Firestops In Mass Wood Timber Buildings

FCIA Canada Symposium 2020

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HILTI

Outline

- Drive Towards Mass Wood Timber Buildings
- Mass Wood Timber Projects
- Firestop Testing in Mass Wood Timber Assemblies
- Closing Remarks

DRIVE TOWARDS MASS WOOD TIMBER (MWT) BUILDINGS

CODE Changes

Upcoming - Canada

- 2020 National Building Code of Canada (NBCC) draft language plans to allow 12-story buildings that use mass timber (Ref. 3)
- Key phrase is **encapsulated mass timber construction (EMTC)** (Ref. 1)

Complete - Canada

- British Columbia has already adopted allowances for 12-story EMTC (Ref. 3). Relies on technical content from 2020 NBCC draft
- Ontario published "Ontario's Tall Wood Building Reference: A Technical Resource for Developing Alternative Solutions for Ontario's Building Code" in 2017
- Alberta has allowed a pathway to 12-storey EMTC via a STANDATA document in February 2020

Complete – U.S.

- 2021 International Building Code has expanded the prescriptive capabilities of **Mass Wood Timber (MWT)** buildings in the U.S.
- Max 18 stories using the most stringent requirements for encapsulation of MWT
- Max 9 stories for exposed MWT (except for MWT used in exterior walls)

Draft 2020 NBCC Highlights for EMTC – Minimum EMTC Dimensions

Table 1: Draft 2020 NBCC Language for EMTC Dimensions (Ref. 1)		
Structural Wood Elements	Minimum Thickness, mm	Width x Depth, mm x mm
Walls that are fire separations or exterior walls	96	
Wall that require a fire resistance rating, but are no fire separations	192	
Floors or roofs	96	
Beams, columns, and arches (2- or 3-sided fire exposure		192 x 192
Beams, columns, and arches (4-sided fire exposure)		224 x 224

Draft 2020 NBCC Highlights for EMTC – Increased Fire Resistance to Separate Occupancies

Major Occupancy Type Separations	**General Fire-resistance Rating Requirement (NBC 2015)**	**Fire-resistance Rating Requirement for Mid-rise Combustible Construction (NBC 2015)**	**Proposed Fire-resistance Rating Requirement for Tall Encapsulated Mass Timber Construction**
Group C from Group D	1 h	1 h	1 h
Group C from Group A Division 2	1 h	2 h	2 h
Group C from Storage Garages	1 h	1 h	2 h
Group D from Group A Division 2	1 h	2 h	2 h
Group D from Group E	-	-	1 h
Group D from Group F Division 2 and 3	-	-	1 h

Figure 1: Draft Language from 2020 NBCC Regarding EMTC Construction (Ref. 1)

New Test standard to evaluate encapsulation materials for EMTC

CAN/ULC-S146:2019

STANDARD METHOD OF TEST FOR THE EVALUATION OF ENCAPSULATION MATERIALS AND ASSEMBLIES OF MATERIALS FOR THE PROTECTION OF STRUCTURAL TIMBER ELEMENTS

1 Scope

1.1 This test method evaluates the temperature transmission performance of an encapsulation material or assembly of materials installed over a wood substrate when the test specimen is subjected to a standard fire exposure condition following the standard time-temperature curve as described in Section 6 (Test Conditions).

1.2 It is the intent that the encapsulation period established by this test method indicates the period of standard fire exposure when an encapsulated structural timber element is not expected to reach temperatures sufficient to cause charring or combustion, potentially resulting in contribution to fire severity,
and shall not be construed as having determined the fire endurance period of the encapsulation material or assembly of materials, or of the structural timber element.

1.3 It is the intent that the encapsulation period established by this test method indicates performance only during the fire exposure period and shall not be construed as determining suitability for use after fire exposure.

Figure 2: Description of CAN/ULC-S146-2019 (Ref. 4)

MWT Projects proceed with Performance-based designs

- The reality is that prescriptive codes changes do not allow the types of MWT buildings that existed prior to the code changes taking effect.

- Performance-based designs will continue to play a major role

Performance-Based designs: Brock Commons

- Location: University of British Columbia
- Mixed-use residential complex including commercial and assembly spaces
- Houses 404 students
- Budget approved in 2015. Project completed in 2018

- The building's footprint exceeds any proposed code allowances for EMTC
  - 18 stories
  - 162,700 sq. ft.

