Block shear testing of CLT panels : an exploratory study

Author:	Casilla, Romulo C. Pirvu, Ciprian Wang, Brad J. Lum, Conroy
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Edition:	39375
Material Type:	Research report
Physical Description:	35 p.
Sector:	Wood Products
Field:	Sustainable Construction
Research Area:	Building Systems
Subject:	Timber Laminate product Design Building construction
Series Number:	Transformative Technologies #TT1.07 W-2846
Location:	Vancouver, British Columbia
Language:	English

Abstract:

A study was conducted with the primary objective of examining the efficacy of a standard block shear test method to assess the bond quality of cross-laminated timber (CLT) products. The secondary objective was to examine the effect of pressure and adhesive type on the block shear properties of CLT panels. The wood material used for the CLT samples was Select grade nominal 25 x 152-mm (1 x 6-inch) Hem-Fir. Three adhesive types were evaluated under two test conditions: dry and vacuum-pressure-dry (VPD), the latter as described in CSA standard O112.10. Shear strength and wood failure were evaluated for each test condition.

Among the four properties evaluated (dry and VPD shear strength, and dry and VPD wood failure), only the VPD wood failure showed consistency in assessing the bond quality of the CLT panels in terms of the factors (pressure and adhesive type) evaluated. Adhesive type had a strong effect on VPD wood failure. The different performance levels of the three adhesives were useful in providing insights into how the VPD block shear wood failure test responds to significant changes in CLT manufacturing parameters. The pressure used in fabricating the CLT panels showed a strong effect on VPD wood failure as demonstrated for one of the adhesives. VPD wood failure decreased with decreasing pressure. Although dry shear wood failure was able to detect the effect of pressure, it failed to detect the effect of adhesive type on the bond quality of the CLT panels.

These results provide support as to the effectiveness of the VPD block shear wood failure test in assessing the bond quality of CLT panels. The VPD conditioning treatment was able to identify poor bondline manufacturing conditions by observed changes in the mode of failure, which is also considered an indication of wood-adhesive bond durability. These results corroborate those obtained from the delamination test conducted in a previous study (Casilla et al. 2011).

Along with the delamination test proposed in an earlier report, the VPD block shear wood failure can be used to assess the CLT bond quality. Although promising, more testing is needed to assess whether the VPD block shear wood failure can be used in lieu of the delamination test. The other properties studied (shear strength and dry wood failure), however, were not found to be useful in consistently assessing bond line manufacturing quality.

Building construction - Design

Cross-laminated timber

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Checking in CLT panels : an exploratory study

https://library.fpinnovations.ca/en/permalink/fpipub2772

Author:	Casilla, Romulo C. Lum, Conroy Pirvu, Ciprian Wang, Brad J.
Date:	December 2011
Edition:	39389
Material Type:	Research report
Physical Description:	29 p.
Sector:	Wood Products
Field:	Sustainable Construction
Research Area:	Building Systems
Subject:	Panels tests Panels Laminate product Building construction
Series Number:	Transformative Technologies # TT1.07 W-2877
Location:	Vancouver, British Columbia
Language:	English

Abstract:

A study was conducted with the primary objective of gathering information for the development of a protocol for evaluating the surface quality of cross-laminated timber (CLT) products. The secondary objectives were to examine the effect of moisture content (MC) reduction on the development of surface checks and gaps, and find ways of minimizing the checking problems in CLT panels. The wood materials used for the CLT samples were rough-sawn Select grade Hem-Fir boards 25 x 152 mm (1 x 6 inches). Polyurethane was the adhesive used. The development of checks and gaps were evaluated after drying at two temperature levels at ambient relative humidity (RH).

The checks and gaps, as a result of drying to 6% to 10% MC from an initial MC of 13%, occurred randomly depending upon the characteristics of the wood and the manner in which the outer laminas were laid up in the panel. Suggestions are made for minimizing checking and gap problems in CLT panels. The checks and gaps close when the panels are exposed to higher humidity.

Guidelines were proposed for the development of a protocol for classifying CLT panels into appearance grades in terms of the severity of checks and gaps. The grades can be based on the estimated dimensions of the checks and gaps, their frequency, and the number of laminas in which they appear.

