

Mechanical Properties Estimation by Non-destructive Testing of Irish Hardwood Round Timber from Thinnings for Construction Purposes

Daniel F. Llana¹, Ian Short², Conan O’Ceallaigh³, Annette M. Harte⁴

^{1,3,4} Timber Engineering Research Group and Ryan Institute, National University of Ireland Galway, Ireland, ¹daniel.llana@nuigalway.ie, ³conan.oceallaigh@nuigalway.ie, ⁴annette.harte@nuigalway.ie

² Forestry Development Department, Teagasc, Ashtown, Dublin, Ireland, ian.short@teagasc.ie

Keywords: hardwood thinning, non-destructive testing (NDT), small round timber

ABSTRACT

Thinning involves the removal of competitors of high quality trees, and trees for extraction racks, all to favour the growth of the selected trees. Many felled trees are small-diameter and in Ireland hardwood thinnings are mainly used for energy production (DORAN 2012; MOCKLER 2013) or for wood-based panels or in the pulp industry (CAMPION AND SHORT 2016). Since the 1990’s the Irish Government has been encouraging private owners to combine agricultural and forest commercial activities. Grant aid was initially provided each year for the first 20 years (nowadays 15) in order to compensate the loss of agricultural land use. Furthermore, the first and second hardwood thinning is also grant aided. There is commercial value in seeking to use hardwood thinnings in higher value-added end uses as structural components within the construction industry and to develop its volume use in local rural industry (WOLFE AND MOSELEY 2000; CUMBO ET AL. 2004; GORMAN ET AL. 2016). The Exploitation And Realisation of Thinnings from Hardwoods (EARTH) project aims to investigate potential added-value uses of hardwood thinnings and develop a grading system for sorting into different classes, estimating mechanical properties using non-destructive testing (NDT).

Materials and methods

38 first and second thinning trees and round timber obtained from four Irish hardwood species (common alder, European ash, European birch and sycamore) were used. Time-of-flight (ToF) of acoustic waves over a 1 m length using Treasonic (Fakopp, Sopron, Hungary) device was measured on standing trees before felling. One log from the bottom part of the tree with a length 25 times its diameter was selected from each tree. According to some authors there are differences in static (MOE) and dynamic (Edyn) modulus of elasticity between bottom and top logs from the same tree (KRAJNC ET AL. 2016). The minimum diameter of selected logs was 8 cm. MTG (Brookhuis, Enschede, The Netherlands) was used to determine fundamental frequency in longitudinal direction on felled selected logs just after harvesting. After conditioning the roundwood at 65% relative humidity and 20°C, testing in four-point bending over a span of 18 times its diameter.

Results and discussion

Mechanical properties (bending strength, MOE and density) were determined in logs in order to characterize small round timber from thinnings for construction purposes. Regression models were developed to investigate the correlation between velocities obtained in standing trees and green selected logs from NDT (ToF and natural frequency) and mechanical properties obtained in conditioned logs by mechanical testing. In the regression models between acoustic velocity obtained by ToF on standing trees and mechanical properties, good correlation was found with MOE as other authors found in black poplar (CASADO ET AL. 2013). As result ToF

measurements could be considered a good method to segregate standing trees before felling them. Better correlation was found between acoustic velocity obtained in green selected logs by the resonance method and MOE as other authors showed in previous research (SANTA CLARA AND MERLO 2011).

Conclusions

Non-destructive testing measurements on standing trees and green logs are suitable methods to estimate the mechanical properties of the final product, in this study round hardwood timber. Good correlation between acoustic velocity obtained in standing trees from ToF using stress waves and mechanical properties was found. Better correlation between velocity obtained from natural frequency in green logs using a resonance device and mechanical properties was found. It is possible to develop a grading system based on NDT measurements for sorting hardwood thinnings into different end-use classes.

