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State of The Art Report on Bamboo Reinforcement

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ABSTRACT

India has one third of the world's poor. 87.2% of the population of Indians live below the poverty line. Since the population is on the rise the demand for basic needs increases. We civil engineers deal with providing shelter for humans. Our main aim is to provide best facilities at an economic cost. Concrete has various advantages such as low cost, availability, fire resistance etc. But it cannot be used alone because of its low tensile strength; usually it is reinforced with materials that are strong in tension (often steel). Since some of the citizens cannot afford to utilize steel in reinforcement due to its cost, we go in for a material which can be replaced for steel. Bamboo is a giant woody grass, that grows chiefly in the tropics, where it is widely cultivated. Bamboo proves to provide good reinforcement and is eco-friendly. Moreover it is very economic. In this paper, a review of the research carried out on bamboo reinforced concrete is given with emphasis on experimental work.

Keywords – concrete, bamboo, reinforcement.

1. INTRODUCTION

Concrete is a composite construction material made primarily with cement, aggregates and water. Concrete is widely used for making architectural structures, foundations, brick/block walls, pavements, bridges, roads, dams, pools, etc. It has relatively high compressive strength, but significantly lowers tensile strength. It has various advantages such as low cost, availability, fire resistance etc. Because of its low tensile strength it is usually reinforced with materials that are strong in tension (often steel). But the cost of steel is high and it cannot found everywhere. To overcome this problem civil engineers and scientist were searched for the low cost material to reinforce the concrete. At last they found bamboo which is used for replacements of reinforcing bar in concrete for low cost constructions.

Bamboo is natural, cheap, widely available material. It is strong both in tension and compression. The tensile strength of bamboo is relatively high. Bamboo is a kind of giant grass and an orthotropic material. Many research has been done on the properties of bamboo to be used as bar in a reinforcing concrete. From the studies it was found that bamboo can potentially be used as substitute for steel reinforcement.

2. BAMBOO AS A CONSTRUCTION MATERIAL

The use of bamboo as reinforcement in Portland cement concrete has been studied extensively by Clemson Agricultural College. (Ref 1) Bamboo has been used as a construction material in certain areas for centuries, but its application as reinforcement in concrete had received little attention until the Clemson study.

A study of the feasibility of using bamboo as the reinforcing material in precast concrete elements was conducted at the U. S. Army Engineer Waterways Experiment Station in 1964. (Ref 2) Ultimate strength design procedures, modified to take into account the characteristics of the bamboo reinforcement were used to estimate the ultimate load carrying capacity of the precast concrete elements with bamboo reinforcing.

Some of the positive aspects such as a lightweight design, better flexibility, and toughness due to its thin walls with discretely distributed nodes and its great strength make it a good construction material. Bamboo is used as structural material for scaffolding at construction sites in India, China and other countries as it is a tough, flexible, light weight and low cost material.

2.1 Advantages of Bamboo

- Bamboo is an extremely strong natural fiber, on par with standard hard woods, when cultivated, harvested, prepared and stored properly. The strongest part of a bamboo stalk is its node, where ranching occurs.
- Bamboo is an exceptionally versatile material. It is used in a myriad of ways for building, such as for scaffolding, roofing, concrete reinforcement, walls and piping. It may be used structurally and as a decorative element.
- Bamboo is extremely flexible. During its growth, it may be trained to grow in unconventional shapes. After harvest, it may

be bent and utilized in archways and other curved areas. It has a great capacity for shock absorption, which makes it particularly useful in earthquake-prone areas.

- It is considered to be sustainable and renewable alternative to hardwoods, foremost because it regenerates at exceptionally fast rates.
- It is cost-effective, especially in areas where it is cultivated and is readily available. Transporting lightweight bamboo is less costly than transporting its heavier alternatives.

