Proceedings of the 61st International Convention of the Society of Wood Science and Technology and Japan Wood Research Society
November 5-9, 2018 – Nagoya, Japan

Durability of cross laminated timber against termite damage

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ABSTRACT: Mass timber is a category of framing components that can be built with a variety of materials. Engineered wood products have become the backbone of the mass timber movement. Some of the most common mass timber structural elements used in buildings are glue-laminated beams (glulam), laminated veneer lumber (LVL) and cross laminated timber (CLT). However, wood is a natural material which is susceptible to decay and termite attack. Subterranean termites cause billions of dollars in damage each year and their primary food is wood. In the past few years, there has been an effort to expand the use of mass timber products, especially CLT products, in the U.S. However, to date no termite infestation study has been done for the product. This study evaluates the natural resistance against termites of three wood products available in the market: untreated pine, CCA treated pine, and CLT. Some necessary modifications to the AWPA E1 standard were made in order to test the bigger samples (CLT blocks). The results indicate that CLT is susceptible to *Coptotermes formosanus* attack.

Keywords: CLT, subterranean termite, *Coptotermes formosanus*, mass loss, visual rate.

INTRODUCTION

Cross-laminated timber (CLT) is a prefabricated solid engineered wood product, made of at least three orthogonally oriented, facially bonded, layers of kiln-dried lumber. Lumber is bonded with structural adhesives and pressed to form a solid, straight, rectangular panels. CLT can be used for roof, floor, and wall applications (Pagnoncelli and Morales, 2016).

CLT is a new generation of engineered wood, first developed in Europe. In the early 1990s, CLT was introduced in Austria and Germany and has since gained popularity in residential and nonresidential construction applications. In the mid-1990s, Austria undertook an industry-academia joint research effort that resulted in the development of modern CLT (FPI 2010).

In the early 2000s, CLT construction increased significantly. The growing use of CLT in construction is due to its advantages such as its appeal to the green building movement, high insulation efficiency, product approvals for inclusion in international building codes, and improved marketing and distribution channels. In recent years, CLT has been introduced as an emerging building system in North America and new wood construction technology (Guigou-Carter et al., 2016).

In order to expand this product to the U.S. wood market, it is necessary to make an evaluation of the product's resistance to situations where biological degradation may be favorable. Such conditions are commonly found in the southeastern portion of the U.S. Objectives of this study were to: (1) evaluate the natural resistance of CLT against *Coptotermes formosanus* attack, and (2) compare the results with untreated southern yellow pine and chromated copper arsenate (CCA)-treated southern yellow pine.

MATERIAL AND METHODS

A modified version of standard AWPA E1-16 (AWPA 2016a) was used as basis for this study. The modifications included: size of the specimen, size of the container, amount of sand and water in each container, number of termites, and duration of test.

The dimension for the specimens in this standard were 1 x 1 x ¼ in. (25 mm x 25 mm x 6 mm). For this study, CLT samples were cut into approximately 4 x 4 x 1 in. (10.16 x 10.16 x 2.54 cm) blocks. The wood products tested in this study were CLT, CCA-treated southern yellow pine, and untreated southern yellow pine. Pine lumber was treated to a retention of 0.25 pcf with CCA, which is a recommended retention for above ground exterior applications (AWPA 2017b).

All samples were autoclaved and then conditioned at 12% EMC (equilibrium moisture content). Subterranean termites (*Coptotermes formosanus*) were collected at the Formosan Termite Research Facility (McNeill, MS) and kept under favorable conditions until the test was initiated. The termite colony used for this test had approximately 10% soldiers. The test was conducted at the Mississippi State University Formosan Termite Research Facility located in McNeill, MS.

Clear plastic boxes with lids were used to accommodate the sample size. Containers were prepared with 1000 mL (1715 g) of sand, 100 mL water, and approximately 1000 termites (3.5 g of termites). Containers were covered and left on the bench top in a climate-controlled laboratory for eight weeks. Ten replicates were used for the CLT blocks and five replicates each for untreated and CCA-treated pine.

Mean comparison tests for different wood products were performed at an $\alpha = 0.05$ level using PROC GLM function in SAS (version 9.4, 2013).

RESULTS AND DISCUSSION

Table 1 details the percent weight loss, visual block rating (rate of damage made by the termites on each block), and visual rating (rates termite behavior in terms of tunneling, position in the container, and termite mortality) for all samples tested. The results clearly show that the CLT samples were susceptible to *C. formosanus* attack, with extensive tunneling and feeding behavior observed in each block. Statistical analysis of percent mass loss showed that all three treatments means were significantly different from each other. Treatments in order of highest to lowest percent mass losses were: untreated pine (7.2%), CLT (6.0%), and CCA-treated pine (3.9%). The distribution of the percent mass loss data is also shown graphically in the boxplot of Figure 1.

