

Edited by Michaela Kostelecká

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# Proceedings of the Conference on the Rehabilitation and Reconstruction of Buildings CRRB 2013

Selected, peer reviewed papers from the 15<sup>th</sup> International Conference on Rehabilitation and Reconstruction of Building (CRRB 2013),
November 14-15, 2013, Prague, Czech Republic

Edited by

Michaela Kostelecká



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## **Preface**

The 15<sup>th</sup> International Conference on Rehabilitation and Reconstruction of Building – CRRB 2013 was held in Prague, Czech Republic from November 14 till November 15, 2013. The 2013 year was organised by Scientific Society for the Restoration of Buildings and Care of Monuments WTACZ together with Klokner Institute of the Czech Technical University in Prague.

The 2013 conference was attended by 37 participants from the Czech Republic, Slovakia, Ukraine and Germany.

The CRRB 2013 conference continued the previous meeting (14<sup>th</sup> International Conference on Rehabilitation and Reconstruction of Building – CRRB 2012) held in Brno.

The conference discusses recent results of research and developments in protection and restoration of wood, half-timber, masonry and concrete structures of buildings, and in restoration of stone. The focus was also on surface treatment, physical-chemical properties and static and dynamics of structure too.

The CRRB 2013 conference organizers would like to thank all the speakers, session chairpersons, invited speakers and participants for making this conference successful.

## EDITOR

Michaela Kostelecká



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# **CHAPTER 1: Protection and Restoration of Wood Structures**

# Durability evaluation of wood based board materials against brown-rot fungi effect

Vanerek, Jan<sup>1,a\*</sup>, Palovcikova, Dagmar<sup>2,b</sup> and Venhodova, Ester<sup>1,c</sup>

- <sup>1</sup> Brno University of Technology, Faculty of Civil Engineering, Veveri 331/95, 602 00 Brno, Czech Republic, tel. +420 541 147 514
  - Mendel University in Brno, Faculty of Forestry and Wood Technology, Zemedelska 3, 613 00 Brno, Czech Republic, +420 545 134 117

<sup>a</sup>vanerek.j@fce.vutbr.cz, <sup>b</sup>dagmar.palovcikova@mendelu.cz, <sup>c</sup>venhodova.e@fce.vutbr.cz

Keywords: board material, brown rot fungi, durability, wood.

**Abstract.** The aim of the experiment was to determine the durability of wood based board materials against wood-rot fungi (*Serpula lacrymans*) effect. The particle boards, oriented strands boards and plywood as the testing materials were chosen. The spruce solid wood as the reference testing material was selected due to the fact that is most common timber species in the Central European region. The testing samples were exposed to wood-rot fungi and in the individual time periods the weight loss (declaring the deterioration process) and mechanical properties (static bending strength and tensile strength perpendicular to the plane of the board) was investigated. It was found that the deterioration of board materials in a very small weight decreases (up to 1.0%) leads to a significant decrease of their strength properties.

## 1. Introduction

If the wood-based materials are exposed to favorable conditions allowing the development of wood-destroying factors, then they are deteriorated. This deterioration can be a microbial nature (due to the action of wood decay fungi, mold and blue stain fungi, and bacteria), or it may be a degradation due to the effects of abiotic factors or degradation of the synergistic action of the above effects. The action of wood-rot fungi on wood reduces the durability of wood, which is reflected in particular by reducing physical - mechanical properties. Therefore, in construction practice is necessary to create the conditions that themselves prevent the emergence and development of degradation factors [1]. In particular, these include the reduction of moisture exposure using appropriately selected construction modifications of building elements. Description of the moisture effect on the development of brown- rot fungi is specified in many studies, eg. [2, 3]. Typical macroscopic expression of wood damage by wood-destroying fungi is evident in the numerous documents and studies, including specification of optimal conditions for the development of these degradation factors. [4].

