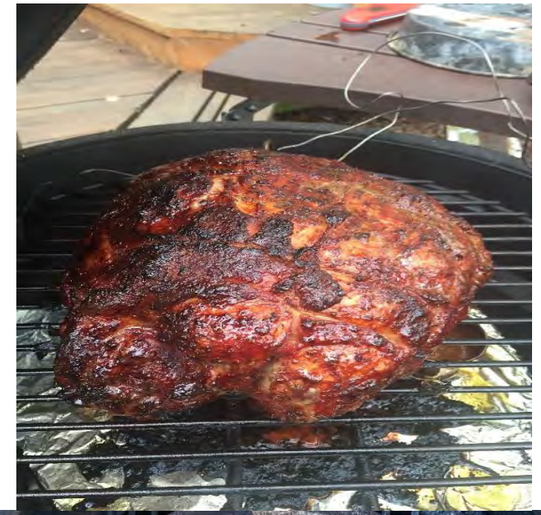
HOW WOOD SPECIES INFLUENCE FLAVOR PROFILES IN FOOD, BBQ, SINGLE MALT SCOTCH, BOURBON, & WINE



Matt Hunter, Single Malt Afficionado & BBQ Pitmaster
Northeast Regional Manager
American Wood Council

Mass Timber Fire Testing at RISE

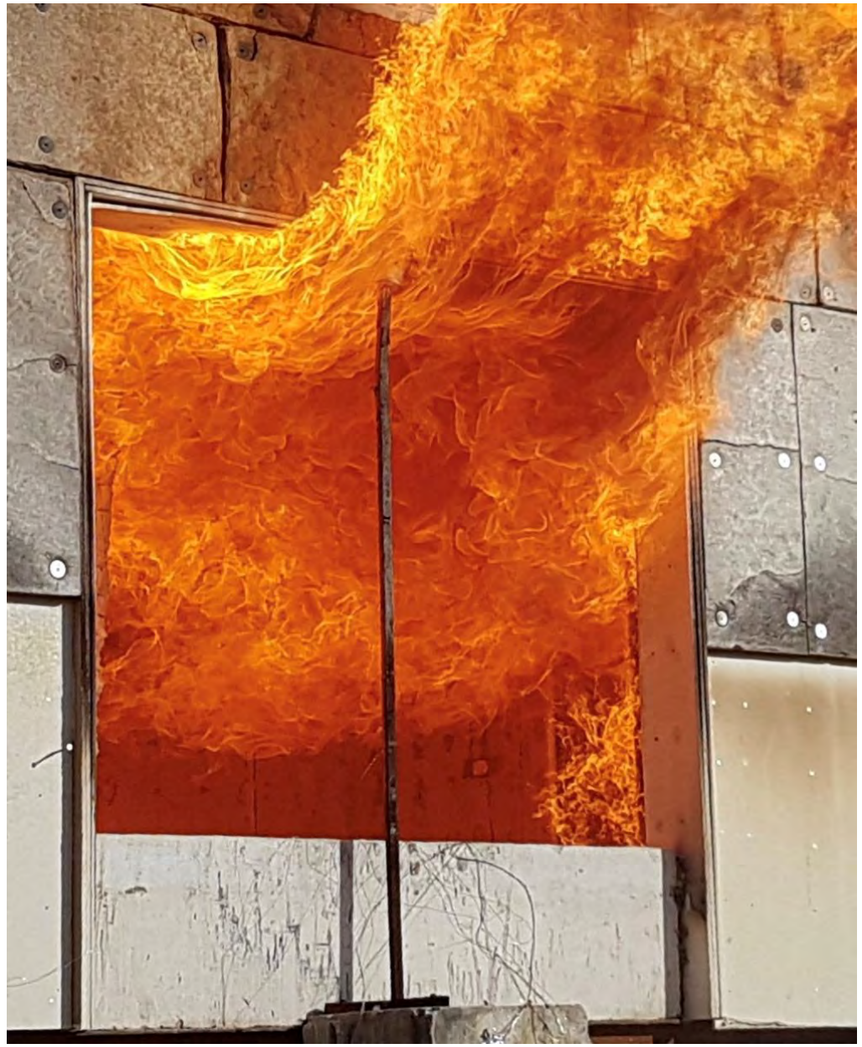
Establishing Safe Exposed Area Limits For the New Generation of Mass Timber

