EXPERIMENTAL INVESTIGATION ON BEHAVIOR OF BAMBOO AS REINFORCEMENT IN STRUCTURAL CONCRETE ELEMENTS

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Abstract: Now a day's concrete is used as the basic materials for the construction works. The concrete is good in compression but weak in the tensile strength. So steel is used as reinforcement in the concrete to achieve the tensile strength. The tensile strength of bamboo is quite high and can reach up to 125 MPa. This makes bamboo a pretty alternative to steel in tensile loading applications. The bamboo concrete composite elements can be used as alternate for concrete, steel and wood used in housing and other products required in the day to day applications. In this study it has been attempted to develop engineered bamboo structural elements for use in low cost housing. The flexural test, split tensile test and compression test were performed on Plain, Steel & Bamboo reinforced members.For example, the total six beams of 100x100x500mm, six cylinders of 150mm diameter, 300mm length and six cubes of 150mmX150mmX150mm were casted using design mix M20 and mix proportion of 1:1.74:3.18 as per IS code. These beams and cylinders included two of plain concrete, two of steel reinforcement, and two of untreated bamboo reinforcement Bamboo concrete composite structural members can provide tailored solutions to the eco-housing initiatives at cheaper costs. The results obtained accrue the advantage obtained by the composite members when compared to standard reinforced concrete and plain concrete.

Keywords: CTM, Composite Member, Bamboo Reinforced Concrete, Experimental Investigation, TensileStrength.

1. INTRODUCTION

Concrete is a basic material for construction used all over the world. Concrete is strong in compression and weak in tension. To counteract this steel is used as a reinforcement material to gain tension. The steel is expensive and corrodes easily which leads to deterioration of structure. This can be overcome by bamboo due to its properties like light weight, strength, durable and easily renewable. So, the tradition method of using steel reinforcement is replaced by using bamboo as a reinforcement material in construction industries. Bamboo is a natural, economical and abundant material. It is having required compression and tensile strength. The deflection in mid span can be reduced by providing bamboo reinforcement. We are going to compare the performance of steel and bamboo to find the optimum result.

1.1 Objectives of theStudy

The goal of this paper is to determine the practicability of bamboo reinforcement for concrete beams and cylinders. Therefore, the aim of this study is to provide a preliminary contribution toward the adoption of the bamboo as reinforcement in structural concrete elements.

2. MATERIALS AND METHODOLOGY

2.1 Water

Water from municipality was used to prepare concrete mix and cure the testspecimens.

2.2 Cement

Through the investigation, Ordinary Portland Cement (OPC) wasused.A cement is a binder, a

substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Cement is the most widely used material in existence and is only behind water as the planet's most-consumed resource.

2.3 Aggregates

Natural sand and coarse aggregates were used in this test preparation. The aggregates were first washed and dried. Maximum size of 20mm aggregate was used for this test. The fine aggregate which passes through on 4.75mm sieve, and the coarse aggregate, which passes through 25mm sieve and retained on 2omm sieve of an Indian standard micron sieve were used in the experiment to test the concrete elements.

2.4 Bamboo

Bamboo is commonly compared to wood products due to its similar chemical structure. The physical structure is the aspect that differentiates bamboo from wood. Wood has anisotropic properties and contains grains oriented in the same direction throughout the whole structure. Bamboo contains parallel fibers that are reinforced along the axial direction of the Culm. In this project 8mm diameter bamboo was used in compression, flexural and split tensile tests.

2.4 Steel Reinforcement

The steel reinforcement used in this project was High yield strength deformed (HYSD) bars of 8 mm diameter. The yield tensile strength of bars which were used is 415 N/mm^2 (Fe 415).

2.5 METHODOLOGY

The tests conducted on concrete elements were Compression Test on cubes by using CTM, flexural test (two-point load flexural test) on beams and split tensile test on cylinders. The number of specimens for each type of test is shown in Table1.

