

A Review Study on Sustainable Construction using Bamboo

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Abstract— In India the construction industry, uses the most of green clean energy and also produces most of the carbon dioxide (CO₂) gas, which is a main greenhouse gas, which is very harmful to the environment and living beings. To counteract this horrible environmental problem, we have a better alternative option “Bamboo”, which is economical, eco-friendly, easily available and also have a very good tensile strength, also the production of one ton of steel and concrete emits approximately more than two tonnes and one tonne respectively, of carbon dioxide gas, whereas production of one tonne of bamboo consumes approximately more than one tonne of carbon dioxide gas from the environment. Bamboos are evergreen perennial flowering plants in the subfamily Bambusoideae of the grass. Bamboo is a sustainable, economical, orthotropic, natural, lightweight, non corrosive and easily available material. One of the major disadvantages of bamboo is that it attracts living organism such as fungi and insects. Bamboo is more prone to insects than other trees and grasses because it has a high content of nutrients. In order to overcome this problem, it becomes necessary to treat bamboo properly to protect it from the environment effect. Therefore, in this study, a review of the existing research work on Bamboo Reinforced Concrete with the special importance of the several factors, which are considered as the demerits of bamboo reinforced concrete construction. This research study may serve as the dream of common people to have their own home, come true.

Key words: Bamboo, Advantages, Application Sustainable material, Bamboo Reinforcement Concrete, Mechanical Properties, Economic, and Environmental Friendly Reinforcement

I. INTRODUCTION

Bamboo is a likely complex material with a high strength-to-weight ratio helpful for the structures. Bamboo as a construction material is conventionally connected with the cultures of East Asia, South Asia, and the South Pacific, to some extent in Central and South America. In India and China, bamboo was used to hold up simple postponement bridges, either by making cables of split bamboo or twisting entire culms of adequately pliable bamboo as one.

Bamboo has been also used as scaffolding, but the practice has been banned in China for buildings having height over six stories, however its use is continuous used for skyscrapers in Hong Kong city.

In the Philippines, the nipa hut is a fairly typical example of the most fundamental type of housing where bamboo is primarily used, the walls are split and woven bamboo, and bamboo slats and poles may be used as its support. In architecture, bamboo is used primarily as a supplemental and decorative component in buildings such as fencing, fountains, grates, and gutters, mostly due to the ready abundance of quality timber.

A variety of structural shapes may be obtained by training the bamboo to imagine them as it grows. Square sections of bamboo can be created by compressing the growing stalk of bamboo within a desired square form. Arches may also be created similarly by forcing the bamboo's growth into a desired form, costing of such shape is much lower than that compared to other timber wood with the same shape. More traditional forming methods of bamboo are such as the application of heat, fire and

II. FEASIBILITY TESTS

To check the feasibility and reliability of using bamboo splints as reinforcing material in concrete elements & to select and prepare the most appropriate kind of bamboo specimen to be used in concrete element as reinforcement.

The following tests were performed till date on different bamboo specimens: -

- 1) Density test.
- 2) Initial moisture content test.
- 3) Water absorption test.
- 4) Compression test.
- 5) Tension test.
- 6) Bond test.

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

Table 1:

III. LITERATURE SURVEY

- 1) The research and investigations reported in International Network for Bamboo and Rattan INBAR (2002) had revealed bamboo's advantages and disadvantages as a construction material. The advantages of bamboo are ecological value, competitive mechanical properties, social and economic value and low energy consumption. On the other part, disadvantages of bamboo are requirement of better preservation and fire safety.
- 2) Another project Utthan, initiated by International Network for Bamboo and Rattan INBAR (2003), had rehabilitated and renovated villages Kotwa and

