Shading Aboveground L-Joint and Lap-Joint Tests: Comparison of White Pine and Sugar Maple Test Assemblies

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Abstract

Five-year performance ratings are presented for two types of untreated, uncoated wood joints (L and lap) in aboveground tests under shaded conditions. The effect of shading on moisture entrapment in pine and maple L and lap joints was evaluated in a moderate decay zone (Madison, Wisconsin). Variations were observed between wood species, visual ratings, joint type, moisture content readings, and fungal growth on the specimens. Representative fungal fruiting bodies were identified as members of the *Peniophorella praetermissa* species complex by microscopic and DNA analyses. After 5 years, the highest average rating (indicative of most severe deterioration) occurred in white pine L-joint specimens followed by maple lap joints and maple L joints. Pine and maple L-joint specimens demonstrated considerably lower rating variation between specimens compared with lap-joint specimens. White pine lap joints shaded with a tarp had lower average moisture content but showed similar average ratings to pine lap joints shaded by a tree. Regardless of the shading method, white pine lap joints had the lowest average decay rating. Under shaded conditions in a moderate decay zone, untreated and uncoated L-joint performance was notably more uniform from specimen to specimen than lap-joint performance following 5 years of outdoor exposure. A single-point moisture content taken at the time of inspection was not a reliable indicator of the degree or rate of decay for aboveground joint test assemblies evaluated in this study. Likewise, uniform specimen wetting or drying is not predictable under shaded conditions.

Aboveground performance of wood has been the subject of numerous studies worldwide (Scheffer 1971; Fougerousse 1976; Savory and Carey 1979; Carey et al. 1981; Highley 1984, 1993; Carey and Bravery 1986; DeGroot 1992; Williams et al. 1995; Carey 2002; Morris and McFarling 2007). Aboveground tests are equally useful for predicting performance of wood preservation systems to protect wood used in exterior applications (Nicholas and Crawford 2003) and evaluating the natural durability of building components intended for applications that are partially protected from the environment. A number of standardized and alternative test designs have been evaluated, e.g., post-rail, cross braces, Y joints, simulated deck test, L joints, and lap joints (DeGroot 1992, Hedley et al. 1995, Morris and McFarling 2007). Lap-joint and L-joint ''model'' test assemblies recognized by the American Wood Protection Association (AWPA) are used most often (AWPA 2006, 2008). Lap-joint tests simulate situations in which wood is exposed to the weather out of contact with the ground. L-joint tests simulate joinery units with intended exterior application out of ground contact and exposed to the elements. Numerous aboveground field tests have been conducted in New Zealand comparing treated and untreated ''standard'' L joints with decking units, Y joints, fence battens, and weatherboards with and without surface coatings for locally grown wood species (Hedley et al. 1995).

Relative durability of domestic US wood species in aboveground exterior application has been reported by Highley (1995) using the cross-brace test design. Studies by Highley and others demonstrated that L joints were more difficult to protect from decay than cross-brace units (Highley 1993, Highley et al. 1994). In these studies, untreated pine and maple cross-brace units were severely decayed after 12 years of aboveground exposure at the US Forest Service national exposure site near Madison, Wisconsin. Eslyn et al. (1985) published the longevity of several wood species and the associated decay fungi cultured from them through 12 years of exposure in the high decay hazard climate of Mississippi.

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Forest Prod. J. 61(3):265–269.

Modifications of standard test methods are often presented that target a specific application. For example, one modification of the L-joint design incorporated incisions to evaluate difficult to treat Western wood species (Morrell et al. 1998). A modification to the typical lap joint, incorporating thin sticks within the joint for the purpose of repeated mechanical assessments, was aimed at enhancing the rate of performance data collection (Nicholas and Crawford 2003). Alternate specimen or test frame configurations (e.g., simulated deck test or A-frame) address the need for accelerated test methods to speed up the otherwise lengthy period of time necessary to acquire sufficient performance data for new preservatives (Williams et al. 1995, Morris and McFarling 2007).

