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Nondestructive Evaluation of Oriented Strand Board Exposed to Decay Fungi

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Abstract

Stress wave nondestructive evaluation (NDE) technologies are being used in our laboratory to evaluate the performance properties of engineered wood. These techniques have proven useful in the inspection of timber structures to locate internal voids and decayed or deteriorated areas in large timbers. But no information exists concerning NDE and important properties of wood composites exposed to decay fungi. For our pilot study on several types of wood composites, we examined the relationship between nondestructive stress wave transmission, decay rate and the bending properties of OSB exposed to the brown-rot fungus, *Gloeophyllum trabeum* (MAD-617). The following measurements were taken: stress wave transmission time (pulse echo test method), static bending test (ASTM D3043-95), and decay (expressed as percent weight). Stress wave measurements correlated with strength loss and with increasing rate of fungal decay. Stress wave NDE has great potential as a method for inspection of wood composite load-bearing (in-service) structures, detection of decay in laboratory tests, assessment of chemical additives to improve wood composite durability, and prediction of long term composite performance.

Keywords: decay fungi, OSB, NDE, stress wave evaluation

Introduction

Engineered wood composites are becoming important structural materials in the construction of houses in the United States. Biological or thermal degradation may weaken the load bearing (in-service) structural materials. Therefore, it is important to periodically examine these structures 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 composites.

In a study on the use of ultrasonic NDE technologies for inspection of timber pilings, Aggour (1989) found a useful working relationship between sound transmission times (perpendicular to grain) and compressive strength (parallel to grain) of piles. Pellerin and others (1985) conducted the most systematic investigation on the use of stress wave NDE techniques to estimate the residual strength of wood. These researchers focused on speed of stress wave transmission and found a useful correlative relationship with the parallel-to-grain compressive strength of wood attacked by brown-rot fungi. A relationship between the longitudinal speed of stress wave transmission and compressive strength was not found in members attacked by termites. Termites attack earlywood but not latewood, which is still able to transmit a longitudinal stress wave.

A more recent study (Ross and others, 1997) examined the relationship between stress wave speed and attenuation and parallel-to-grain compressive strength of biologically degraded wood. Speed of stress wave transmission and attenuation characteristics of clear wood specimens exposed to decay fungi and termites under field conditions were determined. These nondestructive parameters were then incorporated into a multivariable regression model and used to predict parallel-to-grain compressive strength of the specimens. Excellent agreement was found between predicted and actual compressive strength values.

Most recently, Ross and others (2001) examined the relationship between stress wave transmission times and the compressive properties of timbers removed from service. Utilizing timbers from two different structures, they revealed a useful relationship between stress wave transmission time and the residual strength of a small sample of large 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 study to examine the relationship between stress wave transmission times and residual bending strength of engineered wood composites exposed to decay fungi. This paper summarizes the results of our pilot study for decay of oriented strand board (OSB) exposed to the brown-rot fungus, *Gloeophyllum trabeum* (MAD-617).

Materials and Methods

In an earlier study (Yang and others, 2001) fourteen brown-rot and eight white-rot wood decay fungi were screened for their capacity to degrade OSB. Samples were evaluated for decay using the American Society for Testing and Materials standard test method for wood preservatives by soil-block cultures (ASTM D1413-76). The percent weight loss was calculated at the end of a 12-week incubation period. Five replications were used for each fungus.

The brown-rot fungus *Gloephyllum trabeum* (Mad-617) was selected for the present study. To determine the rate of OSB degradation, the weight of five replicate specimens was measured 0, 2, 4, 6, 8, 10, and 12 weeks after exposure. Southern yellow pine samples were used for comparison.

Gloephyllum trabeum was inoculated on malt extract agar (MEA) (2%) in a special incubation chamber (Figure 1), placed in a 27°C incubation room at 70% relative humidity, and allowed to grow for 7 days to obtain confluent growth before the OSB stakes (12.7 by 25.4 by 305 mm) were added.

