Bonding Mixed Species for Advanced Biomaterials

Interest in using hardwood species for advanced structural materials has grown in the United States and globally because of an anticipated increase in hardwood timber resources in the near future. Hardwoods are known for better strength properties associated with their relatively higher mean density values compared with most softwood species. Therefore, incorporation of hardwood species with higher mechanical properties for structure reinforcement, where locally or globally high-strength performance is required, has been considered for solid wood-based structural products, such as glulam and cross laminated timber (CLT). To ensure material integrity of mixed-species structural products, bonding properties, including strength and durability, must be studied. However, due to the complexity of hardwood anatomic features and surface chemistry, bonding properties of hardwoods are more complicated than those of softwoods. In this study, we will investigate adhesive bonding properties of several common hardwood and softwood species from forest lands in the Great Lakes states, where many hardwood species have been undervalued.

Background

Tall timber buildings have gained more and more attention in North America. Massive composite timbers, such as CLT, are essential for tall timber buildings that require use of locally available wood resources to reduce manufacturing costs and minimize environmental impacts. This opens a potential sustainable market for undervalued hardwood forest feedstock dominating the Lake States and the Northeast region of United States.

Current commercial CLT building products are almost exclusively made from softwood species, primarily spruce and fir. Although those softwood CLTs generally

Cross-laminated timber made from mixed species (sugar maple and southern pine).

can meet code requirements, they have some deficiencies inherent from the material that they are built up from. For example, the low rolling shear strength is due to low stiffness and strength properties of softwoods. One recent study showed improvement of rolling shear properties when beech wood was used as the cross layer of European spruce CLTs. However, bonding properties of such hybrid/mixed CLTs, which are critical to the long-term material integrity and safety, rarely have been studied.

Objective

The objective of this project is to provide key baseline technical data on adhesion properties for using hardwoods in CLT products. Properties of wood-adhesive bonding are affected by many factors, such as wood species, moisture content (MC) of wood at gluing, wood surface preparation, wood grain orientation, adhesive, and bonding parameters. The focus of this project will be wood species. Our specific objectives are to investigate (1) bonding strength, (2) bonding durability, and (3) dimensional stability of mixed-species CLT panels.

Approach

Our overall approach is to study the effects of wood density and anatomic features associated with wood species on the bonding properties of cross-laminated wood samples. This study will include eight hardwood and four softwood local species that represent the typical density range and anatomic variation of wood from the Great Lakes states. A total of 900 CLT test specimens will be fabricated with various combinations of these species. Laboratory tests for determining the bonding properties will be conducted according to standards, including ASTM D 2559, ASTM D 905, ASTM D 5266, and AITC Test T110-2007. Test results will be analyzed using ANOVA with a significance level of 0.05.

Expected Outcomes

This project is expected to reveal if cross-laminated mixed hardwood and softwood species would have bonding properties similar to softwood CLT using commercial adhesives for timber laminating. The results will provide baseline data on adhesion properties of bonding mixed northern wood species. The results will show if current bonding parameters specified by the adhesive providers work with mixed species in CLT production. The findings will be

Distribution of sugar maple in the east region of the United States (Woodall et al. 2010).

shared with adhesive suppliers, CLT manufacturers, hardwood loggers and processers, and colleagues within the forest products community.

Timeline

Preparation of the lumber materials of the 12 selected species will be completed by August 2017. Fabrication and testing of specimens will begin September 2017 and be completed by August 2018. Data analysis will begin in January 2018, and a final report will be submitted by October 2018.

Cooperators

USDA Forest Service, Forest Products Laboratory
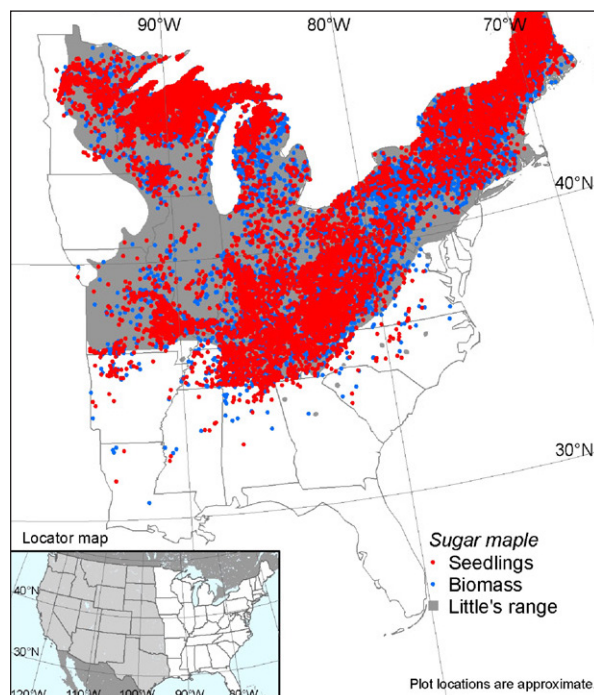
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References

Aicher, S.; Hirsch, M.; Christian, A. 2016. Hybrid cross-laminated timber plates with beech wood cross-layers. Construction and Building Materials. 124: 1007-1018.

Park, H.; Fushitani, M.; Byeon, H.; Yang, J. 2016. Static bending strength performances of cross-laminated wood panels made with six species. Wood and Fiber Science. 48(2): 1-13.

Ross, R.; Erickson, J. (eds.). 2005. Undervalued hardwoods for engineered materials and components. Madison, WI: Forest Products Society. 134 pp.

Song, Y.; Hong, S. 2016. Evaluation of bonding strength of larch cross-laminated timber. Journal of Korean Wood Science and Technology. 44(4): 607-615.

Woodall, C.; Oswalt, C.; Westfall, J.; Perry, C.; Nelson, M.; Finley, A. 2010. Selecting tree species for testing climate change migration hypotheses using forest inventory data. Forest Ecology and Management. 259: 778-785.