Hindawi
Advances in Materials Science and Engineering
Volume 2023, Article ID 6931291, 11 pages
https://doi.org/10.1155/2023/6931291

Research Article

Experimental Analysis on the Feasibility of Bamboo Reinforcement in Concrete Mix Design and Comparison with Steel Reinforced Concrete

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Received 20 July 2022; Revised 23 August 2022; Accepted 13 July 2023; Published 14 September 2023

Academic Editor: Pudhupalayam Muthukutti Gopal

Besides being chief construction ingredients, concrete and steel produce a high amount of CO_2, and high energy consumption promotes global warming. To evade this problem, green and low energy consuming alternative is required. Rapid growing time with the least period to attend optimum strength made bamboo a new immerging mainstream constituent in construction. Bamboo, as one of the probable alternate structural materials, not only promises a sustainable and sturdy option but also reduces the environmental carbon footprint. In this research, article authors replaced steel reinforcement in concrete with bamboo. To establish bamboo as a construction material, a concrete beam of 200 mm × 500 mm is made in which bamboo bars of diameter 20 mm are used with a variation of 1 to 4% of the reinforcement area. Various tests were performed to provide the feasibility of bamboo as construction materials after 28 days of curing, in which test results were found promising. The impact test shows only 25% of wear and tear. Also, bamboo reinforced concrete (BRC) without changing cross sections provided 50% axial compressive strength compared to steel reinforced concrete (SRC). However, in the tensile test, BRC outperformed SRC by providing 50% more resistance against tensile load. Authors also performed rate analysis between SRC and BRC to find that it almost reduces 18% of the cost at a small scale. Hence here, comparative research is provided, and the authors believe that it would pave the road on which forthcoming researchers will walk to reach the destination of finding an alternate, sustainable, and green construction material in the form of bamboo.

1. Introduction

In naming construction materials, concrete holds one of the top positions on the list. Concrete is generally made of cement, fine aggregate, coarse aggregate, and water. The reaction of cement components with water provides sufficient and required binding property with the strength of the concrete. Cement gets into smaller gaps existing between fine sand, filling the pore and providing impermeability to concrete. The property of binding different constituents of concrete initiated after adding water to concrete after that initial setting and hardening of concrete take place. This process imparts strength to fine aggregate and makes it a solid mass. Fine aggregate fills the gaps between the coarse aggregate. They consist of silica grains in angular or rounded shapes. Allowing water through its pores helps to harden the cement, helping lower the shrinkage cracks. The reaction between cement constituents and silica of coarse aggregate made concrete a solid mass, providing resistance against crushing. However, the hardness of concrete also brings some problems in the structure as concrete shows a very brittle nature against loads. Concrete can easily withstand compressive load but have very poor ductility and provide little resistance against tensile load. To complement the properties of concrete, a ductile material is required to withstand with both forces and will show only ductile failure.

In the 19th century, researchers used steel bars as reinforcement for concrete. The selection of steel as a reinforcing material in compliance with some of its properties, i.e., steel is highly ductile. Young's modulus is equal for both compression and tension; it has high tensile strength compared with concrete, and most importantly the thermal coefficient of steel and concrete is almost identical, thus preventing bond failure between them [1–3].

However, the usability of cement and steel in construction has issues. The first and obvious issue is the weight of the structure, i.e., dead load. The high specific gravity of concrete and steel can make structures very heavy. This not only contributed to the calculation of load combinations for structure design but also increased the cost of structures. For heavy structures, it is likely to be noted that it suffers more in an earthquake. The second issue is not visible but is more concerning than the first issue and has a negative impact on the environment. The production sector of this constituent is one of the most polluting industries. Production of cement requires burning fossil fuels to burn the limestone and other ingredients to make clinker which later grinds to make cement. This process produces an enormous amount of CO_2. One ton of cement contributes 750 kg of CO_2 to the environment. Similarly, for steel, the production of 1 ton steel contributes 1.9 tons of CO_2 to the atmosphere. This is estimated as half a ton of CO_2 per person [4]. The third issue associated with these ingredients is that it is costly. The advancement of any country depends on the development of the infrastructure sector. Hence, rising cost of ingredients only contributes to problems rising for developing countries. Therefore, it is easy to say that headlong production and use of cement and steel adversely impact the atmosphere. Various problems, i.e., cost, degradation of cement, weight, and nonrenewability of each material, change the focus of the study to the more sustainable and ecofriendly options.

