Structural Analysis of Bamboo Wall Framed Structure – An Approach

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Abstract: Structural applications of indigenous materials such as bamboo are considered as an integral part of the sustainable development. In the study, the author has tried to analyze bamboo wall framed structure using half strip bamboo anchored to a sheathing material. It has been modeled in STAAD Pro software and different load as- Dead Load, Live Load, Seismic Load, Wind load were applied on the frame. The material properties of bamboo were defined using the value of modulus of elasticity, Poisson's Ratio, density, and shear modulus obtained from the tests conducted here in laboratory.

***Keywords*: Bamboo, half split bamboo wall, STAAD Pro, Framed Sturucture**

1. Introduction

The insufficiency of construction in developing countries, motives the exploration for alternative substances that can be used to build affordable houses for different categories of citizens. The center of attention of researcher is on non –conventional materials and methods at time of such environmental situation. In recent years, use of timber for construction, has increased in demand but, on the other hand the forest resources are diminishing at a very high rate. Hence the usage of timber is being replaced by **BAMBOO**. In particular, it is a promising alternative, as for its less growing period, short rotational age, and great strength at the same time.

Always we have a requirement of affordable mass housing schemes for people of zone of earthquake and cyclone affected. **With an aim to utilize the strength properties of bamboo in low costing houses, an approach has been taken for construction of energy efficient and eco-friendly housing system using bamboo as wall framed structure.**

2. Literature review

Sushil G Nikam A.C. Attar (2013), developed an walling system with bamboo fixed to timber as sheathing material by nailing, which can tolerate high values of deformations and deflection in the elastic range i.e., being able to sway back and forth during an earthquake, without any damage to the bamboo wall panel.

Maulik D. Kakkad, Capt. C. S. Sanghvi (2011), studied that as bamboo is very flexible material and also light weight material, the seismic force in bamboo is used as main structural element because of its ductility and performance.

Rushab A. Shah, Hitesh D. Bambhava (2013), stated that the whole stem, halved or strips of bamboo can be nailed to one or both the sides of the bamboo frame and split bamboo mates can be fastened to the bamboo posts or mats can be woven.

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

*Jorge A. Gut*ierrez, in his technical report had mentioned that one of the most remarkable characteristics of the traditional bamboo housing is their lightness. When the walls are left as exposed esterilla without mortar, the weight of the house may be less than 10% of the weight of the similar masonry houses.

Sharma (2014), had studied that the properties of bamboo as peak grade building material and increased availability of bamboo in our country makes it potential to use bamboo on the field of construction broadly. Its high value consumption not only promotes the economic development but also saves forest resources to protect our ecological balance as a wood substitute.

D.K. Tamang (2013), carried out research on Bamboo`s Diversity, Distribution patterns and its use in Himalaya (India) which has different species of bamboo found in different region.

B. Bhattacharjee and *A. S. V. Nagender (2007),* performed the analysis of the design of the multi-storied structure in The STAAD Pro software. In this they explained the various fundamental properties of the software and developed the proper result of the structure using the software with possible factors of the materials used.

3. Significance

The raw materials required for constructing a bamboo house needs to be available locally and accessible. Moreover, the bamboo-based housing system is of low and basic material. Bamboo can bear high values of deflections in the elastic range i.e., possesses high elasticity. Bamboo has no CO_2 emissions like of R.C. buildings. Some of the positive

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aspects such bas a lightweight design, better flexibility, and toughness due to its thin walls with discretely distributed nodes and its great strength make it a good construction material. Hence bamboo houses with the alternate developed walling system when properly constructed will be ductile in nature i.e., being able to bear the sway movement horizontally during the earthquake, without any damage to the bamboo wall panel. This walling system is actually the alternative of cement mortar based bamboo grid wall used for the houses made today.

Not just the advantages of bamboo are being discovered but the researches have helped in knowing the demerits too. Bamboo fails in buckling. To rectify the failure the length is to changed further or the cross-section in other words.

4. The structural model

A model of 1.22m x 1.22m x 2.44m is being developed with mono-sloped roof.

