

Performance Evaluation of Axially Loaded Element Using Bamboo as Reinforcement

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Abstract-There is a long-standing tradition of Bamboo Construction, dating back many hundreds of years. Different cultures have found in this material an economical system of building, offering sound yet light and easily replaceable forms of shelter. Bamboo can be used to make all the components of small buildings, both structural and non-structural. It is, however, often used in conjunction with other materials, cost and availability permitting. This study represents the use of Bamboo as reinforcement in axially loaded cement concrete members. In this study, various surface treatments on bamboo have been used before using as reinforcement in axially loaded element. The various chemicals used are Araldite, Epoxy and Bitumen. The cage of Bamboo using Bamboo stirrups was prepared for reinforcing in cement concrete column element.

Keywords: Bamboo strips, Column, Compression Test, Cracks, Tensile test.

I. INTRODUCTION

Bamboo are tall grasses found in tropical and sub tropical regions of Asia, Latin America and Africa. In India, majority of the rural areas use bamboo as a construction material for the construction of the houses. Due to the advantageous characteristics of the bamboo, in the last few years the research has been carried out for the use of bamboo as a structural member. Fikremariam Mengistu Assaminew^[1] in his study has reflected about the results of the various test on bamboo such as compression and tension test. He also performed the flexure test on the beams reinforced with the bamboos. He concluded that the compressive strength of the bamboo is smaller than that of the tensile strength of the bamboo. The ultimate tensile strength of the bamboo decreases from bottom to the top. The treated bamboo shows higher strength than that of the untreated one. Khosrow Ghavami^[2] has described about the use of the bamboo as an engineering material and also about the properties of the bamboo. He has carried test on the beams and columns using bamboo as reinforcement also performed various test on the bamboo to check and to conclude its various characteristics such as tension capacity, bond strength, etc. He concluded that the failure of the under reinforced section is due to the collapse of the bamboo for flexure element in bending.

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In over reinforced section the failure was leaded by the crushing of the concrete. M.A.Salu and A.S.Sharu^[3] have represented their results on behaviour of bamboo strip reinforced laterised concrete columns. They concluded that the bamboo doesn't prove to be effective in load carrying capacities of the concrete columns.

Musbau Ajibade Salau^[4] has shown his work about the structural strength of the concrete column reinforced with the Bamboo strips. The number of the Bamboo stirrups is varied. The results showed that the load carrying capacity of the column increased with increase in percentage of Bamboo stirrup reinforcement but the increase is not proportional to the percentage of reinforcement. Md. Ashan Sabbir, Md. Shahid, Saiada and Fuadi Fancy^[5] conducted tension test on the bamboo specimen. The specimens having three nodes were used. They concluded that the stress strain relationship was found almost linear up to its failure load. Satjapan Leelatanon, Suthon Srivaro and Nirundorn Matan^[6] has performed the test on the short columns with different type of reinforcement under concentric loading to investigate the strength capacity and ductility. The bamboos used as reinforcement were untreated. He concluded that the element containing bamboo without treatment shown less ductility than that of the bamboos with surface treatment. Youngsi Jung^[7] has very well described about the uses of the bamboo as technical as well as non technical. He has carried out various tests on the bamboo such as tension test and pullout test. Moso and solid bamboo were used for the test. He concluded that the moso bamboo achieved higher strength and ductility. Also the bond strength of the bamboo was lower than that of the steel in the concrete.

II. METHODOLOGY

To study the behaviour of the bamboo as reinforcement in axially loaded cement concrete elements the following tests were performed:

1. Compression Test on cement concrete cube.
2. Compression test on Bamboo reinforced Cement Concrete column elements.

A. Preparation of Cement Concrete Cubes

To verify the compressive strength of the M20 grade concrete the compression test on the cement concrete cubes was conducted. The cubes were of dimension 150*150*150 mm. After casting of the concrete cubes they were demoulded after 24 hours and were placed for curing for 28 days. The details of concrete cube specimen are shown in table below.

