Probabilistic sensitivity analysis of the extensibility of wood at the ultrastructural scale

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The aim of this work is to investigate the extensibility of wood at the ultrastructural scale in the presence of parametric uncertainty, by means of a multi-scale finite element analysis. In particular, our objective is to determine a set of micromechanical parameters which have the largest influence on the ultimate strain of the material.

At the ultrastructural level, wood is composed of a periodic alternation of amorphous and crystalline cellulose regions, embedded in a hemicellulose-lignin matrix. Normally, these three basic phases present considerable scatter in their microstructure and mechanical properties. In order to introduce uncertainty in the definition of the material, we propose a modelling strategy which perturbs a set of micromechanical parameters chosen for this study. As we are interested in understanding the influence of each of these parameters on the maximum extensibility of the material, all the parameters are perturbed simultaneously in order to obtain a more realistic description of the uncertainty in the material response. The variance of this response can then be decomposed in such a way that the contribution of each parameter to the variance of the response, as well as a measure of the interaction between parameters can be computed. This variance-based sensitivity analysis will prove important not only because it quantifies the relative importance of each micromechanical parameter, but because it provides a strategy for replacing a complex and often expensive model with a more parsimonious, less expensive alternative.

Keywords: sensitivity analysis, variance decomposition, ultrastructural scale, wood