New studies show that using natural fibre, sustainable and green concrete technology can be developed [5]. In this area, past studied fibres are jute [6, 7], coconut coir [8, 9], sisal [10], babadua [11], date palm [12], bamboo [13], and bamboo fibre [14]. Although every fibre shows potential but rapid growth, attainment of optimum strength in a few years and lush amount of supply provide the bamboo fibre with little advantage over all other natural fibres.

Past studies report the notable mechanical and physical properties of bamboo [5]. Fast-growing, timber-like bamboo is associated with the grass family *Poaceae*. In just three years, it attains its optimum strength and maturity at the age of 5 years. The tensile strength of some bamboo species is the same as the yield strength of mild steel. Other than that, a six-time greater specific weight ratio is achieved by bamboo compared with steel. Bamboo can take a tensile and compressive load similar to steel, but the remarkable point is to notice that the required energy for producing 1 m^3 of steel is 50 times higher than bamboo. All these properties made researchers use bamboo in place of steel reinforcement [15].

Mansur and Aziz [6] use bamboo mesh in woven form with cement mortar. It is used to act as reinforcement. This study suggested that a significant increment had been seen in ductility and toughness. Using bamboo imparts a considerable increase in tensile, flexural, and impact strength. Akeju and Falade [16] research on the reduction of water absorption of bamboo by coating it with bitumen and sand. They used treated bamboo for reinforcement in column and beam member. Ghavami [15] enlightens that ultimate load carrying capacity is increased four times using bamboo as reinforcement with nonreinforced concrete. However, the author also provided suggestions that the bond strength of steel is higher for steel and concrete than that of bamboo with concrete, which made bamboo reinforced concrete (BRC) carry less tensile load. The author described the application of bamboo as a structural element using as a frame, beam, and shutter, which would be subjected to bending stress.

Prasad et al. [17] used low-cost panels for cheap houses using bamboo reinforced cement-sand mortar panels in hilly areas. Mats were made of bamboo and coated with bitumen, and a spray of sand was used for wall and roof elements. A plaster of 12 mm made with mixed cement: sand (1 : 6) is applied to both faces to bear stresses; however, no test was reported supporting that. Maity et al. [18] suggested the use of precast BRC wall panels. Lima et al. [19] performed the durability analysis by applying calcium hydroxide and tap water on BRC and stated that after 60 days of the continuous wetting and drying cycle, BRC did not show any variation in tensile strength and Young's modules.

Single and double beam using bamboo as reinforcement and column analysis were performed by Rahman et al. [20] and Salau et al. [21], respectively. It is stated by Terai and Minami [22] that RCC's formula to evaluate fracture behavior is sufficient to perform for BRC. Also, Yamaguchi et al. [23] used bamboo as main rebar and stirrups with flexural load and studied its performance.

Different studies, such as roofs' top by insertion of bamboo strips [24, 25], their behavior, and strengthening the bamboo by chemical treatments, regarding the use of bamboo as structural elements are performed [26]. Using bamboo pegs in reinforcements and also the bond between them, all are studied and elaborated on in past research studies [27–29].

Regarding carbon embodied energy, the manufacturing sector of both reinforcing materials shows significant differences positively towards bamboo. Embodied energy of bamboo columns is only 4–6 MJ/kg in comparison with medium carbon steel with an energy of 29–35 MJ/kg [30].

Similarly, the carbon footprint of steel is significantly greater than bamboo's, with 2.2–2.8 kg·CO_2/kg (equivalent kg of CO_2 per kg of the material) for medium carbon steel [30] and 0.25 kg·CO_2/kg for bamboo [31–33].

Authors in this research studied the bamboo called as Katang (*Bambusa bambos*) shown in Figure 1 available locally in Maharashtra. A thin layer of bitumen and sand is applied to protect it from corrosion and water absorption. Various tests were performed to find the different mechanical properties of bamboo and applied it as the main bar in the beam arrangement using bamboo sticks as stirrups. The test list and results are discussed below.

