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Performance Evaluation of Bamboo Reinforced Concrete Beam

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Abstract—Bamboo, which is a fast-growing and ecologically friendly material for structural applications, is being considered quite appropriate. Which consist property similar to the steel so bamboo drew the attention of many researchers for use as reinforcement in concrete. Some physical and mechanical property test are conducted in the specimen of messy and manga bamboo. Moisture content test, density test, compressive test & tensile test. The tensile strength of bamboo is high and reached up to 109.9 to 118.37 mpa. This makes bamboo a pretty alternative to steel in reinforcement loading applications. In this study, it has been attempted to develop engineered bamboo structural elements for use in low-cost housing or G+1 structures.

Keywords—Bamboo Reinforced Concrete, Universal testing machine (UTM), Tensile Strength, Compression Strength, Flexural Strength.

I. INTRODUCTION

Steel costs have risen dramatically in recent years. Steel is difficult to get in underdeveloped countries due to high pricing, and its use in the building industry is now restricted. Steel manufacture uses a lot of fossil fuels, thus the steel discharge in the construction of structures has been given, demonstrating how research institutions can drastically reduce it. Bamboo, as one of the fastest-growing plants, has a lot of economic potential among the many options for such substitutes. Bamboo has been utilised in Asia for thousands of years to build bridges and buildings. Bamboo is easier to harvest and carry than other plants. As a result, bamboo has lower manufacturing costs than steel. As a result, even countries and locations with no advanced manufacturing technologies or construction skills are projected to be able to use bamboo. The bamboo reinforced concrete composite elements can be used as an alternative to concrete, steel, and wood used in housing and other products required in day-to-day applications.

II. LITERATURE REVIEW

There are no of research paper, discussing about the possibility of bamboo as a reinforcing material. According to Arpita sethia bamboo as suitable reinforcement concrete. from stress strain curve of bamboo shows that it has a low modulus of elasticity as compared to steel. That's why it is unable to prevent the cracks on concrete under ultimate load. But flexure test of bamboo reinforced beam it has observed using bamboo as reinforcement in concrete can increase load carrying capacity of beam.

Saurabh jayagond is studied the load carrying capacity of bamboo reinforcement concrete beam was nearly 3 times of plain concrete beam as the same dimension of the beam. The deflection of a bamboo reinforcement concrete beam is around 1.5 times that of a steel reinforcement concrete beam. Tensile strength of a bamboo is roughly 1/3 that of steel.

Zang.Et.al. (2012) calculated the elastic modulus and compressive strength of recombinant bamboo to be 37 Gpa and 129 Mpa , respectively. Patel has investigated bamboo reinforcement slab panels and found a deflection of 10mm for singly reinforce panels and 6.85mm for doubly reinforced panel of size 900mm x250mm x 75mm.

III. OBJECTIVE

A. To determine the feasibility of bamboo by collecting information on the mechanical properties and behavior of bamboo reinforced beams, to reduce the quantity of steel and make the structure economic.
B. To investigate the physical properties of the bamboo as a reinforcement.
C. Examine the deflection of bamboo reinforced concrete under load.

IV. SELECTION OF BAMBOO

There are two types of bamboo involved in this project. Which are sources from the local market at Akurdi, Pune. Those two species include Messy and Manga. These two types of species were selected and left to dry for 2 weeks.

Fig. Manga Bamboo

Fig. Messy Bamboo

V. PROPERTIES OF BAMBOO

A. Physical Property Of Bamboo

Bamboo is commonly compared as a wood product due to its chemical structure. bamboo is light weight, Flexible, tough. Bamboo used in various construction activity. Physical properties based on the given procedure is IS :8242-1976 and IS 6874-2008.

