hardwood_joint

Project objectives

Foster high-performance hardwood structures by developing economic, reliable and innovative joint technologies for hardwood members and the design thereof.

Tasks

(1) Joints with staples and nails
(2) Joints with axially loaded screws
(3) Joints with laterally loaded fasteners
(4) Joints with shallow grooves
(5) Modelling of joints

Authors

Romain Lemaître
Michael Schweigler
Thomas K. Bader

Innovative joints in hardwoods

(5) Modelling of joints

To obtain full and in-depth knowledge of the mechanical behavior of hardwood joints, valid and innovative numerical tools are a prerequisite and are necessary for developing reliable design rules. Validation of numerical models requires comprehensive datasets encompassing input [1] and validation data for comparison with model predictions [2].

Utilization of the so-called Beam-on-Foundation (BoF) modelling approach allows for efficient, and reliable prediction of the nonlinear load-displacement behavior of dowel-type fasteners in hardwoods. In this project, the model was further developed to predict the so-called rope effect in laterally loaded joints, which causes a combination of lateral and axial loads in the dowel-type fastener. Novel test setups were used on the one hand to provide input data to the BoF-model, by studying combined lateral and axial loading of screws and dowels [3], and on the other hand for validation of the rope effect [1] (see Task (3) Joints with laterally loaded fasteners).

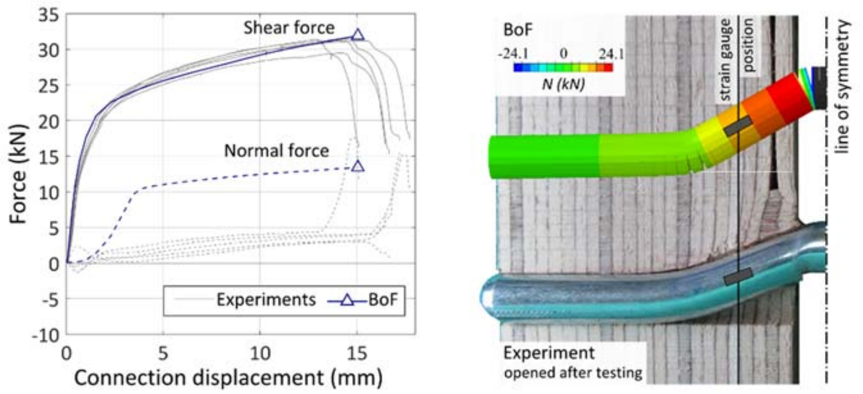

Figure: Comparison of BoF-model with tests on a double shear, steel-to-timber connection in beech LVL; left: shear force per shear plane and normal force in the dowel, plotted over connection displacement at the steel plate; right: deformed state of the dowel from BoF-model and experiment [1].

The validated BoF-model proved the existence of the rope effect even in dowelled joints. It furthermore showed that lateral connection displacements of several millimeters are required to activate the rope effect. Hence, only the connection capacity, but not the elastic connection stiffness is influenced by the rope effect.

For modelling of multiple fastener joints, the BoF-model is combined with 2D plate elements, which allows to consider the wood member elasticity or steel plate elasticity in between the fasteners [4]. Thus, load distribution effects in multiple fastener joints could be studied.

Title:
hardwood_joint –
innovative joints in hardwoods

Start date: 01.02.2019

End date: 31.10.2022

Partners:

hardwood_joint

Project objectives
Foster high-performance hardwood structures by developing economic, reliable and innovative joint technologies for hardwood members and the design thereof.

Tasks
(1) Joints with staples and nails
(2) Joints with axially loaded screws
(3) Joints with laterally loaded fasteners
(4) Joints with shallow grooves
(5) Modelling of joints

Authors
Romain Lemaître
Michael Schweigler
Thomas K. Bader

A parametric analysis was carried out to examine the influence of joint configurations, geometric parameters and number of fasteners on the stiffness of double shear joints. The stiffness was determined from the nonlinear load-slip curve predicted by the BoF-model and the model predictions were gathered in a database. A nonlinear regression analysis was used to determine engineering design equations for each joint configuration.

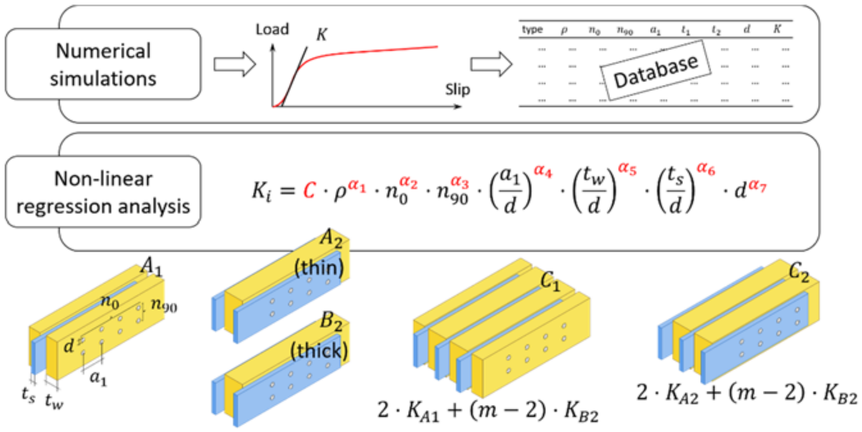

Figure: Schematic illustration of the parametric analysis to determine the influence of joint properties on the joint stiffness with the help of the multiple fastener joint model, for the definition of engineering design equations for the joint's stiffness.

This study proved the nonlinear influence of several parameters, which are currently not included in the design equations, on the joint stiffness. It also demonstrated the need for one design equation per joint configuration and a calculation procedure for the estimation of the stiffness of joints with multiple shear planes was also developed.

References

[1] Schweigler, M., Bader, T. K., Bocquet, J. F., Lemaître, R. & Sandhaas, C.: Embedment test analysis and data in the context of phenomenological modeling for dowelled timber joint. In: Proceedings of INTER/52-7-8, Tacoma, USA, 2019.
[2] Schweigler, M., Vedovelli, M., Lemaître, R., Bocquet, J. F., Sandhaas, C. & Bader, T. K.: Beam-on-foundation modelling as an alternative design method for timber joints with dowel-type fasteners: Part 3: Second order theory effects for considering the rope effect. In: Proceedings of INTER/54-7-8, online, 2021.
[3] Lemaître, R., Schweigler, M. & Bader, T. K.: Combined embedment and axial load tests of a steel dowel in various wood species. Submitted for presentation at WCTE 2023.
[4] Lemaître, R., Bocquet, J. F., Schweigler, M. & Bader, T. K.: Beam-on-foundation modelling as an alternative design method for timber joints with dowel-type fasteners - Part 2: Modelling Techniques for Multiple Fastener Connections. In: Proceedings of INTER/54-7-9, Tacoma, USA, 2019.

Title:
hardwood_joint –
innovative joints in hardwoods

Start date: 01.02.2019

End date: 31.10.2022

Partners: