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Experimental Investigation of Bamboo Reinforced Concrete Slab

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Abstract: - Bamboo is a perennial, renewable, eco friendly, green, fast growing natural material found in almost all part of the world. Bamboo is a lightweight material with good tensile strength. The tensile strength specific weight ratio of bamboo is 20 times more than that of steel. Researchers are working on bamboo as a substitute to steel reinforcement in concrete. An experimental investigation of bamboo reinforced concrete slab cast in the laboratory and subjected to concentrated load at mid span is presented in this paper. The crack pattern, load-elongation curve and the experimental values were investigated. Bamboo reinforced concrete may be a feasible alternative to Steel Reinforced Cement Concrete Structural elements

Keywords: *- bamboo, bamboo composites, bamboo reinforced concrete, brc slab*

I. INTRODUCTION

The depletion of natural resources has posed a serious problem of existence before the next generations. Researchers are working on replacement of conventional materials of building construction with eco friendly material for sustainable development. Bamboo has been in use of mankind for various purposes since a long time. There are more than 1000 species of bamboos and are used for more than 1500 uses all over the world. Bamboo regenerates and can be used within four years, Bamboo has, therefore, acquired a place in the list of material of green technology and renewable source. Bamboo has been used for building construction in different parts of world. Various techniques have been developed for housing. Walls, Roofs, Trusses, Doors, Ccomposite laminates made up of bamboo have been used.

Use of bamboo as a reinforcing material in concrete was first investigated by US Naval Civil Engineering Laboratory, California and have published report in 1966 to assist the construction personnel in design and construction of bamboo reinforced concrete structural members. Some design charts and working stress method is suggested. Yet elaborate standards on bamboo as a structural material have not been developed in many countries. ISO-22156 for Bamboo Structural Design and ISO-22157 for Determination of physical and mechanical properties of bamboo have been published by International Standards. Indian Standards have published several codes on bamboo, however, there are only few for bamboo as a structural material. Bamboo as a reinforcement in concrete slab has been investigated by the authors in the laboratory and the results are presented.

II. LABORATORY PROGRAM

Laboratory Mix design of M20 concrete was used for the experiment. Bamboo samples were collected from the farm Lohgad, 40 km away from Nagpur (India). The species of bamboo was Dendrocalmus Strictus which is predominantly found in India. The age of bamboo used was 5 years. The bamboo splints of width 15 mm were prepared as reinforcement. The water absorption capacity of bamboo split is upto 32% and it swells when water is absorbed. In green concrete, bamboo splints absorb water and swells. When the concrete becomes dry, the bamboo splints contracts and leave spaces between the contacts. The bond strength decreases and the members fail in bond. To overcome this limitation various sealant materials were tested and asphalt was found to be the best economical alternative. All bamboo reinforcements were embedded in asphalt, sand was sprinkled on those to improve bond and were dried. Bamboo splints were tied about 10 cm c/c to form a reinforcing mesh. Binding

wire was used to tie the reinforcements. A slab of 600x600x120 mm was cast with clear cover of 15 mm to reinforcement grid. The slab was cured with water and tested under computerized universal testing machine after 28 days.

Table 1: Test Data for BRC slab

Particulars	Values
Specimen Type	Bamboo Reinforced Slab
Concrete Grade	M20
Size of slab	600x600x120 mm
Effective depth	99 mm
Effective span	490 mm
Reinforcement	Bamboo splints of Dendrocalmus Strictus
Area of reinforcement along span	1154.03Sqmm
Tensile strength of reinforcement	95.81MPa
Ultimate Load	16.200 KN
Eb	18600 MPa
Ec	22361 MPa

Figure 1: BRC slab under test

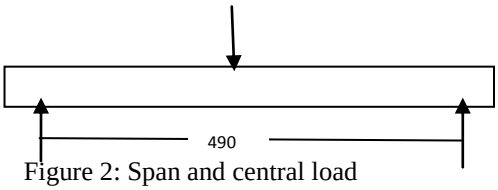

Figure 2: Span and central load

2.1 Experimental Observations and Output

The slab was placed under UTM and load was applied at a constant rate. A visible crack was observed at a load of 15.65 KN at the mid span and the machine paused and did not take any load however the load started dropping up to 9.8 KN. Again the slab took load; the peak load observed was 16.200 KN. At this stage the crack widened and the load started dropping down up to 7.8 KN. Again the slab took load and reached to another lower peak of 10.65 where the crack widen further, After this peak the load dropped continuously and the slab failed.

