

# Fire Performance of Adhesives Used for Southern Pine CLT

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*Forest Products  
Laboratory*

**Project is a Part of a More  
Comprehensive study;**

**Solid and Hollow-Core Cross-  
Laminated Timber Systems for Low-  
and Mid-Rise Construction**

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# Cross-Laminated Timber (CLT)



www.nordicewp.com

- At least three layers of solid-sawn or structural composite lumber
- Grain orientation of adjacent layers are perpendicular to each other.

# Cross-Laminated Timber (CLT)

## Typical Dimensions

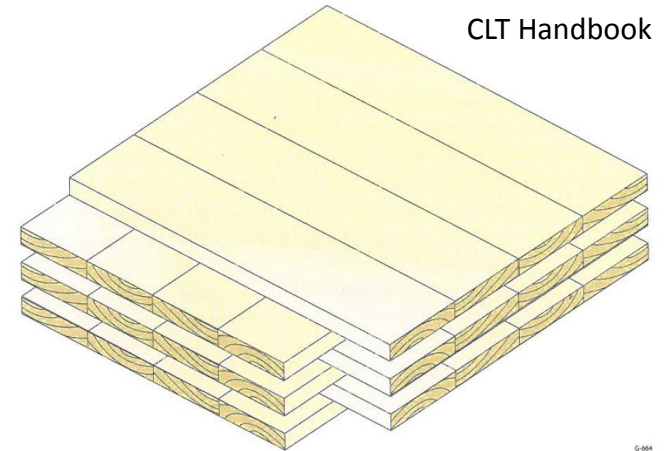
- Widths: 2, 4, 8, and 10 ft. (0.6, 1.2, and 3 m)
- Lengths: up to 60 ft (18 m)
- Thickness: up to 20 inches (0.5 m).



# Benefits of CLT

# High Strength and Stiffness

- Excellent dimensional stability
- Provides 2-way action
- Cross-lamination provides mechanical restraint
- Wall, Floor or Roof



# Superior Seismic Performance

- Seven-story CLT building on a shake table
- Earthquake of 7.2 magnitude and 0.8 to 1.2 g
- No residual deformation after the test



# Good Fire Resistance



<http://www.masstimber.com>

- Wood burns at slow, predictable rate (0.02 in/min)
- Char helps insulate the rest of panel
- CLT can burn for a significant amount of time
- Tests showed CLT walls exceeding requirements for heavy timber construction



# Good Fire Resistance

- ASTM E119 fire endurance test on a CLT wall by American Wood Council
- 5-ply CLT (approximately 7 inches thick), covered on each side with gypsum wallboard
- Specimen lasted 3 hours, 6 minutes

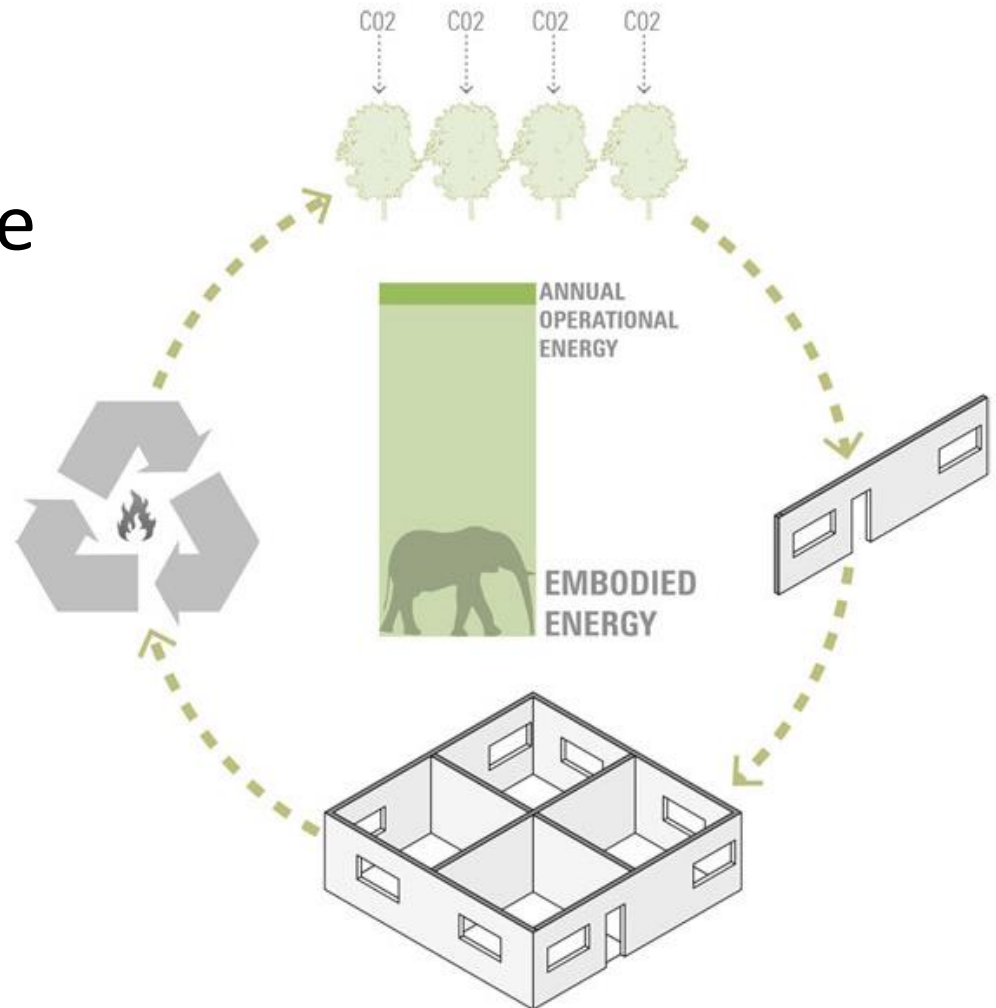
# Construction Efficiency

- Off-site manufacturing
- Shorter installation time
- 75% lighter than concrete
- Safer on-site working environment
- Less demand for skilled workers on site



