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Correlation between the share of latewood and the density of sawn timber from the Silesian Forestry Region

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Abstract: *Correlation between the share of latewood and the density of sawn timber from the Silesian Forestry Region.* The paper describes the results of density measurements and the share of latewood in pine wood samples (*Pinus sylvestris* L.) from the Silesian Forestry Region in Poland. The samples were obtained from sawn timber from different kinds of log: butt, middle and top. The place from which the timber was obtained (three different log kinds) was taken into account when assessing the correlation between wood density and the share of latewood.

Keywords: pine wood, Silesia, latewood proportion (LWP), density.

INTRODUCTION

Wood is used in civil engineering as a construction material. One of the basic requirements is that wood needs to have specific resistance parameters, which means that it has to be strength graded. Visual strength grading consists in inspecting each piece of timber closely and classifying it in the appropriate strength grade, on the basis of the defects of wood structure, shape and processing present in the given piece of timber. The following wood defects were taken into account: knots, twisted fibres, cracks, resin pockets, inbarks, wounds, rot, insect tunnels and compression wood. One of the criteria for visual strength grading is the width of annual growth rings of the timber being sorted. The standards of visual strength grading specify the maximum permitted average width of annual growth rings, at the same time indicating the manner of measuring this parameter. According to the German standard for visual strength grading: DIN 4074-1:2012 Sortierung von Nadelholz nach der Tragfähigkeit. Nadelschnittholz, the maximum permitted average growth ring width amounts to 4 mm for the highest class S13, and 6 mm for the medium class S10 and for the low quality class S7. These requirements refer to beams with square cross-section, boards and round beams edgewise bent. Douglas fir has slightly different requirements: growth ring width up to 6 mm in class S13, and up to 8 mm in S10 and S7. The manner of measuring the annual growth rings is specified in DIN-EN 1310:1997 Rund- und Schnittholz – Messung der Merkmale. The same requirements concerning the growth ring width can be found in the Austrian standard ÖNORM-DIN 4074-1:2012 Sortierung von Nadelholz nach der Tragfähigkeit. Nadelschnittholz.

According to the Slovak standard, STN 49 1531:2001+Z1:2006 Drevo na stavebné konštrukcie. Časť 1: Vizuálne tredienie podľa pevnosti; structural timber is classified in one of the three grades: S0, SI or SII. The best class, S0, allows annual growth ring width of 4 mm as a maximum. The medium class, SI, allows growth ring width up to 6 mm. The average growth ring width is not limited for the lowest class, SII. The British standard, BS 4978:2007+A1:2011 Specification for visual strength grading of softwood, describes two classes of visually strength graded timber: a better class SS, and worse class GS. For the SS class, the average width of annual growth rings cannot exceed 6 mm, and in the GS class, it cannot exceed 10 mm. The manner of measurement of the annual growth rings is specified in BS-EN1310:1997 Round and sawn timber – Method of measurement of features. According to the Italian standard UNI 11035-2:2010 Legno strutturale Classificazione a vista dei legnami secondo la resistenza meccanica. Parte 2: Regole per la classificazione a vista secondo la resistenza meccanica e valori caractteristici per tipi di legname structurale, pine timber is classified in three grading classes: S1, S2, and S3. The requirements concerning growth rings are the following: for the best class, S1, the average annual growth ring width cannot exceed 6 mm, while for the remaining classes the average growth ring width cannot exceed 15 mm.

According to the standard binding in Poland for the process of visual strength grading, the PN-D-94021.2013, the KW class can include timber with average annual growth rings not larger than 4 mm, KS class - not more than 4 mm, and timber classified in the KG grade cannot have growth rings larger than 10 mm. In case of coniferous wood, it is known that wood with narrow growth rings has better resistance parameters than wood with wide growth rings. The width of annual growth rings is correlated with bending strength, modulus of elasticity (Buksnowitz et al. 2012) and wood density (Adamopoulos, 2009).

The width of annual growth rings is easy to measure and characterises the wooden raw material well. The measurement is performed on a section indicated on the cross section, in perpendicular to the annual growth rings.

The width of growth rings is often treated as an indicator of the technical properties of wood. Other researchers have investigated the correlations between the width of annual growth rings and wood density (Gartner, 2002), between the compressive strength parallel to the grain and the width of annual growth rings (Giagli, 2019), wood density, the annual growth ring width changes with tree age (Niklas, 1997), the height of the trunk (Tomczak et al. 2007), and position in the log's cross section (Gartner, 2002).

In our study, the width of growth rings was assessed in reference to the density of timber obtained from various kinds of logs (butt (O), middle (S), and top (W)).

