DEVELOPING BAMBOO CONCRETE COMPOSITE ARCH AND COLUMN AS STRUCTURAL LOAD BEARING ELEMENTS

by

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CERTIFICATE

This is to certify that the thesis entitled ***"Development of bamboo concrete composite arch and column as structural load bearing elements"***, being submitted by **Korde Chaaruchandra** to the Indian Institute of Technology Delhi, is worthy of consideration for the award of the degree of '**Doctor of Philosophy**' and is a record of the original bonafide research work carried out by him under my guidance and supervision. The results contained in the thesis have not been submitted in part or full, to any other University or Institute for the award of any degree or diploma.

I certify that he has pursued the prescribed course of research.

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ABSTRACT

The growing demand for housing has increased pressure on the existing resources and ecological concerns have forced the researchers to search for alternative materials which are green and renewable. Among the natural building materials perhaps bamboo is unique for the extent of *negative carbon foot print*, quality timber and its extremely short maturity time (3-5 years). Bamboo, a 'timber grass', thus has the potential to qualify itself as a rapidly renewable material. The present thesis explores innovative structural load bearing applications of bamboo. This is expected to enhance the acceptability of bamboo as a key engineering material of the 21st century.

A new innovative form of bamboo concrete composite (bamcrete) arch and column are developed as structural load bearing elements. Under the process of development the concept of integrating two or more bamboos together using an innovative joint, termed as Haritha IITD Bamcrete (HIB) joint, is applied for making parabolic tied arches and columns for their strength characterization. In order to test the arches & columns to their ultimate capacity, new test setups are developed, keeping in mind their remote operations & handling by marginally skilled labor in rural areas.

Bamboo has inherent variability from bottom to top where it tapers and inside to outside where the fiber density increases being densest at the skin. A comprehensive literature study is undertaken to understand the status of research on bamboo structures. Also, a most widely available species of India, Dendrocalamus strictus, which is 45 % of Indian bamboo, is used to develop the structural elements. More than 18 arches of nearly

similar rise to span ratio are fabricated. From their performance under various forms of loading, it is determined that they give a very narrow band of variation under acceptable limits of building guidelines, which can be considered as reproducible. Also, a closed loop expression is developed for predicting the crown deformation of the arch, as will aid in deciding the size of bamboo and rise to span ratio before fabricating of a parabolic tied arch. It is also concluded & demonstrated form this analysis that the deformation at crown of a parabolic tied arch has contributions from arch and tie elements independently. Further, the arch is modeled using a software to study the stress conditions in the arch and parametric study is undertaken to study the effect of change of various parameters of an arch such as span, diameter of bamboo, rise to span ratio, slenderness ratio and stiffness ratio. A bamcrete column is fabricated using HIB column joints and its performance is tested under the developed test setup in laterally restrained pure axial loading conditions. Further, fabrication, testing and designing procedures are also given for bamcrete arch and column.

The HIB construction technology, using these structural elements, is then demonstrated through construction of demonstration structure. The experience gained in working with the artisans and cost estimations of the demonstration structure, a cost prediction is made for future expected cost of construction of a 27 m^2 structure, after proper supply chains are established, using this technology. However, since the acceptability of a bamboo house being one of the key issues to be addressed, few strategies for popularizing bamboo in housing are also proposed.

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