile strength	18 Mpa at 7 days
7	Shear bond strength	18 Mpa at 7 days

III. TESTS ON BAMBOO

3.1. Density test

The density test was performed to find out the basic mass per volume or density of bamboo. The density of bamboo can be used as an appropriate parameter for classification of bamboo because unlike other physical and mechanical properties of bamboo, it depends only on the green volume and the oven dry mass. Hence density is an indicator of purity of a material.

Table 2: Density test result

Specimen No.	Oven dry mass (gm)	Volume of specimen (cm^3)	Mass density (gm/cm3)
1	1.60	2.70	0.593
2	1.60	2.80	0.571
3	1.50	2.60	0.577
4	1.85	2.60	0.712
5	2.25	3.50	0.643
6	2.30	3.55	0.648
7	3.25	3.85	0.844
8	3.60	4.25	0.847
9	3.65	4.55	0.802
10	3.80	5.10	0.745
11	4.25	5.85	0.726
12	4.15	5.65	0.734

Water absorption test

Bamboo like wood changes its dimension when it loses or gains moisture. Bamboo is a hygroscopic material, tending to absorb moisture from air and surroundings. The water absorption capacity of bamboo splints is more than 50% by weight, hence it absorbs and reduces a part of water added in the concrete mix for hydration reactions. 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.

Table 3: Water absorption test result

Type	Water absorbed after 15 days,gm	Water absorbed after 30 days,gm
A-1	24.80	25.65
A-2	56.70	57.80
A-3	85.40	90.25
B-1	08.25	10.05
B-2	11.25	14.05
B-3	24.55	29.70

Tensile test

1. As the bamboo is used as to take tensile load in the flexural element the tensile test was conducted on the bamboo.
2. The Bamboo strip was of the length 520 mm and the thickness of the Bamboo was average 10 mm. Specimens of such specifications were prepared. The ends of the specimen were roughed at both the ends to have a better grip in Universal Testing Machine.

Table 4: Description of tensile test

S.No	Specimen size		Cross sectional area(mm^2)		
	L (mm)	T (mm)	A	B	Avg
1.	520	10	262	256	260
2.	520	10	142	198	170

3.	520	10	215	207	211

IV. MIX PROPORTIONING

Concrete mix design is done as per IS 10262. The grade designation adopted is M40. The type of cement used is OPC 43 grade. The maximum size of coarse aggregate used is 20mm. Maximum water cement ratio adopted is 0.45 and maximum cement content used is 450kg/m3. Mix calculation is done for 1cubic meter of concrete. The cross section of the beam specimen is 150*150mm. The total length of the beam is 1000mm. The mix proportion calculated for the required size of the specimen is listed in table 5.

Table 5: Size of Specimens

S. No	Specimen	Size (mm)	No of specimen
1	Cube	150x150x150	9
2	Beam	100x100x500	9
3	Cylinder	150dia.,300 h	9

Table 6: Mix design for M40 grade concrete

Materials	By weight	By proportion
Cement	395 kg/m^3	1
Fine aggregate	856 kg/m^3	2.17
Coarse aggregate	1093 kg/m3	2.77
Water	157.6 kg/m3	0.40
Admixture	7.9 kg/m^3	0.0068

V. CASTING

Conventional Steel Beam

Steel reinforced beam is casted as the conventional beam for this experimental investigation. The characteristics of the test specimen are as follows. The size of longitudinal tension bar is 12mm diameter and the stirrup and spacing is of 8mm diameter bar @ 100mm c/c respectively. The clear cover of the beam is 30mm.

Fig 4: Conventional steel beam specimen

Treated Bamboo Reinforced Beams

Bamboo reinforced beams with Thermo Mechanically Treated (TMT) rods and Bamboo as a stirrup material is treated by applying a thin layer of epoxy followed by a coating of fine sand. The epoxy solution used for treating the bamboo is Concresive Master Inject 1315. This treatment of Bamboo gives high bonding strength.

Fig 5: Treated Bamboo Reinforced Beam

Future Work

The conventional reinforced and bamboo reinforced beam specimens is to be casted and after 28 days of curing and should be tested for its flexural strength, deflection, crack pattern and modulus of elasticity. Finally the results obtained should be compared.

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