Thermal Degradation of CLT Bracket-type Connection Under Cyclic Lateral Loading

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OBJECTIVE
Characterize thermal degradation of a bracket-type CLT shear wall connection as a function of time and temperature. Determine the dependence of degradation rates for peak load and initial stiffness on exposure temperature using a first-order kinetics model based on Arrhenius Activation Energy Theory.

MOTIVATION
Thermal performance of mass timber lateral systems is important for height limitations in the International Building Code (IBC), as well as post-earthquake and post-fire scenarios, including residual capacity to gravity and lateral loading such as those from aftershocks. Lateral performance of CLT shear wall systems has never been tested at elevated temperatures. CLT shear wall performance is largely governed by the connection performance because of the high in-plane stiffness of the panels themselves. Investigation into the thermal performance of the connections can be used to assemble an understanding of the performance of the system as a whole.

SPECIMENS
• Three-ply V1 Douglas fir CLT from D.R. Johnson (Riddle, OR)
• 12-gauge Grade 33 galvanized steel brackets (Amini et al. 2018)
• (2) 5/8 in A307 hex bolts
• (8) 8d common smooth shank nails

TEST MATRIX
• 7 exposure temperatures:
  • 75 °C, 100 °C, 125 °C, 165 °C, 180 °C, 190 °C, and 200 °C
• Heated in 6.6 kW drying oven with 200 °C capacity
• 4 exposure durations:
  • 0.5-hr, 1.0-hr, 1.5-hr, and 2.0-hr
• 28 total exposure groups
• 4 samples in each exposure group
• 4 control samples
• 116 total specimens

CYCLIC TESTING AND DATA
• Abbreviated CUREE Protocol with max displacement of ±1 inch (25.4 mm)
• Initial stiffness and peak strength values taken from backbone curve of hysteresis data

RESULTS
• Degradation of cyclic performance, peak load and initial stiffness over time occurred at a linear rate, and was dependent on temperature according to Arrhenius activation energy theory: $k(T) = A e^{-E_a/RT}$ → $\ln(k(T)) = \ln(A) - \frac{E_a}{RT}$

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