Figure 3: Rendering of Brock Commons Structural Frame (Ref. 2)

Performance-Based designs: Brock Commons

- The code requirements involved overlapping jurisdictions: University, local, provincial, and national.
  - Takeaway: complicated

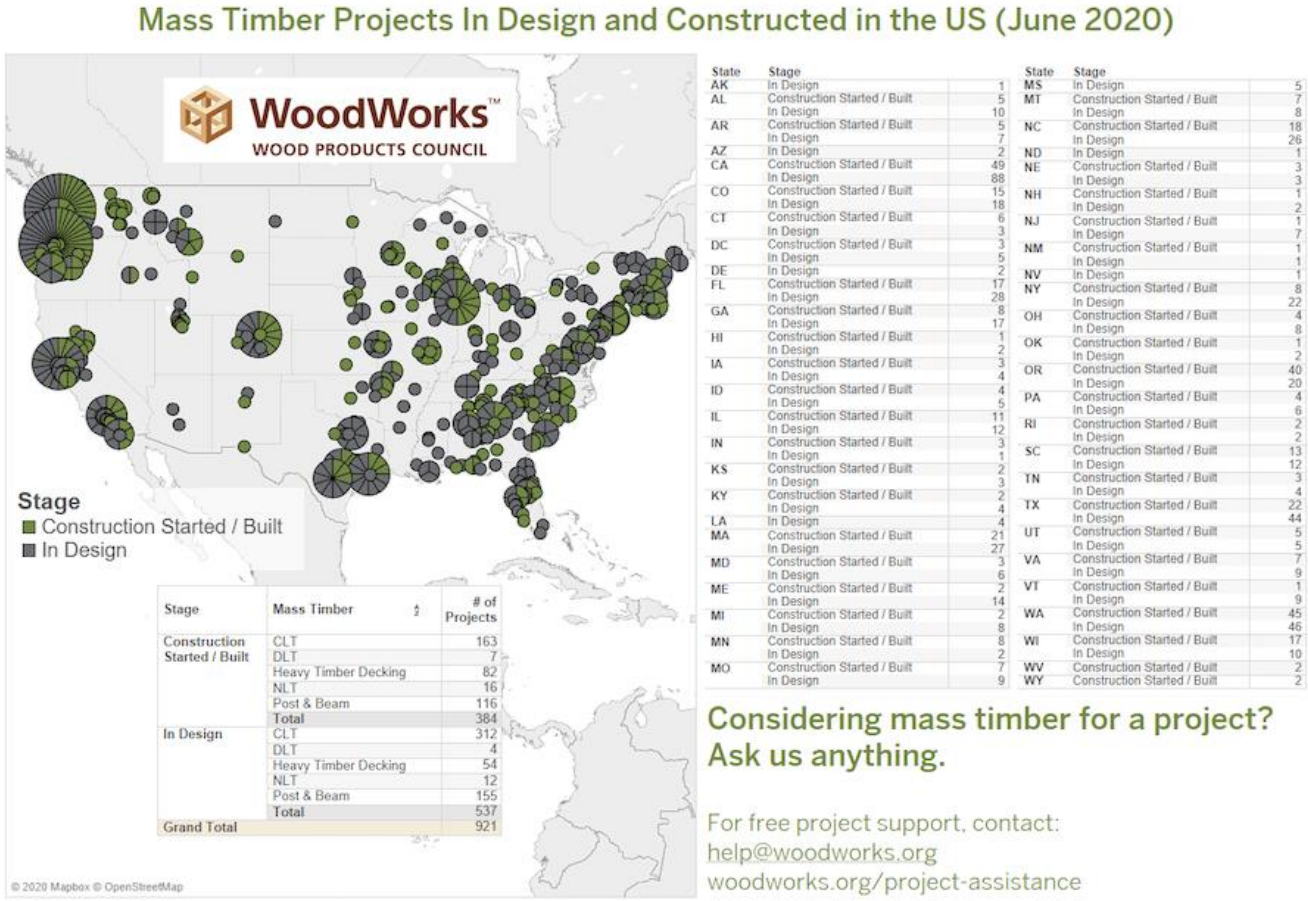
- Fire performance: no project-specific testing was performed.
  - Design team chose conservative approach to encapsulate mass timber in 3-layers of Type X gypsum
  - Team consisted of an expert panel on fire safety

One key question: do 3 layers of type X gypsum board make a MWT assembly equivalent to a material already in listed firestop systems, such as concrete?

MASS WOOD TIMBER PROJECTS

921 MWT Projects in the U.S. built or in design – 2013 to June 2020

This is before the 2021 IBC changes had been adopted. As in Canada, U.S. projects are relying on performance-based designs ahead of code updates.



