Mechanical properties of Polish-grown Pinus silvestris L. structural sawn timber

S. Krzosek[1], M. Grześkiewicz[2], M. Bacher[3]

[1] Faculty of Wood Technology, Warsaw University of Life Sciences – SGGW,
159 Nowoursynowska St., 02-787 Warsaw, Poland, slawomir_krzosek@sggw.pl
[2] Faculty of Wood Technology, Warsaw University of Life Sciences – SGGW,
159 Nowoursynowska St., 02-787 Warsaw, Poland, marek_grzeskiewicz@sggw.pl
[3] MiCROTEC GmbH, Julius Durst Straβe 98, 39042 Brixen (BZ), Italy, martin.bacher@microtec.eu

ABSTRACT

Tests of the Polish-grown Pinus silvestris L. structural sawn timber from five forestry regions have been carried out. Three sets of sawn timber were taken from each region, two sets with the same cross section, 50mmx120mm and 50mmx140mm, which is typical of the Polish structural sawn timber market, and the other sets with cross sections of 50mmx225mm, 75mmx175mm, 63mmx160mm, 38mmx200mm and 100mmx100mm. The length of the structural sawn timber boards used for testing was 4.5m for the 50mmx225mm cross section and 4.0m for the remaining tested material. Each set contained 50 boards. The total number of boards was 750 and their volume was about 24.5m^3. The sawn timber was not planed, which is typical of the Polish building materials market. Before the test, the sawn timber was dried to the humidity level of about 12%. First, the timber was measured with the grading machines GoldenEye-706, VISCAN and Timber Grader MTG. Then the knot size, average annual ring width and density were measured in the laboratory. A bending test was performed with the offline testing machine TiraTest 2300, with the maximum load of 100kN, to determine MOE (global, local) and MOR according to PN-EN 408. The paper presents the results both for all tested boards, and for particular forestry regions in Poland. It covers correlations between different methods of testing the mechanical properties of Polish-grown structural sawn timber.

INTRODUCTION

In accordance with EU regulations, starting from September 2008, "Standard PN-EN 14081. Timber structures – Strength graded structural timber with rectangular cross section. Part 1-4" was introduced for all EU members.
In all EU countries sawn timber can be graded visually according to national standards, as long as national standards are compatible with the requirements included in PN-EN 14081 - Part 1. At present, the visual method of grading predominates in Poland. Sawn timber is graded according to PN 82/D94021. (*Tarcica iglasta konstrukcyjna sortowana metodami wytrzymałościowymi*. - Structural sawn timber visual strength grade). Based on structural defects of wood and their size (knots, slope of grain, cracks, resin pockets), distortion and cutting faults (wane, different types of distortion, twist), and annual ring width, 3 classes of sawn timber have been identified: KW - upper class, KS- average class, KG – undergraded and rejected. In order to assign strength classes to sawn timber graded visually on the basis of different national standards (for example DIN 4074 - classes S7, S10 and S13; BS - classes GS and SS; INSTA - classes T1, T2 and T3) "Standard EN 1912. Structural timber – Strength classes –

Assignment of Visual Grades and Species" was introduced. It assigns particular strength classes to visual grading classes identified on the basis of EN 338. No Polish sawn timber visual grading classes have been included to present day in the EN 1912 Standard. The results of the research project could be useful for introducing Polish classes of visually graded sawn timber into EN 1912

MATERIAL

At the Faculty of Wood Technology at the Warsaw University of Life Sciences (SGGW) the research project „Strength of Polish grown structural sawn timber according to UE requirements" is being carried out. As part of this project, mechanical properties of Polish-grown pine structural sawn timber, coming from five forestry regions, have been tested (Fig. 1). Three sets of sawn timber were chosen from each region (Table 1). Two of the sets had the same cross sections of 50mmx120mm and 15mmx140mm for each region, which is often used on the Polish market of wooden building materials. The boards belonging to the third set from particular regions had cross sections of 50mmx225mm, 75mmx175mm, 63mmx160mm, 38mmx200mm and 100mmx100mm.
The length of the boards with the 50mmx225mm cross section was 4.5m, and the length of the remaining boards was 4.0m. The total number of tested boards was 764, so each region was represented by about 150 pieces (three sets of about 50 boards each). The volume of the tested wood was about 24.5m^3. The humidity level of the tested wood, dried in sawmills, varied from 15 to 18%, but before testing the mechanical properties of sawn timber using a destructive method, it was seasoned to the humidity level of about 12%. During the tests, the density of the wood was determined using various methods, annual ring width and the modulus of elasticity in bending (MOE) using non-destructive methods and a destructive test. The overall modulus of rapture MOR was determined. Table 2 presents the results of the density and annual ring width (rate of growth) determination.

