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SHORT NOTICES

TIMBER STRENGTH GRADING OF *PINUS SYLVESTRIS* L. USING A VISUAL METHOD ACCORDING TO POLISH STANDARD PN-82/D-94021 AND GERMAN STANDARD DIN 4074

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ABSTRACT

Polish-grown *Pinus sylvestris* L. structural timber was strength graded according to Polish Standard PN-82/D-94021 and German DIN 4074. Dependencies between bending strength and density, modulus of elasticity and density and bending strength and modulus of elasticity for timber graded into Polish and German strength classes were determined after visual grading. Dependencies between knottiness coefficients determined by PN-82/D-94021 and DIN 4074: 2003 were also tested.

KEYWORDS: Structural timber, visual strength grading.

INTRODUCTION

Dynamical growth of structural timber application in building industry has been presented in Poland last years. Thanks to a modern production technologies and an application of preservation the techniques become continuously wider. Nowadays, not only individual houses are built from wood, but also multistoried buildings. Wood is not applied only for rafter framing (traditional and prefabricated), but also for frame types of walls (Gotych et al. 2009).

Because of the building safety regulations, structural timber must be strength-certified, which requires strength grading. Two basic methods of strength grading are used: visual and

machine-based grading. Visual method is commonly being used in Poland. The method is based on visual inspection of each board and according to the size of natural and machining defects.

Legal EU structural timber strength grading EN 14081 standard allows application of national strength grading standards, valid in the European countries, if they are not conflicting with EU 14081-1 standard. These standards are: Polish standard PN-82/D-94021, German standard DIN 4074-1: 2003, British standard BS 4978, Slovak standard STN 49 1531 and Austrian standard ÖNORM DIN 4074-1. Lots of Polish sawmills products including structural sawn timber are exported to Germany. The differences between Polish and German timber grading accordingly to the national standards make significant task. Wood Technology Faculty of Warsaw University of Life Sciences undertook a research based on the comparison of visual grading of structural timber in accordance to Polish Standard PN-82/D-94021 and German DIN 4074. The timber grading into three classes and a waste is used in both standards. There are KW, KS and KG classes for Polish standard and S13, S10 and S7 classes for German standard. The different methods of knottiness coefficient determination are incorporated for Polish and German standards. Based on the previously performed tests it was concluded that the knottiness determination grading results are similar despite of different methods. The fact that KW class of sawn timber has similar properties as S13 class lumber, KS class lumber has similar properties as S10 graded timber and KG graded timber has properties similar as S7 grade sawn timber (Krzosek 2009) was concluded in relation with knottiness grading. The connection between bending strength and density, modulus of elasticity and density and bending strength and modulus of elasticity for timber graded into classes according to Polish and German standard is examined in this work. Knottiness coefficient determined in accordance with PN-82/D-94021 and DIN 4074: 2003 was also tested.

MATERIAL AND METHODS

659 boards of commonly used dimensions of structural pine timber coming from five different Poland regions (Fig. 1) were used as a research material.

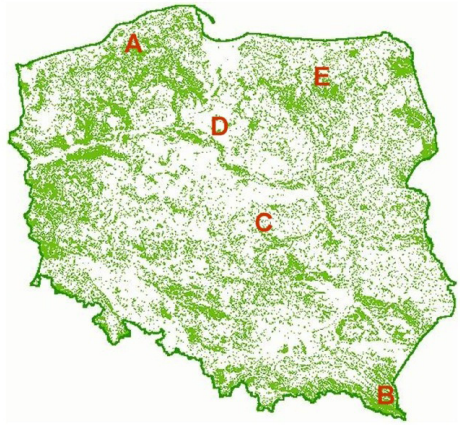


Fig. 1: The origin of the timber (Pinus sylvestris L.) used for the tests by sawmills and regions A- POLTAREX, Korzybie, B- DANKROS, Krościenko, C- TARTOM, Tomaszów Mazowiecki. D- TPPD, Brodnica, E- CDiOD, Kolonia.

The tests were based on a lumber knottiness determination in accordance to PN -82/D-94021 (Fig. 2) and DIN 4074-1: 2003 (Fig. 3).

