Ongoing Termite Studies on Cross Laminated Timber (CLT) Panels

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INTRODUCTION

The development of composite mass timber products in the late 20th century continues to generate new developments in the design and production of multi-layer wood products in a wide variety of orientations and for a wide variety of uses. In the US Congress' Agricultural Act of 2014, provisions were specified in Section 7310 to establish a series of priorities for research into the needs of the forestry sector. Specifically, collaborative research efforts into the increased use of CLT in support of the expansion of this portion of the forest products industry were addressed. Cross laminated timber products have been included in updates to national and international building codes, and new production facilities continue to come online. WoodWorks (2019) reports that 105 CLT based construction projects are in construction or completed, and 200 are in the design process. These projects are scattered across the United States, including in the highest areas of decay potential (Figure 1).

Mississippi State University Department of Sustainable Bioproducts has several ongoing projects to investigate the durability of CLT under various conditions. These are partnerships with other investigators, primarily with USDA Forest Products Lab personnel, and are housed at both MSU Department of Sustainable Bioproducts facilities in Starkville, MS as well as Forest Products Lab locations in Madison, WI, McNeill, MS, and Saucier, MS. CLT is being tested in several different formats and in test pieces of different sizes. In an ideal situation, CLT panels would be tested at their full size, however, the time it would take to do so, and the logistics of handling pieces of typical size is prohibitive for rapid assessment of the product. Assessments of CLT to date have focused on examining the durability of CLT when exposed to hazards that occur in the high hazard zones of deterioration, such as fungi, termites, and natural weathering. This report describes the collaborative testing of CLT against termite infestation and damage.

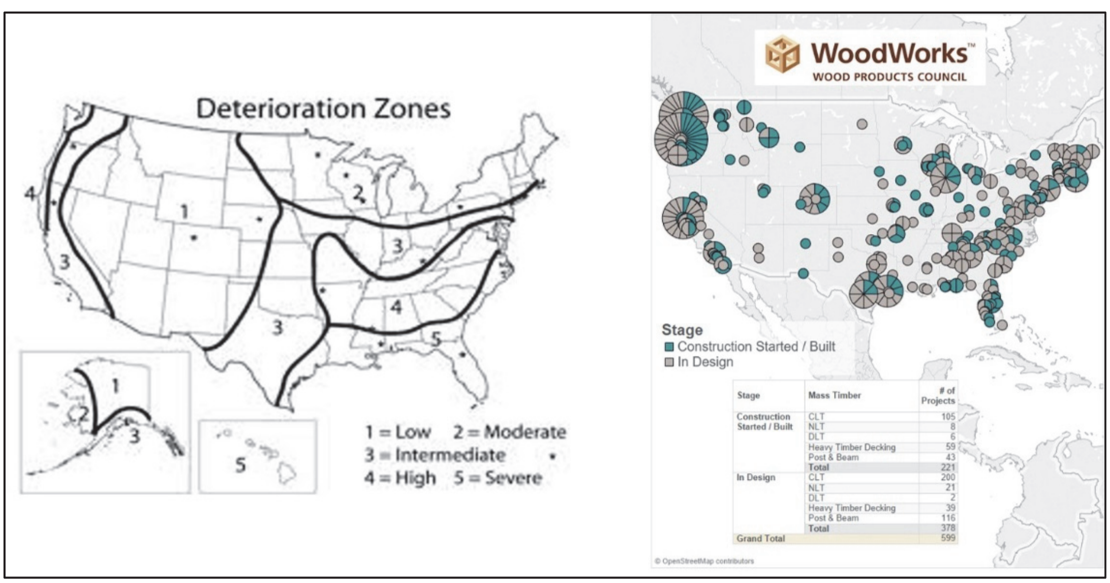

Figure 1. Deterioration zones and mass timber building projects currently under construction. Images courtesy of USDA Forest Products Laboratory and WoodWorks (2019).

