Relationship between stress wave transmission time and bending strength of deteriorated oriented strandboard

Robert J. Ross*
Vina W. Yang
Barbara L. Illman
William J. Nelson

Abstract

Stress wave nondestructive evaluation (NDE) technologies are used in the inspection of timber structures and frequently complement visual inspection procedures. Inspectors use stress wave NDE techniques to locate internal voids anddecayed or deteriorated areas in large timbers. Although those techniques have proven useful in inspections, no information exists concerning the relationship between stress wave transmission time and important residual strength properties of oriented strandboard (OSB) that has been exposed to decay fungi. We examined the relationship between stress wave transmissiontime andbending strength of OSB subjected to brown-rot decay fungi. Stress wave transmission time was measured on small OSB specimens that hadbeenexposed to brown-rot decayfungi for up to 11 weeks. Static bending tests were then performed on the specimens. A strong relationship was observed between stress wave transmission time and residual bending strength.

The degradation of a wood load-bearing (in-service) member may be caused by a variety of agents. Organisms that derive their nourishment or shelter from the wood substrate, swelling caused by moisture uptake, or exposure to high temperature are all agents that may deteriorate wood-based materials. Therefore, it is important to periodically examine wood structural components to determine the extent of degradation so that degraded members may be replaced or reinforced to avoid structural failure.

Stress wave nondestructive evaluation (NDE) techniques are used in such examinations, often as a complement to visual inspection procedures (Ross and Pellerin 1994). Stress wave NDE techniques are used to locate internal voids and decayed or deteriorated areas in large timbers. Although professional inspectors have found these techniques useful, little information exists on the relationship between stress wave parameters and important residual strength properties of wood-based materials.

A limited number of studies that focused on prediction of residual strength have been completed. Aggour (1989), Pellerin et al. (19851, and Ross et al. (2001,1997) used stress wave techniques to assess the residual strength of piles, small clear specimens, and timbers.

Based on the encouraging results from these studies and the potential use of stress wave NDE for inspection of wood composites, we designed a pilot study to examine the relationship between stress wave transmission times and residual bending strength of oriented strandboard (OSB). This paper summarizes the pilot study.

Materials and methods

A schematic diagram of the study protocol is shown in **Figure 1.** The common brown-rot fungus *Gloephyllum trabeum* (Mad-617) was selected for use

The authors are, respectively, Project Leader, Microbiologist, Project Leader, and Project Leader, USDA Forest Serv., Forest Prod. Lab., One Gifford Pinchot Dr., Madison, WI 53705-2398. This paper was received for publication in May 2002. Article No. 9496.
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in our study. To determine the rate of southern yellow pine OSB degradation, the weight of five replicate specimens was measured 0, 2, 4, 6, 8, and 11 weeks after exposure.

Gloephyllum trabeum was inoculated on malt extract agar (MEA) in an incubation chamber **(Fig. 2),** placed in a 27°C incubation room at 70 percent relative humidity, and allowed to grow for 7 days to obtain confluent growth before the OSB specimens were added. The OSB specimens were 12.7 by 25.4 by 305 mm.

Stress wave transmission times were determined for each specimen using a pulse echo test method (Ross et al. 1994). Note that this test was conducted while the OSB specimens were still in the incubation chamber. Transmission times were measured at 0, 2, 4, 6, 8, and 11 weeks after exposure.

The specimens were then removed from the incubation chamber, conditioned to 12 percent moisture content, and tested to failure in bending in accordance with ASTM D1037 (ASTM 1998).

Results and discussion

Average weight change, stress wave transmission time (dT), and modulus of rupture (MOR) values for the various exposure groups are summarized in Table 1. Figure 3 illustrates the relationship between weight change, inverse of transmission time, and exposure time. We observed no weight loss until the fourth week of exposure. Interestingly, after only 2 weeks of exposure, MOR decreased and dT increased.

Note that the inverse of transmission time (1/dT) was used as a predictor of both weight loss and strength properties of decayed southern yellow pine in previous research by Pellerin et al. (1985). Figure 4 illustrates the relationship between the inverse of transmission time and MOR. In general, the inverse of transmission time was found to be related to MOR. More important, however, was the discovery that initial strength loss was detected not by loss of specimen weight but by the inverse of stress wave transmission time. These two discoveries for OSB were similar to those reported by Pellerin et al. (1985) for a similar study conducted with small clear southern pine specimens. The researchers found that stress wave transmission times were longer in wood that had been exposed to brown-rot decay fungi. They also showed that compressive strength parallel to the grain decreased with longer exposure times. We believe that transmission times are longer due to the deterioration of the wood substrate. Prior research has shown that as wood components are deteriorated, strength decreases and transmission times become longer. Our results parallel those found by others on clear wood and timbers. The relationships between MOR, transmission times, and elevation of exposure are similar to those observed by others (Pellerin et al. 1985).

