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AN EXPERIMENTAL STUDY ON BAMBOO REINFORCED CONCRETE

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Abstract

The following project report that we have done, is a theoretical demonstration of the comprehen-sive use of bamboo as a reinforcing material in concrete construction.It is used extensively in the substitute of steel, as reinforcement in concrete for load-bearing members. The use of bamboo in place of steel is used as a whole and as a combination of both bamboo and steel. It is used as such to ensure the reduction in weight, economic advantages with its strength compromised to a slight and safe level. The glory of construction is mainly determined by financial factors. The cost of a project is mainly influenced by two major factors i.e. labor and material. Since labor is indispensable as it affects efficiency, alternatives of materials like cement and sand. But there has not been a strong replacement for reinforcement used, it is high time to provide such replacements, Therefore, this document focuses on the possibility of replacement of steel with seasoned bamboo. By conducting various tests and analyzing the results we say that we can use the bamboo as reinforcement to various structural elements where load intensity is less such as roof slab for security cabin, car parking, toilets, etc. and achieve our objective. This requires further significant research efforts to undermine the potential of bamboo as a sustainable building material. The great potential of bamboo for the construction industry by achieving significant bond strength compared to steel reinforcement.

Keywords: Bamboo, Strength, Steel Reinforcement,

1. INTRODUCTION:

Concrete is the most widely used binding material in the construction industry. It is a composite material, which is a mixture of binding material, coarse aggregate, Fine aggregate and water. Mixes of fixed proportions generally by ‘volume’ which ensure adequate strength. As per I.S 456-2000 up to M25. Concrete on its own doesn’t make good structural material. There are just too many sources of tension that it can resist by itself. So in most situations, we add reinforcement to improve its strength.

Reinforcement within concrete creates a composite material, with the concrete providing strength against compressive stress while the reinforcement provides strength against tensile stress and the most common type of reinforcement used in concrete is deformed steel, more commonly known as rebars.

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In an "un-reinforced" sample the type of failure forms a brittle mode, where there is no warning, before a complete loss of strength.

In "reinforced" sample the type of failure forms a ductile mode where you see the cracks forming there is a warning, before a complete loss of strength.

1.1TYPES OF REINFORCEMENT: -

1.1.1.Steel reinforcement: -Are steel bars that are provided in combination with plain cement concrete to make it reinforced concrete. Hence these structures form steel-reinforced cement concrete structure (R.C.C). Steel reinforcement is commonly called as 'rebars'.

In plain concrete is weak in tension and strong in compression the tensile property provided
by the steel reinforcement will prevent and minimize concrete cracks under tension loads.The design engineer will combine both the elements and design the structural element such a way that the steel resists the induced tensile and shear force, while the concrete takes up the compressive forces.

1.1.2 Types of Steel Reinforcement:-

- Hot-rolled deformed steel bars
- Cold worked steel bars
- Mild steel plain bars
- Prestressing steel bars

1.1.3Bamboo reinforcement:- -Bringing up the innovation of bamboo as a structural steel replacement, would be a great alternative. The tensile strength property which is the main requirement of reinforcing material is seen appreciable for bamboo, compared with other materials including steel. Bamboo reinforced concrete construction follows the same design, mix proportions, and construction techniques as used for steel reinforced. Just steel reinforcement is replaced with bamboo reinforcement.

Natural the bamboo mainly used in strength bearing material. It is used for building shelters from an earlier time. Bamboo as reinforcement material is an innovation in the civil engineering construction field. This innovation was based on Clemson's study that has been conducted in the Clemson Agricultural College.

The steel as a reinforcing material is a demand that is increasing day by day in most of the developing countries. It is essential to have an alternative that is worth compared to steel. Bamboo is found in abundance, they are resilient. Hence these can face the demand as a reinforcing material and become an ideal replacement for steel.