Table 1: Cross section of tested sawn timber

Size	**A**	**B**	**C**	**D**	**E**	**All**
38x200		50				**50**
50x120	50	50	49	50	53	**252**
50x140	50	50	50	50	52	**252**
50x225	50					**50**
63x160			49			**49**
75x175				50		**50**
100x100					61	**61**
All	**150**	**150**	**148**	**150**	**166**	**764**

Table 2: Density and annual ring width (rate of growth) of tested sawn timber

	Region	**A**	**B**	**C**	**D**	**E**	**All**
Density [kg/m^3]	Average	524	443	474	522	468	**486**
	Coefficient of variation [%]	12	11	8	11	11	**13**
Rate of growth [mm]	Average	2.05	4.00	2.46	2.58	3.11	**2.85**
	Coefficient of variation [%]	**27**	**22**	**31**	**24**	**37**	**37**

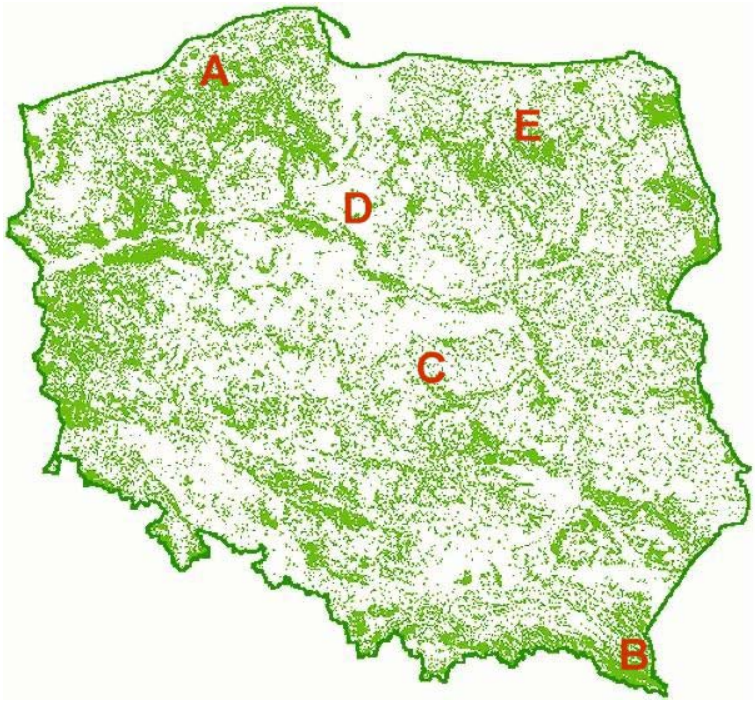

Figure 1: Origin of the sawn timber (Pinus sylwestris L.) used in the tests. NAME OF SAWMILL, name of localization: A- POLTAREX, Korzybie, B- DANKROS, Krościenko, C- TARTOM, Tomaszów Mazowiecki, D- TPPD, Brodnica, E- CDiOD, Kolonia

METHODS

The following devices were used for determining the mechanical properties of structural sawn timber: GoldenEye 706, Mobile Timber Grader and TiraTest 2300 offline testing machine with the maximum load of 100kN. The tests with the use of GoldenEye 706 were carried out in industrial conditions in STEICO, the company that has been the first to use this type of device in Poland. Timber Grader MTG was bought by the Faculty of Wood Technology specially for the research project and it was the first device of this type used in Poland. It is worth stressing that these two devices have not yet obtained a technical approval for testing Polish-grown structural sawn timber. Their application has enabled the determination of MOE of the tested boards with the use of a non-destructive method. Before a destructive test, a visual method of grading according to the Polish Standards PN 94021 and DIN was applied, but the results of this grading are not presented in this paper. For destructive tests, a special beam with an electronic set was constructed to determine the local and global modulus of elasticity (MOE) and the modulus of rapture (MOR) according to PN-EN 408. During all tests the dimensions, density, annual ring width and humidity level of wood were determined using various methods and equipment for detailed characteristics of each board.

