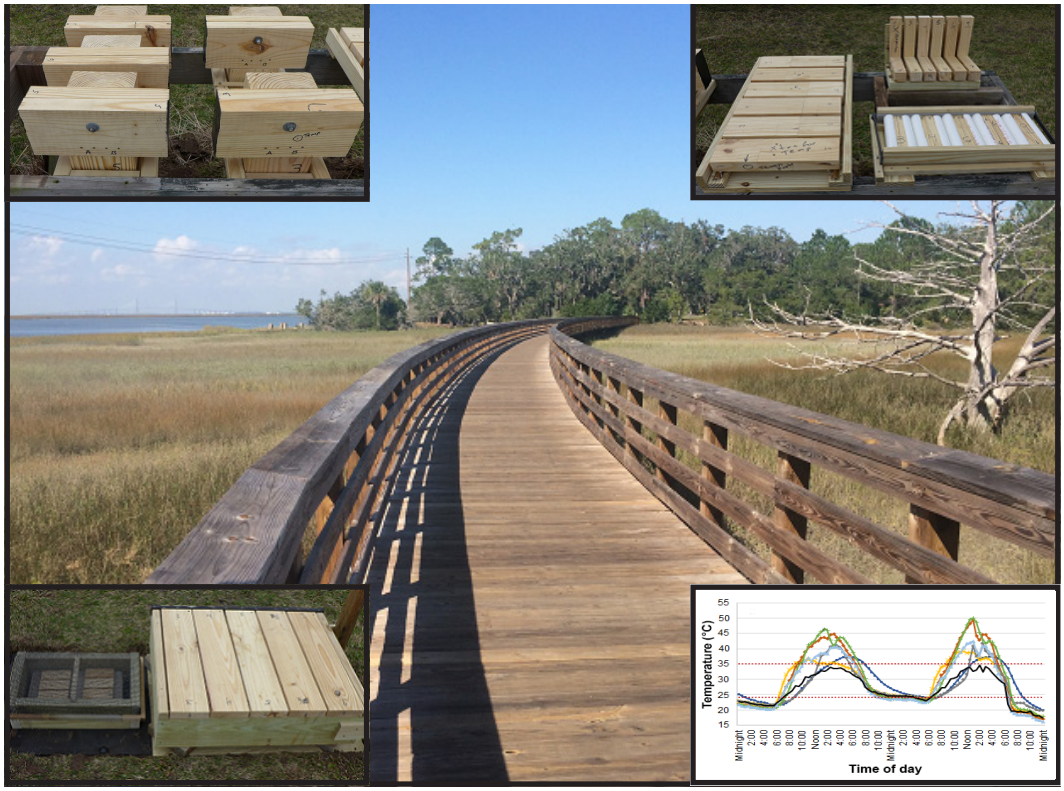
United States Department of Agriculture

Internal Moisture Content and Temperature of Standardized Aboveground Wood Durability Test Specimens

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Forest Service
Forest Products Laboratory
Research Paper FPL–RP–694
July 2018

Abstract

Durability of wood products intended for use in outdoor aboveground applications are evaluated using one or more standardized test methods. These methods use relatively small specimens in an effort to accelerate decay growth and allow detection of decay. In this study, we evaluated internal moisture content and temperature of standardized specimens and compared them with specimens of a simulated post and beam connection that is recommended for residential deck construction. Specimens of each type were cut from end-matched Southern Pine timbers and exposed above ground at a test site near Madison, Wisconsin. Pairs of stainless steel screws were inserted at multiple locations within each specimen to allow moisture content determination with a resistance-type moisture meter. Internal temperature was monitored in one specimen of each type using a thermistor probe and data logger. The specimens of the simulated post and beam connection sustained higher moisture contents and experienced less moisture content fluctuation than any of the standardized test specimens. Internal temperature also varied by specimen type but not to the extent observed for moisture content. The findings of this study suggest that frequent drying of standardized specimens has the potential to inhibit decay and may underestimate the decay hazard present within larger members of aboveground structures. Of the current standardized methods, the E18 ground proximity test appears to offer the best combination of relatively high moisture contents and ease of inspection. Other approaches, such as those that stack or layer groups of smaller specimens to entrap moisture and enhance decay, may warrant further consideration.

Keywords: durability testing, aboveground, standardized specimens, moisture content, temperature

July 2018

Lebow, Stan T.; Lebow, Patricia K. 2018. Internal moisture content and temperature of standardized aboveground wood durability test specimens. Research Paper FPL–RP–694. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 14 p.

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Internal Moisture Content and Temperature of Standardized Aboveground Wood Durability Test Specimens

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Introduction

In the past decade, there has been increasing interest in using less toxic preservative systems or lower retentions of preservative for wood used above ground. Preservative formulations intended for aboveground applications are not necessarily evaluated with ground-contact stake tests and instead are evaluated using standardized aboveground test methods (AWPA 2017a). These methods typically use relatively small specimens to facilitate inspection, and it is unclear how consistently these test specimens sustain moisture contents necessary to allow rapid growth of decay fungi. Moisture content is a critical factor in the risk of biologic and nonbiologic degradation of wood used above ground (Lebow and Carll 2011, Lebow and Highley 2008, Meyer and Brischke 2015, Zabel and Morrell 1992), and in many climates, it is the primary determinant of the aboveground decay hazard. Decay fungi require a moisture content of at least 20% to sustain any growth, and higher moisture contents (over 29%) are required for initial spore germination (Clausen 2010, Morris 1998, Zabel and Morrell 1992). Most brown and white rot decay fungi prefer wood in the moisture content range of 40% to 80% (Zabel and Morrell 1992), although Schmidt (2007) concluded that moisture contents in excess of 100% are within the favorable range of decay fungi. Growth at lower moisture contents is much slower, and typically, wood with a moisture content of less than 25% cannot be attacked unless the fungus has another source of moisture nearby. In addition, wetting and drying cycles can negatively affect fungal growth, with the return to decay activity significantly delayed after a drying period (Wadsö and others 2013).

Moisture conditions in structures are dependent on construction details that affect the uptake of free water and the dissipation of water (primarily by evaporation) from the wood. Although the importance of moisture content is widely acknowledged, there has been relatively little effort to evaluate moisture content within in-service wood products or within test specimens used to evaluate durability. Of the current American Wood Protection Association (AWPA) methods for evaluating the durability of wood products used above ground, only method E28 (Standard Field Test for Serviceability of Decking) suggests monitoring of wood moisture content (AWPA 2014). Interestingly, E28 is intended as a test of decking appearance and dimensional stability rather than a test for decay development. In addition, these standard test specimens have relatively small dimensions compared with some of the members used in construction. As a result, specimens in this test may dry more rapidly than some areas within actual structures. For example, the American Wood Council (AWC) Prescriptive Residential Deck Construction Guide specifies that deck beams be supported on a notched 140- by 140-mm (nominal 6- by 6-in.) or larger post (AWC 2015). This configuration would be expected to trap moisture in the area where the beam members sit on the end-grain of the post. The lack of data on specimen moisture contents limits our ability to relate the results from test specimens to in-service structures.

Materials and Methods

Test specimens were prepared according to five different AWPA evaluation methods. A simulated post and beam connection as prescribed for deck construction by the AWC (AWC 2015) was also prepared as a “real world” comparison. Moisture content was monitored as these specimens were exposed to natural weathering.