There are limitations to standardized aboveground test procedures, including the subjective nature of the rating system and lack of accurate methods for detecting and measuring the extent of decay, particularly incipient decay. Both L- and lap-joint tests were designed to effectively trap water and provide conditions favorable for wood decay. Whereas lap joints create a relatively large interfacial zone where water can be trapped (Highley and Scheffer 1989), the L-joint design favors end-grain penetration of rainwater (Highley 1993, DeGroot and Highley 1995). Both depend on rainfall, temperature at the test site, and exposure time for a reliable set of performance data. For a field test, exposure to moisture via rainfall or condensation may influence the performance data and shading of test units may in turn have a profound effect on moisture and drying of those test units.

By shading the test fence or covering the test units with a tarp to trap condensation and prevent rapid drying, aboveground tests may provide accelerated performance data. Test assemblies described in this article were installed and periodically inspected for the first 120 weeks. Evaluation methods included the pick test, immunodiagnostic decay test, and fungal isolation. It was previously reported that maple lap joints were the first to show visible signs of decay after 68 weeks, and overall, decay was detected in lap joints earlier than in L joints (Clausen et al. 2006). *Irpex lacteus* was the predominant fungus isolated from both pine and maple test specimens after 12 to 16 weeks of exposure. It was also reported that moisture accumulation in the joints was not related to measured rainfall. The objective of this study was to compare the effects of shading by two methods on the natural durability of two domestic US wood species in L- and lap-joint test units in a moderate decay hazard zone.

Materials and Methods

L-joint specimens

L-joint specimens were prepared from white pine (*Pinus strobus* L.) and sugar maple (*Acer saccharum* Marsh.) sapwood according to AWPA E9-06 (AWPA 2008). Specimens were untreated and uncoated and were not end sealed. The average initial moisture content (MC) of the L joints was 8.5 percent. Fifteen L-joint specimens of each wood type were installed with joist holders for support and spacing on weathering racks that were designed to hold specimens sloped at a 10° angle. The racks were located under the shade of a silver maple tree at an exposure site near Madison. The climate in Madison is moderately favorable for promotion of decay (decay hazard Zone 2), with an absence of decay-supporting conditions during late fall and winter months (Scheffer 1971, Carll 2009).

Lap-joint specimens

Lap-joint specimens were prepared from white pine sapwood and sugar maple sapwood according to a modification of AWPA E16-98 (AWPA 2006). Specimens were untreated and uncoated and lacked an end seal. The average initial MC of the lap joints was 8.5 percent. Fifteen specimens of each wood type were fastened together with stainless steel clips for easy access to the joint during multiple inspections. Specimens were separated from each other and elevated from the test rack with sections of foam pipe insulation secured to the exposure rack. Specimens were mounted on horizontal aboveground exposure racks under the shade of a silver maple tree at an exposure site near Madison. Fifteen additional pine lap joints were exposed aboveground under the shelter of the same tree, but they were also covered with a tarp to prevent drying. The tarp was slit the length of each specimen at approximately 0.75-cm intervals directly over the test specimens to allow for wetting with rainwater. This group of specimens was manually wetted with 4 liters of deionized water from a sprinkling can after each inspection during the first two growing seasons (April through November), but water was not intentionally introduced to the test set-up during subsequent growing seasons.

Five-year inspection

Visual rating, color changes in the wood, presence of bleaching and staining, softening (pick test; Wilcox 1983), microbial growth, and signs of moisture accumulation in the joint or lap were noted. Joints were rated according to the grading system in Table 1 (AWPA 2006). The average rating and standard deviation of each wood and joint type are shown in Table 2. Four joints with resupinate (crust-like) fungal fruiting bodies were collected during the 5-year inspection. Fruiting bodies were examined microscopically and the internal transcribed spacer (ITS) region of rDNA

Table 1.—Lap- and L-joint visual grading system.[a]

Rating	Condition of joint
0	Sound
1	Trace attack
2	Slight attack
3	Moderate attack
4	Severe attack
5	Failure

[a] AWPA E16-98 (AWPA 2006).

