An Experimental Evaluation of Mechanical Properties of Bamboo Fiber Reinforced Concrete

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Abstract – *For construction, one of the most important materials is concrete. Concrete is preferred because of its Low cost, High strength, Thermal & fire resistance, Availability, Durability, Diversity etc. Concrete cannot be used at places where tensile forces are predominant alone because concrete is known to have low tensile strength.*

Bamboo is rich in fiber, natural, cheap, easily available and importantly strong enough both in tension and compression. To check the compressive and flexure strength, concrete cubes reinforced with bamboo fiber have been tested by changing the percentage of fiber.

***Key Words*: Concrete, High strength, Durability, Bamboo fiber, flexural strength and Modulus of elasticity**

1. INTRODUCTION

Concrete having brittle property with less value of tensile strength and strain capacities, hence is preferred with fibers. Fiber reinforced concrete (FRC) had overcome this problem since 1960s. In past fibers were widely used in many types of mortar and concrete for providing stability. Steel, organic polymers, glass, carbon, asbestos, and cellulose are most commonly used fibers.

Adding fibers to concrete matrix has been long recognized as a way to enhance the energy absorption capacity and crack resistance of the plane concrete, Consideration of toughness and the fracture energy is important since it determines the ductility and crack resistance of the structure assuring the safety and integrity of the structural element prior to its complete failure [1–4]. Bamboo Fiber shows good potential and increased strength when used in the Fiber reinforced concrete and the fibers acts as a crack resistors, hence take up a lot more load as compared to the conventional concrete [5]. The mechanical properties of Bamboo in the physical, as well as mechanical properties vary with respect to diameter, length, age, type, position along column, and moisture content of bamboo and studies showed that the ultimate load of a concrete beam reinforced with bamboo increased by 400% as compared to un-reinforced concrete [6-7]. Also; the thorough investigation into the structure and purposes of the nodes, which they found to be strengthen by the Bamboo culm fiber.

1.1 Bamboo

Bamboo is a natural source of fiber and one of the fastest growing giant's grasses with great mechanical and economic potential belonging to a family of the family of the Bambusoideae. Bamboo gets fully mature within three to four years consuming less energy to harvest. For constructions of various structures like bridges, houses and for scaffolding bamboo has been continuously used since thousands of years world-wide.

Due to its superior properties like low weight to strength ratio, high tensile strength and factors like being Hollow cylindrical in shape its Maxwell's strength is high, less expenditure, easy availability and environment affable during service, bamboo has constantly attracted the attention of scientists and engineers for use as reinforcement member in concrete in construction industries. Recently, many researchers have tried to use bamboo as a whole or its parts in as substitute of steel in reinforced concrete.

Table No. – 1: Fibers with different characteristic values

Fibers	Density (g/cm^3)	Tensile Strength (MPa)	Elastic Modulus (MPa)
Carbon	1.8	3500	200
Glass	2.5	2500	70
Sisal	1.5	600	10
Kenaf	1.5	900	50
Cotton	1.5	400	10
Bamboo	1.5	700	10

1.2 Research Significance:

Bamboo is the fast-growing and highest-yielding renewable natural construction material available to mankind. The focus of this paper is to show that fiber derived from the bamboo in cement-bonded concrete matrix with satisfactory engineering properties and dimensional stability to satisfy international standards. The utilization of materials from shrubbery in the construction industry poses two major challenges. First it relates with the highly inconsistent and by and large lower engineering properties of its residues themselves. The second, and important, is the presence of sugars, starch and cyclic hydrocarbon compounds all of which have a greatly adverse affect on the setting and strength development of the cement matrices. This paper shows that a holistic approach combining cement

replacement materials, chemical accelerators and modern production processes can lead to a wide range of cement-bonded particleboards for applications in the housing, building and infrastructure sectors.

2. LITERATURE REVIEW

2.1 Workability

Thingujam Jackson Singh et al [1] have given a critical review of the characterization for natural fiber reinforced composite. The mechanical properties of the natural fiber composites (bamboo, sisal) primarily depend upon the fiber interfacial adhesion. Though the natural fibers are superior in properties, but due to its hydrophilic nature, it possesses poor bonding nature with the hydrophobic polymer matrix. This has resulted in the degradation of its mechanical properties. The optimum fiber length, loading and low moisture absorption nature of the fibers have improved the mechanical properties of the composite. The addition of flame retardants have resulted in the increase of thermal stability of the composite. The natural fiber reinforced composites got high potential of replacing the conventional material used in the electrical appliances.

Kavitha. S et. al [2] has obtained results showing that the slump value decreased from 110 mm for normal concrete to the 60 mm for 1.25% fiber content. The slump values with corresponding fiber content varying from 0.5 -1.25 percentage of cement is 95 – 60 mm which considerably decreases on increasing fiber percentage in concrete mix proportion.

2.2 Compressive Strength

Compressive strength of concrete is one of the most important properties of concrete. It is a qualitative measure of concrete. Failure of concrete under compression is a mixture of crushing and shear failure. The compressive strength varies as a function of both cement paste and fibers. Higher binder ratio gives higher compressive strength.

Dr. Shakeel Ahmad et al [3] have studied that concrete cubes reinforced with 1% bamboo fibre by volume have been tested in compression testing machine and stress -strain curve has been plotted.

