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PROPERTIES OF OSB SUBJECTED TO THE BOILING TEST

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Abstract. The aim of the study was to determine physico-mechanical properties of OSB subjected to the boiling test. The tests were conducted on OSB/3 and OSB/4 of 12, 15 and 22 mm in thickness, produced in the years 2002 and 2009. All tested boards were resinated in the core layers with PMDI, while in the face layers MUPF was applied. It results from the tests that OSB/3 of 15 mm in thickness and OSB/4 exhibit very high resistance to the boiling test and their high initial physico-mechanical parameters make it possible to satisfy the respective standards also after the test.

Key words: OSB, mechanical properties, ageing tests

INTRODUCTION

Oriented strand boards (OSB), characterised by good mechanical properties and considerable resistance to the action of variable environmental conditions, are readily used both in housing and structural building engineering. They are applied not only as sheathing elements of walls or roofs, boarding and fencing elements, but are also used to close doorway and window openings. While boards used to cover walls or roofs generally are not exposed to the direct action of water, in the other cases these boards are subjected to cyclical soaking, strong sun exposure and the action of negative temperatures, frequently at their considerable moisture content. For these reasons numerous studies are conducted in many research centres, aiming at the determination of properties of boards subjected to different ageing tests in order to determine the effect of external factors on properties of boards. In these studies the effect of air with varying humidity was determined at constant temperature [Lang and Loferski 1995, Mohammad and Smith 1996, Wu and Suchsland 1997], short-term action of elevated temperature [Bekhta et al. 2003] or cyclically changing temperatures and/or humidity [Dziurka et al. 2005, Mirski et al. 2005]. It results from a review of literature that the action of ageing factors results in relatively big deterioration of mechanical properties of boards, first of all bending strength. The boiling test is one of the basic tests determining water resistance

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of boards and thus their durability under changeable environmental conditions. In accordance with the standard PN-EN 1087-1 board samples are subjected to boiling, next soaking in cold water and in the final test – to drying at a temperature of 70°C. In this case internal bond is a parameter evaluating board quality. In contrast, it was decided in this study to investigate the other properties of boards subjected to the boiling test.

MATERIAL AND METHODS

Tests were conducted on commercial OSB resinated with PMDI in the core and with MUPF in the face layers, with three nominal thicknesses and of two types, i.e.:

– OSB/3 of 12, 15 and 22 mm in thickness – manufactured in 2009 – denoted as N
– OSB/3 and OSB/4 of 15 mm in thickness – manufactured in 2002 – denoted as S.

From each type of boards, both for the longer and shorter axes, samples were collected of 50 × (20 h + 50) mm^2, where h refers to the nominal board thickness. Such prepared experimental material was conditioned for four weeks in a conditioning chamber at a temperature of 20°C and at 65RH. After the conditioning process, in accordance with the assumptions of the standard PN-EN 1087-1, samples were subjected to the boiling test. At the completion of the test samples were again placed in the conditioning chamber for 4 weeks.

Both prior to the onset of the proper testing and after the boiling test the following properties of boards were determined:

– Modulus of elasticity in accordance with PN-EN 310
– Internal bond in accordance with PN-EN 319
– Swelling in thickness after 24 h in accordance with PN-EN 317.

Bending strength of OSB subjected to the boiling test was presented in a previous paper [Mirski and Derkowski 2010]. In turn, this study presents strength in terms of changes in linear dimensions, i.e. length and thickness.

RESULTS AND DISCUSSION

In accordance with the respective standard, bending strength is determined at the spacing of supports set for the nominal thickness of boards. Such a solution is appropriate when the thickness of a board falls within the limits of tolerance determined by the respective standards. However, it seems justified, similarly as it was done in his study by Wu [1998], that at considerable changes in board thickness it would be appropriate to refer to breaking resistance – defined as a product of modulus of rupture and section modulus S, MOR·S (1):

$$MOR \cdot S = \left[\frac{3F_{max}l}{2bt^2}\right] \cdot \left[\frac{bt^2}{6}\right] \quad (1)$$

where:

F_{max} – the load (force) at the fracture point,
l – the length of the support span,

b – specimen width,
t – specimen thickness.

