Hybrid glulam beam made of beech and spruce laminations – experimental and numerical investigation

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A standard four point bending test was performed on a hybrid glulam beam made of beech and spruce laminations. The beam consisted of 8 spruce laminations with the thickness of 18 mm in the core of the glulam cross section and of 6 beech laminations with the thickness of 13 mm on both outer sides. The total dimensions of the cross section were b/h = 140/300 mm, where the length of the beam between the supports equaled 470 cm. The length of finger joints equaled 19 mm for all laminations. The melamine urea formaldehyde (MUF) adhesive was used for the finger jointing and for gluing the laminations. The described glulam beam failed in a brittle manner (Figure 1). The outer beech laminations predominantly remained undamaged, whereas the critical areas were the longitudinal adhesive layers and the finger joints. In the core of the cross section, which consisted of spruce laminations, a diagonal crack occurred across the laminations.

On the basis of the experiment, a numerical model was defined in Abaqus software. Model consisted of parts with linear elastic and orthotropic behavior for beech laminations, whereas for the spruce laminations orthotropic elastic and perfectly plastic behavior in tension were assumed. The adhesive layers between the laminations and the finger joints were modelled by cohesive surfaces, using a nonlinear cohesive zone model (CZM). The input elastic parameters for the Slovenian beech and spruce were based on previous studies [1]. On the other hand the nonlinear fracture parameters for the CZM were selected according to the literature dealing with adhesively bonded beech timber [2].

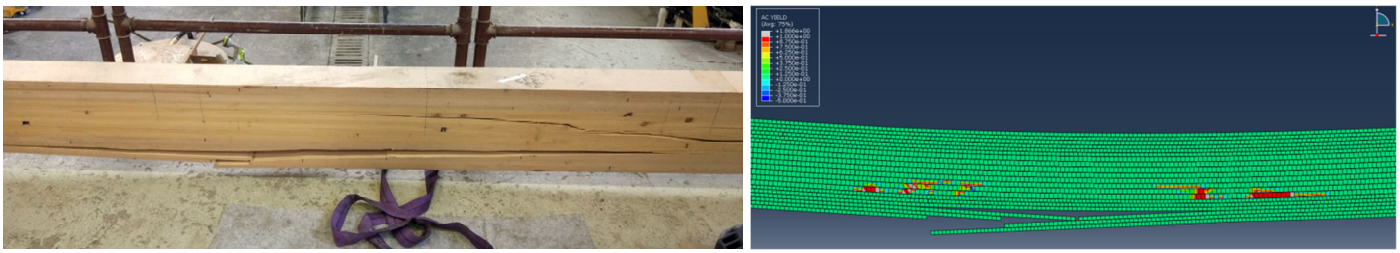

Figure 1: The failure of the hybrid glulam beam: experimental (left) and numerical (right)

The comparison between the numerical model and the experiment showed good agreement for global output parameters (Table 1). The model fits best in the elastic part of bending as well as in estimating the force at the initiation of failure, whereas for estimating the post-failure response the model needs to be improved.

In the conference contribution the influence of input parameter variation on the response of the numerical model will be presented. It was found, that the initiation of failure of the hybrid glulam beam model was highly dependent on the nonlinear input parameters for the CZM of the finger joints and the longitudinal adhesive layers.

Table 1: Comparison of experimental results and calibrated numerical model

	Experimental	*Numerical*
Local modulus of elasticity in bending $E_{m,l}$ [MPa]	1563	1378
Beam deflection at failure w [mm]	64,6	68,9
Force at failure F [kN]	133,4	138,6

The research was a part of a Slovenian national project (TIGR4smart), where the use of beech timber in structural applications was encouraged. The results of experiments and numerical modelling indicate that the capacity of the finger joints in beech and/or the adhesive layer between the beech laminations should be improved.

References

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