FOLIA FORESTALIA POLONICA

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EFFECT OF LOADING DIRECTION ON MECHANICAL PROPERTIES OF WOOD-BASED PANELS IN BENDING[1]

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SYNOPSIS. Investigations of the elasticity modulus in bending and the bending strength of wood-based panels: particleboard, laminated particleboard, OSB, MDF, HDF, laminated HDF and hardboard are presented. Two directions of loading: perpendicular and parallel to the board plane were taken into account.

KEY WORDS: wood-based panel, particleboard, fibreboard, modulus of elasticity, bending strength

INTRODUCTION

Wood-based panels are characterised by anisotropy of physical and mechanical properties, which is a result of the structure and process engineering of these materials. Mechanical properties in the direction perpendicular to the panel face are considerably different from those in the direction parallel to the board plane. In the case of particleboard and medium density fibreboard the modulus of elasticity in the perpendicular direction is several times smaller, about seven and eight, respectively, than that in the direction parallel to the board plane (Wilczyński and Kociszewski 1999 a, b).

Another problem resulting from heterogeneous structure of wood-based panels is that they react differently in bending by means of forces perpendicular and parallel to the board plane. A square cross-section bar, cut from panel, for example along the direction of its mat forming, when loaded with the force perpendicular

[1]Paper presented at the IV Symposium "Composite wood materials", Zvolen (Slovak Republic), 26-28 June 2002.

to the plane of the board bends differently than after it is turned by an angle of 90° and loaded with the force which is the same, but directed parallelly to the planes of board. In the latter case, the elastic deflection of the bar is very likely to be greater. It is related with the value of its elasticity modulus in bending. Therefore, it can be stated that this modulus for wood-based materials depends on the direction of bending in relation to the plane of the board. A similar statement can be referred to the bending strength of these materials.

While mechanical properties of wood-based panels in bending by means of forces perpendicular to the board plane are known and given by manufacturers, there is very little available data about these properties in bending by means of forces parallel to the panel face. Only Bao et al. (1996) took bending under such loading into consideration in their research of fatigue properties of particleboard and medium density fibreboard. The knowledge of these data for the rational design of wooden constructions is necessary. That is why investigations of mechanical properties of wood-based panels in bending in different directions have been conducted at the Institute of Technology of Kazimierz Wielki University in Bydgoszcz (Kociszewski et al. 2000, Tydryszewski and Wilczyński 2001 a, b). In this paper investigations of mechanical properties in bending for some kinds of wood-based panel are presented.

MATERIALS AND METHODS

Wood-based panels, available in the Polish market, were tested in this research. Particleboard, laminated particleboard, oriented strand board (OSB), medium density fibreboard (MDF), hardboard, high density fibreboard (HDF) and laminated HDF were taken into consideration. The last board was floor panel. Seven different kinds of panels were obtained that way. Properties of these panels are given in Table 1.

Test specimens were cut from one sheet of each kind of panel. Two types of test specimens were used as is shown in Figure 1. The test specimens for bending by means of forces perpendicular to the board plane (Fig. 1 a) were cut in accordance with PN-EN 310. The test specimens for bending by means of forces parallel to the board plane (Fig. 1 b) were glued with Rakoll® Express 25 from the layers with the thickness t. The number of layers was: 16, 16 and 6 for hardboard, HDF and laminated HDF, respectively. Other specimens were glued from 3 layers of panel. All parallel specimens were cut 18 mm in depth and 410 mm in length. Thirty specimens for each kind of panel and type of specimen were prepared.

Both the modulus of elasticity in bending and the bending strength were fixed in accordance with the procedures specified in PN-EN 310. The span in bending by means of forces perpendicular to the board plane was 100, 100, 160 mm for hardboard, HDF, laminated HDF, respectively and 360 mm for MDF, OSB and particleboards. The span in bending by means of forces parallel to the board plane was 360 mm for each kind of panel.

Table 1. Physical properties of tested panels
Tabela 1. Właściwości fizyczne badanych płyt

Kind of panel Rodzaj płyty	Thickness Grubość [mm]	Density Gęstość [kg/m^3]	Moisture content Wilgotność [%]
Particleboard Wiórowa	18.0	705	8.0
Laminated particleboard Wiórowa laminowana	18.1	680	7.5
OSB	18.0	645	8.0
MDF	18.0	760	6.9
HDF	3.0	920	7.5
Laminated HDF HDF laminowana	8.0	920	7.7
Hardboard Pilśniowa twarda	3.2	975	8.0

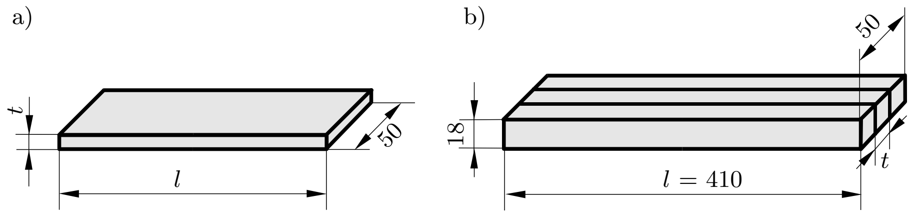

Fig. 1. Test specimens for determination of mechanical properties of wood-based panels in bending: a) by means of forces perpendicular and, b) parallel to the board plane; t – panel thickness, l – specimen length
Rys. 1. Próbki do oznaczania właściwości mechanicznych płyt drewnopochodnych przy zginaniu: a) siłami prostopadłymi do płaszczyzny płyty, b) siłami równoległymi do płaszczyzny płyty; t – grubość płyty, l – długość próbki

RESULTS

Results of the tests – the mean values and variation coefficients of the modulus of elasticity in bending and the bending strength of tested panels determined in loading in two directions are given in Table 2.