Table 1. Type of testing of number of specimens

S.No.	Type of Testing	Specimens	No.s	Dimensions(in mm)
1	Compression Test	Cube	3	150X150X150
2	Split Tensile Test	Cylinder	6 2- plain 2- bamboo 2-steel	150X300
3	Flexural Test	Beam	6 2- plain 2- bamboo 2-steel	100X100X500

2.5.1 CompressiveTest

The compression test was performed on the cement concrete cubes to check the compressive strength of the concrete & hence to justify the proportion of ingredients to have specific strength of concrete. The resulting concrete was poured in moulds of size 150*150*150 mm. After casting concrete samples were kept in wet place and demolded at 24 hours age they were submerged in open water tank for curing up to 28 days as required for test. The bamboo samples must be well seasoned and well finished before placing it on CTM for compressive strength of bamboo and about 3 of such samples were created.

Fig.1: Test Setup to check compressive strength of cube

2.5.2 Flexural Strength Test

In order to check flexural strength of Bamboo Reinforced cement concrete, beam specimens are casted with dimension 100X100X500 mm. The Bamboo strips of the length 450 mm were used as reinforcement. To be acquainted with the behavior of Bamboo in concrete, different Bamboo reinforced concrete beam specimens were prepared. The different types of flexural beam specimen were:

- Plain Cement concrete beam without bamboo strips.
- Cement concrete beam with bamboo strips.
- Cement concrete beam with steel reinforcement.

Fig.2: Test setup to check flexural strength of beam

2.5.3 Split Tensile Test

- As the bamboo is used as to take tensile load in the flexural element the tensile test was conducted on the bamboo.
- The Bamboo strip was of the length 450 mm and the thickness of the Bamboo was average 8 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.

Fig.3: Test Setup to check split tensile strength of cylinder

2.6 Concrete MixDesign

Indian Standard mix design (M20) method used for normal steel reinforced concrete is applied in the preparation of mix design with mix proportion (1:1.88:3.16) for bamboo reinforced specimens. However, concrete slump is made as low as workability will allow minimizing excess water which causes swelling of the bamboo.

3. TESTRESULTS

The results of the compression tests, two point loaded flexural test and split tensile tests were performed with Bamboo reinforced concrete for different percentage.

3.1 Compressive Strength Test Result

Table No.2 shows the compressive strength results of cube of 150X150X150mm. Compression strength of cubes were calculated using the following formula

$$\text{Compressive strength} = P/A$$

Where, P = load applied on specimen cube

A = Area of the specimen cube

Table 2: Test results of compression test on plain cubes

S.No.	specimen	formula	Compression strength(N/mm$^{2)}$		
			7 days	14 days	28 days
1	Cube	P/A	16.66	18.44	24.88

3.2 Flexural Strength Test Result

Table No.3 shows the two point loaded flexural strength results of beam of dimensions 100X100X500 mm. the following formula was used to determine the flexural strength of the beam specimen with bamboo as reinforcement.

Flexural Strength = PL/bd^2

(when, a>200mm for 150mm

a>130mm for 100mm)

Where, P = load applied on beam specimen

L = Length of the beam specimen

b = width of the beam specimen

d = depth of the beam specimen

a = crack length

Table 3: Test results of flexural strength test on beams

S.No.	specimen	formula	Flexural strength(N/mm$^{2)}$	
			7 days	28 days
1	Plain beam	PL/bd^2	5,75	6.75
2	Bamboo beam	PL/bd^2	5.75	8.75
3	Steel beam	PL/bd^2	17.5	25

3.3 Split tensile Strength Test Result

Table No.4 shows the split tensile strength test results of cylinder of dimensions 150mm diameter and 300mm length. The split tensile strength of the cylinder can be obtained by using the following formula.

