International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 06 | June - 2021 ISSN: 2582-3930

PERFORMANCE EVALUATION OF BAMBOO AS A BUILDING MATERIAL

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Abstract - Construction industry is an important part of human civilization and in the world of development it plays an vital role for any individual development. So for reducing financial crises 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 is a detailed research 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 project 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.

Key Words: bamboo, steel, bamboo reinforcement, steel replaced by bamboo

1.INTRODUCTION

Bamboo is a versatile, strong, renewable and environment friendly material . It is exceedingly strong for its weight and can be used both structurally and as a finish material. Bamboo is recognized as one of the most important non timber forest resources because of the high socio-economic benefits from bamboo based products. Bamboo can be recombined into useful products and elements such as flooring, ceiling, walls, partition walls, trusses, domes, etc. Bamboo reinforced concrete construction follows same design, mix proportions and construction techniques as used for steel reinforced. Just steel reinforcement is replaced with bamboo reinforcement. Properties of bamboo reinforcement, mix proportion of concrete, design and construction technique with bamboo reinforced concrete will be discussed in our project. Nature's material, bamboo has been widely used for many purposes. Mainly as a strength bearing material . It is used for building shelters from an earlier time. Bamboo has used for scaffolding works, formwork supporting stands and many in building construction works.

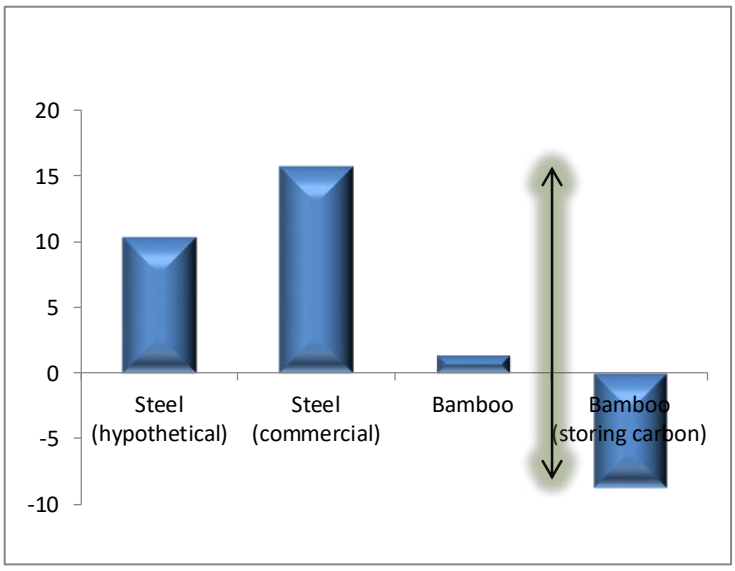
These are limited to medium-large projects. Even though existence of bamboo has been found from centuries, bamboo as reinforcement material is an innovation in the civil engineering construction field. This innovation was based on Clemson's study that has been conducted in the Clemson Agricultural College .Bamboo is a biodegradable and renewable in nature. It is energy efficient as it is of natural origin and environmentally sustainable in nature. These properties have forced to use this in the construction field for centuries. 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. In this project we have designed a beam section of (150*150*700)mm using bamboo as well as steel .Where flexural test is performed on both the sections .Results of these sections are referred from previous published research papers.

2. METHODOLOGY AND ADVANTAGES

2.1 Major benefits of Bamboo over steel

- The strength of bamboo is greater than steel.
- Steel has a tensile strength of 23,000 pounds per square inch.
- Bamboo has tensile strength up to 28,000 pounds per square inch.
- Bamboo is easily accessible than Steel.
- Bamboo lowers the cost of construction.
- Increases the strength of the buildings.
- Bamboo can crack and deflect more than steel reinforcement.
- Bamboo is also environment friendly as we know as it grows naturally without any chemical process unlike the case of steel bars which causes a huge amount of emissions of CO during their production,
- In case of bamboo the rapid growth plant growth requires the grass to absorb large quantities of CO meaning that its cultivation as a building material would help reduce the rate of climate change these factor alone are incentive for investment in developing bamboo as a reinforcement.



2.2 Material used:

1} CEMENT-
The binding material used in concrete are ordinary portland cement . This cement is of 53 grades confirming to IS456-2000 and is having desire properties . The properties of cement were determined by adopting standard procedure.
The properties are given in the following table.

