The road from creating a material model to a structural component of wood for automotive applications

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Current and future strategic challenges in the automotive industry (i.e. fuel reduction, CO2- balance, self-driving cars, electro-mobility, small city cars and special vehicles) require innovative vehicle concepts. Novel materials, material combinations and composites are urgently needed. Wood provides high stiffness, strength, excellent damping, high resistance against fatigue and very low density. Properly applied, modern wood composites are competitive to metals and fiber-reinforced polymers. Wood is a carbon-neutral and renewable resource paired with low material cost. Especially in Europe high quality wood materials are available. Decades of experience in aeronautical, nautical and even automotive engineering provide abundant proof of wood and wood composites being a reliable construction and engineering material.

However, the application of wood and wood composites in automotive engineering requires precise and reliable data for material selection and further numerical crash simulations. A few selected car components were used as an example to show that wood can compete and outperform the baseline products (made of aluminum and fiber-reinforced polymers) in terms of structural properties, weight and cost.

Input data for the FE-models and crash simulation was generated through quasi-static material tests. Therefore solid wood (beech, ash, pine and birch), laminated wood (beech and birch) and plywood (pine, beech and birch) were investigated. Tensile-, compression-, flexural properties and density were measured in fiber direction and across the grain. For an initial validation of the material models, the quasi-static tests were simulated with very good correlation of the results.

All dynamic tests of the components yielded high reproducibility within each test setup. Only minor deviations in the load-displacement behavior and failure characteristics could be observed. The comparison between crash simulations and real crash tests of the components could show once more a good correlation of deformation and failure behavior. The characteristic difference of quasi-static and dynamic loads could be reproduced in the simulation model with high accuracy. The crossbar beam was used to prove the applicability of the material model in the simulation of a full car. The computational effort did not increase as the element size and time increments were not altered. Hence it could be shown that challenging crash situations can be simulated and evaluated. In this study it has been proven that wood and wood-based products can be sufficiently well simulated by means of finite element methods under static and dynamic loads as well as in crash situations.