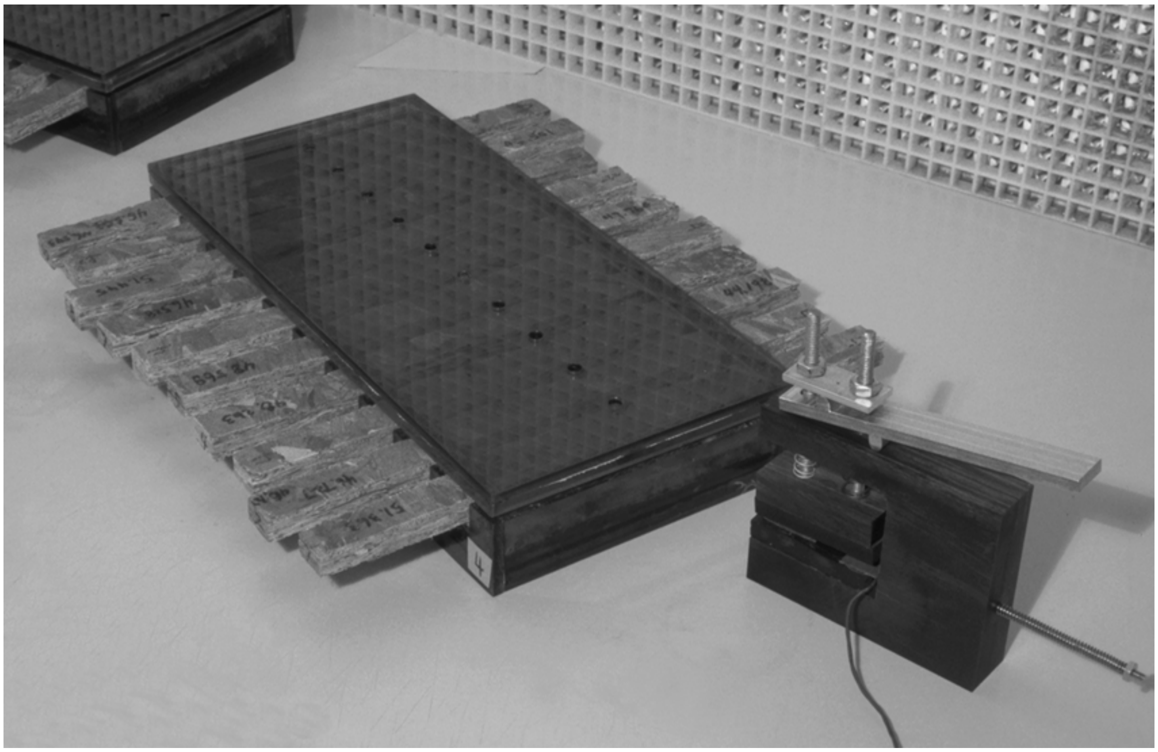

Figure 1. Stress wave device and fungal incubation chamber with OSB.

Speed of sound transmission was determined for each specimen using a pulse echo test method. Note that this test was conducted while the specimens were still in the specially designed incubation chamber. Sound transmission values were measured at 0, 2, 4, 6, 8, 10, and 12 weeks after exposure.

The specimens were then removed from the incubation chamber, conditioned to percent moisture content, and tested to failure in bending in accordance with standard method for structural panels in bending (ASTM D3043-95).

Results and Discussion

Nondestructive stress wave analysis was successfully used to detect fungal decay of OSB. Changes in stress wave transmission times correlated with decreasing strength of OSB with increasing time of exposure to *G. trabeum*.

Average weight loss, stress wave transmission time, and modulus of rupture (MOR) values for the various groupings are summarized in Table 1.

Table 1. Decay, NDE and strength loss of OSB exposed to *Gloeophyllum trabeum*

Exposure time, weeks	Average weight loss (gain) percent (standard deviation)	Average Stress wave transmission time, µsec/ft (standard deviation)	Average Modulus of rupture, psi (standard deviation)
0	(0.17) (0.09)	151 (14)	1515 (233)
2	(0.47) (0.15)	168 (26)	1312 (229)
4	0.54 (0.34)	170 (24)	1095 (269)
6	1.58 (0.55)	171 (27)	1108 (155)
8	5.08 (3.3)	176 (31)	832 (490)
11	8.39 (3.0)	192 (59)	547 (422)

Average weight loss and stress wave transmission time are shown graphically in Figure 2. In general, longer stress wave transmission times were found in the specimens that were exposed to fungi for longer periods of time. Similarly, MOR values decreased with extended exposure times. The relationship between stress wave transmission times and the modulus of rupture (MOR) is illustrated in Figure 3.

These two findings are similar to those reported by Pellerin et al (1985) in a study conducted with small clear southern yellow pine specimens. They found that stress wave transmission times were longer in wood that had been exposed to brown-rot fungi. They also showed that compressive strength, parallel to the grain, decreased over time.

The success of this pilot study has led to application of NDE to other composite materials. We are currently analyzing data obtained for laminated veneer lumber (LVL) and for wood fiber plastic composites. Stress wave NDE has great potential as a method for inspection of engineered wood composites, detection of decay in laboratory tests, assessment of chemical additives to improve wood composite durability, and prediction of long-term composite performance.

