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Conclusion

This research established the tensile modulus of elasticity E_t and bending modulus of elasticity E_b, for 6 groups of specimens taken from defined segments along the culm and across the wall thickness of *Dendrocalamus Ginganteus* species. It was found that bottom section had the lowest E_t (7,47 GPa and 7,85 GPa, inner and outer respectively). Then values for middle section were (1,62 GPa and 1,61 GPa) and for top were (1,2 GPa and 1,8 GPa). Outer segments were found to have higher values than inner ones, as literature (Vema & Chariar, 2012 and Li, 2004) has established for elastic constants on micromechanics of bamboo. However, top sections values were found to be lower than middle section ones dissenting from literature. Bending modulus of elasticity E_b, calculated for 6 types of beams assembled by layers from each segment, were 19,88 GPa and 12,88 GPa for middle section which presented higher values, followed by top section (6,46 GPa and 9,71GPa) and bottom section (5,2 GPa) which presented the lowest values.

Although a statistical analysis showed no significant differences among segments, it provided marginal values for elastic constants based on data dispersion. Those values allowed introducing a relation between E_t and $E_{b,}$ (by apparent MOE methodology), which could introduce equivalent values for the bending properties using the solid mechanics theory. This is principally because division in segments reduced the variation of properties along the culm, making group properties more homogeneous while they are still heterogeneous within the section. In addition, as laminated analysis theory assumes perfect bonding, material properties and layers orientation, by using adhesive with strength higher than τ, homogenized sections aligned in the same direction let introduce a solid mechanics discretization.

Divergences on trend of top section with literature could be attributed to experimental errors and low number of trials. However, difference between regions and species, could be important facts to explain those differences. Based on the results, it can be suggested that middle sections segments, both inner and outer, would generate best beams subjected to bending loads. Top segments, are proposed to use the whole layer without splitting, because there were not significant differences among them to make it worthwhile and divergences of their elastic constants with literature values. Secondly, bamboo walls reduce as it rises from bottom to top; therefore layers resulting from top sections are not sufficiently thin to carry out a proper division. Bottom segments are suggested to compose beams subjected to lower bending loads or compose axially loaded elements, as bottom section has the highest compressive stress than middle and top according Li, 2004. For bottom and middle sections, it is recommended to split them in half when it is necessary improving design accuracy or reduce properties variation on the element.

Accurate equivalences introduced using solid mechanics approach require a wide and segmented characterization of materials, however; bamboo anisotropy makes this harder as it depends on factors beyond what can be determined. Therefore, for a local and decentralized production this study demonstrates that re-arranging beams assembly, bending design and beams performance could be improved.

Further research is required to include factor such as ply orientation on lamination, adhesive used, layered combination, and moisture content, to enhance the approach presented and allow scaling-up to small scale commercial manufacture.