Influence of growth parameters on mountain pine wood properties

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1 Introduction

Mountain pine (*Pinus uncinata* Ramon ex DC) is an important forest species in the Pyrenean Mountain, both in France and Spain [1]. In a project dealing with its use as timber [2], physical and mechanical tests were performed on clear wood specimen.
Wood properties are determined both by genetics (species and provenance) and by growth adaptation to the tree's environnement through variations in ring width (RW), basic density (BD), microfibril angle (MFA) and chemical composition of the cell wall matrix. The square of sound speed called here specific modulus (SM) is a good proxy for MFA [3] and fibre saturation point (FSP) can be a proxy of chemical composition of the cell wall.
Shrinkage parameters: total radial (RS), tangential (TS), volumetric (VS) as well as shrinkage anisotropy (SA=TS/RS) are important physical properties for timber use. Longitudinal modulus of elasticity (MOE), resistance to compression (CS) and deformability (strain limit before damage beginning in compression) are key mechanical properties both for tree mechanics and timber technology.
All these properties are known to vary, even in a given species, often up to two or threefold, mostly due to adaptation to growth condition, and this is a drawback for timber use. This presentation will focus on the links between variations of growth parameters and wood properties with the objective to build regression models of properties.

2 Measurements

The study was conducted on 183 rods of clear wood, issued from 62 trees that have grown in 9 different forest plots. Each rod was initially cut from dried boards with dimensions 500 mm x 20 mm x 20 mm in L, R and T directions, respectively. These rods and further samples cut from them were kept in a regulated room at standard conditions (65% RH, 20 °C).
From each of these rods were cut one shrinkage specimen (10 mm x 20 mm x 20 mm LRT), one compression specimen (60 mm x 20 mm x 20 mm LRT) and one vibration specimen (360 mm x 20 mm x 20 mm LRT).
Shrinkage specimen was used to measure FSP and shrinkage properties (RS, TS, VS, SA) using the following procedure: i) measurement of mass and dimensions at each step, ii) total rehydration, hygroscopic equilibrium at 4 different climates more and more dry, total dehydration at 103 °C in oven. Wet dimensions were the basis to calculate shrinkage while anhydrous mass was the basis to calculate equilibrium wood moisture content at each step. FSP was obtained using the linear regression between surface diminishing and moisture content. Basic density can be calculated as the ratio between anhydrous mass and wet volume.
Beam specimen have allowed to measure the Specific modulus (SM) by a free flexural vibration test using Timoshenko equation, after measurement of specimen mass, dimensions

and 3 first eigenfrequencies [4] [5]. Standard density (SD) was also calculated from these data allowing to calculate MOE=SM*SD.
Compression specimen was used to measure compressive strength (CS) in a quasi-static standard test. The ratio SL=CS/MOE was calculated as a proxy for deformability.

3 Results

Table 1 describes the relationships between parameters and properties, while table 2 gives the result of multilinear stepwise regressions used as models to predict properties from growth indicators. Ring width never appears as efficient explaining parameter. Apart from tangential shrinkage and shrinkage anisotropy, the models are able to predict 70% or more of properties variations opening the way to efficient sorting.

Tab. 1 Matrix of the regression coefficient R^2 between parameters and indicators.

Data	RW	BD	FSP	SM	RS	TS	VS	SA	MOE	CS	SL
RW	**100%**										
BD	0,0%	**100%**									
FSP	2,8%	0,0%	**100%**								
SM	5,8%	1,3%	2,0%	**100%**							
RS	1,3%	28%	31%	36%	**100%**						
TS	0,6%	11%	21%	32%	46%	**100%**					
VS	1,0%	21%	30%	40%	82%	86,2%	**100%**				
SA	0,7%	17%	21%	15%	72%	5,0%	31,3%	**100%**			
MOE	3,7%	31%	3,0%	75%	60%	40%	58%	29%	**100%**		
CS	2,9%	57%	0,5%	21%	48%	25%	41%	27%	57%	**100%**	
SL	1,1%	0,0%	2,8%	67%	16%	16%	19%	5,0%	48%	0,6%	**100%**

Tab. 2 Multilinear stepwise regressions featuring for each explained parameter (first line in bold character) the used indicators in the entering order and the progressive regression coefficient R^2

TS	R^2	**RS**	R^2	**VS**	R^2	**SA**	R^2	**CS**	R^2	**SL**	R^2
SM	0,32	*SM*	0,36	*SM*	0,40	*FSP*	0,21	*BD*	0,58	*SM*	0,67
FSP	0,46	*FSP*	0,58	*FSP*	0,62	*BD*	0,38	*SM*	0,72		
BD	0,54	*BD*	0,81	*BD*	0,78	*SM*	0,46				

References

[1] *Inventaire National Forestier* - French national forest inventory: raw data and results of the campaigns from 2009 to 2013 - http://inventaire-forestier.ign.fr/spip/

[2] *Projet UNCI'PLUS* - project for the management of the forest stands and enhancement of Mountain pine wood value - http://www.unciplus.eu/

[3] Brémaud I., Ruelle J., Thibaut A., & Thibaut B. (2013). *Changes in viscoelastic vibrational properties between compression and normal wood: Roles of microfibril angle and of lignin.* Holzforschung, *67*(1), 75-85.

[4] Bordonné P.A. (1989) Module dynamique et frottement intérieur dans le bois. Mesures sur poutres flottantes en vibrations naturelles. PhD, Wood Science. Nancy, Institut National Polytechnique de Lorraine. pp.109.

[5] Brancheriau L., Baillères H. (2002) Natural vibration analysis of clear wooden beams: a theoretical review. Wood Sci. Technol. 36:347 – 365.