Moisture Content Determination

Moisture contents were determined using a resistance-type (also referred to as pin-type or conductance-type) moisture meter. This approach allows for estimating moisture content at various depths within the wood, depending on the placement of the metal pins. Although these meters are widely used in wood drying and for monitoring indoor wood moisture content, their use for measuring the moisture content of wood exposed outdoors has been more limited. This is largely because the meters were thought to have little value for measuring moisture contents above the wood fiber saturation point (approximately 25% to 30% moisture

content) (ASTM 2014, James 1988), and some commercial meters do not display moisture contents above 40%. However, some change in resistivity does occur at higher moisture contents, and researchers have presented data indicating that measurements above 30% can be at least semiquantitative (Smith and others 2007, Brischke and Lampen 2014). Recent research noted that some of the variability at higher moisture contents was attributable to poor contact between the wood and the electrodes and that this variability could be lessened by using screws rather than pins as electrodes (Lebow and Lebow 2016). A segregated regression model was developed to relate moisture content readings above the fiber saturation point to oven-dry moisture content, and temperature correction was also developed to allow monitoring moisture content in specimens exposed outdoors (Lebow and Lebow 2016). This approach was used successfully to monitor moisture content in leaching specimens exposed to natural precipitation (Lebow and others 2017).

In this study, pairs of trim-head stainless steel screws spaced 25 mm apart were used as electrodes. The depth of the screws and their location depended on the type of specimen, but in each case, the screws were driven to at least the center of the specimen. The moisture meter used was a General Electric Protimeter Timbermaster (General Electric Sensing, Danbury, Connecticut, USA), which displays moisture content readings between 7% and 100%. A hole was drilled in one replicate of each specimen type to allow insertion of a temperature probe at the time readings were taken.

Internal Temperature Monitoring

One additional replicate specimen of each type was added to the exposure for use in monitoring internal temperature. A 6-mm-diameter hole was drilled into each specimen, allowing a thermistor probe (5 mm diameter, 25 mm length) to be inserted into the center of the specimen near an area of moisture content determination (Figs. 1–6). The hole was then sealed around the probe wire using silicone caulk. The thermistor probe was connected to a thumb drive data logger (EL-USB-TP-LCD, Lascar Electronics Incorporated, Erie, Pennsylvania, USA), which was programmed to record temperature at 30-min intervals. An additional thermistor probe and data logger were installed to monitor ambient air temperature at the exposure site.

Test Specimen Configurations

Specimens were cut in accordance with AWPA standards E9, E16, E18, E25, and E27 (AWPA 2017b-f). In addition, a simulated post–beam connection was devised to simulate the AWC deck construction recommendations (AWC 2015). Five replicates of each specimen type were prepared. To minimize moisture content differences resulting from wood properties, matched specimens of each type were cut from five replicate 140- by 140-mm (nominal 6- by 6-in.) timbers. Inclusion of heartwood was avoided except in the case of the "post" member in the simulated post and beam specimens, which used the entire cross section of the timber. The various specimen configurations are described in the following paragraphs:

- E9, L-joint method (AWPA 2017b): In this method, two 38- by 38-mm (1.5- by 1.5-in.) pieces are joined at right angles with a mortise and tenon joint (Fig. 1). A protruding tenon cut at the end of one piece fits into a matching recess (mortise) in the other piece to create a moisture-trapping joint. In this study, moisture probe screws (30 mm long) were drilled into three locations within each specimen as shown in Figure 1. In accordance with the standard, specimens were exposed on a rack tilted at a 10° angle, with spacers to prevent the specimens from lying flat against the test rack.
- E16, lap-joint method (AWPA 2017c): This method prescribes that specimens 89 mm wide and 38 mm thick be cut to create an overlapping joint as shown in Figure 2. In this study, sets of moisture probe screws 76 mm long were drilled into a narrow face of each specimen in such a way that they crossed its width and extended to within 13 mm of the opposite narrow face. An additional set of 30-mm-long moisture probe screws was drilled directly into the lap joint from the bottom wide face of the specimen in such a way that they extended to within 8 mm of the upper wide surface (Fig. 2B).
- E18, ground proximity method (AWPA 2017d): This method does not use a moisture trapping joint but instead places 19-mm-thick by 50-mm-wide specimens on concrete blocks that are resting on the ground. The test array is covered with shade cloth to further slow drying. In this study, four 41-mm-long moisture probe screws were drilled into a narrow face of each specimen in such a way that they extended to within 9 mm of the opposite narrow face. The distance between the screws was 25 mm, allowing three moisture readings to be taken from each specimen (Fig. 3).
- E25, decking test (AWPA 2017e): This method simulates a deck constructed near the ground and uses commodity-sized 38-mm-thick by 140-mm-wide specimens. One end of the specimens is butted against what the standard refers to as an "inert material" while the other is open to the air. In this study, the inert material was wood covered with rubber roofing membrane. A space of 3 to 5 mm was left between the specimen and the rubber membrane. Sets of moisture probe screws 102 mm long were drilled into the narrow faces of the specimens near each end at the midpoint. The screws extended to within 38 mm of the opposite narrow face (Fig. 4).
- E27, accelerated lap joint (AWPA 2017f): This method uses three overlapping parts held together with PVC pipe

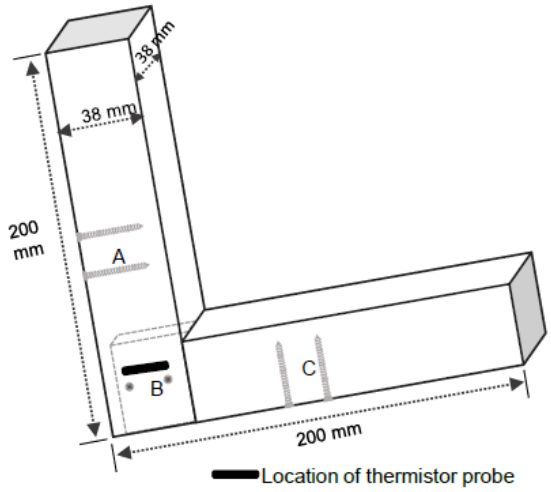


Figure 1. E9 L-joint specimen showing location of screw electrodes (A, B, and C) for five replicate specimens and location of thermistor probe (one additional specimen).

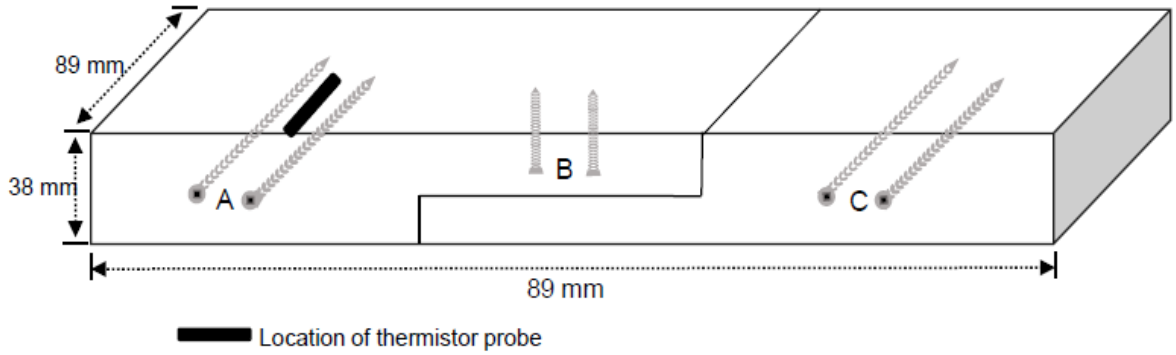


Figure 2. E16 lap-joint specimen showing location of screw electrodes (A, B, and C) for five replicate specimens and location of thermistor probe (one additional specimen).