ACKNOWLEDGEMENTS

EARTH project has been funded by the Department of Agriculture, Food and Marine's Competitive Research Funding Programmes (COFORD). Project reference: 15C666.

REFERENCES

- CAMPION, J., SHORT, I. (2016) The uses of small-diameter roundwood from 1st and 2nd thinnings. Report. 44 p.
- CASADO, M.M., ACUÑA, L., BASTERRA, L.A., HEREDERO, S., SANMARTIN, R. (2013) Estimación de la calidad de la madera en rollo de *Populus x euramericana* mediante ultrasonidos. Proceedings of 6^o Congreso Forestal Español. June 10-14. Vitoria, Spain. 11p.
- CUMBO, D.W., SMITH, R.L., BECKER III, C.W. (2004) Value analysis of lumber produced from small-diameter timber. Forest Prod. J. 54(10):29-34.
- DORAN, M. (2012) Biomass resources in the island of Ireland. ICLRD briefing paper series. 10:1-8.
- GORMAN, T., MILLER, B., KRETSCHMAN, D. (2016) Wood I beams manufactured from small diameter logs. Proceedings of World Conference on Timber Engineering (WCTE 2016). August 22-25. Vienna, Austria. Pp. 1250-1257.
- KRAJNC, L., FARRELLY, N., HARTE, A.M. (2016) Mechanical characterisation of green Sitka spruce logs. Proceedings of Civil Engineering Research in Ireland Conference. August 29-30, Galway, Ireland. Pp 557-561.
- MOCKLER, N. (2013) Physical characterisation and quantification of total above ground biomass derived from first thinnings for wood fuel consumption in Ireland. Master thesis. Waterford Institute of Technology. 131 p.
- SANTA CLARA, O., MERLO, E. (2011) Acoustic segregation of *Pinus pinaster* logs for structural lumber production according to strength classes. Proceedings of 17th International Nondestructive Testing and Evaluation of Wood Symposium. September 14-16, Sopron, Hungary. P. 755.
- WOLFE, R., MOSELEY, C. (2000) Small-diameter log evaluation for value-added structural applications. Forest Prod. J. 50(10):48-58.



8TH HARDWOOD CONFERENCE
**WITH SPECIAL FOCUS ON "NEW
ASPECTS OF HARDWOOD
UTILIZATION - FROM SCIENCE TO
TECHNOLOGY"**

*25-26th October 2018
Sopron
Hungary*

*Hardwood Conference
Proceedings*

Volume 8

*Editors: Róbert Németh, Alfred Teischinger,
Peter Rademacher, Miklós Bak*

8TH HARDWOOD CONFERENCE

**WITH SPECIAL FOCUS ON “NEW ASPECTS OF HARDWOOD UTILIZATION - FROM
SCIENCE TO TECHNOLOGY”**

HARDWOOD CONFERENCE PROCEEDINGS

VOLUME 8

Editors: Róbert Németh, Alfred Teischinger, Peter Rademacher, Miklós Bak

Constant Serial Editors: Róbert Németh, Miklós Bak

8TH HARDWOOD CONFERENCE

WITH SPECIAL FOCUS ON “NEW ASPECTS OF HARDWOOD UTILIZATION - FROM
SCIENCE TO TECHNOLOGY”

HARDWOOD CONFERENCE PROCEEDINGS

VOLUME 8

Editors: Róbert Németh, Alfred Teischinger, Peter Rademacher, Miklós Bak

Constant Serial Editors: Róbert Németh, Miklós Bak

Responsible for publication: Tibor Alpár, vice rector for research and international affairs, University of
Sopron

Publisher: University of Sopron Press, Sopron, Hungary



Sopron, 2018

Acknowledgement to COST

COST is an EU-funded programme that enables researchers to set up their interdisciplinary research networks in Europe and beyond. The COST Association provides funds for organising conferences, meetings, training schools, short scientific exchanges or other networking activities in a wide range of scientific topics. By creating open spaces where people and ideas can grow, COST Actions unlock the full potential of science.