Table 1. Data summary for Group 1 (Untreated southern yellow pine), Group 2 (CCA-treated pine), and Group 3 (CLT blocks) following eight weeks of exposure to *C. formosanus*

	Sample ID	W_1 (g)[a]	W_2 (g)[b]	% Mass Loss	Visual Block Rating[c]	Visual ratings[d]		
						T	P	M
1	1	155.2	143.8	7.3	8.0	+	d	s
	2	155.9	145.4	6.7	8.0	+	d	m
	3	151.8	141.2	7.0	8.0	+	d	s
	4	155.6	143.6	7.7	8.0	+	d	s
	5	157.3	146.0	7.2	8.0	+	d	s
			Average	7.2a	8.0			
			STDEV	0.4	0.00			
Group	Sample ID	W_1 (g)[a]	W_2 (g)[b]	% Mass Loss	Visual Block Rating	Visual ratings[d]		
						T	P	M
2	1	153.1	147.2	3.9	10.0	+	-	x
	2	155.2	149.1	3.9	10.0	+	-	x
	3	154.8	148.5	4.1	10.0	+	-	x
	4	156.0	149.9	3.9	10.0	+	-	x
	5	153.6	147.8	3.8	10.0	+	-	x
			Average	3.9c	10.0			
			STDEV	0.1	10.0			
Group	Sample ID	W_1 (g)[a]	W_2 (g)[b]	% Mass Loss	Visual Block Rating	Visual ratings[d]		
						T	P	M
3	B1	133.7	125.2	6.4	7.0	+	d	x
	D3	159.9	150.5	5.9	8.0	+	d	s
	D4	144.9	137.4	5.2	8.0	+	d	s
	E2	138.8	129.7	6.5	7.0	+	d	m
	B4	145.5	136.8	6.0	8.0	+	d	s
	C2	144.4	136.1	5.7	7.0	+	d	s
	D5	153.0	144.0	5.9	8.0	+	d	s
	B2	146.5	138.3	5.6	7.0	+	d	s
	A1	130.6	122.0	6.6	7.0	+	d	s
	B5	148.4	138.9	6.4	8.0	+	d	s
			Average	6.0b	7.5			
			STDEV	0. 5	0.5			

**Significant differences in mean percent mass loss among treatments are indicated by different letters at $\alpha = 0.05$

[a]W_1: weight of the sample before exposure to termites

[b]W_2: weight of the sample after exposure to termites

[c]Block Ratings:10 = Sound; 9.5 = trace nibbles permitted; 9.0 = light attack; 8.0 = moderate attack; 7.0 = moderate/severe attack, penetration; 6.0 = severe attack; 4.0 = very severe attack; 0.0 = failure.

[d]Visual Rating

T = tunneling "+" = Yes; "-"= No

P = majority termite position "u" = on surface; "d" = beneath surface

M = approximate termite mortality "s" = slight (0% to 33%)
"m" = moderate (34% to 66%)
"h" = heavy (67% to 99%)
"x" = complete (100%)

