Single Plant Fiber Transverse Compression: Investigation of Influential Parameters and Identification of Mechanical Properties

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Plant fibers offer an alternative to synthetic fibers and monofilaments that satisfy current societal and policy maker demands for renewable and environmentally friendly materials. Just like their man-made counterparts they can be used in composite or textile materials for various applications. However, their complex morphology and micro-structure makes them a more challenging material to characterize. While their longitudinal properties have been investigated under tensile tests, their transverse properties remain largely unknown. Composite bearing strength and ballistic cloths are examples where knowledge of these properties is crucial. To identify them, single fiber transverse compression tests can be used. Yet, to the authors knowledge, no such tests have been performed on plant fibers and the influence of several parameters on the fiber's identified properties have not been investigated, even in the case of synthetic fibers.

This communication will showcase the transverse mechanical behavior of nettle, flax and hemp fibers with the use of specialized micro-mechatronic setup. Through a combination of actuators, custom sensors and protocols, sub mNewton and µmeter precision is achieved while maintaining platen parallelism under 0.1°. With the use of numerical simulation and experimental studies the influence of several key parameters on the identified transverse elastic properties is also investigated. The impact of compression platen parallelism as well as fiber ellipticity, lumen and viscoelasticity will be presented.

Transverse material properties are obtained through inverse identification with the help of analytical models. However, by considering fibers as transversely isotropic elastic cylinders, these models are shown to be sensitive to all studied parameters. While some deviations can be minimized through experimental protocols, an evolution of these models or inverse identification based on finite element models could improve transverse property identification.

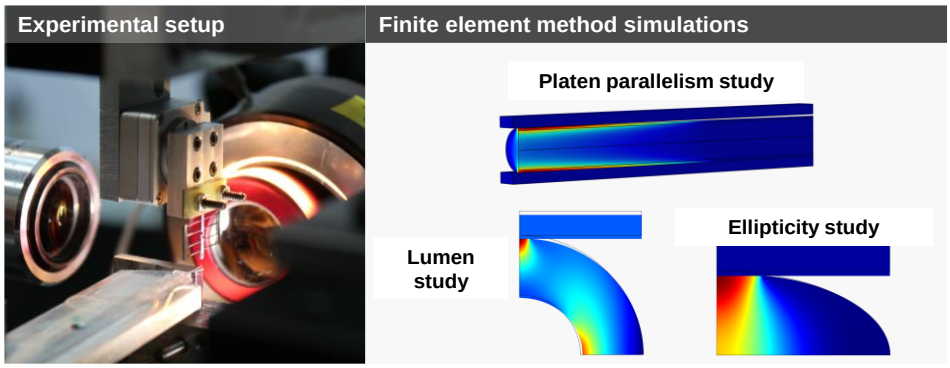

Figure 1. Single fiber transverse compression: experimental configuration and examples of numerical studies.

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