Optimisation of Surface Finishes for Oriented Strand Board in Order to Increase Its Moisture Resistance

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Optimisation of Surface Finishes for Oriented Strand Board in Order to Increase Its Moisture Resistance

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Abstract. The purpose of the research is the optimisation of surface finishes for application to oriented strand board (OSB) in order to increase its moisture resistance. The aim of the research is to compare test specimens with different types of coating, spray, primer and waterproofing under predefined conditions and different forms of moisture exposure. The paper contains a definition of the basic material, test specimens and test methods, and covers 8 different types of surface finish materials selected for application to the test specimens. The results include graphs showing growth in humidity over time, specifically graphs showing the causal relationship between increases in weight and moisture absorption, as well as graphs depicting swelling in thickness. The results are also discussed. In the conclusion the results are evaluated and an outline of the next steps to take with regard to further research is formulated. The results are of benefit to all subjects concerned with wooden structures in which OSB is used, both at the design stage and at the stage of the preparation and execution of construction with respect to unpredictable weather conditions that can irreparably damage unprotected structures. In addition, these are results which are important for the operation of buildings during which a suitable surface finish can alleviate the consequences of later accidents and defects. They may also be beneficial during the construction of buildings from structural insulated panels who's facing most often consists of OSB. Construction periods tend to be adversely affected by changes in the weather. The application of suitable surface finishes to OSB immediately during the prefabrication stage could eliminate this issue.

1. Introduction

OSB is an important material which sees extensive use particularly in the area of wooden structures. It is the most frequently used material for structural insulated panels (SIPs) as extensive testing has shown that it can be used as a load-bearing material. Another reason is the fact that it is available in the large sizes that are demanded by the SIP industry. OSB is composed of thin, rectangular-shaped wood strands which are arranged in layers at right angles to one another. The wood strands that make up the face layers are oriented parallel to the longer edges of the panels, while in the core layers they are oriented perpendicular to them. OSB structural panels are made by bonding individual layers together under heat and pressure. The different orientation of the layers improves the mechanico-physical properties of the panels [1].

It is known that OSB is prone to water absorption and that it swells up as a result. This is attributed to the hygroscopic properties of wood and the internal stress created during hot pressing [2]. This characteristic of OSB is undesirable, as not only can it have a negative impact on the physical and mechanical properties of the material, it can also make it prone to attack from wood-destroying insects, rot or mould. The results are aesthetic problems, as well as adverse effects on the health of inhabitants [3]. Generally, the measures which can be taken to eliminate this undesirable effect can be divided into three categories: pre-treatment of the wood supplied for the production of OSB, treatment during the course of the manufacturing process, or the post treatment of the finished product [4].

It is not possible to make alterations to the OSB production process during the stage when the wooden structures that incorporate the material are already being constructed. The research thus focused on the possibility of increasing the resistance of OSB to water and air humidity absorption via the application of a suitable surface finish. Sanding and a subsequent coating with UV-cured finishes has proved efficient in reducing the swelling of OSB [5]. Favourable water repellent effects have been demonstrated when a highly elastic polyurethane coating is applied [6]. For the purposes of this research, mainly surface finishes which are easily available on the market and which are not too expensive were chosen. The same logic was also applied during the selection of coatings for the testing of OSB for air permeability [7]. The majority of the selected surface finishes are already used in the construction of wooden structures on the Czech market. The main aim of the research is the optimization of these finishes, or to show adaptations which have proved to be unsuitable for a given purpose, or do not fulfil their declared function.

2. Materials and methods

2.1. OSB specification
OSB/4 with a thickness of 15 mm was selected for the purposes of this research. OSB/4 is classified in the relevant standard as a heavy-duty load-bearing board for use in humid conditions [8]. This type of board was chosen with regard to its use as facing for structural insulated panels by the main distributor of this construction system on the Czech market. The guaranteed characteristic bulk density of the board is greater than 600 kg/m^3. The base materials it contains are shown in the table below (Table 1).

Table 1. Base materials of tested OSB/4.

Content of base material	Type of base material
85-92 %	Absolutely dry wood weight (mainly softwood of the pine and spruce type, hardwood content up to max. 30 %)
4-6 %	Water (wood moisture)
3-6 %	PMDI glue in the surface and core layers
≤1 %	paraffin wax emulsion

2.2. Test specimens
The collection of samples took place in accordance with standard EN 326-1 [9]. The dimensions of the test specimens were kept at 50 x 50 mm and they were conditioned to a constant weight at a mean relative air humidity of 65 % and a temperature of 21 °C in accordance with the requirements of European standard EN 317 [10].

