Experimental evaluation of fracture properties and cohesion law of wood-adhesive bond-line in mode II using end-notched flexure

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The use of European beech (*Fagus sylvatica* L.) has a high potential in timber construction as it represents a considerably large growing stock in European forests. In general, the bondability of European beech compared to Norway spruce (*Picea abies* L.) can be more complex due to its structure and material characteristics. To increase its usability as a construction material, the characterization of bonding properties is of fundamental importance. Therefore, this study aims to evaluate these bonding properties through fracture analysis of the adhesive bond-line system in mode II using several different construction adhesives: emulsion polymer isocyanate (Epi), phenol-resorcinol formaldehyde (Prf), melamin-urea formaldehyde (Mu), and polyurethane (Pur). This analysis will provide material data to build a finite element (FE) model of a wood adhesive bond-line loaded in shear mode. After conditioning, clear beech boards were planned. Waxed paper was inserted between two boards to reduce the friction in the crack along the fiber direction and to create an initial crack of 182 mm [1]. The quantity of adhesive and bonding pressure applied on the beech boards was defined according to the manufacturers' recommendations. After curing, base samples were cut to the final dimensions of $b \times h \times l = 18 \times 20 \times 500$ mm. A three-point end-notched flexure (3ENF) test in mode II was performed with all the specimens. A universal testing machine (Zwick/Roell Z050) equipped with 50 kN load cell was used. Position control was used at a constant rate of 5 mm/min. To derive the cohesive law model for particular bond line systems, surface displacements must be measured [2]. To achieve this a stochastic pattern was applied to the specimen surface for optical measurement of displacements using the digital image correlation (DIC) technique. Displacements were measured using a pair of 23 mm lenses and Aramis GOM system. Images were captured once per second until ultimate failure. The force-deflection data were then used to calculate the strain energy release rate (G_{II}) [3]. The optically measured displacement slip together with the G_{II}, enabled the development of the cohesive law model for all adhesive-wood systems.

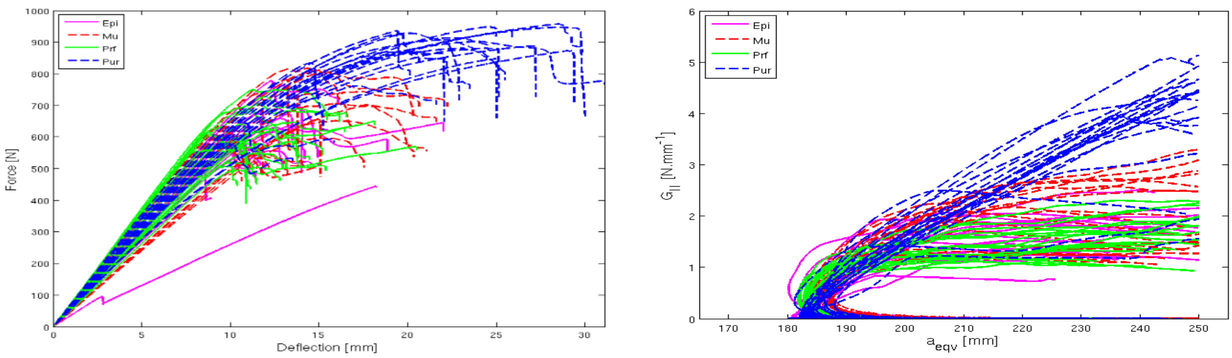

Figure 1: Force-deflection diagram (left) and strain energy release rate in dependence of equivalent crack length (right)

Preliminary results show the highest strength achieved with the Pur adhesive and the lowest with the epoxy adhesive (Fig. 1, left). The Pur adhesive exhibited a high portion of plasticity until it reached the ultimate load. The other adhesives exhibited more brittle behavior than Pur. As seen in Fig.1, the wood-adhesive systems show high variation in strength, stiffness, and consequently in G_{II}. The variability of test results is accounted for by the natural variability of wood, variability in adhesion quality, and adhesive surface coverage for individual specimens after the solidification. G_{II} values are highly dependent upon researcher routines in data processing and identification of crack initialization.

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