# Sustainability

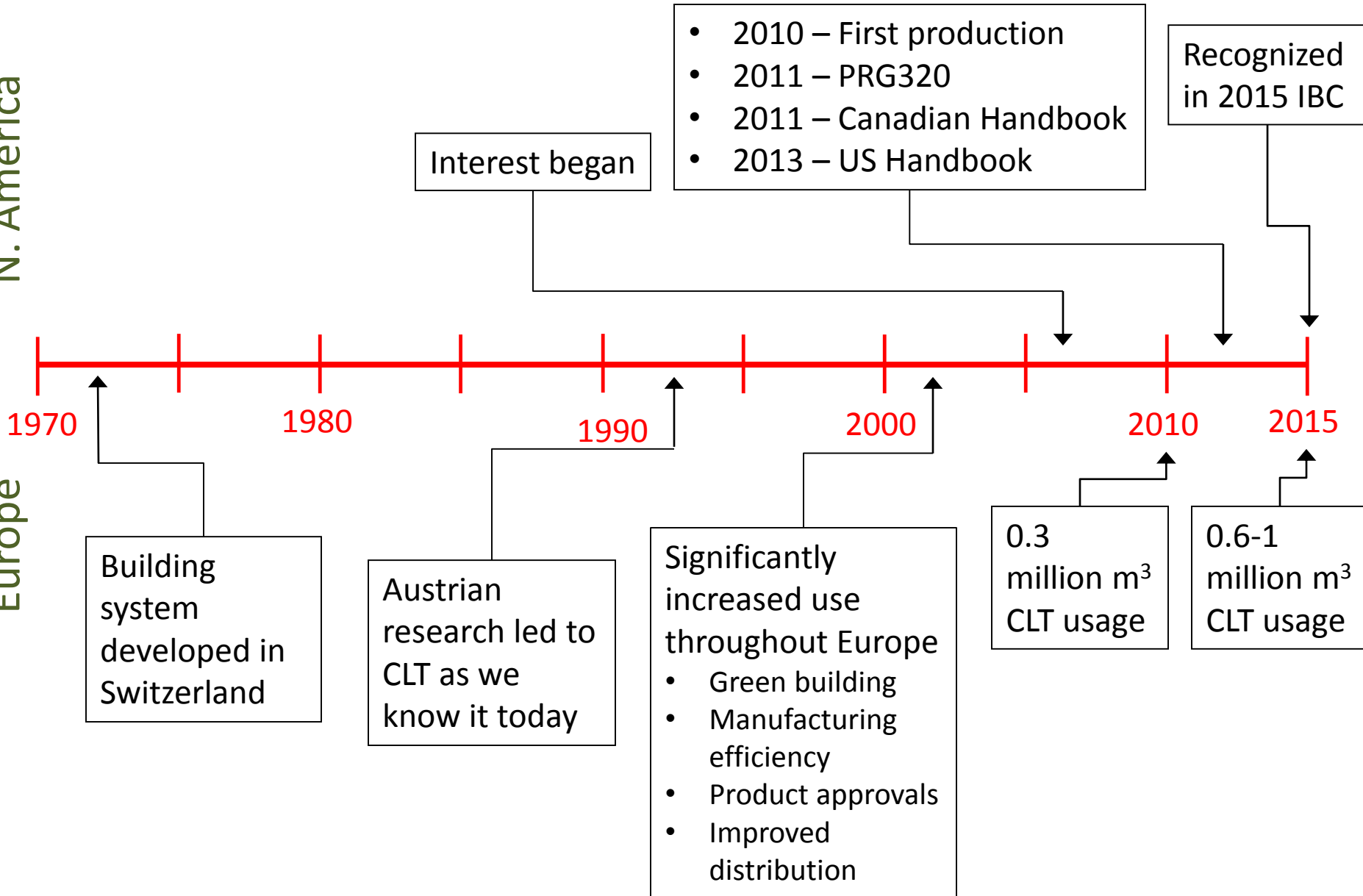
- Carbon sink
- Reduced greenhouse gas emission
- Excellent thermal insulation
- Low embodied energy



# CLT History Timeline

N. America

Europe



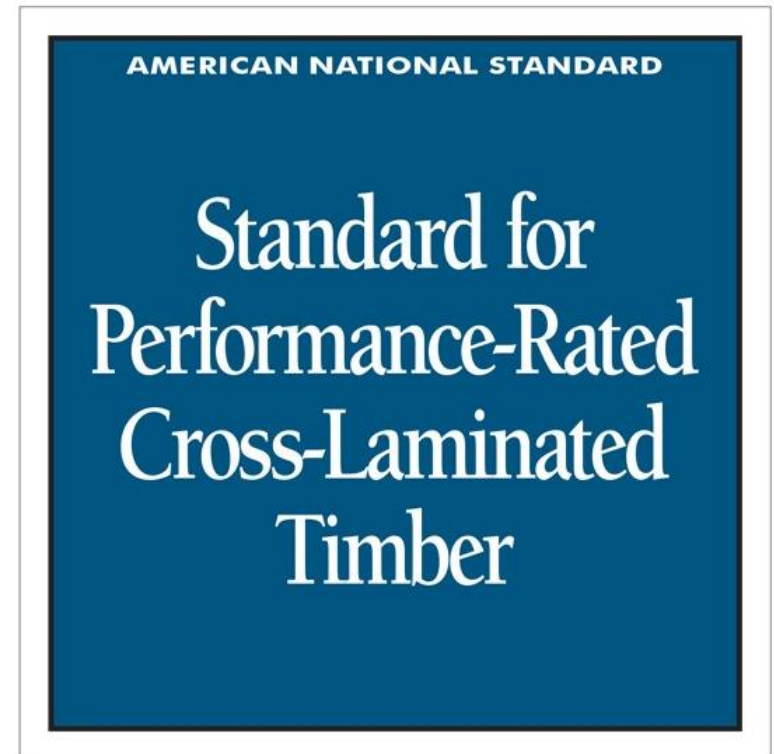
# Product Standard (2011)

