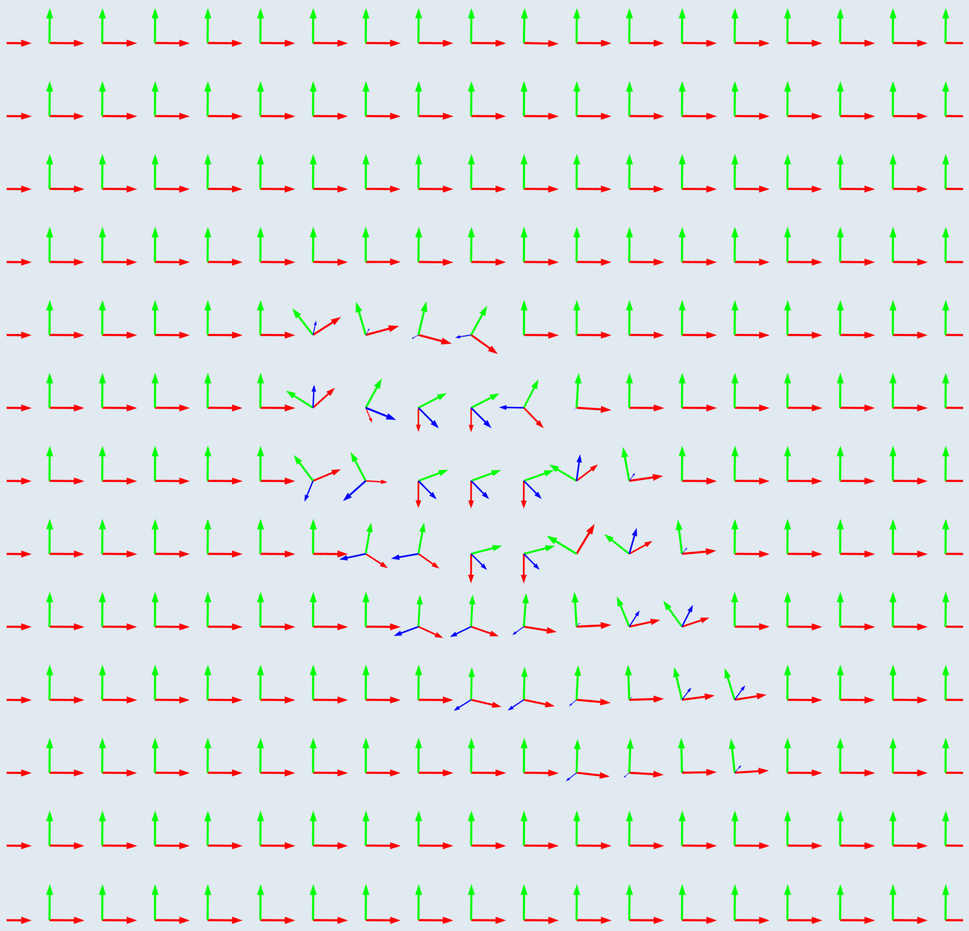

Prediction of Douglas-Fir Sawn Timber Strength based on X-ray CT and FEA

Analyzing large X-ray computed tomography data sets using COMSOL's Java® API to optimize the presorting of Douglas-Fir sawn timber boards

B. Sandor, A. Weidenhiller

Holzforschung Austria, Vienna, Austria

Introduction

Due to climate change impacts the species composition of European forests is being diversified, incorporating more hardwoods as well as drought-resistant softwood species, such as Douglas-fir. As a result, there is demand for enhanced strength prediction and grading methods for Douglas-fir to ensure proper allocation to the most appropriate end products. In this study, X-ray computed tomography images from 53 Douglas-fir logs were employed to predict the stiffness of 357 sawn timber boards. From the 3D data the density, knot volume and pith distance throughout the log could be determined. From this data virtual 2D boards were cut according to the real cutting pattern. The density distribution of each board was then used to resolve the fibre orientations around knots with an existing fibre reconstruction algorithm [1].

