iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** II **Month of publication:** February 2017

DOI: http://doi.org/10.22214/ijraset.2017.2048

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Volume 5 Issue II, February 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Performance of Bamboo Reinforced Concrete Beam a Review

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Abstract: ***To minimize the cost of construction so that houses and other structures may be made in fairy price to the common man of the society, in these paper work bamboo strips had been provided as potential reinforcement in concrete beams or concrete structure in place of steel. Bamboo is a giant woody grass that grows mainly in the tropical & sub tropics, where it is widely cultivated. Bamboo proves a good reinforcement and also environmentally friendly. Moreover, it is very low cost material. In this paper, a review of the research carried out on bamboo reinforced concrete is given with emphasis on experimental work.***
Keywords – Concrete, Bamboo, Bamboo reinforcement, Advantage, Tensile strength, Cost effective, future scope.

I. INTRODUCTION

Concrete is a building material, which is a mixture, made up of broken stone or gravel (coarse aggregate), sand (fine aggregate), cement, and water, which can be spread or poured into molds and forms a stone-like mass on hardening. Concrete is more frequently used for making foundations, architectural structures, pavements, brick/block walls, bridges, dams, roads, pools, etc. It has comparative very high compressive strength, but significantly very low tensile strength. It has different advantages such as easily availability, economical; resistance to fire etc.

Due to its low tensile strength, it is generally reinforced with materials which are strong in tension (Generally steel bars). But the price of steel is very high and also it cannot find in all the places. To overcome this problem, Architecture, Civil Engineers, Industrialist research and Scientist were searched for the new alternative eco- friendly & lowest cost material to reinforce with concrete. At last they all found one alternative material, i.e. bamboo, which is very used for replacements of reinforcing bar in concrete for eco-friendly & low cost constructions.

Bamboos are evergreen perennial flowering plants in the subfamily Bambusoideae of the grass. Bamboo is an economical, orthotropic, natural, and easily available material. It is relatively strong in tension compare to compression. Many observers and researchers have been working on the properties of bamboo to be used as reinforcing bar in a reinforced concrete. From the previously researchers and observers studies, it was found that bamboo strip bars can potentially be used as alternative for steel reinforcement.

II. USED AS CONSTRUCTION MATERIAL

Bamboo is used as reinforcement in Portland cement concrete and it has been studied to a large, detailed degree by Engineering Experiment Station Clemson Agricultural College in 1950 (Ref 1). Bamboo had been used as a major and very common construction material in certain areas for centuries, but its application as reinforcement in concrete structures had received very little attention until the Clemson study.

A study on the feasibility of bamboo culms/bamboo strips used as the reinforcing material in pre stress/pre cast concrete members/elements, which was set up and conducted at the U. S. Army Engineer Waterways Experiment Station in 1964 (Ref 2). Factored or Ultimate strength design procedures, modification to take into account, the characteristics of the bamboo reinforcement were used to estimate the factored or ultimate load carrying capacity of the pre stress/pre cast concrete members/elements with bamboo strip bars.

Common & general positive aspects of bamboo such as a better flexibility, light weight, easy design, and toughness and strength due to its thin walls with separately and individually distributed nodes and its high tensile strength make it a good construction material. Bamboo is very much commonly used as structural supporting material for scaffolding at all construction sites in the Philippines, Indonesia, India, China and other countries as it is a hard, tough, flexible, low weight and economical construction and structural material.

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III. ADVANTAGES OF BAMBOO

Bamboo is an extremely very strong natural fiber, available 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 countless of ways for building, such as for furniture, decorative home work, scaffolding, roofing, structural work concrete reinforcement, walls and piping.

Bamboo is extremely flexible. During its growth, it may be trained to grow in unconventional shapes. After harvest, it may be bent as required and used in a curved structure forming a passage or entrance and other curved areas. It has a great capacity for vibration or shock absorption, which makes it particularly useful in high earthquake-prone areas.

It is considered that bamboo is to be maintained at a certain level of pollution, also renewable material, substitute to hardwoods, important because it regenerates at unusually fast rates.

It is economical material, especially in areas where it is cultivated and is readily available. Transportation charge of low weight bamboo is cheaper than transporting its heavier concrete section alternatives.

