The quality of LVL from secondary quality Oak and Beech

Mission report for GDR Bois

By

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Context of the mission

This scientific mission enable Lerfob (Laboratoire d'Etude des Ressources FOrêt-Bois) Nancy and LaBoMaP (Laboratoire Bourguignon des Matériaux et Procédés) Cluny to collaborate through PhD student works. Technically, the aimed of this mission are to produce 24 LVL panel made from secondary quality Oak and Beech and measure its mechanical properties in terms of bending stiffness and strength. While the objectives of this work are to *i*) study the relationship between wood and veneer properties and mechanical properties of LVL made from secondary quality hardwood in terms of modulus of elasticity (MOE) and modulus of rupture (MOR) and ii) find the adapted veneer thickness that give optimum mechanical properties to LVL. Moreover, we also compare Sylva-test and Bing as non-destructive measurements methods with destructive testing.

Method

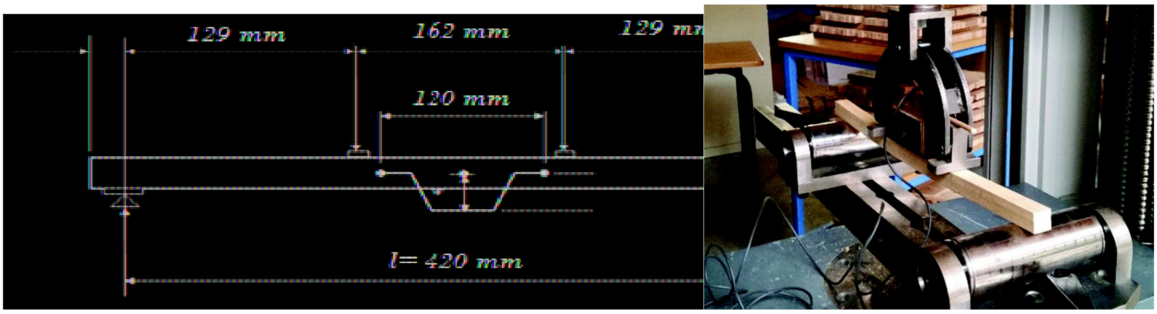
We prepared 16 bolts of Beech and Oak of 60 cm in length for rotary peeling. To minimize veneer lathe checks, all bolts were put in log boiler and soaked in hot water at 60 °C for 24 hours before peeling. Following this, bolts were peeled into three veneer thickness (2.1 mm, 3 mm, 4.2 mm) using rotary peeling machine. During peeling operation, we also monitored online the energy consumption, thickness variation, and lathe check frequency. Each bolt was peeled to produce one particular thickness. After peeling, the veneer were numbered and clipped in 0.6 x 0.5 m sheets and dried using vacuum drying machine to reduce veneer moisture content (MC) to 18% and air dried to 10%. Veneer from each bolts was separated into two different stack by its radial position i.e. internal and external. Veneer quality of fresh cut veneer were assessed by measuring the thickness variation, lathe checks depth and lathe checks frequency using "Systeme de Mesure d'Ouverture des Fissures" (SMOF) device.

a b c

Figure 1. a) Rotary peeling machine, b) Veneer made from secondary quality Oak, C) Measurement of lathe checks depth and frequency using SMOF device

After veneer MC reached 10 %, we continued with the assembly of LVL. For gluing parameters, we used PVAc (Polyvinyl Acetate) with glue spread of 180 g/m^2 and 60 minutes of cold press under a pressure of 0.8 MPa. For each combination of treatment (species, veneer thickness, and radial position in bolt), we made 2 LVL boards with a thickness of 21 mm, width of 500 mm, and length of 500 mm. After gluing and pressing, we stacked the LVL panel and let it stabilized for two weeks. After that, we cut all the panels into specimens with dimension of (21x21x500) mm^3 which results in total of 380 specimen. We measured the density and also measured MOE using Bing in two direction (flatwise and edgewise) and also Sylvatest.

Following the non-destructive test, we continued with 4 point bending test to measure MOE and MOR in two direction (figure 2). Half of the specimens are dedicated for flatwise bending test and the other for edgewise test.



a b

Figure 2. a) Test arrangement for measuring local MOE using 4 point bending test b) MOE measurement using universal testing machine

Preliminary results

Veneer quality

From figure 3 we can see that lathe check depth and lathe check distance are increasing along with the increase in veneer thickness bot in Oak and Beech. Statistical analysis show that the difference between veneer thickness in significant.

