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EVALUATION OF ORIENTED STRAND BOARD BEHAVIOR ON FIRE

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Abstract:
Wood based panels including oriented strandboard (OSB) are being used quite extensively on the construction market, therefore the fire performance knowledge is required. The aim of this paper was to evaluate the performance to fire of treated and untreated OSB panels compared to untreated and treated softwood panels. The tests were performed on the laboratory conditions based on the SR 652 method, analysing the weight loss of specimens subjected to combustion. Three type of fireproofing products (receipts: R1, R2 and R3) were applied by superficial treatments (brushing and dipping). The results indicated that the treated OSB and softwood had a good behavior to fire, at a retention level of about 280g/m^2 and by dipping treatment, registering a lowest weight loss with receipt R3, below 10%, the standard limit being 30%. Treated specimens were more fire resistant than untreated ones which weight loss ranged between 38%-68% (the greatest value was acquiered for OSB). Overall OSB performance to fire was comparable with softwood but burning was occured more rapidly as can be seen in higher weight loss during test.

Key words: *weight loss; treatment; solid softwood; OSB; fire-retardant.*

INTRODUCTION

Oriented strand board (OSB) is an engineered wood structural panel that has rapidly conquered the construction market replacing partially the plywood panels. OSB panels gained popularity for various applications like: subfloor underlayment, roof sheathing, wall sheathing, I-joists products and other industrial applications such as furniture, packaging, vehicle and wagon interiors etc. (APA 2000). The OSB production continued to increase reaching in 2011, in North America 13.5 million m^3, 4.7 million m^3 in Canada and 4.5 million m^3 in Europe (Eastin et al. 2012). Therefore, from general use to structural applications, OSB panels found success dominating more than half of the structural panel market (Ainsworth 2007; RISI 2015). An important issue in building construction, besides mechanical properties, is the fire performance. This property can be significantly improved by using proper chemical treatments. The most common fire retardant chemicals used for wood based panels are boron compounds (borax and acid boric), inorganic salts, phosphoric acid, ammonium sulfate, zinc chloride (Candan 2012; FPL 1999). The chemicals for treatment are incorporated with wood particles just before, during, or after gluing and wax-blending processes, by impregnation or other means during the product manufacturing (White 2006) obtaining the fire-retardant-treated (FRT) OSB panels. The OSB panels treated by surface methods are not included in this category. Surface coatings (dip, spray, or brush), or direct placement in the product (such as borate rods), are all post-manufacture treatments (PMT), and the main issue with these treatments is the chemical gradients within the product (Kirkpatrick 2006). For the most treated wood and wood based products, preservatives are applied by using pressure. However, sometimes this is not possible, and special facilities are required to do this treatment. As a consequence the surface treatments are used to apply the preservative chemicals.

The surface burning behavior and resistance to flame penetration are some fire performance properties of OSB panels studied by White (2006), along with the cone calorimeter test to assess the combustibility. The results provided by APA (The Engineered Wood Association) showed that untreated OSB panels have a FSI (flame spread rating or index) between 127 and 172 depending on the panel thickness (0 is for noncombustible materials). The flame spreading index (FSI) varies between 0 and 200 being classified into: Class I (or A) 0–25, Class II (or B) 26–75 and Class III (or C) 76–200) (ASTM E 84). The lowest FSI is permitted for areas where the fire hazard is most severe and the highest values in rooms of most occupancy

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except hospitals (APA 2017; White et al. 2010). Fire-retardant-treated wood (impregnated by a pressure process) must have a FSI of 25 or less in accordance with ASTM E 84 test, with no evidence of significant progressive combustion, when the test is continued for other additional 20 minutes. Also the flame front shall not progress more than 3.2 m beyond the centerline of the burner at any time during the test (White and Winandy 2006). In the public buildings such as cinemas, theatres, libraries, schools, offices, hotels foyers and hospitals, where is a higher risk of fire, the fire retardant panels should be used. The flame retardant products in a building help to suppress the spread of fire and permit a safe evacuation of the persons. Wood frame walls, floors and roofs using conventional wood framing can be designed to provide up to 2 hours resistance to fire (CWC 2000).

There are 7 classes according to fire reaction, defined by EN 13501-1 (Eurocode 5): A_1, A_2, B, C, D, E and F (A1 & A2 are incombustible). The wood based products (among which are OSB panels) are included in D and E classes as combustible materials (medium to highly contribution to fire). The OSB 3* panels, having $\rho \geq 600 kg/m^3$ and thickness ≤8mm, belong to E class and D class in case of thickness greater than 9mm, respectively. These panels are classified as CWFT (Classification Without Further Testing).

