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EFFECT OF GROWTH RING ORIENTATION ON THE ROLLING SHEAR PROPERTIES OF WOODEN CROSS LAYER UNDER TWO-PLATE SHEAR TEST

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ABSTRACT: The design and application of cross laminated timber (CLT) is strongly influenced by rolling shear properties of cross layers. Hence, predicting the mechanical behaviour of CLT requires accurate information about its rolling shear properties. In this study, black spruce wood laminates with three different growth ring orientations (flat sawn, in-between, quarter sawn) were edge glued to produce wooden cross layer (WCL). Two-plate shear tests were carried out on WCL to investigate the influence of growth ring orientation on the rolling shear properties. The experimental results showed that the growth ring orientation had a significant effect on rolling shear modulus of WCL, however, almost no effect on the rolling shear strength. The WCL of in-between end grain had the maximum rolling shear modulus of 89MPa and rolling shear strength of 2.13 MPa.

KEYWORDS: Rolling shear modulus, Rolling shear strength, Two-plate shear test, Growth ring orientation, Cross laminated timber

1 INTRODUCTION

Under shear stress, the shear strain in CLT is not uniform and the off-axis wood cells in the alternate laminates tend to roll over in the radial-tangential (RT) plane rather than experience true shear, which is called rolling shear. In real situation of CLT in its application, such as short-span, concentrated load, etc., shear strain in the cross layer is significant due to the fairly low rolling shear strength. Two-plate shear test was considered feasible in determining shear properties since it could produce nearly uniform shear stress at the surface and through the thickness of a specimen and the specimen length ensures that the effect of secondary stresses is minimal. Studies showed that rolling shear properites depended on many factors, including wood species, lamination size and growth ring orientation [1- 4]. It was found that the rolling shear modulus remained almost constant for growth ring orientation around 0° or 90°, and increased significantly around an annual ring orientation of 45°.In this study, two-plate shear tests were conducted on wooden cross layer to evaluate the effect of growth ring orientation of wood laminates on the rolling shear properties of wooden cross layer (WCL) used in CLT.

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2 MATERIALS AND METHOD

2.1 MATERIALS AND SPECIMEN PREPARATION

Black spruce (*Picea mariana*) lumber was obtained from a local sawmill in New Brunswick, Canada. All materials were stored in a conditioning chamber set at a temperature of 20℃ and a relative humidity of 65%, with a target equilibrium moisture content of 12%. After conditioning, lumber was cut into clear wood strips with sectional dimension of 9 × 36mm. Then, the density of each strip was measured, which ranged from 0.420 to 0.445 g/cm^3. All wood strips were divided into a group according to growth ring orientations (flat sawn, in-between, quarter sawn) and their density values with an aim at guaranteeing, to a large extent, cross layers of all specimens had similar anatomical structure and properties. Wood stripes were glued side by side using a one-component polyurethane (ISOSET SX-1050) adhesive to fabricate a downscaled panel, which was then vertically cut into 36mm-wide strips to form WCL for 2-plate shear tests. Nine replicates were made for each growth ring orientation. .

2.2 METHODS

Two-plate shear testing was performed in referring to ASTM D2718 [5], Figure 1. Steel plates were bonded to a WCL specimen using a commercial fast-curing epoxy adhesive (Speed Set: Epoxy) under a pressure of 0.6N/mm^2 for 24 hours to achieve the full strength. As shown in

Figure 1, two V blocks are aligned to assure the load goes through the centre of the specimen. The loading rate was 0.508 *mm/min*. The displacement of one plate relative to the other was measured using a 10-mm linear variable differential transformer (LVDT).

Figure 1: *Experimental set-up for 2-plate shear test*

The rolling shear modulus (G_{rt}) and strength (τ) are calculated using the equations [5]:

$$\tau = \frac{\cos\theta P_{\max}}{bL} \quad (1)$$

$$G_{rt} = \frac{d}{bL}\frac{\Delta P}{\Delta y} \quad (2)$$

3 RESULTS AND CONCLUSIONS

Figures 2 and 3 give a summary of rolling shear modulus (G_{rt}) and rolling shear strength (τ) of WCL under two-plate shear test with regard to the growth ring orientation. It was found that the highest and lowest values of G_{rt} appeared in the WCL of in-between and flat sawn growth ring orientation, respectively. However, it seemed that the growth ring orientation did not have a significant impact on τ. It was suggested that the higher rolling shear modulus could be obtained if more attention was paid to the cutting patterns of the lumber to get the wood laminates with higher portion of 45° growth ring orientation.

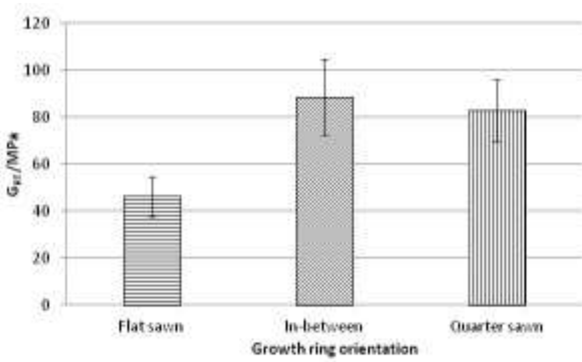

Figure 2: *Effect of growth ring orientation on rolling shear modulus*

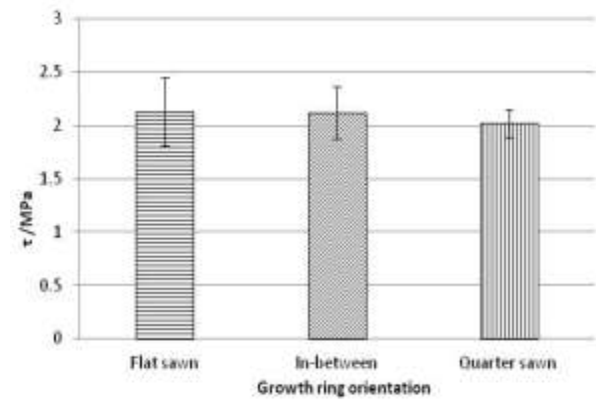

Figure 3: *Effect of growth ring orientation on rolling shear strength*

4 CONCLUSIONS

(1) The growth ring orientation of WCL had a statistically significant effect on its rolling shear modulus;
(2) The growth ring orientation of WCL had no statistically significant effect on rolling shear strength; and
(3) The WCL of in-between end grain had the maximum rolling shear modulus of 89MPa and rolling shear strength of 2.13 MPa.

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REFERENCES

[1] B. P. Munthe and R. L. Ethington: Method for evaluating shear properties of wood. US Department of Agriculture, Forest Service, Forest Products Laboratory, 1968.

[2] Aicher S. and Dill-Langer G.: Basic considerations to rolling shear modulus in wooden boards. Otto-Graf-Journal, 11, 157, 2000.

[3] R.A. Joebstl, T.Bogensperger, G. Schichofer and G. Jeitler: Mechanical Behaviour of Two Orthogonally Glued Boards. University of Graz, Graz, 2002.

[4] D.Yawalata and F. Lam: Development of technology for cross laminated timber building systems. Research report submitted to Forestry Innovation Investment Ltd, University of British Columbia, Vancouver, BC, 2011.

[5] ASTM. Standard Test Methods for Structural Panels in Planar Shear (Rolling Shear). D2718, American Society for Testing and Materials, West Conshohocken, PA, USA, 2011.