Matthew "Matt" Hunter, BCO
Northeast Regional Manager
American Wood Council

Advancing Mass
Timber Construction 2021

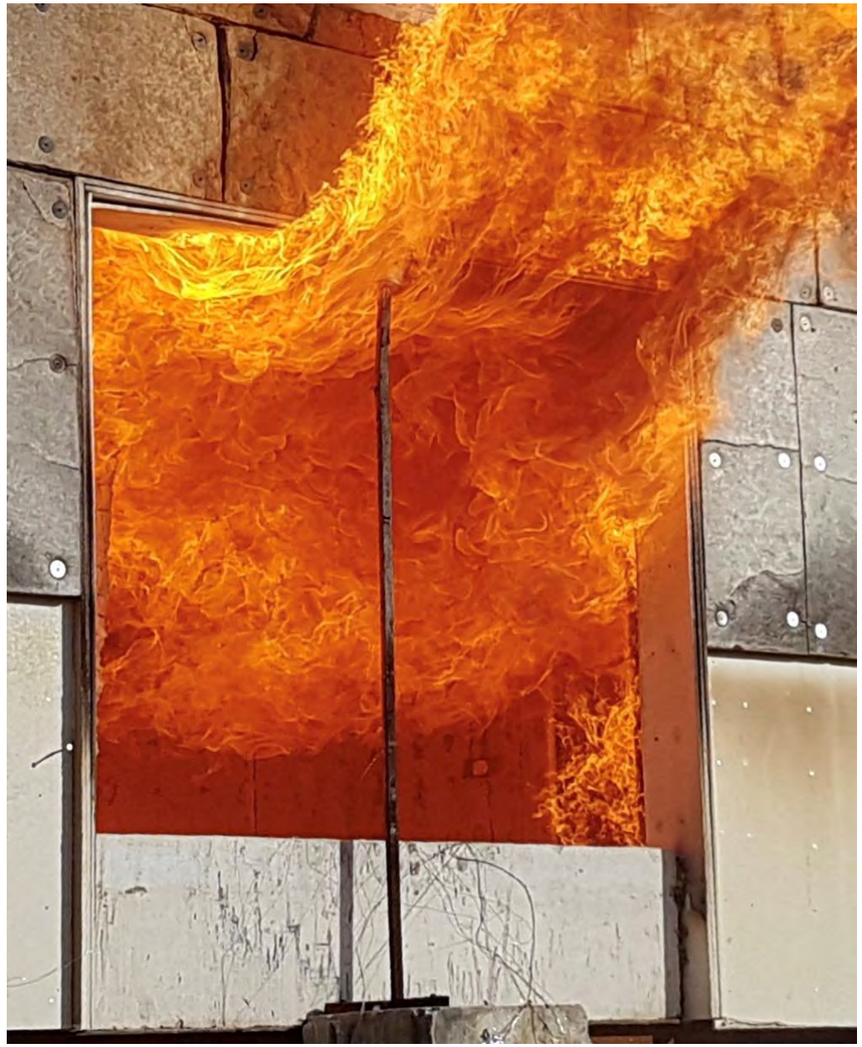
OUTLINE

- Development of New Mass Timber Construction Types
- Summary of Previous Testing
- Reason for Additional Testing
- Fire Testing Performed at RISE
- Applying What We've Learned



LEARNING OBJECTIVES

- Development of New Mass Timber Construction Types
- Summary of Previous Testing
- Reason for Additional Testing
- Fire Testing Performed at RISE
- Applying What We've Learned



