Durability Evaluation of Madake bamboo by FE Analysis of Fracture with Consideration of Fibre Direction

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ABSTRACT

The flexural stiffness of bamboo is inherently influenced by heterogeneous material characteristic owing to its unique hierarchical structure. In addition, low interfacial strength and unequal distribution of fibres lead to a complex fracture behavior in the material [1-3]. This research study aims to probe into the limited durability of MADAKE bamboo (*Phyllostachys bambusoides*), namely its hygroscopic nature and fracture mechanism through experimental and numerical investigations. In the first section, a comparative evaluation of the mechanical properties of Japanese bamboo, namely green, naturally dried, chemically dyed and carbonized was conducted. The fracture behavior as a function of material anisotropy was evaluated in various layered sections of bamboo strips by analyzing the load-deflection curve in three-point bending test. The effects of homogeneity and heterogeneity on fracture behavior of culms were further investigated through FE analysis on LS-DYNA. Thick-walled cylindrical solids of standardized dimensions, consisting of radially layered sections, were simulated in pure bending mode using orthotropic elastic material data. The Young's modulus of compliance matrix of anisotropic material was derived from experimental results of three-point flexural test. Analysis results of heterogeneous material showed consistent axial strength prevailing in fibre direction. A decrease in transverse stress was observed with respect to increase in longitudinal to transverse stiffness ratio from 1:1 to 1:100. This study has revealed the remarkable strength of treated bamboo. Numerical study of material heterogeneity is a step further in understanding the fracture mechanics of functionally graded materials.

REFERENCES

[1] E. Obataya, P. Kitin, and H. Yamauchi, "Bending characteristics of bamboo (Phyllostachys pubescens) with respect to its fiber-foam composite structure", *Wood Sci Technol*, **41**, 385-400 (2007).

[2] M.K. Habibi, A.T. Samaei, B. Gheshlaghi, J. Lu and Y. Lu, "Asymmetric flexural behavior from bamboo's functionally graded hierarchical structure: Underlying mechanisms", *Acta Biomaterialia*, **16**, 178-186 (2015).

[3] Z. Shao, C. Fang and G. Tian, "Mode I interlaminar fracture property of moso bamboo (Phyllostachys pubescens)", *Wood Sci Technol*, **43**, 527-536 (2009).