The authors' objective of this study is to investigate the different civil advantages of using bamboo as a reinforcing material in place of steel for making reinforced concrete sections. Past studies using bamboo reinforcement did alter the cross section of the concrete beam. The authors in this study intended to achieve the maximum compressive strength possible from bamboo reinforced sections compared with steel reinforced sections without altering the cross section of the concrete beam. Also, a cost analysis is performed by the authors in this study to compare the economic difference in steel reinforced and bamboo reinforced concrete sections.

FIGURE 1: Image of *Bambusa bambos* [34].

2. Experimental Program

Experimental program for bamboo reinforcement is depicted in a flow diagram in Figure 2.

2.1. Material Selection and Properties

2.1.1. Bamboo. For this study, we selected a bamboo species called *Bambusa bambos* or giant thorny bamboo locally available in Maharashtra state. In the local language, it is called Katang [35]. It is perennial *Poaceae* having a clump height of 20–35 m. It almost takes 12 years to reach maturity [36]. The interesting fact with bamboo is that it attains its maximum height in the very first year with a 30 cm growing rate per day [37, 38]. Specifications of *Bambusa bambos* are represented in Table 1.

2.1.2. Cement. While defining cement, the adhesive and cohesive property plays a key role. The property of cement assists in compacting different fragments together. For this study, we selected Portland pozzolana cement (PPC), which will later be used in making concrete. Different tests were performed to determine cement's properties, i.e., consistency (IS code 8112-1976), initial setting time (IS code 12269: 1987), final setting time (IS code 12269:1987), specific gravity of cement (IS code 2720- part 3), fineness modules (IS code 4031:1996 part 1), and soundness of cement using Le Chatelier's apparatus (IS code 4031-1996 part 2) and IS code 5514-1996. Different test results are tabulated in Table 2, and also chemical composition of cement is presented in Table 3.

2.1.3. Aggregate. Inert, inorganic, granular material having stones or stone-like solid is named as aggregate. Aggregate is a very chief ingredient in concrete making. It occupies about 3/4th of the volume of concrete. It provides required strength to the concrete structure, while cement is associated with particle binding. Changes in aggregate property can bring a change to the tangible property due to the large volume fraction. Aggregate also provides economical control to the concrete and also provides durability and stability in the concrete mix. Two types of aggregates are generally used in the concrete. They are described as follows:

(a) *Coarse Aggregate*. Aggregates retained on sieve no. 4 (4.75 mm) are predominantly named as coarse aggregates for the concrete-making process. The maximum size can be taken as large as 150 mm. Different properties of coarse aggregates used in this project are determined referencing IS code 383:1970. The different test results are shown in Table 4.

(b) *Fine Aggregate (Sand)*. Aggregates those passed no. 4 sieve (4.75 mm) and retained on no. 200 sieve (75 microns) are considered fine aggregates. Fine aggregates fill the pores of coarse aggregates providing better load transfer property by creating better contact between particles. The various tests to analyze the properties of fine aggregates are used in this project, referencing IS code 383:1970, as described in Table 4.

2.1.4. Water. Water used to prepare different samples of concrete had been clean and free from impurities and dirt. No such foreign matter was presented in water, i.e., oil, salts, alkalis, and sugar. The pH value is greater than 6 for applied water in this study.