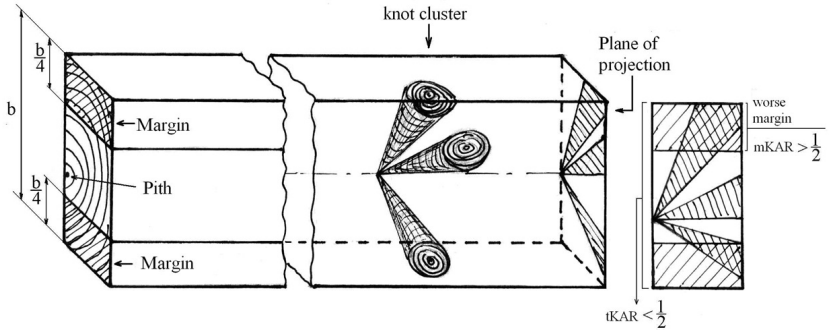
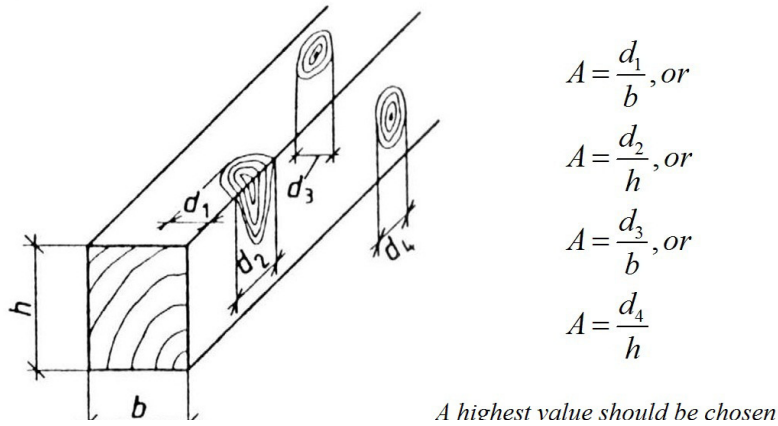


Fig. 2: Method of the knottiness coefficient determination (according to PN-82/D-94021).

According to the Polish Standard PN-82/D-94021, the ratio of a surface of knots which appears as weakest in the cross- section, and a surface of the entire cross-section of timber is a knottiness coefficient of the total cross-section of a given timber tKAR ($U_{sęk}$). The ratio of a surface of the knots located in worse margin and its surface area is a knottiness coefficient mKAR ($U_{msęk}$).

A combination of two coefficients mentioned above determines the class a given piece is assigned to.



$$A = \frac{d_1}{b}, or$$

$$A = \frac{d_2}{h}, or$$

$$A = \frac{d_3}{b}, or$$

$$A = \frac{d_4}{h}$$

Fig. 3: Knots measurement and the knottiness coefficient determination according to DIN 4074-1: 2003, d_1 – knot arc height on the edge, d_2, d_3, d_4 – knot diameters, b, h – cross-section dimensions.

In German standard a knottiness coefficient A is determined by ratio of appropriate knot dimension (diameter or arc height) depended on its placement and one of the section's dimensions. The highest value obtained is obligatory. Methods of the knottiness coefficient determination are different for squared timber, boards and planks. The method of knottiness determination for squared lumber, appropriate not only for squared lumber but also for boards and planks under vertical bending stress (width in vertical layer) is being used in the presented work.

RESULTS AND DISCUSSION

The dependencies of bending strength and density, modulus of elasticity and density and modulus of elasticity and bending strength of lumber graded according to Polish standard (KW, KS, KG) and the same timber graded according to DIN (S13, S10, S7) are shown in Tab. 1. All tested values as modulus of elasticity, bending strength and density were determined in accordance to EN 408 and verified by EN 384. The density of the timber was measured on the specimens that have represented the entire cross-section of the timber piece examined. The specimens were cut out from the surroundings of the rupture and the possible defects were omitted after determination of the elastic modulus and bending strength of the timber piece.

Tab. 1: Correlation coefficient R between modulus of elasticity and density, bending strength and density and modulus of elasticity and bending strength for structural lumber graded in accordance to PN–82/D–94021 and DIN 4074: 2003.

