Bending, Shear, and Compressive Properties of Three- and Five-Layer Cross-Laminated Timber Fabricated with Black Spruce

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Publisher: SpringerOpen
Year of Publication: 2020
Format: Journal Article
Material: CLT (Cross-Laminated Timber)
Topic: Design and Systems
Mechanical Properties
Keywords: Black Spruce
Panels
Bending
Thickness
Language: English
Research Status: Complete
Series: Journal of Wood Science

Summary:

Cross-laminated timber (CLT) is an innovative engineering wood product made by gluing layers of solid-sawn lumber at perpendicular angles. The commonly used wood species for CLT manufacturing include spruce-pine-fir (SPF), douglas fir-larch, and southern pine lumber. With the hope of broadening the wood species for CLT manufacturing, the purposes of this study include evaluating the mechanical properties of black spruce CLT and analyzing the influence of CLT thickness on its bending or shear properties. In this paper, bending, shear, and compressive tests were conducted respectively on 3-layer CLT panels with a thickness of 105 mm and on 5-layer CLT panels with a thickness of 155 mm, both of which were fabricated with No. 2-grade Canadian black spruce. Their bending or shear resisting properties as well as the failure modes were analyzed. Furthermore, comparison of mechanical properties was conducted between the black spruce CLT panels and the CLT panels fabricated with some other common wood species. Finally, for both the CLT bending panels and the CLT shear panels, their numerical models were developed and calibrated with the experimental results. For the CLT bending panels, results show that increasing the CLT thickness whilst maintaining identical span-to-thickness ratios can even slightly reduce the characteristic bending strength of the black spruce CLT. For the CLT shear panels, results show that increasing the CLT thickness whilst maintaining identical span-to-thickness ratios has little enhancement on their characteristic shear strength. For the CLT bending panels, their effective bending stiffness based on the Shear Analogy theory can be used as a more accurate prediction on their experiment-based global bending stiffness. The model of the CLT bending specimens is capable of predicting their bending properties; whereas, the model of the CLT shear specimens would underestimate their ultimate shear resisting capacity due to the absence of the rolling shear mechanism in the model, although the elastic stiffness can be predicted accurately. Overall, it is attested that the black spruce CLT can provide ideal bending or shear properties, which can be comparable to those of the CLT fabricated with other commonly used wood species. Besides, further efforts should focus on developing a numerical model that can consider the influence of the rolling shear mechanism.

Online Access: Free

Resource Link

https://jwoodscience.springeropen.com/articles/10.1186/s10086-020-01886-z