- Rahimabad in Uttar Pradesh (India), which were destroyed by brick mining. Due to this whole project not only land was rehabilitated but also a new alternative was also provided to the villagers to facilitate their livings.
- 3) An urgent, "Review on the role of bamboo in green building construction and design" is presented by Reijenga Tjerk,
 - It suggested the viability of bamboo to replace certain general traditional construction materials, such as wood, brick, steel, and concrete.
 - Although, he also mentioned the need of confirmation projects to convince people to use this incredible building material i.e. bamboo grass on the earth for design purpose.
 - He also provided sufficient examples of green buildings using bamboo for the design purpose.
 - Most of the developing countries have several problems; housing problem is one of them.
 - The housing problem has been related to lack of research in field of green concrete, smart material and low cost housing projects.
 - 4) Sreemathi Iyer (2002) conducted an "observation survey on different types of building & their failure patterns after the devastating destruction Bhuj earthquake in Gujarat".
 - The survey and observation analysis report exhibited that a lot of lives and damage could have been saved, if some safety precaution in the conventional building design had been used in buildings.
 - One of them was the use of bamboo as a reinforcing material with the brick masonry wall according to the report analysis.
 - The report also provided the guidelines and standards for building bamboo reinforced masonry buildings.
 - 5) Anurag Nayak, Hirdesh Tiwari, Arehant S Bajaj, Abhishek Jain, Apoorv Khandelwal, "Replacement of Steel bar Reinforcement by Bamboo Reinforcement", (IOSR-JMCE), IOSR Journal of Mechanical and Civil Engg. Volume 8, Issue 1 (Jul. - Aug. 2013), PP 50-61.
 - In this study, the effect of replacement of steel reinforcement by bamboo reinforcement, design procedure and Flexural testing have been conducted on one way slab of size 3000 mm x 7000 mm with providing beam of 7000 mm length and 250 mm x 250 mm cross sectional dimension.
 - In this research work, the designs are done on the basis of shearing and bending. Bamboo reinforcement bars technique is used for both main as well as distribution reinforcement, as it was same earlier done for steel reinforcement.
 - Bamboo reinforcement technique is approximately more than 3 times cheaper than steel reinforcement technique. It is clear from the above results that the bamboo reinforcement technique is definitely cheaper than steel reinforcement technique especially low rise structures such as single story structure.
 - 6) Jigar K. Sevalia, Nirav B. Siddhpura, Chetan S. Agrawal, Jai V. Kapadia, Deep B. Shah, "Study on the Bamboo as Reinforcement in Cement Concrete", International Journal of Engineering Research and Applications, Vol. 3, Issue 2, March -April 2013, pp.1181-1190.

In this study, the assessment of the viability of Bamboo as reinforcement in concrete members. In this research the Bamboo was used as a reinforcing material without any treatment and stirrups.

Based on the experimental study, the following conclusions are made,

 - Tensile test performed on Bamboo strip that revealed elastic behavior,
 - Both Singly as well as Doubly Bamboo Reinforced Beam has shown elastic behavior while performing flexural tests on them,
 - Doubly Bamboo Reinforced Beam has performed more elastically as compared to Singly Bamboo Reinforced Beam while performing flexural tests,
 - Load carrying capacity of Doubly Bamboo Reinforced Beam increased by 29.31 % as compared to Singly Bamboo Reinforced Beam.
 - Vertical cracks are formed and seen on failure of the beam, within middle third region of the beam. This type of failure indicates the existence of pure moment without development of any type of shear.
 - Modulus of Elasticity of the Doubly Bamboo Reinforced Beam is more than twice that of the Modulus of Elasticity of the Singly Bamboo Reinforced Beam.
 - 7) Avula Ganesh Reddy and A. Joshua Daniel, "Study on the Behaviour of the Bamboo Reinforcement with Coconut Shell as the Aggregate Concrete in Compression Member with Different Lengths", (IJIREM), International Journal of Innovative Research in Engineering & Management Volume-3, Special Issue-1, April-2015

In this study, Short columns of a different range of lengths were studied.

 - The columns with replaced coconut shell as aggregate with bamboo as the reinforcement and columns with replaced coarse aggregate with steel as the reinforcement were compared with the conventional type of concrete with steel as the reinforcement specimens.
 - As the length of column increases, the ultimate load carrying capacity of the columns decreased.
 - The stiffness of the structural member i.e. columns also decreased with the replacement of aggregate and reinforcement.
 - The ultimate load carrying capacity for the column of 1m length with coconut shell as the aggregate and steel as reinforcement was about 86% of the column with conventional aggregate and steel as the reinforcement and coconut shell with bamboo as the reinforcement was about 63%.
 - The ultimate load carrying capacity for the column of length 1.3meter with coconut shell as aggregate and steel as reinforcement was about 77.5% of the column with conventional aggregate and steel reinforcement and coconut shell with bamboo reinforcement was about 67.5%.

