Fire Design of Mass Timber Connections:

Detailing Strategies and Compliance Paths

Presented by: David Barber, CHM Fire

Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.

WoodWorks | The Wood Products Council is a registered provider of AIA-approved continuing education under Provider Number G516. All registered AIA CES Providers must comply with the AIA Standards for Continuing Education Programs. Any questions or concerns about this provider or this learning program may be sent to AIA CES (cessupport@aia.org or (800) AIA 3837, Option 3).

This learning program is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

AIA continuing education credit has been reviewed and approved by AIA CES. Learners must complete the entire learning program to receive continuing education credit. AIA continuing education Learning Units earned upon completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

This course provides architects and engineers with a practical overview of fire design considerations for mass timber connections in buildings of all types and sizes. Participants will examine common connection types—concealed steel hardware, panel joints, timber-to-timber interfaces, and exposed steel elements—through the lens of fire safety and code compliance. The session explores detailing strategies that support passive fire protection, including the use of char calculations, encapsulation materials, sealants, and connection geometry. Emphasis will be placed on the 2024 IBC fire-resistance provisions, with notes on compatibility with earlier code editions. The session will also examine available databases to further equip design professionals with the tools necessary to make informed decisions about fire-resistance connections for mass timber projects.

Learning Objectives

1. Identify fire performance challenges unique to mass timber connections and how these affect both exposed and encapsulated design approaches.

2. Distinguish among the primary fire-resistance compliance paths in the 2024 IBC (tested assemblies, IBC §722 calculations, and the AWC NDS/FDS methods), with backward-compatibility guidance for prior IBC versions.

3. Evaluate the fire-resistance contribution of different connection types, including concealed steel hardware, timber-to-timber load paths, and protected exposed steel, across a range of structural conditions.

4. Use the WoodWorks Fire Design Database to inform selection and detailing of mass timber connections, supporting code-compliant and performance-based design decisions.

Ascent Tower – concealed beam to column connection

Agenda

- Introduction
- IBC requirements for mass timber connections
- Use of the NDS and FDS
- Connection typologies and fire resistance rating solutions
- Approvals and documentation
- Mass Timber Fire & Acoustic Database
- Questions

New Guide In Development: ***Fire Design of Mass Timber Connections***

Apex Energy HQ

Mass Timber Connections

All primary structure includes connections – some need a fire resistance rating (FRR)

Stacked glulam beams on glulam girder for MEP circulation

80 M St – Concealed glulam beam to glulam girder connections

Glulam beams bearing on glulam column

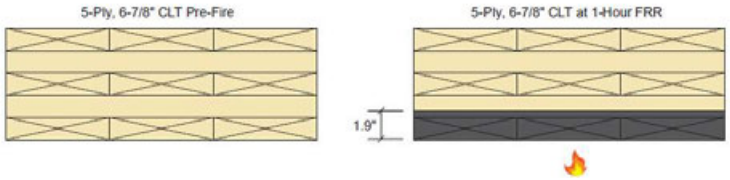
What is a Fire Resistance Rating?

Time a component or assembly can function when subjected to a controlled fire exposure

- Resisting heat
- Preventing flame and hot gas passage
- Supporting applied loads (if applicable)

