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Properties of black poplar wood *(Populus nigra* L.*)* in terms of structural applications

ANDRZEJ NOSKOWIAK, GRZEGORZ PAJCHROWSKI, GRZEGORZ SZUMIŃSKI, LECHOSŁAW JABŁOŃSKI
Wood Technology Institute, Winiarska 1, 60-654 Poznań, Poland

Abstract: *Properties of black poplar wood (Populus nigra* L.*) in terms of structural applications*. The paper presents the results of research on structural timber with nominal cross-section of 50x150mm made of black poplar harvested from plantation in Mieczewo forest sub-district. After the test according to *EN 408* and the characteristic values calculation according to *EN 384* it was found that the timber with visual grades KS, and KW can be assigned to the strength classes C14 and C20 respectively.

Keywords: black poplar, structural timber, bending strength, strength grading

INTRODUCTION

All over the world acreage of plantations of trees of fast growing species is steadily growing. While in Poland opinions concerning tree cultivation on plantations are divided, the global trends are clear [1,2]. Due to the growing wood consumption in the world, plantations of fast growing trees will become economically important [3]. Proper utilization of such wood requires knowledge of its properties and differences between wood harvested on plantations and wood harvested in typical forest stands.

In Poland the use of hardwood in building is limited only to the oak wood and the very specific components of a building [4]. Other hardwood species such as poplar, ash, beech, alder and willow are used only exceptionally, in the absence of access to softwood, widely recognized as being more useful. Poplar wood is relatively often used in construction of farm buildings, mainly barns. This timber after drying under variable humidity hardens but remains lightweight and extremely durable (resistant to fungi and insects) [5].

Poplars are the fastest growing of all the trees in our climate zone. Therefore, with the constantly increasing demand for timber, foresters in different countries drew an attention to the poplars as the most promising fast growing tree species for planting. Particularly useful are hybrids of European black poplar and American black poplars (*Populus nigra* x *Populus deltoides* L Marsh.): *Populus* ‘Gelrica, Populus ‘I-214, *Populus* ‘I-154, *Populus* ‘Robusta, and *Populus* ‘Grandis [6,7].

Poplar tree plantations are established primarily for the purpose of processing in the industry of pulp and paper and wood-based panels [8,9]. It is recognized, however, the possibility of processing such timber in the sawmill industry, particularly for the production of products with lower quality requirements, e.g. for production of wooden packaging [10,11].

Research on mechanical properties of full-size structural components of poplar wood has not been carried out in Poland so far. It should be presumed that such studies have been performed in France and Germany since there is an assignment of visually graded poplar timber from these countries into appropriate strength classes in the standard EN 1912 "Structural Timber - Strength classes - Assignment of visual grades and species".

MATERIALS AND METHODS

Black poplar timber harvested from plantation (five trees in age of 35 years with DBH of 45±5 cm) was four-sided planed to final cross-section dimensions of 150 mm × 50 mm and kiln-dried to an average moisture content of 14.6%. Nominal length of boards was 4 m. The

timber was visual graded according to the standard *PN-D*-94021 and its basic properties were determined according to the methods described in relevant European Standards: moisture content by electrometric method according to *EN 13183-2*, weight, dimensions according to *EN 1309-1* and bending strength and modulus of elasticity according to *EN 408*.
On the basis of obtained results, calculations of the characteristic values, essential in determining the assignment of visual grades to the strength classes, were performed.

RESULTS
The results of visual grading are summarized in Table 1.

Table 1. Results of visual grading of tested black poplar timber (Source: [12])

Grade	pcs	%
Reject	17	22
KG	28	37
KS	21	27
KW	11	14
Total	77	100

Data presented in Table 1 shows that 17 boards (22%) of tested black poplar timber did not meet the minimum requirements for structural timber. Moreover, collected research material did not allow for performance of full strength tests according to the rules from the standard *EN 384* for each strength grade separately (the minimum sample size for one grade should not be less than 40 pcs).
Figure 1 shows dependence between the static bending strength of tested black poplar timber and its local modulus of elasticity for grades KW, KS and KG (without rejects).