Split tensile Strength = $2P/\pi DL$

Where, P = load applied on cylinder specimen

D = Dia of the cylinder specimen

L = Length of the cylinder specimen

Table 4: Test results of split tensile test on cylinders

S.No.	specimen	formula	Split tensile strength(N/mm$^{2)}$	
			7 days	28 days
1	Plain cylinder	$2P/\pi DL$	1.41	2.54
2	Bamboo cylinder	$2P/\pi DL$	1.41	2.82
3	Steel cylinder	$2P/\pi DL$	1.06	2.36

4 ESTIMATION AND COSTING

4.1 Estimation

Before undertaking the construction of a project it is necessary to know its probable cost which is worked out by estimating. An estimate is a computation or calculation of the quantities required and expenditure likely to be incurred in the construction of work. The primary object of the estimate is to enable one to know beforehand, the cost of the work. In the first case we have used steel as reinforcement in both tension and compression, in the other case we have used Bamboo as reinforcement. A rough estimate has been shown to understand the benefits of using bamboo with steel as a reinforcing material in construction.

4.1.1 Actual cost: The actual costof a work is known at the completion of the work. Account of all expenditure is maintained day to day during the execution of the work in the account section and at the end of the completion of the work when the account is completed, the actual cost should not differ much from the estimated cost worked out at the beginning.

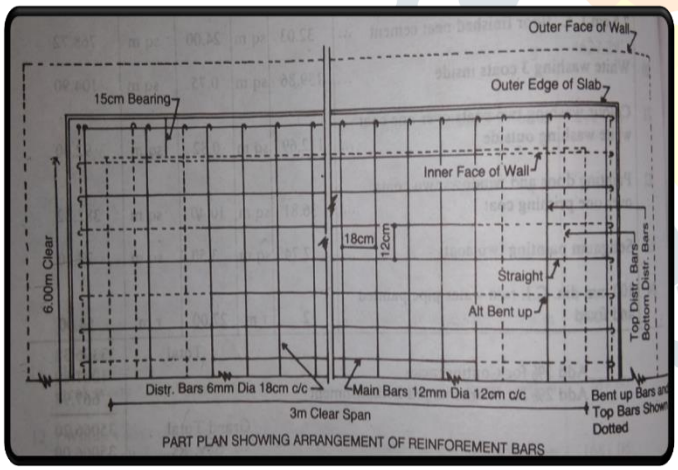
4.1.2 Detailed Estimate: Preparation of the estimate consists of working out the quantities of different items of works and then working out the cost i.e., the estimate is prepared in two stages:

Details of Measurements and calculations of Quantities – The whole work is divided in to different items of work as earthwork, concrete,

brickwork, etc., and the items are classified and grouped under different sub-heads, and details of measurement of each item of work are taken out and quantities under
each item are computed in prescribed form.

4.1.3 Abstract of Estimated cost: The cost under item of work is calculated from the quantities already computed at workable rate, and the total cost is worked out in a prescribed form, Abstract of Estimate Form. A percentage of 3 to 5 per cent is added for contingencies, to allow for pretty contingent expenditure, unforeseen expenditure, change in design, change in rates etc., which may occur during the execution of the work. A percentage of 1 ½ to 2 percent is also added to meet the expenditure of the work-charged establishment. The grand total thus obtained is the estimated cost of work-charged establishment. The grand total thus obtained is the estimated cost of the work.

4.2 Estimation Of Steel Reinforced Slab



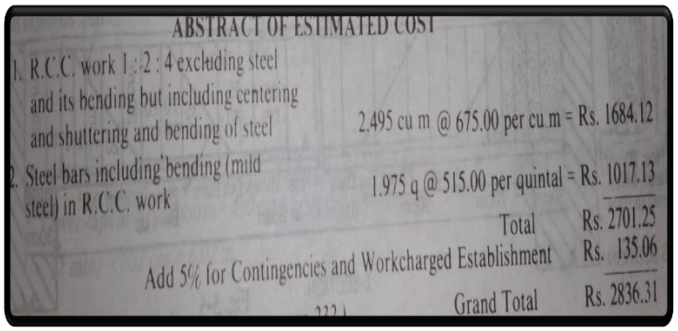


Fig.4 Estimation Of Steel Reinforced Slab

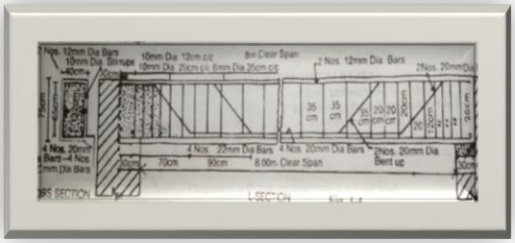
4.2.Estimation Of Bamboo Reinforced Slab