This is so because the analysis of data on breaking resistance on the one hand eliminates the effect of changes in thickness, while on the other hand it prevents a comparison of strength for boards with different nominal thicknesses.

Breaking resistance of OSB used in this study, determined for the longer axis, is given in Table 1. As it results from the presented data, breaking resistance after the boiling test amounts to approx. 60% initial value for boards of 12 mm and 22 mm in thickness and as much as almost 90% in case of OSB/3 of 15 mm in thickness. A reduction of strength for these boards determined in this way is much lower than that recorded for the determination of bending strength. In an earlier paper it was shown that a decrease in strength caused by the boiling test on average amounts to 50%, irrespective of the type of boards, their thickness and year of manufacture [Mirski and Derkowski 2010]. Thus it seems that this method of determination of changes shows the actual effect of a given process on fluctuations of changes occurring in the course of processes intensively affecting the modification of dimensions, particularly thickness, of boards.

Table 1. Breaking resistance of OSB
Tabela 1. Odporność na złamanie przy zginaniu płyt OSB

Board Rodzaj płyty	Numerical value MOR·S – Wartości MOR·S					
	before V100 przed próbą gotowania			after V100 po próbie gotowania		
	mean średnia	standard deviation odchylenie standardowe	coefficient of variation współczynnik zmienności	mean średnia	standard deviation odchylenie standardowe	coefficient of variation współczynnik zmienności
	$N \cdot mm^{-2} \cdot cm^3$		%	$N \cdot mm^{-2} \cdot cm^3$		%
OSB/3 12N	**25.0**	*1.35*	*5.4*	**15.0**	*1.45*	*9.67*
OSB/3 15N	**52.7**	*6.13*	*11.6*	**46.8**	*4.43*	*9.47*
OSB/3 15S	**60.7**	*8.69*	*14.3*	**54.0**	*7.23*	*13.39*
OSB/4 15S	**68.0**	*10.3*	*15.1*	**49.9**	*8.19*	*16.41*
OSB/3 22N	**104.8**	*9.71*	*9.3*	**62.4**	*6.80*	*10.90*

Results of the studies on modulus of elasticity determined before and after the boiling test are presented in Tables 2 and 3. It results from data given in Table 2 that values of modulus of elasticity for tested boards considerably exceed those specified in the standard PN-EN 300. This pertains particularly to the modulus recorded for the shorter axis, since for as many as three types of boards the observed value of the modulus was over 2 times higher than the requirements specified by the standard. Such good initial properties of boards probably result in the fact that – except for 12-mm boards – the other boards after the boiling test also meet these requirements. Generally, except

Table 2. Modulus of elasticity of OSB
Tabela 2. Moduły sprężystości poddanych badaniom płyt OSB

Board Rodzaj płyty	Numerical value MOE, N·mm^{-2} Wartości modułu sprężystości, N·mm^{-2}					
	longer axis – oś większa			shorter axis – oś mniejsza		
	PN-EN 300	mean średnia	standard deviation odchylenie standardowe	PN-EN 300	mean średnia	standard deviation odchylenie standardowe
OSB/3 12N	***3 500***	**3 890**	*470*	***1 400***	**2 610**	*280*
OSB/3 15N	***3 500***	**4 820**	*490*	***1 400***	**2 220**	*210*
OSB/3 15S	***3 500***	**5 860**	*470*	***1 400***	**3 420**	*245*
OSB/4 15S	***4 800***	**5 950**	*510*	***1 900***	**3 140**	*220*
OSB/3 22N	***3 500***	**5 110**	*330*	***1 400***	**3 170**	*265*

Table 3. Modulus of elasticity of OSB after the boiling test
Tabela 3. Moduły sprężystości płyt OSB po próbie gotowania