FUN / ICEBREAKER POLLING QUESTION

According to the rock media, the Greatest Rock and Roll band of all time is?

a) Spinal Tap

b) AC/DC

c) The Rolling Stones

d) Led Zeppelin

e) Motörhead

f) All of the Above

OUTLINE-KEY TAKEAWAY

Mass Timber ≠ Conventional Light-Frame

≠

DEVELOPMENT OF MT CONSTRUCTION TYPES

TWB identified six fire safety performance objectives to be met:

1. No collapse under reasonable scenarios of complete burn-out of fuel without automatic sprinkler protection being considered

2. No unusually high radiation exposure from the subject building to adjoining properties to present a risk of ignition under reasonably severe fire scenarios

3. No unusual response from typical radiation exposure from adjacent properties to present a risk of ignition of the subject building under reasonably severe fire scenarios

DEVELOPMENT OF MT CONSTRUCTION TYPES

TWB identified six fire safety performance objectives to be met:

4. No unusual fire department access issues

5. Egress systems designed to protect building occupants during design escape time, plus a factor of safety

6. Highly reliable fire suppression systems to reduce risk of failure during reasonably expected fire scenarios. Degree of reliability proportional to evacuation time (height) and risk of collapse.

DEVELOPMENT OF MT CONSTRUCTION TYPES

TYPES OF CONSTRUCTION

TYPE IV-A Mass Timber with noncombustible protection

- Noncombustible protection shall provide 2/3 of the required Fire Resistance Rating for Building Elements (Table 601, 602)
- Not permitted to have exposed mass timber

TYPE IV-B Mass Timber with limited portions of noncombustible protection omitted

- limits on how much mass timber can be exposed
- limits on how close exposed areas can be to one another

TYPE IV-C Mass Timber with no requirement for noncombustible protection, except certain locations

DEVELOPMENT OF MT CONSTRUCTION TYPES

TYPE OF CONSTRUCTION

TYPE IV-A Mass Timber with noncombustible protection

- Noncombustible protection shall provide 2/3 of the required Fire Resistance Rating for Building Elements (Table 601, 602)
- Taller buildings therefore not permitted to have exposed mass timber

TYPE IV-B Mass Timber with limited portions of noncombustible protection omitted

- limits on how much mass timber can be exposed
- limits on how close exposed areas can be to one another

TYPE IV-C Mass Timber with no requirement for noncombustible protection, except certain features

POLLING QUESTION

Which of the following is NOT one of the TWB Ad Hoc performance objectives?

a) No collapse under reasonable fire scenarios

b) No unusual fire department access issues

c) Egress systems protect occupants during escape

d) Occupants protected without leaving the building initially

DEVELOPMENT OF MT CONSTRUCTION TYPES

TYPE IV-B: Mass Timber with limited portions of noncombustible protection omitted

- limits on how much mass timber can be exposed
- limits on how close exposed areas can be to one another

Maximum Height	180 feet
Number of Stories	**≤12**
Exposed Mass Timber	Limited
Sprinklers	Yes
Primary Frame FRR	2 hours
Floor FRR	2 hours
Fire Resistance from Non-com	80 minutes
Stairs Tower	NC or Mass Timber with Protection
Concealed Spaces	Permitted but must have protection

NONCOMBUSTIBLE PROTECTION IN TYPE IV-B

602.4.2.2.2 Protected Area. All interior faces of all mass timber elements shall be protected in accordance with Section 602.4.2.2.1, including the inside faces of exterior mass timber walls and mass timber roofs.

Exceptions:

1. Unprotected portions of mass timber ceilings and walls complying with Section 602.4.2.2.4 and the following:

   1.1. Unprotected portions of mass timber ceilings, including attached beams, shall be permitted and shall be limited to an area equal to 20% of the floor area in any *dwelling unit* or *fire area*; or

   1.2. Unprotected portions of mass timber walls, including attached columns, shall be permitted and shall be limited to an area equal to 40% of the floor area in any *dwelling unit* or *fire area*; or

   1.3. Unprotected portions of both walls and ceilings of mass timber, including attached columns and beams, in any *dwelling unit* or *fire area* shall be permitted in accordance with section 602.4.2.2.3.

