Some Physical and Mechanical Properties of White Poplar *(Populus alba* L.) Wood Grown in Varaždin Region

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ABSTRACT

Investigation of physical and mechanical properties of wood is important for application of wood as a raw material. Nowadays, large quantities of wood from fast-growing species, especially from agricultural unusable land, are available on the market. One of them is poplars. The available data on physical and mechanical properties of white poplar wood grown in Croatia is insufficient. In this work, some of this properties were investigated on white poplar (*Populus alba* L.) from the region near Varaždin. Also, the distribution of this properties from pith to bark was investigated. This preliminary study was carried out on five trees, using only segments with north and south orientation in the wood at breast height. This article presents charts of listed properties from pith to bark for trees where the correlation of properties was highest. The average values of results in this preliminary study are: density in absolute dry condition is 0,390 g/cm^3, density at 12% of moisture content is 0,422 g/cm^3, maximum volume shrinkage is 15,1%, static bending strength is 62,8 MPa, modulus of elasticity at static bending is 12,99 GPa, compression strength parallel to grain is 34,3 MPa. In order to determine the statistical reliability, research must be continued on a larger number of samples.

Key words: White poplar *(Populus alba* L.), Physical properties, Mechanical properties, Radial direction, Distribution

1. INTRODUCTION

So far, research has been carried out on white poplar in Croatia (Horvat, 1960) on physical and mechanical properties on location in Slavonija. Unfortunately, these studies were carried out in an older way that was appropriate to this time and the possibilities of data processing. Research of anatomic properties was carried out at the same location (Ištok *et al.,* 2017) as this research of physical and mechanical properties. Based on the interesting results of this research, we began to this test research of the physical and mechanical properties of white poplar. Defining the distribution of physical and mechanical properties in the radial direction was the primary goal. The research was conducted on a relatively small number of samples as a pilot study. Defining the distribution of properties in the radial direction contrubutes to a better application of white poplar for different types of products: wood for packaging fruits and vegetables, wood as a raw material for the production of heat energy, wooden small products ... Knowing the distribution of properties in the radial direction allows us to determine the most valuable parts of logs to produce products with the highest added value. The advantage of white poplar is fast-growing rate regardless to the type of soil even on soils that are not suitable for agricultural production. The area of Varaždin and Međimurje or north-western part of Croatia has a lot of land that can be used for growing poplar or clones of poplars. In developing clones of poplars (Šefc *et al.,* 2009; Ugrenović, 1950), it is also important to create a database of physical and mechanical properties of white poplar characteristics that will allow comparison of the properties of clones with white poplar. Such comparisons allow us to evaluate new clone of poplar in this area.

2. MATERIAL AND METHODS

The material necessary for researching of white poplar properties was taken from test trunk samples of five trees in Lipovac Forest Administration. From ten selected trees, three were located in the Varaždin Forest Administration, forest area of Varaždinske podcravske šume, department 3a (*Figure 1*).

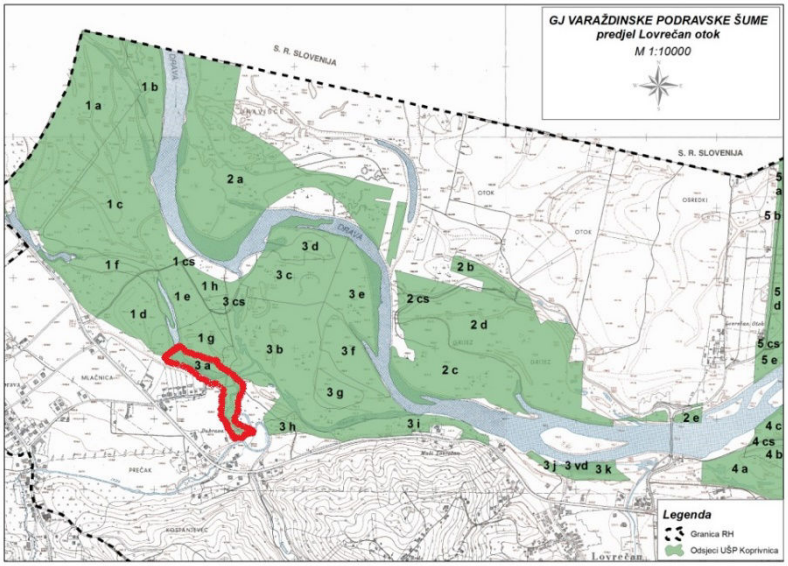

Figure 1. Mapp of the location the test trees.