The comparison of these values is shown in Figures 2 and 3. The values of mechanical properties determined in bending by means of forces perpendicular to the board plane were assumed as a base of the comparison.

As it was expected, the mean values of the elasticity modulus and bending strength determined in bending by means of forces parallel to the board plane are

Table 2. Modulus of elasticity and bending strength of tested panels in bending by means of forces perpendicular (⊥) and parallel (||) to the board plane
Tabela 2. Moduł sprężystości i wytrzymałość na zginanie badanych płyt przy zginaniu siłami prostopadłymi (⊥) i równoległymi (||) do płaszczyzny płyty

Kind of panel Rodzaj płyty	Loading direction Kierunek obciążenia	Modulus of elasticity in bending Moduł sprężystości przy zginaniu		Bending strength Wytrzymałość na zginanie	
		mean value wartość średnia [MPa]	variation coefficient współczynnik zmienności [%]	mean value wartość średnia [MPa]	variation coefficient współczynnik zmienności [%]
Particleboard	⊥	3 080	4.0	13.3	8.9
Wiórowa	||	1 790	4.1	9.2	4.2
Laminated particleboard	⊥	3 480	5.0	14.1	8.1
Wiórowa laminowana	||	1 900	7.4	10.0	4.8
OSB	⊥	6 560	4.4	37.1	11.6
	||	3 750	7.5	22.7	9.7
MDF	⊥	4 000	1.6	34.5	3.5
	||	3 080	3.4	28.8	3.0
HDF	⊥	3 630	3.4	39.3	4.0
	||	3 310	3.8	30.6	3.5
Laminated HDF	⊥	6 390	2.7	50.7	7.0
HDF laminowana	||	4 960	3.6	38.4	5.4
Hardboard	⊥	3 150	7.0	33.2	6.2
Pilśniowa twarda	||	2 920	4.2	24.8	4.9

smaller than those determined in bending by means of perpendicular forces for each kind of tested panel.

The relative difference in the elasticity modulus in bending in two assumed directions significantly depends on the kind of tested material. In the case of particleboards (particleboard, laminated particleboard and OSB) these differences range from 41.9 to 45.4%. There are smaller differences for MDF and laminated HDF (about 23%), whereas for HDF and hardboard the relative differences are rather unimportant: 8.8 and 7.3%, respectively. This greater difference for particleboards can be explained by the strengthening effect of density profile of these panels. Face layers play a greater role for bending by means of forces perpendicular rather than parallel to the board plane. In the case of MDF high dense outer layers of this panel play a similar role.

The finishing of panel faces also influences the differences between directions of bending. The laminated panels are characterised by greater relative differences than raw ones by about 3.5 and 13.6% for particleboard and HDF, respectively.

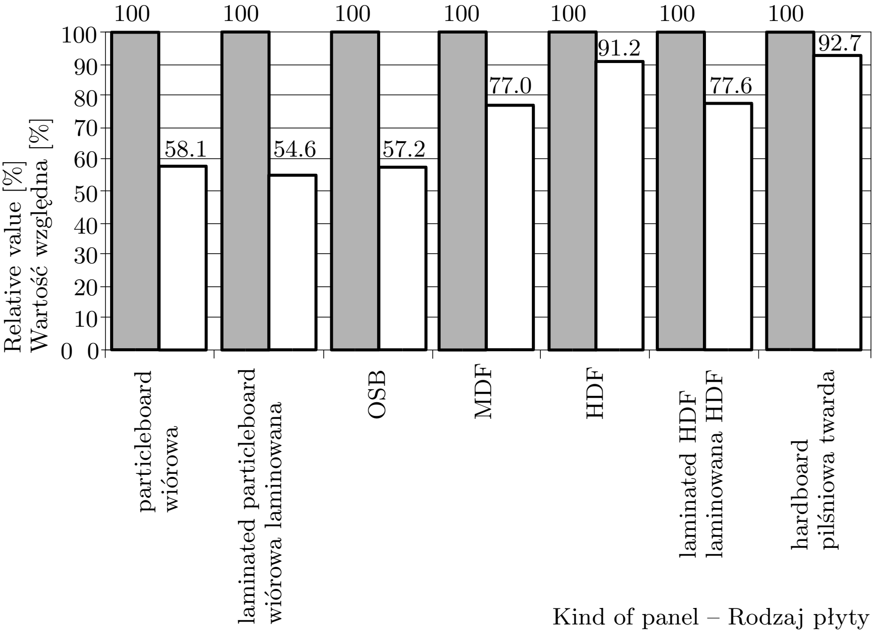

Fig. 2. Comparison of elasticity modulus of panels in bending by means of forces perpendicular (■) and parallel (□) to the board plane
Rys. 2. Porównanie modułów sprężystości płyt przy zginaniu siłami prostopadłymi (■) i równoległymi (□) do płaszczyzny płyty