Stage	Mass Timber	# of Projects
Construction Started / Built	CLT	163
	DLT	7
	Heavy Timber Decking	82
	NLT	16
	Post & Beam	116
	Total	384
In Design	CLT	312
	DLT	4
	Heavy Timber Decking	54
	NLT	12
	Post & Beam	155
	Total	537
Grand Total		921

State	Stage		State	Stage	
AK	In Design	1	MS	In Design	5
AL	Construction Started / Built	5	MT	Construction Started / Built	7
	In Design	10		In Design	8
AR	Construction Started / Built	5	NC	Construction Started / Built	18
	In Design	7		In Design	26
AZ	In Design	2	ND	In Design	1
CA	Construction Started / Built	49	NE	Construction Started / Built	3
	In Design	88		In Design	3
CO	Construction Started / Built	15	NH	Construction Started / Built	1
	In Design	18		In Design	2
CT	Construction Started / Built	6	NJ	Construction Started / Built	1
	In Design	3		In Design	7
DC	Construction Started / Built	3	NM	Construction Started / Built	1
	In Design	5		In Design	1
DE	In Design	2	NV	In Design	1
FL	Construction Started / Built	17	NY	Construction Started / Built	8
	In Design	28		In Design	22
GA	Construction Started / Built	8	OH	Construction Started / Built	4
	In Design	17		In Design	8
HI	Construction Started / Built	1	OK	Construction Started / Built	1
	In Design	2		In Design	2
IA	Construction Started / Built	3	OR	Construction Started / Built	40
	In Design	4		In Design	20
ID	Construction Started / Built	4	PA	Construction Started / Built	4
	In Design	5		In Design	6
IL	Construction Started / Built	11	RI	Construction Started / Built	2
	In Design	12		In Design	2
IN	Construction Started / Built	3	SC	Construction Started / Built	13
	In Design	1		In Design	12
KS	Construction Started / Built	2	TN	Construction Started / Built	3
	In Design	3		In Design	4
KY	Construction Started / Built	2	TX	Construction Started / Built	22
	In Design	4		In Design	44
LA	In Design	4	UT	Construction Started / Built	5
MA	Construction Started / Built	21		In Design	5
	In Design	27	VA	Construction Started / Built	7
MD	Construction Started / Built	3		In Design	9
	In Design	6	VT	Construction Started / Built	1
ME	Construction Started / Built	2		In Design	9
	In Design	14	WA	Construction Started / Built	45
MI	Construction Started / Built	2		In Design	46
	In Design	8	WI	Construction Started / Built	17
MN	Construction Started / Built	8		In Design	10
	In Design	2	WV	Construction Started / Built	2
MO	Construction Started / Built	7	WY	Construction Started / Built	2
	In Design	9			

Figure 4: U.S. Project List for Mass Timber Buildings (Ref. 7)

MWT Projects in Canada, Any Stage, 2013 to YTD 2020, Using Constructconnect.

- B.C. clearly leads. May attribute to incorporation of 2020 NBCC EMTC guidelines in B.C.
- 108 Total projects