1.1. Wood-Decay Fungi. Degradation of the wood is generally a biochemical process in which there is a simultaneous degradation of wood components, depending on whether it is a brown-white- or soft-rot fungi. Brown-rot fungi utilize hemicellulose and cellulose in the cell wall, leaving lignin essentially undigested [5, 6]. Thus attacked wood turns brown, shrink and break into typical brick-shaped piece that easily crumble. The process of degradation by brown rot fungi is accompanied by a rapid decline in strength, in contrast to white-rot and is caused by rapid depolymerisation holocellulose, and degradation products are formed faster than they are utilized [7]. The degree of polymerization of holocellulose rapidly decreases at the initial stage of brown rot decay before measurable sign of weight loss [8, 9]. The brown-rot fungi affect several strength properties of wood before significant weight loss is detected [10]. Toole [11] found brown rot that caused about 18% loss in compressive strength perpendicular to the grain at 2% weight loss.

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Similarly, in [12] Mizumoto found a 10% reduction in compressive strength parallel to the grain at 2% weight loss.

Degradation of polysacharidic part can be described as a variety of chemical processes; especially hydrolytic degradation due to synergistic action of enzymatic products produces by wood decay microorganisms. The other oxidative reactions participate in the degradation of crystalline cellulose [13]. The degradation of polysacharides is affected by generally several factors, especially by pH value and temperature.

1.2. Objective of the Paper. In terms of evaluation durability of wood, there are normatively classified as natural durability class that reflects the resistance of wood against action of degrading organisms. These classes are specified in EN 350-2, it is a wood resistance against action of wood-destroying insects, wood-destroying fungi, termites and marine pests. From the viewpoint of durability of printed circuit board materials which are bonded with different kinds of binder (a thermosetting resin, silicate binder) is not normatively adjusted their durability. Therefore, an experiment was performed to determine the durability of these materials during exposition of dryrot fungus (Serpula lacrymans) belonging to the brown rot wood-destroying fungi (brown-rot fungi).

## 2. Materials and methods

- **2.1. Fungal strain specification and cultivation methods.** For assessment were selected fungus *Serpula lacrymans* (strain 777) as decaying fungi, obtained from deposited in the Culture Collection at the Department of Forest Protection and Wildlife Management, Mendel University in Brno. The strain was grown on agar malt extract medium (3% MEA 137, fi HiMedia) at a Petri dish and were stored in climatization box for 3 weeks at 17 ° C in the dark. After that was sterilization of polymer boxes started, in which the specimens were exposed (autoclave at 0.1 MPa, 121 ° C, 20 min). 500 ml of sterilized malt extract agar (3% MEA 137 HiMedia Fi) were poured to the sterilized polymer boxes and was allowed to solidify. Then culture media were inoculated with the test fungi with mycelia and using a small agar slant from the Petri dish into plastic boxes and deposited in areas with a temperature of 13-15 °C for a period of one month. After this time, the specimens could be exposed into the box. Samples were stored in a sterilized glass tubes to prevent direct contact with agar malt extract medium. The prepared test boxes were closed and left in areas with a constant temperature of 13-15 °C.
- **2.2.** Wood decay fungi exposure. Due to the size of the test samples were selected plastic boxes with covers instead Kolle flasks for exposure test samples. In order to better air circulation were plant boxes provided with two holes in the cover, which was threaded through by a sterile glass tube filled with cotton wool. Cultivation boxes can resist to sterilization temperatures and doesn't occur any significant chemical reactions, which could affect the growth and development of wood decay fungi. For exposing the testing samples against rot fungi, the time intervals of 42, 56 and 84 days were chosen. Before performing the tests themselves the exposed samples were mechanically purified from mycelia, weight and left for one week to acclimatize in the laboratory environment.
- **2.3. Testing samples.** Dimensions of test specimens are determined by the requirements of the standards which described the relevant property. The choice of material thickness respected product range, material thickness is specified in Table. The number of samples for each test in the test period was set at 10 pieces to the material.