The test trees were selected as the best representatives of their age, size, habitus, dendrometric elements and outer trunk properties. The test trees were healthy, normal, with regular crowns, straight stems, average flawlessness and fullness of bole as well as grain texture (*Table 1*).

Table 1. Basic data on test trees.

number of test trees	height of the tree (m)	height to the first thick branch (m)	diameter on breast height (cm)
27	16	7,5	50,5
28	14	6	51
29	14,3	8	41
30	14,1	8,2	44,5
31	13	7,3	39,2

The test trunk samples used for establishing the physical and mechanical properties were taken from the breast height (HRN ISO 3129:2015). The trunk samples were taken immediately upon felling and after that, the heart boards oriented North-South were made out of them. The heart boards were stacked and naturally dried until the water content was around 20%. For testing the physical properties we made samples for testing the density in absolute dry condition, and samples for testing density at 12% of moisture content in accordance with HRN ISO 3130:1999 and HRN ISO 3131:1999 For testing the mechanical properties we made samples for testing compression strength parallel to the grain and samples for testing bending strength and modulus of elasticity at bending strength in accordance with HRN ISO 3787:1976 and HRN ISO 3133:1975.

3. RESULTS AND DISCUSSION

The basic test results of physical and mechanical properties for all test trees are given in *Table 2*.

Table 2. Basic statistical test results for all test trees.

PROPERTI	ρ o	ρ 12%	$\sigma_{c\|}$	σ_B	E_B
UNIT	[g/cm^3]	[g/cm^3]	[MPa]	[MPa]	[GPa]
COUNT	53	62	62	57	52
MIN	0,254	0,319	19,6	40,8	2,2
AVERAGE	0,413	0,429	34,3	62,5	5,2
MAX	0,563	0,586	46,7	81,3	12,9
STEDEV	0,062498	0,057368	6,243973	10,87632	2,180905
VAR	0,003906	0,003291	38,9872	118,2943	4,756348

Legend: ρ o- density in absolute dry condition, ρ 12%- density at 12% of moisture content, $\sigma_{c\|}$- compression strength parallel to the grain, σ_B- bending strength, E_B- modulus of elasticity at bending strength, COUNT- number of samples, MIN- the minimum value of the tested samples, AVERAGE- the mean value of the tested samples, MAX- maximum value of the tested samples, STEDEV- standard deviation and VAR- variance

For the purpose of obtaining a radial distribution of physical and mechanical properties in the radial direction, a basic representation was made with the lines of the polynomial second degree and the coefficient of correlation in Excel. The results are shown in Table 3.

Table 3. Results of the correlation coefficient of the distribution of physical and mechanical properties in the radial direction.

PROPERTI	ρ o	ρ 12%	$\sigma_{c\|}$	σ_B	E_B
R^2	0,18	0,12	0,12	0,13	0,03

Legend: ρ o- density in absolute dry condition, ρ 12%- density at 12% of moisture content, $\sigma_{c\|}$- compression strength parallel to the grain, σ_B- bending strength, E_B- modulus of elasticity at bending strength and R^2- coefficient of correlation.

As an example, the Excel rendering results for density in the absolute dry state are shown in *Figure 2*.

