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Resistance of accelerated aged wood-based panels to nail-head pull-through

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Abstract: *Resistance of accelerated aged wood-based panels to nail-head pull-trough.* Resistances of OSB and SB5 panels to nail-head pull-through were determined. Tests were made with regard to panels subjected to three cycles of accelerated aging. An additional variable was a nail size. The level of decrease in the pull-through resistance of the panels subjected to accelerated aging was determined for the given sizes of a fastener.

Keywords: OSB, head pull-through, nail, accelerated aging

INTRODUCTION

Oriented strand board has been developed for the building trade and found a wide use in it. It is used, e.g. in producing sheathing for roofs, ceilings, floors, and walls. Panels are fixed in constructions mainly with nails and screws. The resistance of these joints depend on many factors such as a type of panel, its thickness, density and strength properties, a type and dimension of a fastener, as well as a type of a load acting on a joint. Therefore it is important to correctly choose parameters of joint. Another factor considerably affecting the load capacity of the joint is a quality of board that depends on its structure, a type of used resin, resin content, and manufacturing process. The quality of a panel can deteriorate due to contact with atmospheric conditions (Kojima and Suzuki 2010).

One of basic tests of this type of joints is the determination of the head pull-through resistance of a fastener. It is carried out according to PN-EN 1383. It allows to determine the joint strength in axial loading directed in line with a fastener's point. Such tests were conducted by, among others, Herzog and Borjen (2006), who determined the withdrawal strength and nail-head pull-through resistance of plywood and OSB. In testing they considered the effect of a nail type, panel thickness and exposure conditions, with nail-head pull-through tests being conducted only for thin panels and one size of a nail. Wang et al. described localized density effects on some common fasteners' holding capacities in wood-based panels. They determined screw-head pull-through resistances of OSB of three different thicknesses. The effect of exposure conditions on the direct withdrawal and head pull-through performance of nails in structural wood-based panels was analyzed by Chow et al. (1988). They considered among others the OSB panel that was soaked for 24 hours and subjected to 6 cycles of accelerated aging according to the ASTM standard. They found out slight differences between the values of nail-head pull-through resistances obtained for the specimens of tested panels subjected to different exposure conditions.

Insufficient is however knowledge on the nail-head pull-through resistance of OSB panels subjected to aging according to the PN-EN 321 standard, including that on the effect of a nail size on this property.

Besides, in the literature there are no results of tests made on other panels used in the building trade. Therefore, investigations were carried out to determine nail-head pull-through resistances of wood-based panels. OSB and SB5 panels and 4 dimensions of nails were considered in testing.

MATERIALS AND METHODS

The tests were made on two commercially available wood-based panels intended for use under conditions of high humidity: OSB/3 and SB5. Only one thickness of a panel, 18 mm, was taken into consideration. Basic properties of these panels are presented in Table 1.

Table 1. Properties of tested panels

Kind of panel	Density (kg/m3)	MOE (MPa)	MOR (MPa)	IB (MPa)		Thickness swelling (%)	
				before accelerated aging	after accelerated aging	after 24h immersion in water	after accelerated aging
OSB/3	590	5380*	26.8*	0.66	0.25	16.0	19.5
SB5	728	3570	16.2	0.65	0.45	5.1	19.7

* properties in parallel direction

Fasteners were nails designated for investigations by the symbols: 2.5, 3.0, 3.5 and 4.0. The symbol is connected to a nominal size of a nail's shank diameter. Mean parameters of nails are presented in Table 2

Table 2. Mean values of nail sizes

Symbol	Length (mm)	Shank diameter (mm)	Head diameter (mm)
2.5	61.3	2.49	5.69
3.0	81.2	3.06	6.36
3.5	100.5	3.51	7.33
4.0	118.5	4.00	8.76

According to the standard the specimen should have a shape of a square with a value of an edge length amounting at least four times to that of thickness. Therefore 120 specimens, measuring 80 x 80 mm, were cut from each panel and next conditioned. Afterwards an appropriated nail was driven with a manual hammer at the central point of each specimen until a head-nail had reached the specimen surface. That way were prepared 30 specimens for every combinations of a panel type and a nail size, that were next separated into 2 groups. One of the group was kept under laboratory conditions, while the other was subjected to the effect of cyclic humidity exposure according to the PN-EN 321 standard. This test consists in subjecting a panel to 3 cycles of changes in humidity and temperature. Each cycle included the following stages:

- immersion in water at 20°C for 72 h,
- freezing at −12°C for 24 h,
- drying at 70°C for 72 h,
- settling at room temperature for 4 h.

After the accelerated aging process the specimens were kept under laboratory conditions for 2 weeks. Afterwards head pull-through tests were carried out. To do this, the specimens were placed in special holding jaws of the universal testing machine and loaded, making a nail-head pull through the panel till the maximum strength was reached. The loading speed was chosen so that the maximum strength would be reached after about 300 seconds.

