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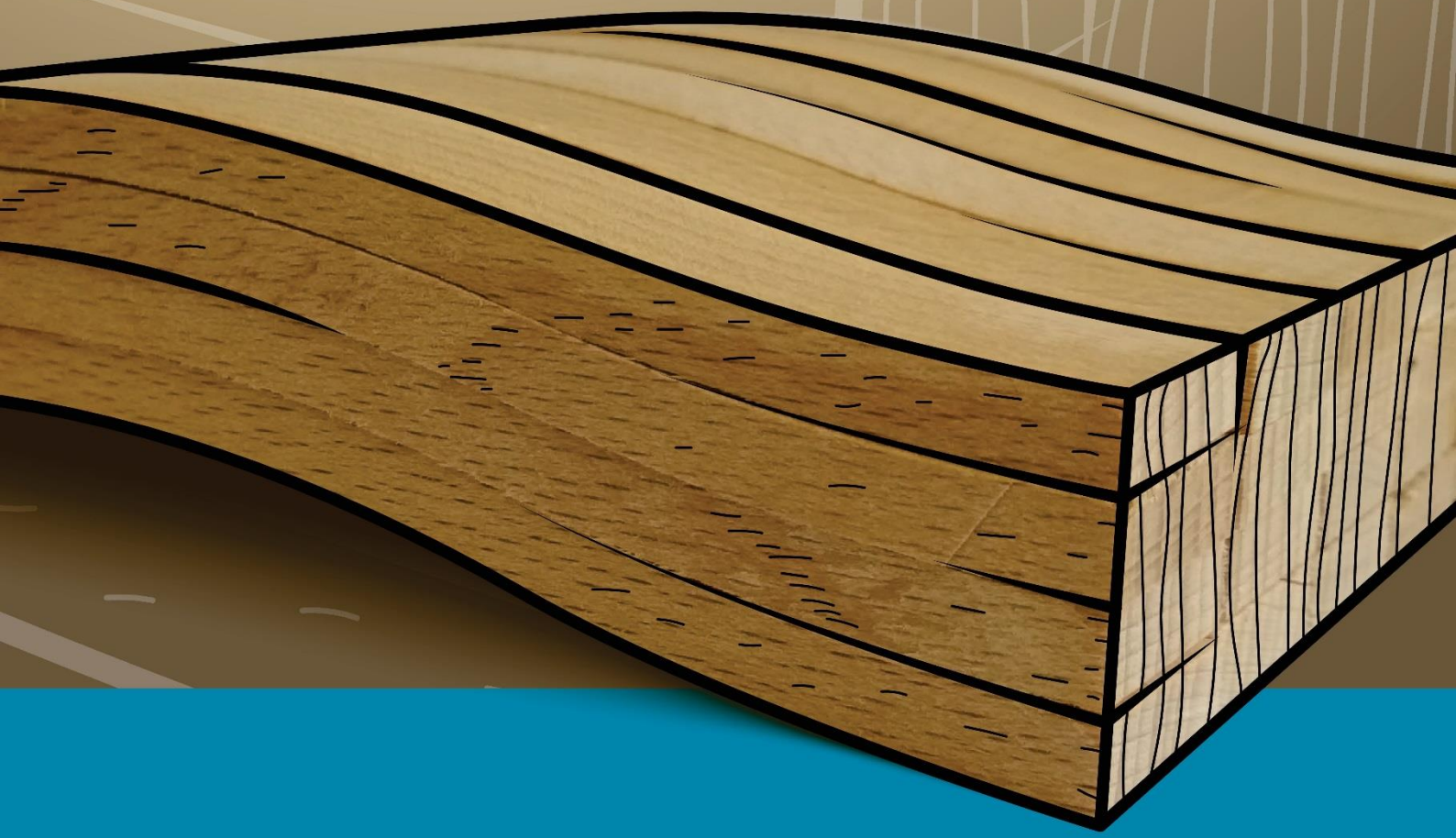

