

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

Sinković, T.¹; Jambreković, B.¹; Šefc B.¹; Ištok I.¹; Veseličić F.²; Sedlar, T.¹

¹Authors are professor, assistant, associate professor and PhD assistants at Department for Wood Science, Faculty of Forestry, University of Zagreb, Zagreb, Croatia

² Author is a student at Faculty of Forestry, University of Zagreb, Croatia.

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/cm³, density at 12% of moisture content is 0,422 g/cm³, 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 contributes 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*).

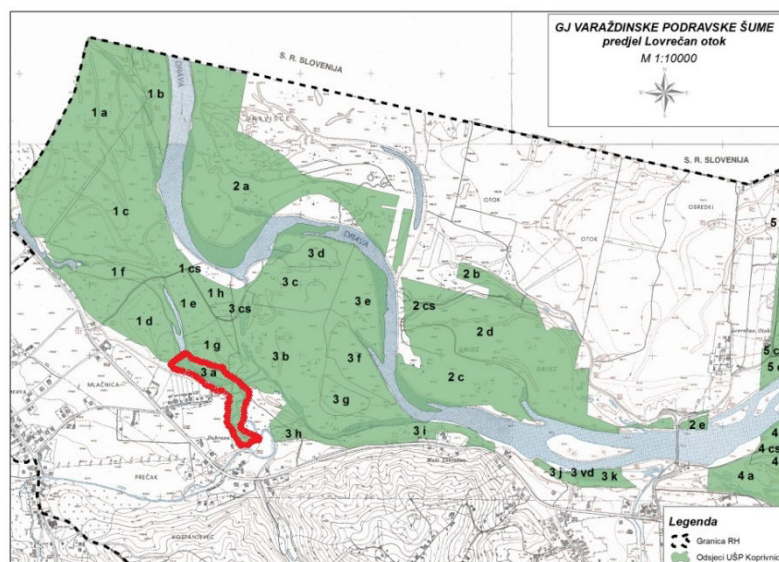


Figure 1. Map of the location the test trees.

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	$\rho_{12\%}$	$\sigma_{c }$	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, $\rho_{12\%}$ - 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	$\rho_{12\%}$	$\sigma_{c }$	σ_B	E_B
R^2	0,18	0,12	0,12	0,13	0,03

Legend: ρ_o - density in absolute dry condition, $\rho_{12\%}$ - 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.

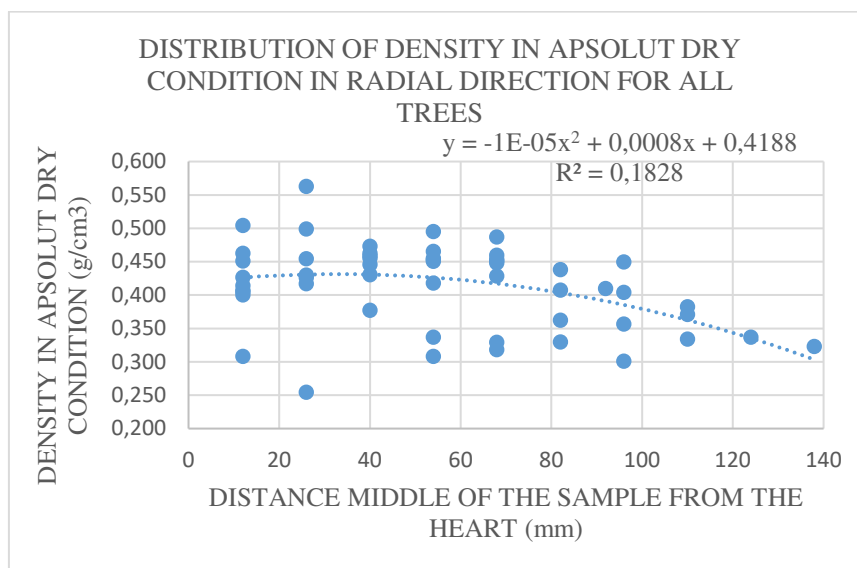


Figure 2. Distribution of density in absolute dry condition in radial direction for all test trees.

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.