2.3. Specification of surface finishes
8 types of surface finish suitable for application to OSB were selected. Each of them is supposed to increase the resistance of OSB against the effects of moisture and protect it against weathering effects. Surface finishes which are standardly available on the market were selected. A more detailed specification of the surface finishes used is shown in the following table (Table 2).

Table 2. Specification of tested surface finishes.

Number of composition	Specification of the composition of the surface finish	Use: interior vs. exterior
1	Silicone waterproofing coating – 1 layer	Exterior
2	One-component polymer-based waterproofing screed – 1 layer	Exterior
3	Acrylic copolymer water emulsion penetration primer – 1 layer Cork mixture for application by spraying (organic mixture of crushed cork, acrylate emulsion in a water dispersion, pigments and water) – 2 layers	Exterior
4	Wood treatment lacquer suitable for primers (composition: acrylate, TiO_2, $BaSO_4$, white spirit, Na-phosphate, water, conservation additive) – 2 layers	Exterior and interior
5	Acrylate wood colour (composition: acrylate, TiO_2, Fe_2O_3, silicate, white spirit, glycol, preservatives, water) – 2 layers	Exterior and interior
6	Protective water-based agent for end grain wood (composition: a mixture of 5-chlor-2-methyl-2H-isothiazol-3-on and 2-methyl-2H-isothiazol-3-on (3:1), 1,2-benzisothiazol-3(2H)-on) – 1 layer	Exterior
7	Adhesive bridge (one-component solvent-free coating, mixture of fillers and aggregates in a water styrene-acrylate dispersion) – 1 layer	Exterior and interior
8	Polyurethane-based wood strengthening agent – l layer Wood treatment lacquer suitable for primers – 2 layers	Exterior and interior

In the case of some of the selected surface finishes, the manufacturer's instructions required their application in combination with another product. Before the application of the sprayed cork mixture, the surface of the OSB had to be treated with an emulsion penetration primer – composition 3 (Table 2). Polyurethane-based wood strengthening agent was supposed to be provided with other coatings after drying – composition 8 (Table 2). Here, a lacquer which is suitable for primers was selected. It was also included independently in the selected surface finishes – composition 4 (Table 2). This choice made it possible to clearly compare the effects of both substances.

For one of the sets, each of the OSB samples was treated with surface finishes across the whole surface. As it is known that there is a large tendency towards water absorption occurring on edges first [1, 11, 12], a second set of specimens was prepared and treated with surface finishes only on the edges.

2.4. Test for the determination of swelling after immersion in water and the monitoring of weight gain
The test is based on the European standard EN 317 [10], according to which the test specimens are immersed in water at a temperature of 20 °C for 20 days. Every day their thickness is measured and each of them is weighed on laboratory scales with an accuracy of 0.001 g. The number of samples is 8 pcs for each surface finish, as specified in the standard EN 326-1 [9]. In order to compare the effect of the surface finishes, test specimens without a surface finish are also included in the tests. The main aim of

the test is to monitor the behaviour of OSB when exposed to the long-term effects of moisture, which will be demonstrated by graphs depicting both swelling in thickness and growth in weight over time. Another aim of the selected method is to discover whether the consequences of moisture will stabilize after a certain time.

2.5. Determination of moisture resistance using a cycle test

The test is based on the European standard EN 321 [13]. The test involves the immersion of the test specimens in water with a temperature of 20 °C for 70 hours, followed by their exposure to a temperature of -20 °C for 24 hours, and finally by exposure to a temperature of +70 °C for 70 hours. This cycle is repeated three times. The number of specimens is, again, 8 pcs for each surface finish. The same number of specimens without a surface finish are subjected to the test. This test makes it possible to predict the durability of the individual surface finishes and their reactions to weather changes as a result of the changing seasons. After the test ends, the same specimens are subjected to a swelling test after placement in water and again, both the swelling curve and the increase in weight in direct relation to water absorption are determined. The procedure is described in Chap. 2.4.

3. Results and discussions

Samples of OSB without a surface finish and samples treated with 8 types of surface finish across their whole surface were subjected to a swelling test after placement in water in accordance with the conditions stated above. The results of this test are visible from the graphs shown in the following images (Figure 1, Figure 2).