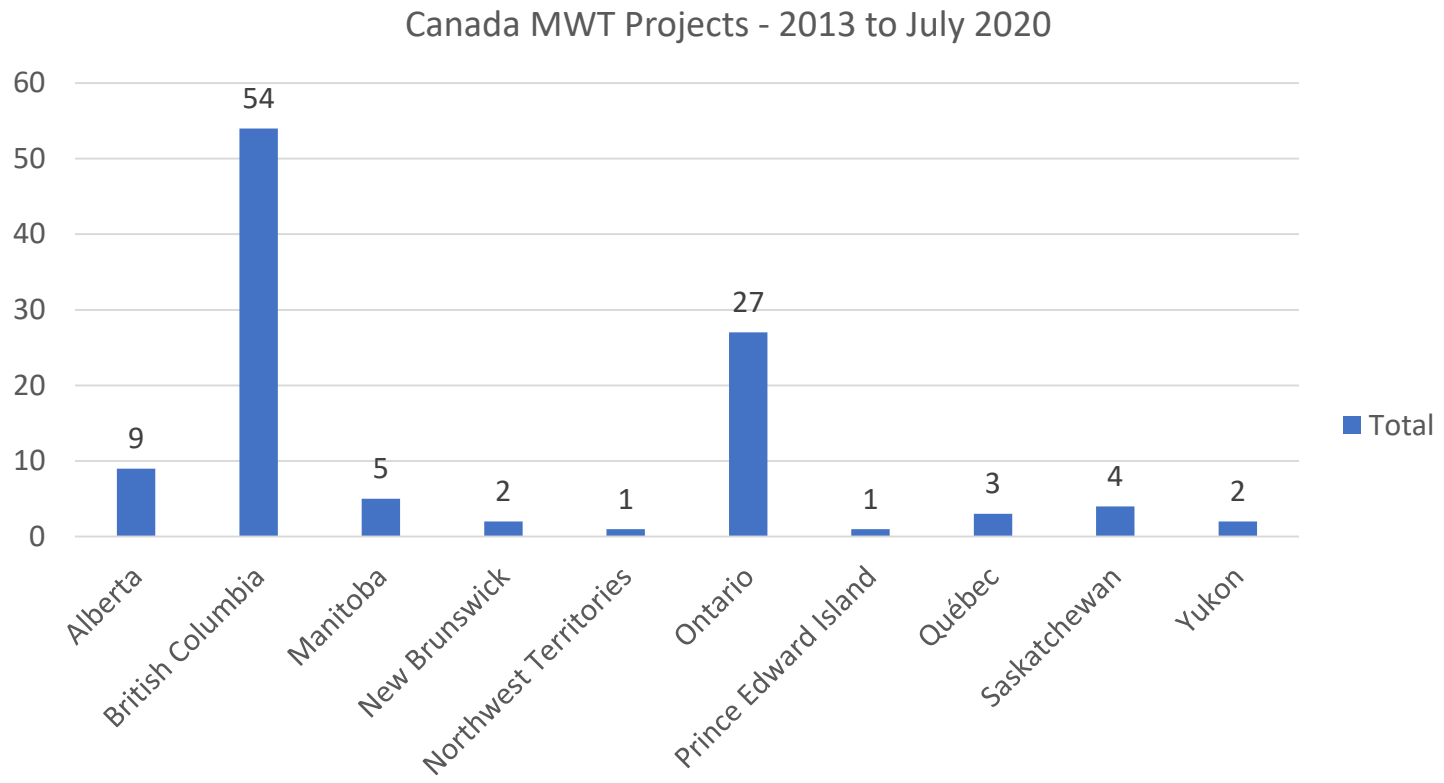


Figure 5: ConstructConnect MWT Project Count in Canada, Courtesy of Hilti Inc.

