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BAMBOO REINFORCED CONCRETE: A Review

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Abstract-The integral part of human civilization is construction industry and in the world of development it plays an vital role for any individual development. So for reducing financial factors we have introduced an alternative of steel bars in reinforcement, the features of bamboo is almost same as compared to steel bars mostly its tensile strength. The following project report is a theoretical demonstration of the comprehensive use of bamboo as a reinforcing material in concrete construction and its extensive use in the substitution with steel as reinforcement in concrete load bearing members. The report has been derived with the help of conclusions and results of the previous reports of various conducted experiments for determining the mechanical properties of bamboo and its use as a material in construction. The construction principles involved in the designing of bamboo reinforced members and structures has been discussed in this document, the use of bamboo in the place of steel as a whole as well as with steel is shown to ensure the reduction in weight, economic advantages with its strength compromised to a slight and safe level.

Various researches and study results will be used for the deduction of a method most suitable for the replacement of bamboo as reinforcing material in the right amount and the right proportion and the best possible placement in place of steel and or with steel. A method that would not compromise with the factor of safety of the structure has to be shown in the report.

1. INTRODUCTION

The use of bamboo as reinforcement in Portland cement concrete has been studied extensively and at primary stage by the Clemson Agricultural College. Bamboo has been used as a building material globally by human civilization since a very long period of time but after the Clemson study, its use as reinforcement has gained little attention.

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. 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. This study has been taken as a reference in the study conducted henceforth.

The investigation of the use of bamboo as a complimentary material with steel in RCC construction has been shown in this study with the economy, safety, convenience and durability of application of the particular idea. Since the use of bamboo in the ancient times for housing purposes, it has been diminishing in our world in the form of a building material despite its rich properties, strength and economical advantages. There are several methods presented and deduced by universities and the U.S navy and has proven the validity of the use of bamboo in structural members such as columns and girders. Hence in this report, the methods are presented by the members of this group for the better strength and more applicable methods with the least compromise in strength. Methods that have been put forth in this report are not guaranteed to have the best outcomes or with any assurance of the maximum strength of a structure, the designs being presented are those which have been tested on software simulation for safe working load and failure analysis. This could be very helpful and have a very good breakthrough in the field of concrete designing with prominent economical benefits over steel (being used with it) and its benefits related to the reduction of carbon emission in the atmosphere, if methods like these are applied extensively and studies for the

development of a code pertaining to concrete design with bamboo reinforcements can be brought forward for a better future of economical and eco-friendly RCC construction.

1.1. Scenario of Bamboo

This review paper is containing the information related to Bamboo as an alternative and this information collected from different sources such as research papers, journals, magazines and websites. In this review paper we tried to collect much information related to bamboo reinforcement from already published article.

2. SIGNIFICANCE OF STUDY

In this study we are trying to focus on the very special type of engineering reinforcing material like bamboo. Their property is well known to us by through upcoming decades and thus it is not yet properly utilized. In some extent bamboo contain some advantageous property like CO2 absorption as well as reduction in environmental pollution.

3. LITERATURE REVIEW

GENERAL STUDY

Building with bamboo looks back on an ancient tradition in the region in which plant grows in abundance, such as South America & Africa. Bamboo is one of the oldest construction materials. There has been a lot of construction activity in the developing world, especially India & China, for the last one and a half decade. Although not directly visible construction industry is one of the most polluting industries in the world. Production of both concrete and steel causes substantial deterioration of environment.

"BAMBOO AS GREEN ALTERNATIVE TO CONCRETE AND STEEL FOR MODERN STRUCTURES" BY- Suresh Bhalla (International Organisation of Environmental Research, Goa, 18-20 Dec. 2008). Despite the long tradition of building with bamboo, the material is not used frequently in modern building construction. Bamboo can be a perfect alternative for steel in the present and the future, as it possesses all the required mechanical properties, and can perfectly replace steel, depending on the situation and the application.

ANALYTICAL STUDIES AND RESEARCH

Tjerk Reijenga "Role of bamboo in Green Building design". In this project we are comparing steel reinforcement with bamboo reinforcement, its structural cost and techniques of replacement of steel with bamboo while reinforcing.

