Ongoing Field Evaluation of Douglas-fir Cross Laminated Timber in A Ground Proximity Protected Test in Mississippi

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ABSTRACT

Current design standards incorporate the use of preservative treated and naturally durable wood where conditions are suitable for deterioration, but treatment options for mass timber products, particularly, cross laminated timber (CLT) remain to be addressed. Termiticide treatment is a necessity for CLT structures, especially in southeastern climates. Wood species currently used to fabricate CLT are non-durable, and current design standards do not properly address incorporation of preservative treatments into these systems. In this study, 12” x 14” x 4” Douglas-fir CLT pieces were installed in a ground proximity protected test at the Harrison Experimental Forest (HEF), (Saucier, MS). Test samples were placed in sets of two in 30” x 30” subplots on bricks approximately 3-4” above soil and covered with ventilated waterproof covers. A total of 20 test pairs (40 total samples) with four different treatments were installed. The treatments consisted of a soil termiticide treatment, a preventive borate spray treatment at initiation, a remedial treatment with the spray-on borate one year post initiation and untreated controls. Soil below five pairs of samples was treated the with a soil termiticide (Termidor® SC). For the preventive borate at initiation treatment, one sample per pair of five other sets was treated with a spray-on borate preventative treatment (Bora-Care®). The remaining ten pairs were left as untreated controls. Temperature and humidity inside some of the covered units is being monitored throughout the test. The ten control sets will be examined for termite attack 12 months after installation. Five of the attacked sets will be treated with spray-on borate as a remedial treatment for active termite attack.

INTRODUCTION

Wood has many qualities that make it a preferred construction material over steel or concrete (Robertson et al. 2012). The development of mass timber products has allowed wood to be used in much taller buildings formerly restricted to steel and concrete. The use of mass timber for multi-level construction has increased substantially in recent years due to a general desire to use more environmentally sustainable materials coupled with changes to construction codes. Mass timber has excellent seismic (Popovsky et al. 2012) and thermal properties (Pei et al. 2012), can allow parts of structures to be prefabricated, and provides increased carbon sequestration making it an attractive construction material (Brandner et al. 2016).

Initially popular in Central Europe and Scandinavia, mass timber construction is also gaining popularity in North America, Australia and Asia (Karacabeyli and Lum 2014; Pei et al. 2016; Singh and Page 2016; Stokes et al. 2017; Wang et al. 2018). Until recently, structures built with mass timber were uncommon and considered novel construction. However, the number of buildings constructed within the last 5 years using mass timber as well as the number of companies producing these products have greatly increased. These structures are already changing global perceptions about wood construction (Mallo and Espinoza 2014). Several high-rise buildings and other structures using mass timber including cross-laminated timber have been built or are in planning and architects and engineers are reevaluating wood construction (Mallo and Espinoza 2015). Although use of mass timber is becoming more widely accepted there is limited information on the durability of this material and the information currently available does not offer realistic methods for limiting the risks of deterioration. Currently mass timber used in construction is not chemically treated to prevent decay or insect attack. All materials including wood can degrade, particularly when exposed elevated moisture levels. Many structures being built or in planning will be in areas with potentially high decay and termite activity and thus prone to biological attack (Wang et al. 2018). In recent laboratory tests exposing CLT to subterranean termites, termites readily attacked CLT material, tunneling along glue lines (Stokes et al. 2017).

Understanding the conditions that are conducive to deterioration of mass timber elements and identifying methods for preventing this damage will be essential for expanded use of these materials. Even though mass timber will be used out of ground contact where the risk of damage is lower, various buildings will be constructed in areas prone to subterranean termite attack. In this paper, we discuss the methodology and initial results of a field study examining the ability of soil termiticides and spray-on borate treatments to protect cross laminated timber materials in a ground proximity protected test. This is the initial descriptive phase of a five year study initiated in September 2017.

MATERIALS AND METHODS

Three ply cross laminated timber (CLT) made from Douglas-fir was provided by D.R. Johnson (Riddle, Oregon). The material varied in width and height with a constant thickness of 4 1/8" (105 mm). Forty samples were cut into approximate 12" x 14" x 4 1/8" (305mm x 355mm x 105 mm) pieces for testing. Samples were conditioned at 75° F and 12% relative humidity for approximately 60 days and weighed before initiation of the field test. Two moisture measurements were made with a Wagner MMC 220 pinless electronic moisture meter (Wagner Meters, Rogue River, OR) on the face of each sample after the 60 day equalibration period.