Table 2.—Average visual rating for each wood type, joint type, and shading method.[a]

Wood species	Joint type	Shading method	Average (SD) rating
White pine	L	Tree	3.8 (0.3)
White pine	Lap	Tree	2.2 (1.7)
White pine	Lap	Tarp	2.4 (1.7)
Sugar maple	L	Tree	3.3 (0.9)
Sugar maple	Lap	Tree	3.5 (1.2)

[a] $n = 15$.

was sequenced to facilitate identification. DNA was isolated, sequenced, and identified as previously described (Clausen et al. 2006).

Moisture content

MC readings were taken at an approximately 5-mm depth with a Delmhorst RDX-1 moisture meter (Delmhorst Instrument Co., Towaco, New Jersey) in the joint of each specimen. Individual moisture readings were recorded for each specimen and have been superimposed on the individual ratings seen in Figures 1 and 2.

Results and Discussion

A number of observations can be drawn from the average rating (i.e., decay) for each tree-shaded wood type and joint configuration shown in Table 2 and Figure 1.

For white pine:

- Average L-joint ratings were the highest (3.8) for all groups and most uniform from specimen to specimen.
- Average lap-joint ratings were lowest (2.2) with a high standard deviation (1.7). Individual ratings were inconsistent from specimen to specimen.

For sugar maple:

- L and lap joints had similar average ratings of 3.3 and 3.5 indicating moderate levels of attack.
- Individual ratings for lap joints were more variable (standard deviation, 1.2) than for L joints (standard deviation, 0.9).

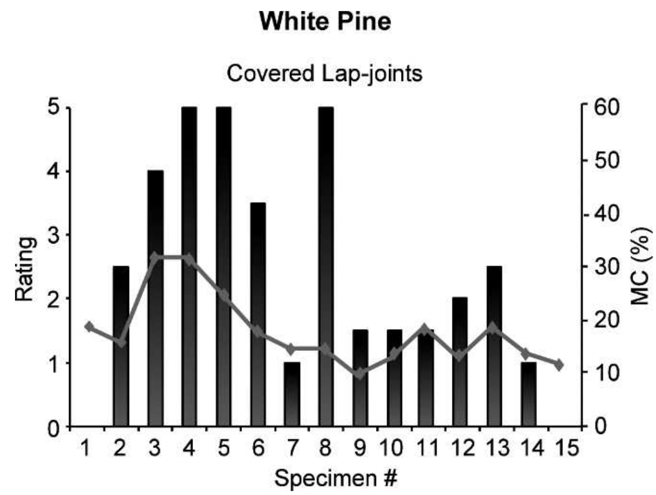

Figure 2.—Five-year rating (black bar) and moisture content (MC; solid line) for individual white pine lap joints covered by a tarp.

MC is merely a snapshot of the conditions at the moment of inspection, although it might reflect the overall ability or lack thereof for the joint area to trap moisture or dry following exposure to moisture. Accumulation of leaf litter and detritus also plays a role in trapping moisture on test racks for both methods, although the angled design for the L-joint rack trapped and held leaf litter and water in the joint area to a greater degree than the horizontal rack (Fig. 3). The results of this inspection showed that MC generally

