Comparative Study of Bamboo Material Performance in Civil Engineering Structure

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Abstract
Bamboo is the world's fastest growing woody plant. Bamboo grows three times faster than most other species. Housing is one of the priority items and sensing the current shortage of the dwelling units, the present administrative leaders around the world find tough to hit upon a solution for. Apart from the other substances already in practice, bamboo appears to be the most promising material. Bamboo building construction is characterized by a structural frame approach similar to that applied in traditional timber frame design and construction. Bamboo has shown its suitability based on a combined low weight, high strength, beauty and durability. The properties of these species vary significantly. A successful application of bamboo in engineering firstly relies on the selection of a correct species. Therefore recognition of bamboo species is necessary before its efficient utilization. It has also been widely used in building applications, such as flooring, ceiling, walls, windows, doors, fences, housing roofs, trusses, rafters and purlins; it is also used in construction as structural materials for bridges, water transportation facilities and skyscraper scaffoldings. This study on bamboo also can contribute to a sustainable development in which not only technology and economics but also environment, culture and tradition should all be considered thoroughly.
Keywords: Cost Estimation,, concrete, bamboo, reinforcement, Water absorption, bonding strength

1 INTRODUCTION

The Industrial Revolution more and more new industrial materials have been invented and developed to meet the ever growing needs of people in the industrial world. As a symbol of the industrialization cast iron and later steel have been developed and widely used in mass production since the middle of the 19th century. Now people can find them everywhere: from building construction in the industry to the kitchen knife in the household. Another industrial material – aluminium – has been mass produced and used in industry no more than one hundred years, but now has taken over the place of steel in many fields because it is as strong as steel, but lighter Compared to steel, cements and plastics bamboo has many advantages like strength, elasticity and lightness, but also disadvantages in processing and connection: its tube structure is very good for tensile and press loadings. At last they found bamboo which is used for replacements of reinforcing bar in concrete for low cost constructions. Bamboo is available in commercial quantities using the established supply system. It is a renewable plant with a short rotation period. Bamboo grows to its full size for about a year. Another two or three years are required for the plant to gain its high strength. A natural material which is available in bulk and ease of use in the rural areas in the developing countries is bamboo. Bamboos occur mostly in tropical and subtropical areas, from sea level to snow capped mountain peaks, with a few species reaching into temperate areas

2 LITERATURE REVIEW

Fujji et al. [1993] investigated the chemistry of the immature culm of a mosobamboo (*Phyllostachys pubescens Mazel*). The results indicated that the contents of cellulose, hemicellulose and lignin in immature bamboo increased while proceeding downward of the culm. The increase of cellulose in the lower position was also accompanied by an increase in crystallinity.

Amada et al. (1997) investigated the mechanical and physical properties of Bamboo. They conducted a thorough investigation into the structure and purposes of the nodes, which they found to strengthen the Bamboo Culm. They also commented on the advantage Bamboo has over other natural building materials with its fast growth rate.

Mardjono (1998) provided research with the effort to give some sort of organization of a system to building with Bamboo between cultures, species, and countries having varying designs. The objective of their research was to improve the functions of Bamboo buildings by this organization to provide privacy, safety, comfort, durability, and accessibility. Overall Bamboo used as a structural material suffers from an incredible disadvantage due to inadequate applied scientific research. They do feel that Bamboo products should be brought to the level of acknowledged and received building materials. The results of their research will be published as a thesis and guide for designing Bamboo structures to be dispersed to people in developing countries.