WOOD KPLUS

Mendel University in Brno

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Impregnability tests of experimental Pannonia poplar based glued-laminated timber

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Keywords: Pannonia poplar, *Populus* × *euramericana* cv. Pannonia, glued-laminated timber, impregnation, impregnability, copper sulphate, indicator, retention, penetration, impregnated area ratio

ABSTRACT

Our research aimed to compare the impregnability of Pannonia poplar before and after gluing. A significant amount of Hungarian Pannonia poplar trees are maturing to cutting age, which has inspired much research focusing on the properties of this hybrid. Considering the potential structural use of the hybrid, investigated preservative treatment of the wood using copper sulphate. The treatment parameters were 550 mbar vacuum for 45 min and atmospheric pressure for 120 min. The tested bulk samples originated from Hungarian growing areas. The glued and unglued reference lamellas were cut from a board along the grain to observe the variation in the degree of treatability in glued and unglued conditions. According to CEN EN 14734, a copper sulphate solution and indicator solution were used to evaluate the treatment. The amount of preservative applied, preservative penetration and the percentage of the impregnated area of the cross-section treated with the indicator were determined. The amount of glue applied did not affect preservative uptake. There is no difference in the minimum adhesive absorption depths between the glued-laminated and lamella specimens, because this property is independent of the adhesive. Based on the observed preservative uptake properties, impregnation should be performed after bonding.

Figure 1: Hungarian noble poplar plantation

INTRODUCTION

Poplar hybrids are the subject of much research today. The present study focuses on Pannonia poplar, an abundant poplar hybrid in Hungary, for the following reasons. In Hungary, low-durability timber such as pine must undergo fungicide and insecticide treatment prior to installation. Poplar research in recent years has produced positive results. These suggest that Pannonia stems, which are currently maturing in large quantities in Hungary, may be suitable for structural use. Due to the low natural durability of Pannonia poplar and the specifications for structural materials, a deeper understanding of its suitability for use as a protective agent was required. Our research investigated bulk wood from Hungarian production areas. The main aim of the study was to compare the protective treatments before and after gluing.

EXPERIMENTAL METHODS

Our study concentrates on the impregnation treatment of Pannonia poplar wood. Hungarian poplar specimens were cut from different growing areas after conditioning in a normal climate (relative humidity = 65%, air temperature = 20°C). Based on anatomical orientations, two groups of samples can be defined: standing and lying annual rings. Specimens cut along the grain were used as glued specimens, while unglued specimens were used as reference specimens. The size of the reference lamellas was 55×110×7 mm. The glued test specimens were made in three pieces with a final size of 55×110×21 mm. The adhesive was Jowat 686.60 PUR adhesive, which is also used in the industry. We performed the bonding according to the technical data sheet of the adhesive. The amount of adhesive applied was the specified minimum for half of the specimens and the maximum for the other half. We sealed the end grain surfaces of the specimens with APP PU 50 flexible polyurethane sealant. The protective treatment was performed according to CEN EN 14734 with the specified copper sulphate solution. Treatment parameters determined based on preliminary experiments differed from those specified in the standard (45 min 10 mbar vacuum, 120 min atmospheric pressure). The treatment parameters were 550 mbar vacuum for 45 min and atmospheric pressure for 120 min. We measured specimen mass before and after treatment to determine the amount of protective agent applied.

Figure 2: Arrangement of test specimens in the treatment tank (left) and the tank in the vacuum drying cabinet before treatment (right)

After treatment, the specimens were dried (Fig. 3) and then exposed using a circular saw for visual analysis of penetration. When the specimens were dry, we sawed some of the glued specimens with standing annual rings and lying annual rings and the corresponding reference lamellas in two in the fibre direction. It was possible to check the quality of the end sealant. The remaining specimens and unglued lamellas were cut in two transversely on a circular saw. We treated the cut surface of the test specimens with a reagent consisting of chromium azurol S, sodium acetate and distilled water, as defined in CEN EN 14734. The impregnation profile was visible in the specimens using the reagent. Upon exposure to the indicator solution, the wood tissue sections saturated with the protective agent immediately turned bright blue (Fig. 4).

