RESEARCH in Progress

Forest Products Laboratory

Increasing Durability of Mass Timber Products in Interior Applications

Durability against fungal degradation and termite attack and fire resistance remain the biggest concerns with using cross-laminated timber (CLT) products in multistory buildings. Although mass timber products are inherently fire resistant due to their size, improving their fire performance in a way that further delays the spread of fire is always desirable. Additionally, in certain climates, such as the southern part of the United States, where wood products are exposed to hot and humid weather, a condition that is favorable for fungal growth and termite attack, CLT products should be properly protected. Borate is an environmentally friendly preservative that can be used to improve the fire performance of CLT products while also protecting them from deterioration by decay fungi and termite attack. This study is focused on investigating how borate treatment will affect the adhesive bonding properties and fire, decay, and termite resistance of cross-laminated timbers.

Background

In the United States, most CLT boards are made of southern yellow pines and Douglas-fir, the two wood species that are not naturally durable (unlike cedar) and need to be treated by preservative formulations. Borate has been proven to effectively protect wood against decay fungi and termites. In addition, borate does not change the color of wood or hide the beauty of wood grain, unlike typical fire-retardant coatings. In one of our previous studies, we tested the fire performance of borate-treated spruce against a class I (highest rating) fire-retardant coating. The borate-treated wood performed significantly better than the class I fire-retardant coating (Figure 1). The primary problem with using borate as a protectant is leaching, specifically when wood is exposed to exterior weathering. However, the majority of CLT products are used for interior structures (Figure 2).

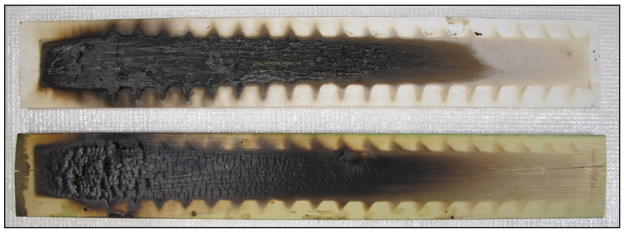

Figure 1. Fire test samples. Top, Class I fire-retardant coating; bottom, borate-treated spruce.

Figure 2. Interior view of a CLT building (image source: www.archdaily.com).

U.S. Endowment for Forestry and Communities

U.S. Department of Agriculture • Forest Service
Forest Products Laboratory
www.fpl.fs.fed.us

MICHIGAN STATE UNIVERSITY

The main challenge that remains is the lack of evidence on borate treatments used in combination with polyurethane adhesives typically used in CLT production.

Objective

The objectives of this research are to investigate changes in surface properties of borate-treated wood, specifically how it might affect adhesion of different formulations to treated wood; and to determine the efficacy of borate treatment in improving decay, termite, and fire performance of CLT.

Approach

The project is planned for several steps:

1. Obtain borate pressure-treated-wood samples and study how borate treatment will change the surface properties of the wood by
   a. measuring contact angles of different adhesive formulations on treated wood in comparison with untreated wood samples and
   b. analyzing surface chemistry of treated wood using Fourier transform infrared spectroscopy (FTIR) and X-ray photoelectron spectroscopy
2. Obtain at least three different commercially available adhesives recommended for CLT applications, such as polyurethane (PU) and phenolic (PF) adhesives
3. Measure adhesive properties (including solid content, pH, viscosity, and Tg (glass transition temperature) using differential scanning calorimeter (DSC), and thermal stability using thermal gravimetric analyzer (TGA)
4. Make small-scale CLT samples in the laboratory using borate-treated wood and different adhesive formulations
5. Evaluate adhesion performance (lap shear strength) of different adhesive formulations on borate-treated and untreated wood samples
6. Use different borate formulations to spray on Douglas-fir and southern yellow pine CLT samples
7. Study effects of borate treatment on adhesion strength and performance of CLT in regards to decay, termite, and fire resistance

Expected Outcomes

This research will determine how borate can improve decay, termite and fire performance of mass timber products with emphasis on exposed-glue lines whether starting with treated wood or the use of a spray solution to CLT. In addition, it will identify which adhesive formulations are more suitable for borate treated CLT.

Timeline

This is a two-year project initiated in January 2018. Analysis of adhesive and surface properties of borate-treated wood is expected to be completed by September 2018. Following these analyses, decay, termite, and fire performance tests will be conducted for both CLT samples sprayed with borate solution and pressure-treated CLT samples made in the laboratory using different adhesives.

Cooperators

USDA Forest Service, Forest Products Laboratory

Michigan State University

Contact Information

Mojgan Nejad
Michigan State University
East Lansing, Michigan
(517) 355-9597; nejad@msu.edu

Katie Ohno
USDA Forest Service, Forest Products Laboratory
Madison, Wisconsin
(608) 663-5176; kohno@fs.fed.us

Rachel Arango
USDA Forest Service, Forest Products Laboratory
Madison, Wisconsin
(608) 231-9573; rarango@fs.fed.us