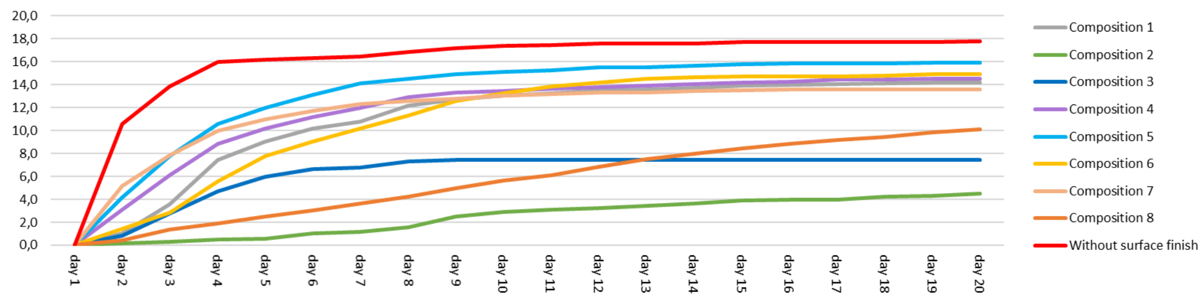

Figure 1. Graph showing curves for swelling in [%] for samples treated with surface finishes across their whole surface.

The value for the swelling of OSB/4 after 24 hours is set as 12% by the EN 300 standard [8]. The average swelling value obtained in this research for samples without a surface finish is 10.6%. The tested OSB/4 samples thus showed a lower swelling value after 24 hours than is required by the standard. On the 20th day of measurement, the swelling value reached 17.8%. The graph above (Figure 1) shows that the swelling curve of samples without a surface finish had almost stabilized after 9 days of measurements. Based on the measurements, composition 2 – one-component waterproofing screed – can be evaluated as the best surface finish. Samples of OSB treated with this finish had an average swelling value of 0.1% after 24 hours and an average value of 4.5% after 20 days. The second best option appears to be composition 8 – the composition with polyurethane-based wood strengthening agent. In the case of this surface finish, the swelling value after 24 hours was 0.4% and after 20 days 10.1%. The swelling of OSB treated with both surface finishes has a tendency to increase further over time, unlike in the case of other treatments, when the swelling stabilized after several days. The third best surface finish, based on the swelling curve, was composition 3 – the composition with a cork mixture for application by spraying. This had a lower swelling value after 20 days than composition 8

(7.5%). It can be stated that all surface finishes were capable of retarding swelling. Within the first 24 hours, swelling was lowered by at least one half for all samples treated with a surface finish.

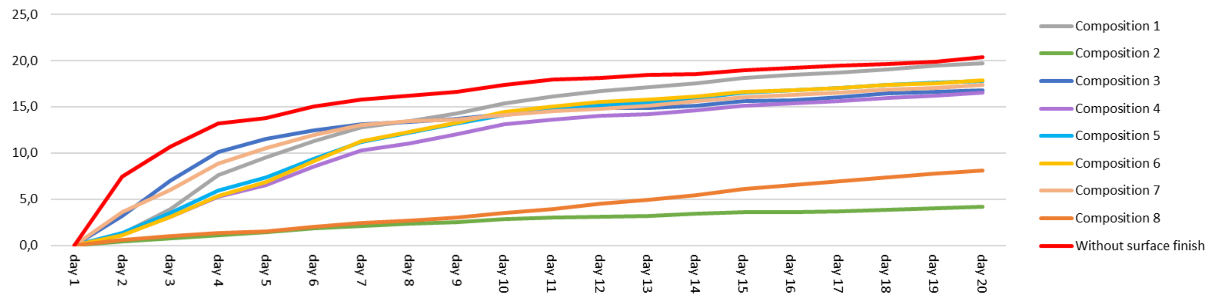

Figure 2. Graph showing the increase in weight in direct relation to water absorption in [g] in samples treated with surface finishes across their whole surface.

The graph featured above (Figure 2) showing the increase of weight in direct relation to water absorption in samples treated with a surface finish across their whole surface basically confirms the results obtained from the swelling measurements. Only composition 3 – the composition with a cork mixture for application by spraying – had a significantly worse result. This method of obtaining data about the quantity of absorbed water didn´t show itself to be completely suitable during the research for this surface finish composition as the grains of crushed cork contained in the mixture had a tendency to absorb water themselves. It wasn´t possible to determine the difference between the quantity of water absorbed by the board and that absorbed by the surface finish itself using this procedure. It can be stated that for all types of surface finish there was generally a constant gradual growth in weight in direct relation to increasing water absorption. A stabilized state still had not been achieved after 20 days of measurement, but the experiment was terminated after 20 days with regard to swelling.

The samples that were only treated with 8 types of surface finish along their edges were also subjected to the swelling test after placement in water. The results can be seen in the graphs shown in the following images (Figure 3, Figure 4).