Figure 3: Dried glued specimens (left) and reference lamellas in dryer (right)

Figure 4: Longitudinally-cut glued-laminated specimens before (left) and immediately after (right) treatment with reagent

The distinct colours allowed the measurement of the minimum penetration depth required by the standard on samples treated with the reagent. The minimum penetration depth was measured on the samples not fully impregnated in cross-section. Penetration measurements were performed at the Materials Testing Laboratory of the University of Sopron, using a NIKON SMZ 800 stereomicroscope on specimens not fully impregnated in cross-section.

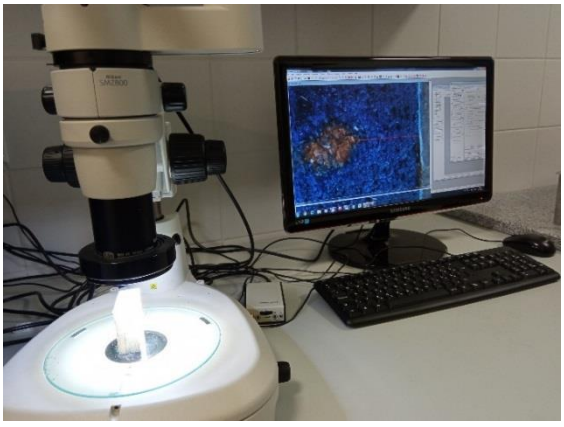

Figure 5: Measurement of minimum penetration on a NIKON SMZ 800 stereomicroscope

The area ratio of the saturated cross-section was determined on the transversely bisected surface of 1-1 standing annual ring and 1-1 lying annual ring lamella and glued-laminated specimen. The photograph of

the cross-section was scanned to scale in AutoCAD. Utilizing the drawing program, we drew the outlines of the specimens and the unsaturated patches, the areas of the whole cross-section and the saturated part were determined using the area measurement command. The percentage of the impregnated area of the cross-section was calculated from the measured data using the following formula:

$$A_{treated} = a_{treated}/a_{whole} \times 100$$

where: $A_{treated}$ = impregnation of the cross section of the test specimen in %
$a_{treated}$ = the area of the impregnated part defined in the test in mm^2
a_{whole} = cross-sectional area of the test specimen in mm^2.

The following pictures (Figs. 6-9) illustrate the steps of the area definition in the drawing program.. In the images, the unimpregnated parts of the total area to be extracted are marked with red fill.

