Experimental Study on Strength Properties of Bamboo as A Reinforcement

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ABSTRACT

Construction is highly influenced by the cost of the construction materials. In this a major part of the estimation is to be provided for the steel. Steel is not only expensive but also increases the overall dead load of the structure. In addition to these drawbacks, corrosion of steel is also a serious problem which has to be taken care. In order to overcome these problems, steel can be partially replaced with bamboo. Bamboo is an environmentally sustainable product and one of the fastest growing plants in the world. Hence it can be widely used in construction. These are of very less weight and of low cost; therefore it can highly reduce the overall cost of construction. As it is a natural composite material with high-strength to weight ratio it is useful for structures. It also has higher compressive strength than timber, bricks or concrete. It has appreciable tensile strength than rivals' steel. Bamboo construction can be highly used in earthquake prone areas and hilly regions as they are good absorbers of shocks. Bamboos are easily available and can be easily worked with; therefore repairs and alterations to these works can also be done easily.

Keywords: Bamboo, Concrete, Tensile test, Compression test, Flexural test

INTRODUCTION

Bamboo is a perennial grass and not a tree as is commonly perceived. One of the fastest growing plants on Earth, because of the presence of unique rhizome dependent system. Its growth rate ranges from 30cms to 1m in 24 hours. In bamboos, the stems are usually hollow. The strongest part of a bamboo stalk is its node, where branching occurs.

Bamboo is an extremely strong natural fibre, on par with standard hardwoods, when cultivated, harvested, prepared and stored properly. Bamboo is highly flexible and extremely lightweight. During its growth, it may be trained to grow in unconventional shapes. After harvested, it may be bent and utilized in archway and other curved areas. It has a great capacity for shock absorption, which makes it particularly useful in earthquake prone areas.

Bamboos generally take CO_2 and release about 30% of O_2. Hence, using bamboo in construction can increase the demand on the raw material and it results in the plantation of bamboos and it enhances good ecological balance.

LITERATURE REVIEWS

1) Jigar K. Sevalia, Nirav B. Siddhpura, Chetan S. Agrawal, Deep B. Shah, Jai V. Kapadia, "Study on Bamboo as Reinforcement in Cement Concrete", International Journal of Engineering Research and Applications, Vol. 3, Issue 2, March -April 2013, pp.1181-1190 In this study presents the assessment of the viability of the employ of Bamboo as reinforcement in concrete members. In this research the Bamboo was used as a reinforcing material without any treatment and stirrups. Based on the experimental study, the following conclusions are made, - Tension test performed on Bamboo strip revealed elastic behavior - Both Singly and Doubly Reinforced Beam has shown elastic behavior while performing flexural tests on them - Doubly Reinforced Beam has performed more elastically than Singly Reinforced Beam while performing flexural tests. - Load carrying capacity in Doubly Reinforced Beam increased by 29.31 % as compared to Singly Reinforced Beam. - Vertical cracks are developed, on failure of the beam, within middle third region of the beam. This type of failure is a proof existence of pure moment without any shear. - Modulus of Elasticity of the Doubly Reinforced Beam is more than twice of Modulus of Elasticity of the Singly Reinforced [5]
2) Ayesha Syeda, Barvaliya Shrujal Jayesh Kumar, A Case Study on Bamboo as Green Building material, International Journal of Engineering and Advanced Technology (IJEAT), Volume-4 Issue-2, December 2014 Bamboo is lighter in weight than bird but is stronger than steel. It takes carbon dioxide in and releases 30% more oxygen than tree. It grows a meter in one year and is mature in almost 3 years. Houses constructed using this bamboo are cool in summer and stays warm in

wintry weather and more over it can resist earthquakes and can stand forever. The environmental and financial comparison demonstrates that bamboo can compete with building material. Bamboo is a natural product and will therefore always have some extent of irregularity. It is therefore suggested that the bamboo Culm should be used in functions were the measurement requirements are not entirely precise or fixed, as in temporary buildings (e.g., pavilions and tents) or small civil projects. Furthermore, bamboo can play a role as a non-supporting or finishing material.

3) Avula Ganesh Reddy, A. Joshua Daniel, "Study on Behavior of Bamboo as Reinforcement with Coconut Shell as Aggregate Concrete in Compression Member with Different Lengths", International Journal of Innovative Research in Engineering & Management (IJIREM), Volume-3, Special Issue-1, April-2015 In this study, Short columns of a range of lengths were studied in this work. The columns with replaced coconut shell aggregate with bamboo reinforcement and columns with replaced coarse aggregate with steel reinforcement were compared with the conventional concrete with steel reinforcement specimens. The ultimate load carrying capacity of the columns decreased with the increase in length. The stiffness of the columns also decreased with the replacement of aggregate and reinforcement. The ultimate load carrying capacity for the column of 1m length with coconut shell aggregate and steel reinforcement was about 86% of the column with conventional aggregate and steel reinforcement and coconut shell with bamboo reinforcement was about 63%. The ultimate load carrying capacity for the column of 1.3m length with coconut shell aggregate and steel reinforcement was about 77.5% of the column with conventional aggregate and steel reinforcement and coconut shell with bamboo reinforcement was about 67.5%. [6] 3
4) Anurag Nayak, Arehant S Bajaj, Abhishek Jain, Apoorv Khandelwal, Hirdesh Tiwari, Replacement of Steel by Bamboo Reinforcement, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 8, Issue 1 (Jul. - Aug. 2013), PP 50-61 In this study, the effect of replacement of steel reinforcement by bamboo reinforcement, designs have been conducted on one way slab of size 3000 x 7000 sq-mm with providing beam of 7000 mm length and 250 x 250 sq-mm. In this paper the designs are done on the basis of shearing and bending. Bamboo