- 8) Ayesha Syeda, Barvaliya Shrujal Jayesh Kumar, "A Case Study on Bamboo as Green Building material", International Journal of Engineering and Advanced Technology (IJEAT), Volume-4 Issue-2, December 2014.
- Bamboo is lighter in weight yet stronger than steel. It absorbs carbon dioxide (CO₂) gas from environment and releases 30% more oxygen than tree. It grows very fast about 1m in one year and almost matured in 3 - 4 years.
 - Houses constructed using the bamboo are very economical, eco friendly, also cool in summer and stays warm in winter weather and more over it can resist earthquakes and can stand forever.
 - The environmental and financial comparison demonstrates that bamboo can compete with all the building material.
 - Bamboo is a natural occurring product and will therefore always have some degree of irregularity. It is therefore suggested that the bamboo strip or culm should be used in functions, where the measurement requirements are not entirely important, precise or fixed, as in temporary buildings (e.g., bamboo hut, pavilions and tents) or small civil temporary projects.
 - In addition all the above advantages, bamboo also plays a significant role as a non-supporting or finishing material.
- 9) P. Sharma, S. Mehta and K. Dhanwantri "Bamboo as a Building Material", International Journal of Civil Engineering Research (IJCER), Volume 5, Number 3 (2014), pp. 249-254
- In view of the fact that time immemorial, bamboo has played a significant role in the growth of mankind. It is used for a wide variety of day-to-day purposes, both as a woody material and as food.
 - It has been the spine of much of the world's rural life and will stay up so as the population increases.
 - The properties as peak grade building material and increased availability of bamboo in our country makes it potential to use, bamboo in the field of construction broadly.
 - Its high valued consumption not only promotes the economic development, but also saves jungle resources to protect our ecological environment as a wood substitute.
 - As a cost-effective building material, rate of bamboo productivity and crop cycle of annual harvesting is very less compare to any other naturally growing resource, suppose if you today planted three or four structural bamboo plants, then in 4-5 years later you will have mature clumps, and in 8-9 years you will have enough mature material to build a comfortable, eco friendly & low cost material house.
- 10) Sani Haruna, M. Lakshmi pathy, "Ductility Behavior of the Bamboo Reinforced Coconut Shell Concrete Beams", International Journal of Scientific Engineering and Research (IJSER), Volume 3 Issue 5, May 2015.
- From their research work and experimental result obtained the following conclusions they have made:
- Tension test performed on bamboo strip revealed elastic behavior and its ultimate strength was 112.05N/mm²
 - The modulus of elasticity of coconut shell concrete was found to be 12075.2N/mm² which represents 54%, 57%, 43.88% and 60.36% that of modulus of elasticity of conventional concrete for IS 456, ACI-318, EU and BS 8110 codes respectively.
 - The load carrying capacity of the NWC beams were slightly higher than CSCS, BCSC, and BCSCB beams
 - The stiffness behavior of CSC beam showed similar trend as that of NWC up to failure
 - Energy absorption was more for BCSC than NWC, BCSC and BCSCB beams. This is attributed due to the high deflections due to applied loads
 - Deflections are higher in BCSC and BCSCB beams when compared to NWC and CSCS beams and by wrapping the split bamboo with binding wire the deflections were slightly reduced in BCSCB beams compared to BCSC beams.
- 11) H. Sakaray, N.V. V. K.Togati and I.V. Ramana Reddy, "Investigation On the Properties Of Bamboo As Reinforcing Material in Concrete", (IJERA) International Journal of Engineering Research & Applications, Vol. 2, Issue 1, pp.077-083, Jan-Feb 2012.
- It focuses on the study of natural material so as to reduce the energy consumption and CO₂ gas emission.
 - The research work indicates that the compressive stress value obtained for central node specimen is greater than that of end node specimen and without node specimen.
 - The study also showed that nodes possess brittle behavior and intermodal region possess ductile behavior.

IV. CONCLUSION

From this literature survey study of a Bamboo, anyone can conclude that

- Bamboo is a natural material which is eco-friendly and economic material.
- Bamboo also controls and absorbs the CO₂ gas, which is a main Greenhouse gas.
- Also Bamboo is used as Sustainable Construction Material.
- The mechanical properties of bamboos are satisfactory and comparable with concrete and steel.
- Though it has low stiffness and strength compared to steel, but it can be used as reinforcement in limited storeys.
- And bamboo must be treated before using as reinforcement in concrete.
- It is rightly being said that Bamboo is a Green Gold, as we can see, the topic on bamboo remains evergreen as the plant itself.

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