Fracture simulations of wooden boards with knots as a basis for timber engineering design concepts

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ABSTRACT

Increased use of wood has led to complex timber constructions and new types of wood-based products. In simulations, however, mainly simplified models are used to describe this material with strongly varying properties. Thus, to exploit the full mechanical potential of wood, a more accurate prediction of the mechanical behavior, especially when it comes to failure, is needed.

Therefore, we developed a multi-surface failure criterion, which is able to describe brittle and ductile failure mechanisms of wood, based on simulations on several length scales [1-3]. Combined with a geometric reconstruction algorithm for knots [4], such a tool can be used to determine effective strength properties of knot sections. Due to the highly orthotropic failure behavior of wood and the strong variations of material directions close to knots, this task is very challenging. Widely used methods in fracture mechanics all have drawbacks when applied to such a material. For example, XFEM is limited by frequently occurring geometric incompatibilities, or the use of plasticity models easily encounters numerical problems due to the quasi-brittle nature of wood failure. Here, the emergence of the phase field method in recent years seems to be a promising solution for these problems [5-6].

Subsequently, such strength properties of wooden boards are condensed into so-called strength profiles [7]. By applying this approach to a large set of wooden boards, probabilistic material models can be developed and used in simulations of wood-based products. Such a framework for sensitivity analysis and robust design optimization should help engineers to design efficient timber structures.

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