A study reported in International Standard Organization (ISO) (1999) fashioned lab manual for

determining the physical and mechanical properties of Bamboo. The purpose for publishing this manual is first of all so that these methods are available all over the world. Research is done in so many places, very precise, yet is stuck in the laboratories. With this document, the methods are made available. Secondly, this document gives a practical step by step explanation of how to perform each test specifically following the International Standard Complement Document "Determination of Physical and Mechanical Properties of Bamboo." Another complement document is Bamboo Structural Design (1999). **Janseen (2000)** conducted her study on building with Bamboo. This book covered a wide variety of aspects of Bamboo going back to the structure of the plant and its natural habitat. It gives calculations to show why it‟s economically competitive, mechanical properties, its many uses, its natural durability, and the preservation of the Bamboo. In much more detail, it discusses the joints and building with pure Bamboo. In relation to this project, her book does touch on Bamboo used as reinforcement in concrete. Listed in her book are several things that are more of a hassle than steel reinforcement. 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

Amada and Untao (2001) mention that bamboo is the most effective material in construction by the superior character of bamboo such as being physically powerful, tough, and a low-cost material. Normally, the Culm of bamboo with outer surface layer withstand strongly to any loading with stronger fracture resistance than the node. It
suggests that the fibers in the node do not contribute any fracture resistance. The tensile strength of bamboo fibers almost corresponds to that of steel. The main discovery is that the fracture properties of bamboo depend upon the origin of fracture. In the nodes, it is found that the average fracture toughness is lower than the minimum value of the entire Culm, suggesting that the fibers in the node do not contribute any fracture resistance

Seinfeld (2001) researched the remarkable current uses of Bamboo around the world. In the United States, it is almost completely used as decoration. A discussion is presented on the astonishing feature Bamboo brings to the table as mentioned in other articles. Another special feature about Bamboo is that harvesting Bamboo does not harm the plant, producing more of its timbers. Bamboo buildings are definitely a prospect of the future in the US; however in Asia, the Pacific islands, and South & Central America, they are quite traditional. The main prevention of Bamboo structures in America are building codes. There are not standardized codes for buildings of Bamboo though there are attempts towards them. Bamboo is also still being looked at as a way to clean environmental pollution. It is a consumer of Nitrogen, which could soon be part of a huge effort to prevent air pollution.

Power (2004) tells of a study conducted by the U.K. Department of International Development in response to a devastating earthquake that killed 40,000 people in Iran. The engineers were looking for cheap earthquake-proof housing to take the place of mud brick. They constructed a prototype Bamboo reinforced concrete house and used an earthquake simulator to find that the house stood sound during a 7.8 (on the Richter scale) earthquake. They found no cracking in the concrete, the Bamboo to be extremely resilient to earthquakes, and the cost to be split in half compared to mud-and-brick construction

The American Bamboo Society (2005) provided a very intricate collection of specialized terms followed by their definitions relating to Bamboo. It also has a glossary of questions and answers common to someone new to the topic. These questions ranged from identifying Bamboo, preserving Bamboo, finding help with your Bamboo, to other topics not as closing connected to the research of this project.

Atul agarwal and Damodar maity (2009) they studied axial compression and bending test was performed on Plain, Steel & Bamboo reinforced members. As explained in there experimental program, For example, a total of 12 columns (150x150x1000mm) were casted using design mix (M20) as per IS code. These columns included 3
columns of steel reinforcement, 3 columns of plain concrete, 3 columns of untreated bamboo reinforcement & 3columns of treated bamboo reinforcements (with varying percentage of reinforcement; i.e. 3, 5, & 8%). The load deformation curves displayed significant nonlinearity, indicating that the bamboo has the capacity to absorb energy. Failure of Columns predominately occurred in shear in shear under compressive loading. Plain concrete and untreated bamboo columns showed brittle behaviour in which, tiny cracks occurred at the surface of the column at about 80% of maximum axial force. After reaching the maximum load, the load capacity decreased abruptly and it finally failed in few seconds. There were no visible signs of spoiled concrete covering to warn of impending failure. Whereas in steel and bamboo reinforced columns more ductile behaviour was observed, wherein tiny cracks became visible at surface of columns firstly at 80-90% of maximum axial force. Final failure was accompanied by growing signs of cracks and spalling of concrete. Furthermore, the results, exhibited that the maximum load carrying capacity of steel reinforced (min reinforcement, 0.8%) column is nearly equivalent to that of treated bamboo (8% reinforcement) reinforced column (owing to the strength of bamboo samples). Transverse load test performed on above set of columns revealed the lateral deflection, strain characteristics and failure mode pattern of the steel, plain and bamboo reinforced columns. Hence, further analysis of results obtained, would assist in evolving comprehensive design methodology in case of reinforced columns. Bamboo concrete composite structural members can provide tailored solutions to the eco-housing

initiatives at cheaper costs. The results obtained accrue the advantage
Obtained by the composite members when compared to standard reinforced concrete and plain concrete. However, further studies to achieve higher mechanical properties and understanding their behaviours in details would make this a reality.