Now, the 8th Hardwood Conference has the pleasure to be linked with one of the current COST Actions, **FP1407**: Understanding wood modification through an integrated scientific and environmental impact approach (ModWoodLife).

As part of the interaction between this Action and Hardwood Conference, the following presenters have been provided with assistance for their involvement at this conference:

Pavlo Bekhta (Ukraine), Fatima Bouchama (Belgium), Lukas Emmerich (Germany), René Alexander Herrera Diaz (Spain), Edo Kegel (Netherlands), Edgars Kuka (Latvia), Andreja Kutnar, (Slovenia), Rastislav Lagana (Slovakia), Jaka Pečnik (Slovenia), Luigi Todaro (Italy), Nebojša Todorović (Republic of Serbia), Aleš Zeidler (Czech Republic)



ModWoodLife

Content

Plenary session	7
Hardwood resources, process chains, challenges and solutions	8
Alfred Teischinger, Christian Huber, Christian Hansmann	
Wood anatomy - the role of macroscopic and microscopic wood identification against illegal logging	10
Gerald Koch, Immo Heinz, Uwe Schmitt, Hans-Georg Richter	
Wood modification – different processes and their use in Europe	12
Dick Sandberg, Dennis Jones	
COST Action FP1407 “Understanding wood modification through an integrated scientific and environmental impact approach” - Building the network and impacts of COST Action's networking tools	14
Andreja Kutnar	
Teaming-up for the European Hardwoods Innovation Alliance (EHIA): Take your action!	15
Andreas Kleinschmit von Lengefeld, Uwe Kies	
Poster Discussion	17
Wood properties of <i>Paulownia</i> Clone in vitro 112.....	18
Szabolcs Komán, Sándor Fehér	
Macroscopic properties and density of Pannonia poplar from West Hungarian sites	20
Domonkos Ete Farkas, Norbert Horváth	
Cultivation of Black Locust Plantations.....	22
Dr. László Erdős	
The measurement of wood shrinkage and bark thickness on increment cores	24
Baptiste Kerfriden, Lucile Savagner, Kevin Dupont-Marin, Jean-Michel Leban	
Relationship between density and moisture content of firewood	26
Sándor Fehér, Máté Miklós, Dávid Major, István Schantl	
The visual classification and strength values of the oak wood from Borsod area in Hungary	28
Horváth Dénes	
Beech timber for structural purposes – relationship between outer log quality and inner timber quality.....	29
C. Fischer, F. Brüchert, U.H. Sauter	
Culture growth of <i>Phellinus contiguus</i> under laboratory conditions.....	33
István Eső, Norbert Horváth	
Performance amelioration of imported timber with environ-safe preservative ziboc	35
Sadhna Tripathi, Akhato Sumi, Sauradipta Ganguly	
Impregnation of <i>Tilia tomentosa</i> with paraffin.....	36
Szabolcs Komán, József Ábrahám, Dávid Varga, Udo Beck, Bence Katona	
The impact of heat treatment on the hardness of European birch wood.....	38
Vlastimil Borůvka, Aleš Zeidler, Tomáš Holeček, Roman Dudík	
Colour modification of poplar wood by steaming.....	40
Endre Antal Banadics	
Thermal properties of thermo-treated native black poplar wood	42
Luigi Todaro, Giacomo Goli, Paola Cetera, Pietro Stefanizzi, Stefania Liuzzi, Antonio M. Pantaleo	