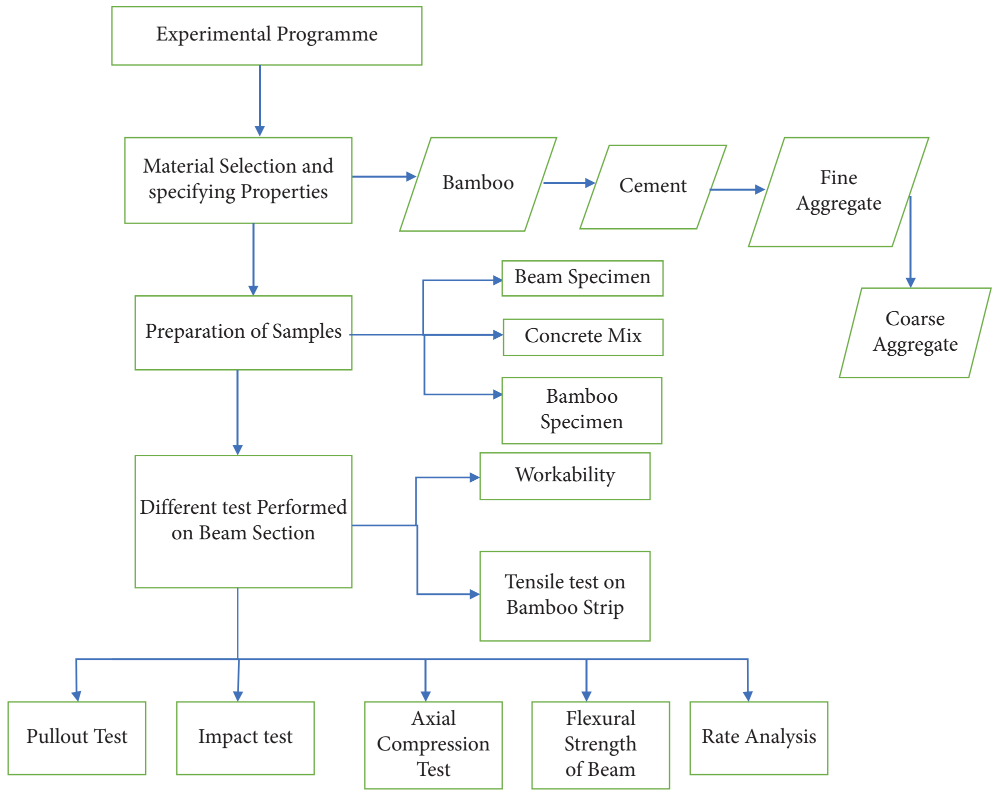

FIGURE 2: Flowchart of experimental program for bamboo reinforced beam (source: author).

TABLE 1: Specifications of *Bambusa bambos* (source: author).

Specification	Property
Full strength attaining period	3–5 years
Full maturity	12 years
Sustainable temperature	22–30°C
Habituality	Evergreen
Height	30 m
Edibility	Moderate

TABLE 2: Properties of PPC (source: author).

S. N.	Description of property	Value in PPC
1	Fineness (cm^2/gm)	3600
2	Normal consistency (%)	31
3	(a) Initial setting time (minute) (b) Final setting time (minute)	55 305
4	Soundness (mm)	2
5	Specific gravity	3.15

TABLE 3: Chemical constituent of PPC (source: author).

S. N.	Oxide	% in cement
1	SiO_2	19.71
2	Al_2O_3	5.20
3	Fe_2O_3	3.73
4	CaO	62.91
5	MgO	2.54
6	SO_3	2.72
7	K_2O	0.90
8	Na_2O_3	0.25
9	Miscellaneous	2.04

TABLE 4: Properties of course and fine aggregate (source: author).

S. N.	Property	Coarse aggregate	Fine aggregate
1	Fineness modules	7.098	2.493
2	Specific gravity	2.85	2.66
3	Water absorption	0.8%	1%

2.2. Sample Preparation

2.2.1. Bamboo. Bamboos were dried and cut into 3/4th inch (20 mm) wide and 7 ft 9 inches (2.36 m) long strips for the tests. Bamboo strips were treated by applying a bitumen coat and sprinkles of sand to them. The treatment is done to avoid the absorption of water when it is cast in the beam. Five points were selected to measure the distance. The effect of nodes was not present in the limited study of authors; hence, the effect of nodes was desired to be investigated. Samples were prepared so nodes would be at the center, and aluminum tabs were provided to protect bamboo from crushing. All assemblies are presented in Figure 3.

2.2.2. Concrete Mix. Concrete mix design is done to achieve suitable strength and durability. By selecting the proper ingredient, we ensure that concrete can perform up to our expectations. Concrete design mainly depends on four major factors: water/cement ratio, cement content, gradation of

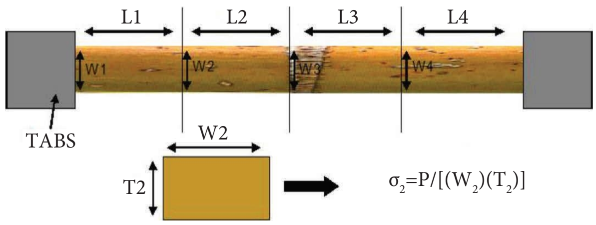

Figure 3: Assemblies for bamboo specimen preparation (source: author).

aggregate, and consistency. Determination of preparation of these four factors is known as concrete mix design. Based on experience, we adopted a 0.45 water/cement ratio but allowed water for absorption to increase the ratio to 0.509. The used proportion for desired concrete is 6 : 9 : 14, which provided mean compressive strength of 31 MPa. Final mix proportion and quantities of concrete are shown in Table 5, and concrete preparation is shown in Figure 4. From Figure 5, the X-ray diffractometer identified the presence of a noncrystalline substance in bamboo reinforced beam.