Building construction - Laminated

Laminated products

Panels - Tests

Documents

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Cross-laminated timber manufacturing

https://library.fpinnovations.ca/en/permalink/fpipub42942

Author:	Wang, Brad J. Pirvu, Ciprian Lum, Conroy
Date:	January 2011
Material Type:	Research report
Sector:	Wood Products
Field:	Sustainable Construction
Research Area:	Building Systems
Subject:	Timber Laminate product Building construction Design
Language:	English
Abstract:	This chapter provides general information about the manufacturing of CLT that may be of interest to the design community. The information contained in this chapter may also provide guidance to CLT manufacturers in the development of their plant operating specification document. Typical steps of the manufacturing process of CLT are described, and key process variables affecting adhesive bond quality of CLT products are discussed. Proposed methods for evaluating panel quality are presented.

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Delamination testing of CLT panels : an exploratory study

https://library.fpinnovations.ca/en/permalink/fpipub39330

Author:	Casilla, Romulo C. Pirvu, Ciprian Wang, Brad J.

Date:	February 2011
Material Type:	Research report
Physical Description:	44 p.
Sector:	Wood Products
Field:	Sustainable Construction
Research Area:	Building Systems
Subject:	Timber
	Mechanical properties
	Laminate product
	Gluing
Series Number:	Transformative Technologies # TT1.07
	W-2811
Location:	Vancouver, British Columbia
Language:	English

Abstract:

A study was conducted with the primary objective of examining the efficacy of delamination test using cylindrical core specimens to assess the bond quality of cross laminated timber (CLT) products. A prototype coring drill bit was fabricated to prepare a cylindrical-shaped specimen, the height of which corresponds to the full thickness of the CLT panel. A secondary objective was to examine the effect of pressure, adhesive type, number of plies, and specimen shape on the delamination resistance of CLT panels. The wood material used for the CLT samples was Select grade nominal 1 x 6-inch Hem-Fir boards. Examples of three adhesive types were evaluated, which were designated as A, B, and C. The delamination tests used were as described in CAN / CSA O122-06 and EN 302-2.

Cylindrical specimen extracted as core was found satisfactory as a test specimen type for use in delamination testing of CLT product. Its efficacy was comparable to that of a square cross-section specimen. The former is recommended as it can be extracted from thicker panels and from any location in the panel. It would also be more convenient to plug the round hole.

Adhesive type had a strong effect on delamination resistance based on the two delamination tests used. Adhesive A exhibited the greatest delamination resistance, followed in decreasing order, by adhesives C and B. It should be noted that no effort was made to find the optimum CLT manufacturing parameters for each type of adhesive. Therefore the relative rankings of the adhesives tested may not be representative. However, for the purposes of this study, the different performance levels from the three adhesives are useful in providing insight into how the proposed delamination test responds to significant changes in CLT manufacturing parameters.

Pressure used in fabricating the CLT panel showed a strong effect on delamination resistance as demonstrated for one of the adhesives. Delamination resistance decreased with decreasing pressure. The effect of the number of plies in the CLT panel was dependent upon the type of adhesive, and this was probably related to the adhesive's assembly time characteristic. These results provide support as to the effectiveness of delamination test in assessing the moisture durability of CLT panels. It was able to differentiate the performance in delamination resistance among different types of adhesives, and able to detect the effect of manufacturing parameters such as pressure and increased number of plies in CLT construction.

The test procedure described in CAN / CSA O122-06 appears to be reasonable in the delamination resistance assessment of CLT panels for qualification and quality control testing. Based on the results of the study along with some background information and guidelines, delamination requirements for CLT panels are proposed. The permitted delamination values are greater than those currently specified for laminated and fingerjoined lumber products. This is in recognition of the higher bond line stresses when bonded perpendicular laminations (i.e. CLT) are exposed to the delamination wetting and drying cycles, as opposed to parallel laminations (i.e. glulam or fingerjoints).