NONCOMBUSTIBLE PROTECTION IN TYPE IV-B

602.4.2.2.2 Protected Area

Exceptions (continued)

2. Mass timber columns and beams which are not an integral portion of walls or ceilings, respectively, shall be permitted to be unprotected without restriction of either aggregate area or separation from one another.

But only Exceptions 1.1 or 1.2 or 1.3 may be used in any dwelling unit or fire area. However, different dwelling units or fire areas may have a different choice.

AND Exception 2 applies to all choices all the time.

POLLING QUESTION

What is the maximum number of stories and maximum overall height in feet permitted for Type IV-B Construction?

a) 6 and 85’

b) 9 and 100’

c) 12 and 180’

d) 14 and 140’

NONCOMBUSTIBLE PROTECTION IN TYPE IV-B

602.4.2.2.3 Mixed Unprotected Areas. In each *dwelling unit* or *fire area*, where both portions of ceilings and portions of walls are unprotected, the total allowable unprotected area shall be determined in accordance with Equation 6-1.

$$(U_{tc}/U_{ac}) + (U_{tw}/U_{aw}) \leq 1 \qquad \text{(Equation 6-1)}$$

where:

U_{tc} = Total unprotected mass timber ceiling areas

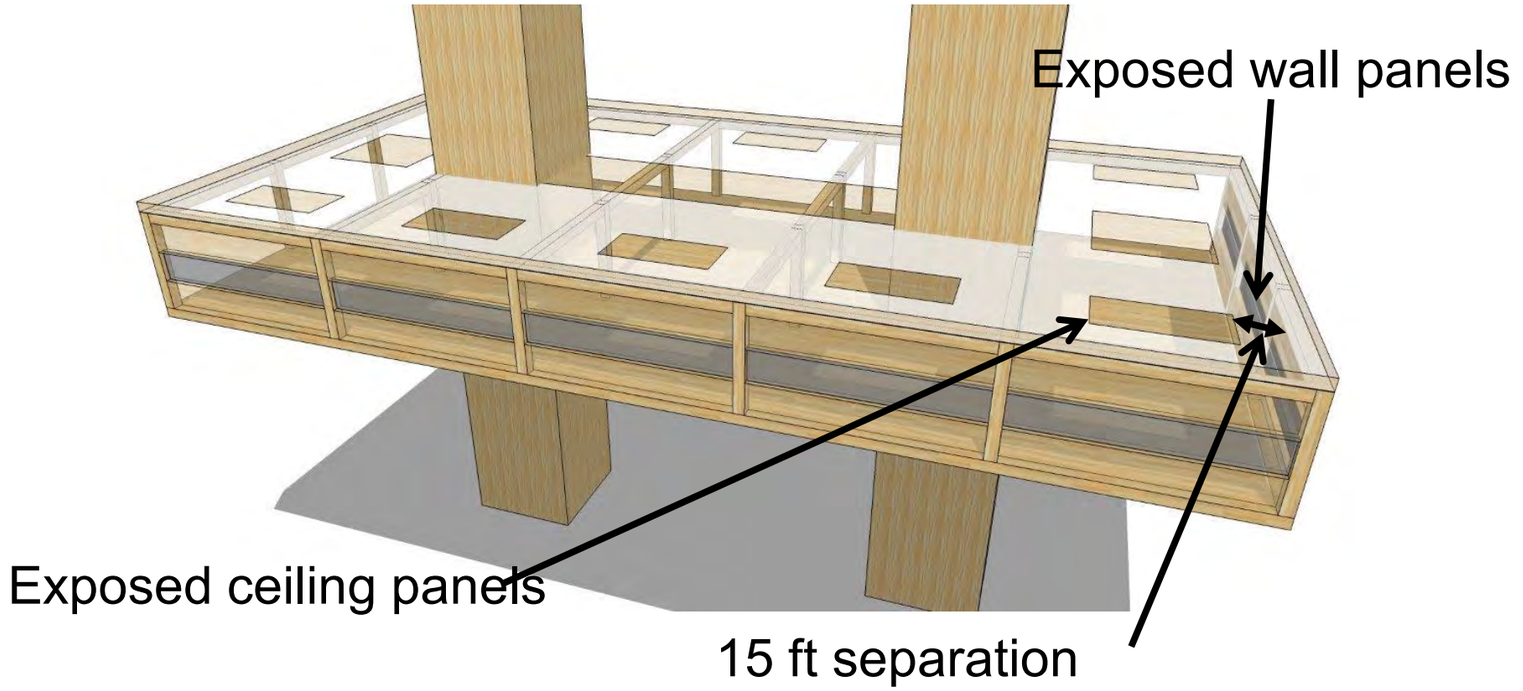
U_{ac} = Allowable unprotected mass timber ceiling area conforming to Exception 1.1 of Section 602.4.2.2.2