Bending strength significantly depends on the bending direction of tested panels. The greatest differences for assumed directions are found for OSB (38.8%). Similarly for particleboard and laminated particleboard these differences are considerable and amount to 30.8 and 29.1%, respectively. By relatively smaller differences are characterised thin fibreboards (HDF, laminated HDF and hardboard), that amount to 22.1, 24.3 and 25.3%, respectively. The smallest dependence of bending strength on loading direction reveals MDF, for which strength in bending by means of parallel forces is 16.5% smaller than in bending by means of perpendicular forces.

CONCLUSIONS

1. The values of the elasticity modulus and bending strength of wood-based panels in bending by means of forces parallel to the board plane are smaller than those in bending by means of forces perpendicular to the board plane.

2. The relative differences of elasticity modulus of particleboards are considerably greater than for fibreboards. In the case of bending strength these differences are significantly smaller.

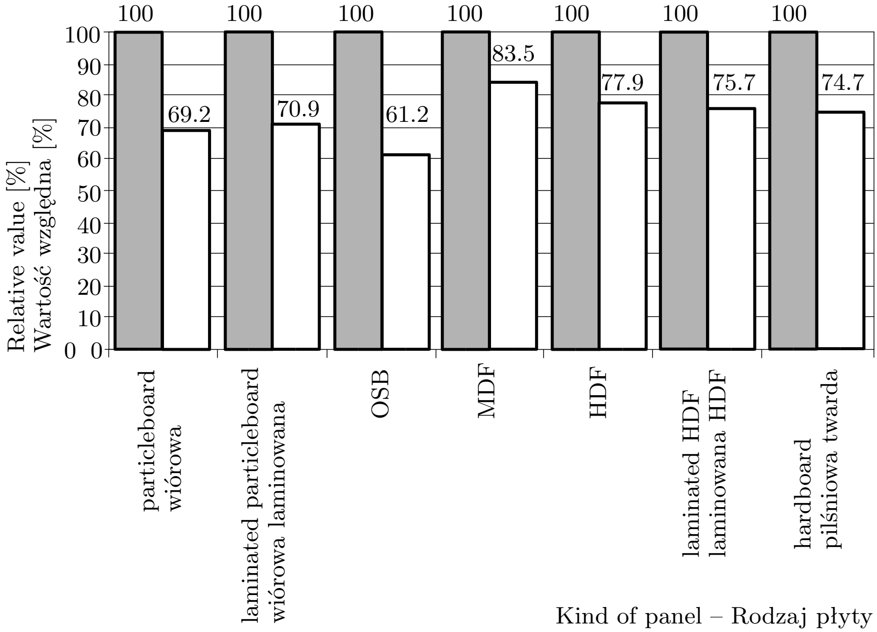

Fig. 3. Comparison of strength of panels in bending by means of forces perpendicular (■) and parallel (□) to the board plane
Rys. 3. Porównanie wytrzymałości na zginanie płyt przy zginaniu siłami prostopadłymi (■) i równoległymi (□) do płaszczyzny płyty

3. The relative difference of the values of elasticity modulus in bending by means of forces parallel and perpendicular to the panel face does not exceed the level of 10% for the thin fibreboards: hardboard and HDF, whereas it is equal to about 23 % for other fibreboards and range from 41.9 to 45.4% for all tested particleboards.

4. The bending strength of tested wood-based panels determined in bending by means of forces parallel to the board plane is by 16.5 to 38.8% smaller than that determined in bending by means of forces perpendicular to the board plane.

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WPŁYW KIERUNKU OBCIĄŻANIA NA WŁAŚCIWOŚCI MECHANICZNE PRZY ZGINANIU PŁYT DREWNOPOCHODNYCH

Streszczenie

Przedstawiono badania modułu sprężystości przy zginaniu i wytrzymałości na zginanie płyt drewnopochodnych: płyty wiórowej surowej i laminowanej, płyty wiórowej o wiórach orientowanych (OSB), płyty pilśniowej o średniej gęstości (MDF), płyty pilśniowej o dużej gęstości (HDF) – surowej i laminowanej oraz płyty pilśniowej twardej. Uwzględniono dwa kierunki obciążania: prostopadły i równoległy do płaszczyzny płyty. Stwierdzono, że właściwości mechaniczne płyty w kierunku równoległym do płaszczyzny mają mniejsze wartości. Względne różnice modułów sprężystości przy zginaniu i wytrzymałości na zginanie zależą od rodzaju płyty.

Received in January 2003

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