Time-dependent behavior of cross-laminated timber

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Date: March 2014

Material Type: Research report

Physical Description: 70 p.

Sector: Wood Products

Field: Sustainable Construction

Research Area: New Construction Materials

Subject: Building construction

Design

Laminate product

Panels

Timber

Series Number: Transformative Technologies No. 1.1.12

W-3092

Language: English

Abstract: Cross laminated timber (CLT) panels were manufactured and tested to assess their time dependent behaviour. This study is intended to help guide the development of an appropriate test method and acceptance criteria to account for duration of load and creep effects in the design of structures using CLT.

Nine CLT panels of different qualities and using different wood species combinations were manufactured at a pre-commercial pilot plant out of local wood species. The CLT panels manufactured in this study were pressed at about 54% lower pressure than the minimum vertical pressure specified by the adhesive manufacturer due to a limitation of the press, so the CLT panels are viewed as a simulated defective sample, which may occur in a production environment due to material- or process-related issues.

Full-size CLT panels were initially tested non-destructively to assess their bending stiffness. Then, billets were ripped from the full-size CLT panels, and tested to failure in 1-minute and 10-hour ramp tests, or assessed in creep tests under sustained load. The constant loads imposed on the CLT billets tested in creep were calculated as to allow for a maximum deflection of L/180. Following two cycles of loading and relaxation, the CLT billets tested in creep were further tested to failure at the end. The principles of ASTM D6815-09 and those of an in-house FPInnovations protocol were applied to assess the time dependent behavior of the CLT billets.

The main test findings are summarized below:

In terms of residual stiffness, the percentage change in the initial bending

In terms of residual stiffness, the percentage change in the initial bending stiffness for the CLT billets subjected to the 10-hour ramp test varied between 0-5%, showing a 3% drop in stiffness on average, while that for the CLT billets tested in creep ranged between 0-3%, showing a 1% stiffness drop on average. These are regarded as relatively small changes in bending stiffness.

In general, decreasing creep rates were observed on most of the CLT billets especially in the first cycle up to 90 days. The creep rates went up after 120 days of loading due to an increase in temperature and relative humidity conditions, which greatly affect the rate of deflection and recovery of wood products.

Fractional deflections were calculated for all the CLT billets after 30-day intervals and found to be less than or equal to 1.43.

Creep recovery was above 36% after 30-day, 60-day, and 90-day recovery periods in the first cycle. However, in the second cycle, creep recovery for some CLT billets dropped below 20% for certain time periods.

ASTM D6815-09 provides specifications for evaluation of duration of load and creep effects of wood and wood-based products. The standard was designed to accommodate wood products that can be easily sampled, handled, and tested under load for minimum 90 days and up to 120 days. The standard requires a minimum sample size of 28 specimens. Because of its large dimensions, CLT products are not feasible for experiments requiring such large sample sizes. However, the findings of this study revealed potential for some of the acceptance criteria in ASTM D6815-09 to be applied to CLT products. The CLT billets in this study were assessed in accordance to the creep rate, fractional deflection, and creep recovery criteria in ASTM D6815-09 standard. All CLT billets tested in this study showed (1) decreasing creep rates after 90/120 days of loading, (2) fractional deflections less than 2.0 after 90-day loading, and (3) higher creep recovery than 20% after 30 days of unloading, as required by ASTM D6815-09. A single replicate billet was used per CLT configuration instead of the minimum sample size required by the standard which may have an effect on the findings.

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