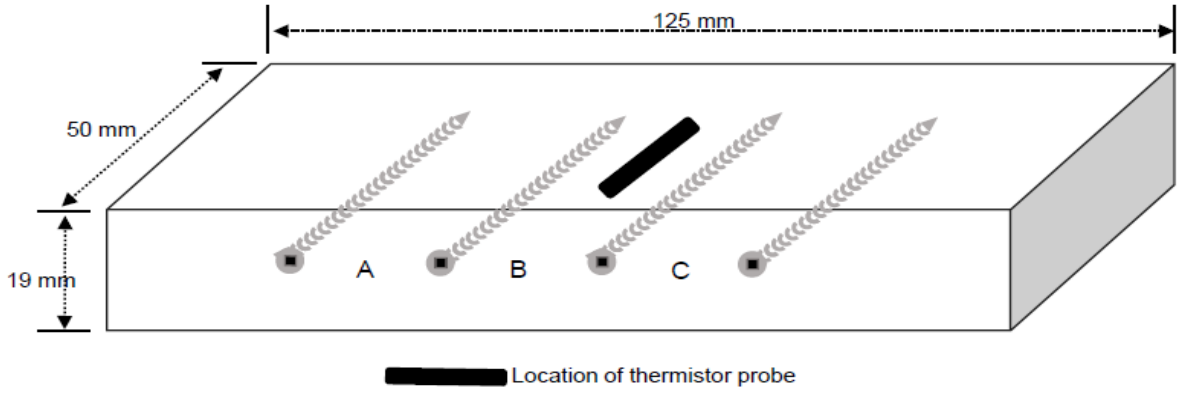


Figure 3. E18 ground proximity specimen showing location of screw electrodes (A, B, and C) for five replicate specimens and location of thermistor probe (one additional specimen).

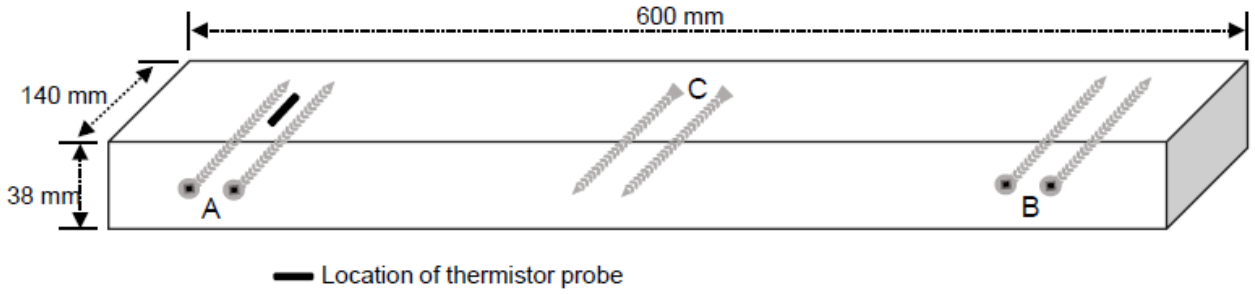


Figure 4. E25 decking specimen showing location of screw electrodes (A, B, and C) for five replicate specimens and location of thermistor probe (one additional specimen).

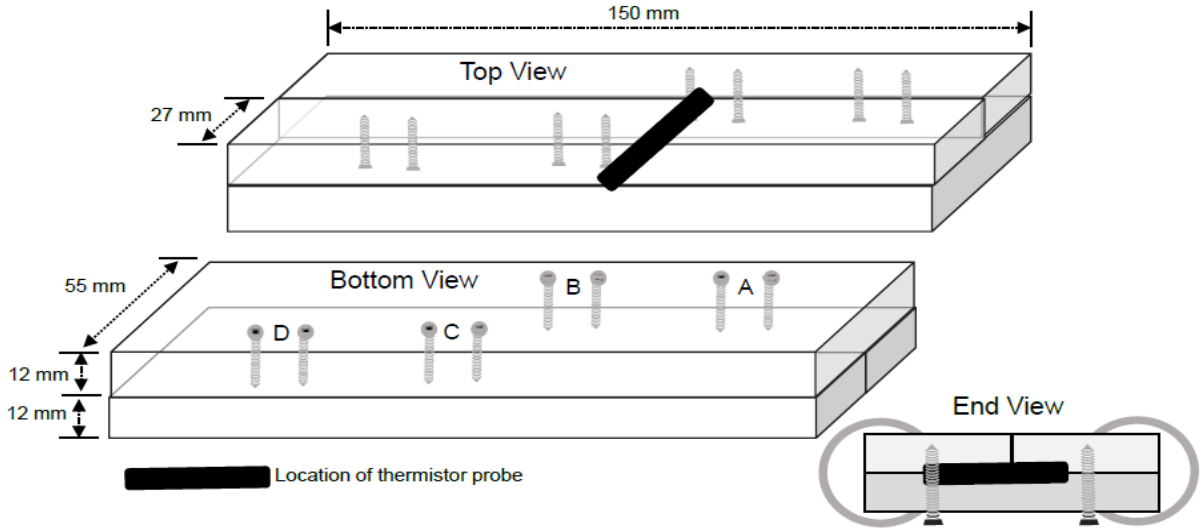


Figure 5. E27 accelerated lap-joint specimen showing location of screw electrodes (A, B, C, and D) for five replicate specimens and location of thermistor probe (one additional specimen).

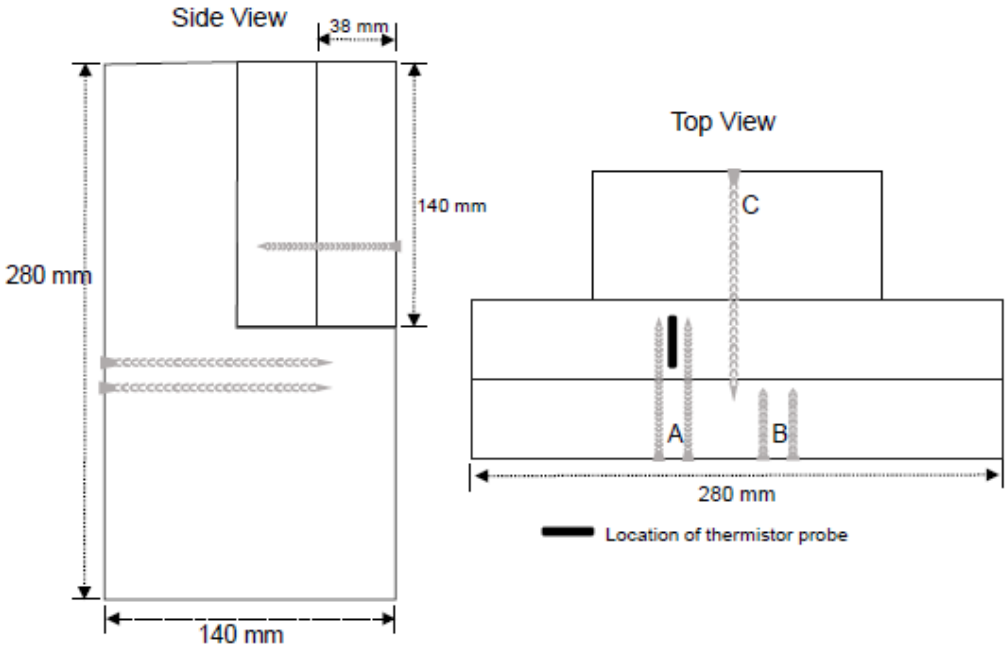


Figure 6. Simulated post and beam specimen showing location of screw electrodes (A, B, and C) for five replicate specimens and location of thermistor probe (one additional specimen).

sections that are cut and slipped over both long edges of the specimens (Fig. 5). The three parts of the specimens have relatively small dimensions. The two upper parts of the specimens are each 12 mm thick by 27 mm wide, whereas the bottom piece is 12 mm thick and 55 mm wide. The PVC clamps along the long edges of the specimens to slow drying. To further slow drying, the standard prescribes that the specimens be placed onto a test rack in such a way that each end is pressed against plastic foam pads. In this study, moisture probe screws were drilled upward from the wide bottom face of each specimen in such a way that they contacted both the bottom piece and one of the two top pieces of the assembly. Four sets of probe screws were installed, two on each side of the specimen (Fig. 5). The length of the screws was 25 mm, but they were left protruding 6 mm from the bottom of the specimen, leaving only 19 mm inserted into the specimen.