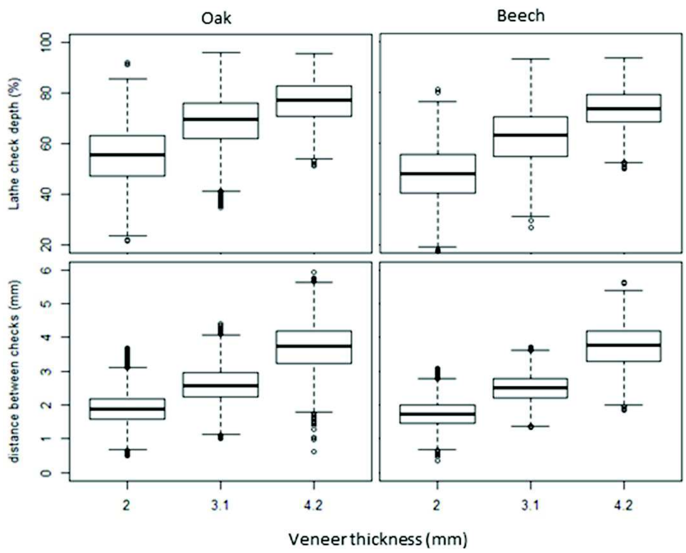


Figure 3. Effect of veneer thickness on a) Lathe check depth in Oak, b) Lathe check depth in Beech, c) lathe check distance in Oak, d) lathe check distance in Beech

LVL mechanical properties

From figure 4 we can see that In Oak, veneer thickness 3 mm gives the highest MOE value both in flatwise and edgewise direction while the highest MOE in Beech can be achieved by veneer thickness 3 mm and 4.2 mm. Here also we see that MOE value is more or less the same in both test direction. Concerning the radial position (internal/external) of the veneer, we did not see any difference the terms of MOE value. For the MOR value, from statistical analysis we can see that there is no effect of veneer thickness on MOR. The average MOR value for both species is around 60-65 MPa.

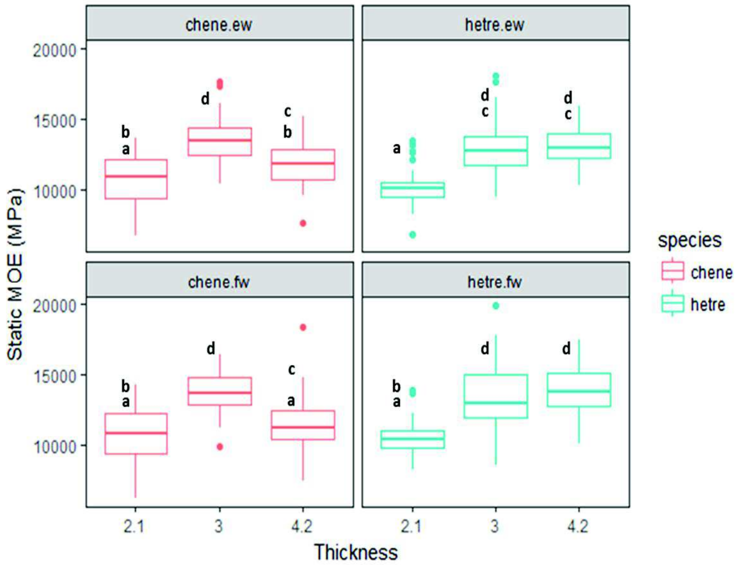


Figure 4. Effect of veneer thickness on a) MOE in edgewise direction in oak b) MOE in edgewise direction in Beech, c) MOE in flatwise direction in oak, d) MOE in flatwise direction in Beech. Same letters on the top of the plots signifies statistically identical populations, based on posthoc Tukey's HSD tests (p < 0.05).

Destructive and nondestructive test

From table 1, we can see that dynamic measurement produce the highest MOE on 3 mm and both 2.1 and 4.2 mm give the same MOE value while the lowest coefficient of variation in Oak is in 3 mm and in beech is at 4.2 mm. But the static measurement tell us that the highest MOE value and lowest coefficient of variation in Oak are at 3 mm but not for Beech.

Table.1 Contrast of different veneer thickness on dynamic MOE (Bing and Sylva-test) and static MOE

Species	Dynamic and static MOE	E_{sylva2}	E_{sylva3}	E_{sylva4}	E_{bing2}	E_{bing3}	E_{bing4}	$E_{static2}$	$E_{static3}$	$E_{static4}$
Oak	Average Value (GPa)	14,135	14,884	14,020	12,458	14,082	12,229	10,645	13,846	11,699
	Standard deviation (GPa)	0,959	0,816	0,955	1,453	0,863	1,108	1,784	1,717	1,697
	Coefficient of variation (%)	6,786	5,484	6,814	11,665	6,130	9,062	16,761	12,402	14,503
Beech	Average Value (GPa)	12,861	15,232	13,089	11,044	13,434	12,244	10,196	13,317	13,141
	Standard deviation (GPa)	1,213	2,005	0,922	1,080	2,089	0,713	1,417	1,929	1,758
	Coefficient of variation (%)	9,429	13,162	7,043	9,778	15,550	5,820	13,894	14,487	13,381

*Bing and Static in this table calculate from edgewise direction only

Future work

Future work will be further analyses of all the data and of the correlation between wood properties and LVL stiffness. This result will be presented in GDR Bois, Nantes 2017 and published in a scientific journal.