Sample	Marking	Thickness [mm]	Bulk density EN 323 ρ <sub>w</sub> [kg,m <sup>-3</sup> ]	
Gypsum fibreboard	GFB	12.5	1219	
Plywood	PW	10.0	599	
Oriented strand boards	OSB	12.0	690	
Particleboards	PB	12.0	768	
Spruce*)	SP	12.0	473	

## 2.4. Testing methods

- 2.4.1. Moisture. The test was performed according to EN 325.
- 2.4.2. Weight loss. The test was performed according to EN 113. With respect to the different material thicknesses were chosen dimensions of test specimens of 50 × 25 × thickness mm. The weight loss was determined as the difference in mass of a sample of the same moisture before and after exposure to wood decaying fungi.
- 2.4.3. Bending strength. The test was performed according to EN 310 on test specimens with dimensions corresponding normative requirements. Even loading was carried out on a testing press Testometric M350-20CT at speed of crossheads 2mm/min.
- 2.4.4. Tensile strength perpendicular to the plane of board. The test was performed according to EN 319. Each specimen was fitted by a test target glued by two-component epoxy adhesive. Even load loading was carried out on a testing press Testometric M350-20CT until the failure of samples.

### 3. Results and discussion

## 3.1. Macroscopic observation.

Testing samples from each wood based board materials were finally evaluated from macroscopic aspect to visually asses the rate of deterioration by rot fungi. However the visual evaluation can not carry out the quantification of sample deterioration, therefore the enzymatic degradation of wood substrate is performed not only by surface mycelium, but moreover by enzymatic action of substrate mycelium existing in material structure.

- 30 days of Exposure. Already after a period of 30 days, it was found that the mycelium of fungi covered spruce wood, in some cases surface mycelium has covered the entire testing sample. Other test samples from board materials were covered by surface mycelium only on the bottom edge of samples which have been in contact with the wood decaying fungi. Therefore the strength characteristics were not performed in this period.
- 42 days of Exposure. During the 42 days of exposure, the surface mycelium of fungi covered unevenly its whole surface of testing spruce samples. Spruce was already after six weeks deteriorated that propagation of slight transverse cracks began. Surface mycelium attacked board materials reaching nearly one third of the sample surface.
- 56 days of Exposure. After 56 days of exposure, the mycelium of fungi was visually observed covering specimens of ca 1/3 to 1/2 of sample surface for all testing samples, but the distribution of surface mycelium was non-uniform along the length of the testing samples. Colour of mycelium

<sup>&</sup>quot;) according to CSN 49 0108

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changed from yellow-white to grayish-yellow and sometimes up to a brown colour, which signaled the beginning of a fructification process of wood-decaying fungi.

**84 days of Exposure.** After a period of 84 days, fungal mycelium was grown to a large extent completely covering the samples of spruce wood except larger testing samples for bending strength evaluation. Other test specimens of board materials achieved complete coverage by the surface mycelium also. Colour of mycelia changed dramatically into yellow-brown to dark brown colour.

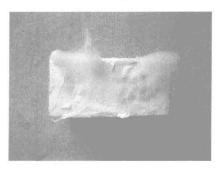


Fig. 1. Spruce sample for weight loss after 56 days of exposure

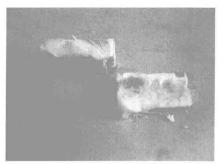


Fig. 2. Particleboard sample for weight loss after 84 days of exposure

## 3.2. Physical and mechanical testing

**3.2.1. Moisture content.** Moisture content of testing samples after colonization of wood decaying fungi increased as it was expected and showed a noticeable increase for solid spruce wood. The values of moisture content in all time periods are shown in the following Fig 3.

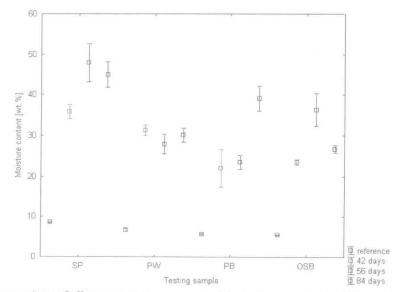


Fig. 3 Comparison of all mean moisture content of the testing samples in different time periods exposed to brown rot fungi, confidence interval 0.95