Dodge Data on MWT project through 2024

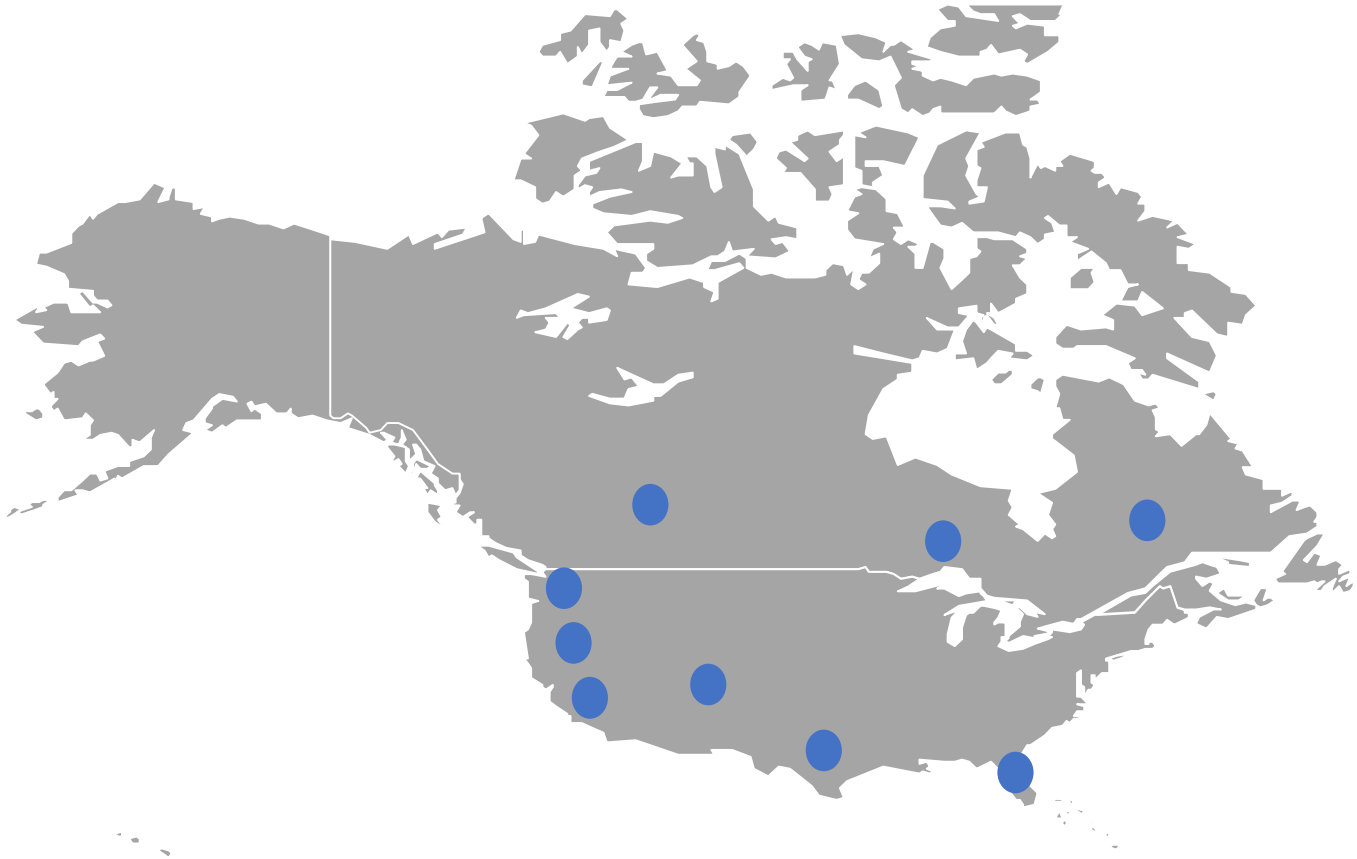


Figure 5: Dodge Data for MWT Project Count in North America, Courtesy of Hilti Inc.

$13.1B in Project Value

California leads charge with over 90 projects

Washington = 57 projects

Oregon with 46

Texas has 43 starts coming

Utah + Florida have 20 projects coming

Canada starting 12 projects by 2022

MWT Project Implications for Firestop

- MWT market value small compared to the overall market in coming years

- Each project carries the same life-safety concerns as any other
  - As MWT buildings get bigger, so does their social profile
  - There are stories of firestop systems without any basis in testing being used in MWT projects

- The potential for liability claims should also give the firestop industry pause
  - What is the industry customary standard? Answer: listings
  - What happens when the above can’t be met: Answer: custom systems based on testing
  - What happens when neither of the above has been satisfied?

MWT Project Implications for Firestop

- With so many MWT projects there are outstanding questions:
  - What firestop testing has been done?
  - Where are the firestop listings (a firestop system published by a 3rd party agency)?

- Listings are lacking as the more common listing/certification agencies have not provided a good pathway
  - Popular listing agency requiring MWT assemblies to be certified
  - Note that firestop system code requirements refer to tested systems, not listed systems.
    - Code compliance can be achieved for a non-listed firestop system based on testing to CAN/ULC S115
  - Attempts have been made to test certified CLT (UL designs M533 and L901), but despite successful results, no listings were promulgated.

FIRESTOP TESTING FOR MWT ASSEMBLIES

MWT industry has been proactive

- 2013 was the start of ramping firestop tests in MWT
- Significant investment made
  - Lead by MWT industry groups with support from key firestop industry participants
- The MWT industry wants to address fire safety
  - Basing firestops on testing may present inconveniences, but it will lead to the industry coming together to support

Test data & photos shared is publicly available.

Firestop Tests in MWT

CLT Panel	Exposed Side Protection	Penetrating Item	Penetrant Centered or Offset in Hole	F Rating	T Rating	Test Protocal	Source	Testing Lab
3-ply (78mm 3.07")	None	1.5" diameter data cable bunch	Centered	1 hour	0.5 hour	CAN ULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07")	None	2" copper pipe	Centered	1 hour	N.A.	CAN ULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07")	None	2.5" sched. 40 pipe	Centered	1 hour	N.A.	CAN ULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07")	None	6" cast iron pipe	Centered	1 hour	N.A.	CAN ULC S115	26	Intertek March 30, 2016

Figure 6: Partial List of Fire Resistance Testing Complied by WoodWorks (Ref. 6)

Firestop Tests in MWT

Firestopping System Description
3.5 in diameter hole. Mineral wool was installed in the 1in. annular space around the data cables to a total depth of approximately 2 – 5/64in. The remaining 1in. annular space from the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.
4.375 in diameter hole. Pipe wrap was installed around the copper pipe to a total depth of approximately 2 – 5/64in. The remaining 1in. annular space starting at the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.
4.92 in diameter hole. Pipe wrap was installed around the schedule 40 pipe to a total depth of approximately 2 – 5/64in. The remaining 1in. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS-One Max caulking.
8.35 in diameter hole. Mineral wool was installed in the 1in. annular space around the cast iron pipe to a total depth of approximately 2 – 5/64in. The remaining 1in. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS- One Max caulking.