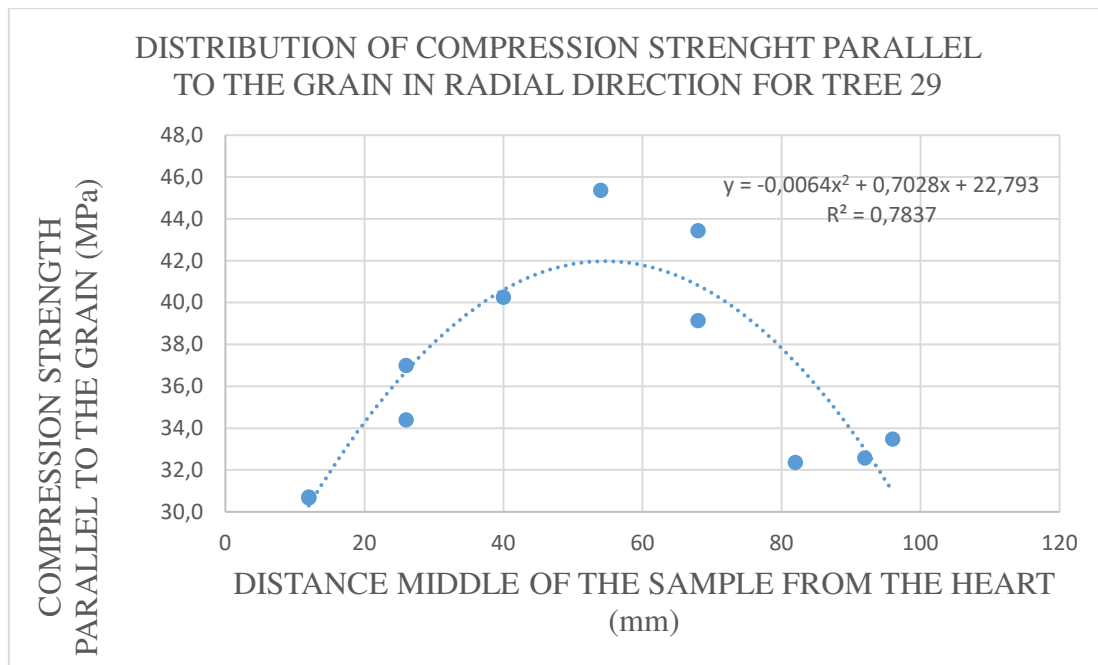


Figure 3. Distribution of compression strength parallel to the grain in radial direction for tree 29.

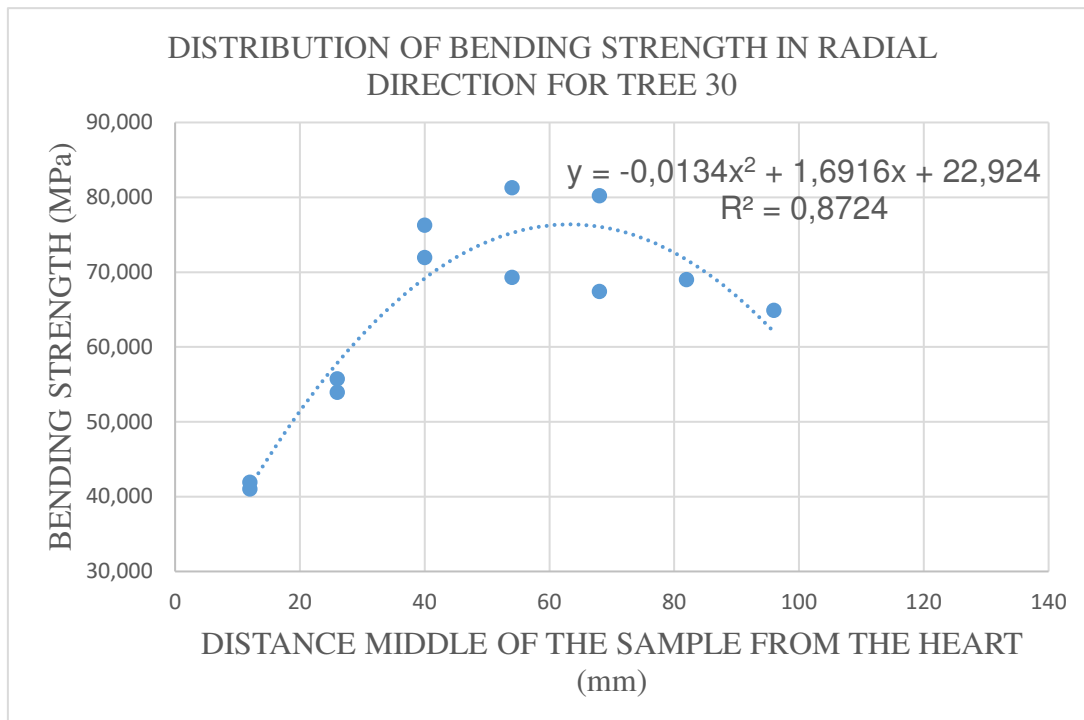


Figure 4. Distribution of bending strength in radial direction for tree 30.