U_{tw} = Total unprotected mass timber wall areas

U_{aw} = Allowable unprotected mass timber wall area conforming to Exception 1.2 of Section 602.4.2.2.2

NONCOMBUSTIBLE PROTECTION IN TYPE IV-B

602.4.2.2.4 Separation Distance Between Unprotected Mass Timber Elements. In each *dwelling unit* or *fire area*, unprotected portions of mass timber walls and ceilings shall be not less than 15 feet from unprotected portions of other walls and ceilings, measured horizontally along the ceiling and from other unprotected portions of walls measured horizontally along the floor.



POLLING QUESTION

What is the minimum offset distance between exposed mass timber ceilings and wall elements?

a) 10′ 6″

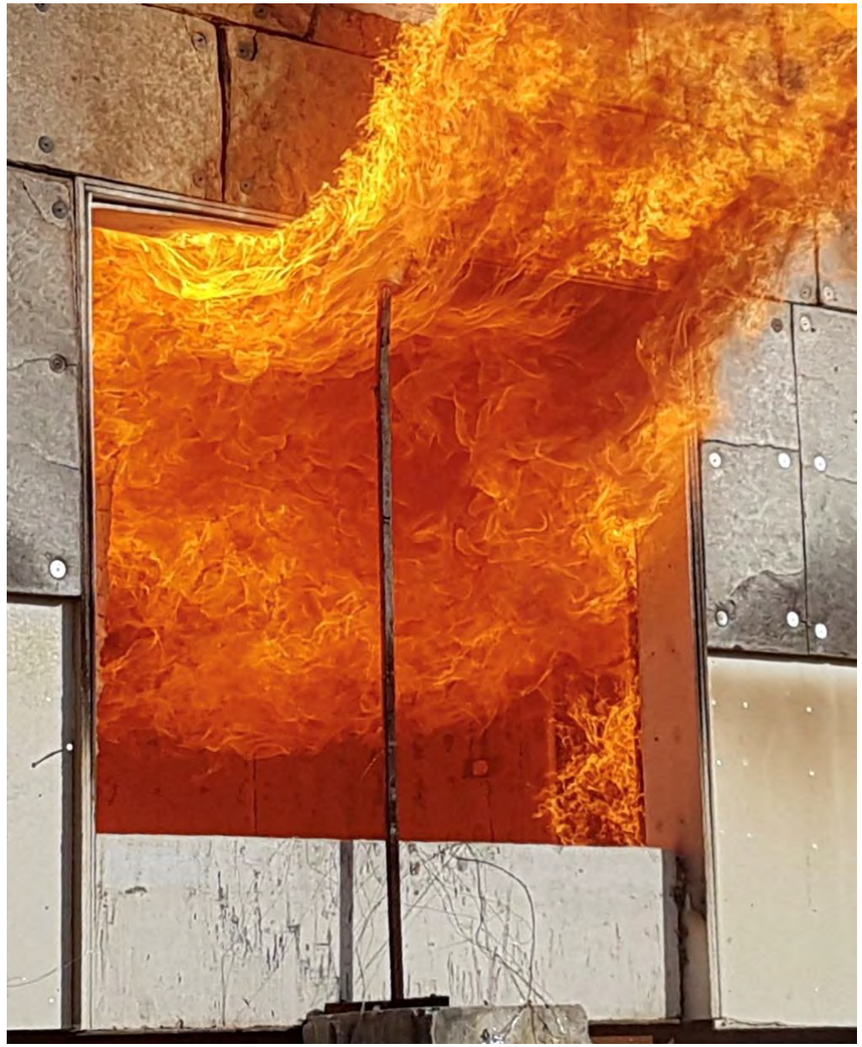
b) 12′ 0″

c) 10′ 0″

d) 15′ 0″

OUTLINE

- Development of New Mass Timber Construction Types
- Summary of Previous Testing
- Fire Testing Performed at RISE
- Applying What We've Learned