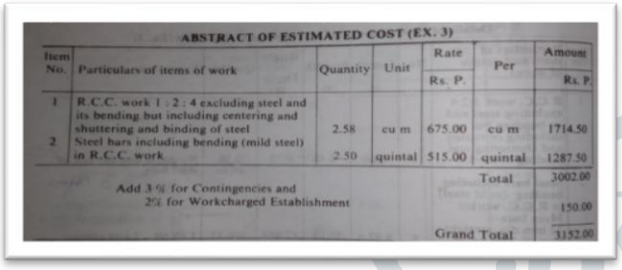
Fig.5 Estimation Of Bamboo Reinforced Slab

Table 5 Abstract estimation of bamboo reinforced slab

S.No	Description	Quantity /Item rate	Rate Rs
1.	R.C.C work 1:2:4 excluding steel and its bending but including centering and shuttering .	2.495 cu.m @ 675.00 per cu.m	1684.12
2.	Bamboo Bars including cutting	16.46 kg's @ 3.5 per kg	57.61
3	Add 5% for contingencies and Workcharged Establishment		87.08
		Grand Total	1828.81

4.3 Estimation Of Steel Reinforced Beam





ABSTRACT OF ESTIMATED COST (EX. 3)

Item No.	Particulars of items of work	Quantity	Unit	Rate Rs. P.	Per	Amount Rs. P.
1	R.C.C. work 1 : 2 : 4 excluding steel and its bending but including centering and shuttering and binding of steel	2.58	cu m	675.00	cu m	1714.50
2	Steel bars including bending (mild steel) in R.C.C. work	2.50	quintal	515.00	quintal	1287.50
					Total	3002.00
	Add 3 % for Contingencies and 2% for Workcharged Establishment					150.00
					Grand Total	3152.00

Fig.6 estimation Of Steel Reinforced Beam

4.3.1 Estimation Of Bamboo Reinforced Beam

Table 6 Estimation Of Bamboo Reinforced Beam

Item. No.	Particulars of items of work	Quantity	Unit	Rate	Per	Amount Rs
1	R.C.C. Work 1 : 2: 4 excluding steel bending but including centering and shuttering	2.58	Cu.m	675	Cu.m	1714.50
2	Bamboo Bars including cutting	20.83	Kg's	3.5	kg	72.905
3	Add 3 % for contingencies and 2% for Work charged Establishment					89.37
Grand Total =						**1876.77**

- By comparing the cost of steel reinforcement slab and bamboo reinforced slab we got to know that the cost is varying by **36 %** (reducing)
- Also, the main objective of civil engineer (i.e., Structure dead load) is reduced by **91.67 %**

CONCLUSION

This work provides bamboo as a potential reinforcement in concrete. For bamboo reinforced concrete beam, the load carrying capacity increased about 3 times that of plain concrete beam having same dimensions. Though the tensile strength of the bamboo is about 1/3rd that of steel, this is sufficient for masonry structure and provides a more economical and environment- friendly alternative that is accessible to every section of the society. Bamboo can be used as a reinforcement in concrete by replacing the steel for the construction of single story masonry buildings.

The structure reinforced fully with steel required an approx. total of Rs.2836.31was spent on reinforcement whereas the structure reinforced with bamboo cost Rs.1828.81 for the reinforcement. For beam its cost about 3152.00 for steel reinforcement and for Bamboo reinforcement it cost' s about Rs 1876.77

Therefore, it can be concluded that the method presented in this report has structural applications better than the conventional ones and can be used for all the aspects of Civil Engineering on an advantageous note i.e. economy, safety, and eco-friendly construction. This study can also be used to further amend the statistics for the development of a code reinforcing steel and bamboo together in conventional concrete construction.

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