- Panel dimensions and dimensional tolerances
- Component requirements
- CLT performance criteria
- Qualification and product marking
- Quality assurance

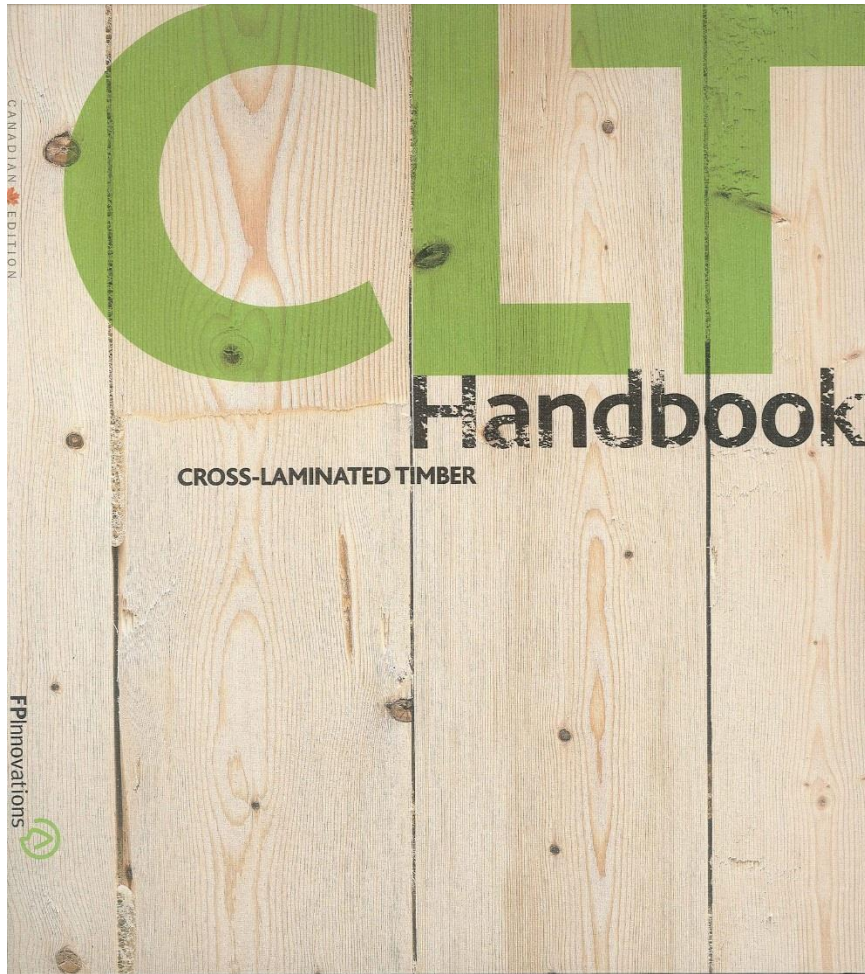


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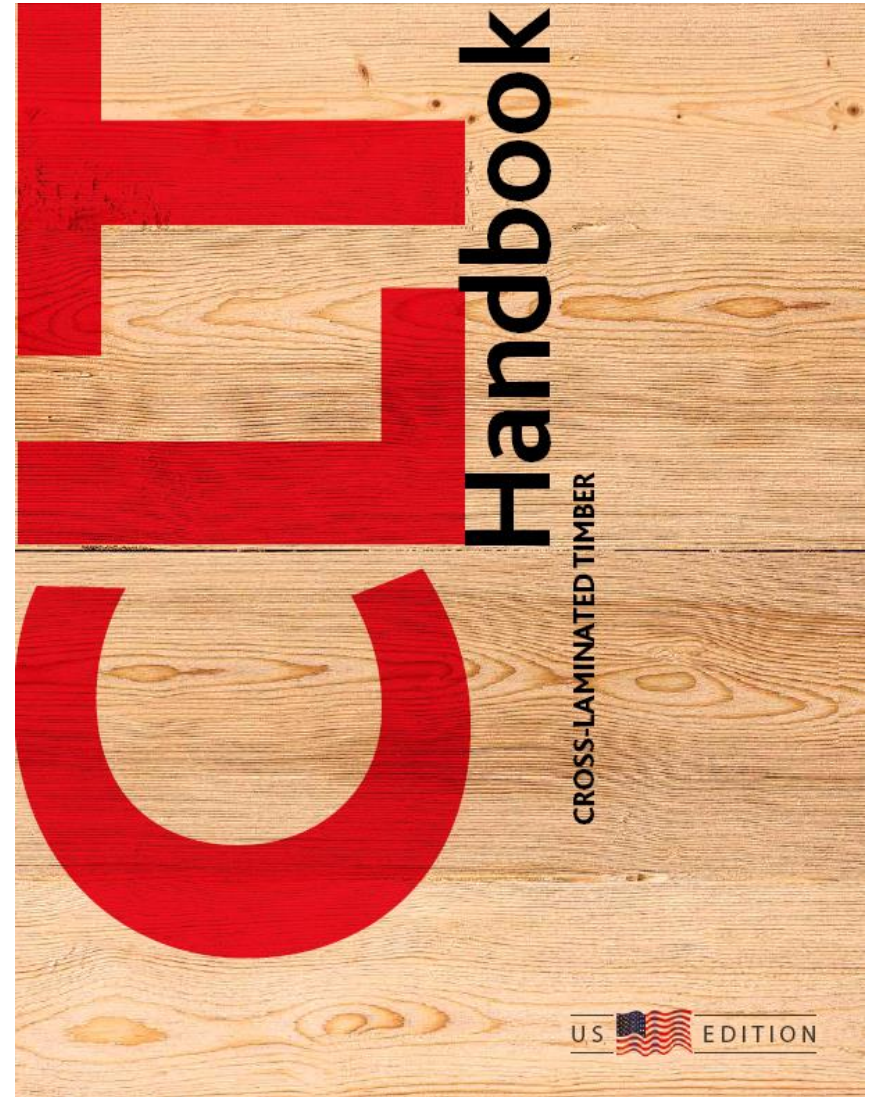
**ANSI/APA PRG 320-2012**



# CLT Handbooks



Canadian Edition (2011)



US Edition (2013)

# Code Approval By ICC

- 2012: International Code Council (ICC) approved the use of CLT through IBC's heavy timber construction classification
- 2015: Code will be immediately available for adoption by jurisdictions.