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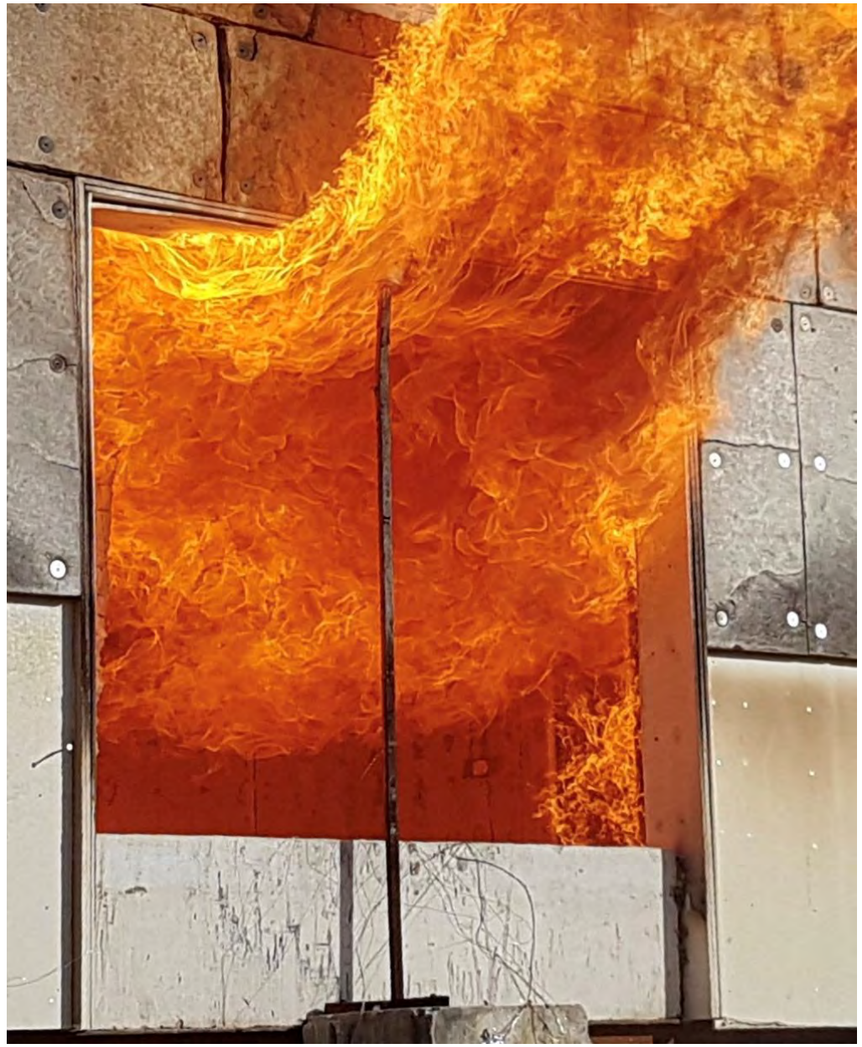