Samples were taken to the Harrison Experimental Forest (HEF) in Saucier, MS where they were installed in a modified AWPA E21 (AWPA 2017) ground proximity protected field test. The modification being that the samples were placed closer to the ground than a typical AWPA E21 test. The test consisted of a large plot measuring 24' x 25' with 25 subplots measuring 30" x 30". A total of 20 subplots were used for the four treatment sets of the study. Five subplots were not used (Figure 1). The 20 subplots were dug up to a 4" depth with a pick axe and any roots or stones were removed. Each subplot contained two CLT samples set on four bricks on a 30 x 30" cleared square on the ground (Figure 2). The treatments were a soil termiticide only treatment, a preventative borate spray on application at test initiation, a remedial borate spray at one year post initiation, and an untreated control. The test was set up in a randomized block design with five blocks containing one treatment per block in the total plot (Figure 1). For the remedial treatment, five plots are being allowed one year of non-disturbance and sustained termite feeding, after which one of each sample pair (in this treatment) will be remedially treated with the spray-on borate solution.

For the five soil termiticide treatment plots, a 24" x 24" area of the 30" x 30" subplot was treated with Termidor® at an application rate of 0.125%. Bricks and CLT samples were placed on the treated area with as little soil disturbance as possible (Figure 3). The borate spray-on (Bora-Care) was applied to one sample in each of five subplots while the other was left untreated. A plastic shield was placed over the adjacent bricks (where the untreated sample would be) before the sample was sprayed to minimize contamination of borate in the non-treated CLT sample (Figure 4). After placement and treatment, the samples were covered with pre-constructed ventilated plywood covers. The covers measured 22" x 19.5" at their base and were 29" high in front and 27" high in back creating a sloped roof for rain runoff (Figures 2, center and right). The covers were constructed from plywood and painted white. The front and back of each cover had three 1" ventilation holes covered with mesh. HOBO temperature and relative humidity (RH) loggers (Onset Computer Corporation, Bourne, MA) were installed on top of one of the CLT samples in three of the Termidor treated subplots (Figures 1 and 2) and monitored conditions every 30 minutes. Other than temperature and RH data collected after six months from the three soil termiticide subplots and moisture contents measured on the six panels using the resistance moisture meter, samples will be undisturbed for one year. Two moisture readings were taken on the face of each sample using the Wagner meter, then the four moisture readings per sample were averaged and compared to readings taken before the test was initiated.

The test samples were installed in September 2017 and will be assessed for degree of termite damage after 12 months. The goal is to find five of the non-treated control samples with termite attack to assess remedial treatment. If five of the ten control plot samples are not attacked, the plots will be re-evaluated at 6 month intervals until there is attack.

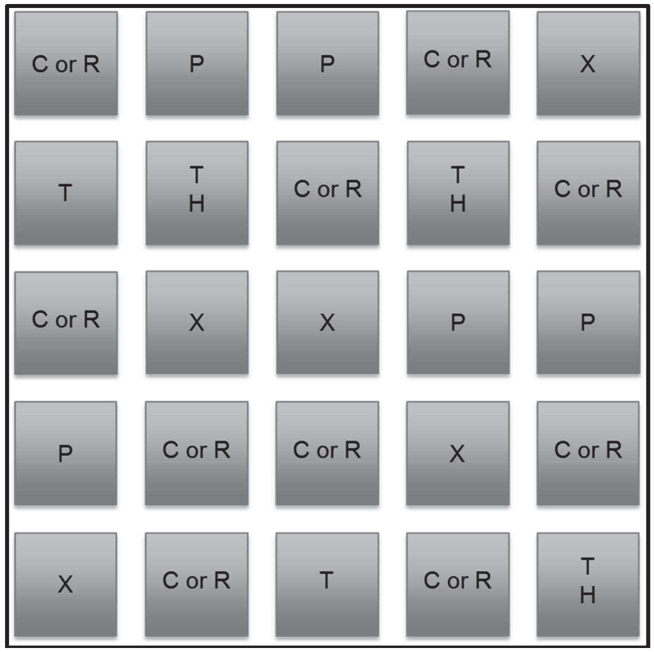

Figure 1. Layout of randomized block design for the modified AWPA E21 ground proximity field test. P = Protective treatment with Bora-Care® (DOT at 23%). T = Treatment with Termidor® SC soil termiticide (0.125%). C or R = Control or Remedial treatment after one year check. Remedial = BoraCare (23% DOT). X = Subplot not used. H = HOBO Data Recorder.