MATERIALS AND METHODS

Termite decay has been under examination for some time, in both laboratory and field testing. The AWPA E1-17 standard "Laboratory Method for Evaluating the Termite Resistance of Wood-Based Materials: Choice and No-Choice Tests" has been used for lab evaluations while AWPA E21-18 "Standard Field Test for Evaluation of Wood Preservatives to be used for Interior Applications (UC1 and UC2); Full-size Commodity Termite Test" has been used for field evaluations (AWPA, 2019).

Initial tests were conducted on 3-ply CLT segments that were cut into 4-inch x 4-inch x 4-inch cubes and tested in 8-liter food safe containers. CLT has been tested in samples that maintain the full thickness of the product in all iterations. Tests of the 4-inch cubes were allowed to run four to eight weeks, as long as populations of *Reticulitermes* sp. could be maintained. Samples were evaluated visually after the tests were broken down, and selected samples were sliced open using a band saw. Depth and location of termite tunneling was determined as possible (Figure 2).

As the standard method of determining change in this method, mass change is measured for each sample tested. Detecting mass loss was difficult for this test setup because of the low volume of material removed by the termites relative to the large volume of the test block overall. The next series of test blocks were reduced in thickness, to an overall size of 4-inch x 4-inch x 1-inch.

Blocks of this size were used in the remaining tests for termite exposure. Tests included variation of the amount of sand provided in the containers for termite habitat, variation in the number of termites in the population, and variation in the type of mass timber product in a no-choice test. Using test blocks of this size, it was also possible to select for more or less direct exposure of end-grain to the termite population during testing, as blocks may be cut to have 1 or 2 layers of end-grain exposure on the wide faces (Figure 3).

Compared to previous 4-inch cube test blocks, the revised size allowed for a more accurate determination of mass change, as well as a more easily viewed cross-section for determining visual rating. Figure 4 shows CLT exposed to different number of termites (1000, 800, 600, and 400, and no termites, respectively). Repeated testing for determination of sand volume and termite population were performed. Testing was also performed with various mass timber products – CLT, LVL, PSL-treated, and PSL-untreated – to determine any preference for material type (Figure 5). In all tests, test blocks were prepared at the revised size of 4-inch x 4-inch x 1-inch, an 8-liter container was used, sand was kept at 18% moisture content, and all tests were housed in a controlled-temperature room.

Field testing of CLT was based on AWPA E21-18, and blocks of CLT were cut to approximately 16 inches, 4 inches wide, and 3-ply. Blocks were placed as recommended by the standard and allowed to stay in the field for 12 months to 24 months. Samples were periodically examined visually to determine the presence of *Reticulitermes* sp. and/or *Coptotermes formosanus*. Test blocks were placed on top of vertically oriented concrete blocks into which untreated southern yellow pine stakes were inserted as bait. Within each grouping, there were CLT test blocks, treated southern yellow pine controls, and untreated southern yellow pine dimensional lumber (Figure 6).

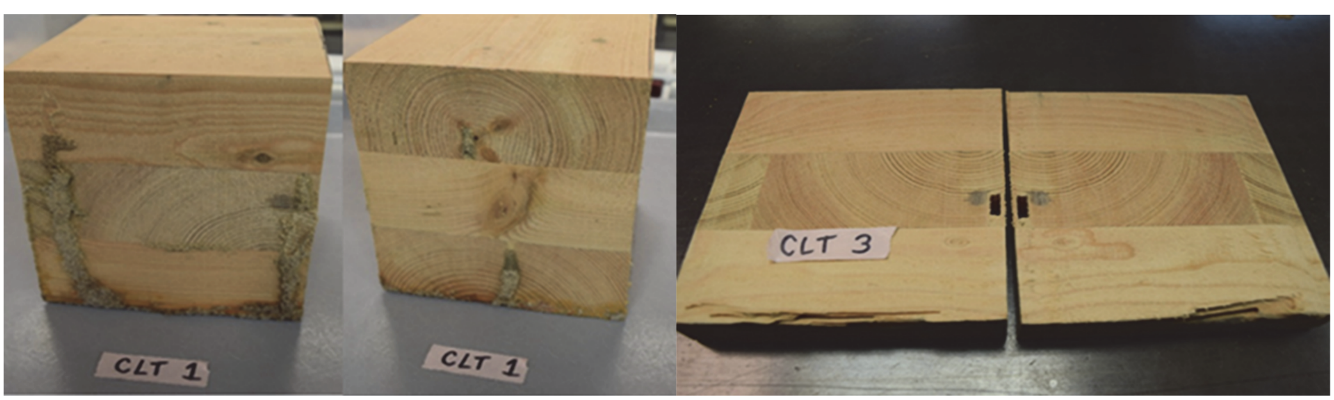

Figure 2. 4-inch cubes after eight weeks of testing. Left – immediately after testing, with mud tubes intact; Right – test block sliced open to determine depth and location of termite tunneling.