- Simulated post–beam: A simulated post–beam configuration was prepared by notching a 280-mm-long section of 140- by 140-mm (nominal 6- by 6-in.) timber to a depth of 140 mm and a width of 76 mm. Two 38- by 140- by 280-mm members (nominal 2 by 6 in.) were then bolted into the notch to simulate a beam (Fig. 6). The cut ends of these beam members were sealed with an elastomeric neoprene maintenance coating (N-700, Republic Powdered Metals Coatings and Lining Systems, Beachwood, Ohio, USA) to simulate the wetting–drying characteristics of a longer beam.

Specimen Exposure and Evaluation

Specimens used for determination of moisture content were exposed to natural weathering in an open field test site west of Madison, Wisconsin, in March 2016 and were monitored through October of 2017. Test racks were constructed to support and expose each type of specimen in accordance with its respective standard. On approximately a weekly basis, moisture content readings were taken from the probe locations shown in Figures 1 through 6. Evaluations were conducted at least 12 h after rainfall events to prevent surface moisture from affecting resistance moisture content readings. Additional specimens for monitoring internal temperature were added to the exposure in August of 2016. Daily precipitation data during the exposure were obtained from a United States Geologic Survey monitoring station 7.3 km northwest of the exposure site (USGS 2017). Madison's climate is characterized as humid-continental (Köppen classification: Dfa) (Schatz and Kucharik 2014) with an average of 876 mm of precipitation annually (NOAA 2017). June, July, and August are the months with the greatest precipitation, and average temperatures in December, January, and February are below freezing.

Results and Discussion

Precipitation During Exposure

The pattern of rainfall that occurred during specimen exposure is shown in Figure 7. Greater than average rainfall occurred during both the 2016 and 2017 exposure periods. A total of 1,902 mm of precipitation was received, which was higher than the 1,566 mm that would have been expected for this period based on historical averages (SCO 2017). Average monthly temperatures were often above and were rarely below historic averages (Fig. 8). Every month, except April 2016 and January, February, September, and October 2017, temperatures exceeded the historical average.

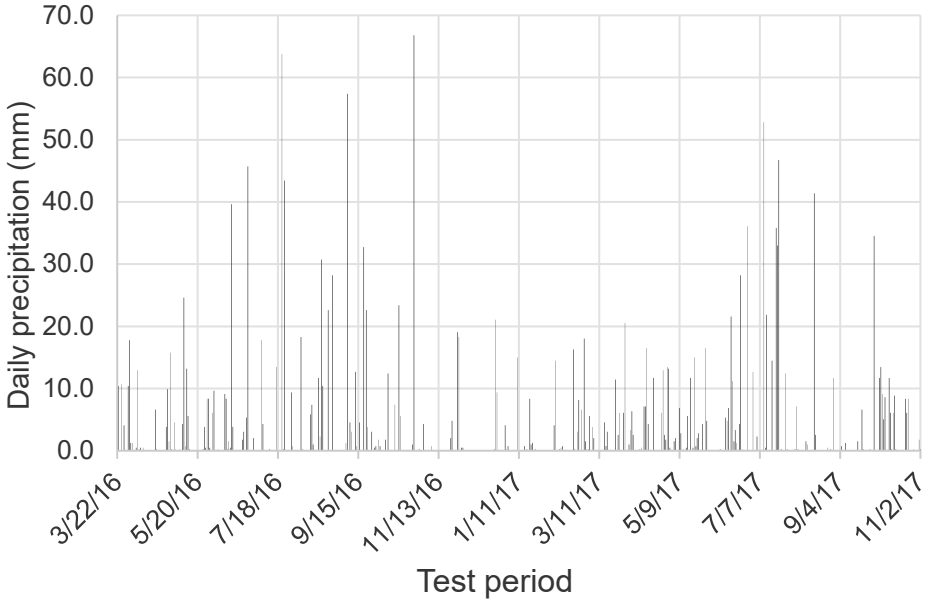


Figure 7. Daily precipitation for the duration of the exposure.

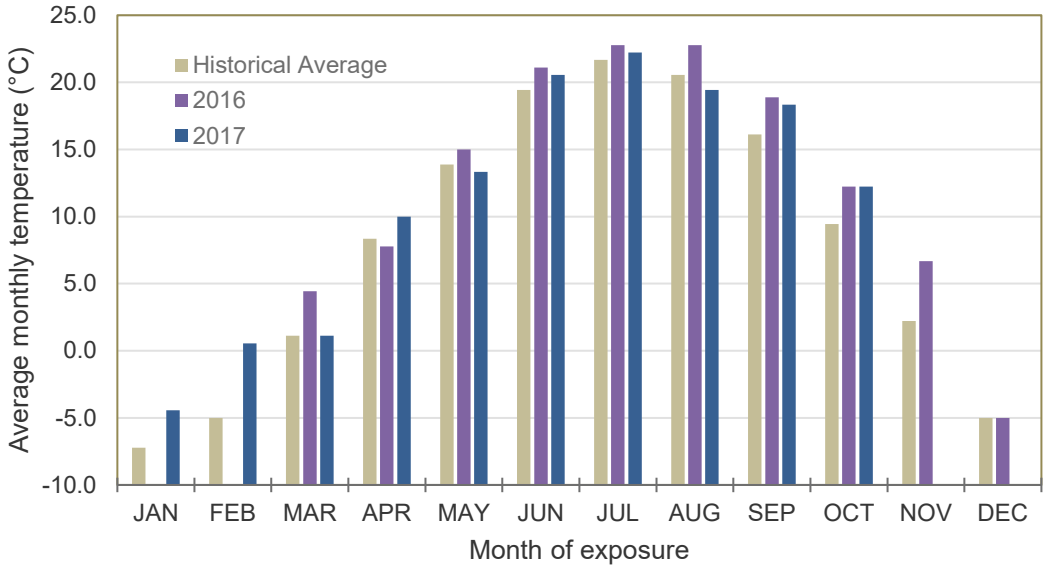


Figure 8. Average monthly temperatures during exposure compared with historical average temperatures.

Observed Specimen Moisture Contents

It is important to note that the moisture probes detect the path of least electrical resistance present anywhere between the probes. Thus, the moisture content reported is the highest in that area and is not necessarily the average or typical moisture within the specimen. For the larger specimens, the highest moisture content is likely to occur near the center of the specimen with lower moisture contents near the surface. The probe moisture contents may be somewhat more representative for the small specimens such as the E18 ground proximity and E27 accelerated lap joint, but even with these specimens, it is likely that the outer portion of the specimen was dryer.

