Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 82, 2013: 330-334
(Ann. WULS - SGGW, For. and Wood Technol. 82, 2013)

Coefficient of optimal structure in relation to the compression strength parallel to grain of Scots pine (*Pinus sylvestris* L.) wood

MARCIN JAKUBOWSKI, JAROSŁAW SZABAN, WOJCIECH KOWALKOWSKI
Poznan University of Life Sciences , Department of Forest Utilisation,

Abstract: *An attempt at appraisal of softwood quality based on coefficient of optimal structure (COS)*. The aim of this study was to find a correlation which exists between coefficient of optimal structure (COS) and compression strength parallel to grain of Scots pine wood (*Pinus sylvestris* L.). Wood for test were taken from a54 years old pine stand damaged by wind. Research was carried out in two variants of test according to moisture content: first for absolute dry wood (dry wood) and second above saturation moisture point (wet wood). A weak correlation was found between the coefficient of optimal structure (COS), and compressive strength for both type of samples wet and dry. Spearman correlation coefficient ranged from 0.4 (wet samples) to 0.5 (dry sample).

Keywords: wood structure, wood properties, wood macrostructure, optimal structure

INTRODUCTION

The aim of this study was to find a correlation which exists between coefficient of optimal structure (Jakubowski 2010) and compression strength parallel to grain of Scots pine wood (*Pinus sylvestris* L.). Research was carried out on trees damaged by wind. Timber from trees broken by wind is characterized by the presence of numerous defects and mechanical damages. (Dunham, Cameron 2000, Pazdrowski, Spława-Neyman 2000) Its research is difficult because of the simplified method for selecting trees (only damaged trees) and difficult way to harvesting wood and prepare sample for tests. The study of some properties of damaged wood were carried out in Polish in recent years (Jakubowski and Pazdrowski 2005, 2006). A small amount of disturbances have been found in the structure of wood in the area immediately adjacent of the damage. A lot of work in the world concerns the question of modeling the resistance of trees to strong wind and disaster prevention methods (Zajączkowski 1991, Peltola et al. 1996, 1999, 2000, Ancelin et al. 2004, Tomczak et al. 2012). Most of the publications takes into account forest or environmental factors (characteristics of stands), while there are few works on the properties of wood. There are small amount of works focused on relation between wood and biometric features of tree. Some researchers take the study biomechanics of trees (Jelonek et al.2013) where the properties of wood are an essential element. In this studies tried to find a correlation between visual elements of the wood structure (COS possible for scanning) and compression strength, as a simple indicator of wood properties.

MATERIALS AND METHODS

The study was carried out on samples of wood from the Scots Pine tree stand at the age of 54 years. Pine accounted for 70% of the total volume of the stand, forest had 54 years, and growth on fresh mixed forest (according to polish classification of forest sites). Research area was located in the Forest District Przysucha in the central southern part of Poland. Examined eight trees damaged by wind. All of tested trees have broken trunk. The sample wood were taken from the 1,3 m height in two directions, according to direction of the wind breakage (compression and tension side of the stem). There were two variants of test according to moisture content: first for absolute dry wood (dry wood) and second above saturation moisture point (wet wood). Coefficient of optimal structure (COS) was calculated for each sample so wet and dry. In the statistical analysis due to abnormal distribution of population applied Spearman correlation.

COS = RLE/RW (coefficient of optimal structure)
RLE = Lw/Ew (ratio of width of latewood and early wood)
RW (ring width) – mean width of annual ring in sample

RESULTS

A total of 97 samples were tested with eight trees. The average value of COS was similar to the compression and tension side of trunk, so for wet and dry samples. Mean value ranged between 0,24 and 0,28 (Tab. 1). Extreme values amounted more than 1, these samples were few. The value over 1 indicates disturbances in the structure of wood (may indicate on reaction wood). The average compressive strength of the dry sample was closely 67 MPa and was almost three times higher than the strength of wet wood (25 MPa). The difference between a compressive and tensile side of trunk were small and not statistically significant. It can be concluded that trees have similar properties in all directions on the cross-section. Median was lower than the average in all variants of tests. This is a result of presence few samples extremely strong, which have no impact on the median, but increase the average. It is possible that these samples have included a compression wood or other disturbances. The aim of this work was to find a correlation between COS value and compression strength. COS is a parameter that contains information about the share of the total latewood, early wood and mean width of rings. This parameter was correlated with the different properties of wood, and as shown by Jakubowski (2010) shows a significantly higher correlation with the wood of spruce than pine. In these research on the wood of trees damaged by wind, weak correlation has been shown in all of tests. The Spearman correlation coefficients oscillate around 0.5 (Fig. 1,2). Scatter plots show that a relationship exists, but it is not clearly defined, it is not even the same type for compression and tension side (Fig. 1,2).

