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A Review on Comparative Study of Bamboo and FRP as Reinforcement in Concrete Beam.

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ABSTRACT:
The research was undertaken to investigate the feasibility of bamboo and FRP reinforced concrete. The use of tiny diameter whole bars and split bamboo has often been proposed as an alternative to relatively expensive reinforcing steel in reinforced concrete. Bamboo has significant durability, strength and environmental friendly. The types and properties of FRP composites are abridged and the applications and evolution of FRP sheets, FRP bars, FRP grids are discussed. This paper covers the FRP strengthening and the response properties of flexural performance and ductility.

KEY WORDS: *FRP, bamboo, evolution, FRP strengthening, evolution and abridged.*

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I. INTRODUCTION

Nowadays bamboo is an extensively used in construction material for its various advantages such as a low cost, high tensile strength, light weight and due to hollow structure, it is high flexible. Bamboo reinforcement concrete is suitable for single story building. Various types of bamboo such as a moso, asper, and guadua can be used. These types have different properties, hence can be used based on the requirements. Fiber reinforced polymer (FRP) composites has been broadly used as a new type of high performance material in concrete structures. FRP has high strength, light weight and corrosion resistance. FRP can be used in the various shapes or mats, laminates bars in concrete structure.

II. LITERATURE REVIEW

2.1 Fiber reinforced polymer (FRP)

Islam et al (2005) performed an experimental survey on RC deep beams which are strengthened by different FRP external strengthening methods. It was found that CFRP grid placed at normal orientation had the higher load carrying capacity comparatively with other methods of orientation and other methods like CFRP strips and wraps. An increase about 40% in strength was recorded while using normally oriented CFRP grids. However, in regular practice it was not found to be effectual in deep beams.

Cao et al (2005) studied the debonding behaviour of FRP shear strengthened RC beams. FRP strengthening was made by complete wrapping. Eventually the failure was due to FRP debonding followed by FRP rupture. The strain distribution was noted and results showed that the increase in load applied causes the increase in strain distribution factor. The shear span-to-effective depth ratio was also found to be in relation with strain distribution factor.

Zheng et al (2011) The corrosion of steel reinforcement embedded in concrete bridge deck has been the cause of major structural deterioration and of expensive in repair and maintenance. GFRP bars provide a promising alternative reinforcement, which exhibit high durability in combination of high strength and light weight. They evaluated the ultimate strengths and compressive membrane action.

Sasmal et al (2011) studied the seismic retrofitting in a non-ductile Beam-Column assembly under cyclic loading. Retrofitting was done using both GFRP wrapping and steel plate jacketing methods. Results showed that proper retrofitting can redeem the original strength of the existing damaged structure. The suggested method was found to regain the strength of the damaged structure substantially.

Gudonis et al (2013) they studied that the fiber reinforcement polymers are consider to be a promising alternative to steel reinforcement. Long term degradation of properties depending on the type of FRP reinforcement, long term strength might decrease two-three times. The maximum decrement of strength is

related to GFRP. Therefor a designer should be aware of the increment of deformation in time of concrete elements with FRP reinforcement.

Baggio et al (2014) investigated the shear strengthening of shear deficient RC beams by using various types of FRPs and FRP anchors. Results showed that U-wrapped FRP sheets for full depth performed well than partial depth. Due to strengthening the failure mode convert from shear to flexure failure. FRP anchors prevented the breakable failure due to debonding increasing the ductility of the RC beam.

Kara and Ashour (2012) they developed a numerical method for evaluate the curvature, deflection and moment capacity of FRP reinforced concrete beams. The moment curvature relationship is obtain by considering force equilibrium and strain compatibility. The beam deflection is then calculated from the mid span curvature. It was found that a large increase in FRP reinforcement slightly increases the moment capacity of FRB over reinforce concrete beams but greatly reduces deflection after first cracking.

Meikandaan and Hemapriya (2017) conducted an experimental study on strengthening of shear deficient RC beam with externally bonded GFRP sheets. The test result showed that the external strengthening with GFRP composites can be used to increase the shear capacity of RC beams, but the efficiency varies depending on the test variables such as fibre orientation, wrapping schemes, number of layers and anchorage schemes. The test result confirms that the strengthening technique of GFRP systems is applicable and can increase the shear capacity of beams and it is the most attractive and economical for concrete repair and strengthening.