3.2.2. Weight loss. While carrying out the weight loss assessment, significant differences between the degradation of spruce and agglomerated materials were found out. No significant

values of weight losses were observed when comparing the achieved values to reference spruce solid wood. The spruce weight loss achieved value of about 31% and the deterioration was almost linear. For board materials containing wood components bonded with organic binders, the percentage weight loss increased to values between 1-4%. The chronological aspect of each percentage changes in weight losses is given in Table. No. 2

Tab. 2 Percentage changes in weight losses in time periods of exposures

Sample	Weight Loss [%]					
	42 days of exposure		56 days of exposure		84 days of exposure	
	mean	S.D.	mean	S.D.	mean	S.D.
Spruce	14.47	3.80	23.76	8.10	31.15	4.67
Plywood	0.52	0.32	0.80	0.11	2.88	0.25
Particleboard	0.63	1.35	0.69	0.15	2.91	0.48
Oriented strandboard	0.73	0.37	1.67	0.71	4.10	2.30

**3.2.3. Bending strength.** The most important reduction in bending strength was achieved after 84 days of exposure for spruce wood and plywood test samples. For the solid wood, the strength reduction achieved about 35 %, for the plywood, the decrease achieved ca. 29.3%. Complete values of strength drops are shown in Table 3 and graphically are shown in Fig 4. However, the test results were partly influenced by the size of the test samples, and also by different growth activities of fungi in individual containers in which the testing samples were exposed. There had been a significantly smaller decrease in weight loss in test specimens for bending strength than these ones, which were found for samples intended for weight loss measurements. For this reason, there was not achieved constant decrease trend of strength properties for some test materials over time. Although the relationship between decreasing strengths and rates of material was confirmed.

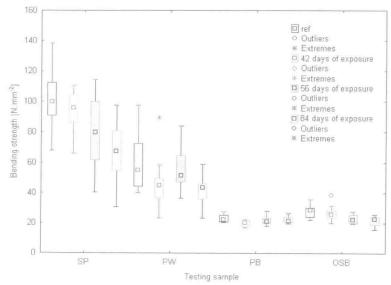


Fig. 4 Comparison of bending strengths of testing samples in different time periods exposed to brown rot fungi.

For spruce testing samples, the dependence of the decreasing bending strength values onto the appropriate weight loss was observed, and is graphically illustrated in Fig 5. The graph confirms the

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assumption that significant declines in strength properties mostly occurred till the stage of 2.0% weight loss decrease.

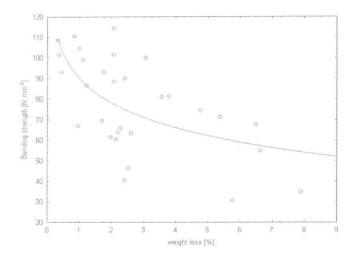


Fig. 5: Graph of bending strength dependent onto the weight losses for a spruce sample, correlation coefficient r = 0.608

Analyzing the results of wood based board materials, it was found that the most important strength declines occurs at very low values of weight losses (up to 1.0%) declaring infestation of testing materials by decaying fungi. The results of these dependencies are shown in Table. 3.

Tab. 3 Comparison of mean bending strength declines onto the appropriate mean weight losses for all testing samples

	42 days of exposure		56 days of exposure		84 days of exposure	
Sample	strength loss [%]	weight loss [%]	strength loss [%]	weight loss [%]	strength loss [%]	weight loss [%]
Spruce	8.1	1.07	22.5	2.26	54.6	4.61
Plywood	21.5	0.59	14.1	0.26	41.4	0.37
Particleboard	13.4	0.26	13.8	0.27	11.4	0.22
Oriented strandboard	4.4	0.20	18.6	0.24	29.8	0.42

**3.2.4. Tensile strength perpendicular to the plane of the board.** Even though it is the strength characteristics for wood based board materials, this test was performed for spruce sample, for which the most significant declines was observed. For all the testing wood based board materials, the significant decrease of adhesion strength was shown even after 42 days of wood decay fungi exposure. The value of the strength decreased up to 40% of its original strength in this time period. It was thus confirmed trend of significant reductions in strengths at low weight loss values for all tested materials.