3. PROPERTIES OF BAMBOO TO BE USED AS REINFORCING IN CONCRETE

The properties of bamboo to be used as reinforcing in concrete have been investigated by Harish Sakaray et.al[1] (2012). Various tests were conducted on physical and mechanical properties of moso type bamboo. The result shows that the tensile strength of moso type bamboo is half the strength of mild steel. The compressive strength and tensile strength of bamboo is nearly same and this behavior is similar to steel. The surface of bamboo is smooth so the bond stress of bamboo with concrete is very low compared to HYSD steel bars. Water absorption of bamboo is very high and waterproofing agent is recommended.

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4. GRIPPING OF BAMBOO REINFORCEMENT

Proper gripping is an important factor for tensile test. Bamboo is relatively soft materials than the materials used for gripping purpose in UTM. At the time of tension tests, early failure was observed at the gripping end as shown in the Fig. 1, possibly due to high stress developed from lateral compression. Moreover, the surface of the bamboo specimen is very slippery and therefore the samples in some case experienced slip at the time of tension test. To solve these gripping problem GI wires (2mm diameter) were wringed spirally at both ends of the specimen. The application of GI spiral around the ends of bamboo specimen has been shown in Fig. 2. Aluminum tabs at both the ends of bamboo can also be used to avoid slipping of bamboo during tensile test.

Three samples of finished bamboo were tested in natural condition (without treatment) and five samples of finished bamboo were tested with GI wire spiral at the ends to improve gripping. Sabbir et.al[2] (2011) were investigated the possibility of using bamboo as a potential reinforcement in the concrete beam to compensate the low tensile property of the concrete. Based on the experimental studies the bamboo wounded by G.I wire gives uniform tensile strength and their failure pattern is also similar as splitting parallel to the grain. The average tensile strength with prepared ends (wounded with G.I wire) has been found to be higher than the specimens without prepared ends. Bamboo specimen shows some nonlinearity before its failure. The modulus of elasticity, E of bamboo is found to be much lower than the steel reinforcement. Therefore, the deflection will be higher considering the steel reinforcement.

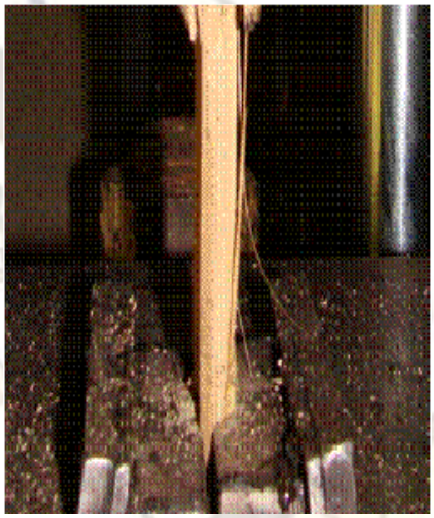

Fig 1 Early failure at the gripping end

Fig 2 GI Spiral around the ends of bamboo specimen

5. CONCRETE COLUMNS REINFORCED WITH BAMBOO STRIPS

Eighteen concrete columns were casted and tested. Load capacity test, deflection and failure

patterns were observed. Varying bamboo, from 4No to 12No, strips of coated seasoned bamboo of cross-section 8x10mm, were used to reinforce the concrete columns. The use of bamboo strips is to induce elasticity in the concrete section, which in turn guide against sudden failure. Bamboo coated with sand will increase the bond and gives good strength. The surface coated with bitumen makes it more resistance to deterioration. It may not be suitable in water retaining structures because of the large deflection accompanying its failure. Musbau et.al[3] (2012) were investigated the structural strength of concrete column reinforced with bamboo strips. The results showed that the load carrying capacity of the column increased with increase in percentage of bamboo strip reinforcement but the increase is not proportional to the percentage of reinforcement. There was also improved post cracking ability of the concrete due to the bamboo inclusion but not as pronounced in steel reinforced column. All columns failed in a similar pattern due to crushing of concrete. The bamboo strips showed no sign of slippage and remain unaffected even after concrete failure.