5 ply CLT after 2 hrs fire test

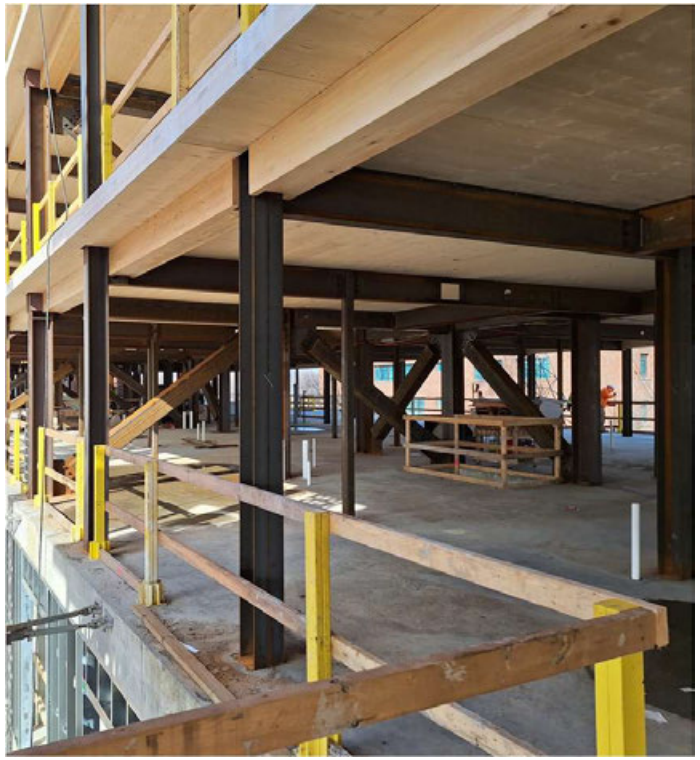
Established through fire tests following standards, i.e. ASTM E119 and UL 263



What Does the IBC Require?

Connections supporting a structural member are required to have the same FRR as the supported structural member or assembly

- Section 703: Fire testing or analysis
- Section 704: Details how a FRR is determined
- Construction Types IV-A, IV-B and IV-C: specific requirements for connections (Section 2304.10.1)



Bakers Place – steel and glulam structure

What Does the IBC Require?

2304.10.1 *Connection fire-resistance rating.*

Fire-resistance ratings for connections in Type IV-A, IV-B, or IV-C construction shall be determined by one of the following:

1. *Testing in accordance with Section 703.2 where the connection is part of the fire resistance test.*

2. *Engineering analysis that demonstrates that the temperature rise at any portion of the connection is limited to an average temperature rise of 250°F (139°C), and a maximum temperature rise of 325°F (181°C), for a time corresponding to the required fire-resistance rating of the structural element being connected. For the purposes of this analysis, the connection includes connectors, fasteners, and portions of wood members included in the structural design of the connection.*

Demonstrating FRR of Connections

Fire Testing (IBC Section 703.2.1)

- Completed by researchers and manufacturers
- Proving fire resistance to meet 2304.10.1(1)
- Two fire resistance test standards:
  - ASTM E119 *Standard Test Methods for Fire Tests of Building Construction and Materials*, or
  - UL 263 *Fire Tests of Building Construction and Material*

Glulam beam to column connection, 2 hrs fire test

Glulam beam to column fire resistance test to ASTM E119 – removal of assembly from furnace

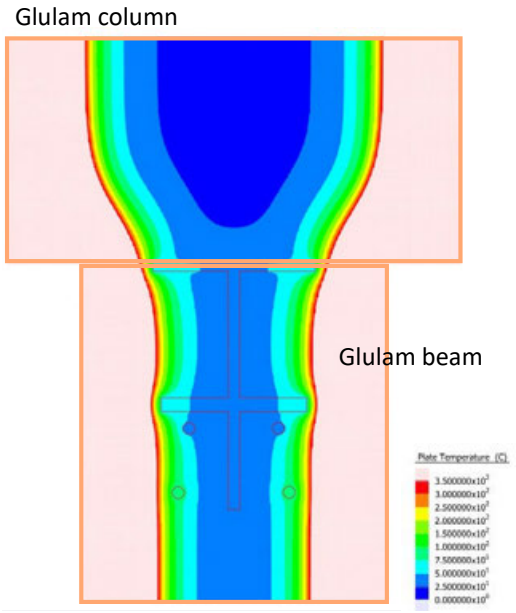
Demonstrating FRR of Connections

Analytical methods (IBC Section 703.2.2)

Pathway for calculations:

