Experimental and numerical analysis on mechanical and fire performance of glue-laminated perforated timber elements

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Objectives / Description / Main outcomes

An important step of the production of laminated timber elements (GLT and CLT) involves stacking and gluing pre-treated lamellas into the composition of the laminated timber element. This research aims to determine the influence of elevated temperature on the adhesives, delamination, and behavior of innovative glue-laminated timber elements. In the case of a one-sided fire scenario, element heating causes a reduction of the timber's stiffness, and the glue line's weakening, combined with the char formation. To preserve the composite action, bond lines must be able to resist not only the normal and shear stress redistribution in the reduced cross-section, but also the increased temperatures within the adhesive. The goal is to do an analysis of the failure modes of specimens in a fire event, and the impact of different types of PUR adhesives. Debonding occurs when an adhesive stop sticking (adhering) to an adherend or substrate material. The type and quality of adhesives play a big role in preventing these phenomena, especially during the fire load. The research consists of an experimental part and FEM analysis. A total of 10 specimens were tested, 5 types of timber specimens with variations of different protection and adhesive between the lamellas. Two types of adhesives were used to connect the lamellae; KLEIBERIT 510.0 PUR adhesive for load-bearing timber structures certified in accordance with DIN 1052, and KLEIBERIT 501, PUR adhesive with high-temperature resistance and water resistance according to DIN/EN 204 stress group D4. The study shows that the bond line behavior is dictated by both the adhesive performance and the adhesive-timber interaction. The behavior of adhesives at elevated temperatures used for the bond line between the lamellas has little influence on the fire resistance of the glued laminated timber elements. The effect of the perforation of the timber element and the reduced glued surface affect delamination. FEM simulation of 4- bending tests and the nonlinear thermo-mechanical analysis was performed to predict the behavior of glue-laminated timber elements exposed to fire.

Figure 1: *Failure mode*

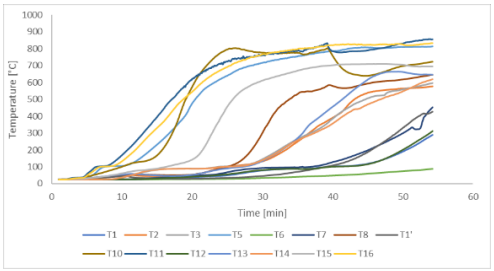

Figure 3: *The measured temperature in the timber specimen during the fire test*

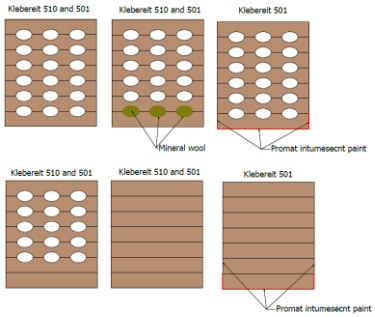

Figure 2: *Glue-laminated timber elements*

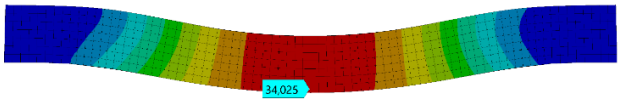

Figure 4: *Numerical simulation of the timber element in a fire event*

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