1.1.4 Fiber reinforcement:- Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented.

Fiber is a small piece of reinforcing material possessing certain characteristics properties it includes steel fibers, glass fibers, synthetic fibers, and natural fibers. Within these different fibers, the character of fiber reinforced concrete changes with varying concretes, fiber materials,

geometries, distribution, orientation, and densities. a convenient parameter called "aspect ratio". The aspect ratio of the fiber is the ratio of its length to its diameter.

Fibers are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce the bleeding of water.

2. LITERATURE REVIEW:

Rakesh J Ghante1, Dr. K.P Shivananda(2019): - The present study reports the flexural strength of BRC (Bamboo Reinforced Concrete) beams and the durability of bamboo as structural reinforcement. In this study, normal bamboo and modified bamboo were used in 1.25% and 2.50% as reinforcement in the beams. Also, bamboo splints without coating and with bitumen coating were dipped in normal water, magnesium sulfate, and potassium chloride solution for alternate wetting and drying of 7,14,28,56 and 72 cycles for the durability analysis. The flexural strength of the BRC beams was studied after 7,14,28 days of curing. The durability of the bamboo was determined through the Tensile strength test. From the results, it is found that the flexural strength of the modified bamboo reinforced beams with 2.50% reinforcement carried more load than the normal concrete beams and untreated bamboo reinforced beams. The Tensile strength of the bamboo splint got reduced after 56 cycles and 72 cycles of alternate wetting and drying in magnesium sulfate and potassium chloride solutions. It could be concluded that bamboo can be used as an alternative material to the rebars in low-cost housing projects. Treated bamboo is more efficient and economical in low-cost housing projects. Suitable treatment must be done for bamboo rebars if in case it is to be used in coastal areas.

Ikechukwu Etienne Umeonyiagu & Chidozie Chukwuemeka Nwobi-Okoye (2019):- In this research, the costs, as well as the flexural and tensile strength of bamboo reinforced concrete material, were predicted and optimized using artificial neural network (ANN) and non-dominated sorting genetic algorithm-II (NSGA-II). The inputs to the ANN were curing days and percentage bamboo content in the bamboo reinforced concrete material, while the outputs were cost, flexural, and tensile strength. The ANN predicted the experimentally determined values of the tensile strength, flexural strength, and costs of the bamboo reinforced concrete material excellently with correlation coefficients of 0.99635, 0.99739, and 1, respectively. Subsequently, the ANN was used as the fitness function for NSGA-II for multi-objective optimization of the cost, flexural, and tensile strength of bamboo reinforced concrete material. The Pareto optimal solution obtained could serve as a design guide for engineers for the optimal design of structures using cost, flexural, and tensile strength of bamboo reinforced concrete material.

S.karthik RM Rao Paul Awoyera. (2018):- In this study, beneficiated pozzolans, ground granulated blast furnace slag (GGBS), and metakaolin (MK) were used as partial replacement of ordinary Portland cement in bamboo-reinforced concrete. In the mixtures, river sand and granite were used as fine and coarse aggregates, respectively. The compressive strength of concrete cubes, split-tensile strength of concrete cylinders, and flexural strength of reinforced concrete beams were determined after stipulated curing regimes. The morphology and mineralogy of bamboo and selected concrete mixtures were obtained using a scanning electron microscope and X-ray diffraction, respectively. The concrete samples having blended cement were found to

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have better compressive and split-tensile strength than those made with conventional binders. Also, the mechanical characteristics of the samples improved up to 40% GGBS substitution. However, steel- reinforced concrete developed better flexural strength than the bamboo-reinforced concrete (BRC). The study recommends pretreatment of bamboo to ensure its adequate bonding with the cement paste, to achieve optimum performance of BRC.