The slump test provided 100 mm of slump for this concrete mix.

2.2.3. Beam Preparation. The aim of the paper is to find the feasibility of bamboo as reinforcement can be achieved by comparing bamboo reinforced beams to the steel reinforced beam. The design of the beam was provided with 0.4 widths to depth ratio, the clear cover is between 45 mm for steel, and clear spacing is prepared with 25 mm or 1.33 times more than the biggest aggregate size. For the bamboo reinforced beam, 200 ∗ 500 mm size of the beam is selected where 20 mm of bamboo dia bar is provided. Clear cover and clear spacing each were provided with 40 mm. Bamboo bars were tied using bending wire. The beam and arrangement of r/f are shown in Figures 6 and 7, respectively.

2.3. Methodology and Experimental Investigation. After mixing the concrete in two batches, it was taken to the formwork. A 40 mm clear cover is placed at the bottom, and reinforcement is placed over it. Concrete was placed around the reinforcement, and rubber mallets were used as vibration tools to compact concrete. Also, steel rods were used to push down concrete so expulsion of air could occur. When all concrete was poured down, the top surface was finished with a smooth surface and curing was done after 24 hours of casting. Cylinders were also prepared for compression tests for a curing period of 7, 14, and 28 days. Strength was found according to that. Different mechanical properties, i.e., compressive strength, split tensile strength, and flexural strength of the sample, were found using the universal testing machine (UTM) at a constant loading rate of 120 KN/min.

3. Results

3.1. Workability. Slump test, compaction test, and Vee-Bee test (shown in Figure 8) and results were found to be high for the mix. It shows that the mix is workable, can be helpful for various desired applications, and can flow well in areas where congestion of ingredients occurs. The different results are shown in Table 6.

Table 5: Finale mix proportion and quantities for concrete (source: author).

Constituent	Mass used	Volume
Water	158.36 lit	
Cement	311.11 kg	1 m^3
Fine aggregate	739.148 kg	2.376 m^3
Coarse aggregate	1351.16 kg	4.34 m^3

Figure 4: Preparation of concrete (source: author).

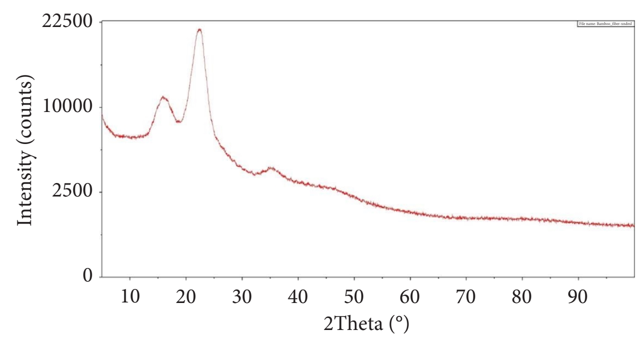

Figure 5: X-ray diffractometer of the bamboo reinforced beam (source: author).

Figure 6: Reinforcement arrangement (source: author).

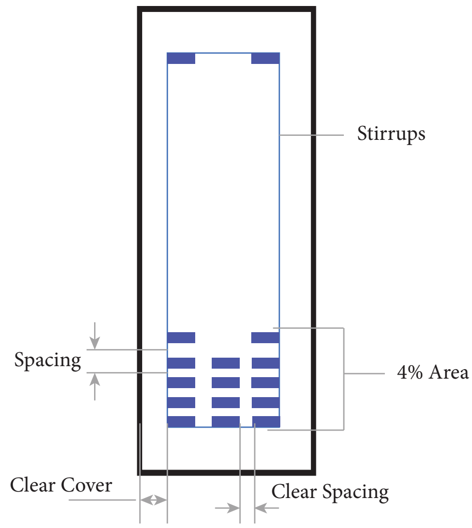

Figure 7: Beam arrangement (source: author).