reinforcement technique is used for both main and distribution reinforcement as it was same earlier done for steel reinforcement. It is three times cheaper then steel reinforcement technique. It is clear from results that this bamboo reinforcement technique is absolutely cheaper then steel reinforcement technique especially for single story structure.

5) Sani Haruna, M. Lakshmipathy, Ductility Behaviour of Bamboo Reinforced Coconut Shell Concrete Beams, International Journal of Scientific Engineering and Research, Volume 3 Issue 5, May 2015.From their research work and experimental result obtained the following conclusions they have made: Tension test performed on bamboo strip revealed elastic behavior and its ultimate strength was 112.05N/mm^2. The modulus of elasticity of coconut shell concrete was found to be 12075.2N/mm^2 which represents 54%, 57%, 43.88% and 60.36% that of modulus of elasticity of conventional concrete for IS 456, ACI-318, EU and BS 8110 codes respectively. The load carrying capacity of the NWC beams were slightly higher than CSCS, BCSC, and BCSCB beams. The stiffness behavior of CSC beam showed similar trend as that of NWC up to failure Energy absorption was more for BCSC than NWC, BCSC and BCSCB beams. This is attributed due to the high deflections due to applied loads. Deflections are higher in BCSC and BCSCB beams when compared to NWC and CSCS beams and by wrapping the split bamboo with binding wire the deflections were slightly reduced in BCSCB beams compared to BCSC beams.

MATERIAL PROPERTIES

PROPERTIES	MATERIAL (BAMBOO)
Specific Gravity	0.522 to 0.620
Average Weight	0.750 kg/m
Modulus of Rupture	612 to 1650 kg/cm^2
Modulus of Elasticity	1.5 to 2.0x10^5 kg/cm^2
Ultimate Compressive Strength	794 to 850 kg/cm^2

Safe Working Stress in Compression	105 kg/cm^2
Safe Working Stress in Tension	160 to 350 kg/cm^2
Safe Working Stress in Shear	135 to 190 kg/cm^2
Bond Stress	6 kg/cm^2

Table 1 Material Properties

TEST CONDUCTED ON VARIOUS SPECIMENS

To know the feasibility of the Bamboo as reinforcement in the cement concrete flexural element the following test were performed:

1. Tension Test on a Bamboo strip.
2. Compression Test on cement concrete cube.
3. Flexural test on the Bamboo reinforced cement concrete beam.

TENSILE TESTING

To check the tensile strength properties of an bamboo which is used as an reinforcement, the tension was conducted. This test is conducted by using an UTM (Universal Testing Machine). Since the test specimen is smooth and shiny the ends are roughened to place it properly in the testing machine.

Fig.1 Bamboo specimen

SAMPLE NO.	SAMPLE POSITION	SPECIMEN SIZE		CROSS SECTION AREA (mm2)		
		LENGTH (mm)	THICKNESS (mm)	END A	END B	AVG AREA
1	End nodes	850	12	224	236	230
2	End nodes	850	12	184	176	180
3	End nodes	850	12	220	244	232

Table 2 Description of tensile test specimen

COMPRESSION TESTING

The compression test was conducted in the cube to check the compression test of the concrete cube of grade M25. Three cubes were casted for this test, to conduct the tests in 7days,14 days and 28days. The test results are tabulated as follows:

SAMPLE NO.	DIMENSION B*L*D(mm)	DAYS	LOAD KN	COMPRESSION STRENGTH(N/mm^2)
1.	150x150x150	7	435	19.33
2.	150x150x150	7	422	18.76
3.	150x150x150	7	392	17.422
4	150x150x150	14	480	21.33
5	150x150x150	14	492	21.87
6	150x150x150	14	460	20.44
7	150x150x150	28	540	24.00
8	150x150x150	28	595	26.44
9	150x150x150	28	580	25.78

Table 3 Details of concrete cube specimens

FLEXURAL TEST ON CEMENT CONCRETE BEAM

Flexural test for beams are generally conducted for the following cases:

1. Plain cement concrete beams
2. Flexural element reinforced with bamboo
3. Flexural element reinforced with normal steel reinforcement

Plain Cement Concrete Beam

The plain cement concrete beam is the one in which the beam is casted only with the concrete and no additional reinforcement for tensile strength improvement is used. In plain concrete it was observed that it was too brittle and the first crack developed at the bottom of the beam. The crack was observed to propagate with the increase in the loading condition.