Abhijeet Dey&Nayanmoni Chetia (2018):- This is a comparative study of bamboo reinforced concrete beams with various frictional properties. The frictional properties of bamboo reinforced concrete beams have been achieved by rolling the bamboo reinforcements with sand, G.I wire and coir. The web material essentially consists of steel stirrups which helps in resisting shear of bamboo reinforced concrete beams. Eighteen such beams have been tested to failure under a four-point bend test. Flexural strength of 28, 45, and 60 days have been taken into consideration for comparison purposes. At failure, it has been observed that beams subjected to higher curing periods and greater reinforcement sizes perform better as compared to beams with lower curing periods and smaller reinforcement sizes. Moreover, higher bond stress has been achieved for beams with G.I rolled bamboo reinforcements. Hence it can be recommended that bamboo can act as a good potential reinforcement for low-cost housing and can replace steel conveniently thereby saving natural resources to a considerable extent.

K.F.Tan, S.C.Chin, S.I.Doh, J.Gimbun & M.T.Mustafa(2017):- properties of bamboo as well as the behavior of bamboo-reinforced concrete beams. Six bamboo samples were tested for compressive strength and tensile tests, respectively. In terms of structural properties, three reinforced concrete beams were tested to failure under four-point bending, which includes a control beam, a fully and partially reinforced beams with bamboo. Results of mechanical properties showed that bamboo with nodes has a higher capability to be able to resist compressive loading compared to bamboo without node. On the other hand, tensile results revealed that bamboo splint managed to achieve 12.5% of the stress of high yieldsteel with comparable strain value. Results of structural properties showed that beam reinforced with bamboo can achieve approximately 46% of the beam capacity of the steel- reinforced beam. Bamboo reinforced concrete beams failed in a brittle manner under bending with vertical cracks in the tension zone.

3. MATERIALS:

3.1 Ordinary Cement: -

The cement used for this present study was OPC 53 grade cement conforming of IS 11269-1987. It is most recently manufactured, is of uniform color, and also free of lumps. The physical and chemical property of the cement is determined considering IS 4031-1985 and IS 4031-1988 respectively.

Fig1.1: Ordinary Portland Cement

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3.2 Fine Aggregate: -

The river sand, passing through a 4.75 mm sieve and retained on 600µm sieve, conforming to Zone-II as per IS 383-1970 was used as fine aggregate in the present study. Typically, the same material used in the normal concrete mixture, and the fine aggregate is clean, silt, and clay.

Fig 1.2: Fine Aggregate

3.3 Coarse Aggregate: -

Throughout this investigation, coarse aggregates of 20 mm and 10 mm size from the local crushing plants were used. The locally available crushed granite stone was used as a coarse aggregate. The aggregate was tested for its physical requirements that are given in Table No: 3.4 under IS 2386-1963(part-1,3and 4).

Fig 1.3: Coarse Aggregate (Gravel 10mm and 16mm)

3.4 Bamboo:-

Before using bamboo for construction, we need to consider the following 3 aspects as follows: -

- Weathering
- Chemical treatment &
- Surface treatment

3.5 Weathering:-

The primary consideration for bamboo before using in construction is "Weathering." Bamboo is a hygroscopic material (a compound that easily absorbs moisture) i.e it contains about 50-60% of water content in them. So, we need to "Air Dry" them. By air drying, we can expel out the water content up to 15%.

3.6 Chemical treatment:-

The second aspect under consideration is "Chemical treatment." Bamboo is chemically treated basically with three chemicals as follows: -

- Boric Acid
- Copper Sulphate &
- Potassium Dichromate

The chemical preservation (with or without the help of special equipment) ensures long term protection. Depending upon the method of bamboo treatment, chemical preservatives can impart short term or long-term protection. With a few exceptions, chemical preservatives to protect bamboo against biological attacks and degradation are **toxic**. These chemicals are mixed with a ratio of 1.5:3:4 by weight and are diluted with water accordingly.

3.7 Surface treatment:-

The last and the most important aspect under consideration is "Surface Treatment." Bamboo is to be coated with "sand" for grip. Before coating with sand, it is to be coated with Epoxy Resin, and

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later it is sprinkled with sand, which is later dried before use. It acts like a ribbed or corrugated in rebars.