Figure 7: Partial List of Fire Resistance Testing Complied by WoodWorks (Ref. 6)

- WoodWorks is an industry group focused on MWT education.
  - Have compiled firestop test records of early efforts in 2016 & 2017
    - Publicly available online

Firestop Industry & Mass Timber Conference 2019 – Penetrations Comparison Study

- Test program compared three (3) CLT assemblies
- Identical through-penetrations & firestops
- Test duration was 1-1/2 hour (90 minutes) in accordance with UL 1479 4th Edition

Goal: Investigate firestop system attributes and develop means for data extension between MWT types

Table 2: Attributes of CLT Floor Assemblies (Ref. 5)

ATTRIBUTE	FLOOR 1 – CLT1	FLOOR 2 – CLT2	FLOOR 3 – CLT3
THICKNESS	5”	6-7/8”	6-7/8”
WOOD SPECIES	Austrian spruce	Spruce-pine-fir (90% black spruce)	Douglas fir
ADHESIVE	Polyurethane (PUR)	Formaldehyde	Formaldehyde
STANDARD	ANSI/APA PRG-320-12	ANSI/APA PRG-320-12	ANSI/APA PRG-320-12

Firestop Industry & Mass Timber Conference 2019 – Penetrations Comparison Study

Table 3: Penetration and Firestop System Details (Ref. 5)

	PENETRATION A	PENETRATION B	PENETRATION C	PENETRATION D	PENETRATION E
ITEM	4” Copper Pipe	4” Copper Pipe	6” Steel w/2” Glass Fiber	4” PVC (sch. 40, vented)	2” Polypropylene Random (PP-R) Pipe (SDR 7.4, closed)
PACKING MATERIAL	Mineral Wool	None	Mineral Wool	None	None
SEALANT	Intumescent	None	Intumescent	None	None
DEVICE	None	Drop-in device with intumescent strips	None	Drop-in device with intumescent strips	Drop-in device with intumescent strips

Firestop Industry & Mass Timber Conference 2019 – Penetrations Comparison Study

Firestop Method 1: Drop-In Device with Intumescent Strips

1. CLT floor assembly
2. Drop-in device
   - Secured to top of floor using 1” long wood screws
   - 2-7/8” height
   - Intumescent strips on outside and inside of device at bottom of device
3. Penetrating item
   - Copper, PVC, and PP-R were tested

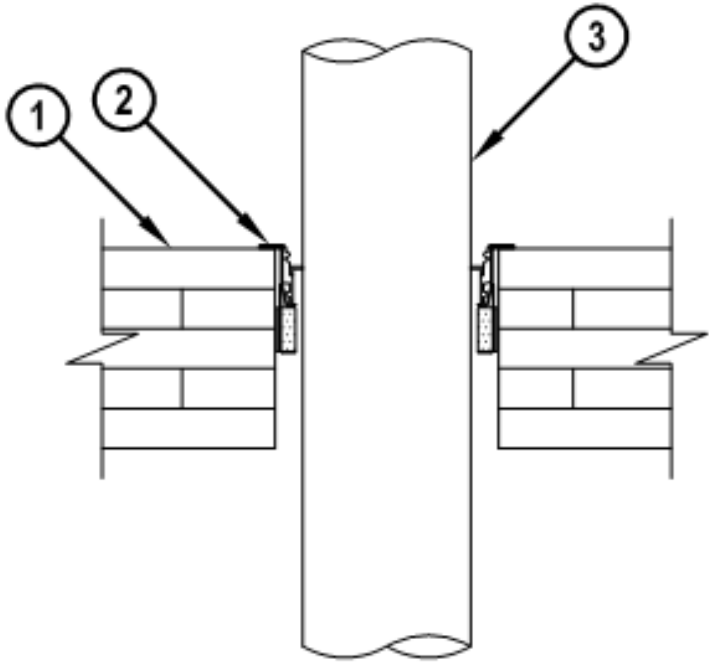


Fig. 8: Section View, Drop-In Firestop System (Ref. 5)