Relationship between	**Strength class according to PN – 82/D – 94021**			
	KW	**KS**	**KG**	**Reject**
DENEN 384 – MOREN 384	0.73	0.61	0.50	0.50
DENEN 384 – MOEEN 384	0.77	0.75	0.71	0.66
MOEEN 384 – MOREN 384	0,75	0,71	0,72	0,69
Relationship between	**Strength class according to DIN 4074: 2003**			
	S13	**S10**	**S7**	**Reject**
DENEN 384 – MOREN 384	0.62	0.70	0.69	0.51
DENEN 384 – MOEEN 384	0.69	0.81	0.80	0.60
MOEEN 384 – MOREN 384	0.74	0.80	0.82	0.69

The highest correlation coefficients were reached for KW according to Polish standard and S10 according to DIN as shown in Tab. 1. By Polish grading procedure values of correlation coefficients drop with grading class decreasing. The correlation coefficients for KS lumber are lower than KW lumber, but higher than KG lumber. Only the correlation coefficient between modulus of elasticity and bending strength for KG lumber grade are higher (0.72) than for KS grade (0.71). The correlation coefficients for higher S13 class are lower than for lower S10 and S7 class in case of DIN. The correlation coefficients of the relation between bending strength and density and the relation between modulus of elasticity and density are insignificantly lower than in case of the adequate S10. The difference between the coefficients was clearly higher in case of KS and KG. The correlation coefficient of the relation between modulus of elasticity and bending strength was highest for S7 with value 0.82 and lowest for S13 with value 0.74 in case of grading by DIN. The all correlation coefficients of timber graded as waste have the lowest values in depending on the sorting standard.

The dependencies between the knottiness coefficients determined in accordance to DIN 4074: 2003 and knottiness coefficients determined in accordance with PN–82/D- 94021: $U_{sęk}$, (Fig. 3) and $U_{m\ sęk}$ (Fig. 4) are shown in Fig. 4, 5.

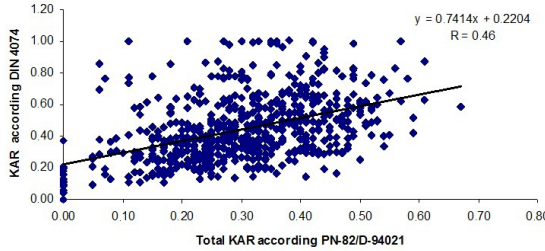


Fig. 4: Dependence between the knottiness coefficient according to DIN 4074: 2003 and the knottiness coefficient for whole cross-section $U_{sęk}$ (Total KAR) determined accordingly to PN – 82/D – 94021, for the same lumber (659 pieces).

The correlation coefficient R of regression between the knottiness coefficient determined in accordance to DIN and the knottiness coefficient of whole section $U_{sęk}$ determined by Polish standard (Fig. 4) is 0.46. The lower correlation coefficient value is caused by using the different methods of the knottiness coefficient determination, but results by knottiness determined by Polish and German standard were similar.

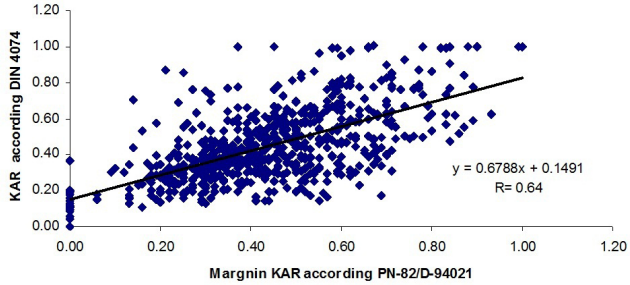


Fig. 5: Dependence between knottiness coefficient determined by DIN 4074: 2003 and worse margin knottiness coefficient Um sęk (Margin KAR) determined by PN – 82/D – 94021, for the same lumber lot (659 pieces).

The value of the correlation coefficient R of relation between the knottiness coefficient determined in accordance to German standard and worse margin knottiness coefficient $U_{m\ sęk}$ determined in accordance to Polish Standard (Fig. 5) is 0.64.

CONCLUSIONS

Based on the analysis above, it may be concluded that:

1) Polish-grown *Pinus sylvestris* L. structural sawn timber can be graded in accordance to Polish standard into the highest class – the KW correlation coefficients between bending strength and density, modulus of elasticity and density and between bending strength and modulus of elasticity were higher than the parallel correlation coefficients graded into highest class S13 in accordance to German standard. For both two other classes reverse numbers were obtained

2) The value of the correlation coefficient between knottiness coefficient $U_{m\ sęk}$ determined

in accordance to Polish standard and knottiness coefficient A coming from German standard is 0.64, determination coefficient between knottiness coefficient $U_{sęk}$ and knottiness coefficient A was lower and its value is 0.46.

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