Figure 8: Vee-Bee test setup (source: author).

Table 6: Workability test results (source: author).

Compaction factor test	0.89
Slump test	68 mm
Vee-Bee	13 sec

3.2. Tensile Test on Bamboo Strip. A tensile test was conducted to know the elastic parameter of reinforcement and ultimate strength (as shown in Figure 9). A total of three specimens were tested, and as the aim was to find the effect on bamboo's nodes, there was only one node in each sample. The measurement of thickness and width is taken from 3 points, and the average is taken for the calculation. It was noted that most of the failures have occurred on sample nodes. The resulting data are presented in Table 7.

3.3. Pull-Out Test. For inner bonding strength calculation, cylinders were made. A total of 3 adhesives are taken: (a) plain bamboo, (b) Araldite, and (c) Araldite with binding wire. In concrete cylinders, 100 mm of strips are inserted. To calculate bond stress, formula $\tau b = F/SL$ is used where F denotes pull-out load, s is the perimeter, and l is the inserted length, i.e., 100 mm. For every adhesive, three samples were made. Results are shown in Table 8. The analysis of the result provides data that Araldite with wire provides the best bond stress. The test represented that most failures happened due to slippage of the bamboo strip.

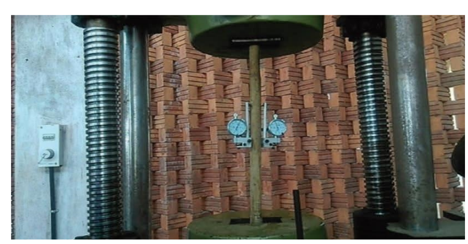

Figure 9: Tensile test setup for bamboo (source: author).

3.4. Impact Test. For the impact test sample, having clean aggregates dried in the oven at 105–110 to achieve constant weight after placing the sample in Los Angeles' machines, 20–30 rpm of rotation is achieved. After 15 minutes, the sample is removed and passed through the 1.75 mm sieve, indicating the percentage of samples passing after the test.

Table 7: Tensile test results (source: author).

S. N.	Length (mm)	Dia of bamboo specimen (mm)	Area (mm^2)	Ultimate load (KN)	Failure stress (MPa)	Strain
1	500.00	28	615.75	17.2	27.93	0.0080
2	510.00	26	530.9	13.8	25.99	0.0080
3	520.00	28	615.75	16.2	26.30	0.0076
		Average			26.74	0.0078

Table 8: Pull-out test results (source: author).

S.N.	Adhesive	Bamboo width (mm)	Bamboo thickness (mm)	Contact area per unit height (mm)	Pull-out load (KN)	Bond stress (MPa)	Avg. bond stress (MPa)
1	Plain bamboo	20.63	3.53	48.32	0.25	0.05	0.16
		22.71	3.10	51.62	1.34	0.26	
		21.85	4.67	53.04	0.99	0.19	
2	Araldite	23.47	3.47	53.88	1.94	0.36	0.31
		20.89	3.07	47.92	1.28	0.27	
		21.34	3.95	50.58	1.53	0.30	
3	Araldite with wire	22.81	2.95	51.52	1.96	0.38	0.50
		20.24	3.39	47.26	2.68	0.57	
		20.64	2.05	45.38	2.54	0.56	

The test data show that the weight of oven-dried sample was $w_1 = 1250$ gm, and the retained portion of the sample after the test was $w_2 = 937.5$ gm; hence, using the formula $W_1 - W_2/W_1 \times 100$, we calculated that the impact test shows only 25% of abrasion in the sample which is good.

3.5. Axial Compression Test. Axial compression tests for short columns were performed using columns of size 160 mm × 160 mm × 1000 mm. A total of 24 columns were casted for mix design of M20, 3 no. of each column for 4%, 6%, and 10% of reinforcement, and three plain concrete columns and RCC column with steel were cast for comparison purpose. From Table 8, Araldite and wire are used for maximum bond strength. The average of three is taken as axial compression for each column type. Because bamboo is a fibrous material, a higher amount of reinforced column with bamboo, i.e., 10%, can sustain with a comparison of steel reinforced column. Load deformation behavior is plotted in Figure 10, where the chart shows that bamboo r/f absorbs more energy. The same result was found in the study of Agrawal et al. [29].

