Modelling of wood under compression perpendicular to the grain with rolling shear in cross-laminated timber

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ABSTRACT

Shear stress in the transverse plane of wood, so-called rolling shear, is an important characteristic in wood-based products, due to very low stiffness and strength under this stress state. It is even further reduced under multiaxial stress conditions. A wooden board subjected to uniaxial compression in this transverse plane already develops a combination of normal stress with rolling shear stress due to the curvature of annual rings, which is typically modelled with cylindrically orthotropic material behaviour. The phenomenon is termed shear-coupling effects in literature [1, 2]. Hence, structural elements made of wood-based products and their connections demand special insight regarding this complex multiaxial stress state. 3-D phenomenological failure criteria, for composite materials, have been proposed for that purpose, but their validation in combination with rolling shear attracted less attention. The present study aims at validating material models under stress perpendicular to the grain with rolling shear considering material non-linearity based on biaxial material tests as well as on cross-laminated timber connection tests.

Material model validation was based on an experimental study on dog-boned shaped specimens of Norway spruce. Experiments were carried out under various displacement paths for biaxial loading with tensile/compressive stress and rolling shear stress interaction. In addition to force and displacement measurements, full field strains on one surface have been measured. Numerical modelling considered the complex shape of the specimen in the experimental setup and elasto-plastic material behaviour of the quasi-homogeneous material, neglecting inhomogeneity due to the annual ring structure. Plasticity was considered by various standard and a user-defined failure criteria with associated plasticity. The user-defined material model was then applied to study compression perpendicular to the grain in cross-laminated timber and to validate the model with experimental data. The numerical model yielded good agreement with the overall force-displacement response and local strain fields measured in experiments.

REFERENCES

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