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NUMERICAL MODELLING OF THE ROPE EFFECT IN LATERALLY LOADED DOWEL-TYPE CONNECTIONS

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Theory of laterally loaded dowel-type fasteners is well understood in relation to their bending deformation as a consequence of lateral embedment stresses in wood. Modelling of the so-called rope effect has however attracted less attention. The rope effect in laterally loaded connections is evoked by withdrawal resistance of the shank as well as by axial resistance of the head of the fasteners. It describes the development of tensile forces along the axis of the fastener, as a consequence of its bending deformation and axial constrains. Hilson [1] emphasized the pronounced contribution of frictional forces in the shear planes that contribute to increased strength of laterally loaded connections. The axial force component parallel to the shear plane however will only become significant for large relative displacements.
Different kind of numerical models have been proposed for the simulation of dowel-type connections, including 3D FEM with elasto-plastic material models, with damage mechanics, or so-called foundation models. In this contribution, calculations with a beam-on-nonlinear foundation method [2] will be presented. The model was extended to account for increased lateral connection strength due to withdrawal resistance of fasteners. This was implemented in terms of axial springs that encompass a withdrawal force-relative displacement relationship, similar to the lateral springs that hold information on the embedment behaviour. Friction between the connected timber members was taken into account by the frictional coefficient times the force component perpendicular to the shear plane, which is a result of the axial force in the fastener.
Calculations were performed for different types of dowel-type fasteners, including screws, smooth shank nails, annular-ringed shank nails and smooth dowels. Model predictions were compared to experimental data and showed good agreement. This encourages the use of the beam model for the engineering design of dowel-type connections in timber structures based on a deeper understanding of structure-connection relationships [3].

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