Mould growth on wood-based materials – a simulated in-service study

Gunilla Bok*, Pernilla Johansson*, Jöran Jermer**

SP Technical Research Institute of Sweden
*Dept of Building Physics and Indoor Environment
Box 857, SE-501 15 Borås, Sweden

**Dept of Wood Technology
Box 5609, SE-114 86 Stockholm, Sweden

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a simulated in-service study

Gunilla Bok¹, Pernilla Johansson¹, Jöran Jermer²
SP Technical Research Institute of Sweden

¹Dept of Building Physics and Indoor Environment
   Box 857, SE-501 15 Borås, Sweden
gunilla.bok@sp.se, pernilla.johansson@sp.se

²Dept of Wood Technology
   Box 5609, SE-114 86 Stockholm, Sweden
   joran.jermer@sp.se

ABSTRACT

Ten different wood-based materials including preservative-treated wood, fire retardant-treated wood, modified wood, WPCs and untreated references of pine sapwood and spruce were placed in three different environments (an attic and two crawl spaces) for a period of 26 months. Mould growth was analysed at five to seven month intervals in an effort to map the growth development. The relative humidity and temperature were logged continuously.

The results obtained from testing in the two crawl spaces generally corresponded well with a previous laboratory study. None of the materials tested could completely withstand mould growth during the 26 months’ exposure time. Most promising results were obtained with the preservative-treated WPC and the least promising with the modified wood materials. For the latter, poor mould resistance is of major concern.

Keywords: mould, crawl space, attic, preservative-treated wood, fire retardant treated wood, modified wood, WPC

1. INTRODUCTION

This study is part of a series of tests to investigate the mould resistance of different wood materials and is a follow-up of a laboratory study presented at the IRG Annual Meeting in 2010 (Johansson et al 2010).

The purpose of this study was to assess the performance of the same materials tested in the laboratory against mould growth in simulated in-service conditions. Thus, test samples were placed in an attic and in two crawl spaces with different climatic conditions. Compared to the laboratory study relative humidity (RH) and temperature in these environments fluctuated and the mould resistance of the different materials was tested for a longer period.

2. MATERIALS AND METHODS

2.1 Materials
The materials tested are specified in Table 1, i.e. the same materials tested in the laboratory study (Johansson et al 2010). The sample size was 50 x 100 mm.
Table 1. Material tested in the study.

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated wood (references)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine (<em>Pinus sylvestris</em>) sapwood</td>
<td>Planed</td>
<td></td>
</tr>
<tr>
<td>Spruce (<em>Picea abies</em>)</td>
<td>Planed</td>
<td></td>
</tr>
<tr>
<td>Preservative-treated wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Celcure AC 800</td>
<td>Active ingredients</td>
<td>Treated according to Nordic class AB, i.e. use class 3 (above ground); purchased by SWPA from timber yards.</td>
</tr>
<tr>
<td>Tanalith E-7</td>
<td>Copper, benzalkoniumchloride</td>
<td></td>
</tr>
<tr>
<td>Wolmanit CX-8</td>
<td>Copper, propiconazole, tebuconazole</td>
<td></td>
</tr>
<tr>
<td>Fire retardant-treated wood</td>
<td>Planed <em>P. sylvestris</em> treated with Dricon, fire- retardant system by Arch Chemicals</td>
<td>Treatment carried out by Woodsafe AB</td>
</tr>
<tr>
<td>Dricon</td>
<td>Copper, boron, bis-(N-cyclohexyldiazene-dioxy-) (HDO)</td>
<td></td>
</tr>
<tr>
<td>Modified wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetylated pine (<em>P. sylvestris</em>)</td>
<td>Acetyl content 22-23%</td>
<td>Prepared at SPs pilot plant</td>
</tr>
<tr>
<td>Furfurylated pine (<em>P. sylvestris</em>)</td>
<td>WPG approximately 35%</td>
<td>Submitted by Kebony ASA</td>
</tr>
<tr>
<td>Thermally treated pine (<em>P. sylvestris</em>)</td>
<td>The thermal process had a maximum temperature of 212 °C for duration of one hour.</td>
<td>Thermal treatment carried out by Scandinavian Finewood AB</td>
</tr>
<tr>
<td>WPC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WPC untreated</td>
<td>~50% M/M <em>P. sylvestris</em> fibres (untreated)</td>
<td>Preservative formulation submitted by Viance LLC</td>
</tr>
<tr>
<td>WPC preservative-treated</td>
<td>~50% M/M polypropylene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>~50% m/m <em>P. sylvestris</em> fibres treated with a isothiazolone-based solution to a retention of approximately 700 ppm, giving a retention of approximately 350 ppm in the WPC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>~50% m/m polypropylene</td>
<td></td>
</tr>
</tbody>
</table>

2.2 Test environments

Two single-family houses, built in 1997 and 2007, and situated in the Borås-Gothenburg area in south-western Sweden were selected for the study. Samples were exposed in both the attic and the crawl space of the older house but only in the crawl space of the younger house.