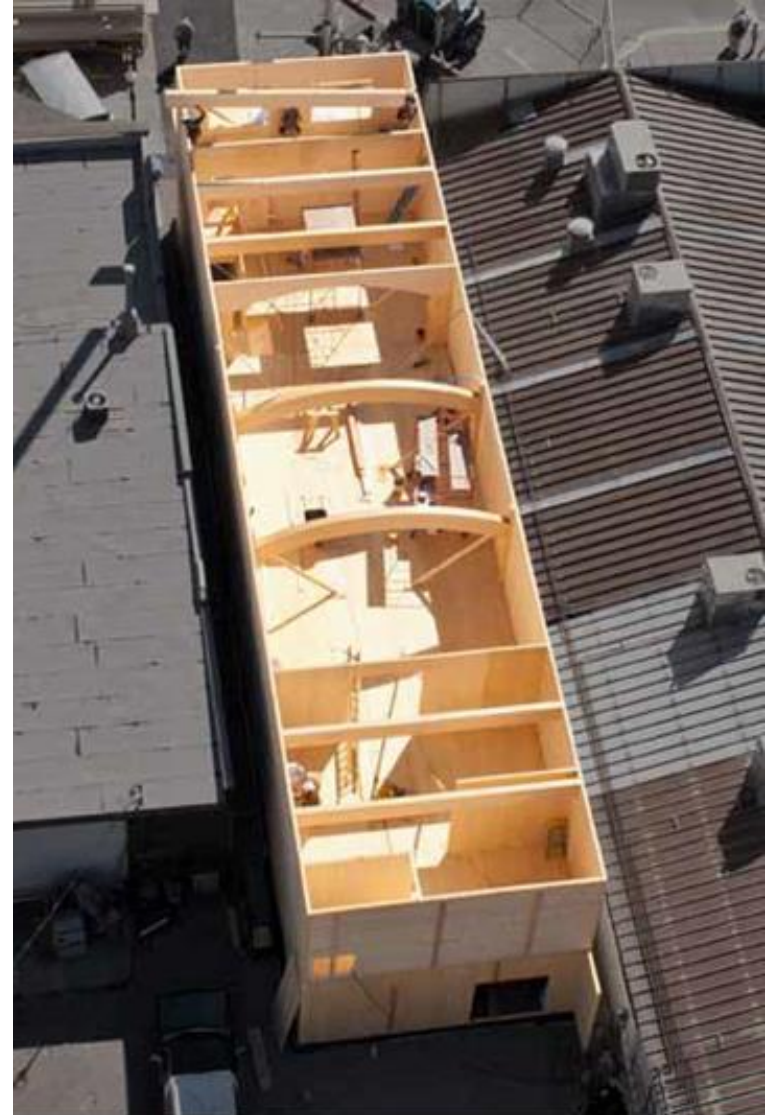
# CLT Projects in North America



[www.nordicewp.com](http://www.nordicewp.com)

Mississauga, ON

[www.woodworks.org/resources/clt-milestone-montana/](http://www.woodworks.org/resources/clt-milestone-montana/)



Whitefish, MT



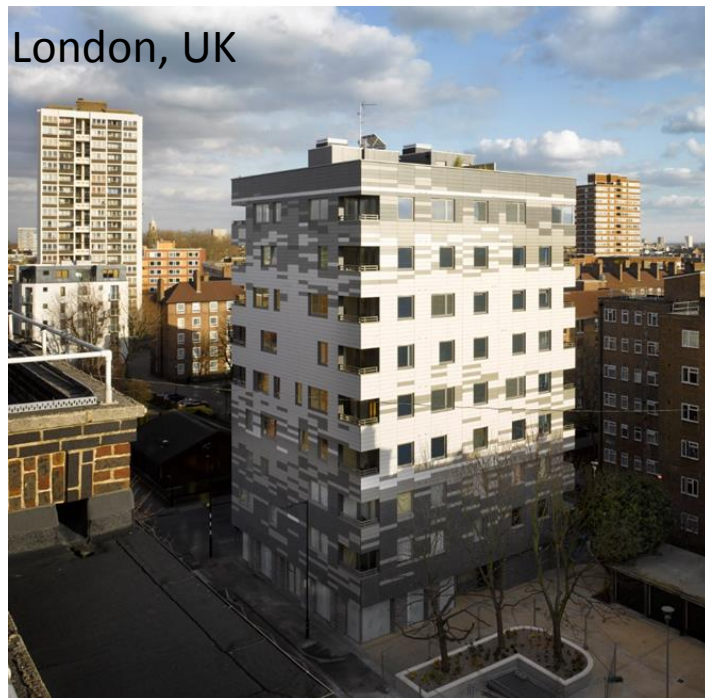
# White House Rural Council

- March 18, 2014 Workshop: *“Building with Wood: Jobs and the Environment”*
- USDA Sec. Tom Vilsack: \$1,000,000 prize for a competition to design and build high-rise wood demonstration projects
- Objective: to accelerate technology transfer and implementation of expanded uses of wood products for building construction in the U.S.