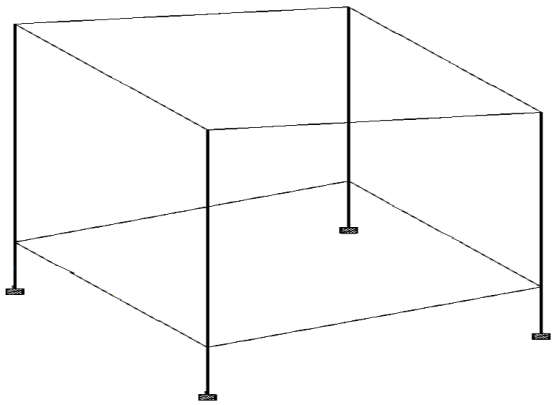

Fig 1: The schematic framed diagram

The wall of the frame is being designed as "*Half spliced*" bamboo placed side by side within a layer of Suitable Sheathing material.

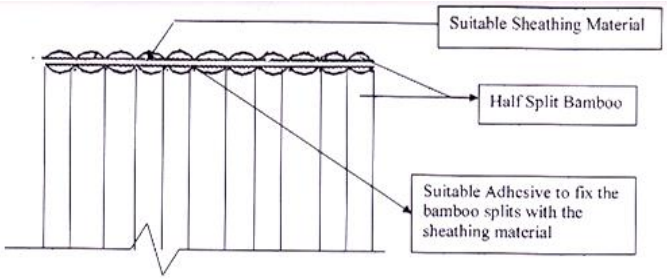

Fig 2: Diagram of the walling system of the model

Design analysis by staad pro software

STAAD Pro is computer-based software used to analyze any structure, frame or building mathematically. This software was first developed by the Research Engineers International at Yorba Linda, CA in the year of 1997. After 2005, the software was authorized by the Bentley Systems.

Frame making

First the frame is created with "system of nodes and Beams". The nodes are placed where the center line of the structure lies. Each node is then connected by beams. After the skeleton structure is made in the software, the section dimension is selected. Supports are assigned as the requirement of the structure.

Table 1: Node placement in the software

Node	X m	Y m	Z m
1	0.000	0.000	0.000
2	2.440	0.000	0.000
3	0.000	0.000	-2.440
4	2.440	0.000	-2.440
5	2.440	2.440	0.000
6	2.440	2.440	-2.440
7	0.000	3.050	0.000
8	0.000	3.050	-2.440
9	0.000	-0.610	0.000
10	2.440	-0.610	0.000
11	0.000	-0.610	-2.440
12	2.440	-0.610	-2.440

Sections and Material creation

As this is completely is a bamboo structure, hence providing a hollow circular section of aggregated wall thickness and a fixed diameter.