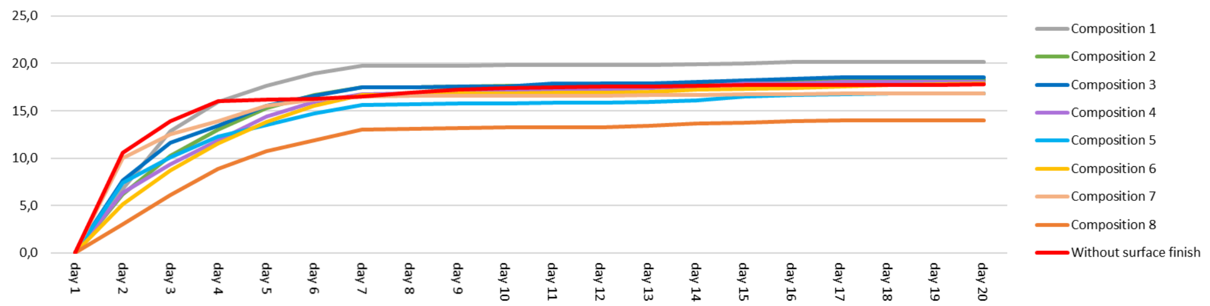

Figure 3. Graph showing curves for swelling in [%] for samples treated with surface finishes only along the edges.

With the exception of surface finish 7 – adhesive bridge, all surface finishes applied to the edges of OSB managed to retard the swelling process during the first three days of measurement (Figure 3). From

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the long-term point of view, however, this OSB treatment method does not seem to be effective. The best result was achieved in the case of composition 8 – the composition with polyurethane-based wood strengthening agent. This result is attributed to the depth penetration ability of the wood strengthening agent due to which a greater surface area of the samples was probably treated than in the case of other applied surface finishes. In the case of some specimens treated with surface finishes on the edges, there was greater swelling than in the reference samples without a surface finish. This fact is attributed to the content of randomly distributed voids with different sizes in OSB and the varied abilities of individual wood strands to conduct water, which is the result of the inhomogeneous covering of the wood strands with resin, and the occurrence of nodes. These imperfections in OSB appear during the production process and result in the uneven transport of water along the board [12, 14], which demonstrated itself in this case.

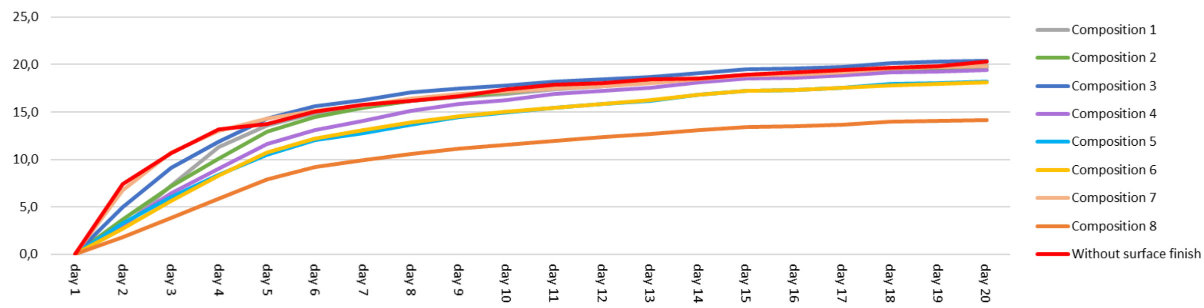

Figure 4. Graph showing the increase in weight in direct relation to water absorption in [g] in samples treated with surface finishes only along the edges.

The graph featured above (Figure 4) showing the increase in weight in direct relation to water absorption in samples treated with a surface finish only along the edges does not depict very different results from those obtained during the measurement of swelling.

In the last stage of research, further samples were treated with surface finishes across their whole surface and the samples without a surface finish were subjected to a cycle test. After this test, the majority of surface finishes showed considerable damage in the form of cracks forming on the edges. The following figure (Figure 5) shows a visibly clear difference between the durability of 3 different kinds of surface finishes applied to OSB samples which were subjected to the cycle test. The composition with the polyurethane-based wood strengthening agent remained practically unchanged even after the cycle test. In the case of the samples treated with a lacquer suitable for the execution of primers, which is also used in the previous case in combination with the strengthening agent, visible cracks appear in the area of the edges. However, the greatest cracks appeared in the samples coated with acrylate wood paint.

Figure 5. Different levels of damage to 3 types of surface finishes applied to OSB samples after the cycle test. From the left: Composition 8 – composition with polyurethane-based strengthening agent, composition 4 – lacquer suitable for primers, composition 5 – acrylate wood paint.