RESULTS

Relationships between the results of MOE and MOR from different types of tests are presented in Fig. 2-7 and in Table 3.

Relationships between the results of density determination according to EN 384 and annual ring with measurements according to EN1310 is presented in Fig. 8.
For comparison the equation given in EN 384 to calculate the shear-free bending modulus of elasticity from global MOE is given in Fig. 3.

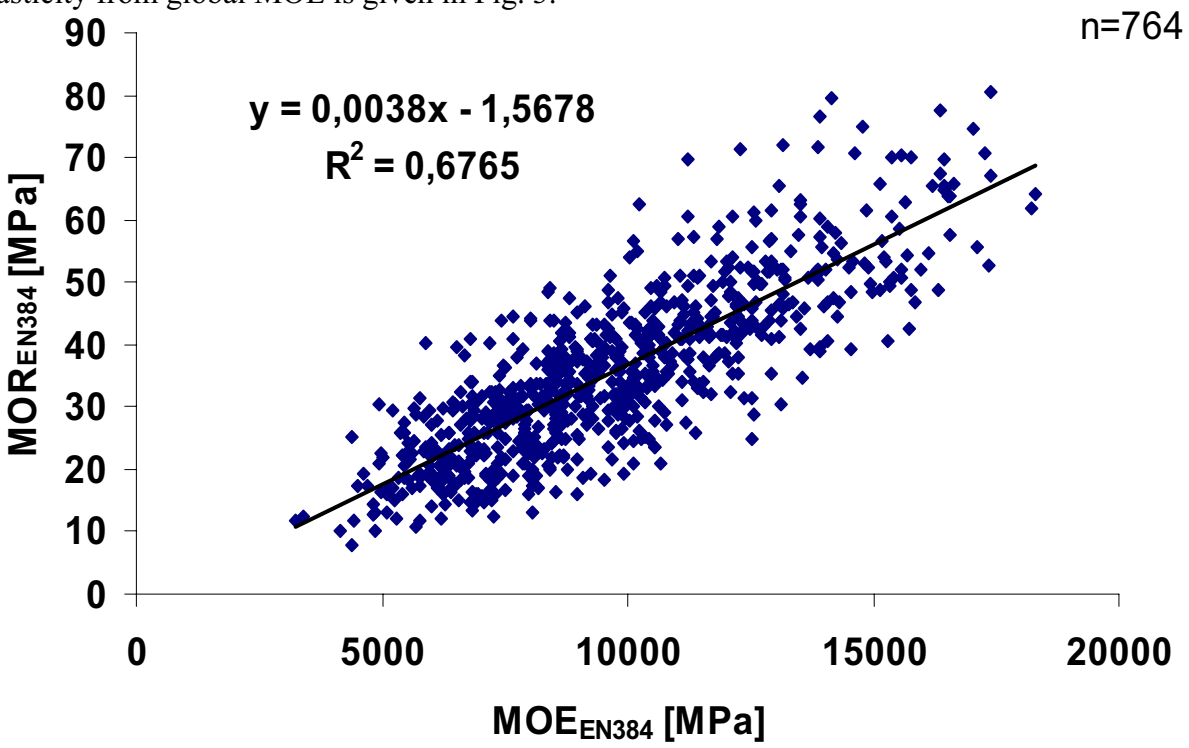

Figure 2: Relationship between MOR from a bending test and MOE from a bending test (wood - Polish-grown Pinus silvestris L.)