The types of test specimens differed substantially in their pattern of moisture absorption and retention. For larger specimens, consistent moisture differences were also observed by location within the specimen. The E9 L-joint specimens tended to have the lowest moisture contents, with rapid redrying after rainfall events (Fig. 9). This is probably attributable to the relatively small dimensions of the specimens and the fact that they were exposed in a manner that allowed air circulation between the specimen and the exposure rack. As expected, the joint tended to have the highest moisture content, whereas the vertical mortise part of the specimen typically had the lowest moisture content. The even smaller dimensions of the accelerated lap-joint specimens (E27) also appeared to allow rapid drying, despite the use of PVC pipe sections on the sides of the specimens and foam pressed against the end-grain (Fig. 10). Moisture contents were relatively consistent among probe locations for these specimens, perhaps because of their small size. The larger E16 lap-joint specimens often had moisture contents equivalent to or greater than the E27 accelerated lap-joint specimens even without the use of PVC pipe or foam to hold moisture. There was not a consistent trend of the joint area of the E16 lap specimens having the highest moisture content, although this was the case initially (Fig. 11). In contrast, the E25 decking specimens exhibited a consistent trend of the highest moisture content occurring near the end of the specimen that was abutted against the inert surface (Fig. 12). The moisture content at this location was often higher than those observed in all specimen types except the post–beam. However, moisture contents at the other two locations on the decking specimen were much lower, with the middle section of the specimen tending to be the driest. Not surprisingly considering their small dimensions and simple design, the E18 ground proximity specimens had much more uniform within-specimen moisture contents (Fig. 13). They also generally had higher moisture contents than the other types of standardized specimens. However, it is notable that these specimen did dry below 20% moisture content at various times despite their direct contact with concrete and shade cloth covering. This tended to occur in the summer months when heat and sunlight were most intense. After initially wetted, the post and inner beam locations of the post–beam specimens more consistently maintained high moisture contents compared with any of the standardized test specimens (Fig. 14). The post part of the specimen was slow to gain moisture but then maintained high moisture contents even during periods when the standardized specimens dried substantially.

These results clearly show that, as expected, specimens with larger dimensions are more resistant to drying and thus have sufficient moisture to promote decay for a greater proportion of time. To better visualize this effect, the percentage of observations for which the geometric mean of each specimen type exceeded various moisture thresholds is

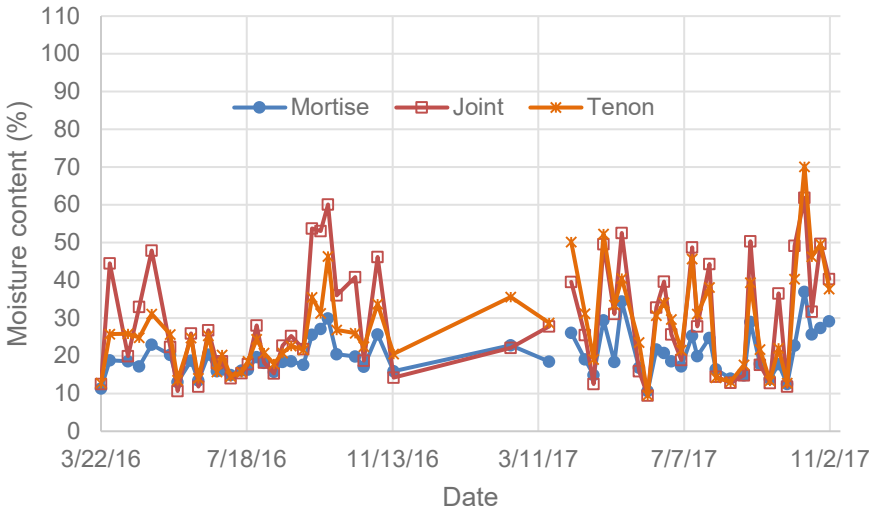


Figure 9. Geometric mean of moisture contents observed for three locations within the E9 L-joint specimens.

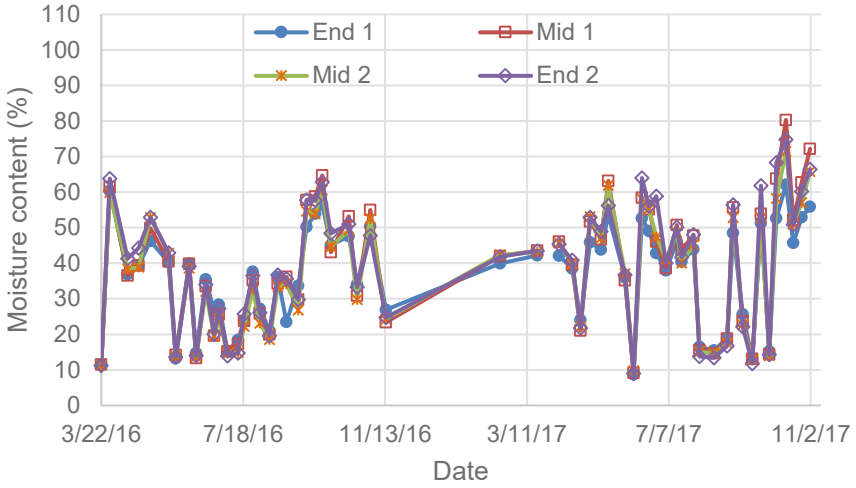


Figure 10. Geometric mean of moisture contents observed for four locations within the E27 accelerated lap-joint specimens.

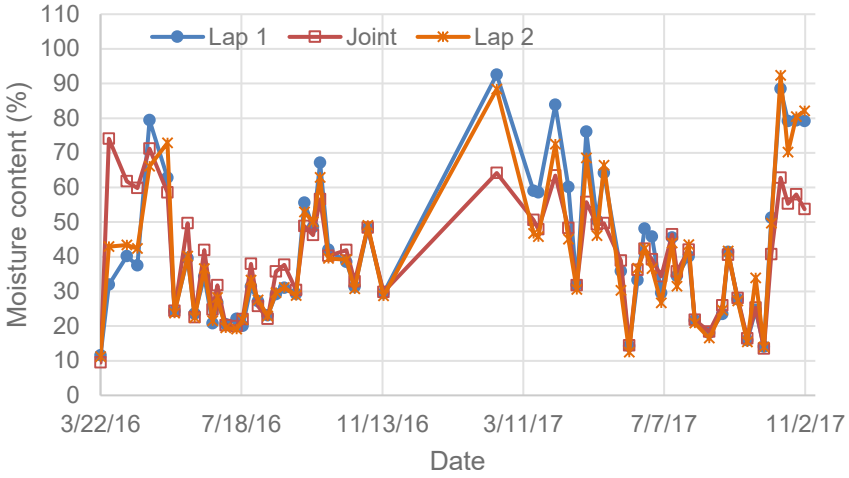


Figure 11. Geometric mean (five replicates) of moisture contents observed for three locations within the E16 lap-joint specimens.

