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Effective nonlinear FE-modelling of progressive failures of (3D) timber structures jointed with multiple-fastener connections

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ABSTRACT

Slotted-in steel plate connections in glulam structures are often critical elements in the design, especially if they are exposed to significant in-plane moment action during varying environmental conditions. In design of optimized multiple fastener connections, correct calculations of fastener forces and their directions during progressive plasticization of the dowel groups are difficult to perform manually. The overall aim of this work is to develop an effective and flexible finite element model to simulate deformations and stresses in glulam structures jointed with mechanical dowel-type connections. The model is a simple (parameterized) 3D-model using effective structural elements for the wood and the steel plate members and non-linear connector elements for the mechanical connections. The connector properties and failure modes are mainly based on the European Yield Model (EYM) by [1]. In this specific study, the model was used to simulate global bending deformations of several glulam beams jointed with slotted-in steel plate connections. Detailed connection behaviours were also computed in terms of slip deformations, load carrying capacities, force distribution within the dowel group and the failure modes of the fasteners, see Figure 1. The proposed model was experimentally verified using results obtained from a joint project with the Material Testing Institute (MPA) at University of Stuttgart. Since the model operates in a 3D-space, it has a potential to be further developed concerning model adaptivity in complex 3D-structures, brittle connection failures, moisture related stresses and rope effect caused by large rotation of the fasteners.

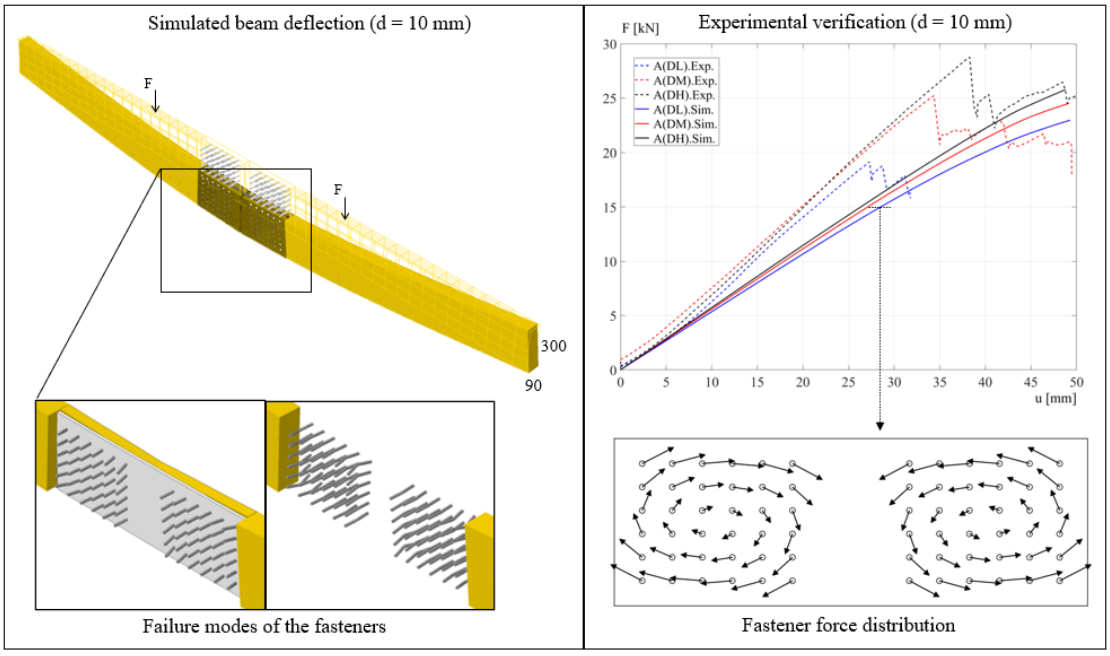

Figure 1: Typical numerical results from the developed glulam model.

REFERENCES

[1] K. W. Johansen, “Theory of timber connections,” Int Assoc Bridge Struct Eng, vol. 9, pp. 249–262, 1949, doi: 10.5169/seals-9703.