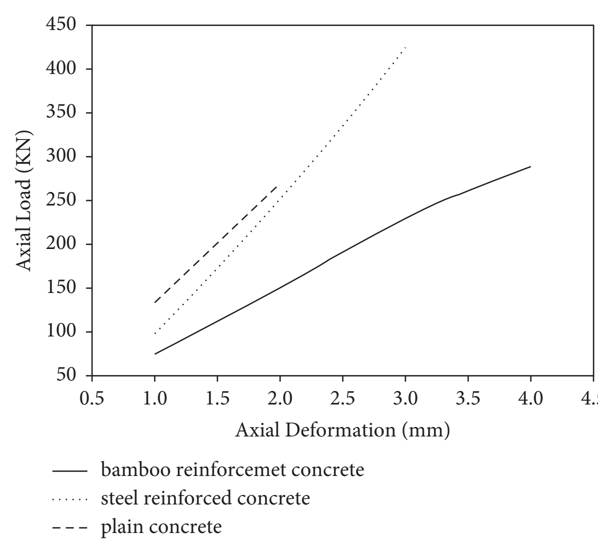

Figure 10: Load deformation behavior (source: author).

3.6. Flexural Strength of Beam. To compare flexural strength of SRC beam with 10% reinforced BRC beam, two beam specimens were made with three samples for each specimen prepared. The sizes were 700 mm × 150 mm × 150 mm. A lab test was performed after 28 days of curing according to IS 516, and average data are considered, suggesting that SRC is better in flexural about almost two times than BRC. The comparative data are represented in Table 9, and performing flexural test setup is shown in Figures 11 and 12, respectively.

3.7. Transverse Loading Test on Concrete Columns. From this test, the authors tried to find out the behavior of bamboo reinforced columns under the action of both axial and transverse loading. Nine samples were made for the transverse loading test: plain concrete, steel reinforced concrete, and bamboo reinforced concrete columns. Each constituent has three samples from which the average is taken as transverse loading. The test is performed under constant 10 KN of axial load. Different samples with different percentages of reinforcing

Table 9: Flexural strength comparison between SRC and BRC (source: author).

Reinforcement type	Length	Width	Depth	Load of failure	Flexural = $(3PL/2bd^2)$ (N/mm^2)
SRC	700	150	150	14.53	4.536
BRC	700	150	150	7.34	2.25

Figure 11: Setup for flexural test (source: author).

Figure 12: Performing flexural test (source: author).

Table 10: Maximum transverse load sustain by columns (source: author).

S. N.	Material	Sample no.	Reinforcement percentage	Transverse load at failure (KN)	Average load (KN)	Maximum deflection (mm)	Average deflection (mm)
1	Plain concrete	1	—	9.89		5.61	
2	Plain concrete	2	—	9.62	9.87	5.21	5.34
3	Plain concrete	3	—	10.1		5.2	
4	RCC	1	0.78	13.98		5.96	
5	RCC	2	0.78	13.64	13.94	5.64	5.79
6	RCC	3	0.78	14.2		5.78	
7	BRC	1	4	11.2		4.9	
8	BRC	2	4	10.8	11.03	4.2	4.56
9	BRC	3	4	11.1		4.6	

material are presented in Table 10. Also, results occurring from these tests are presented in Table 10. Results indicate that steel reinforced column shows 13.94 KN of sustainability of transverse load and bamboo reinforced column shows 11.03 KN of transverse load. The comparison of both samples provides positively 80% of transverse load towards BRC than SRC.

Also, BRC concrete can sustain 11% of more transverse load than plain concrete. All results are plotted in the graph in Figure 13.