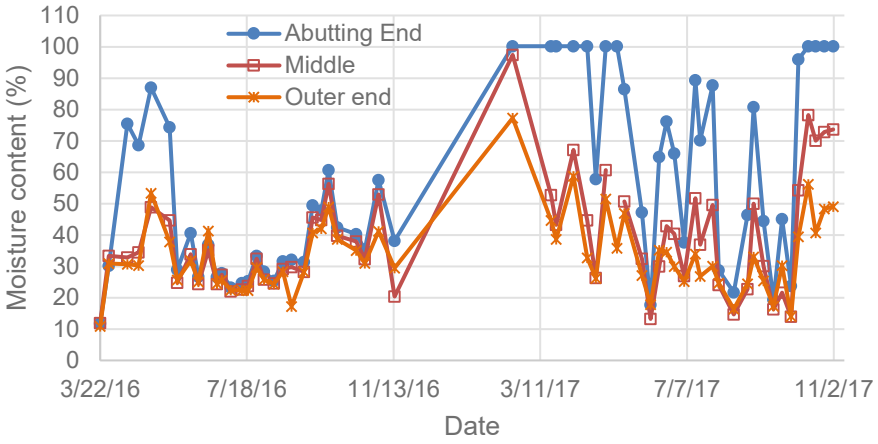


Figure 12. Geometric mean of moisture contents observed for three locations within the E25 decking specimens. Readings capped at 100%.

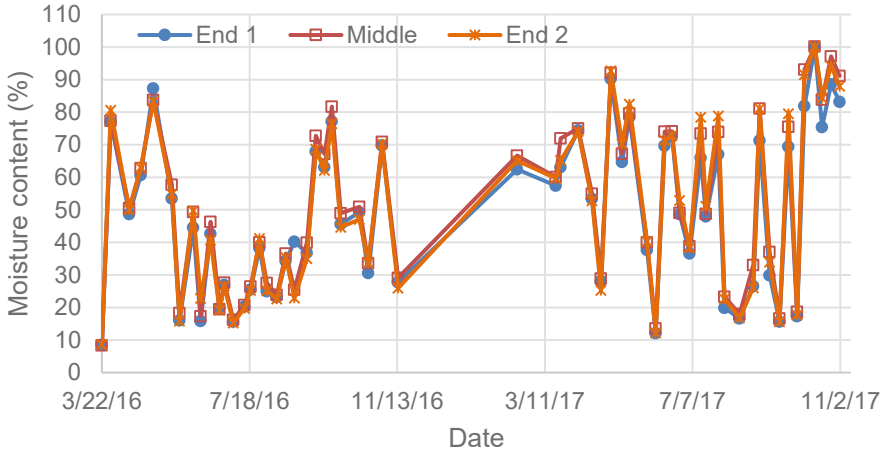


Figure 13. Geometric mean of moisture contents observed for three locations within the E18 ground proximity specimens. Readings capped at 100%.

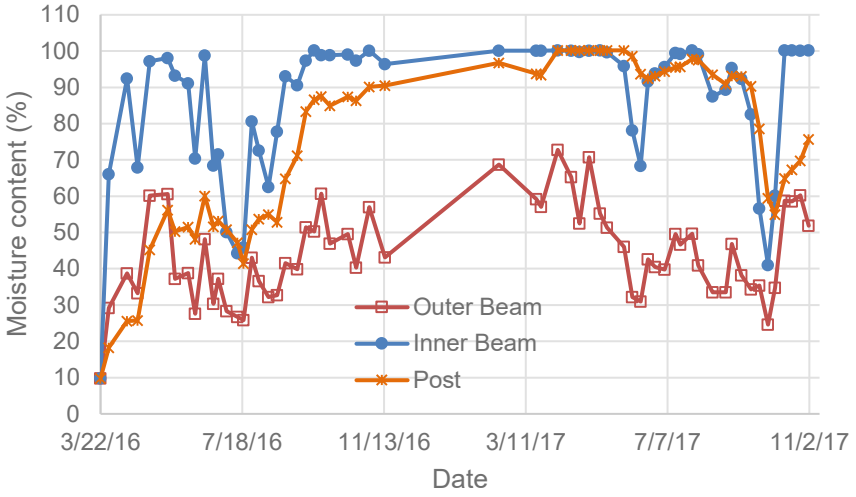


Figure 14. Geometric mean of moisture contents observed for three locations within the simulated post and beam specimens. Readings capped at 100%.

displayed in Figure 15a. For each specimen type, only the probe location that most frequently had the highest moisture content is shown. For example, in the E25 decking specimens, only the moisture contents observed near the end of the specimen that was abutted against the inert surface is shown. Although all specimen types had a probe location with moisture content above 20% for most observations, the proportion of observations above 40% was much lower for the AWPA standard specimens than for the post–beam specimens. This indicates that although standard specimens typically had enough moisture to sustain decay, they were much less likely to reach the 40% to 80% moisture content range thought to be optimal for brown rot decay fungi (Zabel and Morrell 1992). The relatively low moisture contents of the standardized specimens become even more of a concern when viewing only the summer months (June–August), when temperatures are most conducive to decay (Fig. 15b). During these months, even the E18 ground proximity specimens exceeded 40% moisture content for only 42% of observations, and the percentage of moisture contents favorable for decay was even lower for the other types of standardized specimens. This occurred despite

