Numerical modeling of wood-adhesive bond-line in mode II for beech wood glued by various adhesives

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Bond-line creates an interface between two glued surfaces and, therefore, it brings additional complexity into the mechanical behavior of glued components, especially around the bond-line region, because adhesive itself has a very different response to mechanical stress than wood. From this perspective, the bond-line influences the total mechanical response of glued components by both its cohesive and adhesive behavior at the wood-adhesive interface. For timber constructions, there are many adhesives one can use, and each of them has different mechanical characteristics, advantages, and disadvantages.

The goal of this work was to create numerical finite element (FE) models applicable for analysis of fracture problems in mode II in constructional elements. The models were developed for the various adhesives (PUR, EPI, MU, PRF) that are often applied in timber constructions and wooden materials. The FE models include 2D geometry of the bond-line and cohesive law fitted on the outputs of the experimental measurement. The experimental data for developing the numerical models were obtained using three-point end-notched flexure (3ENF) tests with the compliance-based beam method (CBBM), coupled with digital image correlation in order to obtain displacement slip needed for the development of the FE models [1, 2]. Furthermore, within the FE analysis, wood was modeled as an orthotropic material, including both elastic and plastic regions of deformation [3]. The FE models were developed in an Ansys computational system. The specific objectives of the work were to: 1) create cohesive zone models based on experimental data; 2) develop a parametric 2D model of the bond-line reflecting experimental data; 3) validate the FE models based on the experiments; 4) exploit the FE model in analysis of friction in the 3ENF setup; and 5) analyze plastic imprint into the specimens for European beech and Norway spruce.

Implementation of the cohesive law models of various wood-adhesive systems into the FE analysis was successful. The FE analysis provided a force-deflection response that was validated by experiments. The output of the analysis in terms of von Mises stress is shown in Fig. 1a. Despite it is scalar stress, it represents the location where the stress tensor experiences the highest intensity in total. The FE model showed that the influence of friction on the simulated force may be up to 5% of the maximal force, which in some cases cannot be neglected. The effect of friction may be seen via contact stress in Fig. 1b. The FE models further showed that higher imprint into the specimens from the supports and loading head is higher for the spruce wood, which should be taken into an account during the measurement. The imprint also depends on a size of the specimen, the slenderness ratio eventually.

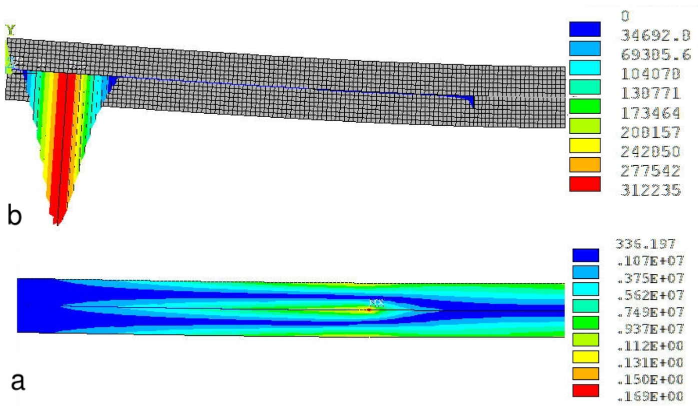

Figure 1: Two-dimensional FE model of the 3ENF: a) von Mises stress [Pa], b) contact stress [Pa].

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