# Vertical Limitation in U.S

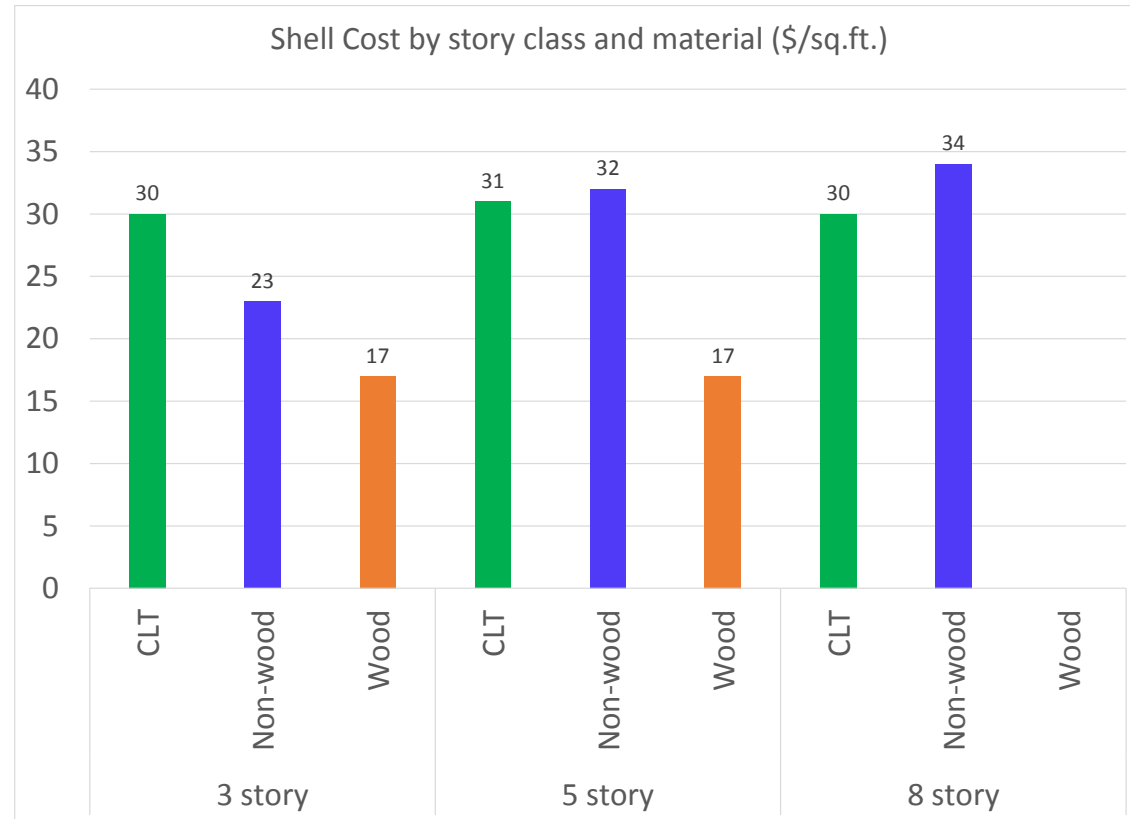
- **At present – not able to build >6 floors due to Fire Code**

Melbourne, Australia



# CLT Market Potential

- CLT shell cost competitive at taller heights or large size
- U.S. market opportunity: 0.9 to 2.7 BBF



# CLT Market Potential

- Potential increase - 2 to 7% in total U.S. softwood lumber demand over 2011 consumption.
- Equivalent to \$2 to \$6 billion of CLT shell value.
- **1-4 story segment represents the largest market opportunity**
- Opportunity will be in the non-residential market, notably commercial and institutional buildings