Cross-laminated timber

Laminated products - Gluing - Strength

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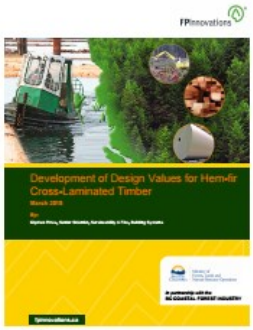

Development of design values for hem-fir cross-laminated timber

https://library.fpinnovations.ca/en/permalink/fpipub44204

Author:	Pirvu, Ciprian
Date:	March 2015
Material Type:	Research report
Physical Description:	33 p.
Sector:	Wood Products
Field:	Sustainable Construction
Research Area:	Building Systems
Subject:	British Columbia
	Laminate product
	Standards
	Tsuga Heterophylla
	Design
Series Number:	BC Coastal Forest Industry
Language:	English

Abstract: The North American product standard for performance-rated cross-laminated timber (CLT), ANSI/APA PRG 320, was published in 2012. The standard recognizes the use of all major Canadian and US softwood species groups for CLT manufacturing and provides design properties for specific CLT layups with visually graded and E-rated/MSR laminations. While design properties for CLT layups with Spruce-Pine-Fir and Douglas fir-Larch laminations are specified in the current standard, no design properties are indicated for CLT layups with Hem-Fir laminations.
Design properties for two proposed CLT grades manufactured with Hem-Fir lumber were developed. These include a CLT layup with visually graded laminations and another layup with E-rated/MSR laminations. Design properties for these two CLT layups were calculated separately for use in Canada and the US.
Supporting information for the addition of design properties for Hem-Fir grades to the CLT product standard was generated. Recommended amendments to the CLT product standard include durability and wood failure requirements of bondlines, and design properties for Hem-Fir layups.

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Development of standards for edge-glued and face-glued engineered products

https://library.fpinnovations.ca/en/permalink/fpipub41365

Author: Pirvu, Ciprian
Date: March 2007
Material Type: Research report
Physical Description: 66 p.
Sector: Wood Products
Field: Sustainable Construction
Research Area: Building Systems

Subject:	Veneer Mechanical properties Specifications Laminate product Joints Gluing Specification
Series Number:	Value to Wood No. FCC 58 W-2384
Location:	Vancouver, British Columbia
Language:	English
Abstract:	Forintek has completed a two-year investigation of the NLGA SPS 6 Standard, Special Products Standard for Structural Face-Glued Lumber. The NLGA SPS 6 Standard prescribes product specifications and qualification and quality control requirements for structural products created by edge-gluing and/or fingerjoining lumber segments. Under the NLGA SPS 6 Standard, the design values assigned are based on the visual grade and the stress level achieved in qualification tests on the glue joints. The project assessed the effect of the following three factors on strength of the NLGA SPS 6 product: 1. Tension proof-loading; 2. Relative location of fingerjoints in adjacent members when fingerjoined material is edge-glued; 3. Strength of the material used to make the NLGA SPS 6 product. Results showed a positive effect of proof-loading, a minor effect of staggering of fingerjoints, and a highly significant effect of density of raw material on tensile stress of edge-glued specimens. It was confirmed that SPS6 products of greater commercial value can be obtained from lower grade lumber. However, visual grading of SPS 6 products proved to be more difficult than visual grading of lumber, because grade-determining wood characteristics were sometimes hidden in the bond line, and could not be properly identified. The findings of this project can be used to fine tune the NLGA SPS 6 standard and the other NLGA fingerjoint and face-glued lumber product standards. The project will help the wood industry maximize the utilization of their raw material resource, resulting in increased profitability. Structural timbers - Mechanical properties Gluing - Specifications Lumber - Gluing Glued joints - Finger Glued joints - Edge Glued joints - Specifications Lumber, Laminated veneer - Strength

Documents

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Duration of load and creep factors for cross-laminated timber panels

https://library.fpinnovations.ca/en/permalink/fpipub42945

Author:	Pirvu, Ciprian
	Karacabeyli, Erol
Date:	January 2011
Material Type:	Research report
Physical Description:	30 p.
Sector:	Wood Products
Field:	Sustainable Construction
Research Area:	Building Systems
Subject:	Timber
	Laminate product
	Building construction
	Design
Language:	English

Abstract: Cross-laminated timber (CLT) products are used as load-carrying slab and wall elements in structural systems, thus load duration and creep behaviour are critical characteristics that should be taken into account in design. Given the nature of CLT with orthogonal arrangement of layers and either mechanically fastened with nails or wood dowels, or bonded with structural adhesive, CLT is more prone to time-dependent deformations under load (creep) than other engineered wood products such as glued-laminated timber.
Time-dependent behaviour of structural wood products is accounted for in design standards by providing load duration factors to adjust specified strengths. Since the Canadian Standard on Engineering Design in Wood (CSA O86-09) does not deal with CLT, it does not provide load duration and service condition factors. Until this can be rectified, two options are proposed for adopters of CLT systems in Canada. These include not only load duration and service factors, but also an approach to accounting for creep in CLT structural elements. The proposed recommendations are in line with the specifications in CSA O86-09 and Canadian National Building Code.

