Influence of grain angle on stiffness and resistance of beech and poplar veneer

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ABSTRACT

Mechanical characterization of veneers is a scientific obstacle for technical products made with them. These products as the LVL (Laminated Veneer Lumber) can have better properties than solid wood. In the objective to produce high-performance technical products, the mechanical characterization of veneers is necessary. To achieve this objective, an experimental protocol of 8 stages has been performed to characterize veneers of beech and poplar and quantify parameters such as the fiber orientation and components of the compliance matrix. This experimental protocol takes into account the manufacturing of specimens, the global and local density, the fiber orientations, the modulus of elasticity (MoE), and the shear modulus. The mechanical properties are found with the digital image correlation.

Keywords: clear wood, mechanical characterization, grain angle, DIC.

INTRODUCTION

The transport industry requires more and more eco-friendly and environmentally-responsible products with the aim to reduce CO_2 emissions and recyclability. To meet the requirements of this industrial sector, structural applications require to sort wood according to its mechanical properties. The challenge is to get the most accurate possible evaluation of these mechanical properties by using non-destructive methods. Visual sorting of veneers is standardized but is not very efficient as shown in Faydi (Faydi 2017). Recently, several studies have tried to predict the stiffness and strength of structural-sized wood products (LVL (Hakkarainen et al. 2019, sawn timber) using local fiber orientation and density measurements (Viguier et al. 2018), resulting in moderate correlations ($R^2 < 0.7$). The question of the effectiveness of these modern non-destructive technologies to predict the mechanical properties of smaller specimens can arise, but surprisingly, no extensive work on this topic yet exists, perhaps because of underestimation of the actual variability of wood visually free from defect, the so-called “clear wood”. The objective of this work is to investigate how the mechanical properties of “clear wood” varies and how modern local non-destructive measurements can account for these variations. In this paper, small, “clear wood” specimens were tested first in a non-destructive way (fibers orientations and density) and then in a destructive way (tensile tests) with an experimental protocol of 8 stages.

MATERIALS AND METHOD

Beech and poplar veneers were made from the peeling process (stage 1). The provenance of the beech is from the Val de Loire in France and the poplar is from the Ain in France. Specimens of 350 mm in length, 20 mm in width, and 2 mm in thickness were made by a laser cutting machine (stage 2). Samples were stored at 24 °C and with a relative humidity of 50%. Specimens were cut with different angles relative to the main veneer direction to highlight the effect of this parameter on the mechanical properties. The specimens' angle distribution is presented in Tab.1. Approximatively 40 veneers were used to manufacture beech samples and 40 for poplar specimens. Specimens were scanned with a laser dot machine (stage 3) which allows measuring the direction of the fibers by the tracheid effect (Simonaho et al. 2002). In brief, this effect consists to project a circular laser on the wood surface. By doing so, the light scatters along wood fibers to create an ellipse, the major axis of the ellipse corresponding to the direction of the fibers in the plane of the surface of the specimen. By repeating this measurement, maps of angles were obtained on the two faces of each specimen. The specimens were also scanned with an image scanner to get color images of the faces (stage 4). The fifth stage consists to measure the weight and dimensions of specimens precisely to determine the global density. The local density was obtained thanks to an X-Ray machine (stage 6). Stage 7 concerns the mechanical tensile tests, performed with a ZWICK-Roell (250 kN) universal testing machine. The displacements were measured with a digital image stereo-correlation system from LaVision technology. The specimens were first loaded with a pre-force of 0.1 MPa. After the pre-force was reached, the specimens were loaded at a different cross-head speed according to their main angle in order to achieve a failure time from 100 s to 180 s. The MoE and strength of each sample in the direction of testing were computed. The last stage was to measure experimentally the angle of fracture of the specimen after testing. This measure was geometrical and by using a caliper. This angle was compared to the mean angle obtained with the laser dot machine.

Cutting angle (°)		**0**	**5**	**10**	**15**	**20**	**25**	**30**	**45**	**90**
Approximative specimens number	Beech	110	50	48	43	60	24	50	35	17
	Poplar	100	40	40	40	50	20	40	35	20

Tab. 1 – Distribution of specimens according to the cutting angle

RESULTS AND CONCLUSIONS

Results will be presented in the final paper. They indicate a strong relationship between the fiber's angle and the MoE. The correlation between specimens' MoE, strength and models based on local fiber angle and density measurement will be presented. Significant differences between poplar and beech mechanical behavior and fiber angle maps were observed and will be discussed.

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