1) *Moisture Content:* Moisture content was determined using small samples with a dimension of 25*25mm, as shown in the figure. The sample was weighted. The test specimens were weighed (m1) to a precision of 0.01gm and then dried in oven for 24 hours at 103 2°C. The sample was weighed again and the weight was recorded in order to quantify the quantity of moisture content left over after being dried in the hot air-drying oven.

$$\text{Moisture content} = \frac{m1 - Mo}{Mo} * 100$$

Where,

M1 = Initial mass of test specimen in gm

Mo = Oven dry mass in gm

Fig. specimen for Moisture Content

Moisture Content Test Results

Type of Bamboo	Sample no.	M1 (gm)	Mo (gm)	Mc in %	Average
Messy					
Top	1	4.13	3.66	12.84	11.36 %
	2	4.28	3.8	12.63	
	3	4.32	3.85	12.21	
Middle	4	4.34	3.87	12.14	
	5	4.23	3.85	09.87	
	6	4.49	4.09	09.78	
Bottom	7	3.94	3.58	10.06	
	8	3.99	3.56	12.08	
	9	4.53	4.04	12.13	
Manga					
Top	1	3.46	3.07	12.70	11.88%
	2	3.09	2.78	11.15	
	3	3.26	2.96	10.14	
Middle	4	2.84	2.57	10.51	
	5	3.02	2.73	10.62	
	6	3.72	3.32	12.05	
Bottom	7	3.18	2.80	13.57	
	8	2.96	2.61	13.41	
	9	3.45	3.06	12.75	

NOTE: As per IS code the desired optimum moisture content of bamboo material is 10-12%.

2) *Density Test:* This test is conducted as per IS 6874-2008. Pieces of bamboo size 25mmx25mm with 10mm thickness. bamboo pieces are measured by water displacement method. then dried in oven for 24 hours at 103 2°C.

$$\text{Density in kg/cm}^3 = \frac{\text{oven dried mass in g}}{\text{Volume in cm3}} \times 10^6$$

Fig. specimen for Density test

Density Test Results

Type of Bamboo	Sample no.	M1 (gm)	Mo (gm)	Volume in cm^3	Density g/cm^3	Average
Messy						
Top	1	4.13	3.66	6.25	0.585	0.621
	2	4.28	3.8	6.25	0.608	
	3	4.32	3.85	6.25	0.616	
Middle	4	4.34	3.87	6.25	0.619	
	5	4.23	3.85	6.25	0.616	
	6	4.49	4.09	6.25	0.654	
Bottom	7	3.94	3.58	6.25	0.726	
	8	3.99	3.56	6.25	0.572	
	9	4.53	4.04	6.25	0.569	
Manga						
Top	1	3.46	3.07	3.125	0.982	0.920
	2	3.09	2.78	3.125	0.889	
	3	3.26	2.96	3.125	0.947	
Middle	4	2.84	2.57	3.125	0.822	
	5	3.02	2.73	3.125	0.873	
	6	3.72	3.32	3.125	1.062	
Bottom	7	2.18	2.80	3.125	0.896	
	8	2.96	2.61	3.125	0.835	
	9	3.45	3.06	3.125	0.979	

NOTE: The optimum density of bamboo is 0.5 – 1.0

B. Mechanical Properties

Bamboo is tested for mechanical properties discussed below.

1) Compressive Strength : For compression test are conducted as per IS:6874-2008. specimens were sliced from the bottom, middle, and top regions. All specimens with free nodes were chosen for compression tests. Universal Testing Machine (UTM) compression tests were performed on the specimen for under constant load as shown in the figure.

Calculation Ultimate failure load in N

Compressive strength = ---------- ----------

Area of application of load in mm^2

Fig. Compression test specimen

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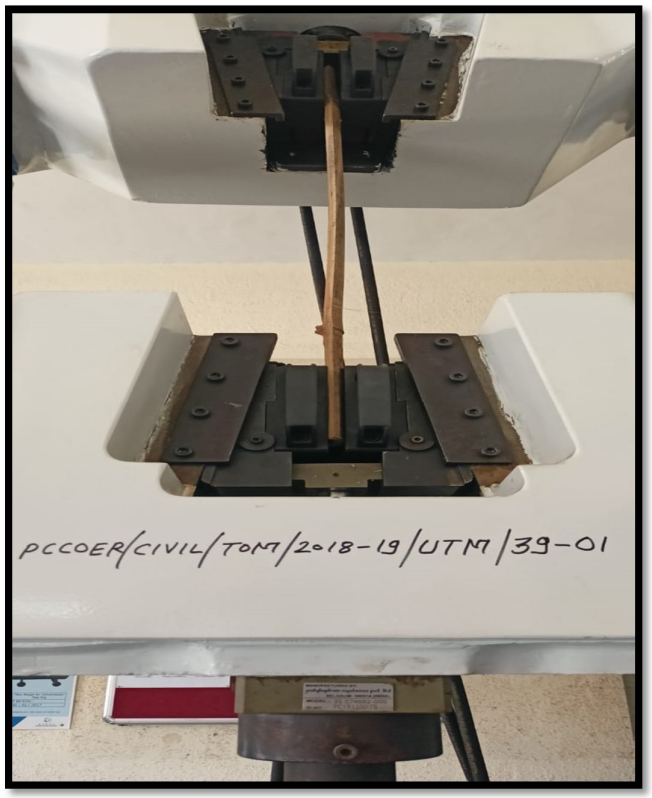
Compressive Test Results

