

# COMPUTATIONAL MODELLING OF WOOD AND WOOD-BASED PRODUCTS WITH SPECIAL FOCUS ON NUMERICAL LIMIT ANALYSIS CONCEPTS

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Wood, as a naturally-grown material, exhibits a highly anisotropic and inhomogeneous material structure, with a complex wood fibre distribution influenced by randomly occurring knots. Thus, for the prediction of effective strength properties of wood, advanced computational tools are required, which are able to predict as well as consider multidimensional strength information at different scales of observation.

Within this work, three such computational methods will be presented: an extended finite element approach [1] able to describe strong strain-softening and, thus, reproduce brittle failure modes accurately; a newly-developed limit analysis approach [2], exclusively describing ductile failure; and an elastic limit approach based on continuum micromechanics. All three methods are applied to earlywood and latewood unit cells and to clear wood, finally yielding effective failure surfaces for a range of multidimensional stress states. These failure surfaces are compared with each other and with experimental results from biaxial tests. Based on these comparisons, the strengths and weaknesses of the three computational methods are discussed, and their applicability to wood is evaluated.

The extended finite element method is a powerful technique that allows for a very realistic description of strength-governing processes. Nevertheless, its complexity and high computational effort prevent widespread use in the engineering field. The plastic limit analysis and elastic limit approaches, however, show good predictive performance compared with the extended finite element method, coupled with excellent efficiency and stability. For this reason, advanced limit analysis formulations have been extended to be applicable to wood, validated by means of well-known reference examples, and, subsequently, applied to estimate the bending strength of cross-laminated timber elements. Thereby, inhomogeneous strength property distributions of wooden boards are considered and the numerical results are compared to experimental observations. Finally, this work is intended as a contribution to performance-based optimisation of wooden structures, a necessity for wood to become competitive with respect to other building materials.

## REFERENCES

- [1] M. Lukacevic, J. Füssl, and R. Lampert. Failure mechanisms of clear wood identified at wood cell level by an approach based on the extended finite element method. *Engineering Fracture Mechanics*, 144:158-175, 2015.
- [2] M. Li, J. Füssl, M. Lukacevic, J. Eberhardsteiner, C.M. Martin. Strength predictions of clear wood at multiple scales using numerical limit analysis approaches. *Computers & Structures*, 196: 200-216, 2018.