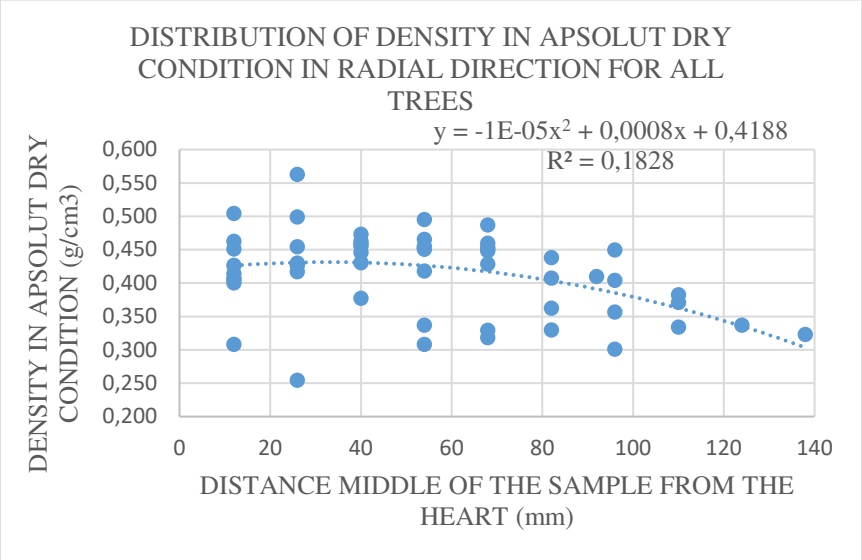

Figure 2. Distribution of density in absolute dry condition in radial direction for all test trees.

By looking at figure per every tree, it was found that in some trees the dependence of physical and mechanical properties in radial direction gives bigger or very large correlation coefficients. The examples are shown in *Table 4* and best results in *Figure 3 and 4*.

Table 4. Results of the correlation coefficient of the distribution of physical and mechanical properties in the radial direction per tree.

	NUMBER OF TREE	ρ 12%	$\sigma_{c\parallel}$	σ_B	E_B
R^2	27	0,54	0,53	0,20	0,83
R^2	28	0,40	0,05	0,44	0,03
R^2	29	0,51	0,78	0,33	0,06
R^2	30	0,59	0,24	0,87	0,16
R^2	31	0,51	0,29	0,31	0,64

Legend: ρ 12%- density at 12% of moisture content, $\sigma_{c\parallel}$- compression strength parallel to the grain, σ_B- bending strength, E_B- modulus of elasticity at bending strength and R^2- coefficient of correlation.

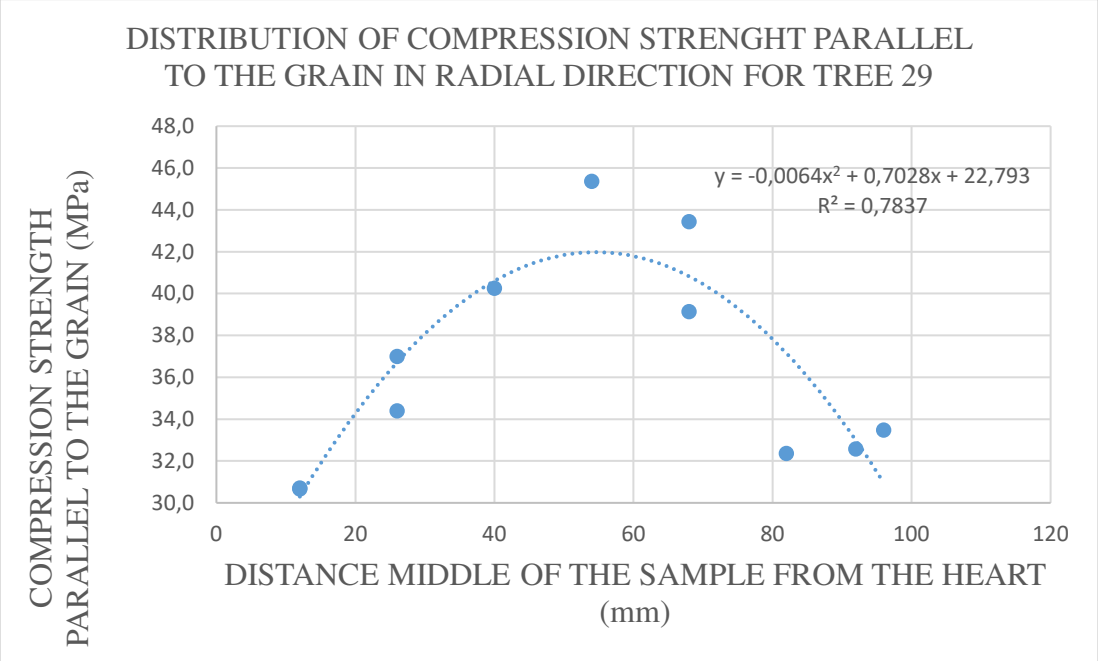

Figure 3. Distribution of compression strength parallel to the grain in radial direction for tree 29.