IV. SELECTION & PREPARATION OF BAMBOO

A. Selection

The following factors should be considered in the selection of bamboo culms (whole plants) for use as reinforcement in concrete structures:

Use only those bamboos which showing a pronounced brown color. This will indicate that the plant is at least 3 to 4 years old.

Select the bamboo culm which has the longest length & large diameter culm.

Never use whole culms of green, untreated, unseasoned bamboo.

Never cut the bamboo culm in rain, spring or early summer session, because these culms are generally weaker due to increased fiber water content.

B. Preparation

1) *Sizing. :*A thin strip of wood or (split culms) are generally more useful than whole culms as reinforcement. Larger culms should be split into thin strip of bamboo approximately 3/4 inch wide. Whole culms less than 3/4 inch in diameter can be used without splitting.
2) *Splitting:* The bamboos culm should be split by separating the base with a sharp knife and then pulling a dulled blade through the Culm. The dull blade will force the stem to split open; this is most effective and useful than cutting because the bamboos splitting will result in continuous fibers and nearly along a straight section.
3) *Seasoning:* When possible, the bamboo should be cut and allowed to sundry to reduce the moisture content for at least three to four weeks before using, also the bamboo culms must be supported at regular interval spacing to reduce buckling and twisting.
4) *Bending:* Bamboo culm and bamboo strip can be permanently bent if heat (either dries or wet), with a sharp nozzle is applied to a section and apply pressure to bend. This process can also be used for forming splints into arc, circular shaped stirrups and for putting hooks on reinforcement for additional anchorage.
5) *Waterproof Coating:* When any seasoned and dry bamboo, either strips or whole, is used as reinforcing material, the culm should be painted with a waterproof coating to reduce swelling when in contact with concrete. Without some type of water coating, bamboo surface will swell before the concrete has attained sufficient strength to prevent cracking and the member may be damaged, especially if more than 4% bamboo is used as reinforcement. The coating type will much depends on the material use. A dip coat of bituminous paint or brush coat is preferable. Native latex, coal tar, bituminous paint, dilute varnish, and water-glass are suitable coatings. In any above cases, only a single thin coating of paint should be applied because thick coating will lubricate the surface and weaken the bond with the concrete.

V. STRENGTH PROPERTIES OF BAMBOO

It has been found experimentally that the ultimate tensile strength (UTS) of some species of bamboo is comparable to that of mild steel and it varies from 140N/mm^2 - 280N/mm^2. The ultimate tensile strength together with other properties has made Bamboo as more visible option as a construction material.

Further, it has been observed that in seismic zones the failure of bamboo is very less as the maximum absorption of the energy is at the joints. Cellulose is the main component present in bamboo which is the main source of mechanical and physical properties of

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Volume 5 Issue II, February 2017
ISSN: 2321-9653

bamboo.

Some general specific properties of Bamboo are as given below:

S. N.	Properties of Bamboo	Value
1	Specific gravity	0.570 - 0.650
2	Average weight	0.625 kg/m
3	Modulus of rupture	610-1600 kg/cm^2
4	Modulus of Elasticity	1.5-2.0x10^5 kg/cm^2
5	Ultimate comp. stress	794 to 864kg/cm^2
6	Safe working stress in compression	105 kg/cm^2
7	Safe working stress in tension	160 to 350kg/cm^2
8	Safe working stress in shear	115 to 180kg/cm^2
9	Bond stress	5.6kg/cm^2

VI. PROPERTIES OF BAMBOO TO BE USED AS REINFORCING BARS IN CONCRETE

The properties of bamboo culm to be used as reinforcing bars in concrete have been investigated by Harish Sakaray et.al[3] (Feb 2012). Several tests were performed on physical and mechanical properties of moso type bamboo. The result shows that the ultimate tensile strength of moso type bamboo species is half the ultimate tensile strength of mild steel. The tensile strength and compressive strength of bamboo is almost same and this behavior of bamboo is similar to steel. The outer periphery surface of bamboo is smooth so the bond stress of bamboo with concrete is very low compared to deformed bars steel bars. Water absorption capacity of bamboo is very high and waterproofing agent is recommended and required.