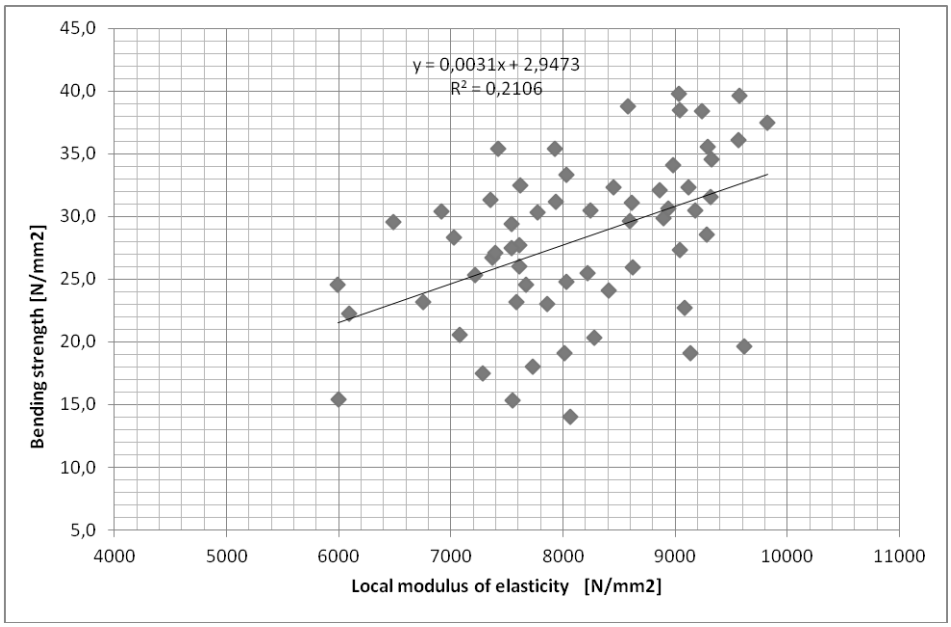

Figure 1. Relationship between bending strength and modulus of elasticity of tested black poplar timber (Source: [12])

Based on presented in Fig. 1 results, it is clearly visible that the correlation between bending strength and modulus of elasticity for tested timber exists, however, the value of coefficient of determination does not exceed 0.25. For dependence between bending strength and density even lower value of the coefficient of determination was found (below 0.01). Low values of these coefficients indicate that the strength of the tested timber depends on other

characteristics to a greater extent than on density. Presumably these are mainly knot indicators and slope of grain.
Based on detailed results of the tests, characteristic values of static bending strength, modulus of elasticity and density were calculated in accordance with the requirements of *EN 384*. The results of these calculations are presented in Tables 2, 3 and 4.

Table 2. Characteristic values of bending strength for black poplar timber with nominal cross-sectional dimensions of 50x150mm harvested from plantation in Mieczewo forest sub-district (Source: [12])

Grade	KG	KS	KW	Total
Number of pieces in the sample	28	21	11	60
Value of the 5th percentile of bending strength f_{05} [N/mm^2]	15.4	20.3	30.4	17.4
Value of k_s	0.73	0.71	0.66	0.80
Characteristic value of bending strength $f_{m,k} = f_{05} \cdot k_s$ [N/mm^2]	11.2	14.4	20.1	13.9
Strength class according to *EN 338*	–	**C14**	**C20**	**C14**

Table 3. Characteristic values of bending modulus of elasticity for black poplar timber with nominal cross-sectional dimensions of 50x150mm harvested from plantation in Mieczewo forest sub-district (Source: [12])

Grade	KG	KS	KW	Total
Number of pieces in the sample	28	21	11	60
Mean value of bending modulus of elasticity [kN/mm^2] adjusted to moisture content 12%	7.81	8.37	8.57	8.15
Strength class according to *EN 338*	**C27**	**C30**	**C30**	**C30**

Table 4. Characteristic values of density for black poplar timber with nominal cross-sectional dimensions of 50x150mm harvested from plantation in Mieczewo forest sub-district (Source: [12])

Grade	KG	KS	KW	Total
Number of pieces in the sample	28	21	11	60
Characteristic density [kg/m^3] adjusted to moisture content 12%	400	395	395	397
Characteristic value of density ρ_k [kg/m^3]	369	378	376	372
Strength class according to *EN 338*	**C20**	**C20**	**C20**	**C20**

Despite relatively small cardinality of the whole sample, and especially subsamples after visual grading, distinct differences in bending strength amongst the grades indicate usefulness of the grading rules developed for softwood (*PN-D-94021*) for black poplar and perhaps also for other hardwood species.

CONCLUSIONS

According to the rules for assigning of visually graded structural timber to the strength classes derived from the European standards, calculated characteristic values of bending strength, bending modulus of elasticity and density allowed to assign visual grades KS and KW to the strength classes C14 and C20 respectively and all grades together to the strength class C14.

Moreover, the results indicate the potential usefulness of black poplar (*Populus nigra* L.) sawn timber made of trees in the second and the older age classes from plantation for structural applications and usefulness of the Polish Standard for softwood grading also for grading of poplar timber. However, due to relatively small sample size acquired from only one population of trees, further research on poplar timber for structural applications including other varieties and populations is necessary.

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Streszczenie: *Właściwości drewna topoli czarnej w aspekcie zastosowań konstrukcyjnych*. W pracy przedstawiono wyniki badań topolowej tarcicy konstrukcyjnej o wymiarach 50x150mm wyprodukowanej z drzew topoli czarnej pozyskanych z 35-cio letniej uprawy plantacyjnej w Leśnictwie Mieczewo (RDLP Poznań). Po przebadaniu pozyskanej tarcicy topolowej według normy EN 408 i obliczeniu wartości charakterystycznych zgodnie z normą EN 384 stwierdzono, że tarcicy tej można przyporządkować następujące klasy wytrzymałościowe:

a) tarcicy sklasyfikowanej wizualnie jako KS – klasę wytrzymałościową C14,
b) tarcicy sklasyfikowanej wizualnie jako KW – klasę wytrzymałościową C20.

Corresponding author:

Grzegorz Pajchrowski, Winiarska 1, 60-654 Poznań, Poland
email: g_pajchrowski@itd.poznan.pl, phone: +48618492412