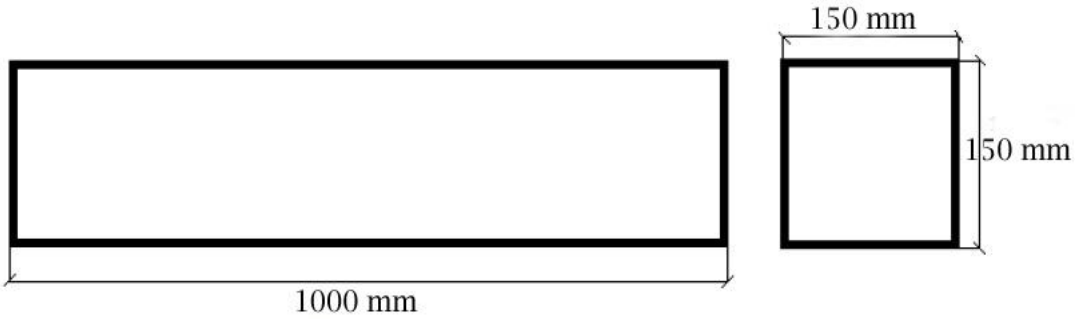
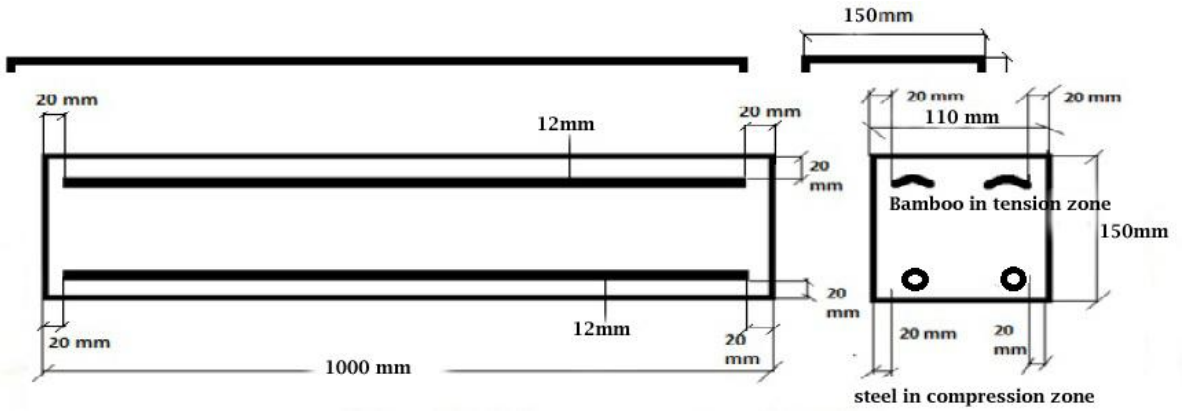


Fig.2 Plain Cement Concrete Beam

SAMPLE NO.	ULTIMATE LOAD(KN)	AVERAGE ULTIMATE LOAD(KN)
1.	13200	13983.33
2.	13970	
3.	14780	

Table 4 Results of plain cement concrete beams

Flexural Member Reinforced with Bamboo



The flexural member is casted with bamboo. The behavior of the member was observed to be different with the normal plain cement concrete beam. The strength properties improved to some extend and they are tabulated as follows:

From the results obtained the modulus of elasticity was calculated by the following formula:

$$E = \frac{23xWxl^3}{648x\delta xI}$$

Where,

W = load.
L = Length of the Beam
δ = Deflection
I = Moment of inertia
E = Modulus of Elasticity

Now,

I = 1/12 ($b*d^3$)

Where,

b = Width of the beam
d = Depth of the Beam.
I = $1/12*(150*150^3)$

I = 42187500 mm^4
L = 1000 mm.

Table 5 represents the results of modulus of elasticity.

SAMPLE NO.	DEFLECTION	LOAD(N)		M.O.E ($N/mm^{2)}$	AVERAGE
		2W	W		
1.	0.1	11200	6000	50480.118	68241.65873
2.	0.06	10000	4700	65904.710	
3.	0.06	11500	6300	88340.148	

Table 5 results of modulus of elasticity

CONCLUSION

The main purpose of this research is to find the possibility of using bamboo as reinforcement. The flexural test was conducted for the three specimens casted and the following observation was made.

1. The plain concrete was observed to be brittle in nature during the application of load, as it failed without any prior notice.
2. The normal steel reinforced flexural member was observed to have a normal behavior with required strength and stiffness. The amount of deflection was also considerably low when compared to bamboo reinforcement.
3. The bamboo reinforced flexural member was observed to be weak when compared to steel reinforced beams which indicates they are weak to take up the shear loads.
4. Modulus of elasticity of the Bamboo is quiet lower than that of the steel.
5. Plain cement concrete Beam failed suddenly and showed brittle failure.

Hence it is clear that bamboo can be used as a partial replacement of steel especially in the compression zone and can be implemented in those buildings with limited number of storey's.

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