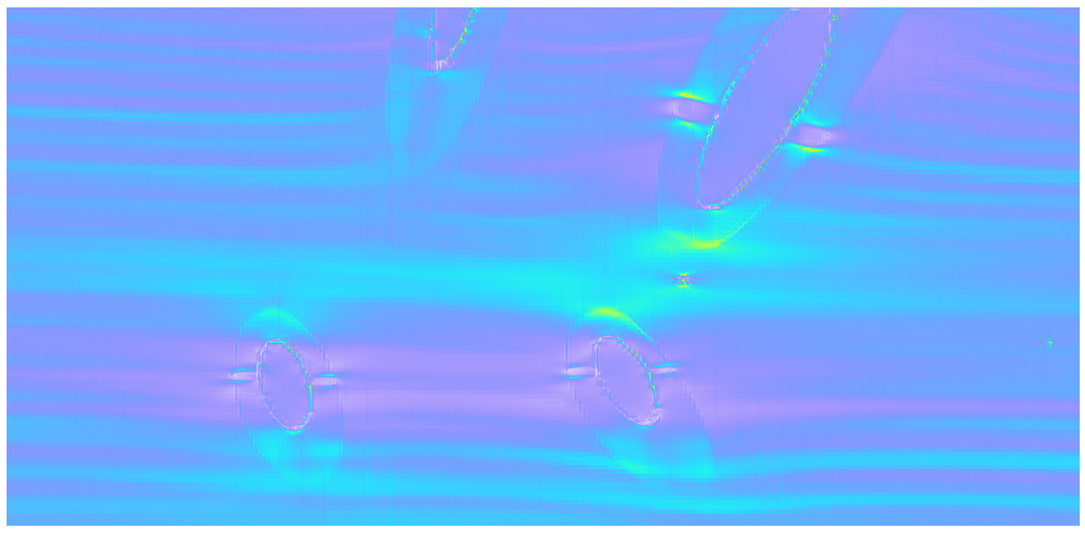

FIGURE 1. Stress concentrations around a group of knots

Methodology

For the finite element model, a locally varying curvilinear coordinate system was used based on the acquired fiber orientations. An orthotropic stiffness tensor was defined and linearly scaled with the density at each integration point. As knots significantly influence the overall stiffness of a board, multiple stiffness properties were explored [2]. Given the size of the data sets and the number of boards the Java® API of COMSOL Multiphysics® was utilized and accessed with Python® to automatically set up the simulations for each board. They were virtually tested by a prescribed displacement of one end and a fixed condition on the other.

Results

The modulus of elasticity (MOE) was calculated from the reaction forces and compared to the real MOE from physical tests. The preliminary results show that the model can reliably resolve the stress concentrations around the knots. However, the calculated MOE is generally overestimating the real stiffness so more investigation must be done in future studies.

With the automated setup those can be done with relative ease since the model itself is the only part of the simulation pipeline that needs to be modified.

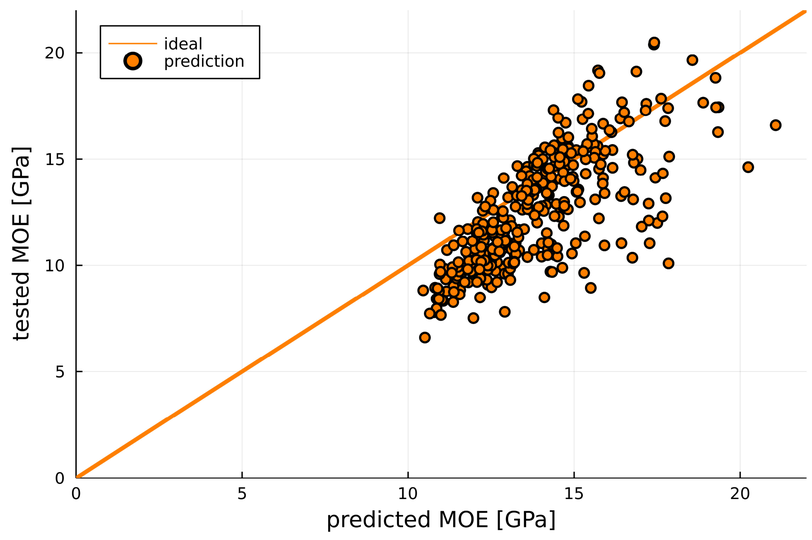

FIGURE 2. Comparison of the predicted and tested Moduli of Elasticity for all boards.

REFERENCES

1. Huber J. et al., “A method for generating finite element models of wood boards from X-ray computed tomography scans”, Computers & Structures, Volume 260, 2022

2. Lukacevic M. et al., “A 3D model for knots and related fiber deviations in sawn timber for prediction of mechanical properties of boards, Materials & Design, Volume 166, 2019

Excerpt from the Proceedings of the COMSOL Conference 2023 Munich