Type of bamboo	**Inner dia in mm**	**Outer dia in mm**	**Area in mm**	**Ultimate failure Load in KN**	**Compressive Strength KN/mm^2**	**Average of Compressive Strength**
Messy						90.49
Top	21	31	408.40	40	97.94	
Middle	13	32	671.51	50	80.41	
Bottom	18	34	653.86	60	93.136	
Manga						102.22
Top	23	31	339.29	47	138.52	
Middle	25	37	584.33	50	85.56	
Bottom	24	45	1138.04	94	82.59	

2) *Tensile Test:* Tensile test is calculated by the applying the tensile load on bamboo splints in the UTM. Species are selected 650mmx35mmx10mm

Fig. Tensile test specimen



Calculation Ultimate failure load in N
Tensile strength = ---------- ----------
Area of cross section load in mm^2

Tensile Test Results

Type of bamboo	**Wide in mm**	**thickness in mm**	**Area in mm**	**Ultimate failure load in N**	**Tensile strength N/mm^2**	**Average tensile strength N/mm^2**
Messy						
TOP	35	10	350	37700	107.71	109.9
Middle	35	10	350	38600	110.28	
Bottom	35	10	350	39100	111.71	
Manga						
Top	35	10	350	40700	116.28	118.37
Middle	35	10	350	41500	118.57	
Bottom	35	10	350	42100	120.28	

VI. DESIGN OF BEAM

Size of bamboo = 150mm x150mm x700mm

A. Process

1) All the bamboo cut down to the length of 650mm as leaving 25mm cover from both sides. Which will replace steel in place of reinforcement.

2) Use the binding wire to bind the bamboo and the stirrups.

3) With the help of measuring tape to maintain exact center to center distance (130mm) between the two stirrups.

4) Casting the beam as use M20 grade concrete, curing 28 days. after the testing are conducted in UTM.

Fig. Casted beam

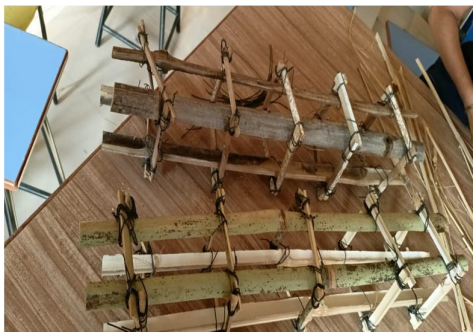


Fig. Reinforcement of beam

After Flexural Testing Result

Type of bamboo	L in mm	B In mm	D In mm	%	LOAD In KN	DEFLECTION In mm	Flexure strength (Mpa)
MESSY	700	150	150	1	19.09	4.57	2.828
	700	150	150	1	27.4	4.38	4.05
	700	150	150	1	23.19	4.48	3.43
	700	150	150	1	17.98	6.49	2.66
MANGA	700	150	150	1	11.07	2.35	1.64
	700	150	150	1	11.84	3.26	1.75
	700	150	150	1	14.95	2.35	2.21
	700	150	150	1	10.34	1.3	1.63

Flexure strength =P. L/BD^2
where,
P= Load at failure in N
L=span in mm
B =width in mm
D=height in mm
F.S = 0.7√fck
= 0.7√20 =3.13 N/mm^2

Minimum strength required is 3.13 N/mm^2 which is easily achieved in all messy specimens tested above.