- Section 703.2.2 Option 3: calculations meeting Section 722 *Calculated Fire Resistance*
- Section 722.1 establishes the methods to calculate fire resistance of structural materials
- Section 722.1.4 references Chapter 16 of ANSI/AWC *National Design Specification for Wood Construction* (NDS)

Same pathway for earlier editions of the IBC



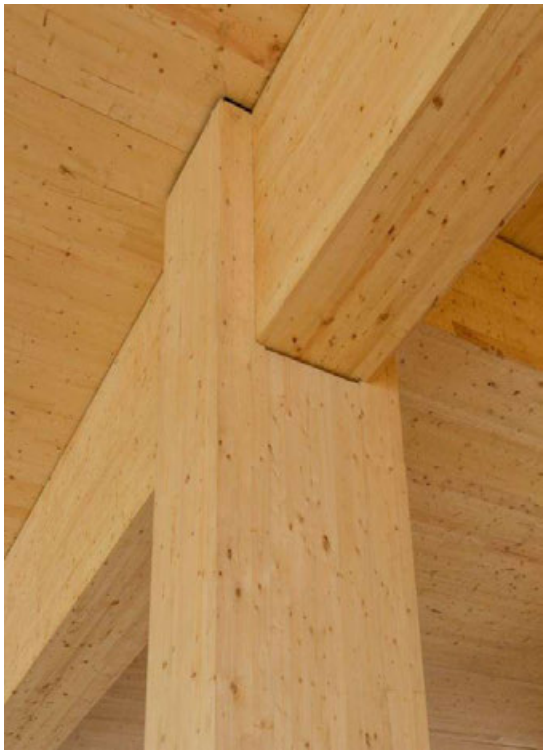
Glulam beam to column connection, finite element modelling results of 2 hrs fire exposure to ASTM E119 (plan – section)

What is the NDS and What Does it Require?

- The *National Design Specification for Wood Construction* by the AWC (view online at awc.org)
- Section 16.5 “Wood connections”, references ANSI / AWC *Fire Design Specification*
- Fire resistance: additional timber, fire rated gypsum board or other approved materials, or a combination

16.5 Wood Connections

Structural wood connections, including connectors, fasteners, and portions of wood members included in the connection design, shall be protected from fire exposure for the required fire resistance time in accordance with the FDS. Protection shall be provided by wood, fire-rated gypsum board, other approved materials, or a combination thereof. Fasteners attaching wood protection shall not be required to be protected.



Glulam beam to column connection, 1 hr FRR

What is the FDS and What Does it Require?

Fire Design Specification for Wood Construction

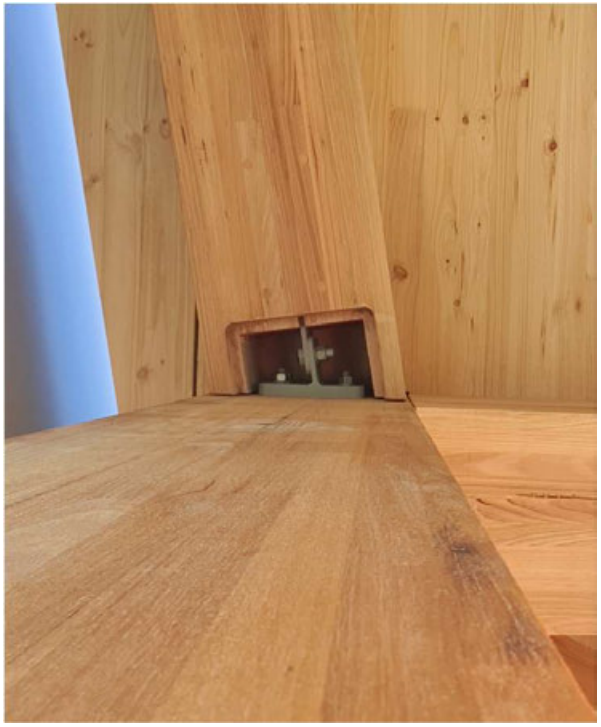
- Analysis methods to determine an FRR
- Methods for timber as “cover” or fire rated gypsum board
- Meets section 2304.10.1(2) for Types IV-A, B, C
- FRR for connections: see FDS Section 3.10

Assembly of glulam beam to column connection (image: DPR Construction)

What is the FDS and What Does it Require?