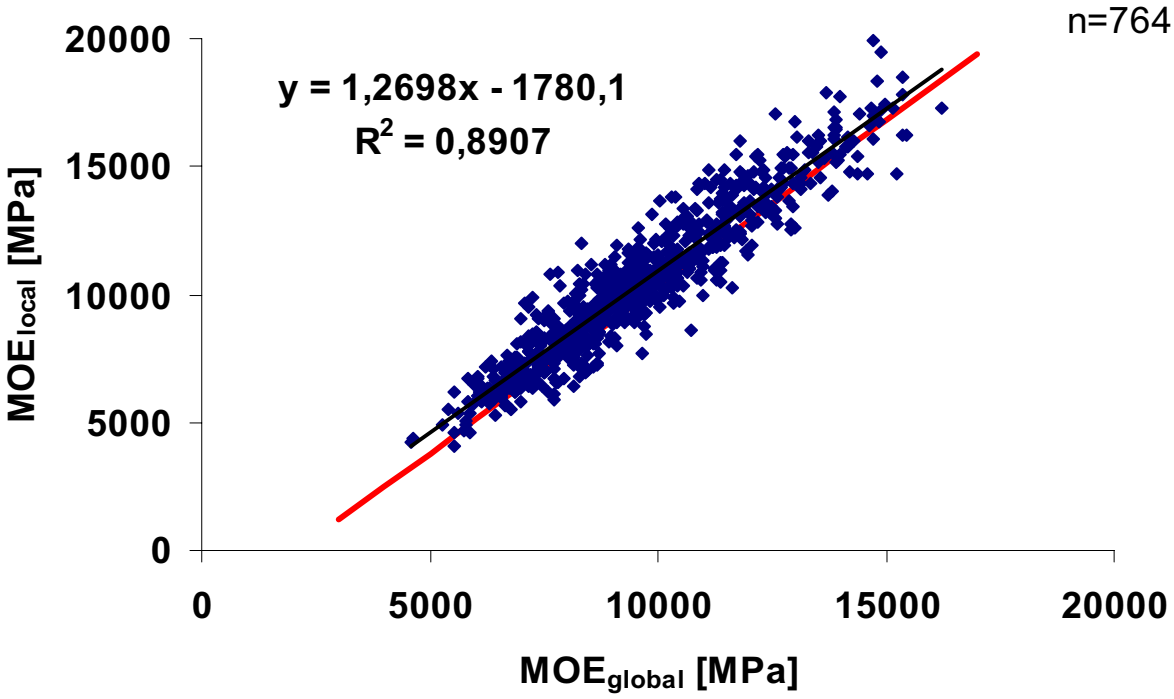

Figure 3: Relationship between MOE local and MOE global from a bending test (wood - Polish-grown Pinus silvestris L.)
*Red line according the formula of EN 384: E_true = 1,3*E_global - 2690*