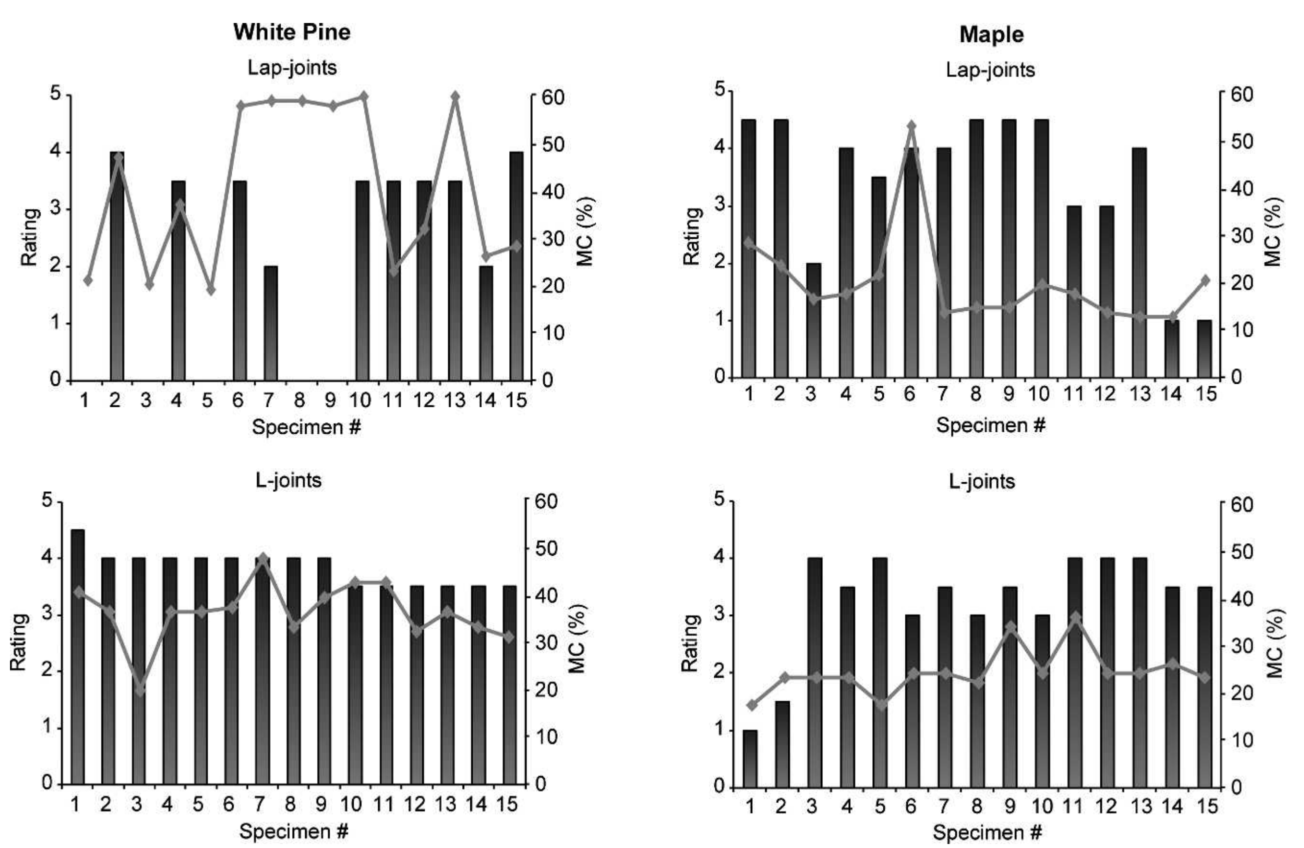

Figure 1.—Rating and moisture content (MC) for individual specimens of each wood type and joint configuration shaded by a tree. Black bars indicate decay rating for individual specimens and moisture content is indicated by a solid line.

Figure 3.—Fungal fruiting bodies and mycelium on white pine lap joint (A), maple lap joint (B), white pine L joints (C), and maple L joints (D).

varied more in the lap-joint than the L-joint assemblies at the time of inspection, although MC readings using a pin-type meter lose accuracy above fiber saturation. MC did not correlate with ratings of individual specimens. These findings are consistent with previous findings following 2 years of exposure of these specimens (Clausen et al. 2006). In a study on the influence of wood MC and wood temperature on aboveground field performance in different microclimates, Brischke and Rapp (2008) similarly concluded that weather data were insufficient for estimating the decay hazard of an exposure situation. They reported that the number of critical days above or below a certain MC and temperature needs to be considered for service life prediction in a given exposure situation.