# Solid and Hollow-Core Cross-Laminated Timber Systems for Low- and Mid-Rise Construction

**Perry Peralta**

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# Cross-Laminated Timber

Enabling innovation: low- & mid-rise buildings

Growing the market for southern pine

Engaging stakeholders



Funding: USDA-NIFA Integrated Forest Products Research Program

# Phase 1: Preliminary Geometry Study

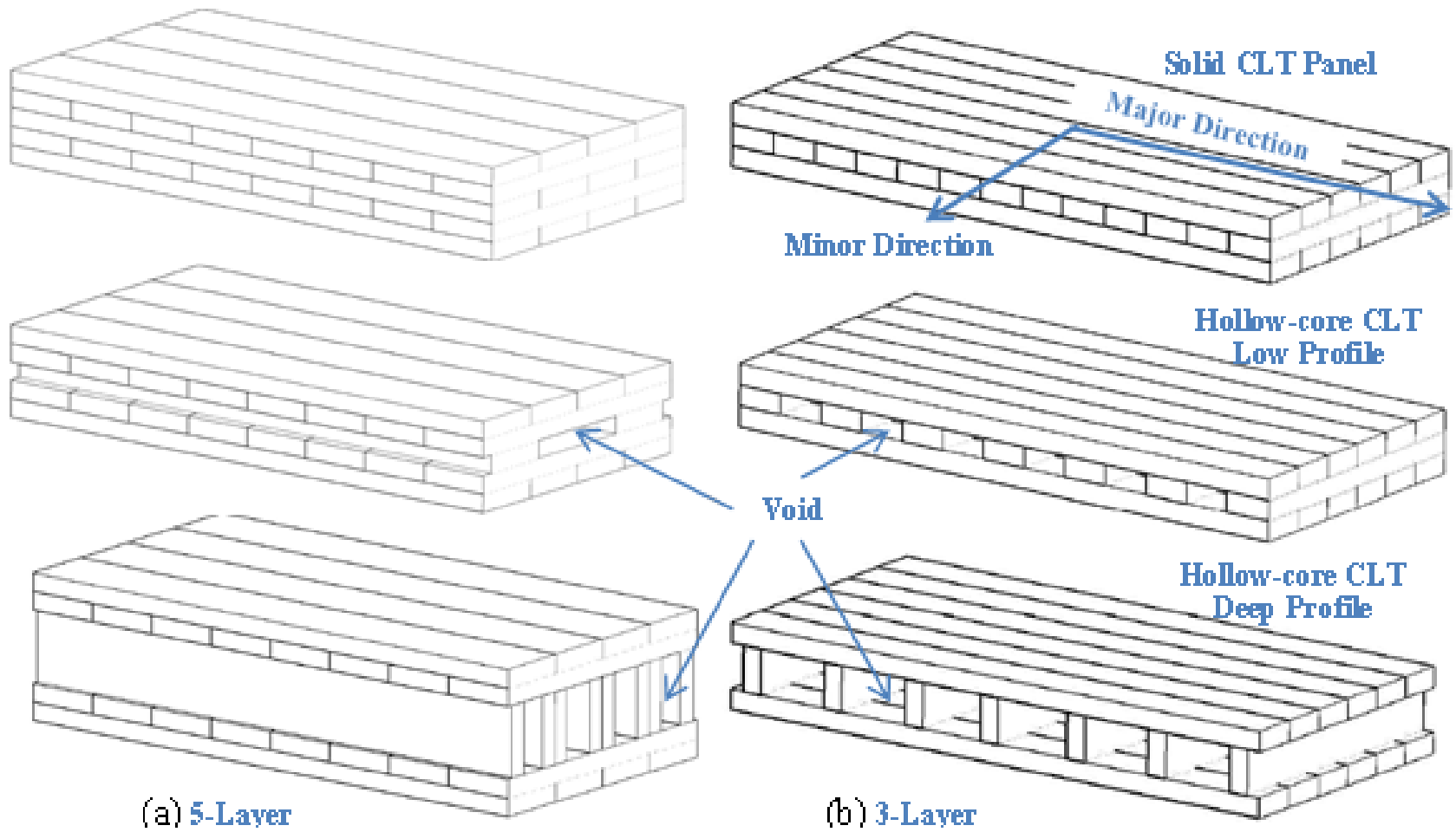


Figure 1: Solid and hollow-core CLT panels; (a) 5-layer and (b) 3-layer system.

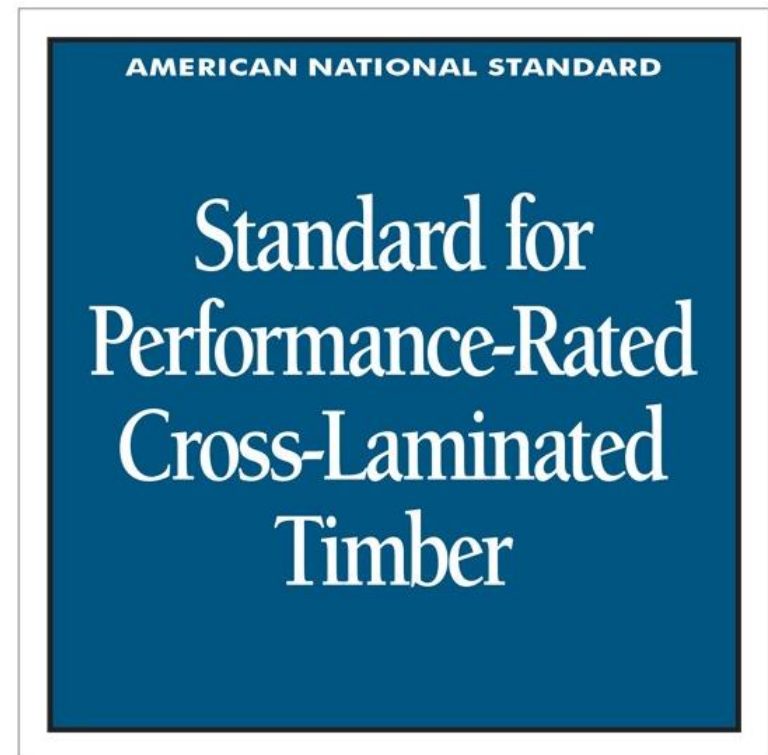
# *Phase 2: Pilot Production, Testing and Analysis of Small Panels*

- PRG 320 Section 6.3b
- ... adhesives shall be evaluated for heat performance in accordance with Section 6.1.3.4 of DOC PS1



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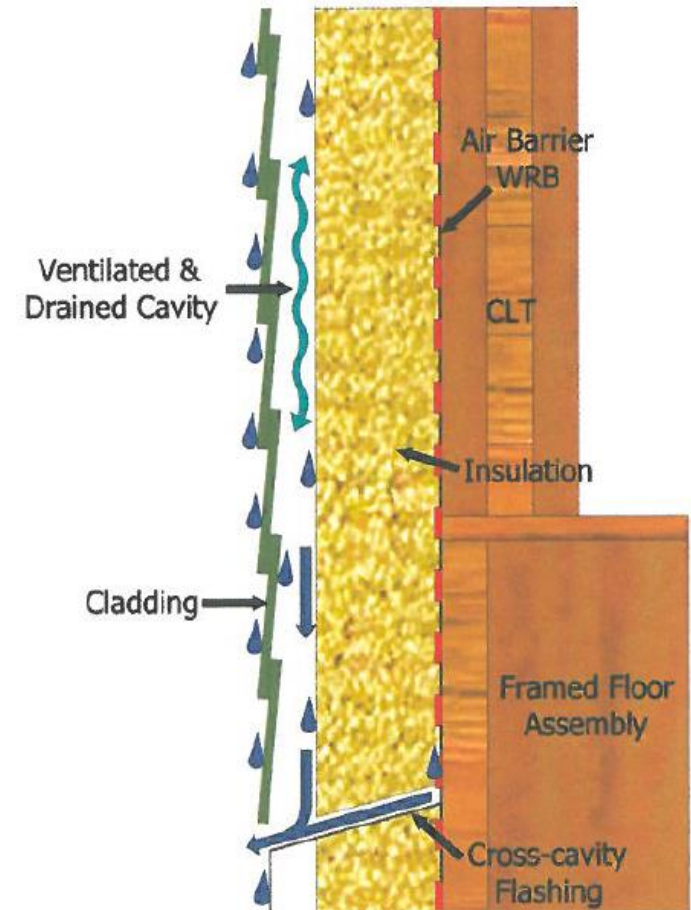
**ANSI/APA PRG 320-2012**