* OSB/3 –load-bearing boards for use in humid conditions (acc. to EN-300:2007).

This classification, according to CEN (European Committee for Standardization) allows to identify rapidly the performance of standardized wood based panels used in construction, in classes specified in EN 1350-1, excepting OSB 3 specified above.

OBJECTIVE

The main objective of this research was to evaluate the OSB behavior on fire by weight loss and to analyse the fireproofing efficacy of surface treatment. Three types of fire retardant chemicals were used on OSB and solid softwood samples and the comparative performance of these two building materials was also investigated.

MATERIAL, METHOD, EQUIPMENT

OSB panels and solid softwood (spruce - *Picea abies L.*) acquiered from a store building materials were used for testing. Specimens of 150mmx70mmx10mm and 15mm respectively were cut from the conditioned panels (Fig. 2). The average moisture content of untreated samples was 6.5% for 10mm thickness and 7.7% for 15mm thickness. The average volum mass was $440 kg/m^3$ and $620 kg/m^3$ for softwood and OSB respectively. The tests were made based on SR 652: 2009, determining the samples weight loss after a combustion process in laboratory conditions using the equipment presented in Fig. 1.

Three types of fire-retardant chemicals for surface coating were applied on samples, by brushing (three layers) and dipping (20 minutes).

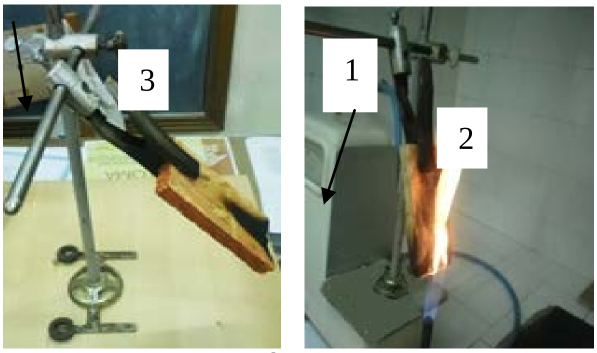

Fig. 1.
Device used in the fire experiments:
1 – scale; 2 - sample; 3 - device for clamping the specimen above the flame.

The chemicals have been chosen based on literature studies (Ayrilmis 2006; Gao 2010; McIntyre 2004) and previous experience in the laboratory tests. The fire-retardant chemicals used were a mixture of different chemicals as follow:

Receipt R1, boron compounds, phosphates, sulfates, isothiazolone, 25% concentration;
Receipt R2, amonium chloride and trisodium phosphate, 20% concentration;
Receipt R3, borax and zinc chloride, 20% concentration.

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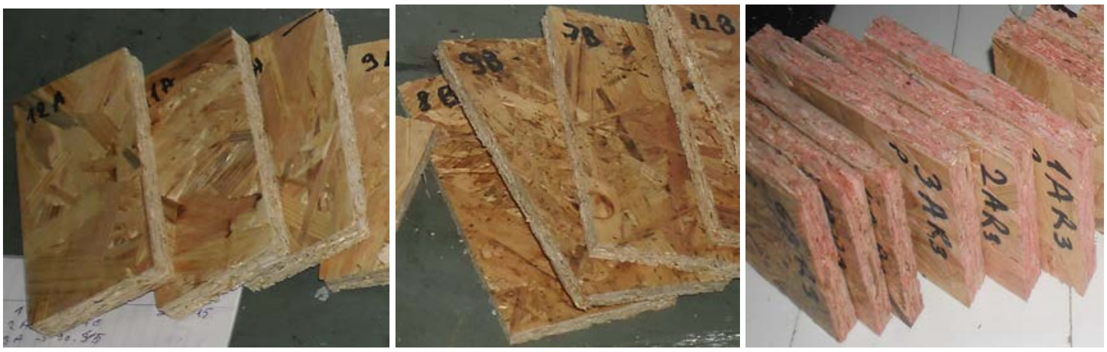


A.

B.

Fig. 2.
A. OSB treated samples: softwood treated samples

The samples were conditioned at 23±2ºC and relative humidity of 50±10% after treatment. Burning was performed in a room without air currents, at a temperature of (20 ± 5)°C, using a gas burner flame with constant flow. The total duration of combustion process was set to10 minutes and at every 2 minutes was measured the weight loss. For each thickness, receipt and treatment, three specimens were tested. It was evaluated the fireproofing efficiency of treated and untreated samples.