Specimens were covered with a slit poly tarp to trap condensation and prevent drying; however, during the first two growing seasons, those assemblies covered with the poly tarp were actually drier than those shaded by the tree (Clausen et al. 2006). Specimens under the tarp were wetted frequently during that period but continued to have reduced MC compared with uncovered lap joints. During the 5-year inspection, average ratings and standard deviations for lap joints covered by a tarp (2.4 ± 1.7) were similar to those shaded by the tree (2.2 ± 1.7); however, MC in individual assemblies was frequently lower in lap joints covered by a tarp (Fig. 2) than the MC in lap joints shaded by the tree (Fig. 1).

Many specimens developed fungal fruiting bodies that shared common characteristics within a given group of specimens. White pine lap joints had extensive white mycelium on all under surfaces (Fig. 3A), maple lap joints had fruiting bodies in the joint (Fig. 3B), white pine L joints had extensive small white fruiting bodies covering the entire tenon (Fig. 3C), and maple L-joint tenons were uniformly and extensively bleached (Fig. 3D). Representative fruiting bodies from L and lap joints, both maple and white pine, were identified as members of the species complex *Peniophorella praetermissa* sensu lato, a successional species complex associated with production of white rot on both conifers and hardwoods (Nakasone 1996). White-rot fungi, primarily *Irpex lacteus,* were the first and most prominent group of fungi isolated from all test assemblies during the first 2 years of exposure.

Conclusions

This study compared two methods of shading on natural durability of two configurations of joint assembly after 5 years of aboveground exposure. Under the conditions of this study, L-joint assemblies provided more consistent ratings from specimen to specimen than lap-joint assemblies for both white pine and sugar maple. There was no difference between shading lap joints with a tree or covering lap joints with a slit poly tarp. From the results of this study, it cannot be determined whether the method of shading increased moisture by slowing the drying of condensation or inhibited moisture by protecting assemblies from rain. Measurement of MC at a single time point could not predict aboveground field performance and did not correlate with field ratings of L-joint or lap-joint assemblies due to inherently slow water uptake in wood and unpredictable drying influences.

Literature Cited

American Wood Protection Association (AWPA). 2006. Standard field test for evaluation of wood preservatives to be used out of ground contact: horizontal lap-joint method. AWPA E16-98. AWPA, Birmingham, Alabama. pp. 334–338.

American Wood Protection Association (AWPA). 2008. Standard field test for the evaluation of wood preservatives to be used in non-soil contact. AWPA E9-06. AWPA, Birmingham, Alabama. pp. 360–363.

Brischke, C. and A. O. Rapp. 2008. Influence of wood moisture content and wood temperature on fungal decay in the field: Observations in different micro-climates. *Wood Sci. Technol*. 42:663–677.

Carey, J. K. 2002. L-joint trials Part 3: Relative performance of a range of preservative products. IRG/WP/30292. International Research Group on Wood Preservation, Stockholm. 15 pp.

Carey, J. K. and A. F. Bravery. 1986. Co-operative research project on L-joint testing. Progress report to March 1986. IRG/WP/2272. International Research Group on Wood Preservation, Stockholm. 16 pp.

Carey, J. K., D. F. Purslow, and J. G. Savory. 1981. Proposed method for out-of-ground contact trials of exterior joinery protection systems. IRG/WP/2157. International Research Group on Wood Preservation, Stockholm. 15 pp.

Carll, C. G. 2009. Decay hazard (Scheffer) index values calculated from 1971–2000 climate normal data. General Technical Report FPL-GTR-179. USDA Forest Service, Forest Products Laboratory, Madison, Wisconsin. 17 pp.

Clausen, C. A., T. L. Highley, and D. L. Lindner. 2006. Early detection and progression of decay in L-joints and lap joints in a moderate decay hazard zone. *Forest Prod. J*. 56:100–106.