3 DESIGNS FOR CONSTRUCTION OF BAMBOO SCAFFOLDS

The commonly used bamboo types are Kao Jue and Mao Jue. They should be 3 to 5 years old and air-dried in vertical positions under indoor condition for at least 3 months before use. The nominal length of both Kao Jue and Mao Jue is 6 m. All bamboo members should be free from visual defects, and meet the following requirements on the cross-sectional dimensions. This section provides detailed standards of design and construction of some typical types of single bamboo scaffold, including double-layered, truss-out and signboard bamboo scaffolds. When the recommended standards given in this section are not followed or when other types of bamboo scaffold not covered in this section are used, they should be designed by a design engineer. For a bamboo scaffold for demolition works, irrespective of its size, the design engineer should also ensure the bamboo scaffold is capable to withstand the increased wind load acting on the plastic sheeting.

3.1 Steel Brackets Scaffolds

Steel brackets are essential to the overall stability of a bamboo scaffold. The details of a steel bracket for the support of posts of a bamboo scaffold for construction site. All steel brackets should be securely mounted onto the structural elements of a building with high quality anchor bolts and comply with the following requirements.

- The horizontal spacing between the steel brackets should not be larger than 1.3 m; and
- The concrete strength of the structural element to which the steel bracket is fixed should be not less than 25 N/mm2. All anchor bolts should be installed strictly in accordance with the manufacturer's recommendations.

There may be occasions that a post of a bamboo scaffold does not rest on the steel bracket; the design engineer should ensure that the loading from the misaligned post can be effectively transferred to the steel bracket

3.1.1Guidelines for Bamboo Scaffolds

- Performance
- Design Engineer
- Drawings and Specifications
- Engineering Justifications

4 CONCRETE MIX PROPORTIONS

The same mix designs can be used as would normally be used with steel reinforced concrete. Concrete slump should be as low as workability will allow. Excess water causes swelling of the bamboo. High early-strength cement is preferred to
Minimize cracks caused by swelling of bamboo when seasoned bamboo cannot be waterproofed.

5 SIMILARITIES WITH STEEL REINFORCED CONCRETE

Bamboo reinforced concrete design is similar to steel reinforcing design. Bamboo reinforcement can be assumed to have the mechanical properties. hen design handbooks are available for steel reinforced concrete, the equations and design procedures can be used to design bamboo reinforced concrete if the above mechanical properties are substituted for
the reinforcement. Due to the low modulus of elasticity of bamboo, flexural members will nearly always develop some cracking under normal service loads. If cracking cannot be tolerated, steel reinforced designs or designs based on unreinforced sections are required. Experience has shown that split bamboo performs better than whole culms when used as reinforcing. Better bond develops between bamboo and concrete when the reinforcement is-split in addition to providing more compact reinforcement layers.

6 CONCLUSIONS

- The use of bamboo as reinforcement in concrete it is established that bamboo can replace steel for modest housing for the urban poor who live close to bamboo growing regions.
- Bamboo reinforcement technique is used for both main and distribution reinforcement as it was same earlier done for steel reinforcement
- The bamboo has high tensile strength and it can be used as a replacing material for steel reinforment because of its low cost.
- The structural behaviour improving the reinforced concrete beam can be strengthening using bamboo sticks as a retrofitted material.
- Bamboo reinforcement technique is used for both main and distribution reinforcement as it was same earlier done for steel reinforcement.
- Modulus of elasticity of the Bamboo is quiet lower than that of the steel.

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