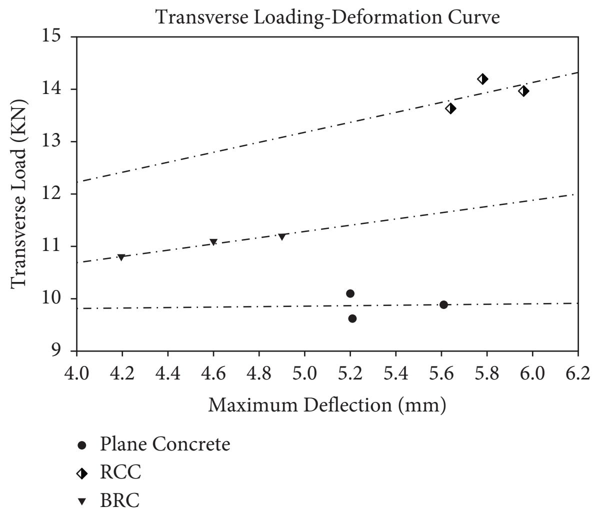

Figure 13: Transverse loading deformation curve (source: author).

Table 11: Rate analysis (source: author).

S. N.	Specimen	Materials	Per	Quantity	Rate (in rupee)	Cost (in rupee)
1	Steel reinforced concrete	Cement	Bag	1	385	385
		Fine aggregate	m^3	0.009325	2170	20.23
		Coarse aggregate	m^3	0.003475	1575	5.47
		R/F	kg	3.475	53.5	185.91
		Total				596.61
2	Bamboo reinforced concrete	Cement	Bag	1	385	385
		FA	m^3	0.009325	2170	20.23
		CA	m^3	0.003475	1575	5.47
		R/F	kg	0.68	17	10.52
		Araldite adhesive	kg	0.05	800	40
		Wire	Coil	1	23	23
		Bitumen	kg	0.05	35	17
		Total				501.22

3.8. Rate Analysis. The comparative rate analysis for both types of beam is presented in Table 11.

Hence, from the data, it is clear that BRC also reduces the cost of structure making by almost 18%.

4. Conclusion

This study tested the possible use and feasibility of bamboo as concrete reinforcement on different beam and column specimens. The study includes a bunch of tests, i.e., tensile test, pull-out test, axial compression test, flexural strength, and comparison on rates performed by authors. It is investigated and found that Araldite with wire exhibits higher bond strength for the pull-out test for the interface.

Tensile test on treated bamboo strip provided an average of 186.3 MPa of failure stress. Also, the impact test on the concrete mix provides only 25% of wear and tear in the Los Angeles test, which is quite good. The axial compression test suggests that columns with a higher percentage of bamboo as reinforcement provide more energy absorption. Each column shows brittle behavior and provides only a little warning before failure. However, the flexural analysis of SRC and BRC provides results that SRC is better in avoiding flexural failure almost by two times than the BRC beam. The authors also provide a rate analysis for SRC and BRC on the current price range and found that BRC reduces cost by almost 18%. Hence, authors believe that bamboo has the potential to become a sustainable and cheap building material as reinforcement and should perform experiments in future to further solidify outcomes from this study.

In this paper, the authors provide novelty in different points from previous studies. Authors replaced the conventional method of steel as a reinforcing material with bamboo reinforcement. Apart from all previous studies, this study focuses on Indian species of bamboo called Katang, which is found in the Maharashtra state of India. From studies of these species, we identified different engineering properties of bamboo listed above. In this paper, a special arrangement of bamboo reinforcement is studied for research purposes, i.e., the arrangement of nodes in the center of the span so that nodes take the maximum load. Without changing the cross section of the bamboo reinforced beam compared to the steel reinforced beam, the authors achieved 50% more compressive strength than the steel reinforced beam. Also, the authors perform a cost analysis to clarify the objective of achieving a cheap alternative of steel reinforced concrete section.

5. Future Scope

The potential of bamboo as reinforcement is tried to justify in this study. Notably, bamboo reinforcement has some issues to rectify. First, to gain the same amount of compressive strength as steel reinforcement, a higher percentage of bamboo is required, which eventually increases the weight of the structure since a large area is required to fit the greater percent of bamboo. So, studies to reduce the weight of the structure can be carried forward. Also, the effect of clear cover for bamboo reinforced structures should be studied in future. A clear cover is provided to protect steel from corrosion, but bamboo is affected by the environment and can decay. So, optimum clear cover can be identified by future work. Also, the effect of hybrid reinforcement using steel and bamboo can be investigated in future.

Data Availability

The data used to support the findings of this study are included within the manuscript.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Authors' Contributions

All authors contributed to the study conception and design. All authors read and approved the final manuscript.

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