Jabbar and Farid (2018) have studied that GFRP is the major strengthening agent in concrete technology. GFRP surfaces are modified by the inclusion of coarse sand to increase the bond strength of rebars with concrete. The results show the tensile strength of GFRP rebar is 593 MPa and bend strength is 760 MPa. The compressive strength was within reasonable range of concrete is 25.67 MPa. GFRP rebar have achieved yield tensile strength about 30% higher than steel rebar. Strength of smooth GFRP achieved 70-82% of steel RC flexural strength.

Mhanna et al (2019) experimentally studied the shear strengthening of RC beams using various CFRP configuration wrappings such as U-wrapping and complete wrapping. Comparative study was done between T beams and rectangular beams. Results showed that U-wrapped RC beams failed due to brittle failure caused by FRP wraps debonding while completely wrapped RC beams failed due to FRP rupture increasing the ductility. Hence complete wrapping was preferred than U-wrapping. However, when complete wrapping cannot be done, U-wrapping can be used along with proper anchoring.

Hadhood et al (2019) conducted an experimental and theoretical study on the strengthening on RC beams using short CFRP strips that are externally bonded and fastened by mechanical fasteners. Variations were made by using various spacing-to-fastener diameter ratios. Results showed that reduction of length of the strips up to 44% attain the similar strength as of long externally bonded strips. The spacing-to-fastener diameter ratio of 5.5 was found to perform well comparatively.

Spinella (2019) studied the behaviour of shear deficient RC beams strengthened by FRP using an analytical model. The model proposed took into account, the effect of FRP strain, principal compressive strain along with the effect of the interaction between external and internal reinforcement. Results showed that the effect of the internal and external reinforcements depend on the rigidity of vertical strengthening. The interaction factor showed better accuracy in shear stress.

Nie et al (2020) studied the effect of beam web opening in FRP strengthened RC beams. Results showed that web opening reduced the flexural capacity of the beam while FRP strengthening increased the shear capacity and stiffness. The FRP strengthening increased the ductility of the beam indicating the strong column weak beam hierarchy. This method can be used in existing structures as post cut method was found to be feasible.

2.2 BAMBOO

Ghavami (2005) have stated that the construction industry is the main consumer of energy and materials. This paper presents the results of some of the recent studies of the microstructure of bamboo as a functionally gradient material. These studies led to the establishment of bamboo's composite behaviour through the rule of mix. The result of the investigation show that bamboo can substitute steel satisfactorily. Treated bamboo has improved the bamboo-concrete bonding.

Rahman et al (2011) they insisted on the replacement of steel with bamboo as reinforcement. To assess this, tensile strength test of bamboo having three and five nodes are performed. 1 m bamboo sticks of varying cross sections are used in this test. Also flexural strength test of bamboo reinforced beam is done to characterize the performance of bamboo as reinforcement. Singly and double bamboo reinforced beams of 750 mm length having 150 mm width and depth are compared with plain concrete beam to carry out in this test.

n recent times, the high cost and general shortage of reinforcing steel in many parts of the world has led to increasing interest in the possible use of alternative locally available materials for the reinforcement of concrete. This is the case especially in the developing countries where about 80% of

the population live in villages. This has led to research on several non-ferrous reinforcing materials in structural concrete. In Ghana for an instance, a tall straggling shrub known as babadua (botanical: thalia geniculata) also reportedly found in parts of Africa, Asia and South America (Irvine, 1961; Lyman, 1965) has been used as a construction material in several rural areas where it is tied into a framework and daubed with mud (Schreckenbach and Abankwa, 1982). The local construction method of using babadua with mud was improved upon in an experimental program by the use of babadua as reinforcing material in concrete structural elements. The strength and deformation characteristics of concrete beams reinforced with babadua bars ranging from 2.87 to 12.13% were tested in bending (Kankam and Odum-Ewuakye, 1999). 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Asamoah and Afrifa (2011) In recent times, the high cost and general shortage of reinforcing steel in many parts of the world has led to increasing interest in the possible use of alternative locally available materials for the reinforcement of concrete. This is the case especially in the developing countries where about 80% of the population live in villages. This has led to research on several non-ferrous reinforcing materials in structural concrete. They recommended that bamboo reinforced concrete beams are reinforced with steel stirrups to improve on its load carrying behaviour.