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Firestop Method 2: Intumescent Sealant Over Mineral Wool

1. CLT floor assembly
2. Penetrating item
   - Insulated steel and bare copper were tested
3. Pipe Insulation
   - 2” thickness of glass fiber
4. Mineral wool
   - Recessed 1” from bottom of floor
5. Intumescent Firestop Sealant
   - ¾” depth

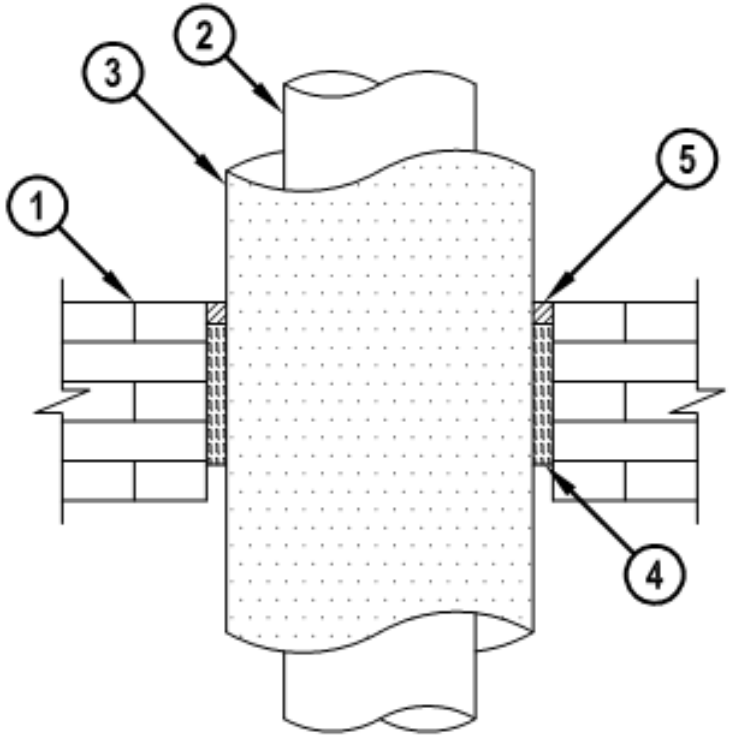

Fig. 9: Section View, Sealant Firestop System (Ref. 5)

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Fig. 10: CLT 1 Non-Exposed Side, Pre-Fire Endurance (Ref. 5)

Fig. 11: CLT3 Exposed Side, Pre-Fire Endurance (Ref. 5)

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Fig. 12: CLT1 Non-Exposed Side, End of Fire Endurance (Ref. 5)

Results

- All penetrations, except 4” PVC, passed for all floors
- 4” PVC passed for CLT1 (5” thick) only
  - Depth of floor vs. depth of firestop
- Passing Includes:
  - Fire Endurance
  - Hose Stream
  - 90 minute F-rating
- Insulated 4” steel pipe achieved T-rating
  - 90 min. for CLT2/CLT3, 60 min. for CLT1

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Fig. 13: CLT1 Exposed Side, Post Fire Endurance (Ref. 5)

Fig. 14: CLT2 Exposed Side, Post Fire Endurance (Ref. 5)

Fig. 15: CLT3 Exposed Side, Post Fire Endurance (Ref. 5)

Firestop Industry & Mass Timber Conference 2019 – Penetrations Comparison Study

Fig. 16: CLT 1 Exposed Side Post Hose Stream (Ref. 5)

Fig. 17: CLT2 Exposed Side, Post Hose Stream (Ref. 5)

Fig. 18: CLT3 Exposed Side, Post Hose Stream (Ref. 5)

Firestop Industry & Mass Timber Conference 2019 – Joint Testing

Test Details

- Gypsum wall (steel stud) to underside of CLT
- 2-Hr rating goal
- ½” nominal joint width
- Class II Movement: 50% compression/extension
- Firestop: Intumescent top track installed over ceiling runner and filling joint
- Standard: UL 2079 5th Edition (applicable to CAN/ULC S115-18)