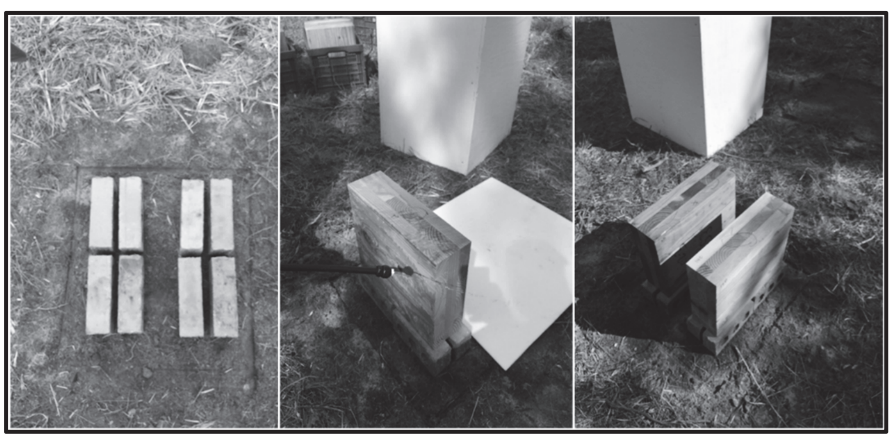

Figure 2. Photographs showing arrangement of ground bricks and CLT in subplots (left), CLT samples on bricks and cover (center) and placement of HOBO recorder on CLT for monitoring temperature and humidity inside covered subplots (right).

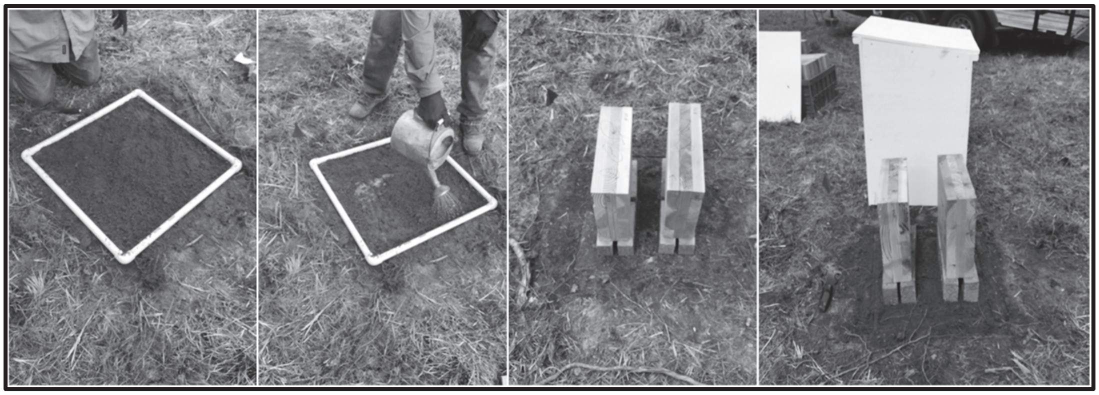

Figure 3. Treatment with Termidor® SC soil termiticide and arrangement of ground bricks and CLT in soil termiticide subplots.

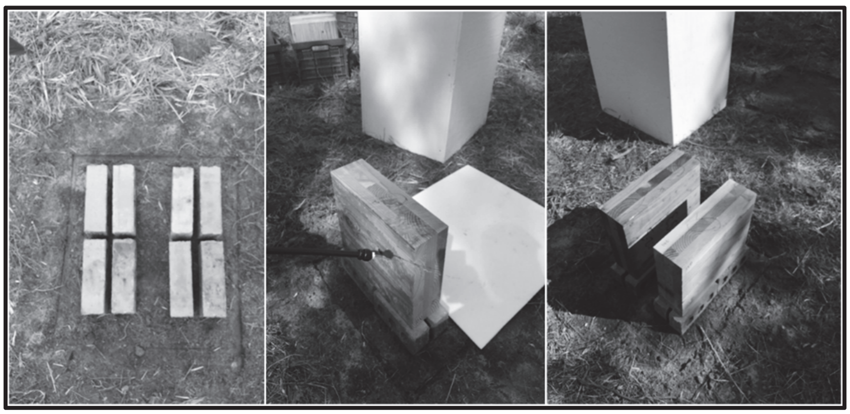

Figure 4. Treatment with spray on borate (Bora-Care®) and arrangement of ground bricks and CLT in the spray on preventative subplots.

RESULTS AND DISCUSSION

Average monthly temperatures ranged from 45ºF in January to 80ºF in September. Average relative humidity ranged from 81% in September to 99% in January indicating that conditions were conducive for termite attack for most of the year (Figure 5). Relative humidity data showed many points at 100%, particularly at low temperatures. Although this may be normal, it also suggests that the HOBO was improperly placed under the subplot cover and the sensor may have been exposed to liquid water as condensation or ice. This discrepancy is currently being evaluated by repositioning the HOBO or using a HOBO with a tailed sensor.

Moisture contents of the CLT panels were initially 11.4 %, which would be close to the moisture content when the panels were target produced. Average moisture content increased to nearly 23.7 % at the end of the first six months of exposure suggesting that the humidity inside the cover boxes was high during the six month period (Figure 6). These results indicate that the CLT samples are sorbing moisture, despite the lack of an overhead moisture source or soil contact and are reaching moisture levels where biodeterioration would become a concern.