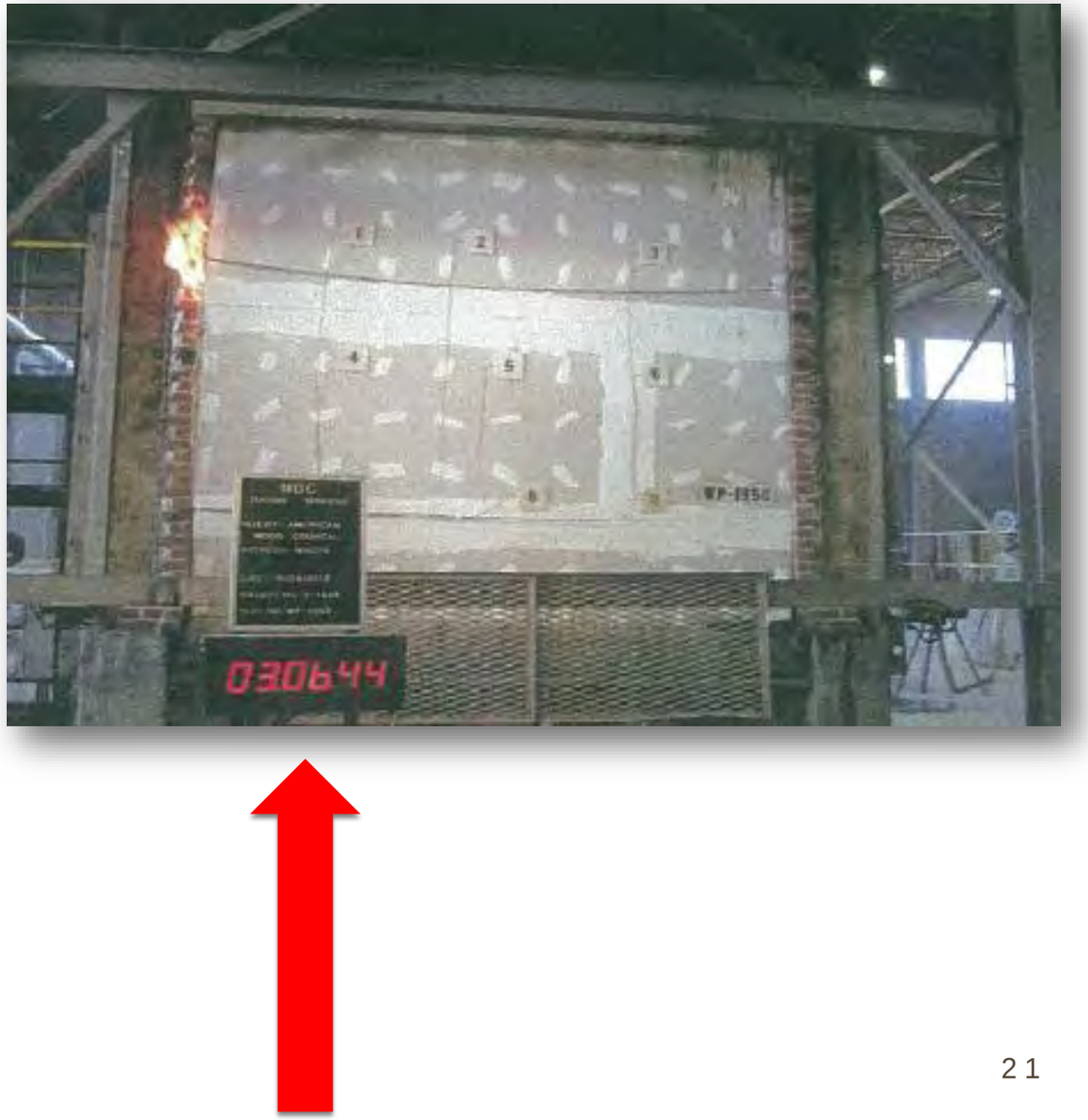
MASS TIMBER/CLT PRIOR TESTING