Sand abrasion testing of acetylated hornbeam (<i>Carpinus betulus</i> L.).....	44
Fanni Fodor, Róbert Németh	
Combined Longitudinal and Transversal Compression of Beech Wood	46
Mátyás Báder, Radim Rousek	
Complex assessment of the antioxidant capacity and polyphenol content of wood bark	48
Eszter Táló-Nebehaj, Levente Albert, Eszter Visi-Rajczi, Tamás Hofmann	
Fractioning of native oak into lignocellulosic materials as an alternative for a sustainable forest management	50
Sebastián Barriga, Leyre Sillero, Jalel Labidi, Eduardo Robles	
Microwave Hardwood Modification Application for Fast Lumber Drying (Technical-Economic Assessment)	51
Alexandra Leshchinskaya	
Determination of the cutting power in processing some deciduous wood species	53
Valentin Atanasov, Georgi Kovatchev	
Influence of the heat on the duration of curing adhesives for veneering.....	55
Vladimir Mihailov, Dimitar Angelski, Vasil Merdzhanov	
Bending strength of High-Density Fibreboards (HDF) Manufactured from Wood of Hard Broadleaved Species	57
Julia Mihajlova, Viktor Savov	
Occurrence of shake in oak (<i>Quercus</i> spp.) and its effect on flooring top-layer quality	59
Victor Grubíi, Jimmy Johansson	
The importance of forest management history in life cycle assessment (LCA) scope definition for currently harvested birch trees in Latvia	61
Edgars Kuka, Dace Cirule, Bruno Andersons	
The influence of saw setting and tensing on quality of beech bandsawing.....	63
Bartosz Pałubicki, Mariusz Horąa	

Parallel Session I.

Silvicultural aspects and material properties of hardwoods.....	65
Research Findings of High Quality Timber Producing Black Locust Breeding Activities	66
István Bach, Bálint Pataki, Jenő Németh, Sándor Horváth, Kálmán Pogrányi, Márton Németh	
Living with ash dieback - Silviculture systems for Irish ash	68
Ian Short, Jerry Hawe	
Potential of short-rotation aspen and willow biomass for novel products in bioeconomy: a demonstration project "AspenWill"	70
Rytkönen Peetu, Viherä-Aarnio Anneli, Hyväluoma Jari, Rasa Kimmo, Suhonen Heikki, Beuker Egbert, Möttönen Veikko, Jyske Tuula	
Demonstration of the database macroHOLZdata computer-aided identification and description of trade timbers	72
Gerald Koch, Immo Heinz, Hans-Georg Richter	
Moisture-dependent elastic characteristics of cherry wood by means of ultrasound and mechanical tests	74
Erik Valine Bachtiar, Peter Niemz	
Drying Characteristics of Sapwood, Discoloured Wood and Infected Wood of Box Elder (<i>Acer negundo</i> L)	76
Denis Plavčák, Željko Gorišek, Aleš Straže, Maks Merela	
Experimental determining of mass transfer coefficient during oak wood convective drying	78
Nikolay Skuratov	

Parallel Session II.

Chemical aspects of hardwood processing 80

Intensification process for the conversion of Kraft-hardwood lignin into small phenolic compounds.....	81
Javier Fernández-Rodríguez, Fabio Hernández-Ramos, Xabier Erdocia, María González Alriols, Jalel Labidi	
Polyols from lignin and sawdust of oak wood.....	83
Silvia Helena Fuentes da Silva, Itziar Egües, Jalel Labid	
Eucalyptus lignins as natural additive for healthcare.....	84
Oihana Gordobil, René Herrera, Marwa Yahyaoui, Jalel Labidi	
Characterisation of extractives from black alder.....	86
Kerstin Wagner, Stefan Willför, Herman Huber, Alexander Petutschnigg, Thomas Schnabel	
In-situ Micro and Nano mechanical investigations of compressed beech wood using Scanning Electron Microscope with Focused Ion Beam	88
Petr Klímek, Dariusz Tytko, Marek Dosbaba, Radim Rousek	
Chemical modification of <i>Eucalyptus nitens</i> using fatty acids	90
René Herrera, Oihana Gordobil, Pedro L. de Hoyos-Martinez, Jalel Labidi, Rodrigo Llano-Ponte	
Monitoring of time dependent ammonia emissions in smoked oak using FTIR spectroscopy.....	92
Elfriede Hogger, Klaus Bauer, Eva Höllbacher, Notburga Gierlinger, Johannes Konnerth, Hendrikus W. G. van Herwijnen	

Parallel Session III.