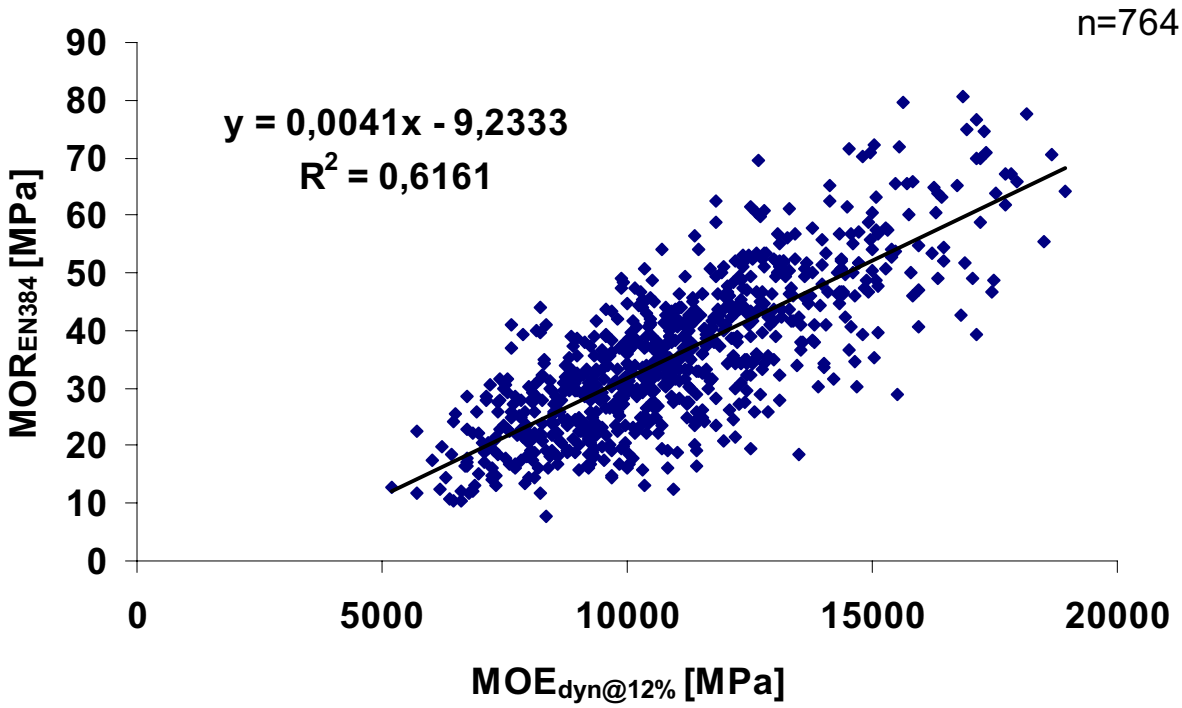

Figure 4: Relationship between MOR from a bending test and dynamic MOE from the Golden Eye -706 (wood - Polish-grown Pinus silvestris L.)

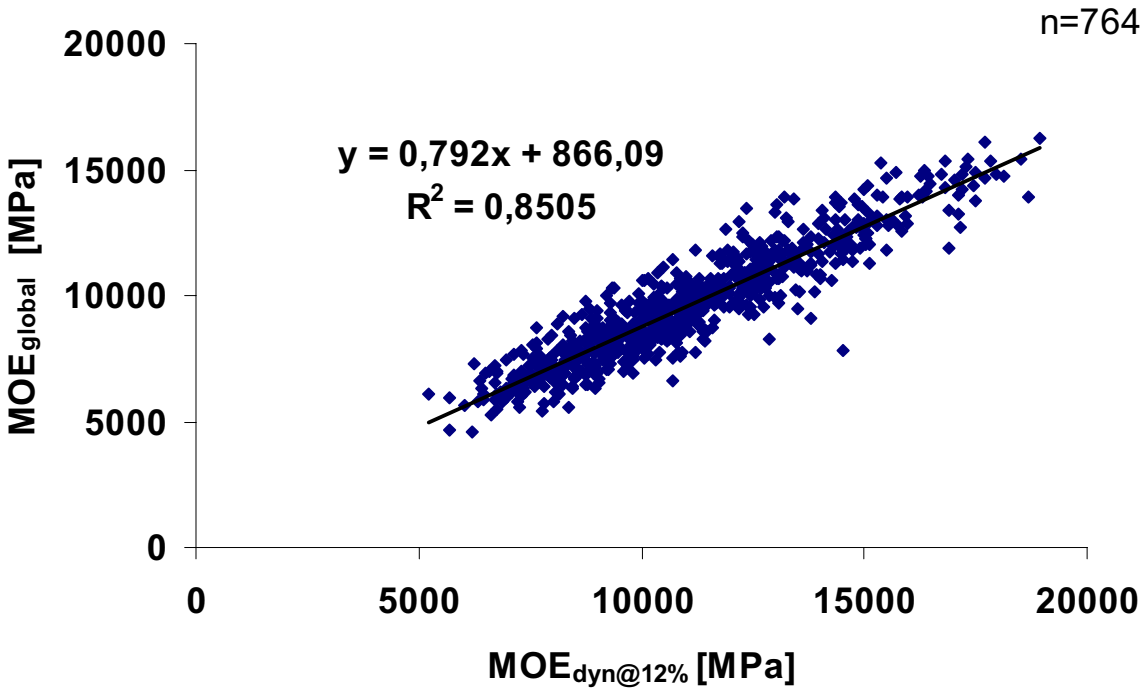

Figure 5: Relationship between global MOE from a bending test and MOE from Golden Eye-706 (wood - Polish-grown Pinus silvestris L.)