Table 1.—Average weight change, stress wave transmission time (dT), *and modulus of rupture values for various exposure groups*[a]

Exposure time	Avg. weight change	Avg. stress wave transmission time	Avg. MOR
(wk)	(%)	(µs/m)	(MPa)
0	+0.17 (0.1)	495 (46)	10.4 (1.6)
2	4.47 (0.2)	551 (85)	9.0 (1.6)
4	–0.54 (0.3)	557 (79)	7.6 (1.8)
6	–1.58 (0.6)	561 (88)	7.6 (1.1)
8	–5.08 (3.3)	577 (102)	5.7 (3.4)
11	4.39 (3.0)	629 (194)	3.8 (2.9)

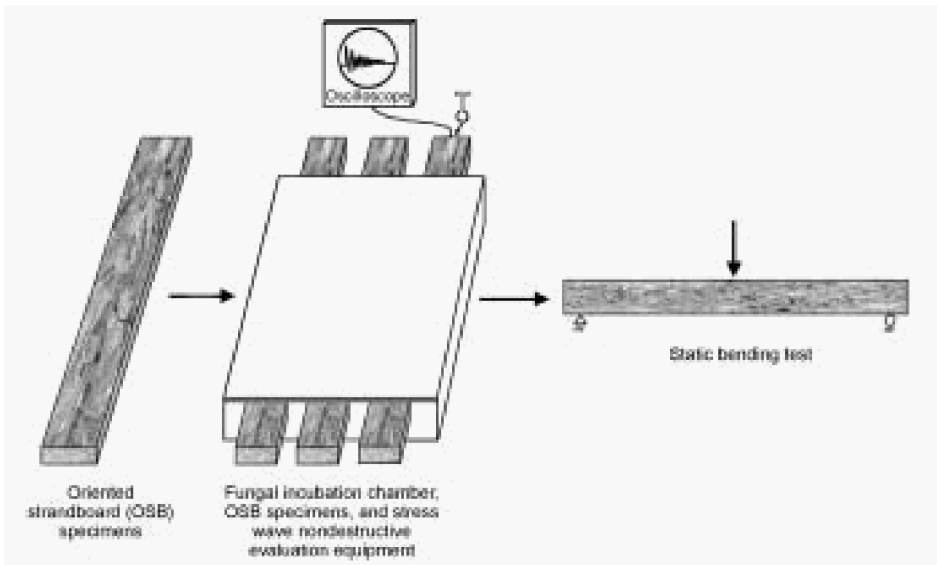

Figure 1.—Schematic diagram of study protocol

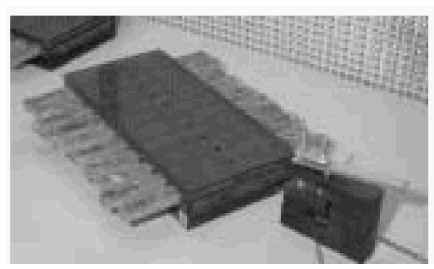

Figure 2.—Stress wave device and fungal incubation chamber with OSB.

Conclusions

Based on results from this pilot study, we conclude the following:

1. OSB strength decreases with exposure to brown-rot decay fungi.

2. Stress wave transmission times increase with exposure of OSB to brown-rot decay fungi.

3. OSB weight loss is not a good indicator of strength loss associated with early stages of decay.

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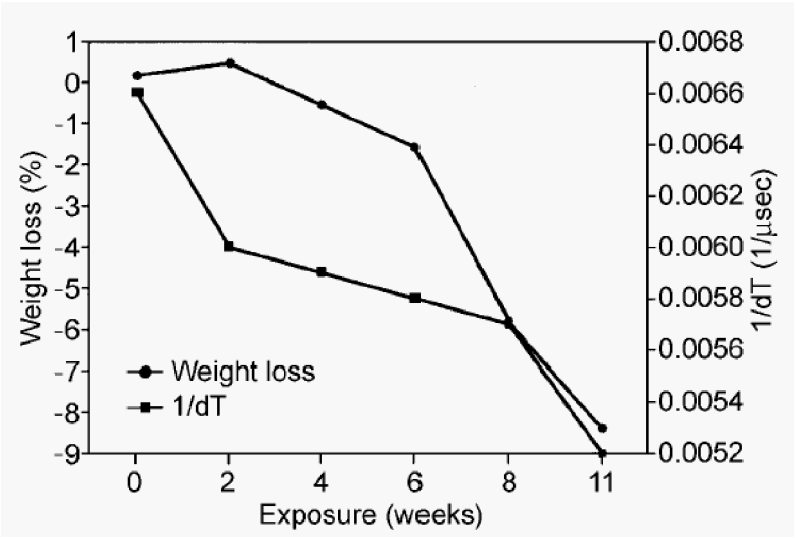

Figure 3.—Weight change and inverse stress wave transmission time of OSB exposed to G. trabeum.

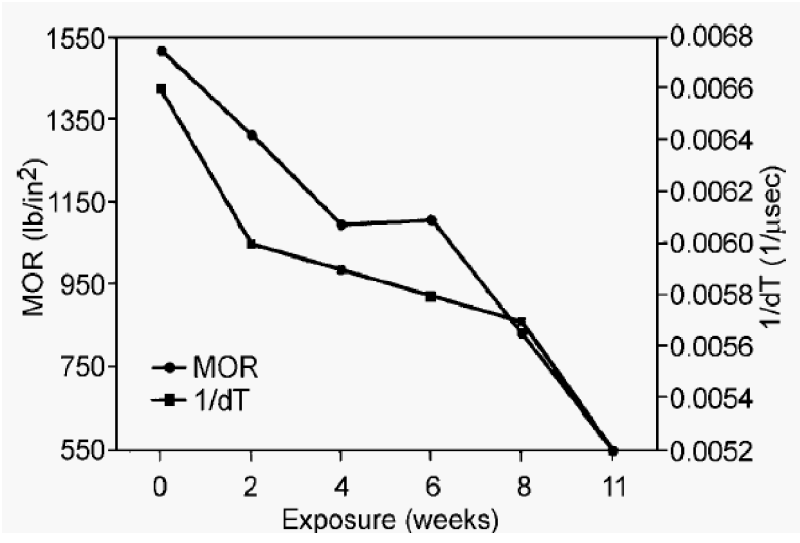

Figure 4.—MOR and inverse stress wave transmission time as a function of exposure time. 1 psi = 6.894 kPa.

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