Based on the value of the maximum strength the head pull-trough resistance of the panel was calculated according to the formula:

$$f = \frac{F_{\max}}{d_h^2}$$

where:

f – head pull-through resistance (N/mm^2),
$F_{\max}$ – maximum force (N),
d_h – nail head diameter (mm)

RESULTS

The research results, that is mean values of the maximum force and head pull-through resistances calculated on their basis for not aged panels and accelerated aged ones were presented in Table 3.

Table 3. Results obtained by nail-head pull-through method (standard deviations in parentheses)

Kind of panel	Size of nail	Maximum force $F_{\max}$ (N)		Head pull-through resistance f (N/mm^2)		Loss of resistance (%)
		not aged	aged	not aged	aged	
SB5	2.5	2394 (176)	1808 (227)	73.8 (4.5)	55.8 (7.2)	24.0
	3.0	2573 (248)	2068 (195)	61.0 (4.2)	49.8 (3.8)	18.4
	3.5	2920 (145)	2323 (89)	54.4 (3.1)	43.8 (2.1)	19.5
	4.0	3319 (169)	2767 (126)	43.4 (3.6)	37.1 (3.5)	14.5
OSB	2.5	1633 (356)	1289 (415)	50.2 (10.5)	39.3 (11.2)	14.0
	3.0	1854 (368)	1559 (344)	46.2 (9.0)	37.8 (7.9)	18.1
	3.5	2165 (375)	1735 (422)	41.5 (7.4)	32.5 (7.4)	19.4
	4.0	2673 (697)	2432 (572)	35.0 (9.1)	31.8 (7.7)	9.3

For both tested wood-based panels the force needed to pull through a nail-head increases with increasing the size of a nail-head. It agrees with expectations as nails of greater sizes are characterized by a larger surface of a head. However, a growth of that force with an increase in size is not the same for both tested panels. The force needed to pull the nail 4.0 through the OSB panel not subjected to aging is greater by above 60% than that to pull through the nail 2.5. In the case of the panel subjected to accelerated aging the relative difference between these forces is even greater and amounts to 90%. This difference is much smaller when nails are driven into the SB5 panel. A change of nails from 2.5 to 4.0 causes an increase of F_{max} by about 37% and 63% for the not aged panel and the one subjected to accelerated aging, respectively.

Contrary to the force needed to pull through the nail, the pull-through resistance calculated on their basis decreases with increasing the size of a fastener. The change of nails from 2.5 to 4.0 causes a decrease in resistance of the nail driven in the OSB panel by 19 and 30 % for the panels subjected to aging and the ones not subjected to aging, respectively. In the case of the SB5 panel a decrease in this resistance amounts to 33 and 41%, respectively.

Subjecting to accelerated aging resulted in a decrease in pull-through resistance for both tested panels. For the SB5 panel a decrease in this property was at a level of 24% when the nail of the smallest size was pulled through, and at a level on average of 17% for the remaining sizes of the nail. In the case of the OSB panel subjecting the panel to accelerated aging caused a decrease in the pull-through resistance on average by 17% for the nails of the sizes from 2.5 to 3.5 and almost 10 % for the nail 4.0.

It is also worth noting that the SB5 panel is characterized by greater pull-through resistance than the OSB panel. The smaller the fastener's size is, the relative difference is the greater. For the nail 2.5 the SB5 panel has pull-through resistance greater by above 46% when it was not subjected to aging and by above 41% when it was subjected to aging. In the case of the nail 4.0 these differences amount to 24 and 14%. It is probably a result of a more homogenous structure of the SB5 panel. It is also proved by considerably lower standard deviations of the tested group of specimens of this panel.

CONCLUSIONS

1. Subjecting the panel to accelerated aging causes a decrease in the head pull-through resistance of wood-based panels on average by 17%. The smallest loss of this property is noted for the panel with the nail of the largest size.
2. The SB5 panel is characterized by a considerably greater head pull-through resistance of nails than the OSB panel.
3. The force needed to pull through a head-nail increases with increasing its size.
4. Nail-head pull-through resistance decreases with increasing the size of a fastener.

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Streszczenie: *Wytrzymałość poddanych przyspieszonemu starzeniu płyt drewnopochodnych na przeciąganie główki gwoździa.* W pracy określono wytrzymałość płyty OSB oraz SB5 na przeciąganie główki gwoździa. Badania przeprowadzono dla płyt poddanych trzem cyklom przyspieszonego starzenia. Dodatkowym czynnikiem zmiennym był rozmiar gwoździa. W rezultacie określono poziom spadku wytrzymałości na przeciąganie płyt poddanych procesowi przyspieszonego starzenia dla poszczególnych rozmiarów łącznika.

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