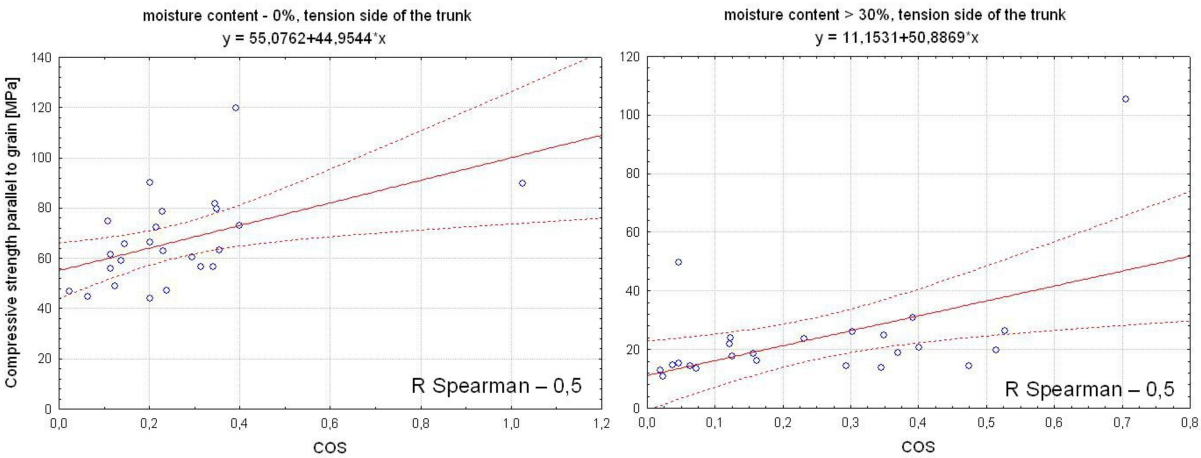

Fig. 1. Correlation between compressive strength parallel to grain and COS value on tension side of the trunk. Confidence interval 95% - the dotted line

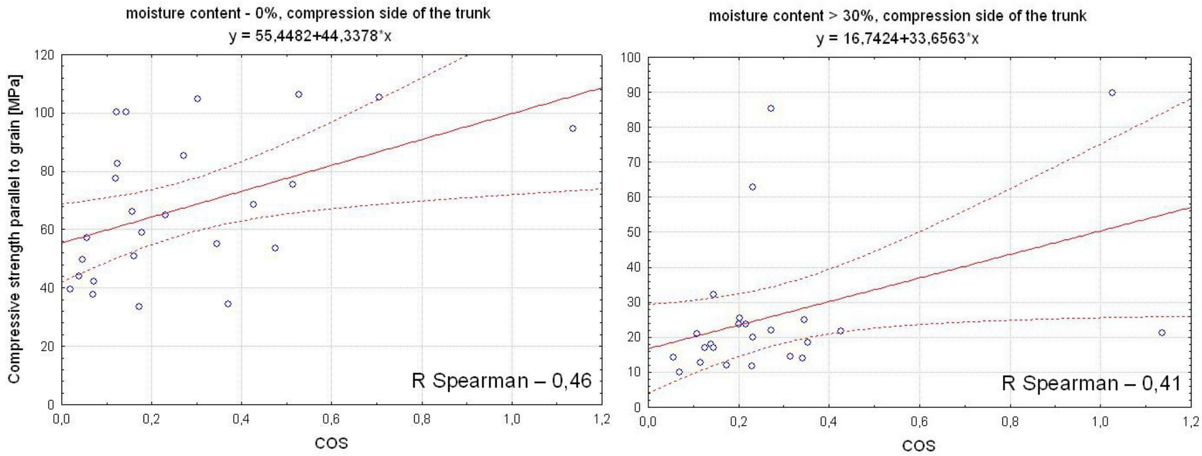

Fig. 2 Correlation between compressive strength parallel to grain and COS value on compression side of the trunk. Confidence interval 95% - the dotted line

Tab. 1 Compression parallel to grain and COS value. Basic statistic

Type of test		N	Mean	Median	Min	Max	Std. dev.
tension side	COS	24	0,26	0,22	0,02	1,03	0,20
	Strength [MPa], Moist.- 0%	24	66,63	62,98	44,09	119,70	17,62
	COS	24	0,25	0,20	0,02	0,71	0,19
	Strength [MPa], Moist.> 30%	24	23,67	18,81	10,89	105,42	19,19
compression side	COS	25	0,27	0,17	0,02	1,14	0,26
	Strength [MPa], Moist.- 0%	25	67,49	64,91	33,49	106,13	24,28
	COS	24	0,29	0,22	0,06	1,14	0,26
	Strength [MPa], Moist.> 30%	24	26,38	20,40	10,07	89,73	21,49

It seems that for dry samples regression line quickly rises, and for the wet samples very gently. This is the only signal, probably research on a larger scale help determine a final conclusions. Variety of strength value can be seen both at low COS value (0.01-0.2 typical for juvenile wood), as well as for higher COS values. However, in mature wood zone the compressive strength ranges much, which may be caused by compression wood and other anomalies in the wood. The study shows that the Scots pine wood has a structure with a significant variation with respect to visual features and mechanical properties. In the practice point of view COS seems to only a little suitable for the prediction of the compressive strength parallel to grain.