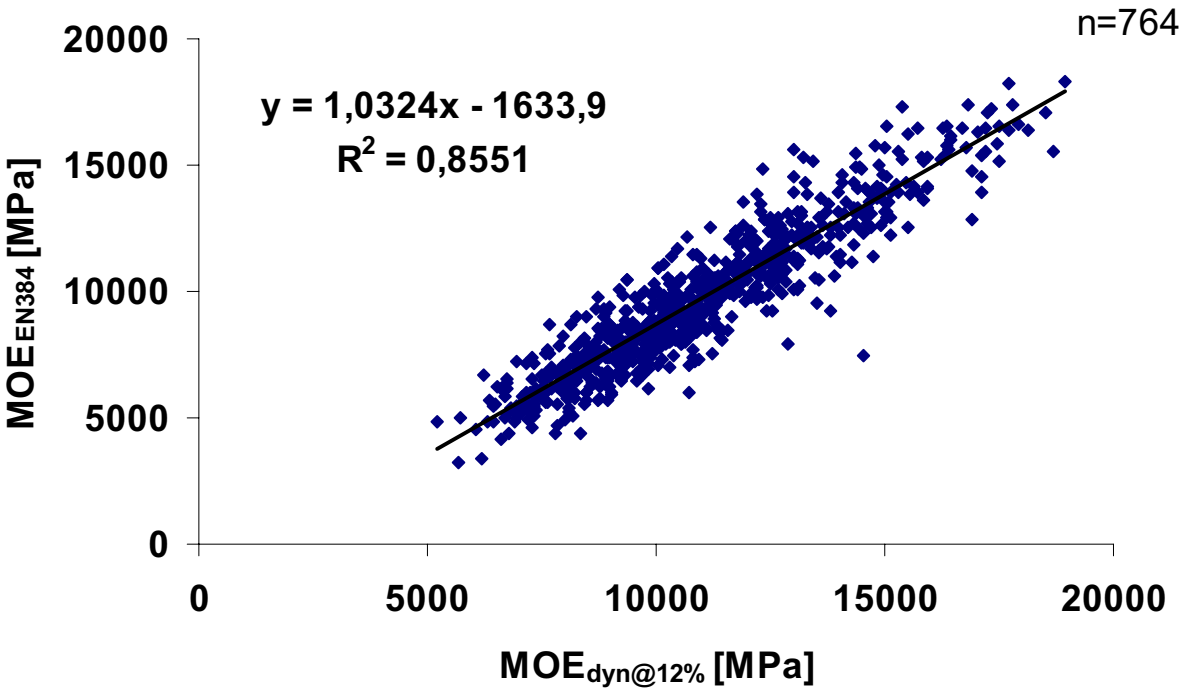

Figure 6: Relationship between MOE from a bending test and MOE from GoldenEye-706 (wood - Polish-grown Pinus silvestris L.)