Specific consumption and retention dose of fire-retardant chemicals

The fire-retardant coats the wood fibres providing a ‘blanket’ of protection, preventing the escape of flammable vapours and access of oxygen (Lowden 2013). Therefore, information on the retained dose of chemicals (d_r) (2) in panels it is important and it was calculated on the basis of specific consumption (C_{sp}) (1).

$$C_{sp} = \frac{M_{tf} - M_i}{A} \quad [\text{g/m}^2] \tag{1}$$

$$d_r = c \cdot C_{sp} \quad [\text{g/m}^2] \tag{2}$$

where:
$M_{i,}$ is the initial mass of sample after treatment, in g
M_{tf}, is the final mass of sample, after treatment, in g
c, is the concentration of fire retardant solution, in %.

Weight loss

The weight loss (WL), was calculated for each treatment and receipt according to formula (3):

$$WL = \frac{M_0 - M_f}{M_0} \cdot 100 \quad [\%] \tag{3}$$

where:
M_0 is the initial weigh of specimens, (before ignition), in g
M_f is the final weigh of specimens, after combustion, in g

Additionally, density (ρ) of each specimen was determined, knowing that besides thickness, chemical constituents and test procedure, density is another factor that influence the flame spread (White 2000) and charing process.

RESULTS AND DISCUSSION

Specific consumption and retention dose

The average specific consumption of OSB specimens ranged between 84-278g/m^2 with some differences between thicknesses (Table1). The lowest values were obtained for the samples with small thickness (10mm) treated by brushing, because of uneven distribution of chemicals on the specimens surfaces. In dipping treatment the specimens are completely submerged in the treatment solution thus a better penetration was achieved.

Table 1

The specific consumption for treated OSB samples

Fire retardant Receipt	Treatment applied/Thickness			
	Brushing		Dipping	
	10mm	15mm	10mm	15mm
	Average specific consumption, g/m^2			
R1	84	132	100	118
R2	104	123	142	201
R3	195	202	237	278

Table 2

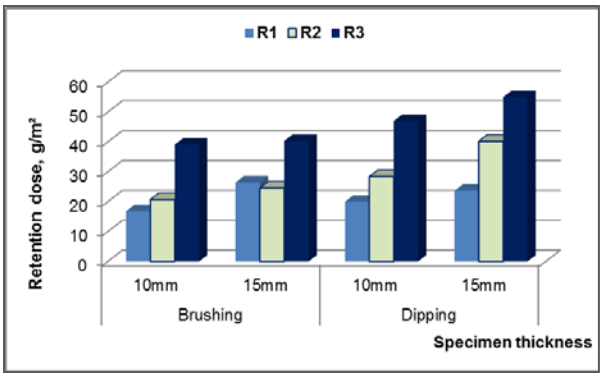
The specific consumption for treated softwood samples

Fire retardant Receipt	Treatment applied/Thickness			
	Brushing		Dipping	
	10mm	15mm	10mm	15mm
	Average specific consumption, g/m^2			
R1	168	210	163	216
R2	208	227	219	279
R3	212	245	238	292

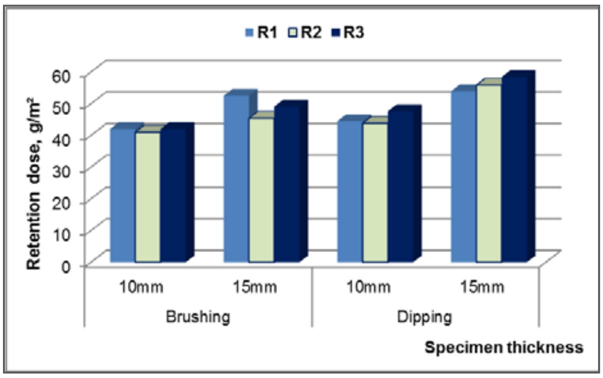
In Table 2, the average specific consumption of fire-retardant chemicals in softwood samples is presented. The higher values resulted for softwood samples compared to OSB samples, obviously due to the anatomical structure of wood and its highly porous nature.

Retention values, as can be seen in Fig. 3 depended on the panels types (OSB and solid wood), thickness, treatment applied and receipts.

It is mentioned that the same concentration of chemicals level was used for the receipts R2 and R3 and the specimens had the same moisture content. The retention dose (d_r) for OSB, ranged between 17g/m^2 and 55g/m^2 and between 41g/m^2 and 58g/m^2, for softwood samples, with the greatest values for 15mm thickness and dipping treatment. Softwood specimens showed no significant differences between receipt and thickness when compared to OSB specimens.