The United States Naval Civil Engineering Laboratory (1966) reported a study providing a set of instructions on how to properly construct a variety of structures using Bamboo. It was recommended in the report that the amount of Bamboo reinforcement in concrete be 3 to 4% of the concrete's cross-sectional area as the optimum amount. Mardjono (1998) provided research with the effort to give some sort of organisation of a system to Building with Bamboo between cultures, species, and countries having varying designs. Janseen (2000) conducted her study on building with Bamboo. It gives calculations to show why it's economically competitive, mechanical properties, its many uses, its natural durability, and the preservation of the Bamboo. The US Naval Corps is the leading institute in research for bamboo reinforcement techniques and it has developed some tables and graphs

4. MATERIAL USED

4.1. Cement

The binding materials used in concrete are Ordinary Portland cement. This cement is of 53 grades conforming to IS 456-2000 and is having desired properties. The properties of cement were determined by adopting standard procedure. The properties are given in the following table. The normal consistency, initial and final setting time, specific gravity and fineness are main basic properties which were determined.

Table 1: Physical properties of cement and their value

PHYSICAL PROPERTIES	VALUE
Normal consistency	32%
Initial setting time(min)	54
Final setting time(min)	340
Specific gravity	3.15
Fineness	7%

4.2. Fine Aggregate

Fine aggregate used is M-sand. Laboratory test was conducted on fine aggregates to determine the different physical properties as per IS 2386 (part-3)-1963(Reaffirmed 2002). The test results are tabulated in table 2. The fineness is obtained using the sieve analysis and the result is such that the fine aggregate is confirming to IS 383 – 1970.the properties of fine aggregate regarding to specific gravity is 2.65and fineness modulus is 5.41 and water absorption is 1.7%.

4.3. Coarse aggregate

The coarse aggregate for the work is crushed stone. Angular shape aggregate of size is 20mm and below. The aggregate which passes through 75mm sieve and retain on 4.75mm are known as coarse aggregate. The grading of coarse aggregates should be as per specifications of IS 383-1970. The fineness is calculated from sieve analysis and the result is such that confirming to IS specifications.

4.4. Water

Water is an important ingredient of concrete. It gives strength to cement and workability to the concrete. Potable water is used for casting and curing.

4.5. BAMBOO

Through research, it has been found that some species of bamboo have ultimate tensile strength same as that of mild steel at yield point. Experimentally, it has been found that the ultimate tensile strength of bamboo is comparable to that of mild steel & it varies from 140 N/mm2 to 280 N/mm2. Bamboo is a versatile material because of its high strength to weight ratio, easy workability & availability. Bamboo needs to be chemically treated due to their low natural durability. It can be used as bamboo trusses, bamboo roofs, skeleton, bamboo walling/ceiling, bamboo doors & windows, bamboo flooring, scaffoldings, etc. It has been found that bamboo acts very well in buckling but due to low stresses then compare to steel and due to it not being straight, it may not be very good further it has been established that in seismic zone 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 properties of bamboo.

Bamboo reinforced concrete construction follow the same design, mix proportion and construction techniques as used for steel reinforced. Properties of bamboo reinforcement are similar to that of STEEL REINFORCEMENT. Bamboo has been used for scaffolding works, formwork supporting stands and many in building construction work. These are limited to medium- large projects. Even though the existence of bamboo has been found from centuries, bamboo as reinforcement material is an innovation in the civil engineering construction field. Bamboo is biodegradable and renewable. It is energy efficient as it is of natural origin & environmentally sustainable in nature,

Some specific properties of bamboo:

Specific gravity	0.575 to 0.655
Modulus of elasticity	1.5 to 2.0 x 10^5 kg/cm^2
Ultimate compressive stress	794 to 894 kg/cm^2
Safe working stress in tension	160 to 350 kg/ cm^2
Safe working stress in shear	115 to 180 kg/cm^2
Safe working stress in compression	105 kg/ cm^2
Bond stress	5.6 kg/cm^2

Figure 1: Bamboo at their age

5.EXPERIMENTAL RESULTS

Flexural strength:-

F=PL/bd2(N/mm2)

Bending moment:-

M=PL/6(N-m)

Where,

P=maximum load,

L =Span of beam (600m),

b = width of beam,

d = depth of beam

According to practical analysis we have found that on taking all the physical quantities constant, the load carrying capacity of BRC and TBRC beams on the experimental basis are found much better with respect to PPC. Whereas the flexural strength of SRC beams are found higher respect to other type of beams which are based on following practical