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.

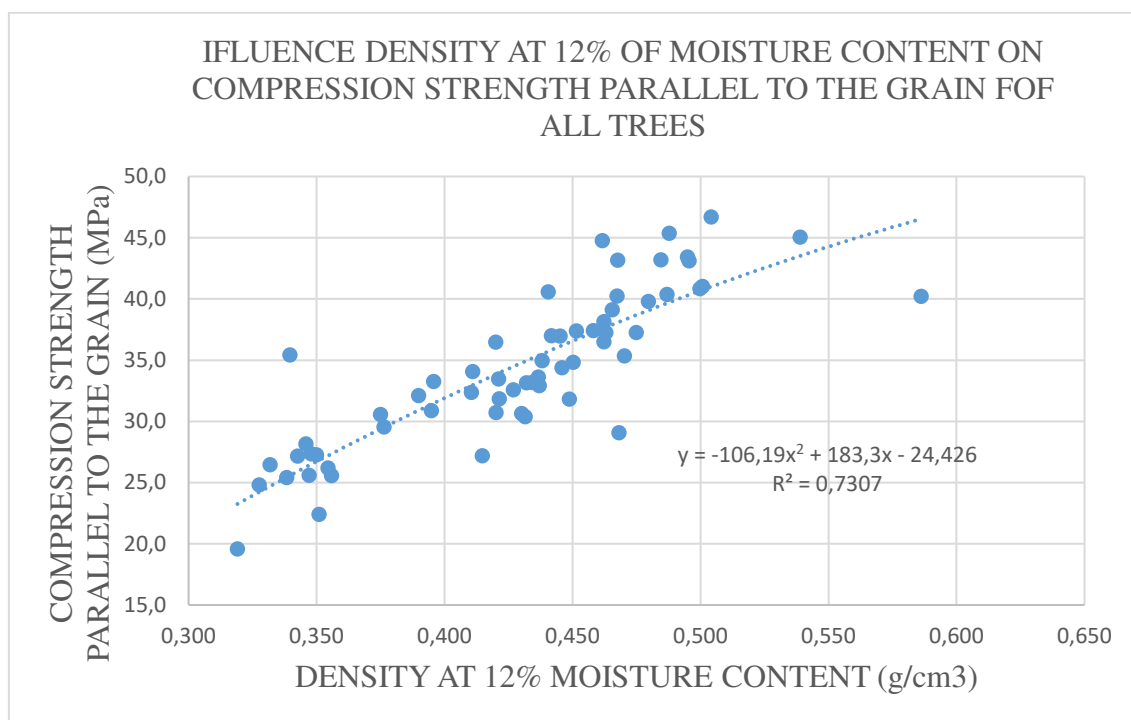


Figure 5. Influence of density at 12% of moisture content on compression strength parallel to the grain for all trees.

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.

5. REFERENCES

1. Horvat, I. (1960): *Prilog poznavanju nekih fizičkih i mehaničkih svojstava bijele i crne topolovine (Populus alba L., Populus nigra L.)*. Šumarski list, 3-4: 95-115.
2. Ištok I., ŠefcB., Hasan M., Popović G., Sedlar T. (2017): *Fiber Characteristics of White Poplar (Populus alba L.) Juvenile Wood along the Drava River*. Drvna industrija, 68 (3): 241-247
3. Šefc, B.; Trajković, J.; Govorčin, S.; Despot, R.; Hasan, M. (2009): *Selected tree characteristics and wood properties of two poplar clones*. Wood Research, 54 (1): 1-8.
4. Ugrenović, A. (1950): *Tehnologija drveta*. Nakladni zavod Hrvatske. Zagreb.
- 5.... required, used HRN and ISO norms

28th ICWST

International
Conference on
Wood Science
and Technology

IMPLEMENTATION OF WOOD SCIENCE IN WOODWORKING SECTOR

PROCEEDINGS

Zagreb, 7th – 8th of December 2017

University of Zagreb – Faculty of Forestry • Biotechnical Faculty, University of Ljubljana •
Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague •
Forest Products Society • InnovaWood