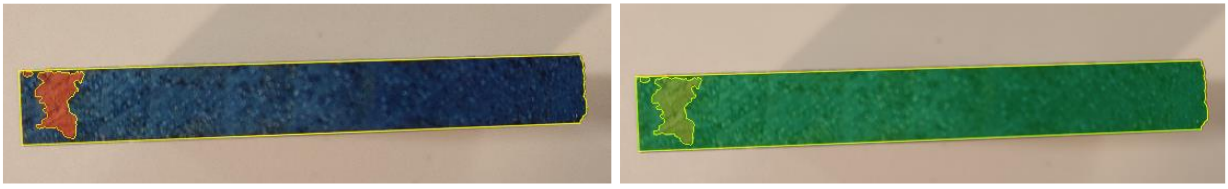

Figure 6: Determination of area ratio on a standing annual ring lamella

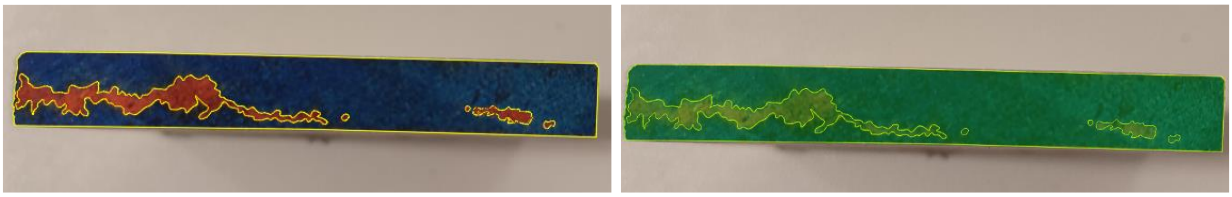

Figure 7: Determination of area ratio on a horizontal annual ring lamella

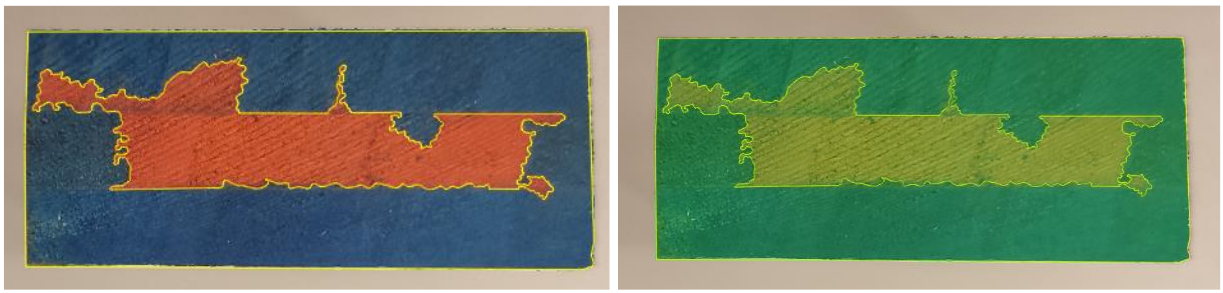

Figure 8: Determination of the area ratio of a standing annual-ring glued-laminated test specimen

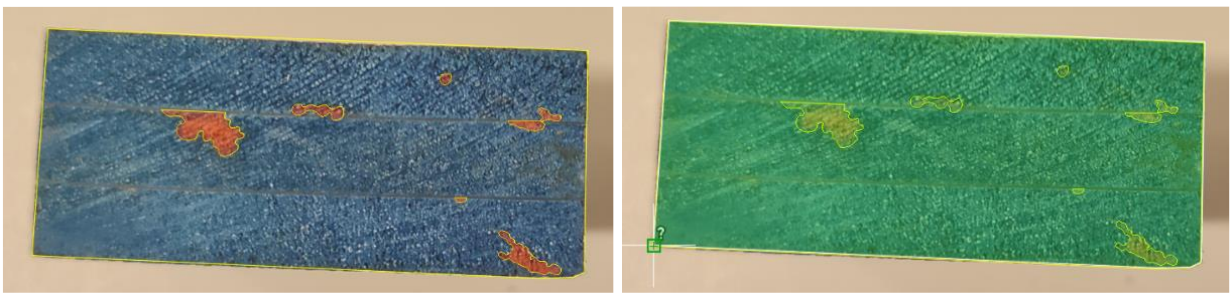

Figure 9: Determination of the area ratio of a horizontal annual ring glued-laminated test specimen

RESULTS AND DISCUSSION

Table 1 summarises the results of the preservative uptake. The average inoculum uptake of the standing and lying annual ring glued samples ranged from 40,471 to 44,449 g. No significant differences were observed for the different amounts of adhesive applied. The average adhesive consumption of the reference lamellae groups for the specimens was 52,923 g for the standing annual-ring specimens and 52,404 g for the lying annual-ring specimens. For the reference lamellae groups, the assumption that they absorb more protective agent due to their higher specific surface area than the laminated-glued specimens was confirmed.