CONCLUSIONS

1. Average compressive strength of pine wood was 67 MPa for the wood tested in the absolutely dry state and 25 MPa for samples tested at a moisture above the fiber saturation point. The difference of strength is almost three times and shows the tremendous impact of moisture content of wood on his properties
2. A weak correlation was found between the coefficient of optimal structure (COS), and compressive strength for both type of samples wet and dry. Spearman correlation coefficient ranged from 0.4 (wet samples) to 0.5 (dry sample).

3. Wood structure of Scots pine has highly variable properties on the cross section both in juvenile wood part of the stem and mature wood.

REFERENCES:

1. ANCELIN, P., COURBAUD, B., FOURCAUD, T. Y. 2004: Development of an individual tree-based mechanical model to predict wind damage within forest stands. Forest Ecol. Manag. 203 (1-3): 101-121.
2. DUNHAM R., CAMERON A.D. 2000: Crown, stem and wood properties of wind-damaged and undamaged Sitka spruce. Forest Ecol. Manag. 135: 73-81.
3. JAKUBOWSKI M. 2010: Promieniowa zmienność makrostruktury drewna wiatrołomów sosny zwyczajnej (*Pinus sylvestris* L.) i świerka pospolitego (*Picea abies* Karst.) w relacji do niektórych właściwości drewna. Rozprawy naukowe 407, Wyd. UP w Poznaniu.
4. JAKUBOWSKI M. PAZDROWSKI W. 2005: Wood defects accompanying widbreaks of Scots pine (*Pinus sylvestris* L.): trees. Ann. Warsaw Univ. Life Sci. – SGGW. For. Wood Technol. 56: 286-290.
5. JAKUBOWSKI M. PAZDROWSKI W. 2006: The bending static strength of Scots pine (*Pinus sylvestris* L.) wood comes from the trees damaged by the wind. Ann. Warsaw Univ. Life Sci. – SGGW. For. Wood Technol. 58: 362-366.
6. JELONEK T. 2013: Biomechaniczna stabilność drzew a wybrane właściwości fizyczne, mechaniczne i strukturalne ksylemu sosny zwyczajnej (*Pinus sylvestris* L.) wyrosłej w warunkach gruntów porolnych i leśnych. Rozprawy naukowe 455, Wyd. UP w Poznaniu.
7. PELTOLA H. 1996: Swaying of trees in response to wind and thinning in stand of Scots pine. Boundary-Layer Meteorol. 77: 285-304.
8. PELTOLA H., GARDINER B., KELLOMÄKI S., KOLSTRÖM T., LÄSSIG R., MOORE J., QUIN CH., RUEL J-C. 2000: Wind and other abiotic risks to forests. Introduction. For. Ecol. Man. 135: 1-2.
9. PELTOLA H., KELLOMÄKI S., VÄISÄNEN H., IKONEN V.-P. 1999: A mechanistic model for assessing the risk of wind and snow damage to single trees and stands of Scots pine, Norways spruce and birch. Can. J. For. Res. 29 (6): 274-280.
10. TOMCZAK A., JELONEK T., JAKUBOWSKI M. 2012: Zmiany w budowie i właściwościach drewna jako efekt oddziaływania wiatru na drzewa. Sylwan 156 (10): 776−783.
11. ZAJĄCZKOWSKI J. 1991: Odporność lasu na szkodliwe działanie wiatru i śniegu. Wydawnictwo Świat.

Streszczenie: *Współczynnik optymalności struktury w relacji do wytrzymałości na ściskanie wzdłuż włókien drewna sosny zwyczajnej* (*Pinus sylvestris L.*). Celem pracy było znalezienie korelacji jaka zachodzi między współczynnikiem optymalności struktury (COS), a wytrzymałością na ściskanie wzdłuż włókien drewna Sosny zwyczajnej (*Pinus sylvestris* L.) pochodzącej z drzew złamanych przez wiatr. Badania zostały przeprowadzone na próbkach pobranych z wysokości pierśnicy. Do badań wyselekcjonowano 8 drzew. Próbki badano w dwóch wariantach: przy wilgotności powyżej punktu nasycenia włókien i przy wilgotności drewna bliskiej 0%. Średnia wytrzymałość na ściskanie drewna sosny wyniosła 67 MPa dla drewna badanego w stanie absolutnie suchym i 25 MPa dla próbek badanych przy wilgotności powyżej punktu nasycenia włókien. Stwierdzono słabą korelację między współczynnikiem COS, a wytrzymałością na ściskanie zarówno dla próbek mokrych jak i suchych. Współczynnik korelacji Spearmana wynosił od 0,4 (próbki mokre) do 0,5 (próbki suche).

Corresponding author:

Marcin Jakubowski PhD
Poznań University of Life Science,
Department of Forest Utilization,
ul. Wojska Polskiego 71A,
60-625 Poznań,
Poland
e-mail: marcin.jakubowski@up.poznan.pl)