Wood modification I. 94

Mechanical Properties of Thermally Treated Beech Wood in Compression Parallel to the Grain	95
Tomáš Andor, Rastislav Lagaňa	
Fracture toughness of thermally modified wood in mode II	97
Václav Sebera, Miguel Redon, Martin Brabec, David Děcký, Petr Čermák, Jaromír Milch, Jan Tippner	
Static and dynamic performance of wood modified with phenol formaldehyde	99
Jaka Gašper Pečnik, Hannes Schwager, Matthew Schwarzkopf, Holger Militz	
Alteration of mechanical properties of ammonia treated and densified beech (<i>Fagus sylvatica</i> L.).....	101
Herwig Hackenberg, Mario Zauer, Tobias Dietrich and André Wagenführ	
Changes in Hardness as a Result of Longitudinal Wood Compression.....	103
Mátyás Báder, Róbert Németh, Ágnes Vörös	
Added value and utilization of untreated and heat-treated poplar (<i>Populus spp. L.</i>) with and without treatment with N-methylol compounds.....	105
Lukas Emmerich, Holger Militz	

Parallel Session IV.

Machining & Manufacturing.....	107
Development of strategies for economic use of bark stripped beech wood	108
Ruven Hänslér, Matthias Zscheile	
Development of a new method for calculating the resulting cutting force using beech as an example.....	110
Thomas Krenke, Carina Rößler, Stephan Frömel-Frybort	
Determination of vibration during milling process of some deciduous wood species	112
Georgi Kovatchev, Valentin Atanasov	
Optimisation of Sawing Strategies for Hardwood using a CT-Scanner.....	114
Carina Rößler, Jörn Rathke, Martin Riegler	
Influence of veneer specie on the duration of veneering.....	116
Dimitar Angelski, Vasil Merdzhánov, Vladimir Mihailov	
Enhancing the fire resistance of poplar (<i>Populus cv. euramericana</i> l214) by using different fire retardants.....	118
Fatima Zohra Brahmia, Tibor Alpár, Péter Horváth György	

Parallel Session V.

Wood modification II.....	120
Properties of less valuable parts of beech and sessile oak wood after thermal modification	121
Nebojša Todorović, Zdravko Popović, Goran Milić, Marko Veizović	
Surface Wetting in Thermally Modified Beech Wood	123
Jozef Kúdela, Tomáš Andor, Rastislav Lagaňa, Csilla Csiha	
Improvement of the dimensional stability of wood by nanosilica treatments.....	125
Miklós Bak, Róbert Németh	
FTIR Analysis of Densified and Steamed Beech Wood	127
Radim Rousek	
Photodegradation of acetylated wood irradiated by xenon lamp and mercury-vapour lamp	129
Fanni Fodor ¹ , Róbert Németh	
Effect of High Intensity Microwaves to Hardwood Structure Modification and Its Applications in Technology	131
Grigory Torgovnikov and Peter Vinden	

Parallel Session VI.

Hardwood in composites and engineered materials.....	133
Utilization of Lesser Known and Lesser Used Hardwoods for Decorative Veneers Purposes ...	134
Roman Réh	
Production of peeled veneer from black locust Pretreatment - Production - Properties	136
Peter Meinschmidt, Christian Dittrich, Dirk Berthold	
Factors influencing cold tack development during the production of birch plywood	138
Elfriede Hogger, Wolfgang Kantner, Johann Moser, Johannes Konnerth, Hendrikus W. G. van Herwijnen	
Heat transfer through the wood layers in the process of veneering of particle board in the hot presses.....	140
Vasil Merdzhánov, Dimitar Angelski	

Physical Indicators of High-Density Fibreboards (HDF) Manufactured from Wood of Hard Broadleaved Species	142
Julia Mihajlova, Viktor Savov	
Machinability of birch compared to pine and wood-plastic composites in routing	144
Ossi Martikka, Timo Kärki	

Parallel Session VII.