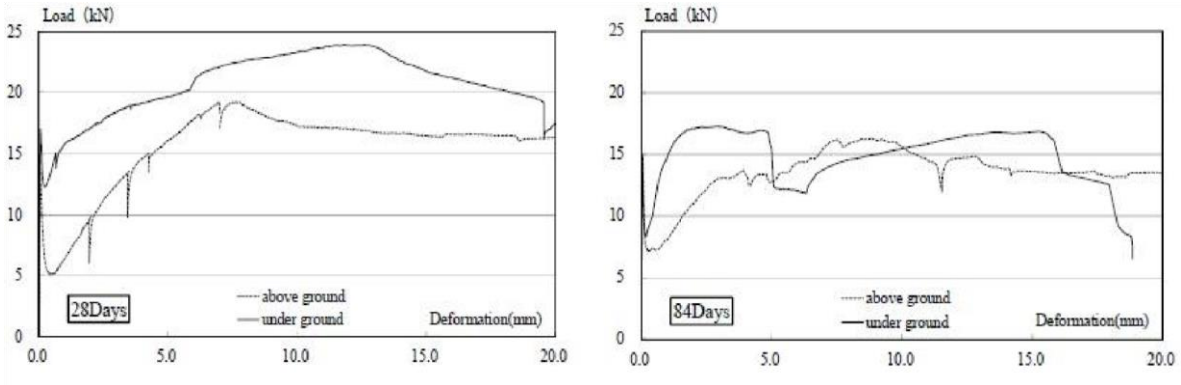
4.3.1 STRENGTH COMPAIRISON

R.C.C, BEAM
SIZE OF SPECIMEN = 0.15x0.30x1(m)
LOADING SINGLE POINT LOAD SYSTEM
FIRST CRACK LOAD = 49KN
SECOND CRACK LOAD = 77KN
FAILURE LOAD =77.8KN

BAMBOO BEAM WITH BAMBOO ANCHOR BAR
SIZE OF SPECIMEN= 0.15x0.30x1(m)
LOADING SINGLE POINT LOAD SYSTEM
FIRST CRACK LOAD = 19.7KN
SECOND CRACK LOAD = null
FAILURE LOAD =40KN

FLEXURAL TEST ON 7 DAYS AND 28 DAYS

Beam desgination for beam size 150x150x700(mm)	Avg. Flexural strength at 7days (N/mm2)	%variation in flexural wrt PPC1	Avg. flexural strength at 28 days	% variation in flexural strength wrt.PPC1
TBRC1 beam	4.18	58.33%	6.57	68.73%
SRC1 beam	10.32	290%	14.84	288.4%



Load deflection curves of beam

6. CONCLUSION

Bamboo has been used for several years since the ancient times as a building material but has gained much attention in the spotlight since the Clemson study. However, there is no such method that can be relied upon for the proper construction of any structure that is reinforced with bamboo. The property of bamboo is the reason for which it was selected as the material for reinforcing beams. It is a sure inevitability that the structural member that has been reinforced with bamboo will lose its strength up to a significant limit, so this project report has focused on providing a method by which steel and bamboo can be used as individual or together so that the strength of the member and thus the structure is not compromised with sighting a reduction in self-weight and making the structure economical. In this report, practical analysed has been used as the simulator which was used to confirm that the structure can be safe and all the members of the structure will pass with a change in the material that is being used in the reinforcement. Therefore it has been concluded that a structure can be reinforced with bamboo in the zones where compression has to be tackled. Steel and bamboo will be used together wherever required and not more than 25% of steel in a member can be replaced while in the whole structure, not more that 40% should be replaced. Bamboo as reinforcement can only be used in structures where light loads are being imparted. Bamboo can also be used as reinforcing the partition walls, but unlike all the load bearing members, 100% of steel can be replaced which will prove to be better than steel as in seismic proofing and prevent the walls from losing integrity by the nature of its stiffness. The G+1 structure that was used for confirming the validity of the strength of the structure with the changed properties of reinforcement can be used conventionally for the application in real life structures or the structure reinforced fully with steel can be reinforced with bamboo and diameters of the bars in the zones it is being used can be increased to maintain the strength factor. A reduction of 716 kg was observed when the

structure with changed properties was used to reinforce with bamboo on paper. The structure reinforced fully with steel required an approx. total of Rs. 121011was spent on reinforcement whereas the structure reinforced with bamboo and steel cost Rs. 65950 for the reinforcement. In the 3rd structure, a total of Rs. 107877 was spent on the reinforcement and saved a sum of Rs. 13134.The results for structure 3 are not as much as desired by a construction professional but can be of huge application when the construction is on a large scale.

Therefore it can be concluded that the method presented in this report has structural applications better than the conventional ones and can be used for all the aspects of Civil Engineering on an advantageous note i.e. economy, safety, and eco-friendly construction. This study can also be used to further amend the statistics for r the development of a code reinforcing steel and bamboo together in conventional concrete construction.

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