VII. END GRIPPING OF BAMBOO STRIPS

Proper gripping is a most important factor for tensile test. Bamboo is relatively very soft material than the other materials used for gripping purpose in UTM Machine. At the time of tensile tests with UTM, early failure was noticed at the gripping end as, possibly due to high stress developed from lateral compression. Furthermore, the outer surface of the bamboo specimen is very slippery and because of this the samples in some case experienced slip at the time of tension test.

o solve this gripping problem, Aluminum tabs or GI wire at both the ends of bamboo can also be used to avoid slipping of bamboo during tensile test as shown in Fig. 5.

samples of finished and seasoned bamboo were tested in the natural condition without any treatment and 5 samples of finished and treated bamboo were tested with galvanized iron wire spiral at the ends to improve gripping. Sabbir et.al[4] (2011) were investigated the possibility of using bamboo as a potential reinforcement in the reinforced concrete beam to recompense the low tensile strength property of the concrete.

Based on the experimental studies the bamboo with aluminum end tabs gives uniform ultimate tensile strength and also their failure pattern is similar as splitting parallel to the grain. The average ultimate tensile strength with prepared ends (with aluminum end tabs) has been found to be higher than the specimens without prepared ends. Bamboo specimen also shows some nonlinearity behavior before its failure.

The modulus of elasticity of bamboo is found to be very low than the steel reinforcement. Therefore, the deflection will be higher considering the steel reinforcement.

VIII. EPOXY RESIN WITH HARDENER

For proper gripping at the ends of the bamboo stick with the Aluminum tabs, here we use two types of epoxy system.

Araldite (AW 106) Standard Epoxy Resin with Hardener (HV 953 IN),

Astral Bond Tite Super Strength Epoxy Syste

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Volume 5 Issue II, February 2017
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Fig. 1 Tensile Specimen without end grips

Fig. 2 Aluminum Tabs

Fig. 3 Araldite Standard Epoxy Resin with Hardener

Fig. 4 Astral Bond Tite Super Strength Epoxy System

Fig. 5 Tensile Specimens with Aluminum Tabs

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Volume 5 Issue II, February 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Fig. 6 Final Bamboo Specimens for tensile test

IX. BAMBOO REINFORCED CONCRETE BEAM

Bamboo as reinforcement in concrete can increases the load carrying capacity of the structure. Bamboo possesses low modulus of elasticity compared to steel. So, it cannot prevent cracking of reinforced concrete under ultimate load.

Rahman et.al (2011) were evaluated the performance evaluation of bamboo as reinforcement in concrete beam. They have conducted tensile test for bamboo species and flexural strength test for bamboo reinforced concrete beam. In this research three types of different beam were used first beam was designed and casted as plain reinforced concrete, second one was designed and casted as singly reinforced beam and last one was designed and casted as doubly reinforced beam having same dimensions. In plain reinforced concrete beam, they used one bamboo stick. In singly reinforced bamboo reinforced beams they used two bamboo sticks placed at the bottom with 25mm clear cover. Similarly, in doubly bamboo reinforced beams they used two bamboo sticks placed at the top and bottom with 25mm clear cover. Compressive Strength Test and Splitting Tensile Strength Test were conducted for cylindrical concrete specimen. Flexural strength test was conducted for beam. Tensile Strength Test was conducted for Bamboo Stick in UTM machine.

X. CONCLUSION

Bamboo has a wide variety of uses. From construction to eating, it has been a part of human culture and consumption for centuries.

Another very common use for bamboo today is as a decorative home tool. Small bamboo plants become very popular in western region for interior design, and Asian cultures have been using it to decorate rooms and altars for centuries.

Based on the research available, it was found that the research work in using bamboo as reinforcement in concrete is vast.

Yet for small application works such as house hold articles, bamboo reinforcement using low weight concrete the numbers of publications available are not enough.

From the test results it was proved and finds that bamboo has high ultimate tensile strength and it can be used as an alternative replacing material for steel reinforcement because of its low cost.

Bamboo reinforced concrete can be used in manufacturing of table, benches and stools in public places such as hotels, schools, parks, railway stations etc to make the environment eco-friendly and for low cost construction.

Constructions made with bamboo can be very durable and strong if it is well immunized and well selected methods are trying to have the best quality of the material

XI. SCOPE FOR FUTURE WORK

Bamboo is a versatile material because of its high strength-weight ratio, easy workability and availability.

The Analysis of the replacement of steel with bamboo as reinforcing material shows that reinforcement with bamboo is very less than that of steel reinforcement.