The test samples were placed in stainless steel spring clips mounted on aluminium strips on the blind floor in the crawl spaces and on roof trusses in the attic (Figure 1). The samples could easily be dismantled from the clips prior to analysis of microbial growth.

![Figure 1. Test pieces and the data logger mounted on the blind floor.](image)
2.3 Measurements of temperature and humidity
The relative humidity and temperature at each test-site were registered every fourth hour by data loggers with internal sensors (Testo 177-H1 and Testo 177 H2). These were placed close to the specimens to ensure that measured conditions matched those the specimens were exposed to. One logger was placed at each test-site.

The data loggers were calibrated after the test periods but the data presented in this report is raw data and not adjusted. It should be regarded as a description of prevailing climate conditions in the different environments. The adjusted relative humidity is expected to be higher than presented, whereas the temperature is expected to be more or less the same.

2.4 Assessment of mould growth
The test samples were analysed with regard to mould growth at intervals of five to seven months. At each inspection they were removed from the racks and the surface that had been exposed to the open air in the attic and crawl spaces was studied under the microscope at 10–40x magnification, making it possible to detect mould growth not visible to the naked eye. The mould growth was rated according to the scale in Table 2.

Table 2. Rating scale for assessment of mould growth.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No fungal growth</td>
</tr>
<tr>
<td>1</td>
<td>Initial fungal growth consisting of scattered hyphae on the surface</td>
</tr>
<tr>
<td>2</td>
<td>Still scattered growth, but more apparent than in 1. Conidiophores may have started to develop.</td>
</tr>
<tr>
<td>3</td>
<td>Patchy distributed heavy growth. Hyphae with developed conidiophores.</td>
</tr>
<tr>
<td>4</td>
<td>Heavy growth over the entire surface</td>
</tr>
</tbody>
</table>

3. RESULT AND DISCUSSION

3.1 Relative humidity and temperature in the attic
The relative humidity and temperature in the attic during the exposure period is shown in Figure 2.

Figure 2. Climate data from the attic.
The attic can be characterized as dry and relatively hot in the summer and more humid in the winter but at the same time cold which reduces the potential for mould growth.

3.2 Relative humidity and temperature in the crawl spaces
Climate data for the two crawl spaces are shown in Figures 3 and 4. Crawl space no. 2 had higher moisture levels than crawl space no. 1. Both crawl spaces can be characterized as warm and humid in the summer and early autumn. This is common for naturally ventilated crawl spaces (Bok et al 2009).

![Figure 3](image3.png)
Figure 3. Climate data from crawl space no. 1.

![Figure 4](image4.png)
Figure 4. Climate data from crawl space no. 2.

3.3 Mould growth in the attic
No mould growth was detected on any of the test samples at any inspection. Thus, the environment in the attic did not support mould growth and this can be illustrated in Figure 5. The curve shows the critical moisture level at different temperatures. The dots represent one measuring point of relative humidity and temperature. The total numbers of measurements above the calculated critical moisture level were relatively few and scattered in time and therefore no mould growth was established.
The result corresponds well with recent results from a study on critical moisture levels on different materials (Johansson et al 2012). The result also corresponds well with practice. Most attics actually have a climate which does not support mould growth.

Figure 5. Monitored relative humidity and temperature in the attic in relation to calculated lowest critical moisture level.
3.4 Mould growth in the crawl spaces
Mould growth was supported in both the crawl spaces, and the median of the ratings is presented for the different materials in Figures 6-11.

The spruce references and untreated WPCs in crawl space no. 2 were assessed to have a lesser degree of mould growth at the last inspection (Figure 11). The estimation of the mould growth is always subjective and can therefore differ between separate occasions. A small difference in estimated growth can result in a noticeable difference in the median value.

Figure 6. Median value of the mould growth on preservative-treated and fire retardant-treated wood in crawl space no. 1.

Figure 7. Median value of the mould growth on preservative-treated and fire retardant-treated wood in crawl space no. 2.
Figure 8. Median value of the mould growth on the modified wood in crawl space no. 1.

Figure 9. Median value of the mould growth on the modified wood in crawl space no. 2.
When considering Figures 6-11 one can conclude that the result for each of the two crawl spaces corresponds fairly well. The somewhat higher moisture load in crawl space no. 2 clearly enhances early mould growth on all materials and on thermally modified wood in particular.

No significant differences with respect to susceptibility for mould growth between different types of preservative-treated or modified wood materials can be observed at the end of the exposure. None of these materials has performed better than the spruce reference. The preservative-treated WPC is the only material that has performed better than the spruce reference throughout the test.
4. CONCLUSIONS

The following conclusions can be drawn from this study:

- The results obtained from testing in the two crawl spaces in general correspond well with the previous laboratory study.

- None of the materials tested could completely withstand mould growth during the 26 months’ exposure time.

- The most promising results were obtained with the preservative-treated WPC and the least promising with the modified wood materials. For the latter, poor mould resistance is of major concern.

Further evaluation of test data from the laboratory and in-service study will be carried out in order to improve the knowledge of the different materials resistance to mould growth.

5. ACKNOWLEDGEMENT

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6. REFERENCES

