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STRUCTURAL ANALYSIS OF TIMBER BY MEANS OF FEM

Michael Kaliske*, Christian Jenkel

Institute for Structural Analysis, Technische Universität Dresden, 01062 Dresden,
michael.kaliske@tu-dresden.de, www.tu-dresden.de/isd

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Wood is one of the oldest building materials and is still used for innovative structures today. However, the utilization of timber was based on practical experiences and traditions in wood construction for a long time. To use timber more efficient, computational models based on experimental investigations are developed, e.g. for woodworking joints. In addition to these approaches, a continuum mechanical modelling of timber structures by means of the Finite Element Method (FEM) offers the potential to analyse the complex material behaviour under loading more detailed. Recently, numerous material models to describe wood in a FE-analysis have been developed on different length scales and under consideration of the hygro-mechanical material behaviour [1]. Most of these models are limited to perfect, homogeneous wood free of discontinuities. To capture all characteristics of the material wood in a FE-analysis, structural and material inhomogeneities should be considered as well.

In this contribution, models and methods for the analysis of timber structures by means of a three-dimensional FEM are presented. To describe the specific features of wood numerically, various material models have been derived. The direction dependency of the material is considered by a cylindrically anisotropic material description. Ductile failure is simulated by multi-surface plasticity formulations and brittle failure under tensile and shear loading by a fracture mechanical based model using cohesive elements and material formulations.

Beside the material models, a method to consider structural inhomogeneities in form of branches is presented in the contribution. Usually, knots (as branches are called in timber) are considered indirectly by branchiness factors and associated material parameters. A direct consideration of each knot in the FE-model is more accurate. Thus, failure initiated by knots can be simulated.

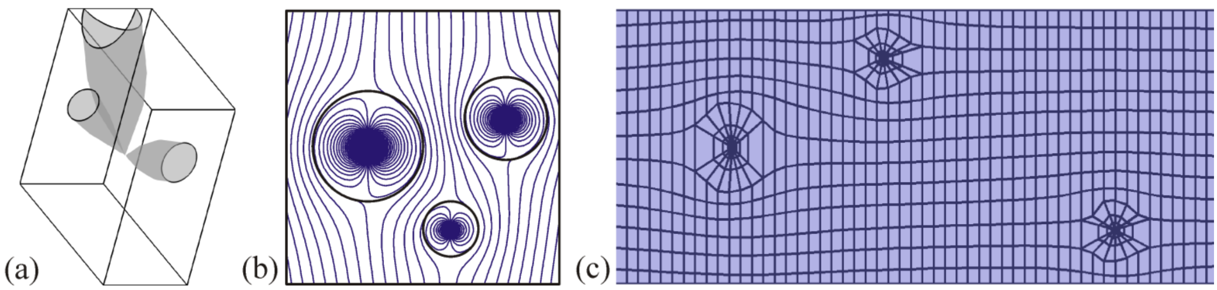

Figure 1: Wooden parts: (a) geometrical model, (b) computation of the fibre orientation and (c) automatic meshing procedure

Here, a method is presented to describe geometrically structural timber parts containing knots in a three-dimensional volume model. For homogeneous timber free of knots, the grain course can be assumed to run parallel to the stem axis. However, in the area of branches the fibre orientation is varying. Based on the geometrical model, the grain course is computed by means of the so-called Streamline Approach [2] and finally the structural parts are discretized by finite elements. In the present contribution, different types of FE-modelling are compared. A new meshing generator based on the Streamline Approach is introduced. In combination with the material models, failure initiated by the branches can be simulated. To model brittle failure under tensile loading, cohesive elements are applied. Here, a method to simulate cracking of timber boards under tensile loading is shown. The methods are illustrated by examples.

Independent of the considered length scale, the material properties are naturally varying. These material inhomogeneities have to be considered in a structural analysis as well. This aspect holds especially for wood, since material parameters can already vary within a single tree. In addition, geometries and external influences cannot be specified exactly and described by deterministic values. To capture these inhomogeneities, uncertainty models are applied. Beside well-known stochastic models, alternative approaches like fuzziness and fuzzy randomness can be utilized to describe the uncertainty more appropriately [3].

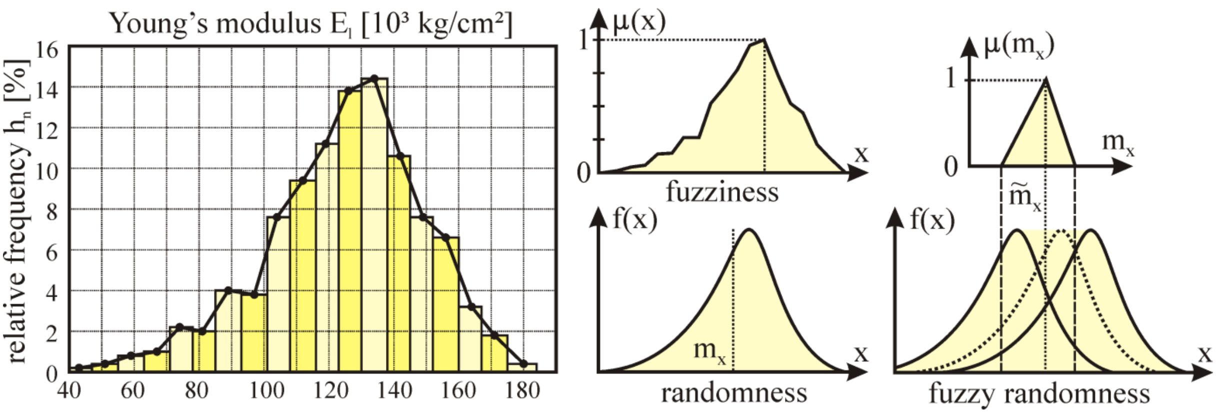

Figure 2: Relative frequency distribution of Young's modulus determined by 1546 ashwood samples [4] and possible models

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