Board Rodzaj płyty	Numerical value MOE – Wartości modułu sprężystości					
	longer axis – oś większa			shorter axis – oś mniejsza		
	mean średnia	standard deviation odchylenie standardowe	coefficient of variation współczynnik zmienności	mean średnia	standard deviation odchylenie standardowe	coefficient of variation współczynnik zmienności
	N·mm^{-2}·cm^{3}		%	N·mm^{-2}·cm^{3}		%
OSB/3 12N	**2 070**	*280*	*13.6*	**1 290**	*180*	*14.0*
OSB/3 15N	**3 920**	*380*	*9.7*	**1 920**	*242*	*12.6*
OSB/3 15S	**4 870**	*470*	*9.7*	**2 220**	*210*	*9.5*
OSB/4 15S	**4 820**	*410*	*8.5*	**2 160**	*497*	*23.0*
OSB/3 22N	**3 450**	*355*	*10.3*	**2 000**	*168*	*8.4*

for 12-mm boards, the modulus of elasticity after the boiling test determined for the longer axis amounts to approx. 65% value of the modulus before the test, while for the longer axis it was 75%. In turn, for boards of 12 mm in thickness a reduction of the value of the modulus for both axes was comparable, amounting to approx. 50%. A bigger reduction of the modulus of elasticity recorded for the shorter axis results probably from the structure of the board itself. Samples collected for the shorter axis are characterised in the face layers by a statistically higher number of chip elements and thus the number of chip-chip bonds, i.e. elements more susceptible to the effect of this test. OSB/3 of 15 mm in thickness, irrespective of the date of their manufacture, proved to be most resistant to the conditions of the V100 test. However, it needs to be stressed that OSB/3S after the boiling test met the requirements in terms of the modulus of elasticity imposed for OSB/4. Such a situation is probably caused both by the very good quality of chips used in the manufacture of these boards and the relatively high resination rate. Very good properties of OSB/3 probably contributed to a reduction of the scale of production of OSB/4 and at present in Poland this type of boards is not available in retail outlets.

Values of internal bond for boards before the boiling test (IB) and after the boiling test (V100) are presented in Table 4. Recorded data are standard determinations required by the standard PN-EN 300. Tested boards exhibited considerable initial strength (IB), being over 2 times higher than the recommendations of the standard; however, after the boiling test boards with a thickness of 12 mm and 22 mm did not meet the requirements of the standard in terms of their water resistance.

Table 4. Internal bond of OSB
Tabela 4. Wytrzymałość na rozciąganie prostopadłe do płaszczyzn płyt OSB

Board Rodzaj płyty	Numerical value IB, $N \cdot mm^{-2}$ Wytrzymałość przed próbą gotowania, $N \cdot mm^{-2}$			Numerical value V100, $N \cdot mm^{-2}$ Wytrzymałość po próbie gotowania, $N \cdot mm^{-2}$		
	PN-EN 300	mean średnia	standard deviation odchylenie standardowe	PN-EN 300	mean średnia	standard deviation odchylenie standardowe
OSB/3 12N	***0.32***	**0.53**	*0.06*	***0.13***	**0.11**	*0.02*
OSB/3 15N	***0.32***	**0.64**	*0.09*	***0.13***	**0.21**	*0.04*
OSB/3 15S	***0.32***	**0.65**	*0.09*	***0.13***	**0.22**	*0.03*
OSB/4 15S	***0.45***	**0.85**	*0.10*	***0.15***	**0.20**	*0.01*
OSB/3 22N	***0.30***	**0.54**	*0.05*	***0.12***	**0.08**	*0.02*

As it results from the experience of the authors, the unsatisfactory strength of boards of 12 mm and 22 mm in thickness after the boiling test is accidental, previously not observed in earlier studies e.g. on the dimensional stability of OSB/3 [Mirski et al. 2007]. However, it needs to be stressed here that large chips used in OSB production facilitate a considerable reduction of resination rate, making it further possible to manufacture boards with very good properties, e.g. MOE or MOR. However, low resination rates may prove insufficient for the maintenance of full water resistance. Such a reasoning seems to be confirmed by the fact that after the boiling test, particularly for 12-mm boards, they are characterised by a very good modulus of elasticity, mainly accounted for by strand boards, but already a considerable loss of breaking resistance, in case of which the binding agent begins to play a bigger role.

Moreover, both boards are characterised by relatively high values of swelling in thickness after 24 h soaking in water (Table 5), although only 12-mm boards did not meet requirements of the standard PN-EN 300 (< 15%). The effect of the V100 test on tested boards determined by swelling in thickness turned out to be very similar, first of all for OSB/3. In case of these boards the value of swelling in thickness for boards earlier subjected to the boiling test was 10.3-10.8%. As it could have been expected, OSB/4 proved to be slightly less susceptible to the action of the V100 test, since its swelling in thickness amounted to 9.5%.