Fig. 3-point loading in beam

Fig. failure of beam

VII. CONCLUSION

All the experiment were carried out in a testing laboratory on universal testing machine (UTM) capacity of 1000 KN (100tonne) The tensile strength of manga and messy bamboo .flexural strength of manga and massy if compared with strength of steel bar is less than half. For the flexural strength 8 beam were casted in which 4 specimen each for messy and manga comparting each other with beam size 150mmx150mmx700mm, the result clearly showed that the average of manga is less than that of messy bamboo. Minimum strength required is 3.13 N/mm^2 which is easily achieved in all messy specimens tested above.

VIII. ACKNOWLEDGEMENT

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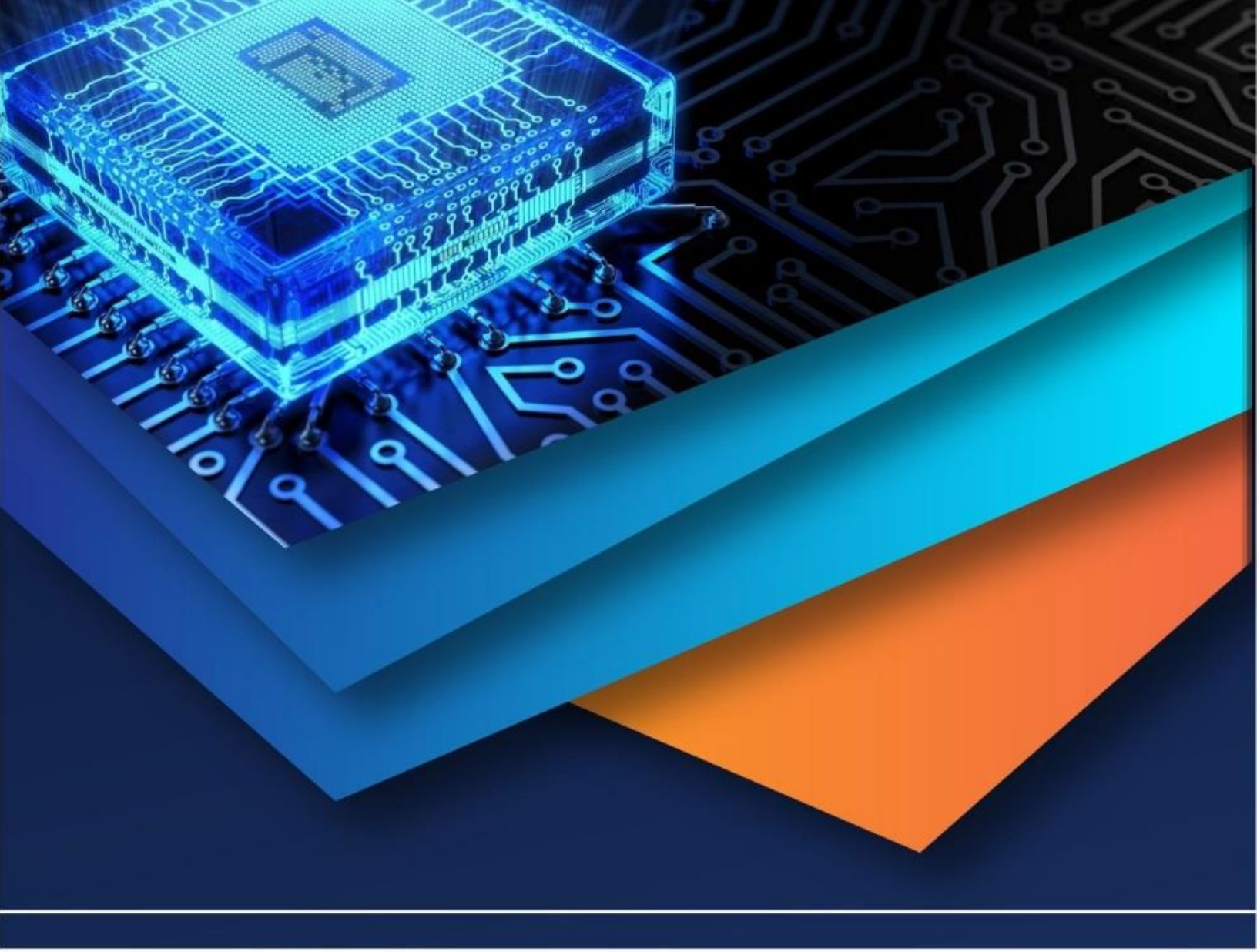

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