Investigation of density variations in molded wood tubes using gamma-ray CT and correlation with load-bearing behavior

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It is well known that mechanical properties of wood correlate with the density [1]. Since wood is a naturally grown material, variations in the density distribution still exist in timber elements leading to a non-uniform distribution of mechanical properties. To investigate the density distribution in timber elements at the meter scale non-destructively, the gamma-ray computed tomography (CT) scanner, firstly introduced in 2007 by Hampel et al [2], has been applied. The CT scanner offers a spatial resolution of about 1-2 mm. Nevertheless, small single structures like cracks or branches can be revealed up to a size of several micrometers.

As object of interest, a molded wooden tube (MWT) [2] with a length of 3 m and a diameter of 0.3 m made of beech (*Fagus sylvatica*) is used. The MWT is produced in a thermo-hydro-mechanical process incorporating densification and recovery of wood transverse to the grain [3]. Thus, besides naturally grown density variations also variations due to the production process of the MWT occur. Figure 1 (left) shows the density distribution in the MWT, measured plane-wisely along the MWT in discrete length distances of 50 mm.

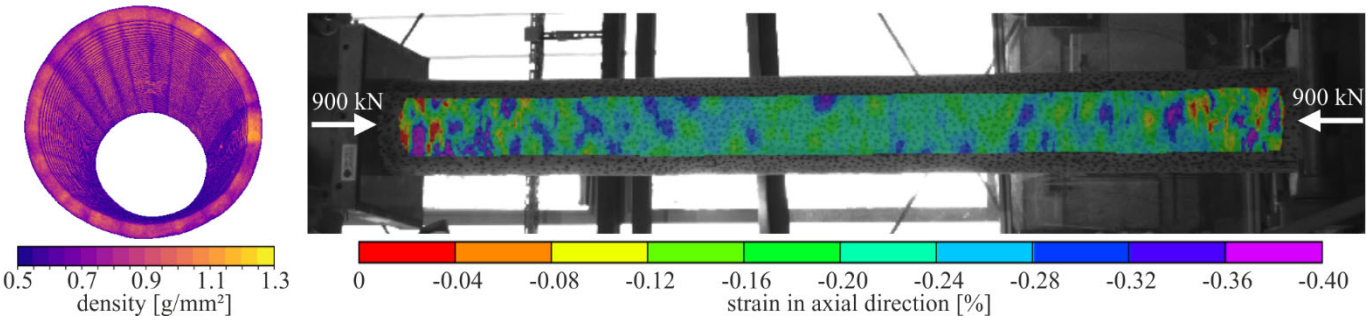

Figure 1: Experimental results. (left): density distribution determined by CT in the MWT (not to scale), (right) axial strain distribution in the MWT at an axial loading of 900 kN

In order to verify the assumption that the mechanical properties correlate with the density, an axial compression test is performed with the MWT previously scanned with CT. The spatial deformations on the surface of the MWT were measured by photogrammetry and digital image correlation (DIC) is applied to determine the strain distribution, see Figure 1 (right).

The density and geometry data gathered by CT is also used to create a finite element (FE) model. Based on the density data, the elastic properties of the respective elements are defined. The axial compression test is simulated and the results in terms of the strain distributions are compared to the experimental data determined by DIC.

The results of the investigations showed that computed tomography is highly suitable for the non-destructive determination of the density distribution in structural elements of timber. Thus, besides for research purposes CT scanning might be used also in the future for industrial grading of timber elements.

References

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