Terai and Minami (2012) have studied the mechanical behavior of bamboo reinforced concrete member and clarified the difference of structural properties from steel reinforced concrete. This paper investigates the mechanical properties of bamboo reinforced concrete structure. They concluded that the tensile strength of bamboo increases with aging, the pull out test behaviour is almost same as plain steel bar showing higher value of 1.2 to 1.35 MPa. Thus, they confirmed the usage of combination of bamboo and concrete structure.

Sakaray et al (2012) This experimental research is focused on the use of bamboo as a reinforcing material instead of steel reinforcement in concrete. Bamboo is seismically resisting material and for sustainable environment development without harming our global environment since it absorbs a lot of nitrogen and carbon dioxide from the atmosphere during its growth. The compressive strength of bamboo is nearly same as the tensile strength of bamboo and this behaviour is similar to steel. As bamboo is eco-friendly material, limiting the use of steel can reduce carbon dioxide emissions. In the green building concept use of bamboo reinforced concrete may be recommendable.

Nayak et al (2013) have studied the effect of replacement of steel reinforcement by bamboo reinforcement. They reported that bamboo has high strength-to-weight, easy workability and also environmental friendly. This is a good idea for low cost economical structure. Bamboo reinforcement technique is used for both main and distribution reinforcement as it was same earlier done for steel reinforcement. It is three times cheaper then steel reinforcement technique. It is clear from results that this bamboo reinforcement technique is absolutely cheaper then steel reinforcement technique especially for single story structure.

Sevalia (2013) In this study the Bamboo was used as a reinforcing material without any treatment and stirrups. Bamboo was used as the struts, posts, roofs in the construction of the houses. 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. Problems encountered with the commonly used construction material like steel are high in cost, corrosion, etc. Due to the advantageous characteristics of Bamboo, in the last few years, studies have been made on the use of Bamboo as structural material and reinforcement in concrete.

Mahzuz et al (2013) The aim of this study is to provide a preliminary contribution toward the collection of several physical and mechanical properties of bamboo. Attempts were also made to understand the bond strength of bamboo with concrete by the experimental setup of Pull out test. Here three types of specimens were prepared. Each type includes two specimens. Pull out test of steel were also made to report a relative comparison. The relative comparison between the unit weight, strength and cost were made.

Mamun and Siddique (2017) they studied that the physical and mechanical properties of bamboo reinforcement. The flexural strength of bamboo reinforcement column is sufficient higher then plain cement concrete and comparable to steel reinforced concrete beam. According to cost analysis, bamboo reinforced beams and column with moderate reinforcement ratio showed the best strength cost ratio among plain cement concrete and steel reinforced concrete.

Bashir et al (2018) have studied that bamboo is one of the suitable substitution of fortifying bar in concrete for ease developments. Bamboo reinforced concrete stands to be a good option in the sustainable development of civil engineering construction. Bamboo can be used to increase the compressive strength of

concrete structures keeping in mind that it reduces the flexural strength of the structures. The authors have reported that compressive strength of concrete increases as we increase the percentage of bamboo and the flexural strength decreases as the percentage of bamboo increases.

Datta et al (2019) they experimentally studied bamboo reinforced beam. They concluded that bamboo can be utilized for low burden bearing structures. This examination primarily concentrating on to decrease the expense of materials which are used for development reason especially steel. Steel is the material which is utilized for a wide range of support in section, bar and piece. They found that the compressive strength of M40 at 28 days is 43.32N/mm² and split tensile test of M40 at 28 days is 3.29N/mm².

Sutharsan et al (2020) they have made use of bamboo, a cheap and mostly available material. The main target of the study is to reimburse the conventional materials like steel by naturally available bamboo sticks. Bamboo proves to provide good reinforcement as it holds very good tension and compressive strength. Environmental Pollution that occurring due to the manufacturing process of steel and an eager effect to find out the alternative material in building construction tends to move our attention towards Bamboo, a cheap and mostly available material. The flexural strength of the beam having bamboo reinforcement shows greater strength which helps to improve the usage of bamboo.

III. CONCLUSION

Following are the major conclusions derived from the literature study,

- FRP anchors or fasteners prevented the debonding of FRP leading the failure to be FRP rupture rather than FRP debonding.
- Complete wrapping of FRP in RC beams provided higher strength than other wrapping configurations. But in inaccessible places, U-wrap can be used.
- The strengthening technique of GFRP systems is applicable and can increase the shear capacity of beams and it is the most attractive and economical for concrete repair and strengthening.
- Compressive strength of concrete increases as we increase the percentage of bamboo and the flexural strength decreases as the percentage of bamboo increases.

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