Table 1: Details of Concrete Cube Specimen

Size of Cube Specimen(mm)	Weight of the Cube Specimen(kg)	Density (kg/m ³)
150*150*150	8.52	25.2
150*150*150	8.36	24.7
150*150*150	8.41	24.91

150*150*150	8.11	24.02
150*150*150	8.24	24.41
150*150*150	8.56	25.36

B. Preparation of Reinforcement Cage and Column Specimens

In order to check the load carrying capacity of bamboo reinforced cement concrete column the specimen of the dimension 130*130*750 mm were prepared. The plain cement concrete column specimen was prepared without any reinforcement. Also the specimens with the bamboo reinforcement were prepared. To restrict the swelling of the bamboo specimen as well as to improve bond between bamboo surface and concrete, various surface treatments have been applied to bamboo surfaces. The various surface coatings used are as follows:

- Araldite
- Epoxy Resin
- Coal Tar

And to achieve the better grip between concrete and bamboo surface, sand coating on the bamboo specimen was done. After drying of the bamboo specimen reinforcement cage were prepared. The bamboo stirrups were used for the preparation of the cage. The binding wire was used for the binding of the stirrups with the bamboo spacemen. The stirrups were placed at 150mm spacing. The reinforcement cage is shown in Fig. 1. The details of the reinforcement cage are shown in the Fig. 2. Three column specimens were prepared for each treatment chemical. The details of the Column specimens are shown in Table 2.

Table 2: Details of Column Specimens

Sr.No.	Dimensions Of Element B*D*L(mm)	Type of Bamboo Surface Coating	Number of Specimens	Code of the Elements
1	130*130*750	None	3	P1, P2, P3
2	130*130*750	Araldite	3	CA1, CA2, CA3
3	130*130*750	Epoxy Resin	3	CE1, CE2, CE3
4	130*130*750	Coal tar	3	CC1, CC2, CC3

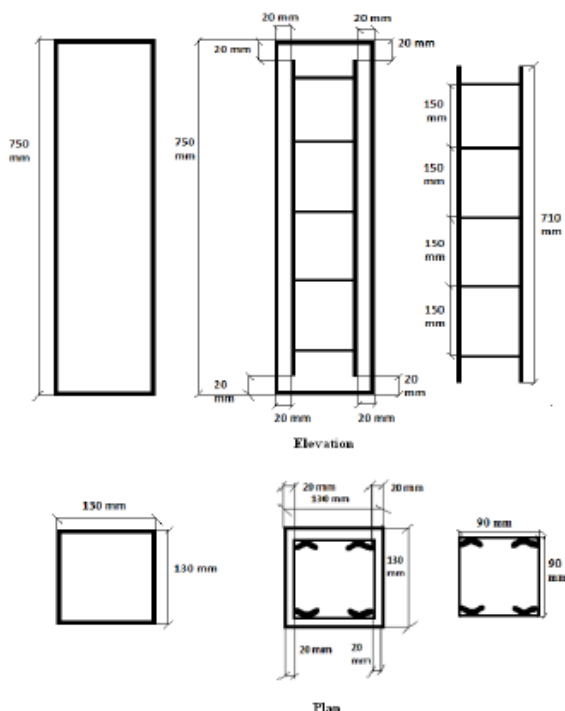


Fig. 1: Cross Sectional Details of Column Specimen

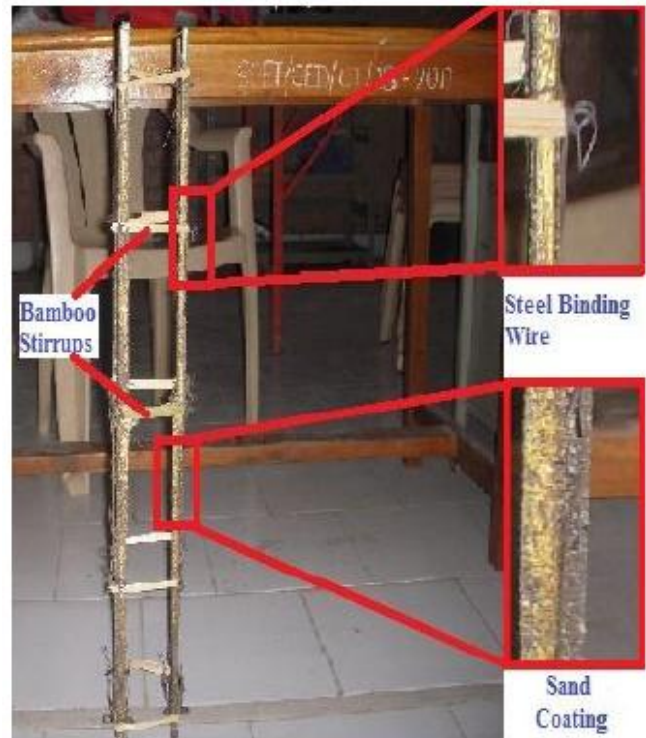


Fig. 2: Typical Reinforcement Cage of Column Elements

III. RESULTS

A. Compression test on Cement Concrete Cubes

Compression test was conducted to check the compressive strength of the cement concrete cubes of grade M20. Three cubes were tested at the age of 7 days and three cubes were tested at the age of 28 days. The results obtained are shown in Table 3.