# Phase 3: Manufacturing, Testing and Analysis of Full-size Panels

- Fire
- Mechanical
  - Bending, shear and connections
- Hygrothermal



Source: CLT Handbook

# *Phase 4: Mock-up Design and Analysis of CLT buildings*

- Relative performances of CLT, light-frame wood, and RC/steel buildings
  - maximum drift under extreme wind event
  - maximum drifts under a suite of design-level,
  - construction cost
  - constructability and construction schedule

# *Phase 5: Outreach to Stakeholders*

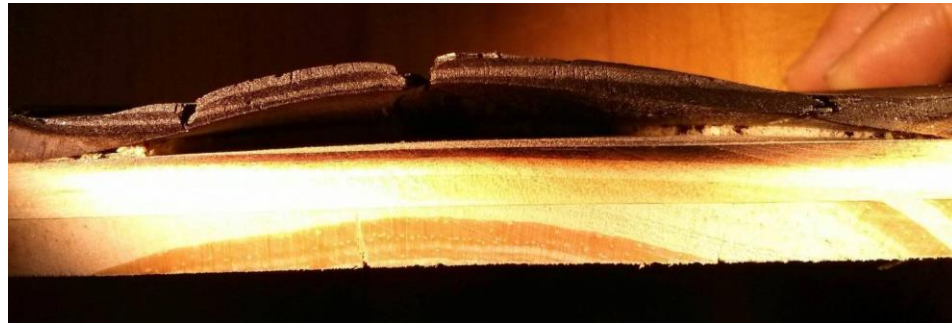
- Develop CLT educational materials
- Use social media for reporting project progress and CLT-related news
- Create extension web site
- Develop apps for CLT design values and hygrothermal requirements



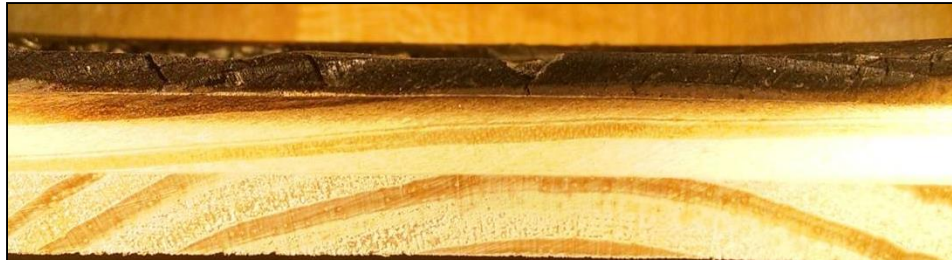
# DOC PS1

- Voluntary Product Standard, Structural Plywood
- Section 6.1.3.4 – Heat Performance Test
- Subject specimen to a 800C to 900C flame from a Bunsen-type burner for 10 minutes

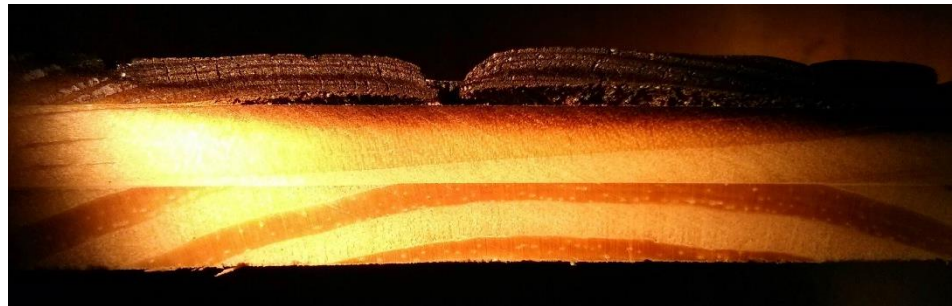




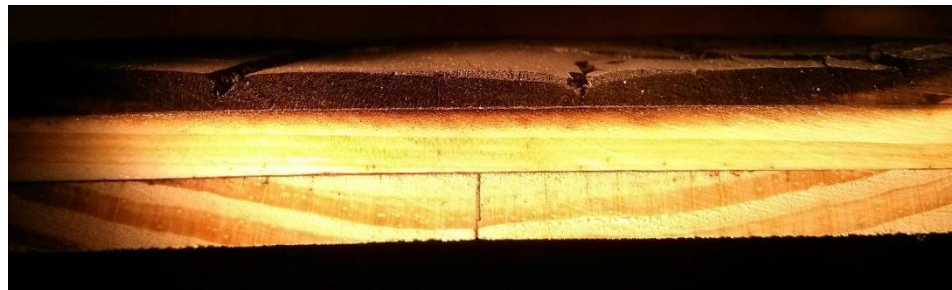
**PUR**  
(Polyurethane)