The positive attributes of Bamboo are listed, supporting its environment-friendly nature. But also there are some negative attributes

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of Bamboo were given, focusing on its tendency to absorb water.

Of those, the bonding between the Bamboo and concrete is considered the biggest problem due to absorption of water and smooth wall of the Bamboo Culm.

Also there is a need for the development of a simple design code for the application of Bamboo as a Construction material. Several Researches are on going to overcome these problems.

Many new techniques are being developed which may make bamboo the best constructional material in future.

It has wide scope in Low Cost Constructions.

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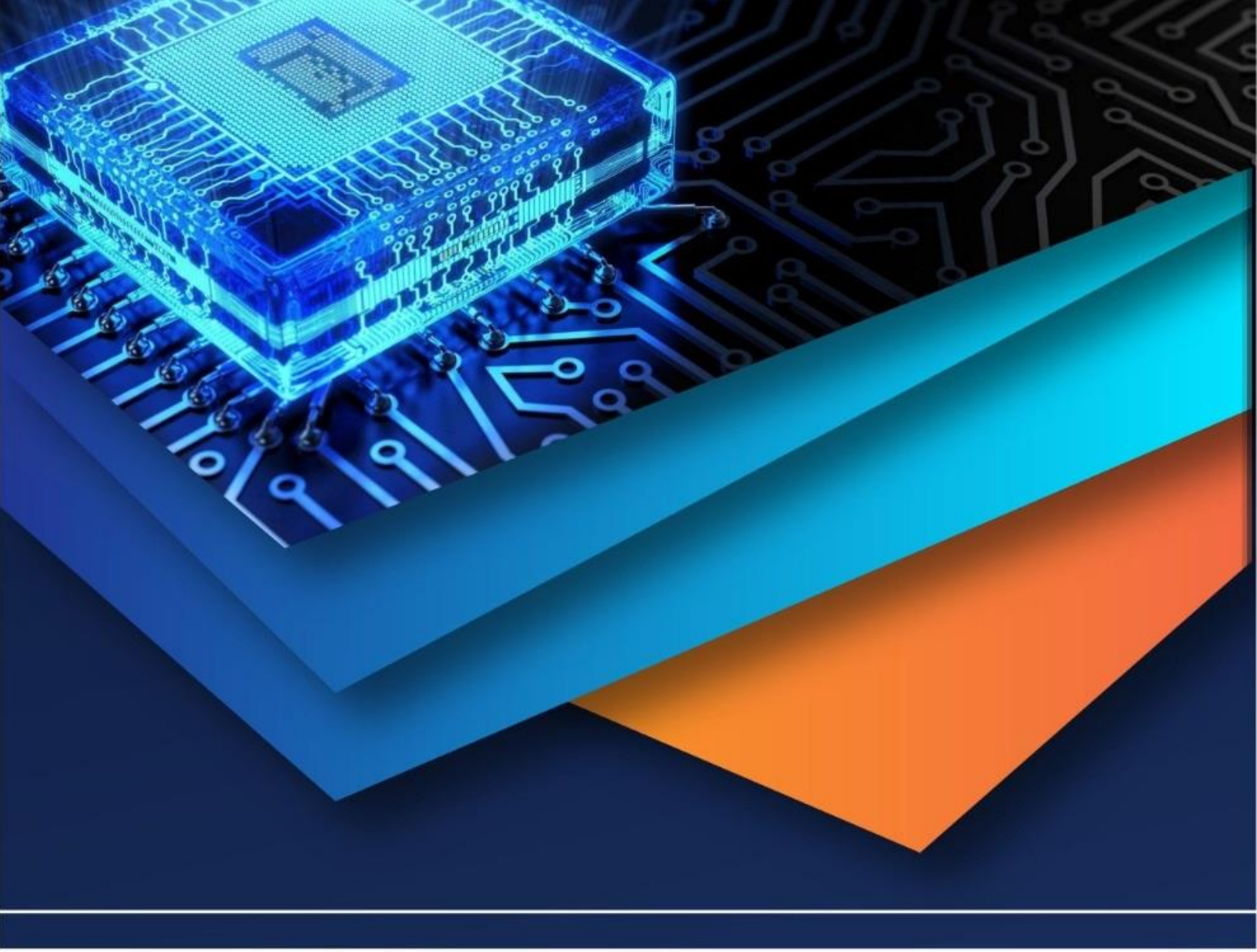

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