Continuum Damage Micromechanics Model for the Compressive Failure of Flax Fiber Composites and Experimental Validation

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We develop a thermodynamically consistent continuum damage micromechanics model for the compressive failure of flax fiber composites. We used a micromechanics-based constitutive model reported recently [1]. It describes the microstructure of a unidirectional composite and captures the material behavior of the fiber and matrix constituents, respectively. The description has been formulated in the reference configuration (i.e. the undeformed state of the composite) and is therefore independent of fiber rotations that may appear during the deformation of the composite. A hyperelastic finite deformation plasticity with power law hardening [3] mimics the compressive elastic-plastic stress-strain response of the fiber (reported in [2]) and the matrix. The model has been extended to account for fiber damage, resulting in a thermodynamically consistent continuum damage micromechanics model. Our results indicate that fiber damage plays an utmost role in the compressive failure of flax fiber composites – it is a major determinant of the material's compressive stress-strain response. X-ray Computed Tomography and Scanning Electron Microscopy show that fiber damage can be attributed to intra-fiber splitting and elementary fiber crushing.

References

- [1] V. Tojaga, S. Hazar, S. Östlund (2019) Compressive failure of fiber composites containing stress concentrations: Homogenization with fiber-matrix interfacial decohesion based on a total Lagrangian formulation. *Composites Science and Technology*, **182**, 107758.
- [2] A. Prapavesis, V. Tojaga, S. Östlund, A.W. van Vuure (2020) Back calculated compressive properties of flax fibers utilizing the Impregnated Fiber Bundle Test (IFBT). *Composites Part A: Applied Science and Manufacturing*, **135**, 105930.
- [3] J. Faleskog, V. Tojaga (2021) A hyperelastic finite deformation plasticity model with power law hardening – Theory and application to necking and fiber kinking. *Manuscript in Preparation*.