A.



B.

Fig. 3
Average retention dose for OSB (A) and softwood (B) treated samples.

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The retention dose was with about 38% and 28% lower in case of brushing and dipping respectively, when compared OSB with softwood specimens, due to differences in porosity and surface wettability.

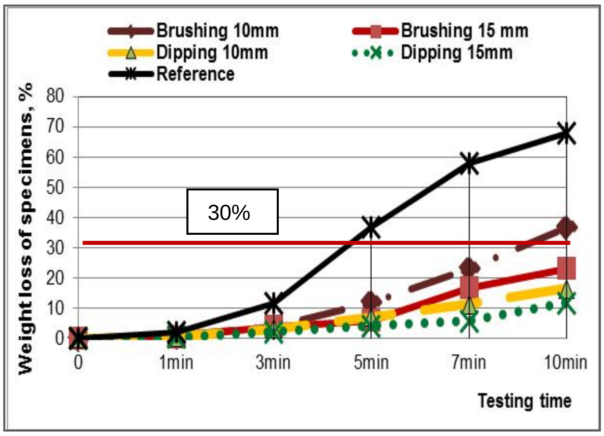
The greatest values of retention level was registered for both OSB and softwood specimens, in case of dipping treatment with the receipt 3 (R3). Receipt 3 included borax and zinc chloride. Due to their effectiveness as a preservative, and relatively low impact on the mechanical properties of wood, boron compounds are often preferable to other fire retardants (Anonymous 1999, Lebow and Winandy 1998). Zinc chloride was found also the most succesful retardant chemical in LVL (Laminated veneer lumber) (Kol 2010). Low perforance was achieved by brushing treatment, because of uneven application, some areas probably being not well penetrated by chemicals.

Weight loss

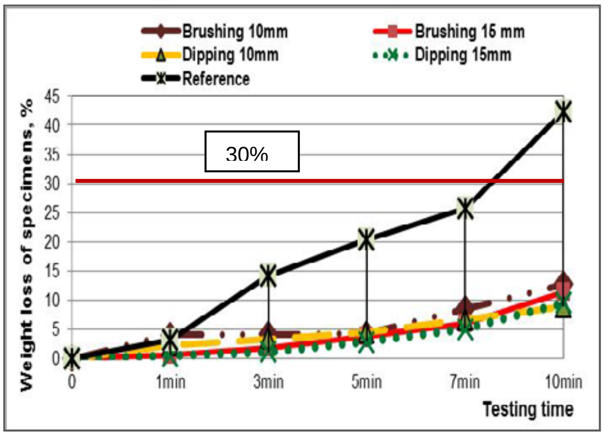
All chemically treated samples had lower weight loss values than those of untreated ones (reference samples) and almost all are below 30%. Untreated samples had the weight loss ranged between 58%-68% and 38%-42% for OSB and softwood respectively.

The evolution of weight losses during test is shown in Fig. 4 A-F, for each receipt and specimen thickness. Horrizontally line (30%) represents the maximum limit up to which the treatment is effective fireproofing according to SR 652. The burning process occured more quickly at OSB specimens,although the ignition time was higher (120sec.) than for softwood specimens (60-80sec.). This behavior could be determined by OSB mass volum, composition, however strands wood burned more easily than solid wood no matter the specimen thickness. After 2 minutes all OSB treated specimens start to loss in weight and after 5 minutes the weight loss was almost double.

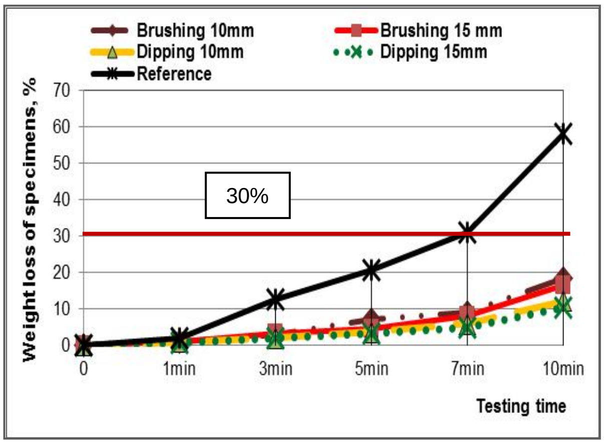
The greater weight loss was acquired in the brushing treatment for all receipts, the poor retention dose didn't succeed to provide sufficient protection to fire. Effectiveness of brushing with R1 was very low on OSB 10mm (Fig. 4A), which didn't pass the limit of 30% recommended by standard SR 652.