3.8 Stirrups:

A reinforcement used to resist shear and diagonal tension stresses in a concrete structural member. The term is usually applied to lateral reinforcement in flexural members and the term ties to lateral reinforcement in vertical compression members. Stirrups are provided to hold the main reinforcement together in a reinforced concrete structure, to hold longitudinal bars during construction and it increases the strength of beam & column.

4. EXPERIMENTAL PROGRAMME:

4.1 INTRODUCTION:

The main objective of this experiment is to study the Bamboo when used in the reinforcement.

4.2 PROCESSING OF BAMBOO:

Before using the bamboo for reinforcement, it is important to treat them. Many developing counties (where most bamboos grow) suffer a lack of awareness and professional treatment facilities. Furthermore, not all curing methods ensure satisfying results which leads to uncertainties about the advantages of using bamboo altogether.

A lot of bamboos used for structural purposes in rural housing are untreated (or the wrong species) and deteriorate in just a couple of years, hence the reason bamboo is still considered a poor man's timber.

Not only does the incorrect use affect the reputation of bamboo, but it also puts heavy pressure on resources**,** since frequent replacement is necessary.

The following steps are taken for processing bamboo: -

4.3 Weathering: Bamboo before using in construction needs to be thoroughly sun-dried. To expel out the moisture content that is present in them. So here we have sun-dried our bamboos for a day before application.

4.4 Chemical treatment:- Chemical treatment is done to protect bamboo from Biological attacks and degradation. There are two types of preservation in bamboo: - A) Non-Fixing type & B) Fixing.

A) Non-Fixing Type Preservatives: -

Non-fixing bamboo preservatives mainly consist of boron salts, which are effective against borers, termites, and fungi (except soft rot fungi). These boron salts are dissolved in water. After treatment, the water evaporates leaving the salts inside the bamboo. They are not toxic and can be used for treating bamboo products like baskets, dry containers, etc. which come in contact with food products.

Ex: Boric acid

B) Fixing Type Preservatives: -

These chemical bamboo preservation formulations are proportionate mixtures of different salts that interact with each other in the presence of bamboo and become chemically fixed. In principle, the degree of fixation and efficacy depends upon the nature of the components and their combination and concentration.

Ex: Copper sulfate & potassium dichromate

These 3 chemicals i.e., Boric acid, Copper Sulphate & Potassium Dichromate are taken in the ratios of “1.5:3:4 “. Mix the above chemicals with 10liters of water and stir then until chocolate brown color

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appears and later pour the liquid on the bamboo sticks and sundry them for 1 -2 days. Later perform the surface treatment.

4.5 Surface treatment:- Final step before using the treated bamboo we need to consider the surface of the bamboo, which is quite important. For surface treatment, we need to first coat them evenly with Resin and later sprinkling of sand. Here we have taken Araldite AW 106 Resin HV 953 U

4.6 BAMBOO REINFORCEMENT:-

The material used as a reinforcement in concrete should show all the essential properties to make the element structurally active under load. In the case of steel, we manufacture steel to the desired proportion and test for the basic strength values as a quality check.

Similarly, the process must be done for bamboo too. Bamboo is found in nature; they have different species. Each species differs in its characteristics, texture, thickness, and strength. Hence it is essential to know which species is best for reinforcing and which is not.

In the bamboo reinforcement, after processing bamboo the bamboo sticks reinforced with stirrups are placed at proper intervals to bamboo sticks, the spacing of 10cm center to center. using 6mm diameter, the 7 -stirrups are required for a 70 cm beam. Stirrups are mainly used to provide stability to the reinforcement of bamboo sticks.

In reinforcement the beam sticks placed in two types, we classified in two stages: -

- In Stage-1 we reinforced the bamboo sticks in the compression zone in Two & tension zone in two.
- In stage-2 we reinforced the bamboo sticks in the compression zone in Two & tension zone in three.

4.7 BATCHING:

The quantities of cement, fine aggregate, natural coarse aggregate, over burnt bricks, water for each batch were measured by a weighing balance according to the mix proportions obtained by the mix design.

