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Fem Models of Glued Laminated Timber Beams Enhanced by Bayesian Updating of Elastic Moduli

Authors : L. Melzerová, T. Janda, M. Šejnoha, J. Šejnoha

Abstract : Two finite element (FEM) models are presented in this paper to address the random nature of the response of glued timber structures made of wood segments with variable elastic moduli evaluated from 3600 indentation measurements. This total database served to create the same number of ensembles as was the number of segments in the tested beam. Statistics of these ensembles were then assigned to given segments of beams and the Latin Hypercube Sampling (LHS) method was called to perform 100 simulations resulting into the ensemble of 100 deflections subjected to statistical evaluation. Here, a detailed geometrical arrangement of individual segments in the laminated beam was considered in the construction of two-dimensional FEM model subjected to in four-point bending to comply with the laboratory tests. Since laboratory measurements of local elastic moduli may in general suffer from a significant experimental error, it appears advantageous to exploit the full scale measurements of timber beams, i.e. deflections, to improve their prior distributions with the help of the Bayesian statistical method. This, however, requires an efficient computational model when simulating the laboratory tests numerically. To this end, a simplified model based on Mindlin's beam theory was established. The improved posterior distributions show that the most significant change of the Young's modulus distribution takes place in laminae in the most strained zones, i.e. in the top and bottom layers within the beam center region. Posterior distributions of moduli of elasticity were subsequently utilized in the 2D FEM model and compared with the original simulations.

Keywords : Bayesian inference, FEM, four point bending test, laminated timber, parameter estimation, prior and posterior distribution, Young's modulus
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