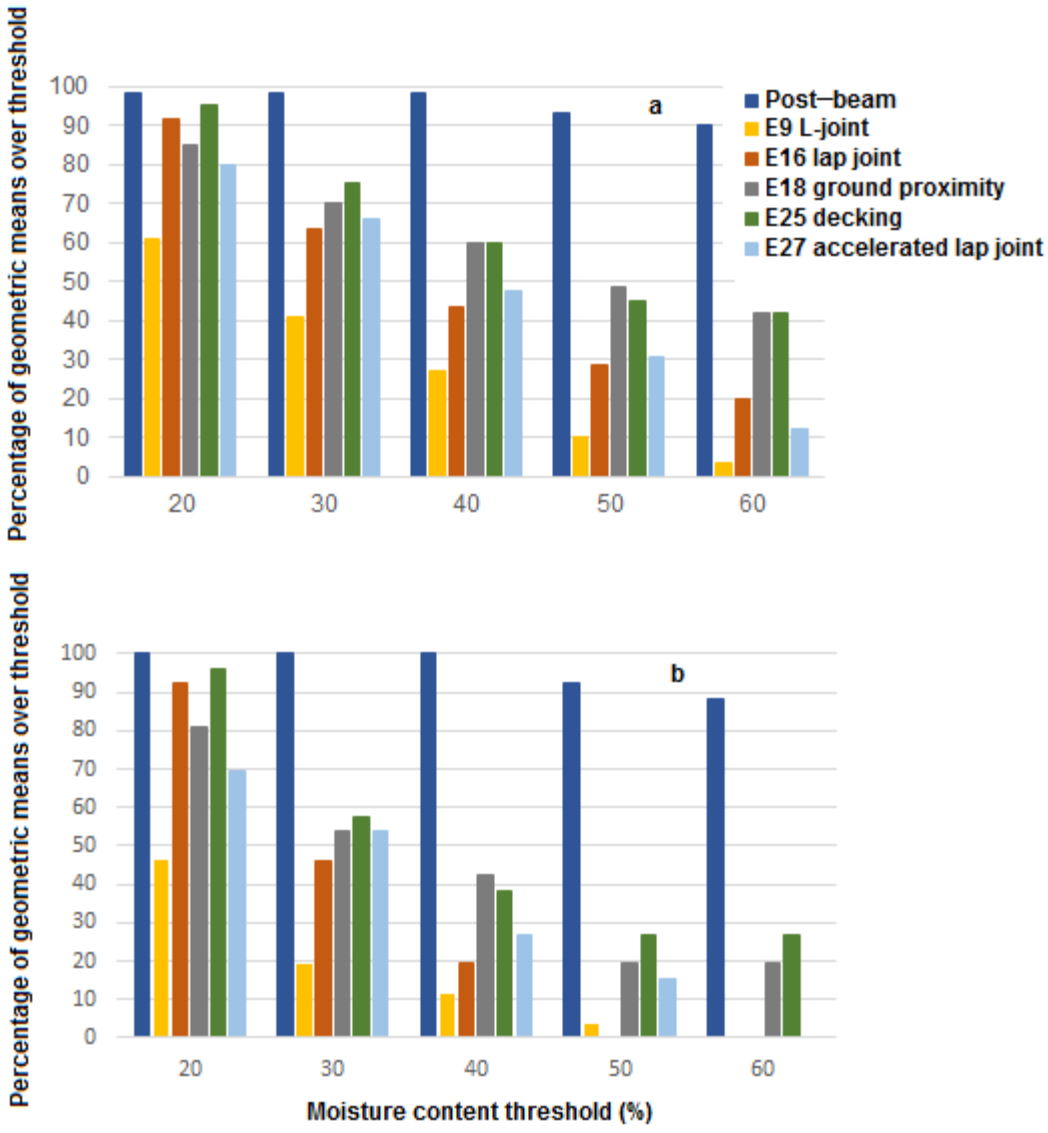


Figure 15. Percentage of moisture content geometric means above various moisture content thresholds for (a) entire exposure period or (b) months of June, July, and August. Data are for the electrode location that most frequently had the highest moisture content within each specimen type. Readings capped at 100%.

relatively frequent rainfall during the summer months. An average of only 3 days passed between rainfall events, and the longest dry spell during the two summers was 9 days. Although the highest moisture content noted for the post–beam specimens was typically above the 80% to 90% reported to be the upper limit for optimal growth (Brischke and Rapp 2008, Zabel and Morrell 1992), the moisture probe detects the area of highest moisture content, and it is likely that a gradient of gradually decreasing moisture content extends toward the surface of the specimen. In addition, Schmidt (2007) concluded that the literature supported preferred moisture content ranges well in excess of 100%.

The effect of drying observed in the smaller specimens may be greater than that solely attributable to time at a lower moisture content. Wadsö and others (2013) noted that there can be a significant delay in the return to fungal activity after a drying period. The differences in moisture content between the post–beam and standard specimens might affect not only the rate of decay but also the types of decay fungi present because moisture tolerances have been shown to vary by type of fungus (Meyer and Brischke 2015).

Observed Specimen Temperatures

The internal temperature of the specimen types differed as a function of air temperature (recorded in the shade adjacent to the specimens). During summer heating (Fig. 16a), the internal temperature of all specimens exceeded the air temperature, with the highest temperatures observed in the E25 decking and E16 lap-joint specimens. Even the E18 ground proximity specimens, which were partially protected by shade cloth, were affected by heating from solar radiation. The post–beam specimens had a more muted and somewhat delayed response to summer daytime temperature increases because of their larger size but still reached temperatures a few degrees above the air temperature. In contrast, the temperature of the specimens was often at or below the air temperature during winter days and nights (Fig. 16b) although the E25 decking and E16 lap-joint specimens still experienced the highest daytime temperatures. The temperature swings within the post–beam specimens were again relatively subdued but not to the extent exhibited by the E18 ground proximity specimens. The E18 specimens stayed notably warmer during the cold nights, perhaps because they rested on concrete that was directly in contact with the ground. The shade cloth may also have served to slow heat loss from the concrete block. However, this same effect apparently limited warming of the E18 ground proximity specimens during warm spring days that followed the freezing temperatures (Fig. 16c). Under those conditions, the E18 specimens remained cooler than the post–beam specimens, which exhibited their characteristic delayed response to changing air temperature.

It is apparent that the effect of specimen dimensions on internal temperature is complex in a climate such as Wisconsin, which has wide seasonal temperature variation. Other researchers have reported that growth of most decay fungi is negligible at temperatures below 2 °C and is relatively slow at temperatures below 10 °C. The growth rate then increases rapidly, with most fungi having optimum growth rates between 24 and 35 °C (Boddy 1983, Clausen 2010, Zabel and Morrell 1992). There are a few wood destroying fungi that prefer temperatures in the 34 to 36 °C range, and these are most commonly found in wood exposed to sunlight (Morris 1998). The rate of growth declines

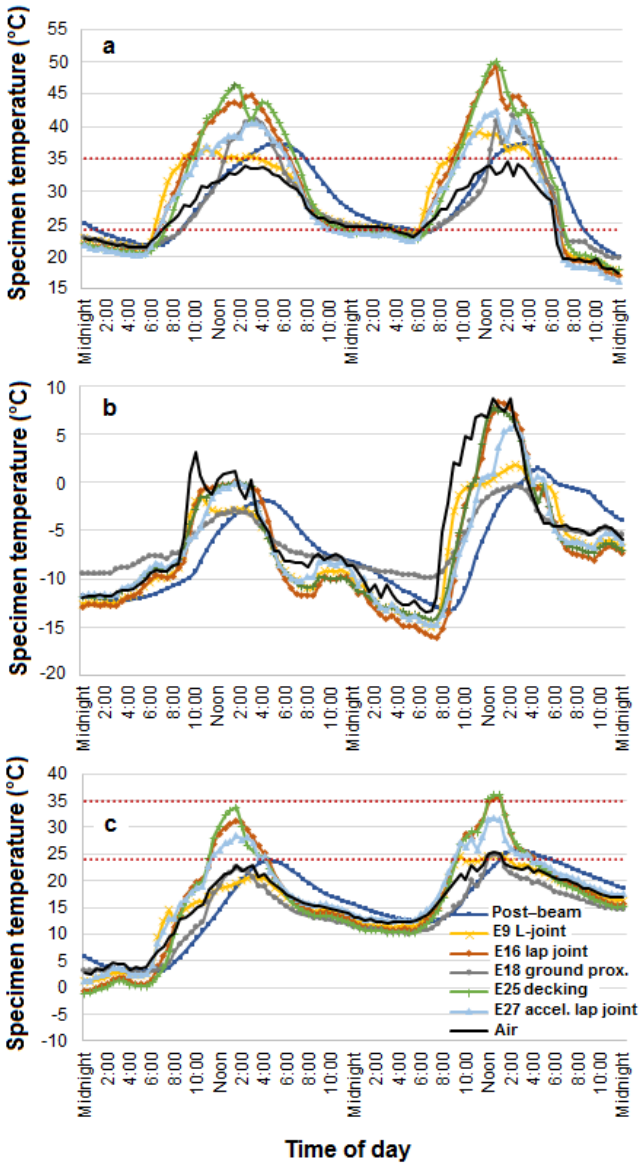


Figure 16. Examples of internal specimen temperatures for 48-h periods in (a) June, (b) January, and (c) April. Dashed horizontal lines (a and c only) indicate the 24 to 35 °C temperature range (c) that is reported to be preferred by decay fungi.

steeply at higher temperatures, with little growth above 40 °C and no growth above 46 °C. The proportions of recorded specimen temperatures from September 2016 to September 2017 falling within three temperature ranges reported to be favorable for growth of decay fungi are shown in Figure 17. Specimen temperatures were within the range where fungal growth is possible (2–46 °C) more than 65% of the time, with the E27 accelerated lap-joint specimens having a slightly higher proportion of temperatures in this range than other specimen types. Between 46% and 50% of readings were within the more favorable 10 to 40 °C temperature range, and in this case, the post–beam specimen had a slightly higher proportion of temperatures within this range. Only 8% to 12% of readings were in the most favored 24 to 35 °C temperature range, with the E18 ground proximity specimens having the lowest proportion of favorable temperatures. It is likely that contact with the concrete block on soil slows initial warming during a heating period and then causes more rapid cooling as the temperature drops. Examples of this trend can be seen in Figure 16a and c. For all specimen types, the highest proportion of favorable temperatures occurred in the summer months when wood moisture contents were often below the range favorable for decay in the standardized test specimens (Fig. 15b).