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Effect of adhesive cure on quality of fingerjoined lumber

https://library.fpinnovations.ca/en/permalink/fpipub39328

Author:	Pirvu, Ciprian
Contributor:	Natural Resources Canada. Canadian Forest Service.
Date:	March 2011
Material Type:	Research report
Physical Description:	45 p.
Sector:	Wood Products
Field:	Wood Manufacturing & Digitalization
Research Area:	Advanced Wood Manufacturing
Subject:	Joints
Series Number:	Value to Wood No. FPI 121W W-2809
Location:	Vancouver, British Columbia
Language:	English
Abstract:	The relationship between proof load level of fingerjoined lumber and degree of cure of adhesive bonds was investigated. Tension tests were completed for two different degrees of cure for a single adhesive. The proof load level determined for the partially cured joints did not cause damage to the joints that survived the proof test. Preliminary guidelines for determining appropriate proof load levels for testing fingerjoined lumber with partially cured joints were proposed. The proposed guidelines will need to be validated through mill trials to demonstrate their efficacy and reliability to the manufacturer and third party inspection agency. Fingerjoined lumber Glued joints - Finger

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2809.pdf

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Effect of adhesive cure on quality of fingerjoined lumber :

updated report

https://library.fpinnovations.ca/en/permalink/fpipub39405

Author:	Pirvu, Ciprian
Contributor:	Natural Resources Canada. Canadian Forest Service.
Date:	March 2012
Material Type:	Research report
Physical Description:	56 p.
Sector:	Wood Products
Field:	Wood Manufacturing & Digitalization
Research Area:	Advanced Wood Manufacturing
Subject:	Lumber Composites Adhesives
Series Number:	Value to Wood No. FPI 121W W-2888
Location:	Vancouver, British Columbia
Language:	English
Abstract:	The relationship between proof load level of fingerjoined lumber and degree of cure of adhesive bonds was investigated. Tension tests were completed for two different degrees of cure for two different adhesives. The proof load level determined for the partially cured joints did not cause damage to the joints that survived the proof test. Preliminary guidelines for determining appropriate proof load levels for testing fingerjoined lumber with partially cured joints were proposed. The proposed guidelines will need to be validated through mill trials to demonstrate their efficacy and reliability to the manufacturer and third party inspection agency. Keywords: fingerjoined lumber; tension proof testing/loading; partially cured adhesive bonds. Curing rate Finger jointed lumber

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Effect of on-line tension proof parameters on fingerjoined lumber performance

https://library.fpinnovations.ca/en/permalink/fpipub37959

Author:	Pirvu, Ciprian
Date:	March 2009
Material Type:	Research report
Physical Description:	87 p.
Sector:	Wood Products
Field:	Wood Manufacturing & Digitalization
Research Area:	Advanced Wood Manufacturing
Subject:	Mechanical properties
	Joints
Series Number:	Value to Wood No. FCC 021W
	W-2668
Location:	Vancouver, British Columbia
Language:	English

Abstract: Tension proof loading has been shown to be effective in eliminating low-strength fingerjoints, and a proof load stress level of 1.3 times the allowable stress value was found to be optimum. This confirms the tension proof loading stress requirement of the Canadian National Lumber Grades Authority (NLGA) for fingerjoined lumber.

Proof loading stress levels were chosen at 1.0, 1.3 and 1.6 times the allowable stress, and loading rates were selected so that target stress was attained in 0.2, 6.0 or 60 seconds. The only effect of loading rate was a small increase in strength values for weaker specimens when tested at faster loading rates, along with increased variability; therefore, it is strongly recommended that very fast loading rates be avoided, and a loading rate be chosen so the desired stress level is attained in about one second.

FPInnovations – Forintek performed this two-year study to provide a sound basis for evaluation of the tension proof-loading of fingerjoined lumber. The findings will be useful to the fingerjoined-lumber industry in refining the process and promoting its benefits to end users and regulators.

Glued joints - Finger - Strength

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