Surface coating and bonding characteristics of hardwoods 146

Surface quality and adherence of thermally compressed and finished birch wood	147
Pavlo Bekhta, Tomasz Krystofiak	
Glossiness of coated alder wood after artificial aging	149
Emilia-Adela Salca, Tomasz Krystofiak, Barbara Lis	
Improvement of ash (<i>Fraxinus Excelsior L.</i>) bonding quality with one component polyurethane adhesive and hydrophilic primer for load bearing application	151
Peter Niemz, Gaspard Clerc, Joseph Gabriel, Dario Salzgeber, Thomas Strahm, Frederic Pichelin	
Structural hardwood bonding and the impact of wood accessory compounds	153
Stefan Bockel, Steffen Harling, Johannes Konnerth, Peter Niemz, Frédéric Pichelin	
Adhesives for Fast Heated Bondlines in Structural Timber-Concrete-Composite Joints	155
Malte Mérono, Carola Link, Gregor Wisner, Elisabeth Stammen, Klaus Dilger, Artur Ginz, Werner Seim	
Birch for engineered timber products.....	157
David Obernosterer, Georg Jeitler, Manfred Augustin	

Parallel Session VIII.

Hardwood in construction 159

Mechanical Properties Estimation by Non-destructive Testing of Irish Hardwood Round Timber from Thinnings for Construction Purposes	160
Daniel F. Llana, Ian Short, Conan O’Ceallaigh, Annette M. Harte	
Mechanical evaluation of French oak timber for use in construction: relation between origin of logs, properties of boards and behaviour of glued laminated products.....	162
Guillaume Legrand, Didier Reuling, Jean-Denis Lanvin, Morgan Vuillermoz, Carol Faye	
Mechanical characterization of French hardwood species for their integration in Eurocodes 5.....	164
Thibault Benistand, Laurent Bleron, Jean-françois Bocquet	
Strength grading of hardwood structural timber	166
P. Schlotzhauer, S. Bollmus, H. Militz	
Cross laminated timber development with Catalan sweet chestnut	168
Marcel Vilches-Casals, Eduard Correal-Mòdol, Carmen Iglesias-Rodríguez	
Innovative processing technologies of inferior beech assortments for the production of lamellas for glulam production “InnoBuLa”	170
Alexander Englberger, Matthias Zscheile	

Parallel Session IX.

New hardwood product approaches 171

Technology Road Map for Hardwood in Lower Austria 172
Christian Hansmann, Christian Huber, Alfred Teischinger

Extended Utilization of Forest Production & Wood Material:
Hardwood Usage from Native Properties to Wood Modification 174
Peter Rademacher, Radim Rousek, Petr Pařil, Jan Baar, Stanislav Horníček, Zuzana
Paschová, Róbert Németh, Tamás Hofmann, Fanni Fodor, Gerald Koch, Andreja Kutnar

European Hardwoods Innovation Alliance: first results of a European survey on hardwoods
research needs and priorities 176
Barbara Rovere, Ana Slavec, Uwe Kies

Parallel Session X.

Product design and marketing initiatives 178

Thermal modification of lesser-known wood species with the hygrothermolytic
FirmoLin® process 179
Edo Kegel, Wim Willems

Eucalyptus globulus single family house in Spain after 16 years of exposure 181
David Lorenzo¹, Juan Fernández-Golfín, Manuel Touza, Alfonso Lozano

How to enrich forest information by the analysis of the hardwood selling prices from
public forests? 183
Jean-Michel Leban, Lucile Savagner, Jean-Baptiste Schwebel, Holger Wernsdorfer,
Jean-Daniel Bontemps