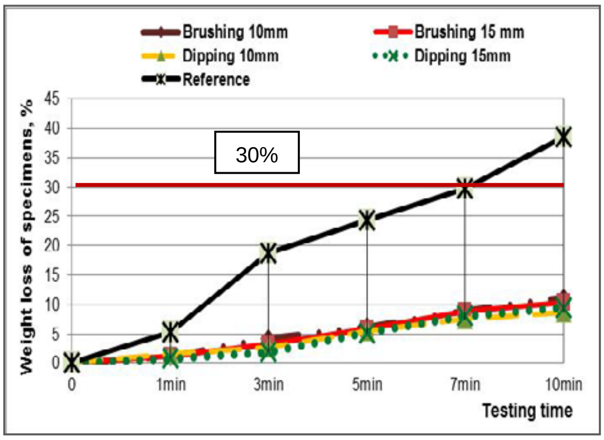
A. OSB - Receip 1(R1)



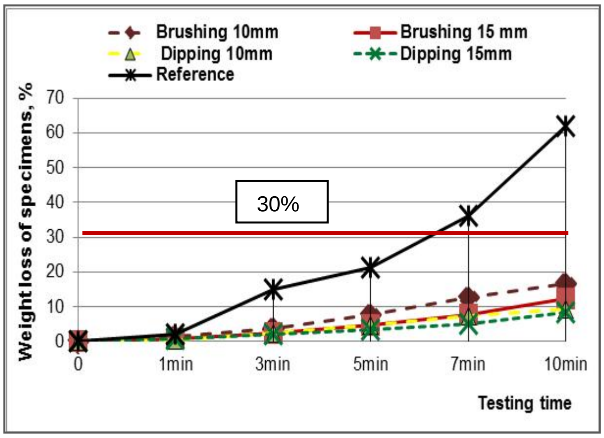
B. Softwood - Receipt 1(R1)



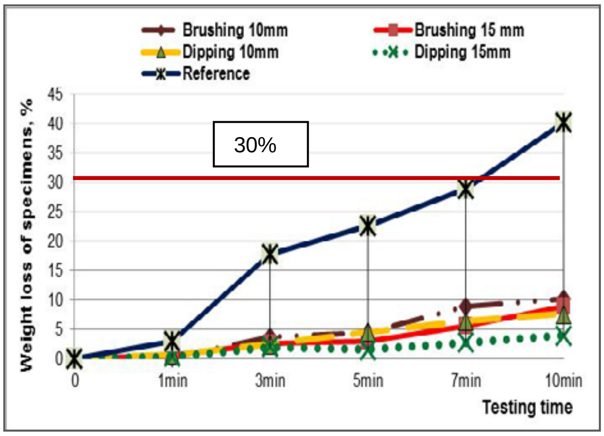
C. OSB - Receipt 2 (R2)



D. Softwood - Receipt 2 (R2)



E. OSB - Receipt 3 (R3)



F. Softwood - Receipt 3 (R3)

Fig. 4.
Fireproofing efficacy by weight loss, on OSB and softwood depending on receipt and thickness of the specimen.

The lowest weight loss values registered during test were observed in the specimens treated by dipping with R3 (3.84 % and 8.25% for softwood and OSB respectively), followed by R2 (9.49% and 10.20%) and R1 (9.52% and 11.66%). The weight losses registered for OSB were with about 25% greater in case of R1 compared to R2 and R3 treatments. Smaller differences (below 10%) was observed in softwood specimens treated with R1 compared to R2 and R3 respectively.

All specimens treated by dipping with R3 had the weight losses below 10%. Dipping treatment improved the fire performance of OSB, however the solid softwood has better behavior to fire regarding the weight loss after 10min testing.

CONCLUSIONS

The results obtained in this study showed that treated samples had better fire performance than untreated ones. OSB samples trated by dipping with R3, had comparable performance with softwood, regarding the weight loss acquierd after 10 minutes fire test. The burn rate was higher in case of R2 and R1, for OSB greater weight loss values being recorded compared to softwood. The best fire performance had the samples treated with R3, followed by R2.

The weight loss performance of the panels was positively affected by the fire retardant chemicals, especially when applied by dipping when higher retention was acquiered by the thick specimens. Surface applications like brushing, is easy to perform but offers only a slight protection in terms of fire perormace compared to dipping treatment.

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