# AN ANISOTROPIC MATERIAL MODEL FOR CHIPBOARD

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In recent years finite element analyses have become an important tool in the design process of fittings and anchor systems for chipboard plates. The numerical determination of the ultimate load of these joints requires reliable material models that consider the highly anisotropic non-linear material behavior of chipboard in both tension and compression.

Chipboard plates typically consist of layers of wood chips of various sizes and shapes. The orientation of the wood chips parallel to the surface of the plate is determined by the manufacturing process, in which glue coated wood chips are steam-heated and compacted. The resulting transversely isotropic material properties are characterized by considerable differences between stiffness and strength in the isotropic plane, i.e. the in-plane direction, and the respective values in the distinguished direction $\boldsymbol{a}$, i.e. the out-of-plane direction. In numerous tensile and compressive tests in both in-plane and out-of-plane directions, non-linear stress-strain relationships associated with irreversible deformations and stiffness degradation have been observed. Tensile loading causes the formation of microcracks that eventually lead to localized brittle failure in both investigated material directions. In contrast to this, compressive loading is primarily associated with plastic processes characterized by irreversible deformations. Increasing loads in the in-plane direction eventually cause ductile failure of the specimen, whereas in the out-of-plane direction strain hardening has been observed beyond strains of 35 %.

The proposed constitutive model describes the material behavior of chipboard in an orthogonal reference frame, represented by structural tensors, in order to capture the anisotropic character of the material and to allow for orthotropic evolutions of damage and irreversible strains. For the modeling of the anisotropic degradation of stiffness and strength as well as the propagation of inelastic deformations in tension, damage surfaces based on a 3D failure criterion of the RANKINE-type are used. The evolution of these surfaces follows non-linear hardening/softening laws that depend on the structural tensors and a tensor of internal variables. In compression, the TSAI-WU [1] criterion is employed. The central elements of this criterion are two strength tensors of second and fourth order, respectively. These tensors are functions of the structural tensors and of a tensor of internal variables that defines the evolution of the strength parameters according to kinematic hardening/softening laws. For the consideration of processes associated with damage and plasticity the approach proposed by MESCHKE ET AL. [2] is used.

The model parameters are calibrated according to monotonic and cyclic uniaxial tests in both in-plane and out-of-plane directions. Several numerical analyses of chipboard plates with different distinguished directions $\boldsymbol{a}$ and the simulation of an anchor pull-out test demonstrate the applicability of the material model.

## References

[1] S.W. Tsai and E.M. Wu, “A General Theory of Strength for Anisotropic Materials,” *Journal of Composite Materials*, v. 5, p. 58-80, 1971.
[2] G. Meschke, R. Lackner and H.A. Mang, “An anisotropic elastoplastic-damage model for plain concrete,” *International Journal for Numerical Methods in Engineering*, v. 42, p. 703-727, 1998.