The results have been compared with plain concrete cubes. He had found that the strength of concrete cubes with fibers doesn't show much improvement up to 28 days but surprisingly strength become double in 50 days testing. Bamboo fibres can be used as replacement with concrete which can save the expensive concrete, 10000cm3 per 1m3 of concrete.

Kavitha. S et. al [4] The compressive strength increases from 32.8 N/mm2 with 0% fiber content to a maximum of 41N/mm2 with 1% of fiber content and then starts decreasing with an increase in fiber content. The compressive strength values in MPa obtained in range of 20-25, 28.2 – 30.6, 33.7-38.9 after 7, 14 and 28 days of curing.

2.3 Split Tensile Strength

Humberto C. Lima Jr et. Al [5] have concluded that the experimental tests on the bamboo species Dendrocalamus giganteus showed that the bamboo tensile strength is comparable with the best woods used in constructions and even with steel. The tensile stress vs. strain curve of the bamboo is linear up to failure. Bamboo average tensile strength is approximately 280 MPa in the specimens without node and 100 MPa in the specimens with node. Finally, 60 cycles of wetting and drying in solution of calcium hydroxide and tap water did not decrease the bamboo tensile strength neither the Young's Modulus.

Ade Sri Wahyuni et. Al [6] have concluded that in general the tensile strength of bamboo fibre reinforced concrete is comparable to that of Normal Concrete. Despite the strange result of a few sample which decrease at the later age, the bigger picture shows the addition of rice husk ash, sea shell ash and bamboo fiber, increase the tensile strength of concrete.

M.Brindha et. Al. [7] concluded that the bamboo fiber reinforced concrete fabricated by initially chopped fibers of 6cm length shows split tensile strength for M40 grade concrete as 3.15 at 1% and 3.31 at 1.5% fiber induction under test. The split tensile strength of cylinder is increased with the addition of bamboo fiber up to 1.5% and addition of bamboo fiber up to 1.5 % exhibits an increase of 37.91% in case of split tensile strength when compared to nominal mix.

2.4 Flexural Strength

R. S. P. Coutts et al [8] have studied that fiber loading of 14% by mass, the autoclaved bamboo fiber reinforced cement composites have a flexural strength greater than 18 MPa and a density of about 1.3 g cm^{-2}. However, the fracture toughness value is low, being less than 0.50kJ rn^{-2} due to short fiber length and high fines' content of the Bamboo pulp. By screening out fines' contained in the original bamboo pulp the flexural strength values can be improved to greater than 20 MPa while fracture toughness exceeds I+0 kJ n--l.

Dr. Shakeel Ahmad et al [9] found that modulus of elasticity of concrete increases by addition of bamboo fibers. The flexural strength of bamboo reinforced beam increases as high as nearly doubled, so bamboo reinforced beam can be used in low cost buildings.

H. Raghavendra Rao et al [10] have studied that the hybrid composites are found to have good Flexural properties. In the case of maximum strength, the values vary between 60 to 213 MPa. The Flexural strength of these composites is found to be enhanced when alkali treated bamboo fibers were used in the hybrid composites.

Kavitha. S et. al [11] concluded that the addition of bamboo fibers make the concrete very resistive in flexural and improvement in 28 days strength was observed to be 7.5 N/mm. Hence addition of fiber content increase the flexural strength, for nominal mix 28 days compressive strength is 32.8 N/mm2 upto 1% there will be a increase in strength from 1.25 % there will be decrease in strength.

W. Yao et. al. [12] the flexural tests were carried out at a loading rate of 0.5 mm/min on a computer controlled MTS810 universal-testing machine with a maximum load of 100 kN. The span for specimens was set as 300 mm. The average flexural strengths are 90.4 and 91.1 MPa. The results of this investigation show that for the laminates with reformed bamboo plate on the bottom as tension layer and the fiber reinforced mortar sheet on the top as compressive layer, the flexural strength values can be improved to greater than 90MPa.

Ajinkya Kaware et. al [13] Volume 2 issue 6, june2013 water absorbtion of bamboo is quite high to reduce this effect seasoning or other suitable treatment should be given tensile strength of bamboo is good for M20 grade 0% of slag 0% of steel fiber compressive strength is 26.33N/mm2. .For 20%slag 1%ssteel fiber strength will be decreases for M40 grade nominal mix strength is 44.59%.for 20% slag&1.5% of steel fibers 45.67N/mm2 .For M30 grade nominal mix flexural strength is 6.07N/mm2 .for 20% slag 1.5% of steel fibers flexural strength will be increases 7.61N/mm2. Our paper investigated that the compressive strength increases upto 1% more than 1% there will be decreases. Split tensile strength increases step by step adding the bamboo fibre.

3. CONCLUSIONS

- Bamboo Fiber showed good potential and increased strength.
- The fibers acts as a crack resistor, hence bears more load as compared to the conventional concrete, with reduced crack-width and deflection of concrete
- Workability decreases with the increase in the length and percentage of the bamboo fiber above 1.5%.
- Flexural strength and Modulus of elasticity increased as compared to conventional concrete.
- Flexural strength of maximum of 1.80times and a minimum of 1.20 times to that unreinforced cube and prism specimens observed in 28 days strength test.

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