DeGroot, R. C. 1992. Test assemblies for monitoring decay in wood exposed above-ground. *Int. Biodeterior. Biodegrad*. 29:151–175.

DeGroot, R. C. and T. L. Highley. 1995. Forest Products Laboratory methodology for monitoring decay in wood exposed above-ground. IRG/WP/95-20074. International Research Group on Wood Preservation, Stockholm. 22 pp.

Eslyn, W. E., T. L. Highley, and F. F. Lombard. 1985. Longevity of untreated wood in use above-ground. *Forest Prod. J*. 35(5):28–35.

Fougerousse, M. 1976. Wood preservatives field tests out of ground contact. Brief survey of principles and methodology. IRG/WP/269. International Research Group on Wood Preservation, Stockholm. 34 pp.

Hedley, M., D. Page, J. Foster, and B. Patterson. 1995. Above-ground field tests undertaken in New Zealand. IRG/WP 95-20063. International Research Group on Wood Preservation, Stockholm. 6 pp.

Highley, T. L. 1984. In-place treatments for waterborne preservatives for control of decay in hardwoods and softwoods above-ground. *Mater. Org*. 19:95–104.

Highley, T. L. 1993. Above-ground performance of surface-treated hardwoods and softwoods. *Wood Prot*. 2(2):61–66.

Highley, T. L. 1995. Comparative durability of untreated wood in use above ground. *Int. Biodeterior. Biodegrad*. 35(4):409–419.

Highley, T. L., J. A. Micales, B. L. Illman, F. Green III, S. C. Croan, and C. A. Clausen. 1994. Research on biodeterioration of wood. 1987–1992. II. Diagnosis of decay and in-place treatments. Research Paper FPL-RP-530. USDA Forest Service, Forest Products Laboratory, Madison, Wisconsin. 7 pp.

Highley, T. L. and T. Scheffer. 1989. Controlling decay in waterfront structures: Evaluation, prevention, and remedial treatments. Research Paper FPL-RP-494. USDA Forest Service, Forest Products Laboratory, Madison, Wisconsin. 26 pp.

Morrell, J. J., D. J. Miller, and S. T. Lebow. 1998. Above-ground performance of preservative-treated Western wood species. *Proc. Am. Wood Prot. Assoc*. 94:249–253.

Morris, P. I. and S. McFarling. 2007. Accelerated above-ground testing of wood preservatives. IRG/WP 07-20358. International Research Group on Wood Protection, Stockholm. 8 pp.

Nakasone, K. K. 1996. Diversity of lignicolous basidiomycetes in coarse woody debris. *In:* Biodiversity and Coarse Woody Debris in Southern Forests: Proceedings of the Workshop on Coarse Woody Debris in Southern Forests: Effects on Biodiversity, October 18–20, 1993, Athens, Georgia; General Technical Report SE 94, USDA Forest Service, Southern Research Station, Asheville, North Carolina. pp. 35–42.

Nicholas, D. D. and D. M. Crawford. 2003. Concepts in the development of new accelerated test methods for wood decay. *In:* Wood Deterioration and Preservation Advances in Our Changing World. B. Goodell, D. D. Nicholas, and T. P. Schultz (Eds.). ACS Symposium Series 845. American Chemical Society, Washington, D.C. pp. 288–312.

Savory, J. G. and J. K. Carey. 1979. Decay in external framed joinery in the United Kingdom. *J. Inst. Wood Sci*. 8:176–180.

Scheffer, T. C. 1971. A climate index for estimating potential for decay in wood structures above-ground. *Forest Prod. J*. 21:25–31.

Wilcox, W. W. 1983. Sensitivity of the pick test for field detection of early wood decay. *Forest Prod. J*. 33:29–30.

Williams, G. R., J. A. Drysdale, and R. Fox. 1995. A note on testing the efficacy of wood preservatives above-ground. IRG/WP 95-20078. International Research Group on Wood Preservation, Stockholm. 5 pp.