# Overview of FPInnovations CLT Fire Resistance Tests

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Cross-laminated timber (CLT), a new generation of engineered wood product developed initially in Europe, has been gaining increasing popularity in residential and non-residential applications in several countries. Numerous impressive low- and mid-rise buildings built around the world using CLT showcase the many advantages that this product can offer to the construction sector.

The inherent fire resistance of massive timber such as CLT can, in many cases, be comparable to that of other building materials, e.g. concrete, masonry, and steel. Full-scale fire resistance tests of CLT floor assemblies have demonstrated that close to a three-hour fire resistance can be achieved even with unprotected CLT under full load conditions.

Cross-laminated timber (CLT), a relatively new building system of interest in North American construction, is helping to define a new class of timber products known as massive timber. It is a potentially cost-competitive, wood-based solution that complements the existing light-frame and heavy timber options, and is a suitable candidate for some applications which currently use concrete, masonry and steel. While this product is well-established in Europe, work on the implementation of CLT products and systems has just begun in Canada and the U.S.

CLT panels have the potential to provide good fire resistance, often comparable to typical massive assemblies of non-combustible construction. This is due to the inherent nature of thick timber members to char slowly at a predictable rate, allowing massive wood systems to maintain significant structural capacity for extended durations when exposed to fire.

In order to facilitate the acceptance of proposed code provisions for the design of CLT panels with regard to fire resistance, an 18-month research project was launched at FPInnovations in April 2010, in close collaboration with the National Research Council of Canada (NRCC). The main objective of the project was to develop and validate a generic fire resistance calculation procedure for CLT assemblies that will foster the design of fire-safe CLT buildings in Canada and the U.S. A series of full-scale fire resistance tests has been completed to allow a comparison between the fire resistance measured during a standard fire resistance test and that calculated using the proposed procedure.

The complete experimental series consisted of 8 full-scale fire resistance tests. The assemblies were tested at the NRCC fire laboratory facilities in Ottawa in accordance with the ULC S101 standard, "Standard Methods of Fire Endurance Tests of Building Construction and Materials",

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which reproduces the standard fire severity of the ASTM E119 standard.

Different load ratios were applied depending on the number of plies and the assembly type (wall or floor). The load ratio is calculated as the percentage that the total applied load (including the dead and live load) is of the full design load i.e., the compressive resistance for walls or the moment resistance for floors. The assemblies were outfitted with thermocouples, embedded throughout the assemblies at five locations and in the panel-to-panel joints, and deflection gauges at nine locations.

Assemblies consisted of three or five CLT panels, which were constructed of either SPF No.1, No.2, No.3 or MSR lumber boards, and came from different manufacturers from across Canada. The dimensions of the floor assemblies were roughly 3607 mm x 4846 mm long and the wall assemblies were 3660 mm x 3048 mm high. All of the assemblies used a half-lapped panel-to-panel joint which was fastened with self-tapping screws. The joints were also sealed during assembling using a 6 mm bead of construction adhesive. The panels were manufactured with a structural polyurethane adhesive conforming to ANSI/APA PRG 320. Some of the CLT panels were fully exposed to fire (unprotected) while others were protected by Type X gypsum board(s). The configuration details of each assembly as well as the results of the tests are summarized in Table 1 below.

## Table 1 : CLT Full-Scale Fire Test Results

**WALL ASSEMBLIES**

| # of Plies | CLT Thickness (mm) | Gypsum Board Protection | Load (kN/m) | Load Ratio (%) | Failure Mode | Fire Resistance (min) |
|---|---|---|---|---|---|---|
| 3 | 114 | 2 x 12.7 mm (1/2") | 333 | 76 | Structural | 106 |
| 5 | 175 | Unprotected | 333 | 37 | Structural | 113 |
| 5 | 105 | Unprotected | 72 | 34 | Structural | 57 |

**FLOOR ASSEMBLIES**

| # of Plies | CLT Thickness (mm) | Gypsum Board Protection | Load (kPa) | Load Ratio (%) | Failure Mode | Fire Resistance (min) |
|---|---|---|---|---|---|---|
| 3 | 114 | 2 x 12.7 mm (1/2") | 2.7 | 36 | No failure * | 77 * |
| 5 | 175 | Unprotected | 11.8 | 59 | Integrity | 96 |
| 3 | 105 | 1 x 15.9 mm (5/8") | 2.4 | 75 | Integrity | 86 |
| 5 | 175 | 1 x 15.9 mm (5/8") | 8.1 | 101 | Integrity | 124 |
| 7 | 245 | Unprotected | 14.6 | 101 | Structural | 178 |

* Test was stopped due to equipment safety concerns. Failure was not reached.

A comprehensive report to be released by FPInnovations in July 2012 will detail the panel configurations, testing procedure, and results. Findings from this testing program will be used by Canadian and American Wood Councils as well as APA – The Engineered Wood Association to support implementation of CLT in Canadian and U.S. building codes and design standards. A fire resistance calculation method also to be published in 2012 will update the existing Chapter 8 of the 2011 Canadian Edition of the CLT Handbook.

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