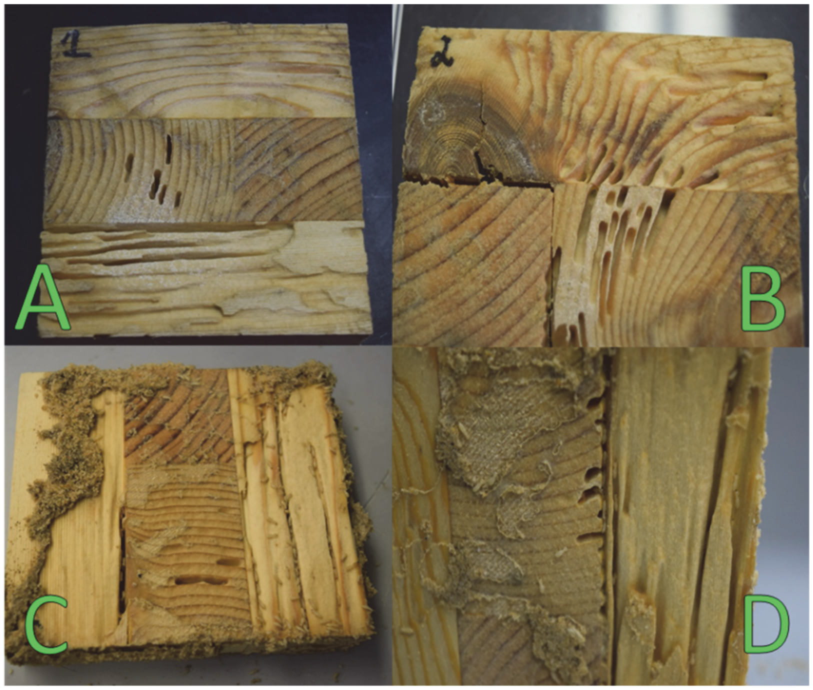

Figure 3. Revised test blocks of smaller thickness (1-inch) following exposure to *Reticulitermes* sp. Excavations can be seen on the exposed surfaces of blocks A and B post-cleaning. Blocks C and D show active termites immediately after removal from test containers, with intact shelter tubes.