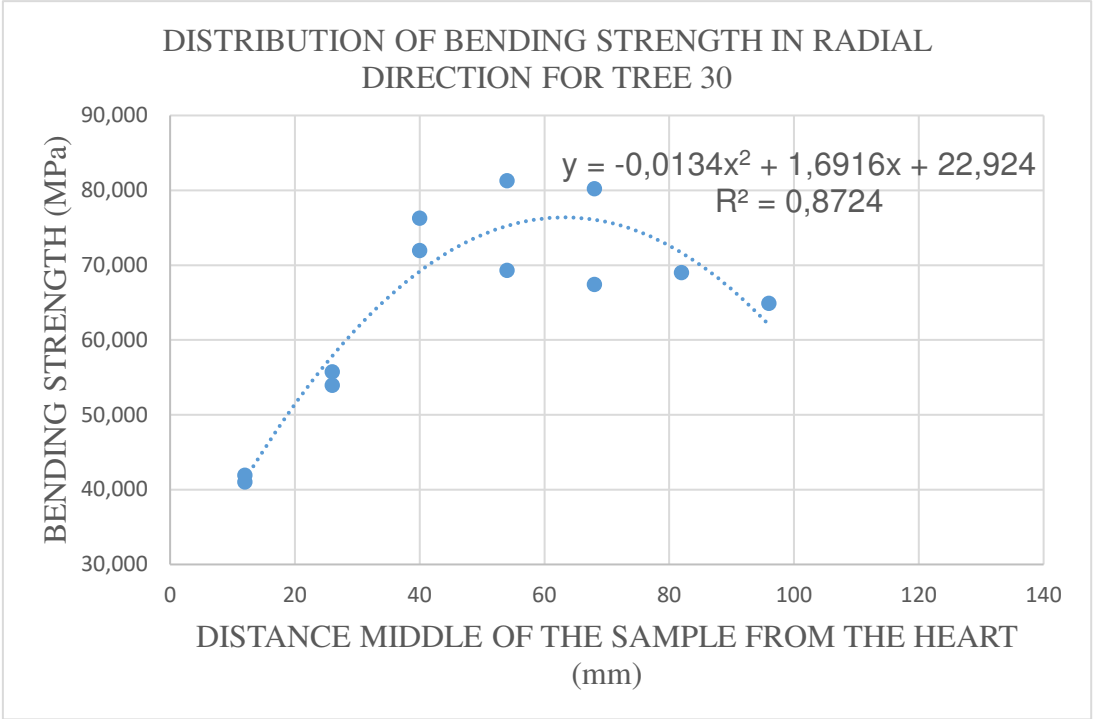

Figure 4. Distribution of bending strength in radial direction for tree 30.

The most interesting illustration of the correlation between physical and mechanical properties was the influence of wood density at 12% water content and pressure strength in parallel with fiber. This correlation is shown in *Figure 5*.