PHYSICAL PROPERTIES VALUE :

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

2} FINE AGGREGATE
Fine aggregates use is M-sand. Laboratory test was conducted on fine aggregates to determine the different physical properties as per the IS 2386(part-3)1963(reaffirmed 2002). The fineness is obtained using the sieve analysis and the result is such that the fine aggregates is confirming to IS 383-1970 . The properties of fine aggregate regarding to specific gravity

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} 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

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

5.1} SOME SPECIFIC AND MECHANICAL PROPERTIES OF BAMBOO:

- Specific gravity = 0.575 to 0.655
- Average weight = 0.625 kg/m
- Modulus of elasticity = 1.5 to 2.0*10^5 kg/cm^2
- Ultimate compressive stress = 794 to 894 kg/cm^2
- Safe working stress in compression = 105 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
- Bond stress = 5.6 kg/cm^2

Mechanical property	Symbol	Value(psi)
Ultimate compressive strength	----	8,000
Allowable compressive strength	S	4,000
Ultimate tensile strength	----	18,000
Allowable tensile stress	S	4,000
Allowable bond stress	u	50
Modulus of elasticity	E	2.5*10^6

5.2} Selection of Bamboo for Reinforced Concrete Construction:

- Selection of bamboo for reinforcement can be done based on these factors:
- **Color and Age -** Employ bamboo having an evident brown color. This shows the age of bamboo to be at least 3 years.
- **Diameter -** Use the one with long large culms
- **Harvesting -** Try to avoid those bamboos that are cut either during spring or summer seasons.
- **Species -** Among 1500 species of bamboo, the best one must checked, tested to satisfy the requirement as a reinforcing material.

Fig -1: BAMBOO TREE

3. BAMBOO REINFORCEMENT

During the casting and curing of concrete, reinforcing bamboo absorbs water and expands. The swelling of bamboo pushes the concrete away. Then at the end of the curing period, the bamboo loses the moisture and shrinks back almost to its original dimensions leaving voids around itself. The swelling and shrinkage of bamboo in concrete create a serious limitation in the use of bamboo as a substitute for steel in concrete.

4. HOW TO PROTECT BAMBOO

DIFFERENT PRESERVATION TREATMENTS:

BORAX – BORIC ACID PRESERVATION TREATMENT

Depending on the diameter of the bamboo, different sized drill bits, attached to a long steel rod, are used to drill into the centre of the bamboo culms throughout their At the preservation treatment pool, bamboo soaks in borax-boric acid solution for 2 days to allow the mineral to penetrate all the nodes and diaphragms. Bamboo is removed and stacked vertically so the

solution can drain and be reused the bamboo poles are left to bask in the sun depending on the amount of sunlight.

The bamboo poles are left to dry slowly in a cool, dry place until they are used for construction.

Fig -1:
BAMBOO PRESERVATION TREATMENT

5. Concrete Mix Proportions for Bamboo Reinforced Concrete:

Water-cement ratio plays an important role in strength and durability of reinforced concrete. Bamboo being a natural building material has the property of absorbing water as discussed earlier the absorption of water causes swelling of bamboo. Thus, concrete mix proportion for bamboo reinforced concrete must have water-cement ratio as low as possible. It should also be considered to use concrete with high early-strength cement to minimize cracks caused by swelling of bamboo. The mix design of concrete can be as per the strength requirement for structure, as per structural design. Since use of reinforcement has no effect on compressive strength requirement of concrete, bamboo reinforced concrete mix proportion can be same as steel reinforced concrete mix design.

6. 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 analysis from research papers we have found that on taking all the physical quantities constant, the load carrying capacity of 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.

STRENGTH COMPARISION :

1} Bamboo beam with bamboo anchor bar size of specimen=0.15*0.30*1(m)

Loading single point load system first crack load = 19.62KN

Second crack load = null

Failure load = 39KN

2} R.C.C, Beam

Size of specimen = 0.15*0.30*1(m)

Loading single point load system first crack load = 48KN

Second crack load = 76KN

Failure load = 77.9KN

FLEXURAL TESTS ON 7 DAYS ANS 28 DAYS:

Beam designation for beam size 150*150*700(mm)	Avg. Flexural strength at 7 days (N/mm^2)	%variation in flexural wrt.PPC1	Avg. Flexural strength at 28 days	%variation in flexural strength wrt.PPC1
TBRC1 beam (Treated bamboo reinforcement)	**4.10**	**57.63**	**6.35**	**68.52%**
SRC1 beam (Steel reinforcement)	**10.21**	**282%**	**14.68**	**279.2%**

3. CONCLUSIONS

Many researchers have been trying to find on non-polluting and eco-friendly materials for the construction. Recently bamboo was consider to make use as a reinforcement material as it behave in-elastically even in light loads. 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. It was found that the bamboo reinforcement is in satisfactory condition after 15 years. But the steel reinforcing bars are severely corroded. Water treatment is needed for good bond strength. It was found that Bamboo can be used as an alternative materials as a reinforcing bar in concrete. Therefore it has been concluded that a structure can be reinforced with bamboo in the zones where compression has to be tackled. 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. Also, a G+1 structure can be constructed successfully using bamboo reinforcement. For a G+1 construction the structure reinforced fully with steel requires an approx total of Rs 121011 and on reinforcement whereas the structure reinforced with bamboo and steel cost Rs 65950 for the steel reinforcement it requires a total of Rs 107877 . Using bamboo reinforcement can save 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 project 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 ecofriendly construction.

ACKNOWLEDGEMENT

This study would not have been possible without the support of the institute Dr. D.Y. Patil College of Engineering, Akurdi, Pune. Authors are extremely grateful to the guide Dr.N.S.Jain for his time to time valuable insight and support in completing this study.

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