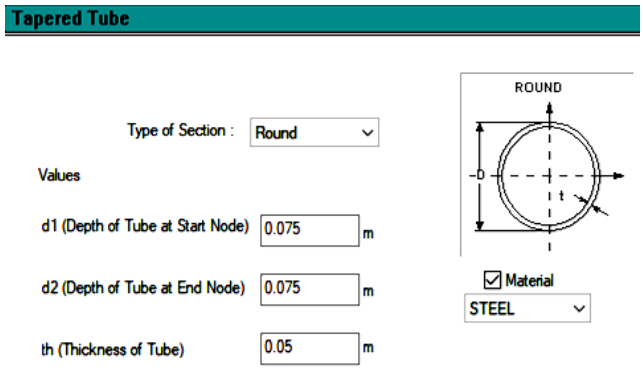

Fig 3: Tapered tube section using bamboo

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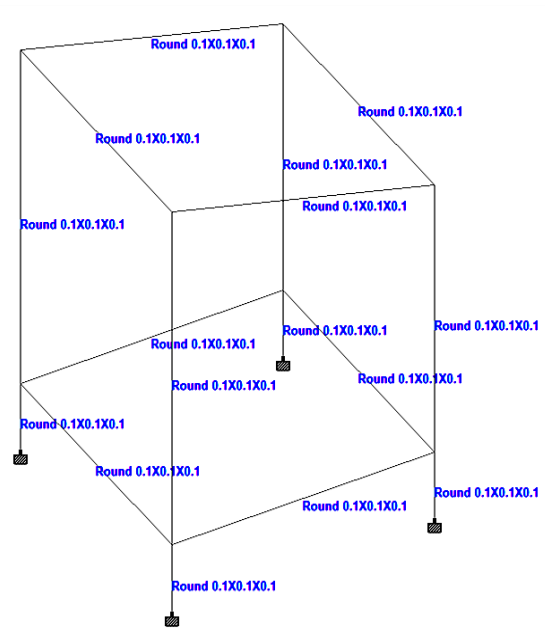

Fig 4: Section allocation to the frame

STAAD usually consists of four basic materials. The materials are namely- **Steel, Concrete, Timber** and **Aluminum**. The structure being bamboo based, a **Bamboo** material is created using the value of the test results obtained from the laboratory.

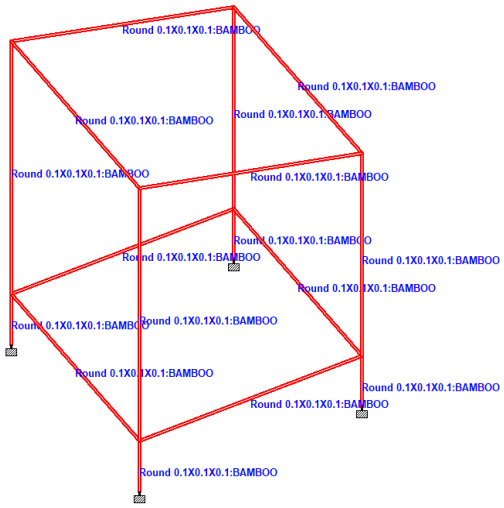

Fig 4: Material "Bamboo" assigned to frame

Load Cases and Defining of load

The load due the various factors are calculated and placed on the exact nodes or beams of the frame. While placing the nodal or member UDL or floor or roof loads, all the possible cases are taken. In this way both the Dead and the Live Loads are assigned.

But for the special cases such as Wind or Seismic or Snow Loads etc., requires to be defined first then provide the factor to it in the Load Cases after the Dead Load and Live Load.