Table 3: Results of Compression Test on Cement Concrete Cubes

Sample No.	Dimensions B*D*L (mm)	Days	Load (kN)	Compressive Strength (N/mm ²)
1	150*150*150	7	309	13.71
2	150*150*150	7	310	13.77
3	150*150*150	7	306	13.66
4	150*150*150	28	575	25.56
5	150*150*150	28	595	26.44
6	150*150*150	28	451	25.36

B. Compression Test on Bamboo Reinforced Column Elements

This test was conducted to check the load carrying capacity of the bamboo reinforced cement concrete column elements. The plain cement concrete column showed a brittle failure. All the columns reinforced with bamboo showed ductile failure. The failure pattern in the columns was crushing and bulging failure. Firstly the micro cracks were developed at the top of the column and further with the increase in the loading the cracks propagated vertically towards the centre of the element. The spalling of the concrete occurred with the increase in the load, which proved to have debonding of the concrete with the bamboo along its length. Finally the element failed by bulging. No failure in the bamboo reinforcement was noted. All the bamboo reinforced column specimens showed the same type of failure. The failure pattern and the buckling failure are shown in the Fig. 3 and Fig. 4. The results obtained are shown in Table 4. The comparisons of the results obtained are shown in Fig. 6.

Table 4: Results of Compression Test on Column Specimens

Sr.no.	Type of Bamboo Surface Coating	Codes of Column Elements	Failure Load(kN)	Average Failure Load (kN)
1	Plain (No Surface Coating)	P1	182	185.67
		P2	190	
		P3	185	
2	Araldite	CA1	278	274.67
		CA2	284	
		CA3	262	
3	Epoxy Resin	CE1	255	242.33
		CE2	260	
		CE3	212	
4	Coal Tar	CC1	330	337.67
		CC2	274	
		CC3	409	



Fig. 3: Failure Pattern of Column Element CA



Fig. 4: Failure Pattern of Column Element CE



Fig. 5: Failure Pattern of Column Element CC

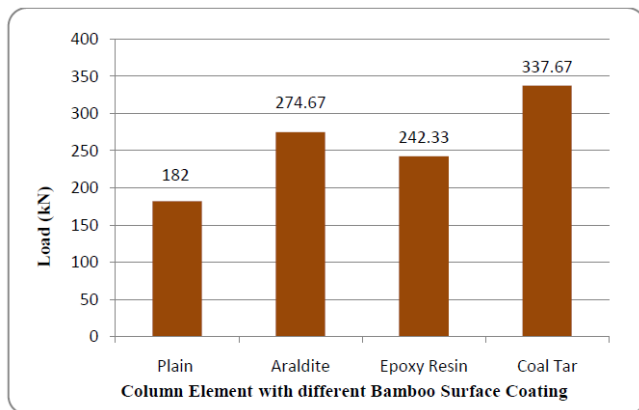


Fig. 6: Comparison of Load Carrying Capacity of Bamboo Reinforced Column with different Bamboo Surface Coatings

IV. CONCLUSIONS

- Plain Column failed suddenly and has shown brittle failure.
- All the column specimens reinforced with bamboo having different surface treatment showed similar type of failure.
- The failure in the column specimen is of type bulging failure and can be seen from Fig. 5.
- The vertical cracks along the length of the bamboo and Spalling of the concrete proved to have lack of capacity of ties of column to prevent bulging failure.
- All column specimens having bamboo as reinforcement showed ductile nature.
- As the bamboo inside the concrete doesn't failed and proved that the concrete was unable to take the tensile load in lateral direction due to Poisson's ratio.
- Elements having bamboo Reinforcement coated with Coal tar proved to resist the highest crushing load and can be seen from Fig. 7.
- Load carrying capacity of the elements having bamboo Reinforcement coated with Coal tar is highest i.e 46% more than that of the plain specimen.

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