4.8 MIXING:

The object of mixing is to coat the surface of all aggregate particles with cement paste and to blend all the ingredients of the concrete into a uniform mass. The mixing should be homogeneous, uniform in color, and consistency. In this study, the process of hand mixing was adopted.

4.9 CASTING OF SPECIMENS:

The cast-iron molds of size 700mm×150 mm×150 mm are cleaned of dust particles and applied with mineral oil on all sides before concrete is poured into the molds. The molds are placed on a level platform. The strength criteria and durability criteria for severe environmental exposure are completely based on mix design. The quotient weight of cement, fine aggregates, and coarse aggregate are obtained and mixed thoroughly in dry conditions. to attain a thorough mix 50% of the water required is added to the dry mix and the remaining water is added to the mix and mixed thoroughly to attain a thorough mix. The concrete is filled for in layers and is compacted with tampering rod, for 25 blows each time. Before pouring the mix

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into the mold, aggregates of 25mm are taken and are placed at the bottom of the mold at all four corners and the bamboo reinforcement is placed on top of the aggregates and lastly, the well-mixed concrete is filled into the molds. Excess concrete was removed with a trowel and top surface is finished level and smooth.

4.10 CURING:

The cast specimens were removed from the molds after 24 hours from the time of adding the water to the ingredients. The specimens then marked for identification. These specimens were then stored in clean water for the required period of curing.

5. TEST RESULTS & DISCUSSION:

In this chapter, the properties of concrete in the fresh and hardened state are discussed and presented. The experimental study is carried out to find out the workability,

flexural strength, Test of 150mm x 150mm x 700mm beams and for different stages, we classified as-

• In Stage-1 we reinforced the bamboo sticks in compression zone in Two (sticks 16mm) & tension zone in Two (sticks 16mm)

• In stage-2 we reinforced the bamboo sticks in compression zone in Two (sticks 16mm) & tension zone in Three (sticks 16mm)

• In stage-3 we reinforced the mild steel rebars in compression zone in Two (bars 10mm) & tension zone in Two (bars 12mm)

The beams are tested for flexural strength Test at 3 days, 7 days, 28 days are detailed below: -

5.1Flexural Strength Tests:

The flexural strength of the concrete was done on 150x150x700 mm3 beams. The flexural strength values are taken as the average of the three test results. The results of the flexural strength of specimens are presented in the tabular forms. The equipment is used Also the graphical representation of the flexural strength of concrete beams of various mixes.

Calculation: -

Dimension of beam =150mm x 150mm x 700mm

Area of the specimen (calculated from the mean size of the specimen)

=22500 mm2

flexural strength of beam $fr = PLbd2$(N/mm2)

Notations: -

fr= flexural strength,

P = peak load,

L = average distance between line of fracture and nearest support,

b = average width (150 mm),

d = average depth (150 mm)

6. CONCLUSION:

From the whole document, we can observe that in the replacement of reinforcement we can consider bamboo as a source of alternative for the future. For the following aspects: -

• **Weight:-** From the weight aspect, it is seen that by using bamboo we can reduce the self-weight of steel to a greater extent.

• **Strength:-** From the flexural strength test conducted we can observe the following:-

i) The stage-1 value of 28 days curing period strength is equivalent to the stage-3 value of 3 days curing period strength.
ii) The stage-2 value of 28 days curing period strength is equivalent to the stage-3 value of 7 days curing period strength.

• **Cost:-** Bamboo as an alternative is majorly considered for this aspect, it's not only environmentally friendly but also lower in cost which is the primary factor for any project.

• **Percentage %:-** By placing 4 bars of bamboo in reinforcement it is seen that the weight of 44.3% is reduced by 100% of steel. Also, by placing 5 bars of bamboo it is seen that a further reduction in weight is noted.

• **Uses & applications:-** Some of the applications and uses of bamboo are as follows: security cabin, car parking, toilets.

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