ORGANISERS

UNIVERSITY OF ZAGREB - FACULTY OF FORESTRY
WOOD SCIENCE AND TECHNOLOGY DEPARTMENT, BIOTECHNICAL FACULTY,
UNIVERSITY OF LJUBLJANA
FACULTY OF FORESTRY AND WOOD SCIENCES, CZECH UNIVERSITY OF LIFE
SCIENCES PRAGUE
FOREST PRODUCTS SOCIETY
INNOVAWOOD

IN COLLABORATION WITH

ACADEMY OF FORESTRY
CROATIAN ACADEMY OF ENGINEERING
THE SCIENTIFIC COUNCIL FOR AGRICULTURE AND FORESTRY – CROATIAN
ACADEMY OF SCIENCES AND ARTS
ASSOCIATION OF ENGINEERS OF WOOD TECHNOLOGY
ZAGREB FAIR

SUPPORTED BY

MINISTRY OF SCIENCE AND EDUCATION
MINISTRY OF ECONOMY, ENTREPRENEURSHIP AND CRAFTS
MINISTRY OF AGRICULTURE
CROATIAN CHAMBER OF ENGINEERS OF FORESTRY AND WOOD TECHNOLOGY
CROATIAN CHAMBER OF ECONOMY
ZAGREB COUNTY



Univerza v Ljubljani
Biotehniška fakulteta



FOREST
PRODUCTS
SOCIETY



UNIVERSITY OF ZAGREB - FACULTY OF FORESTRY

WOOD SCIENCE AND TECHNOLOGY DEPARTMENT, BIOTECHNICAL FACULTY, UNIVERSITY OF
LJUBLJANA

FACULTY OF FORESTRY AND WOOD SCIENCES, CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

FOREST PRODUCTS SOCIETY

INNOVAWOOD

28th International Conference on Wood Science and Technology (ICWST)

IMPLEMENTATION OF WOOD SCIENCE IN WOODWORKING
SECTOR

PROCEEDINGS

Zagreb 7th – 8th of December 2017

Disclaimer:

This book of papers compiles the papers and posters presented at the 28th International Conference on Wood Science and Technology (ICWST) ***Implementation of wood science in woodworking sector*** held in Zagreb, Croatia on 7th and 8th December, 2017. The opinions expressed within are those of the authors and not necessarily represent those of the host, the editors and or any institution included in organisation of this conference.

Although all reasonable efforts were made by the organising team to ensure the scientific quality of the contents of these abstracts, the final responsibility for the content therein and in the final conference proceeding remains with the respective authors. The editors accept no responsibility for the information contained in the proceedings. The editors are not responsible for the contents of external websites referred to in this publication.

A CIP catalogue record for this book is available in the Online Catalogue of the National and University Library in Zagreb as 000979682

Publisher:

UNIVERSITY OF ZAGREB - FACULTY OF FORESTRY

Organizers:

UNIVERSITY OF ZAGREB - FACULTY OF FORESTRY
WOOD SCIENCE AND TECHNOLOGY DEPARTMENT, BIOTECHNICAL FACULTY, UNIVERSITY OF
LJUBLJANA
FACULTY OF FORESTRY AND WOOD SCIENCES, CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE
FOREST PRODUCTS SOCIETY
INNOVAWOOD

In collaboration with:

ACADEMY OF FORESTRY
CROATIAN ACADEMY OF ENGINEERING
THE SCIENTIFIC COUNCIL FOR AGRICULTURE AND FORESTRY – CROATIAN
ACADEMY OF SCIENCES AND ARTS
ASSOCIATION OF ENGINEERS OF WOOD TECHNOLOGY
ZAGREB FAIR

Organizing committee:

Professor **Vladimir Andročec**, PhD (Croatia), Academic **Igor Anić**, PhD (Croatia), Professor **Marian Babiak**, PhD (Slovakia), **Nada Banek**, BSc (Croatia), Professor **Mario Božić**, PhD (Croatia), **Luka Burilović**, BSc (Croatia), **Mariano Perez Campos**, PhD (Spain), Associated Professor **Beata Fabisiak**, PhD (Poland), **Ivica Francetić**, MSc-(Croatia), Professor **Milan Gaff**, PhD (Czech Republic), Professor **Ivica Grbac**, PhD (Croatia), Associated Professor **Miha Humar**, PhD (Slovenia), Professor **Borche Iliev**, PhD (Macedonia), **Iva Ištok**, PhD (Croatia), Professor **Vladimir Jambrečković**, PhD (Croatia), Associated Professor **Vassil Jivkov**, PhD (Bulgaria), Academic **Slavko Matić**, PhD (Croatia), Professor **Sergej Medved**, PhD (Slovenia), Professor **Milan Oršanić**, PhD (Croatia), **Ivana Perić**, PhD (Croatia), Assistant Professor **Andreja Pirc Barčič**, PhD (Croatia), Professor **Tomislav Poršinsky**, PhD (Croatia), **Scott Springmier** (SAD), **Dina Tomšić**, PhD (Croatia), **Silvija Zec**, BSc (Croatia), Assistant Professor **Vjekoslav Živković**, PhD (Croatia), Assistant Professor **Ivica Župčić**, PhD (Croatia)

