Predicting the Effects of Decay on Wood Properties and Modeling Residual Service-Life

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Abstract

One method of extending our existing forest resources is to prolong the service life of the wood currently in-service. It is estimated that over 7 x 10^9 m^3 (3 trillion bd.ft) of wood is now in service within the United States of America. This work evaluates the effects of biological decay on the mechanical properties of wood. We will eventually use this information to develop progressive decay-strength loss models.

Objectives

The academic objectives of our research program are to better understand the decay process, assess environmental conditions leading to fungal colonization, define the cardinal thresholds of wood moisture and temperature required for the initiation of decay and to quantify the rate of progression as a function of environmental exposure. An ***in*** vitro method has been developed to monitor strength loss and weight loss as affected by wood moisture and temperature. Under optimum conditions the percent strength loss is often four times more than weight loss.

Our practical objective is to develop models to predict the residual service life of wood under biological attack. The basic understanding resulting from this work, when coupled with predictive durability and residual service-life models, will better enable engineers to assess and justify measures to extend the residual service-life of wood and composite products used in adverse service conditions. This service-life model will aid code officials, regulators, and engineers in determining replacement time schedules for wood exposed to service conditions which may promote decay.

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Introduction

New laboratory techniques to monitor the effects of decay on wood strength properties have been developed. We call it the cake-pan method (Fig. 1). Using this methodology, wood moisture, temperature and mode of inoculation can be studied and quantified. In this series of evaluations, clear Southern pine (*Pinus* spp.) was exposed to either *Gloeophyllum trabeum* or *Postia placenta* for one of eight periods ranging from 3 days to 12 weeks. After the decay exposure, each specimen was quickly dried to <20% moisture content, equilibrated to constant weight at 23°C and 65 percent relative humidity (RH), then mechanically tested in bending to failure. Decay-induced weight loss was evaluated from a small block cut from the heaviest decay zone. This block was then ground and evaluated for carbohydrate composition (12).

Results

The mean weight loss, loss in stiffness (MOE) and bending strength (MOR) loss, of the specimens are compared in Figures 2 and 3, respectively. It should be noted that no strength (MOR) losses less than 40 per-

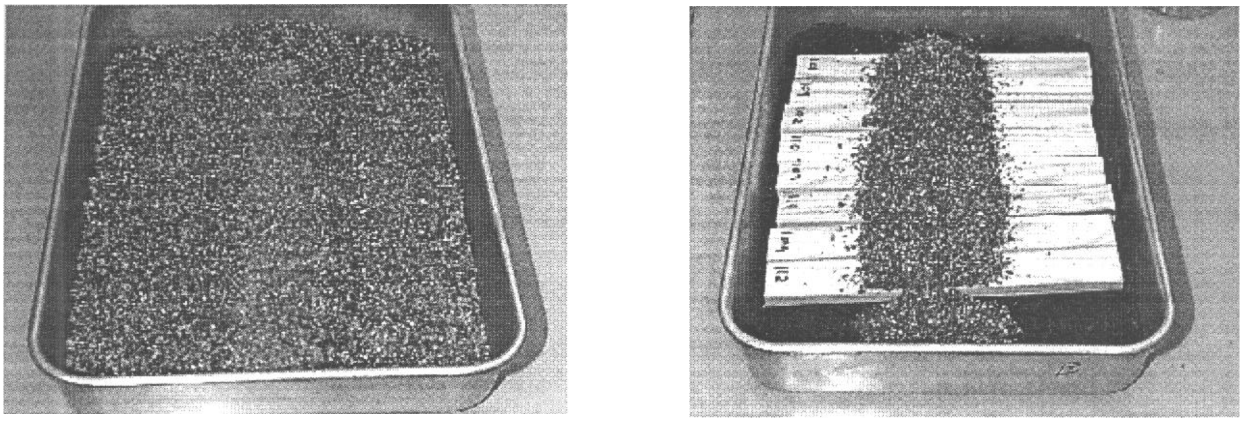

Figure 1.—*Cake-pan decay method used in these studies to evaluate decay-strength relationships (1).*

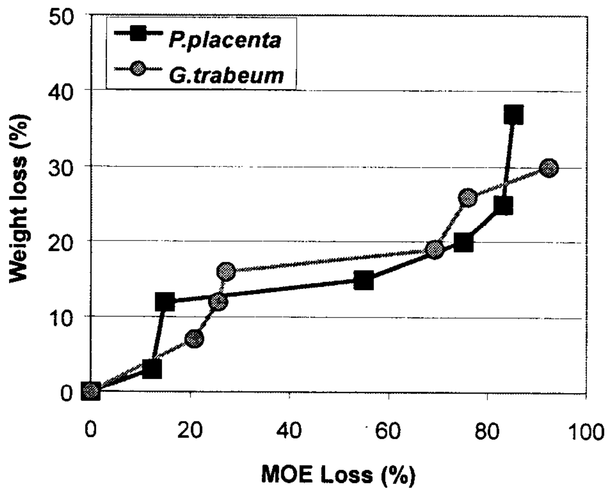

Figure 2.—*Comparison of brown rot induced stiffness (MOE) and weight loss in southern pine.*

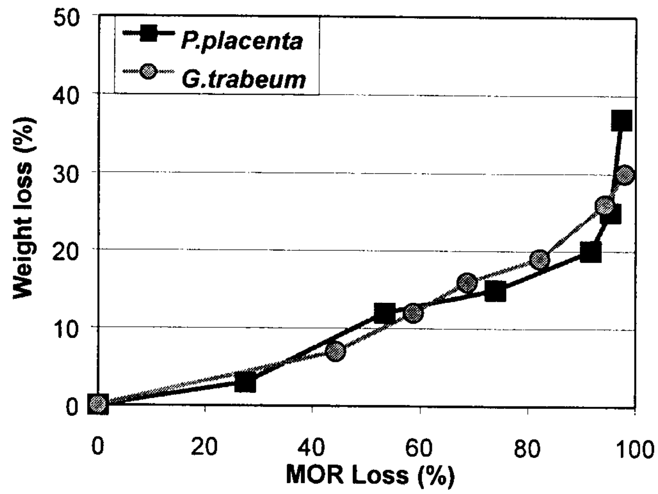

Figure 3.—*Comparison of brown rot induced bending strength (MOR) and weight loss in southern pine.*

G. trabeum and 22 percent for *P. placenta* were obtained after 12 weeks of exposure.

The chemical composition data is shown as percentage loss of the chemical constituent in relation to percent loss in MOR (Figs. 4 and 5).