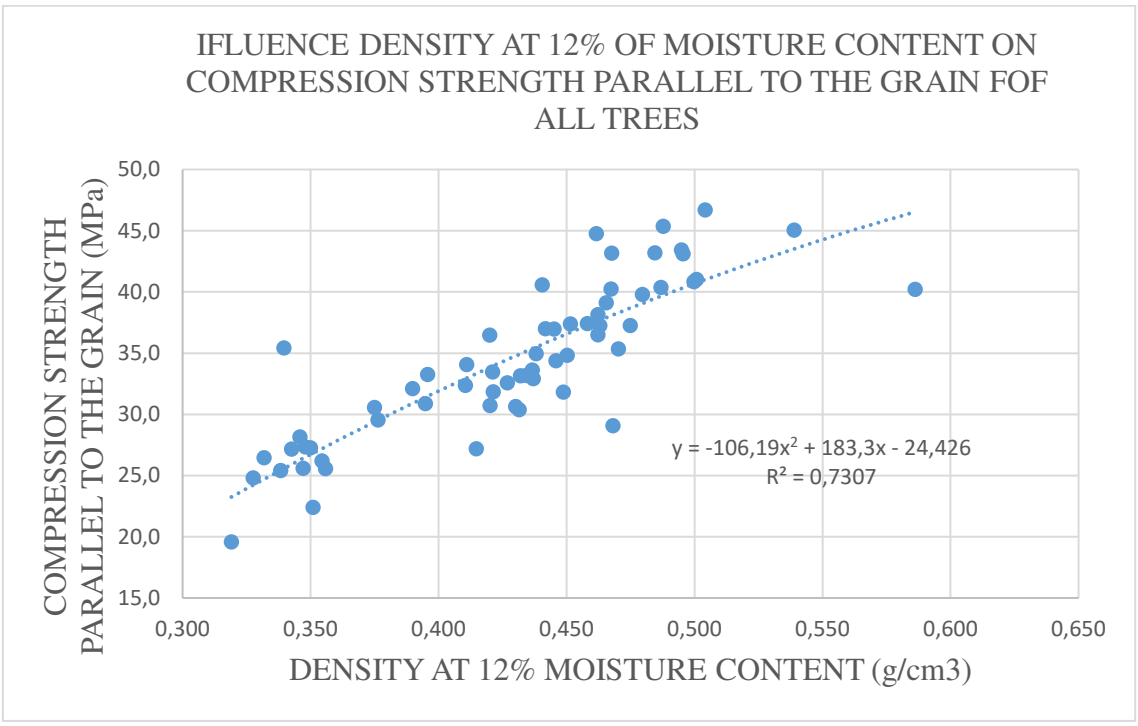

Figure 5. Influence of density at 12% of moisture content on compression strength parallel to the grain for all trees.

4. CONCLUSIONS

1. . The number of samples at this preliminary research for density in absolute dry condition, the density at 12% moisture content, compression strength parallel to the grain, static bending strength and modulus of elasticity in bending of white poplar in radial direction were small to give a statistically correct conclusion on their interdependence.
2. The density at 12% of moisture content distribution in the radial direction shows good coefficients of correlation per individual trees and indicating that it would be necessary to conduct research on a large number of samples to get a statistically correct conclusion.
3. Conclusion on the increase in the number of samples also applies to compression strength parallel to the grain, bending strength and modulus of elasticity at bending strength.
4. The most interesting is the dependence of compression strength parallel to the grain and density at 12% of moisture content that shows the strongest evidence of the need to conduct research on a large number of samples to get statistically correct conclusion.

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5.... required, used HRN and ISO norms

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FOREWORD

Continuous changes on international market open up new horizons and opportunities, and the new strategies adopted by Europe and the world bring new concepts that need to be adapted and followed. This concept seeks increased social cohesion, striking with the harmful effects of climate change, nature preservation and the creation of a healthy environment. At the same time, creative potentials are open to new knowledge and innovative processes whose primary objective is to adapt to the needs of customers and the environment.

One of the activities carried out in recent years in order to preserve and stimulate rational utilization of raw material is certainly the traditional international scientific conference AMBIENTA. During its continuous sequence in the last 27 years it has become a platform for meeting and networking among scientists, teachers, researchers, students and professionals. In the year 2015 this conference has grown into an international conference on wood science and technology (ICWST), and from last year it became a two-day event, hosted by the Faculty of Forestry of the University in Zagreb.

This year's conference, the second in a row held under the title "*The implementation of science in the woodworking sector*" aims to ensure a multidisciplinary forum where all the participants have the opportunity to present and discuss innovations, trends and practical challenges they have faced in the world of wood science and technology, but also in relation to other materials, technologies, design and other related topics whose aim is to upgrade the wood industry.

We hope that this year's conference will contribute to awareness raising about the significance of wood as an irreplaceable natural raw material, and that the application of scientific research has a positive impact on the wood sector as well as any user of wood.

Assistant Professor Ivica Župčić, PhD

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