CHARACTERISTICS OF THE RESEARCH MATERIAL

The material used in this research is pine timber from the Silesian Forestry Region in Poland. The timber has been acquired from lumber raw material about 120 years old. The timber was obtained from logs acquired from a young, mixed forest (Forest Inspectorate: Nadleśnictwo Olesno, Forest District: Leśnictwo Sternalice). The timber used in the research was obtained from sawn timber from three kinds of log: butt, middle and top. It was dried in an industrial chamber drier up to the moisture content of ca. 12%, and then planed on four sides. The nominal dimensions of the sawn timber after drying and planing were: 40 × 138 × 3500 mm. The batch of tested timber contained 210 pieces, 70 from each kind of log (butt, middle, top).

RESEARCH METHODOLOGY

Measurement of the width of annual growth rings and the share of latewood. One sample was obtained from each piece of timber. Their dimensions corresponded to the total cross section of the timber piece (nominal dimensions 40 x 138 mm). The size of samples measured along fibres was 25 mm. A measurement section was marked on each sample, in order to determine the annual growth ring width (in perpendicular to the growth rings), with a use of a microscope, the width of earlywood and latewood zones was measured (with the precision of 0.01 mm) according to PN−55/D−04110.

The share of latewood was determined.

$$LWP = \frac{LW}{(LW + SW)}$$

where:
LWP – late wood proportion [%]
LW – the total width of latewood zones within the measurement section [mm].
SW – the total width of earlywood zones within the measurement section [mm].

The density of timber and of the samples was determined with the stereometric method, in accordance with PN-D-04101:1977.

RESULTS AND ANALYSIS

The characteristic of the wood under research has been presented in Table 1 (timber density) and Table 2 (width of annual growth rings and share of latewood).

Table. 1. Characteristics of timber from different log types (butt, middle, top; O/S/W).

	Timber density [kg/m³]			
	Total	O	S	W
Average	547	575	527	483
Min	417	452	389	413
Max	764	682	663	612
Deviat.	62	54	60	45

The average density of timber is higher in butt logs (O) and gets gradually lower towards the top logs (W) (Tab. 1).

Table. 2. Width of annual growth rings and share of latewood in samples under research

	O		S		W	
	LWP_[%]	Width [mm]	LWP [%]	Width [mm]	LWP [%]	Width [mm]
Average	42	1.68	34	1.90	31	1.94
Min	30	0.66	22	0.60	20	0.67
Max	56	3.80	49	3.86	48	4.10
St. dev.	07	0.60	07	0.80	07	0.84

The tested samples had a small width of annual growth rings (below 2 mm on average) that increased slightly from 1.68 mm for timber from butt logs (O) to 1.94 mm for top logs (W) (Tab. 2).

A similar correlation was reported by Adamopoulos (Adamopoulos et al. 2009). The share of latewood in the samples gets smaller from butt (O) 0.42 to top (W) 0.31 (Tab. 2).

The correlation between wood density and the share of latewood has been presented in Figure no. 1. Together with the increase in wood density, the share of latewood gets higher. This correlation has been confirmed independently of the place from which the timber samples were obtained (butt (O), middle (S) or top (W)). A similar correlation was observed by Hébert (Hébert et al., 2016). For timber samples obtained from butt logs, this correlation is weak (R^2=0.172), while for middle and top log samples the R^2 parameter is significantly higher.

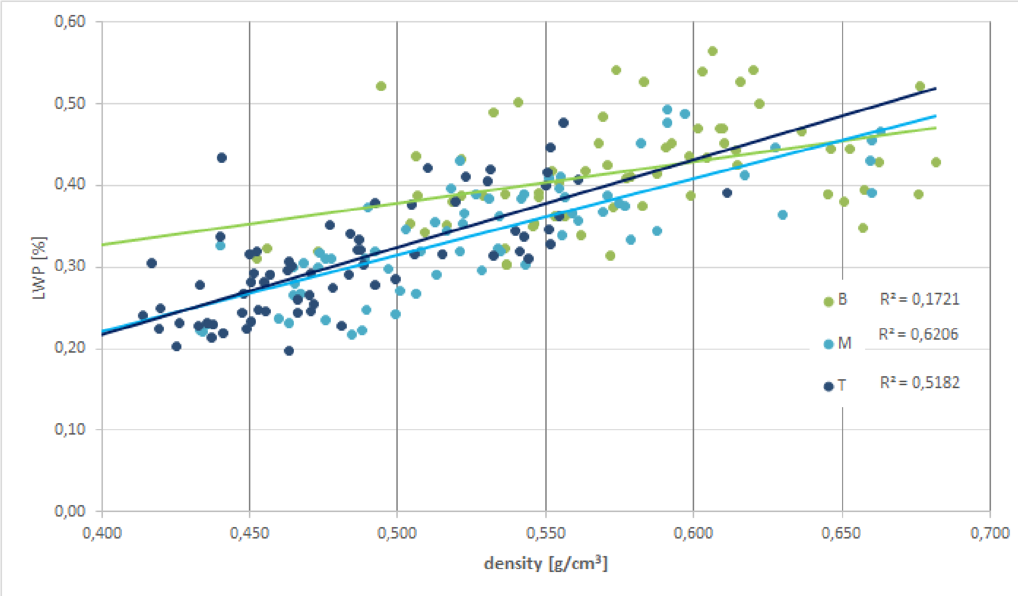

Figure 1. Correlation between the share of latewood and the density of sawn timber from butt, middle and top logs