Agarwal et.al (2011) investigated the behavior of bamboo reinforced concrete members. Axial compression and bending test was performed on Plain, Steel & Bamboo reinforced members. A total of 12 columns (150x150x1000mm) were casted using design mix (M20) as per IS code. These columns included 3 columns of steel reinforcement, 3 columns of plain concrete, 3 columns of untreated bamboo reinforcement & 3 columns of treated bamboo reinforcements (with varying percentage of reinforcement; i.e. 3, 5, & 8%). Plain concrete and untreated bamboo columns showed brittle behavior in which, tiny cracks occurred at the surface of the column at about 80% of maximum axial force. After reaching the maximum load, the load capacity decreased abruptly and it finally failed in few seconds. There were no visible signs of spoiled concrete covering to warn of impending failure. Whereas in steel and bamboo reinforced columns more ductile behavior was observed, wherein tiny cracks became visible at surface of columns firstly at 80-90% of maximum axial force. Final failure was accompanied by growing signs of cracks and spalling of concrete. Bamboo concrete composite structural members can provide tailored solutions to the eco-housing initiatives at cheaper costs.

6. COMPRESSIVE STRENGTH AND DUCTILITY OF BAMBOO REINFORCED CONCRETE COLUMNS

Bamboo treated with water-repellent substance gives more strength and ductility. Satjapan et.al[4] (2010) were investigated the structural and environmentally sustainable aspects of bamboo as a reinforcing material instead of steel reinforcement in concrete columns. Seven small-scale short columns (125 mm x 125 mm x 600 mm) with different type of reinforcements were tested under concentric loading to investigate strength capacity and ductility. The results of this study showed that for the column reinforced by reinforcing bamboo without surface treatment, strength capacity was sufficient to withstand the maximum axial force provided by ACI318-05, while ductility was rather low, especially the column reinforced by 1.6% of bamboo without surface treatment. This was because of the effect of water absorption and loss of bonding strength between concrete and bamboo. The columns reinforced by reinforcing bamboo treated with the water-repellent substance, Sikadur-31CFN, before concrete casting showed more strength and ductility than the columns reinforced by untreated reinforcing bamboo.

7. BAMBOO REINFORCED CONCRETE BEAM

Bamboo as reinforcement in concrete can increases the load carrying capacity. Bamboo possesses low modulus of elasticity compared to steel. So, it cannot prevent cracking of concrete under ultimate load. Rahman et.al[5] (2011) were evaluated the aptness of bamboo as reinforcement in concrete. They have conducted tensile test for bamboo and flexural strength test for bamboo reinforced concrete beam. In this research three types of beam were used first beam was casted by plain concrete, second one was casted by singly reinforced beam and third one was by doubly reinforced beam having same dimensions. In plain concrete beam, they used one bamboo stick. In singly reinforced beams they used two bamboo sticks placed at the bottom with 1 inch clear cover. Similarly, in doubly reinforced beams they used two bamboo sticks placed at the top and bottom with 1 inch clear cover. Compressive Strength Test and Splitting Tensile Strength Test were conducted for cylindrical concrete specimen. Flexural Test was conducted for Beam. Tensile Strength Test was conducted for Bamboo Stick in UTM.

8. CONCLUSION

Bamboo has a wide variety of uses. From construction to cooking, it has been a part of human

culture and consumption for centuries. Another very common use for bamboo today is as a decorative tool. Small bamboo plants are becoming very popular in western interior design, and Asian cultures have been using it to decorate rooms and altars for centuries. Based on the literature available, it was found that the research work in using bamboo as reinforcement in concrete is vast. However for smaller applications such as house hold articles, bamboo reinforcement using light weight concrete the number of publications available are scarce. From the test results it was proved that bamboo has high tensile strength and it can be used as a replacing material for steel reinforment because of its low cost. Bamboo reinforced concrete can be made for benches, tables and stools in schools, parks, hotels, railway stations etc to make eco-friendly environment and for low cost construction. Constructions made with bamboo can be very durable if it is well immunized and well selected trying to have the best quality of the material.

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