Progressive effects of decay on strength, weight and chemical composition can be seen by comparing the loss in bending strength (MOR), loss in work to maximum load (WML), loss in stiffness (MOE) to loss in dry weight (Fig. 6). The average rates of loss for these properties are shown in Table 1.

Discussion (Strength)

Our data consistently demonstrates the fact that considerable bending strength loss occurs before measurable weight loss. The decay-strength relationship appears very consistent as decay initiates and progresses.

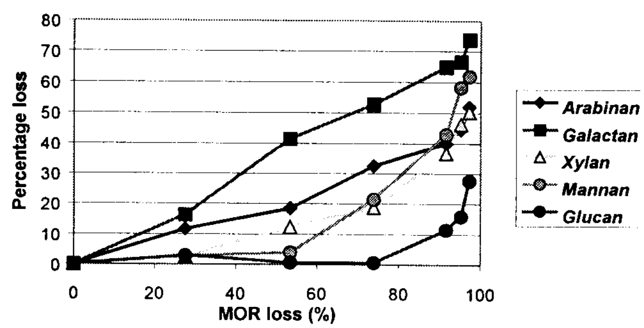

Figure 4.—*Comparison of loss of carbohydrate components with loss in bending strength (MOR) caused by* P. placenta.

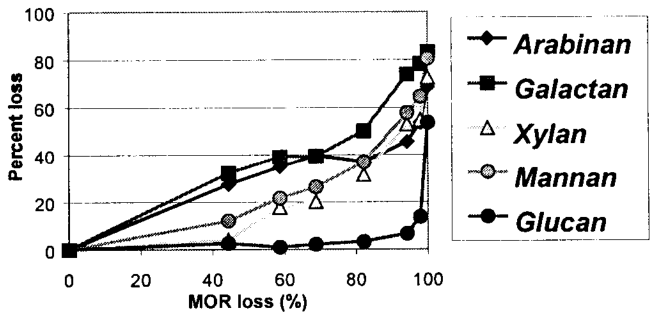

Figure 5.—*Comparison of loss of carbohydrate components with loss in bending strength (MOR) caused by* G. trabeum.

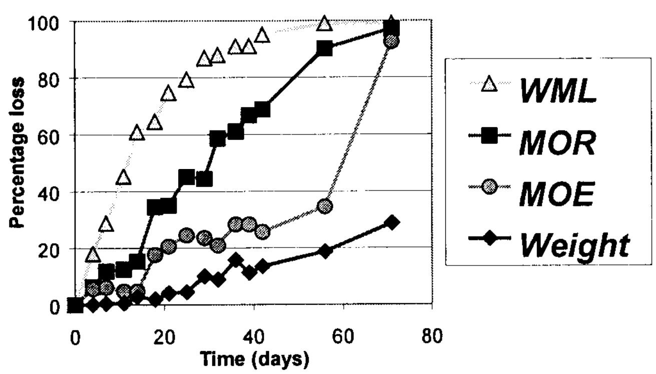

Figure 6.—*Effect of decay by* G. trabeum *on weight loss and mechanical properties.*

The MOE data is less consistent between the two fungi but does show that loss in MOE is not as rapid as the loss in MOR. The data from Figure 6 also show the relationship between weight and bending strength loss is not only qualitative, but may also be quantitative.

At 10 percent weight loss, strength loss was approximately 40 percent and the loss in the energy properties, like work to maximum load, was reduced by 70 to 80 percent.

Discussion (Wood Chemistry)

As decay progressed it sequentially affected different chemical components. Initial loss in the mannan and xylan components correlated with the start of measurable weight loss, both occurred at about 40 percent strength loss. Because mannan/xylan components make up approximately 18 percent of the wood, compared to 8 percent for galactan and arabinan, it is understandable why measurable weight loss is not evident in incipient decay. Final stage of brown-rot decay occurs once the glucan-rich cellulose is broken down, at a strength loss of about 80 percent. It is also at this stage (80% loss in MOR) that loss in stiffness (MOE) increases rapidly suggesting that the stiffness of the wood is related to the cellulose rather than the hemicellulose composition.

Table 1.—*Mean rate of loss in various properties.*

Property	Approximate rate of loss[a]
	(% per day)
WML	3.55
MOR	1.61
MOE	0.61
Weight	0.40

[a] Rate of loss is calculated from linear portion of Figure 6, i.e., 0 to 21 days; 0 to 72 days for MOR; 0 to 56 days for MOE; and 21 to 72 for weight.

Conclusions

- Measurable weight loss from brown-rot decay of southern pine sapwood began after an approximate 40 percent loss in MOR. The relative ratio was 4:1 bending strength/weight loss.
- Initial strength loss, without measurable weight loss, correlated to loss in the galactan and arabinan hemicellulose components.
- The start of visually detectable weight loss correlated to the start of measurable loss in the mannan and xylan components.
- Major weight loss and loss in stiffness (MOE) correlated to loss in the glucan component.

Literature Cited

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