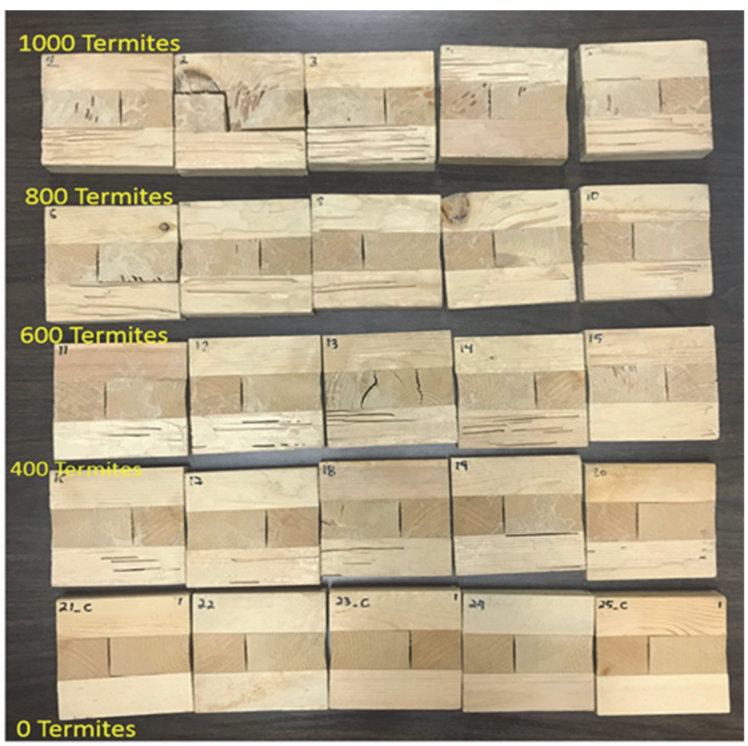

Figure 4. CLT exposed to increasing numbers of *Reticulitermes* sp. 600 or more termites, exposed for 4 weeks, produced detectable mass changes and easily determined visual ratings.

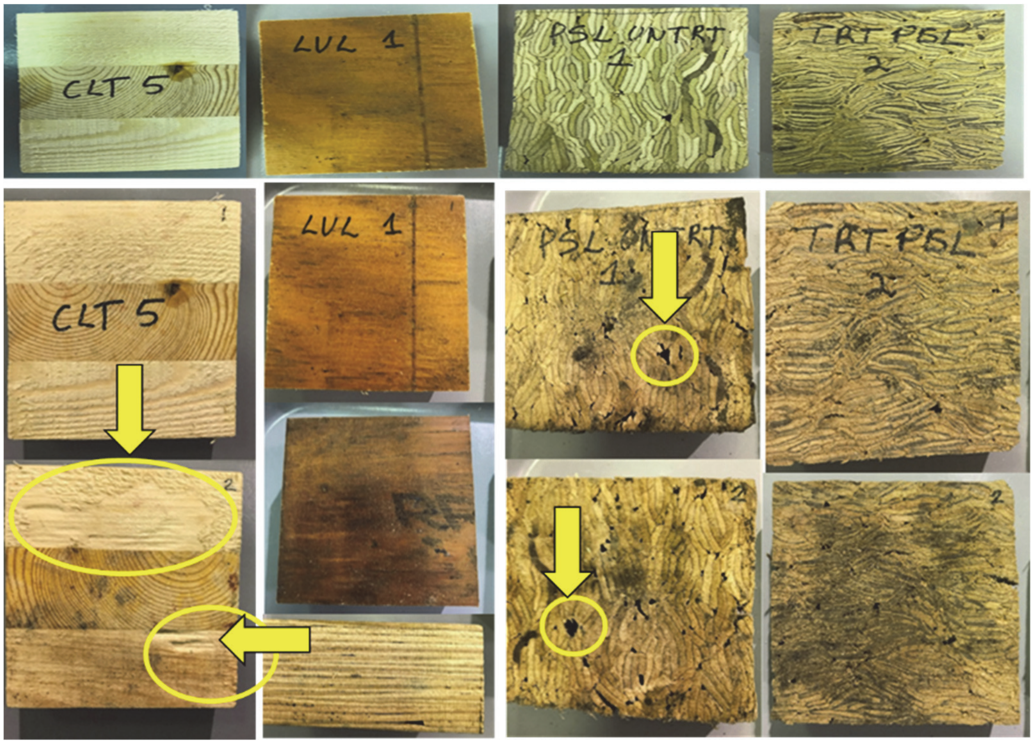

Figure 5. Mass timber products exposed to *Reticulitermes* sp. Indicated areas were sites of feeding behavior, which was low throughout all types of material tested, but highest in CLT. Left to right: CLT, laminated veneer lumber (LVL), untreated parallel strand lumber (PSL), treated parallel strand lumber (TRT_PSL).

Figure 6. Field testing of CLT sections in AWPA E21-18 setups. Left - initial setup of test pieces and controls on concrete blocks with internal feeder stakes; Middle – 24 months of exposure, exhibiting shelter tube formation between concrete support block and CLT test block; Right – hollowed CLT test block, with apparently sound exterior, after 24 months of exposure.