External steel plate protected by timber (1 hr FRR)

Concealed column connection
(image: Simpson Strong-Tie)



Concealed glulam connection prior
to final timber cover installation

What is the FDS and What Does it Require?

External steel plate connectors in the process of being protected by fire rated gypsum board

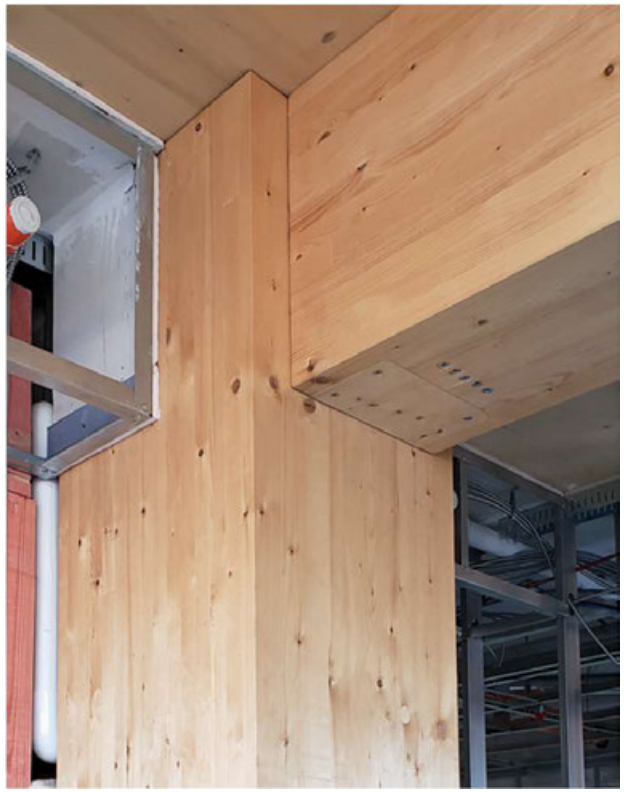
FDS Sect 3.10 *Design of Protected Connections*

Timber protection:

- Check FDS Sect 3.4.1 *Protection by wood* and
- FDS Sect 3.6.1 *Thermal separation*

Also:

- Abutting edges: FDS Sect 3.2.3 (char penetration and fire sealing)
- Burn through: FDS Sect 3.7



Concealed glulam connection, 2 hrs FRR

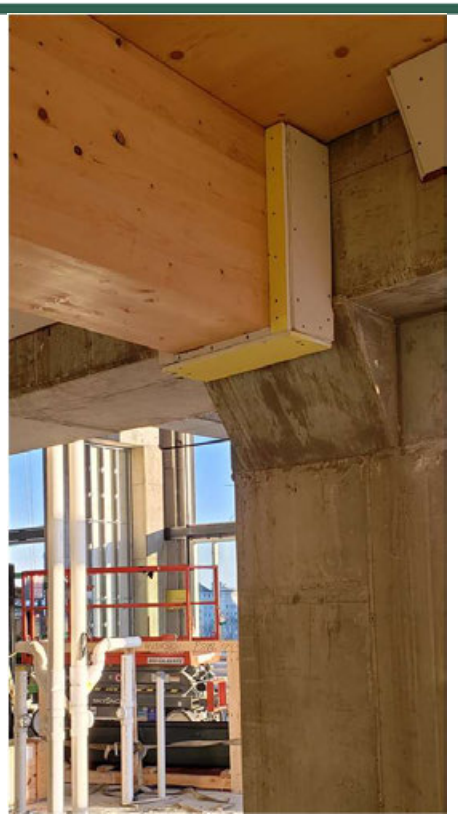
FDS Sect 3.10 *Design of Protected Connections*

