Numerical modeling of dowel-type connections in soft- and hardwoods including the rope effect

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In laterally loaded dowel-type connections, forces are not only transferred perpendicular to the fastener axis via contact forces (so-called embedment forces) and shear forces in the fastener, but also by means of forces evoked by displacement along the fastener axis and frictional forces within shear planes. The latter load transfer, the so-called *rope effect*, is often neglected or simplified in numerical models for laterally loaded connections, but considerably increases strength in case of large bending deformations of the fastener. In partially threaded screws, the rope effect is a result of the withdrawal behavior of the threaded part in combination with the axial resistance of the head of the fasteners. The tensile force along the axis of the fastener causes compression between connected members and frictional forces within the shear planes of the connection, which increase the load bearing capacity [1]. Consideration of the rope effect in numerical models is decisive for valid and suitable prediction of the load-deformation behavior and discussed in this presentation.

Different kind of numerical models, with different levels of complexity have been proposed for the simulation of dowel-type connections [2]. Herein, calculations by means of the beam-on-nonlinear foundation (BOF) method will be presented (see Figure 1). Compared to conventional foundation models, interaction elements that account for increased lateral connection strength due to withdrawal strength and the rope effect of the connection are considered. The behavior was implemented by means of axial springs that encompass a withdrawal force-relative displacement relationship, similar to the lateral springs considering the embedment behavior. In addition, friction between the connected timber members was considered by a frictional force as a consequence of the force component perpendicular to the shear plane. An elasto-plastic material model for steel accounted for possible failure of the steel fastener in shear and/or bending in connections.

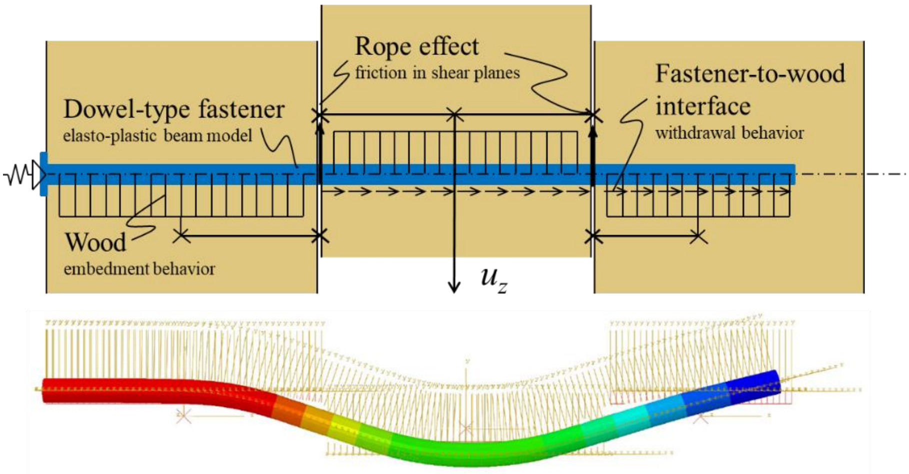

Figure 1: Beam-on-nonlinear foundation model for a partially threaded screw in a double-shear timber-to-timber connection in its undeformed and deformed state.

Simulations were carried out for connections in softwood and hardwood, applying different kind of dowel-type fasteners, including connectors with smooth shanks and screws. Model predictions were in good agreement with results from experimental studies. This raises confidence for application of the beam-on-foundation model for the engineering design of dowel-type connections and for reliable prediction of the structural behavior.

References

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