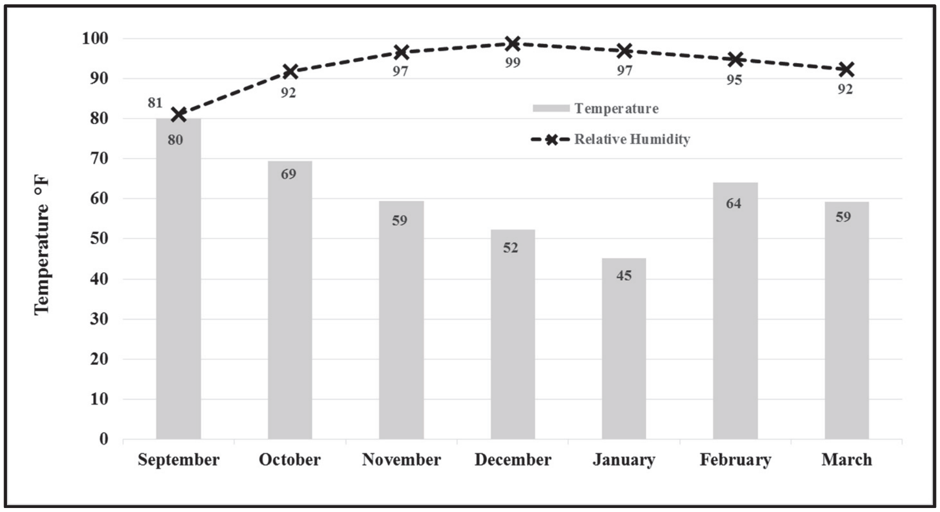

Figure 5. Average monthly temperature and relative humidity inside test boxes for a modified AWPA E21 ground proximity protected test with CLT in Mississippi.

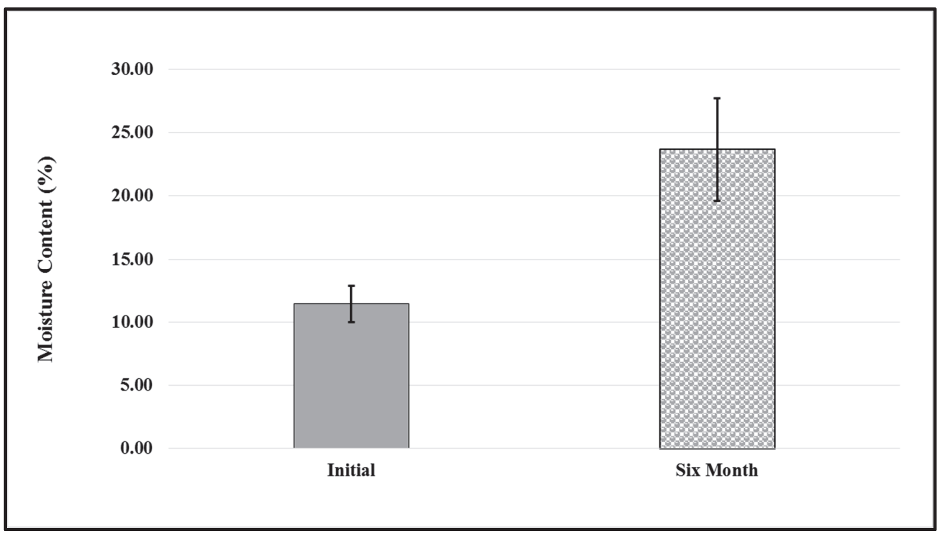

Figure 6. Average moisture content of CLT samples (n = 24) at test initiation and after 6 months of exposure in a ground proximity protected field test in Mississippi.

CONCLUSIONS

Moisture contents in CLT panels exposed in ground proximity under protective covers increased from 11.3% to 23.7 % in six months of exposure. Increased moisture levels suggest that the materials are at an increased risk of biodeterioration from termite and fungal attack. At the six month point no termite activity was observed, but it must be noted that only three of the subplots were checked at this point and that they were soil termiticide treatments only. These panels will continue to be monitored to determine how soil treatments and boron sprays slow this attack and panels that develop termite damage will be used to assess remedial treatment options.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Craig Bell of the FPL for assisting with the experimental setup and Milo Clausen of OSU for preparing and shipping the CLT samples. This project was funded as part of the FPL FY2017 Green Building Research Program.

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of the

AMERICAN WOOD PROTECTION ASSOCIATION

Marriott Seattle Waterfront
Seattle, Washington
April 22-24, 2018

VOLUME 114

AMERICAN WOOD PROTECTION ASSOCIATION
P O BOX 361784 • BIRMINGHAM, ALABAMA 35236-1784 • USA

ISSN 0066-1198

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