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Numerical simulation of moisture induced cracking behaviour in wood cross sections under real climate conditions

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Knowledge about the wood moisture distribution in a timber component is essential to predict its mechanical behavior. Not only stiffness and strength properties are highly dependent on the wood moisture content, but also diffusion coefficients, density, specific heat capacity and thermal conductivity. Since the surrounding climate is changing with time, the moisture content varies over the cross section. These variations lead to dimensional changes, called swelling and shrinking, and stress states, which lead to the occurrence of cracks.

In most engineering standards, climatic changes are considered via service classes, which depend on a rather general definition of the surrounding climate. Changes shorter than a few weeks are not taken into account. Cracks are only considered in current design approaches regarding shear resistance, in which the width of the cross section is reduced by a third, independent of the total width. To verify this assumption of common standards, 18 different cross sections were simulated under real climate conditions with a numerical simulation tool, which is able to describe the moisture transport processes below the fibre saturation point as well as heat transfer [1, 2].

Linear elastic stress calculations were conducted based on the obtained moisture content fields. Expansion due to swelling and shrinking as well as temperature were considered. Furthermore, a multi-surface failure criterion [3, 4] was applied. The results show that areas susceptible to cracking occur due to exceeding tangential strength values: in the warm season in the outer and in the cold season in the inner regions of cross sections. In addition, the extended finite element method was used to obtain crack patterns at time steps with the highest risk of failure, which were obtained during the linear elastic stress calculation. The maximum length of cracks were compared to the assumptions of Eurocode 5. It was found that the reduction of the cross-sectional width for shear stresses agrees well with the results of the simulation in case for widths up to 20 cm. For wider cross sections, the assumption is too conservative.

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