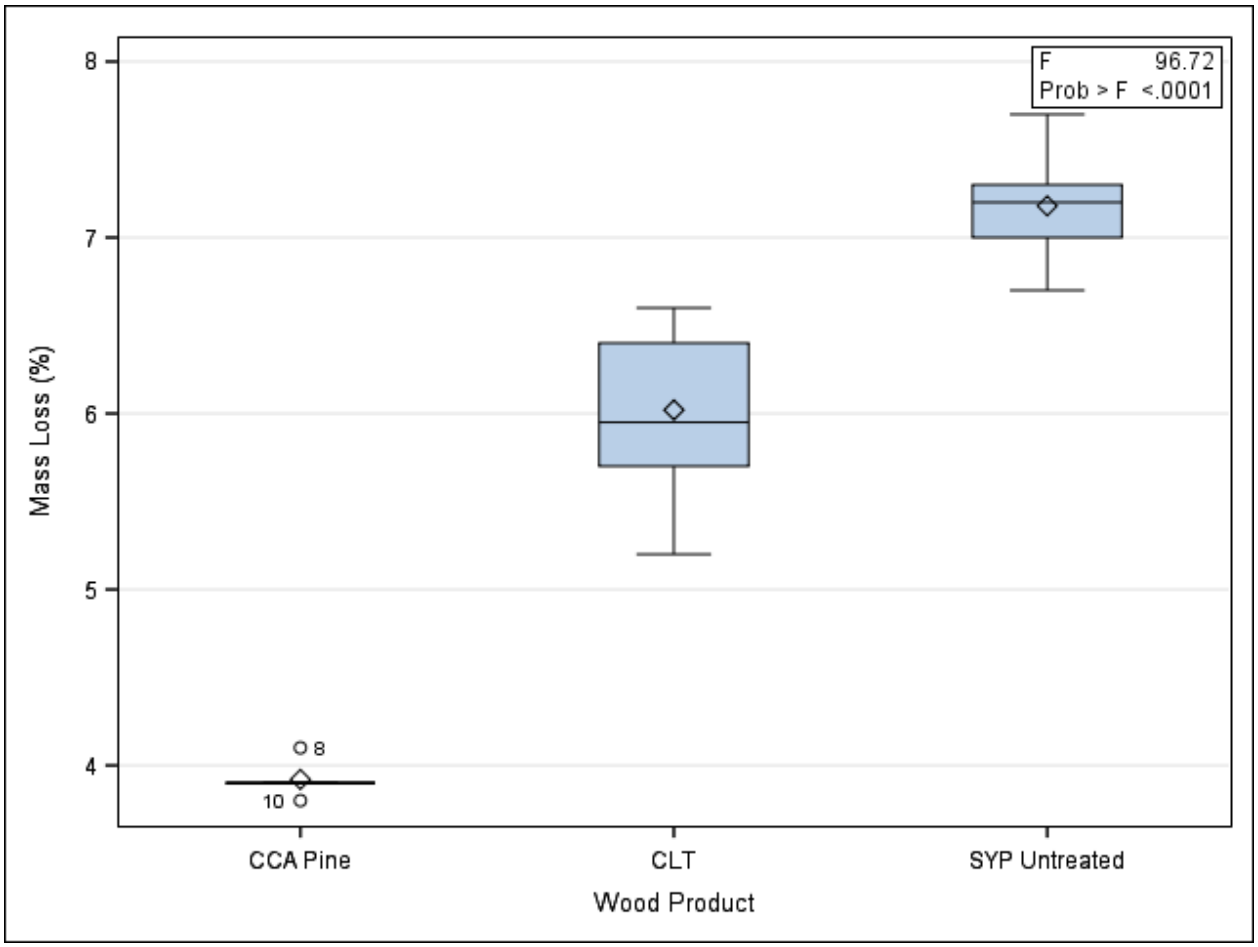

Figure 1 – Boxplot distribution of percent mass loss by mass timber products

Photographs documenting the damage appear in Figures 2, 3, and 4. Even though CLT samples had significantly less percent mass loss than control pieces (untreated pine), the CLT samples exhibited slightly more damage as they received a lower average visual rating (7.5) compared to the untreated pine blocks (8.0). The damage caused by termite attack on CLT samples was considered moderate to severe, with penetration. For untreated pine samples the damage was classified as moderate.

(a)

(b)

Figure 2 – Group 1 untreated southern yellow pine: (a) samples prior to exposure to *C. formosanus*; (b) samples after exposure to *C. formosanus*.

(a)

(b)

Figure 3 – Group 2 CCA-treated pine: (a) samples prior to exposure to *C. formosanus*; (b) samples after exposure to *C. formosanus*

(a)

(b)

Figure 4 – Group 3 CLT blocks: (a) samples prior to exposure to *C. formosanus*; (b) samples after exposure to *C. formosanus*

Treated pine samples averaged the lowest percent mass loss, the least damage with a visual rating of 10.0, and were classified as sound according to the AWPA E1-16 visual rating system. The amount of mass loss that occurred in treated samples could have been due to a small amount of leaching of the product used to treat the samples or to variability associated with conditioning the large blocks.

For visual rating classification, the sand in containers with CLT and untreated samples exhibited signs of termite tunneling. At the conclusion of the test, mortality was estimated between 0% and 33%. For CCA-treated samples, the results included tunneling on samples, no determination of termite position within the container, and 100% termite mortality.

CONCLUSION

The study was conducted according AWPA E1-16 standard with some modifications. The modifications included size of container, amount of sand and water, number of termites, and duration of test. The modifications were necessary in order to accommodate the large scale test on CLT blocks.

The results showed that unprotected CLT is susceptible to *C. formosanus* attack. Untreated pine showed the highest mass loss compared to the other products tested (CLT and CCA treated pine). However, CLT received a lower visual rating than the other wood products, and the damage caused on CLT blocks was classified as moderate to severe, with penetration. For untreated pine samples the damage was classified as moderate, and CCA pine was classified as sound. Based on these results, further testing is planned to determine the impact of *C. formosanus* on larger sections of CLT material.

REFERENCES

American Wood Protection Association – AWPA (2016a) Standard method for laboratory evaluation to determine resistance to subterranean termites. Standard E1-16. AWPA Book of Standards. American Wood Protection Association, Birmingham, AL.

American Wood Protection Association – AWPA (2017b). Use category system: use specification for treated wood. Standard U1-17. AWPA Book of Standards. American Wood Protection Association, Birmingham, AL.

Guigou-Carter C, Villot M, Wetta R (2016) Prediction method adapted to wood frame lightweight constructions, Journal of Building Acoustics, 13(3):173-188.

FPInnovations (2010) Cross Laminated Timber Handbook. FPInnovations, SP-528E, Canada.

Pagnoncelli L, Morales F (2016) Cross-laminated timber system (CLT): laboratory and in situ measurements of airborne and impact sound insulation. Pages 1-11 *in* Proceedings of EuroRegio 2016, June 13-15, 2016, Porto, Portugal.

Pérez M, Fuente M (2013) Acoustic design through predictive methods in Cross Laminated Timber (CLT) panel structures for buildings. Pages 1-5 *in* Proceedings of Internoise 2013 42nd International Congress and Exposition on Noise Control Engineering, September 15-18, 2013, Innsbruck, Austria,.

SAS Institute (2013) SAS software, version 9.4. The SAS Institute, Inc., Cary, NC.