Fire rated gypsum protection:

- Check FDS Sect 3.4.2 *Protection by Type X* and
- FDS Sect 3.6.2 *Thermal separation*

Also:

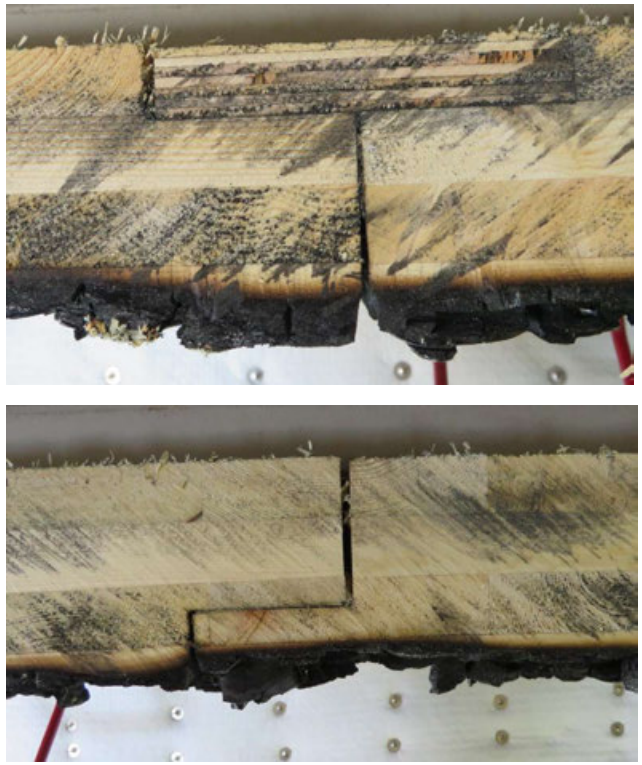
- Abutting edges: FDS Sect 3.2.3 (char penetration and fire sealing)



External steel plate connector protected by fire rated gypsum board

CLT Panel Connections

- Panel depth reduces due to charring
- Loss of cross-section increases stress, deflections
- Surface spline and half-lap are commonly used connections
- Prevent the passage of fire and smoke - connections can be a weak point
- Fire testing: Typical method to determine FRR of the panel connection



CLT connections, spline (top) and half- lap (bottom) after 2 hrs fire test

CLT Panel Connections

Fire testing

- ASTM E119 or UL 263, 1hr or 2 hrs
- Test applied load, connection components, test restraint, additional protection: replicate for construction

Analytical methods:

- FDS section 3.2.3 *Intersections and abutting edges of exposed wood members* applies
- At least 3/8” thick plywood spline to meet draft stopping of FDS section 2.5.3.1