Table 1: Results of the preservative uptake measuring

Specimen group	Mass before the treatment [g]	Mass after the treatment [g]	Preservative uptake [g]
Standing annual ring, glued (applied adhesive: 150 g/m^2)	54.006	95.242	41.235
Standing annual ring, glued (applied adhesive: 230 g/m^2)	54.882	98.167	43.285
Standing annual ring, reference lamellas	53.137	106.069	52.932
Horizontal annual ring, glued (applied adhesive: 150 g/m^2)	53.296	97.746	44.449
Horizontal annual ring, glued (applied adhesive: 230 g/m^2)	53.481	93.952	40.471
Horizontal annual ring, reference lamellas	51.967	104.371	52.404

For the penetration analysis of protective equipment with an indicator, we measured penetration depths using a stereomicroscope and complemented the analysis by examining penetration images. The penetration images reveal that the adhesive layer behaved as a barrier between the lamella layers, regardless of the amount of adhesive used. It is hypothesized that any cross-section of the test specimen with a successful end seal will have a similar impregnation profile. In the cases tested, the end sealing was satisfactory because the penetration profiles showed that the protective agent was laterally absorbed and exhibited a similar pattern on different cross-sections of the test specimen. Regarding lamella impregnation, we observed fully saturated cross-sections in many cases but not the glued-laminated specimens.

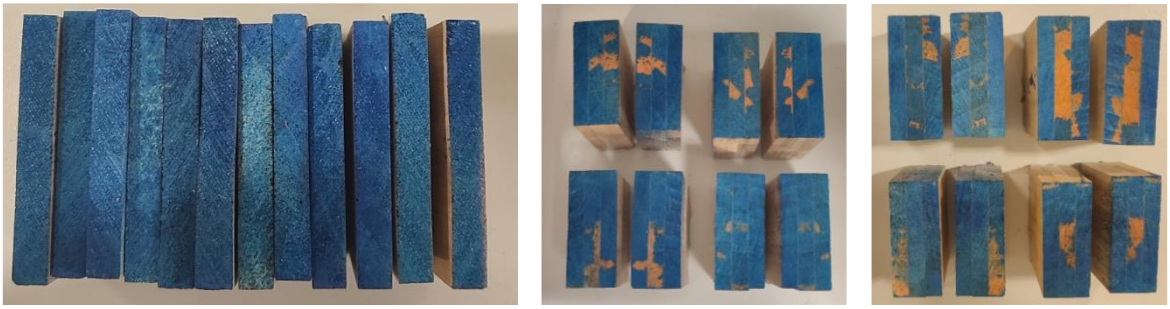

Figure 10: Penetration test specimens cut in half transversely

Table 2 summarises penetration measurement results. The average minimum penetration for the standing annual ring lamellas was 2136 µm and for the lying annual ring samples, it was 2347 µm. The average of the minimum measured penetration depths was 742 µm for the standing annual ring glued samples and 1905 µm for the lying annual ring samples. It can be concluded that the minimum penetration depth is independent of the bonding of the specimens.

Table 2: Results of the minimal penetration measurements

Specimen	Standing growth ring lamellas	Lying growth ring lamellas	Standing growth ring glued specimens	Lying growth ring glued specimens
Penetration (μm)	2136	2347	742	1905

CONCLUSIONS

With its easy handling and good preservative absorption results that allow a higher durability class for treated wood, Pannonia Poplar is proving to be a good choice, from a wood preservation and application point of view. There is no difference between unglued lamellas and glued-laminated specimens in terms of minimum absorption depths because because this property is independent of the bonding. Based on the observed absorption properties, the treatment can be applied after bonding. The relevant literature indicates, further opportunities to investigate the outdoor performance and the quality of the gluing of treated Pannonia poplar timber after treatment.

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CEN EN 14734:2022(MAIN): Durability of wood and wood-based products - Determination of treatability of timber species to be impregnated with wood preservatives - Laboratory method