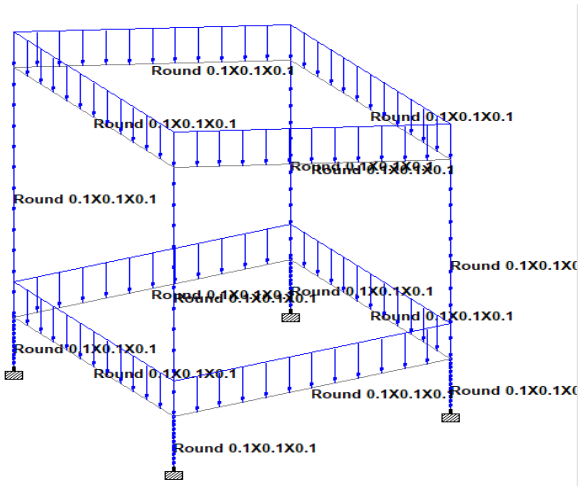

Fig 5 : Assigning Dead Load to the structure

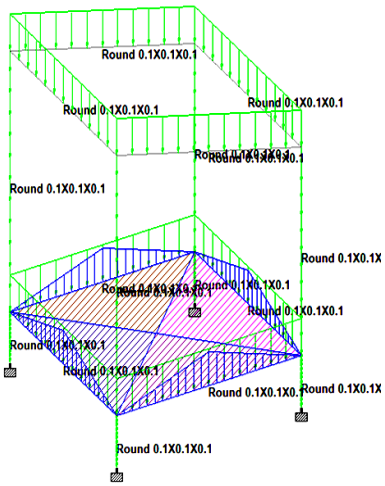

Fig 6: Assigning Live Load to the structure

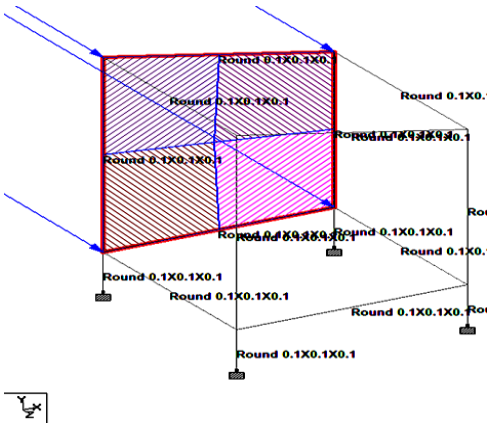

Fig 7: Assigning Wind Load on Windward side

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Run Analysis and Output Results

After completing the following steps, the program of the entire structure needs to be checked for error. If, the run analysis completes with showing any error the model may be reopened as the post-processing mode. The results are henceforth shown there like- Displacement, support reaction, beam displacement, nodal displacement, deflections, stability of the structure etc.

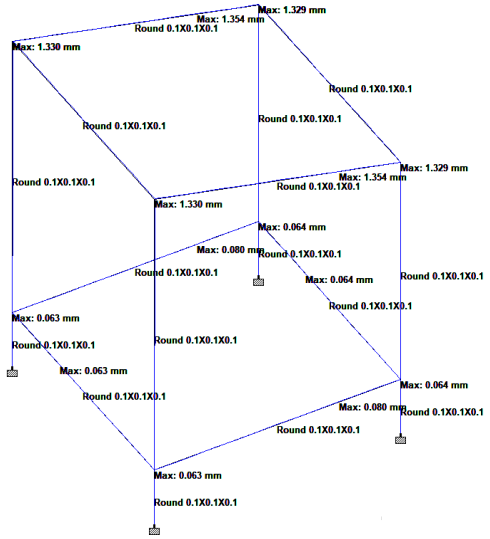

Fig 8: Displacement of the framed structure

The structure is stable as it has a max displacement of **1.330 mm.**

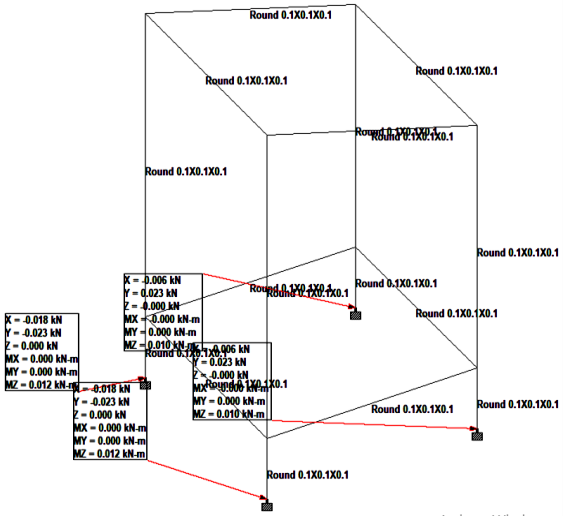

Fig 9: Support Reactions

Conclusion

Earlier, study has been done on walling system using bamboo strip-based **walling system with cement mortar** that has been used for bamboo-based housing system. Hence a new design of houses with half split bamboo-based walling system can be an alternative to housing materials which is needed to meet the current challenge.

For buckling test of bamboo walling system, it has capacity to carry load arising out of **Wind Load, Dead Load, Live load and Seismic Load**. After calculating manually as well as through STAAD Pro software the **displacement** obtained is **1.330 mm (Ref Fig 6)** and there **no moment generation** (Ref Fig 8) on the nodal joints of the supports of the framed structure. This is a positive sign for an approach of this half-split bamboo walling system in future. Some of the positive of this type of walling system is that of better flexibility, and toughness with discretely distributed nodes of bamboo and its great strength making it as a good construction material. Hence bamboo houses constructed with alternate developed walling system when properly constructed will be ductile in nature.

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