In the end, all of the samples which were subjected to the cycle test were subjected to the swelling test after their placement in water, and at the same time the increase in weight in direct relation to water absorption was determined. The results are shown in the following graphs (Figure 6, Figure 7) and they correspond to the level of surface finish damage after the cycle test. Composition 2 – one-component waterproofing screed, and composition 8 – composition with polyurethane-based wood strengthening agent, achieved the best results again. This result corresponds to the fact that the samples treated with these surface finishes did not visually appear to be damaged significantly after the cycle test. In this case, in contrast with the previous ones, composition 1 – silicone waterproofing coating – also obtained better results, attaining a similar result to composition 3 – the composition with a cork mixture. This surface finish displayed very good resistance against changing environmental conditions and the alternation of low and high temperatures. All of the other surface finishes were somewhat degraded by the occurrence of cracks after the cycle test.

Graphs showing the growth in weight in direct relation to water absorption in the samples which were subjected to the cycle test (Figure 7) display similar results to the swelling graph (Figure 6). The problem with composition 3 (the composition with a cork mixture for application by spraying) which was discussed earlier was repeated.

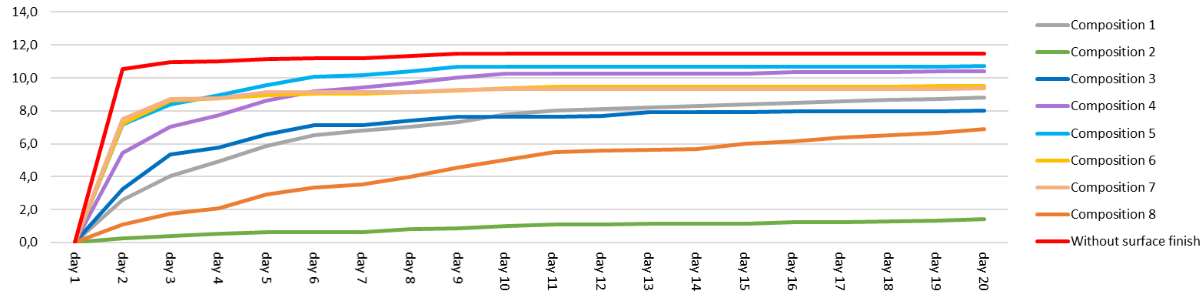

Figure 6. A graph showing curves for swelling in [%] after the cycle test for samples treated with surface finishes across their whole surface.

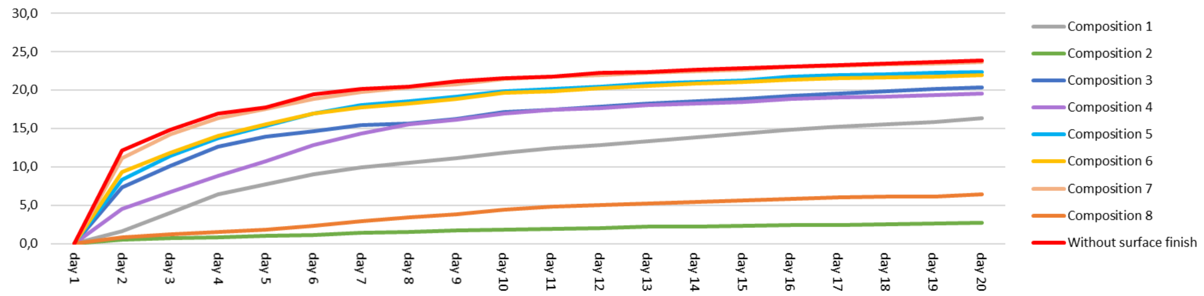

Figure 7. Graph showing the increase in weight in direct relation to water absorption in [g] after the cycle test in samples treated with surface finishes across their whole surface.

4. Conclusions

The results of the experiments confirmed the assumption that the choice of surface finish has a significant effect on OSB subjected to prolonged exposure to moisture. A suitably selected surface finish can have a notable influence on the size of the swelling of OSB, as well as on the quantity of absorbed moisture. All of the used surface finishes which were discussed in this contribution decreased the size of the swelling of OSB, some of them by almost 90% in comparison with the sample without a surface finish. Similarly, all surface finishes lowered the amount of absorbed moisture, some by as much as 75%, in comparison with the sample without a surface finish. It was thus shown clearly that the type of surface finish used significantly affects the results. It was also proved that the treatment of only the edges with a surface finish does not provide significantly better results than those obtained for OSB with a surface finish applied across the whole surface of the test specimen. The last result is the conclusion that swelling stabilises within 10 days, while the increase in moisture continues much longer: a stabilised state is not achieved even after 20 days of exposure.

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