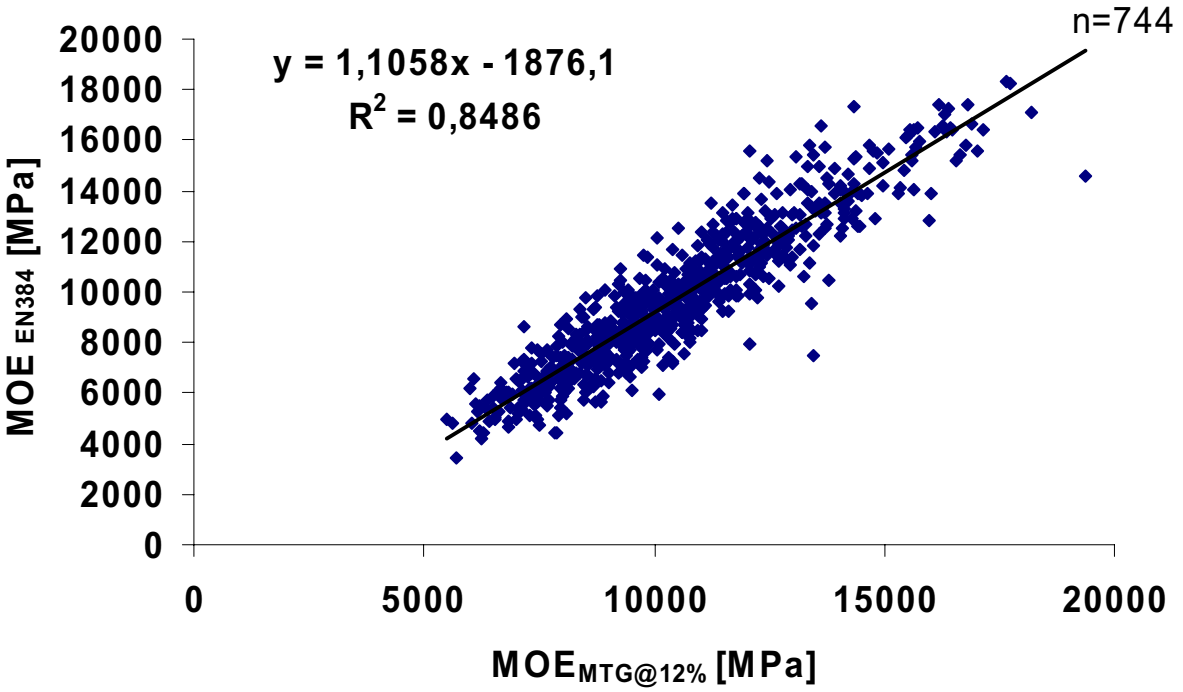

Figure 7: Relationship between MOE from a bending test and MOE from Timber Grader (wood - Polish-grown Pinus silvestris L.)

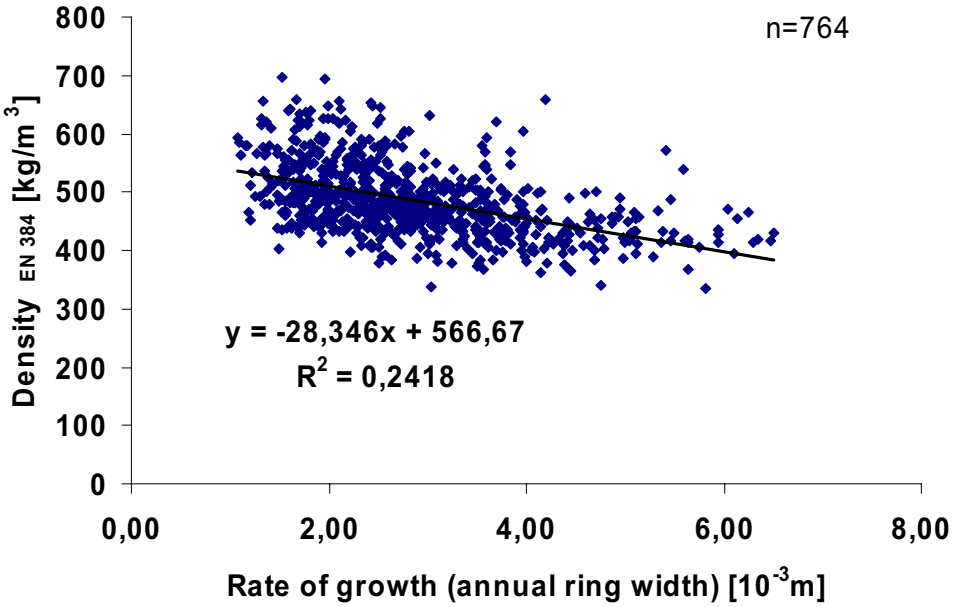

Figure 8: Relationship between density and annual ring width for Polish-grown pine wood including two boards for witch there were no results of MOE and MOR

