A Finite Element Approach to Investigating the Influence of Knots on Cross Laminated Timber

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Cross laminated timber (CLT) typically consists of an odd number of laminated orthogonal layers of high quality dimensional lumber. High quality species have limitations on naturally occurring defects resulting in smaller variabilities in material properties when compared to low-value species. Knots are naturally occurring defects which reduce the strength and stiffness of wood by interrupting the direction and continuity of the wood fibers; however, the composite nature of CLT provides an opportunity to utilize low-value species typically considered inadequate for structural purposes. The cross lamination of the wood boards allows for an averaging effect of the stress concentrations in the panels and reduces local stress concentrations around knots and other defects. This research investigates the influence of knots on the strength and stiffness of wood at two different scales: within dimensional lumber and within a full CLT panel. Three dimensional finite element models of knots in clear wood are presented at these two scales and the influence of knots on the effective material properties are analyzed within the elastic and strength cases. The models are validated through full scale experimental testing.

The costs associated with fabricating and testing CLT panels provide significant limitations when investigating the influence of knots on the stiffness and strength of CLT fabricated from low-value woods. Thus, a stochastic model for the distribution of knots in dimensional lumber is applied to create synthetic geometry for the finite element analysis models of the CLT layups. This allows for a preliminary reliability analysis of low-value woods used as constituents in CLT.

The development of an accurate and efficient three dimensional finite element model of cross laminated timber panels provides significant opportunity for growth and expansion of CLT construction. Finding applications for underutilized species creates potential for a promising market for low-value wood species that are abundant in the United States. Additionally, finding commercial markets for low-value woods supports national forest management strategies to improve forest health, while giving rise to more sustainable building practices and increased job opportunities in rural areas of the United States.

ISBN: 978-91-88898-64-7