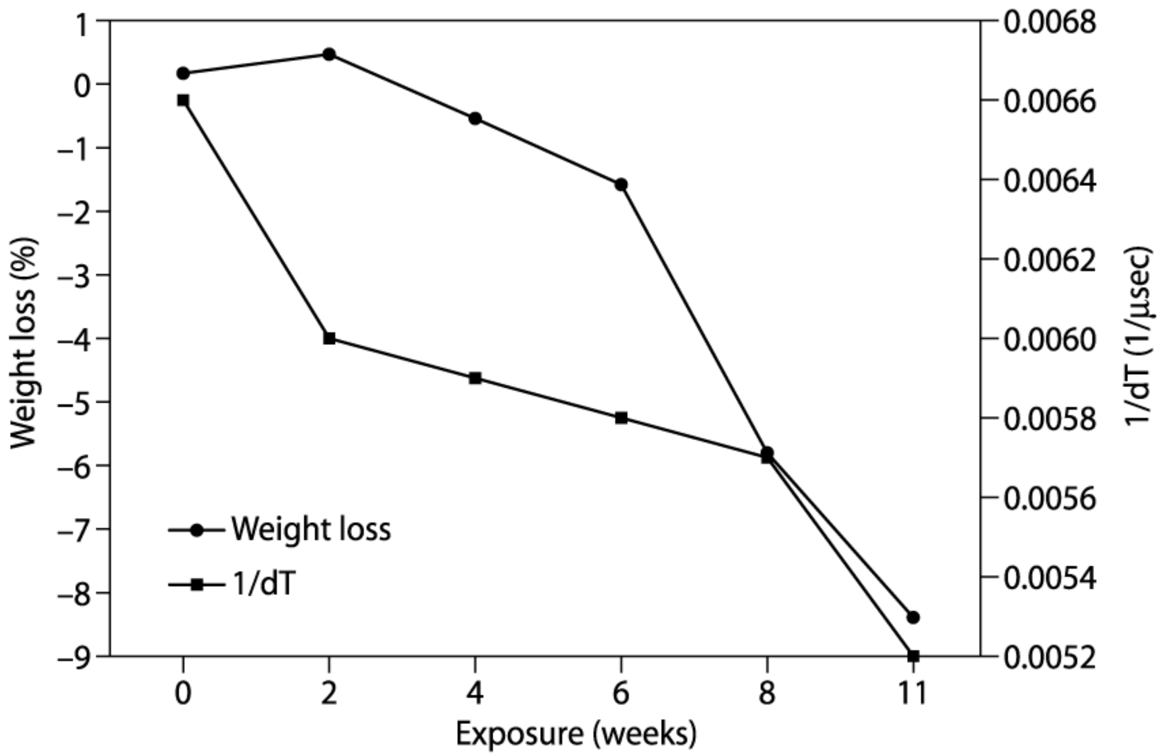

Figure 2. Decay rate and stress wave transmission time of OSB exposed to *G. trabeum*.

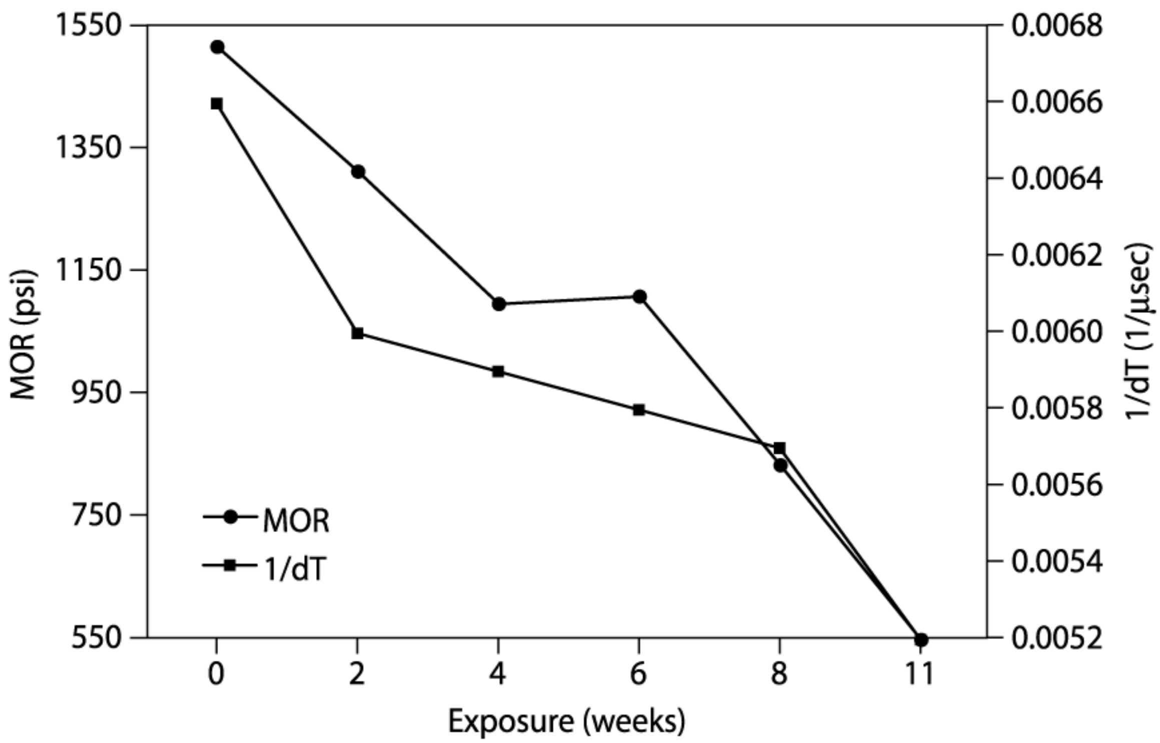

Figure 3. Modulus of rupture and stress wave transmission time in decaying OSB

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