Editors:

Assistant Professor **Ivica Župčić**, PhD
Assistant Professor **Vjekoslav Živković**, PhD
Josip Miklečić, PhD

Technical editor:

Josip Miklečić, PhD

Assistant to Technical editor:

Ms Dubravka Cvetan

Cover photo:

Assistant Professor **Danijela Domljan**, PhD

Programme committee and reviewers:

Assistant Professor **Christian Brischke**, PhD (Germany), Professor **Andrija Bogner**, PhD (Croatia), Assistant Professor **Danijela Domljan**, PhD (Croatia), Professor **Milan Gaff**, PhD (Czech Republic), Professor **Ivica Grbac**, PhD (Croatia), Assistant Professor **Marin Hasan**, PhD (Croatia), Associated Professor **Miha Humar**, PhD (Slovenia), Professor **Mark Irle**, PhD (Belgium), Professor **Vladimir Jambrečković**, PhD (Croatia), Professor **Vlatka Jirouš-Rajković**, PhD (Croatia), Professor **Boris Ljuljka**, PhD (Croatia), **Josip Miklečić**, PhD (Croatia), Professor **Stjepan Pervan**, PhD (Croatia), **Peter Rademacher**, PhD (Hungary), Professor **Andreas Rapp**, PhD (Germany), Professor **Milan Šernek**, PhD (Slovenia), **Nikola Španić**, PhD (Croatia), Assistant Professor **Vjekoslav Živković**, PhD (Croatia), Assistant Professor **Ivica Župčić**, PhD (Croatia)

EDITION

300 copies

ISBN: 978-953-292-053-6

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

CONTENTS

1. Timothy Young	1
INDUSTRY 4.0 – Pragmatic Algorithms, Information Quality and Relational Databases	
2. Tetsuya Inagaki; Moe Kashima; Satoru Tsuchikawa	3
Estimation of Wood Density, Moisture Content and Fiber Orientation by THz Time Domain Spectroscopy	
3. Hikaru Kobori; Sakura Ichijo; Naoki Okano; Yoichi Kojima; Shigehiko Suzuki	7
The Effect of Dry Thermal Treatment on the Vibrational Characteristics of Wood	
4. V. Sierra Sánchez; M. de Luque Ripoll; M. Álvarez San Millán; S. Pérez Mazarío; P. García Espina; Luis de Luque Ripoll	15
NIRWOOD: an EU Innovation Project to Determine Species and Geographical Origin of Timber using NIR Spectrometry	
5. Ahmet Can; İsmail Özlüsoylu; Wojciech Grzeskowiak; Eser Sözen	21
Improvement of Fire Performance of Impregnated Wood with Copper Based Chemicals	
6. Miljenko Klarić; Velimir Nikić; Stjepan Pervan	29
Subfossil Waterlogged Oak-wood (Abonos) Moisture Content Estimation by Electrical Resistance Method	
7. Hajri Haska; Bajram Kullolli; Hajri Ismaili; Eneida Haska	37
Traditional Ways Using of Wood and Forest Products in Housings and in Daily Livelihoods in Albania Populations/Communities	
8. Ivan Žulj; Ivica Župčić; Kristijan Radmanović; Ivica Grbac; Valentino Slivar	43
Temperature as an Important Factor in Rotary Welding of Wood	
9. Nikola Španić; Vladimir Jambreković; Kristijan Radmanović; Goran Mihulja; Jaroslav Kljak	51
Effect of Tartaric Acid Addition to Catalyst on Curing Behaviour of Urea-Formaldehyde Resin	
10. Ivana Perić, Tomislav Grladinović, Jože Kropivšek, Krešimir Greger	59
Relationship between Entrepreneurial Competencies and Firm Performance: A Study on Furniture Manufacturing SMEs in Croatia	
11. Fabiana Chipaia; Claudia Urbinati; Patricia Dos Santos; Alisson Reis	65
Identification of Diagnostic Anatomical Features in Ten Species of Sapindales Occurring in the Brazilian Amazon	
12. Ignacio Urbán Martínez; Ernesto Gutiérrez Tejón; Oscar Santaclara Estévez; Esther Merlo Sánchez	79
Optimization of Juglans sp. Wood Processing from Sustainable Plantations' thinning, Wood Profitability and Final Product Quality	
13. Branimir Šafran; Matija Jug; Kristijan Radmanović; Igor Đukić; Daniel Kramar; Stjepan Risović	81
Analysis of the Raw Material Properties in the Agro-wood Pellets Production	
14. Tomislav Sedlar; Tomislav Sinković; Jelena Trajković; Bogoslav Šefc; Branimir Jambreković; Iva Ištok	93
Relationship between Strength and Density as an Indicator of Sycamore Maple (<i>Acer pseudoplatanus</i> L.) Wood Quality	
15. Tomislav Sinković; Branimir Jambreković; Bogoslav Šefc; Iva Ištok; Filip Veselčić; Tomislav Sedlar	101
Some Physical and Mechanical Properties of White Poplar (<i>Populus alba</i> L.) Wood Grown in Varaždin Region	
16. Anka Ozana Čavlović; Matija Jug; Andrija Novosel	107
The Efficiency of Exhaust System in the Wooden Floor Production: A Case study	
17. Ahmet Can; Cengiz Temiz; Hüseyin Sivrikaya	115
Surface Characterization of some Woods Exposed to Accelerated Weathering	
18. Ahmet Can; Hüseyin Sivrikaya	125
Effect of Water Repellents on the Surface Characterisation of Scots pine (<i>Pinus sylvestris</i>) Exposed to Accelerated and Outdoor Weathering	
19. Marin Hasan; Adriana Hasan; Gordana Orešković; Branimir Jambreković; Suzana Antolović	135
Contribution to the Optimisation of Esterification of Beech Wood by Citric Acid	
20. Milan Gaff; Marián Babiak; František Kačík; Veronika Vondrova; Danijela Domljan	143
Bendability of Thermally Modified Oak (<i>Quercus robur</i> F.)	