Figure 3: BRC slab failure

III. RESULTS AND DISCUSSION

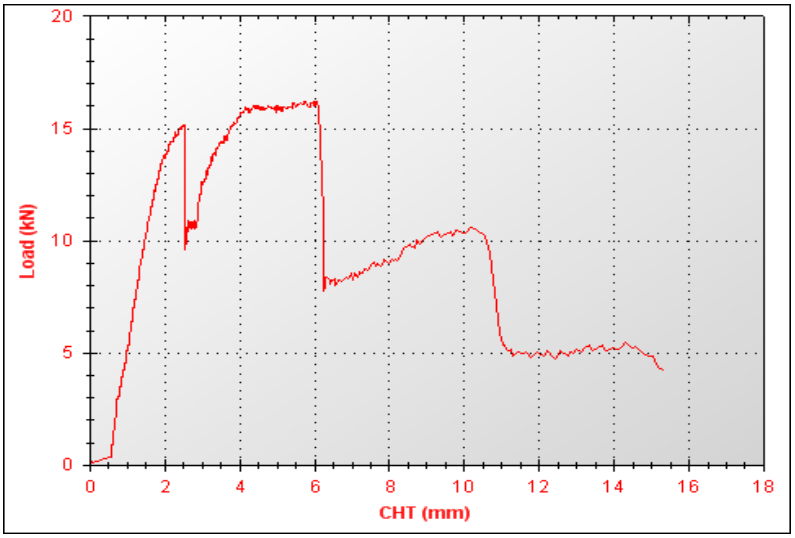

Figure 3: Load Elongation Chart till failure

Dead load= w=24000x0.12=2880 N/m
Point load per unit length= 27000 N/m

Maximum Bending Moment at the peak load= $\frac{WL}{4} + \frac{wl^2}{8} = \frac{27000\ x0.49}{4} + \frac{2880x0.49^2}{8}$
=3393.94 N.m = 3.394 KNm/ m

As per ISO 22156, allowable stresses in bamboo reinforcement are
sall = Rk x G x D / S and allowable stress is 1/7 of characteristics stress
= 13.69 MPa
As per IS-456, Table 21, allowable stress in concrete= 7 MPa
Modular ratio = n = $\frac{Eb}{Ec}$= 0.8
r = $\frac{\text{fb allow}}{\text{fc allow}} = \frac{13.69}{7.0}$ = 1.956
k= $\frac{n}{n+r} = \frac{0.8}{0.8+1.956}$
j= $1 - \frac{k}{3} = \left(1 - \frac{0.29}{0.3}\right)$=0.90
Mdr= fb.j.d.At
Mdr= 13.69x0.90x99x1154.03= 1.408 KNm/ m
Mu/Mdr = 2.41

Design moment of resistance M_{dr} is 2.41 times less than Experimental ultimate moment M_u.

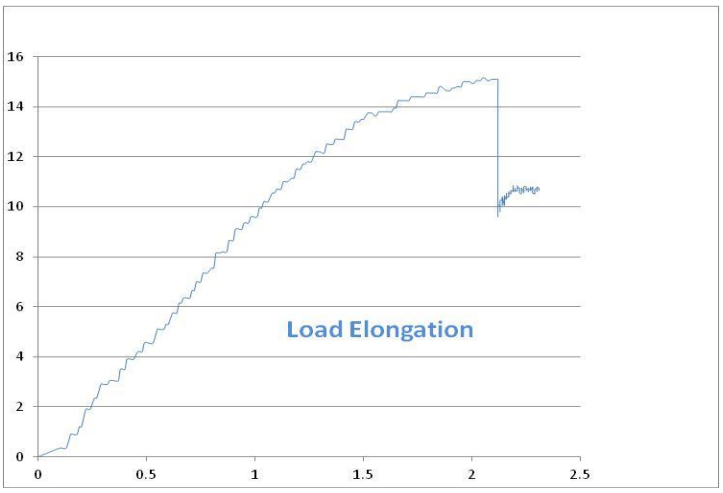

Figure 3: Load Elongation graph up to first crack

IV. RESULTS AND DISCUSSION

The slab under uniformly increasing testing load under UTM was carefully observed. The first crack appeared at a load of 15.65 KN, at this point the concrete surrounding bamboo reinforcement fails and the curve drops sharply, however the reinforcements again start taking load up to a peak load of 16.2 KN and the reinforcement fails in bending along with concrete surrounding it, again other reinforcement and their failure can be visualized from the graphs. The stress strain relationship is linear up to certain limit. The maximum bending moment was at mid section and the crack develops under the load and extends along the horizontal line. Comparing the designed moment of resistance and the ultimate BM at failure, the design moment using working stress method is half of ultimate moment.

V. CONCLUSION

BRC elements follows same pattern as those in steel RCC structural members. The design moment is found less than experimental ultimate moment and thus working stress method can be used to design BRC structural members safely. However, proper sealant such as asphalt shall be used to conceal the reinforcement from water absorption so that they may not swell and degrade the bond.

VI. ACKNOWLEDGEMENTS

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