Table 5 presents also the relative change in thickness determining changes in thickness for boards after the boiling test in relation to the initial thickness. Comparable

Table 5. Swelling in thickness and relative change in thickness of OSB
Tabela 5. Spęcznienie na grubość oraz względna zmiana grubości płyt OSB

Board Rodzaj płyty	Thickness swelling (TS), % Spęcznienie, %		Thickness swelling after V100, % Spęcznienie po próbie gotowania, %		Relative change in thickness after V100, % Względna zmiana grubości, %	
	mean średnia	standard deviation odchylenie standardowe	mean średnia	standard deviation odchylenie standardowe	mean średnia	standard deviation odchylenie standardowe
OSB/3 12N	**17.9**	*1.83*	**10.8**	*1.10*	**26.7**	*2.34*
OSB/3 15N	**11.3**	*1.02*	**10.8**	*0.99*	**20.1**	*2.39*
OSB/3 15S	**8.7**	*1.32*	**10.8**	*0.55*	**19.9**	*2.99*
OSB/4 15S	**10.2**	*0.87*	**9.5**	*0.84*	**16.7**	*1.34*
OSB/3 22N	**13.9**	*1.10*	**10.3**	*0.96*	**20.8**	*1.62*

values of swelling in thickness recorded for OSB/3 after the boiling test, at a comparable relative change in thickness determined for boards of 15 mm and 22 mm in thickness, and significantly different for 12-mm board, indicate that a considerable loosening of board structure takes place during the V100 test. The occurring deformations, amounting to 20% for boards with a thickness of over 12 mm and to over 26% for 12-mm boards, are permanent deformations. Wu and Suchsland [1996] in their study determined permanent deformations of OSB resinated with phenol-formaldehyde resin conditioned at different relative humidity levels (35-95% RH). It results from their studies that for the highest level of relative humidity (RH 95%) permanent deformations recorded by those researchers amounted to 5%, i.e. 4-5 times less than for boards subjected to the V100 test.

CONCLUSIONS

It results from the conducted tests that all boards used in this study exhibit very good properties, considerably exceeding recommendations of the standard PN-EN 300 in terms of the modulus of elasticity, internal bond and bending strength. Subjecting tested OSB to the boiling test resulted in a reduction of their breaking resistance by 10-40%, while that of the modulus of elasticity – by 15-50%. Boards with the thickness of 15 mm proved to be much more resistant to the effect of this test, as in their case values of the modulus of elasticity after the boiling test still met the requirements of the standard for boards not subjected to this test. In turn, 12-mm and 22-mm boards turned out to be less resistant, as in their case the decrease in breaking resistance and modulus of elasticity amounted to 40% and 50%, respectively. Moreover, these boards did not exhibit internal bond after the boiling test recommended by the standard.

However, it also needs to be stressed that in the analyses, in which board thickness was taken into consideration (bending strength and modulus of elasticity), the actual change in the determined parameter was masked by the change in thickness, which may be as high as over 20%.

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WŁAŚCIWOŚCI PŁYT OSB PODDANYCH PRÓBIE GOTOWANIA

Streszczenie: Celem pracy było określenie właściwości fizykomechanicznych płyt OSB poddanych próbie gotowania. W badaniach użyto płyty OSB/3 i OSB/4 o grubościach 12, 15 i 22 mm, wyprodukowane w latach 2002 i 2009. Wszystkie poddane badaniom płyty były zaklejane w warstwie wewnętrznej za pomocą PMDI, a w warstwach zewnętrznych – MUPF. Z przeprowadzonych badań wynika, iż płyty OSB/3 o grubości 15 mm i płyta OSB/4 wykazują bardzo dużą odporność na działanie próby gotowania. Po przeprowadzonym bowiem teście spełniają w zakresie właściwości mechanicznych wymagania określone w odpowiednich normach.

Słowa kluczowe: OSB, właściwości mechaniczne, testy starzeniowe

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