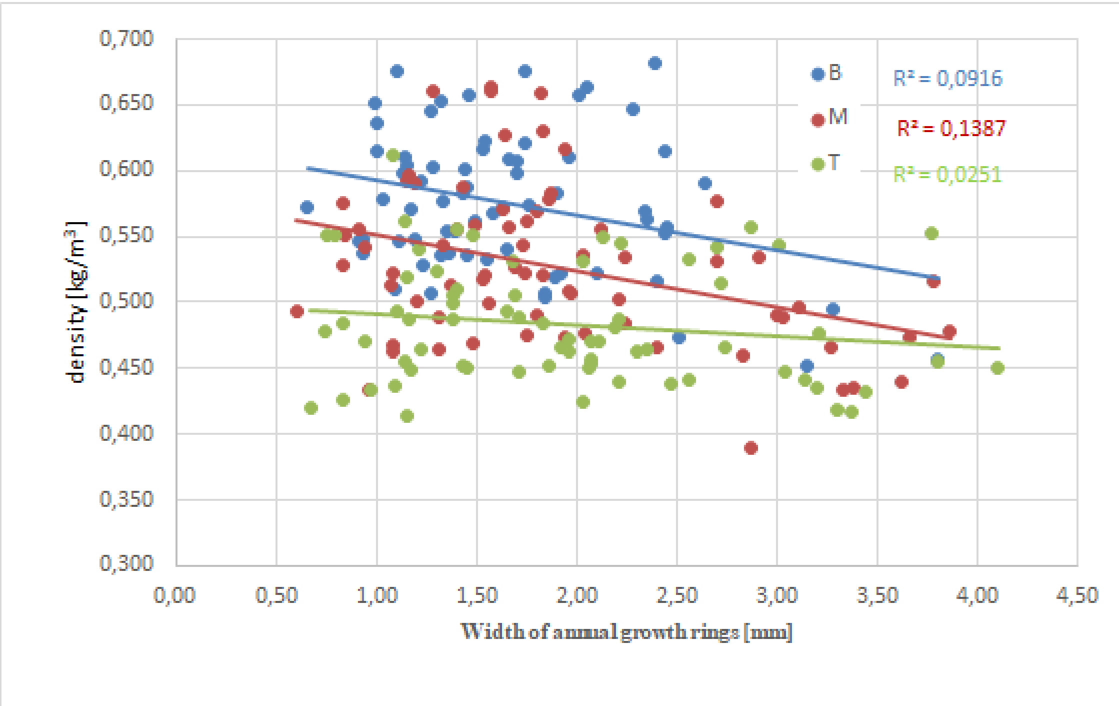

Figure 2. Correlation between the annual growth rings width and wood density

Additionally, the dependence between the annual growth rings width and wood density was also presented (Fig. 2). In all types of logs (B / M / T), density decreases with the increase of the width of annual growth rings. For the dependence between density and the annual growth rings width , R^2 is lower than in case of dependence between LWP and density.

CONCLUSION

1. the highest medium density of pine wood from the Silesian Forestry Region has been observed for timber from the butt logs (575 kg/m^3) and the lowest density, for timber/samples from top logs (483 kg/m^3).

2. The average width of annual growth rings in the timber under research fell in a range between 1.68 mm (for timber from butt logs) to 1.94 mm (for timber from top logs). The timber was characterised by narrow growth rings.
3. The share of latewood in the wood under research was the highest for timber from butt logs (0.42), and the lowest for timber from top logs (0.31).
4. The highest value of coefficient of determination between the density of wood and the share of latewood (0.6206) has been observed for wood from middle logs, and the lowest (0.1721) for butt log wood. The tested coefficient of determination for the timber from top logs amounted to 0.5182.

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Streszczenie: *Zależność pomiędzy udziałem drewna późnego a gęstością drewna tartacznego pochodzącego ze Śląskiej KP-L.* W pracy przedstawiono wyniki pomiarów gęstości drewna i udziału drewna późnego dla próbek drewna sosnowego pobranych z tarcicy pozyskanej z kłód odziomkowych, środkowych i wierzchołkowych pochodzących ze Śląskiej Krainy Przyrodniczo-Leśnej. Wraz z rosnącą gęstością drewna rośnie udział drewna późnego. Dla drewna strefy odziomkowej zależność jest słaba, dla stref środkowej i wierzchołkowej R^2 jest zdecydowanie wyższa. Charakter zmian dla części odziomkowej (O), środkowej (S) i wierzchołkowej (W) jest zbliżony.

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