Both the E16 lap-joint and E25 decking specimens recorded temperatures well above 46 °C on several occasions, at times exceeding 50 °C. This is likely to occur more frequently for specimens exposed in warmer climates, but it is unclear if daily brief periods of high temperatures might have a significant negative effect overall on fungal growth. Previous researchers have reported somewhat conflicting values on the effect of high temperatures on fungal growth, with one report concluding that a temperature of 50 °C is lethal for some types of decay fungi in less than 8 h and lethal for most others evaluated after 24 h (Hulme and Stranks 1976). However, Chidester (1939) found that many decay fungi could tolerate temperatures up to 65 °C for 10 h or more, although one fungus (*Poria incrassata*) was killed at 45 °C. In his summary of the literature, Schmidt (2007) reported that most decay fungi can tolerate temperatures up to 65 °C for at least 4 h. Given that decay of untreated decking proceeds rapidly in southern climates, it seems evident that some types of decay fungi have adapted to intermittent exposure to high temperatures. However, it is possible that the high temperatures experienced by the E16 lap-joint and E25 decking specimens could influence the types of decay fungi that colonize the wood. Temperature affects not only the rate of fungal growth but possibly also the type of fungi that are successful in colonization (Hiscox and others 2016). Fluctuations in temperature have also been shown to increase the diversity of fungi present by limiting the ability of dominant fungi to exclude competitors (Toljander and others 2006). Previous temperature exposures also appear to have a lingering effect, because fungal communities established at warmer temperatures decay wood more rapidly than those established during cooler temperatures (Rubenstein and others 2017).

Not surprisingly, given the climate at the test site, specimen temperatures were often below those thought to be favorable for fungal growth. Although internal temperatures did vary somewhat by specimen type, these differences did not have a large effect on the percentage of readings within ranges favorable for fungal growth (Fig. 17). At this location, specimen configuration apparently had a much greater effect on moisture content than temperature.

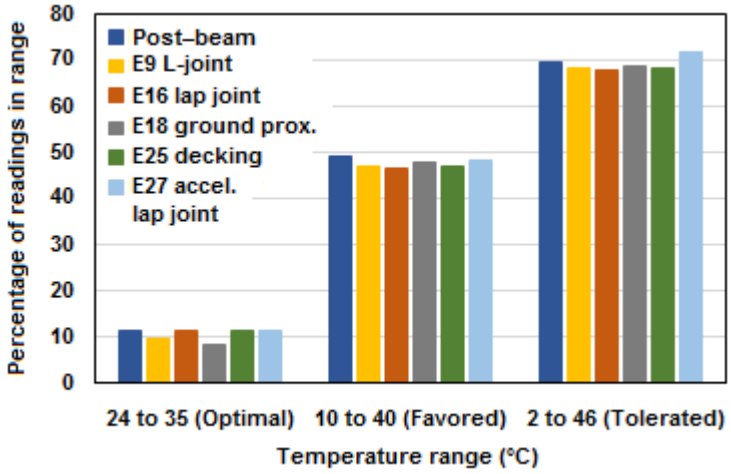


Figure 17. Percentage of temperature readings falling within temperature ranges reported to be optimal (24 to 35 °C), preferred (10 to 40 °C), or tolerated (2 to 46 °C) by wood decay fungi. Based on temperature observations for one year, from September 2016 to September 2017.

Results of moisture content monitoring clearly show that AWPA standardized aboveground test specimens may frequently have lower moisture contents than those that occur in larger members of in-service structures, at least in this location. This was especially apparent in the summer months when temperatures are most conducive to growth of decay fungi. The moisture content of the standardized specimens also fluctuated much more widely than moisture contents observed in the larger post–beam specimens. This finding has implications for the use of current standard test specimen dimensions in evaluating and predicting future long-term performance of preservative treatments. Although these tests are often portrayed as a means of accelerated testing, it is possible that frequent drying in standardized specimens is actually decelerating decay or at least underestimating the extent of the hazard. It is also possible that the lower moisture contents and wider moisture fluctuations observed in the standardized specimens favor a different composition of fungi and other microorganisms than would exist within in-service structures. The types of decay fungi present could influence both rate of decay and, possibly, extent of tolerance to a specific preservative formulation. To evaluate this possibility, decay development in these specimens will be monitored and compared with that observed in the post–beam specimens.

One possible solution to frequent drying could be to use larger specimens. However, it may difficult to detect decay during inspections because decay is likely to develop internally. This is an existing disadvantage of the current E25 decking specimens. Other methods that use stacks or layers of somewhat smaller specimens that serve to trap moisture while still allowing disassembly for internal inspection may warrant further consideration (De Groot 1992, Jenkins 2012, Meyer and others 2016). The E27 accelerated lap-joint method does use two layers, but it appears that larger pieces and/or additional layers are needed to enhance moisture trapping. Of the current standardized methods, the E18 ground proximity specimens appeared to most closely simulate moisture contents observed in the post–beam specimens while still using small dimensions that ease inspection. The E18 specimens did tend to have slightly lower temperatures because of their contact with concrete, but this should be less of a concern in test sites with warmer climates. Tropical or subtropical test sites can provide acceleration of test results for wood products that are subsequently used in cooler or drier climates with lower decay hazard. However, providing conservative durability prediction for wood products that are used above ground in tropical or subtropical areas remains challenging.

Conclusions

The findings of this study indicate that the current AWPA standardized methods for evaluating aboveground durability do not adequately simulate the moisture conditions that can exist within larger wood members used in aboveground construction. The nonstandard post–beam specimens, which simulated a recommended deck construction configuration, sustained higher moisture contents and experienced less moisture content fluctuation than did any of the standardized specimens. This finding suggests that frequent drying of the standardized specimens may underestimate the decay hazard potential for aboveground structures and/or create moisture conditions that favor a different combination of wood decay organisms. Internal temperatures also varied by specimen type, but the temperature differences between specimen types were proportionally much less than the moisture content differences. Further consideration of specimen configurations that enhance moisture-trapping conditions, such as stacks or layers of specimens, appears warranted. Of the current standardized methods, the E18 ground proximity test appeared to offer the best combination of relatively high moisture contents and ease of inspection. The E18 ground proximity method did not appear to present an overly severe test of aboveground efficacy, at least on the basis of moisture content and temperature. Additional data on internal moisture contents of outdoor structures would be beneficial in developing test methods that more closely simulate actual exposure conditions.

Acknowledgments

The authors gratefully acknowledge the assistance of Joseph Balczewski and Steven Halverson of the USDA Forest Service, Forest Products Laboratory, for their assistance in preparing the test specimens.

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a. Guidance document A: data requirement guidelines for listing wood preservatives in AWPA standards.

b. E9-15. Standard field test for evaluation of wood preservatives to be used above ground (UC3A and UC3B); L-joint test.

c. E16-16. Standard field test for evaluation of wood preservatives to be used above ground (UC3B): horizontal lap-joint test.

d. E18-15. Standard field test for evaluation of wood preservatives to be used above ground (UC3B): ground proximity decay test.

e. E25-15. Standard field test for evaluation of wood preservatives to be used above ground (UC3B): decking test.

f. E27-15. Standard field test for evaluation of wood preservatives to be used above ground (UC3B): accelerated horizontal lap-joint test.

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