11th. World Congress on Computational Mechanics (WCCM XI)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

A PROBABILISTIC MODEL TO ACCOUNT FOR STIFFNESS VARIATION IN GLUED LAMINATED TIMBER

Georg Kandler*, Josef Füssl and Josef Eberhardsteiner

Institute for Mechanics of Material and Structures,
Vienna University of Technology, Austria
E-mail: georg.kandler@tuwien.ac.at, josef.fuessl@tuwien.ac.at, ej@tuwien.ac.at

Key words: *Glued laminated timber, Random process, probabilistic finite element approach.*

Since wood is a naturally grown material, its mechanical properties are subject to high variability. In order to exploit the full potential of structural timber, a mechanical modelling strategy should be able to take this natural property fluctuation and the stochastic nature into account. Therefore, within this work a numerical probabilistic approach for glued laminated timber (GLT) is proposed, in order to investigate the variation of its effective mechanical behaviour.

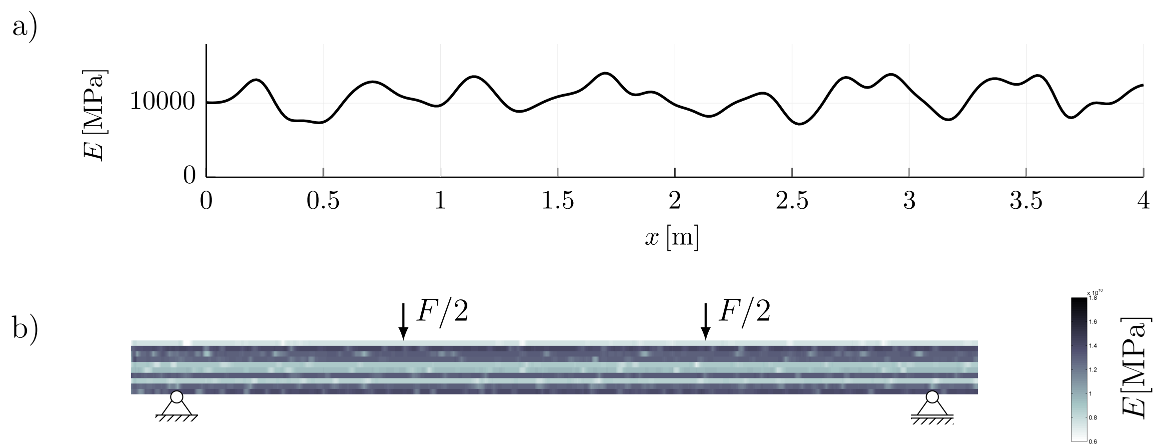

Figure 1: Random stiffness profile of (a) one lamella and of (b) a GLT beam with 10 lamellae.

The local knot-induced grain deviation is obtained from laser scans, subsequently allowing for the computation of the stiffness distribution in longitudinal direction of wooden boards, similar to [1]. Based on the acquired data, a random process model for the stiffness profiles is employed using a numerical eigenvalue decomposition technique. The discretized random process model can be used for the generation of samples to be used within Monte

Carlo simulation (see Figure 1a) but is also capable of being combined with two different probabilistic finite-element approaches: (i) The Perturbation approach, where the system response is expanded in a Taylor-series [2] and (ii) the Spectral stochastic approach, where the system response is projected on the Polynomial-Chaos expansion [3].

Using the presented approaches, the mean and the standard deviation of the effective mechanical properties of GLT with up to ten laminations (Figure 1b) can be computed. Moreover, the well-known lamination- and size effect can be reproduced numerically, giving insight into the optimization potential of GLT. The numerical results agree very well with test results, indicating that a probabilistic approach can deepen the understanding of multi-layer structural elements as well as allowing for a more efficient and comprehensive design of timber structures.

REFERENCES

[1] Anders Olsson, Jan Oscarsson, Erik Serrano, Bo Källsner, Marie Johansson, and Bertil Enquist. Prediction of timber bending strength and in-member cross-sectional stiffness variation on basis of local wood fibre orientation. *European Journal of Wood and Wood Products*, 71(3):319–333, 2013.

[2] Marcin Kamiński. *The Stochastic Perturbation Method for Computational Mechanics.* John Wiley & Sons, 2013.

[3] Roger G. Ghanem and Pol D. Spanos. *Stochastic Finite Elements: A Spectral Approach.* Springer, 2003.