**EPI**  
(Emulsion Polymer  
Isocyanate)

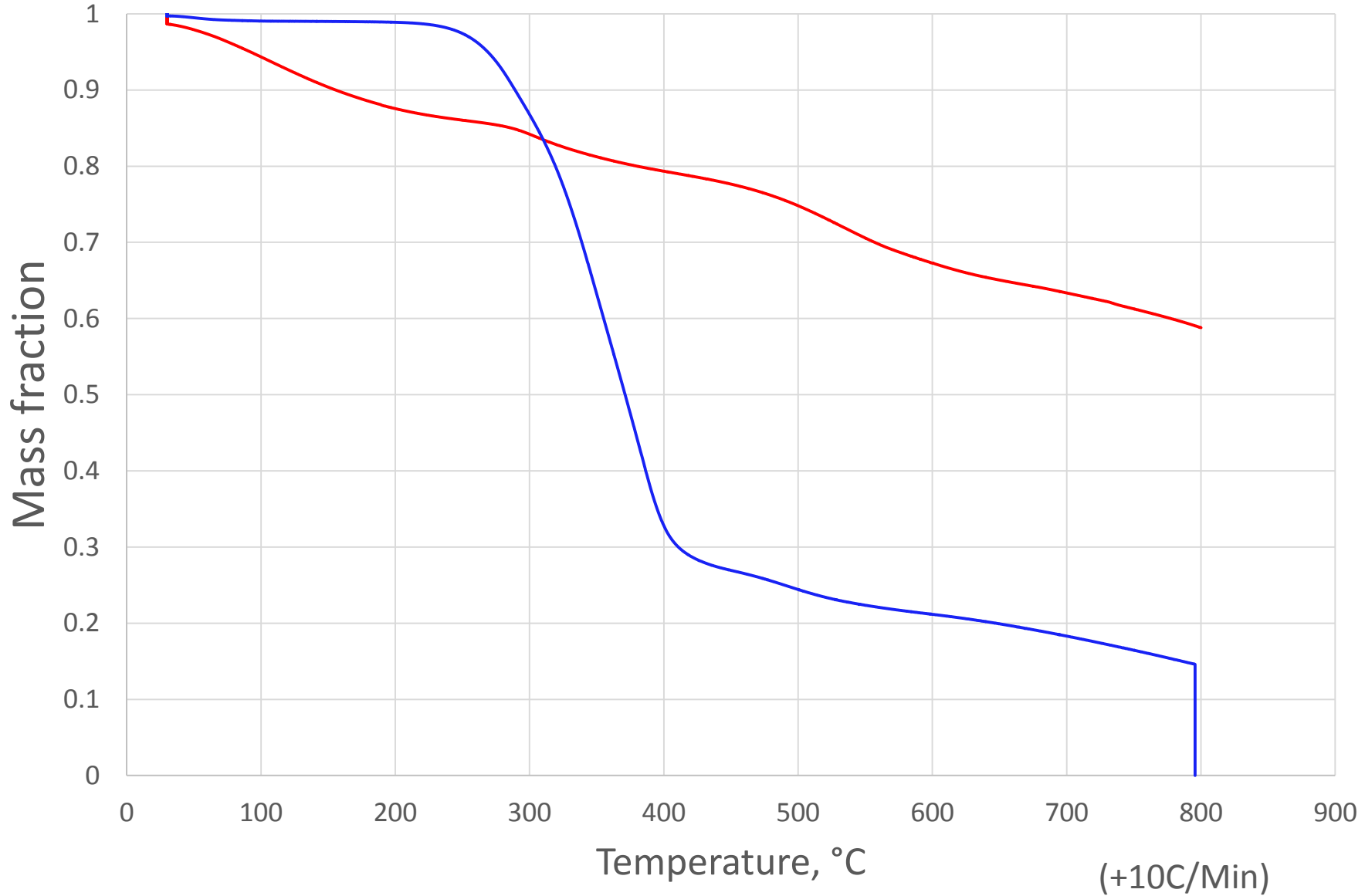


**MF**  
(Melamine  
Formaldehyde)



**PRF**  
(Phenol  
Resorcinol-  
formaldehyde)

— PRF — PUR



# Ongoing Research

- Phase 3 – Fire Test Full Sized Panels
- Series of specimens to be tested in the horizontal furnace at FPL
  - Type of CLT/Wood component
  - Type of adhesive
  - Added fire protection



# Fire Testing Full Sized Panel

- Horizontal furnace used to subject specimens to the ASTM E119 fire exposure

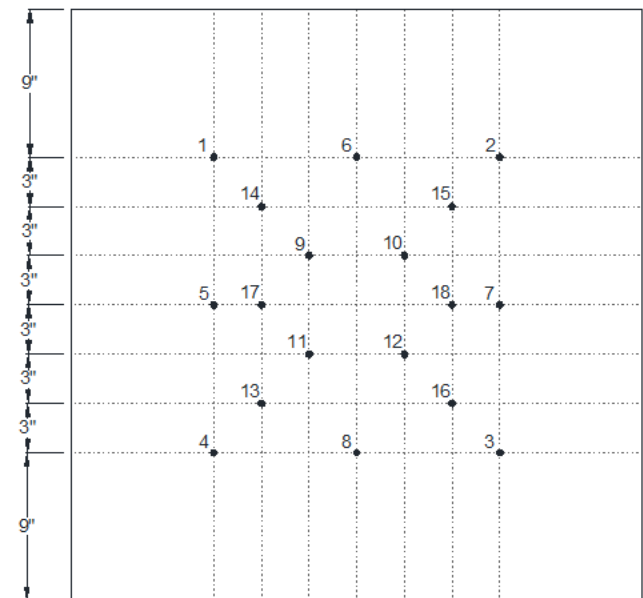


Table 2. Current test matrix.

Test No.	Configuration No.	Wood Component	Adhesive	Protection
1	1	5-Solid	M	None
2	1	5-Solid	M	None
3	2	5-Solid	PRF	None
4	3	3-Low	M	Gypsum w/o joint
5	4	3-Low	PRF	Gypsum w/o joint
6	5	3-Depth	M	Gypsum w/o joint
7	6	3-Depth	PRF	Gypsum w/o joint
8	7	5-Low	M	None
9	8	5-Depth	M	None
10	9	3-Solid	M	Gypsum w/o joint
11	9a	3-Solid	M	Gypsum with joint
12	9b	3-Solid	M	Gypsum with joint
13	10	5-Solid	PUR	None

May consider using EPI in lieu of M

Specimen 1



Thermocouple Array

# Conclusion

- Initial Results Demonstrate Importance of Proper Adhesives at Product Enters Market
- Small panel test highly relevant as product development gains momentum resulting in varying thicknesses and configuration of panels
- Ongoing Research (Phase III→) should continue to provide insight for initial market configurations

# Thank You

- Questions??

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