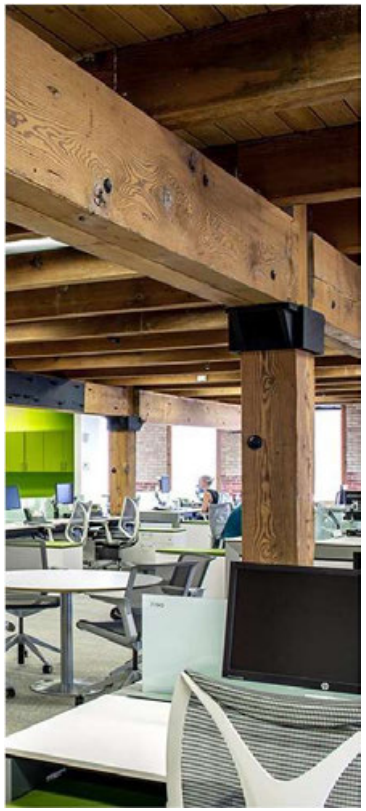
CLT wall after 2 hrs fire test

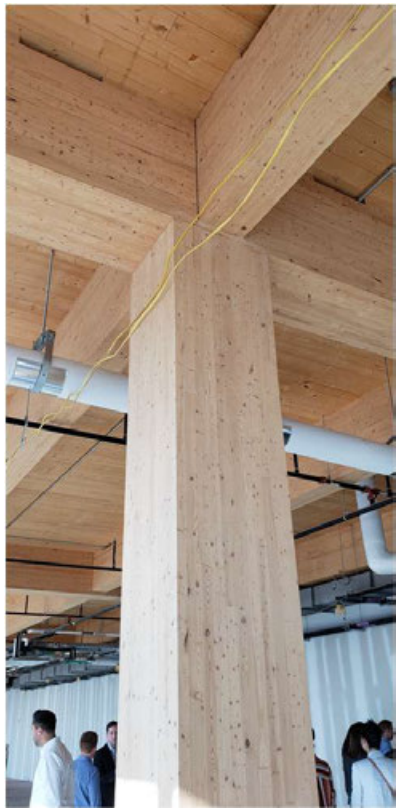
Timber to Timber Connection

Bearing connections

Use analysis methods

- Designed to resist the applied forces, based on the reduced cross-section of both members
- See FDS Section 3.3.1.4 for method
- Detailing is important – gap fire sealing required between all timber members





Beams bearing direct on column:
(left) Historic building, Denver; (right) 80M St

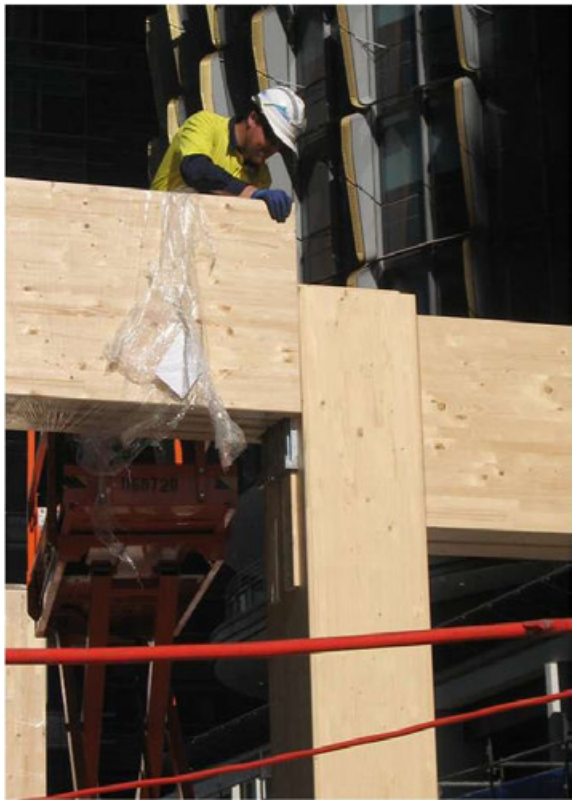
External Steel Plate Connection

- Easy to design and build
- Good for non-fire rated timber structures
- Unprotected steel plates are not viable as fire resistance rated connection
- Understand the heat transfer from all connected steel elements into the timber
- Protect with timber or fire rated gypsum boards (use methods from FDS)

External steel plate connector
prior to fire protection installation

Concealed Metallic Connectors

- Commonly used mass timber connectors
- Proprietary (‘off the shelf’) or project specific
- Can be pre-installed to columns or beams
- Achieve FRR by timber cover
- Timber protects the metallic components and screws



Concealed metallic connectors – site assembly

Concealed Metallic Connectors

- Fire test reports need to be strictly followed
- Loading, timber cover (sides and base), screw type, pattern, depth
- Gaps between members:
  - Construction needs tolerances – gaps will occur
  - Timber shrinkage
  - Intumescing fire seals between abutting members