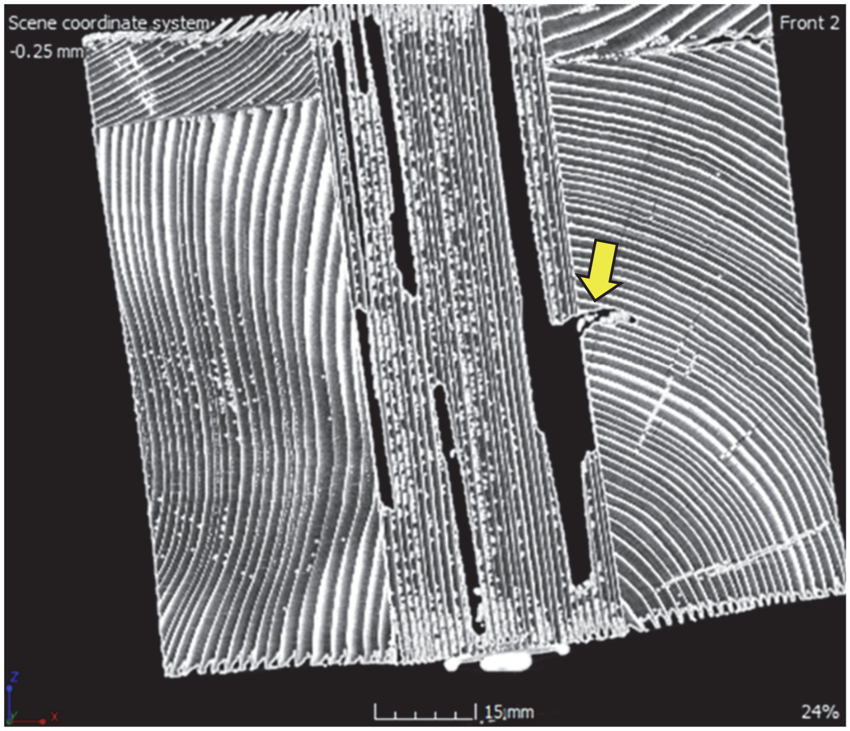

Figure 7. Nikon XRT tomographic scan of CLT exposed to termites. Note tunneling approximately the width of the entire block, with a small surface excavation for visual reference. Additionally, termite tunneling across the glue line was detected for the first time, indicated by arrow.

RESULTS

Mass change and visual rating were collected in all tests for all samples. Comparisons were made within tests for varying amounts of termites, sand volume, and material type. Visual ratings were made based on the standard rating scale included in AWPA E1-17 but were adjusted to account for the larger scale of the test block than the normal 1-inch x 1-inch x ¼-inch test block.

CLT in field tests exhibited high levels of attack by native *Reticulitermes* sp. after 12 months, and even more attack after 24 months. When tapped with a putty knife in field evaluations, the dull knife blade easily pierced the side of the block, indicating that while the exterior appeared intact, and would have received a high visual grade, the interior had been completely perforated by tunnels.

Visualization was attempted following early tests with a 2-dimensional x-ray scanner, which did not provide a resolution high enough to determine internal damage of 1-inch thick test pieces. However, a sample of CLT exposed to termites scanned in the Nikon XRT tomographic scanner housed at the MSU Institute for Imaging and Analytical Technologies did produce a 3-dimensional image of internal damage produced by termites within a test block (Figure 7). However, the practicality of using this technology to scan CLT panels at a construction scale is not feasible.

CONCLUSIONS

CLT that is unprotected is susceptible to attack by termites in high-hazard areas. Internal damage may be unclear and difficult to ascertain without further imaging and analysis. For testing, CLT sections of 3-ply, 4-inch x 4-inch x 1-inch exposed to at least 600 termites and tested for 4 weeks in an 8-liter container with 1-liter of sterilized sand substrate at 18% moisture content produced adequate results to determine mass change due to termite infestation. CLT appears to be more susceptible to termite attack than other commonly used mass timber products, but further testing is needed against other large-scale products. The monitoring of CLT that has a potential to be exposed to moisture and insect activity in high hazard zones should be included in planning of building projects using CLT.

REFERENCES

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2. WoodWorks. 2019. Mass Timber Projects in Design and Constructed in the US. Building Trends: Mass Timber. https://www.woodworkds.org/publications-media/building-trends-mass-timber/

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