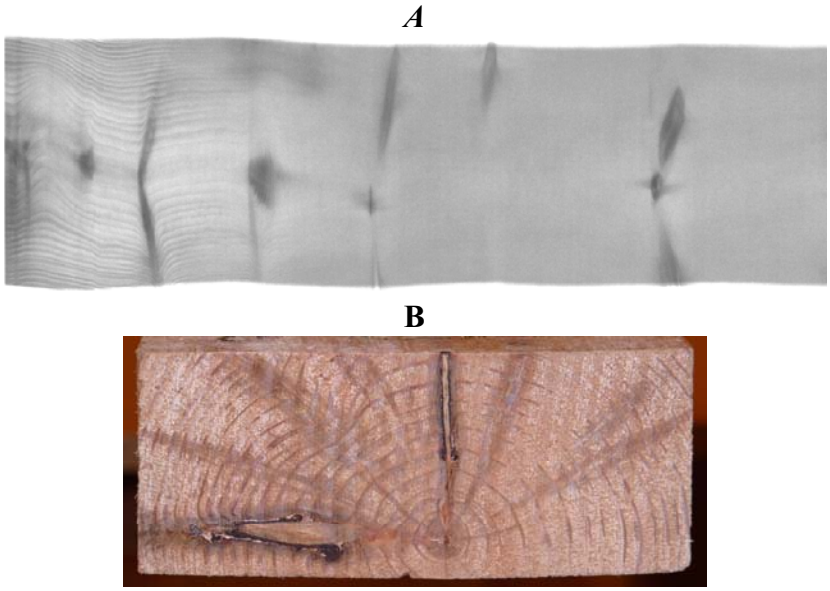

Figure 9: A) X-ray image of the end of tested board from GoldenEye-706
B) Photo of board cross section for which Timber Grade showed on display - Error.
It was impossible to determine MOE of 20 tested boards (2.6% of all tested boards) and their strength class using MTG because of structural defects of the end of the boards

Table 3: Results of MOE and MOR determination for sawn timber from different regions of Poland using a bending test for Polish-grown Pinus silvestris L.

	Region	A	B	C	D	E	All
MOR [MPa]	Average	42.0	25.3	34.7	44.7	32.8	**35.8**
	Coefficient of variation [%]	36	34	27	27	34	**37**
MOE [MPa]	Average	11183	7350	9395	11683	9132	**9737**
	Coefficient of variation [%]	**27**	**24**	**20**	**21**	**29**	**29**

CONCLUSIONS

1. MOR for the pine wood from region A was the highest. The density of the wood from this region was the highest among all regions and the annual ring widths were the smallest.
2. MOE for the pine wood from regions D and A shows the highest value, the density was similar and the annual ring slightly larger for region D.
3. The lowest MOE and MOR were obtained for the pine wood sawn timber from region B. The wood from this region had the largest annual rings and the lowest density. This wood came from formerly arable land.
4. The measured local MOE was higher than predicted by formula of EN 384 for MOE-true.
5. Relationship between MOE from a bending test and MOE from Golden Eye -706 and Timber Grader are similar, but it was impossible to determine MOE and strength class for 20 boards with the structural defects at the end of tested board using MTG.

ACKNOWLEDGEMENTS

The research project has been financed by the Polish Ministry of Science and Higher Education in the years 2006-2008, grant N 309 003 31/0635. Extensive assistance was provided by MiCROTEC and STEICO.

REFERENCE

Arriaga F., Iniguez G., Esteban M., (2005): Assessment of strength and stiffness properties using longitudinal stress wave on structural gross cross section timber of Radiata Pine (Pinus radiata D. Don). *In: Proceedings of the 14th International Symposium on Nondestructive Testing of Wood, University of Applied Sciences, Eberswalde, May 2 – 4*, pp.103 – 109.

Dzbeński W.: Charakterystyczne wartości mechanicznych właściwości iglastej tarcicy budowlano-konstrukcyjnej sortowanej metodą wytrzymałościową. VII Konferencja Naukowa: Drewno i Materiały Drewnopochodne w Konstrukcjach budowlanych, Międzyzdroje, 12 – 13 maja 2006. Materiały konferencyjne, str.107 – 115

Glos P., (2008): Die neue EN 14081 – Verpflichtungen und absehbare Folgen für die Sägeindustrie. *In proceedings of: 3 Internationaler Kongress der Säge- & Holzindustrie, 11 – 12 Februar, Rosenheim*.

Sandoz J-L., Benoit Y., (2007): Timber grading machine using multivariate parameters based on ultrasonic and density measurement. *In proceedings of: COST E 53 Conference – Quality Control for Wood and Wood Products. Warsaw University of Life Sciences, 15–17 October*, pp. 121 – 128.