21. Reza Hosseinpourpia; Stergios Adamopoulos; Carsten Mai; Venla Hemmilä	153
Effect of Bio-Based Additives on Physico-Mechanical Properties of Medium Density Fibreboards	
22. Sergej Medved; Jože Resnik; Vladimir Jambreković; Nikola Španić; Alan Antonović	159
Image and FT-IR Analysis of Blended Particles	
23. Marina Jajcinovic; Wolfgang Johann Fischer; Ulrich Hirn; Wolfgang Bauer	165
Influence of Relative Humidity on the Strength of Hardwood and Softwood Pulp Fibres and Fibre to Fibre Joints	
24 Juraj Stanešić; Tomislav Podvorec; Alan Antonović	175
Influence of Black Poplar Wood Particle Size (<i>Populus nigra</i> L.) on Content and Properties of Bio-oil	
25. Liubov Kozak; Pavlo Bekhta; Ján Sedliačik; Ján Iždinský	183
Influence of Veneering on the Properties of Lightweight Particleboards with Expanded Polystyrene	
26. Łukasz Krzyżaniak; Jerzy Smardzewski	191
Modeling of Externally Invisible Cabinet Furniture Joints	
27. Jiří Tauber; Zdeněk Holouš; Miroslav Kozák; Sarah Szökeová	199
Trends in the Production and Design of Upholstered Furniture	
28. Boris Iliev; Danijela Domljan	207
Comparison between Preschool Tables used in Kindergartens in Croatia, Macedonia and Bulgaria	
29. Zoran Vlaović; Karla Seleš; Ivica Grbac; Ivan Žulj; Danijela Domljan	215
Comfort of Cervical Pillow with Polyurethane Coil Springs	
30. Alena Sobotková; Milan Šimek; Danijela Domljan	223
Furniture Design for the Entrance Hall	
31. Sarah Szökeová; Miroslav Kozák; Milan Šimek	229
Product Line Safari	
32. Roy Damary; Natalia Pryadilina; Sergey Zalesov; Anton Opletaev	237
Outdoor Wooden Furniture as a Component of an overall Municipal Project: “Green City	
33. Franciska Klanfar; Jerzy Smardzewski; Danijela Domljan	243
Management of the Project of Traditional Estate Adaptation into Object of Village Tourism	
34. Marko Dušak	251
Improvements to the Production Management System of Wood-processing in Small and Medium Enterprises	