Glulam beam to column assembly fire test, FRR 2 hrs

Approvals and Documentation

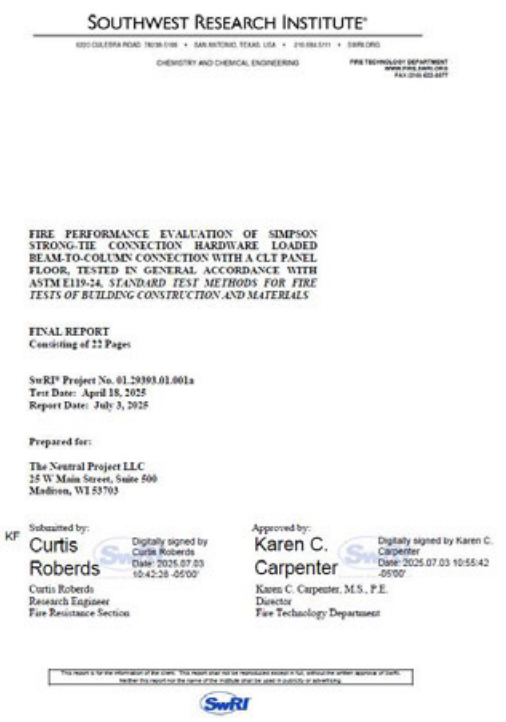
Connector type: Decided by architect, structural engineer, fire protection engineer / code consultant, general contractor, mass timber installer and AHJ

Fire test report

- Show how the project design is consistent with the tested connection

Analytical method

- Hold a pre-submission meeting with the AHJ
- Understand review process



SOUTHWEST RESEARCH INSTITUTE®

6220 CULEBRA ROAD 78238-5166 • SAN ANTONIO, TEXAS, USA • 210.684.5111 • SWRI.ORG

CHEMISTRY AND CHEMICAL ENGINEERING

FIRE TECHNOLOGY DEPARTMENT
WWW.FIRE.SWRI.ORG
FAX (210) 522-5377

FIRE PERFORMANCE EVALUATION OF SIMPSON STRONG-TIE CONNECTION HARDWARE LOADED BEAM-TO-COLUMN CONNECTION WITH A CLT PANEL FLOOR, TESTED IN GENERAL ACCORDANCE WITH ASTM E119-24, *STANDARD TEST METHODS FOR FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS*

FINAL REPORT
Consisting of 22 Pages

SwRI® Project No. 01.29393.01.001a
Test Date: April 18, 2025
Report Date: July 3, 2025

Prepared for:

The Neutral Project LLC
25 W Main Street, Suite 500
Madison, WI 53703

KF

Submitted by:
Curtis Roberds
Digitally signed by Curtis Roberds
Date: 2025.07.03 10:42:38 -05'00'
Curtis Roberds
Research Engineer
Fire Resistance Section

Approved by:
Karen C. Carpenter
Digitally signed by Karen C. Carpenter
Date: 2025.07.03 10:55:42 -05'00'
Karen C. Carpenter, M.S., P.E.
Director
Fire Technology Department

This report is for the information of the client. This report shall not be reproduced except in full, without the written approval of SwRI. Neither this report nor the name of the Institute shall be used in publicity or advertising.

SwRI

And Some Other Items:

Intumescent paint:

- Protects the steel, not the connection
- Needs room to expand
- Effectiveness occurs from ~500°F (250°C)
- Needs to be specifically engineered for the problem
- Work with the intumescent paint supplier (or the product warranty may be voided)

Steel beams protected with intumescent paint supporting CLT floor

And Some Other Items:

Adhesives, sealants, fire seals:

- Required at connections and at panel intersections (IBC Section 703.7)
- Allow for construction tolerances and gaps between members

Special Inspections for connections:

- Need to agree before permit
- What, how, when, by whom and documentation

Intumescent fire seal to column prior to beam installation

Gap between glulam beam end and glulam column face after installation

Mass Timber Fire & Acoustic Database

Introduction to this freely available resource:

www.woodworks.org/mass-timber-fire-acoustic-database/

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

David Barber

CHM Fire

david.barber@chmfire.ca

All images by David Barber unless noted