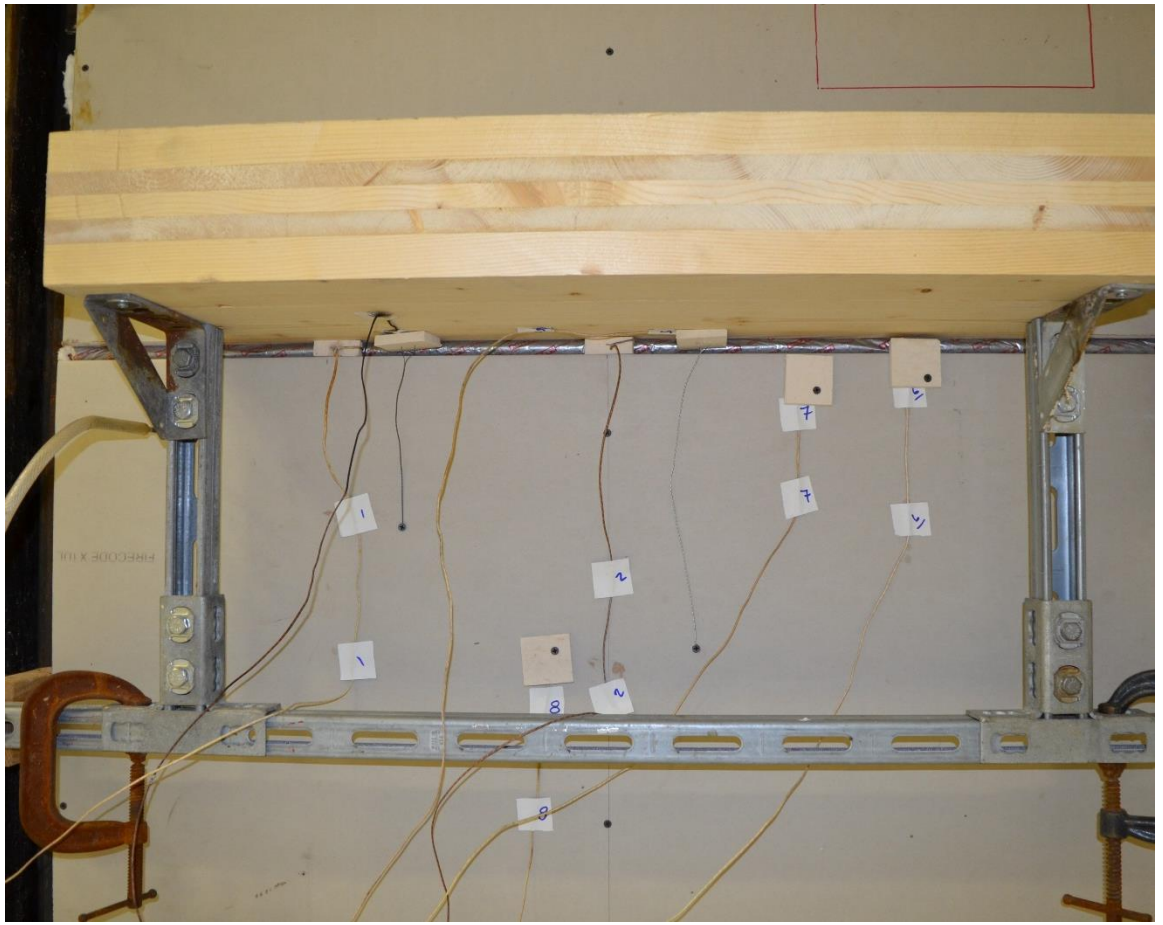

Fig. 19: Test Assy. Non-Exposed Side, Pre-Fire Endurance (Ref. 5)

Firestop Industry & Mass Timber Conference 2019 – Joint Testing

Fig. 20: Test Assembly Profile, Post Fire Endurance (Ref. 5)

Key Learnings

- Material loss from CLT
- CLT degraded unevenly
  - Non-uniform delamination
- Delamination did not physically impair joint or wall
- Test setup modification
  - Insulate front, top and side of CLT

Firestop Testing to 50Pa

- 2-Hr ratings
  - Up to 4” PVC (sch. 40)

- 1-Hr ratings
  - Up to 6” XFR-PVC

- Testing a plastic pipe through MWT at 50Pa is
  - Akin to having fuel in the pipe during the test
    - Effluents from MWT are combustible – think backdraft

Any 50Pa firestop system must be based on testing

Figure 21: Nonexposed side of a CLT test assembly during a CAN/ULC S115 penetration test at 50Pa. Photo courtesy of Hilti Inc.

CLOSING REMARKS

Closing Remarks

- Tested firestop solutions in MWT are available to keep pace with industry growth
- Industry stakeholders have taken initiative to address life-safety via fire tests of MWT assemblies
- It may be that listing & certification agencies are not the best resources during this time of rapid growth and innovation
- MWT projects will continue to become a more common
- Canada should soon have codified provisions for EMTC

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THANK YOU