- Buffalo, NY ASTM E119, 2012
- SwRI-San Antonio, TX Compartment Test, 2015
- NIST/NFPA-Gaithersburg, MD 2017-late winter
- SwRI-San Antonio, TX PRG320-18 Fire Resistant Adhesive Testing, 2017-Fall
- 5 ATFE Tests, Beltsville, MD Summer 2017
- Explosive Testing, FPL, WoodWorks, Tyndall AFB, Panama City, FL 2016-17



PRIOR TESTING-FIRE TEST LABS, NGCTS

- Buffalo, NY ASTM E119 test
- Testing for 2-hour FRR Wall Assembly
- 2 sheets of 5/8” Type X drywall, 1 inside/1 outside inside
- 5 ply, non-compliant w/ANSI/APA PRG 320-18 adhesive-polyurethane, 7 inches thick CLT panels tested
- 3 hours, 6 minutes of fire resistance!



PRIOR TESTING-SOUTHWEST RESEARCH

- SwRI-San Antonio, TX Compartment Test, 2015
- Non-standard, high residential fuel load, “modern furnishings”
- 5.5 Megawatts of heat release
- 2-layers, 5/8” Type X gypsum
- No damage to protected CLT after multiple fire tests of same compartment
- 5.5 Megawatt Fire*

PRIOR TESTING-NIST/NRC

- Gaithersburg, MD 2018
- 6 tests-Baseline testing and exposed ceiling and opening variations
- 1st Generation adhesive used was <u>non-compliant</u> for heat resistant adhesives → Let's discuss!
- <u>Exhibited fire regrowth characteristics</u> → What does this mean?
- Indicated the need for Mass Timber adhesives with enhanced fire performance. → Hence APA/ANSI PRG-320-18

PRIOR TESTING NIST/NRC TEST 1-4

- Large, unprotected areas of ceiling and walls
- Critical importance of the adopted CLT production standard, ANSI/APA PRG-320 in 2021 IBC

PRIOR TESTING-SOUTHWEST RESEARCH

- Compartment Tests, Fall 2017
- PRG320-18 Fire Resistant Adhesive Testing
- Validated the FRR of updated adhesives
- No fire regrowth

PRIOR TESTING-5 ATF TESTS

- Beltsville, MD @ ATF Test Lab
- Largest fires ever tested @ ATF
- 1) Baseline-Fully protected
- 2) Exposed Ceilings
- 3) Exposed Walls
- 4) Normal Sprinkler Activation
- 5) 23 Minute Sprinkler Delay
- All TWBAH objectives met

PRIOR TESTING-ATF TEST #1

- Test Video
- Fully protected-Type X Gypsum
- 18-MW heat release
- CLT was not affected by fire
- ..\CROSS LAMINATED TIMBER and TALL WOOD\ATFE LAB TESTS\ACCELERATED VIDEOS 1-5\ATF Test 1 Superfast HD.mov

PRIOR TESTING-ATF TEST #3

- Test Video #3
- Partially exposed walls
- 23-MW heat release
- Energy equivalent of 360 gallons of gasoline in the compartment
- No fire regrowth
- CLT self-extinguished
- ..\CROSS LAMINATED TIMBER and TALL WOOD\ATFE LAB TESTS\ACCELERATED VIDEOS 1-5\ATF Test 3 - High Resolution.mov

REASON FOR ADDITIONAL TESTING

- Tests performed at ATF used previous generation of CLT
  - PRG 320-18 – compliant CLT not available at the time
  - Type IV-B exposed mass timber limits based on these tests
- 2021 IBC requires compliance with PRG 320-18
  - Mismatch between the material requirements for CLT vs. the exposed mass timber area limits in 2021 IBC
  - Additional testing on PRG 320-18-compliant CLT needed to determine appropriate area limits

RESEARCH AT RISE

Similar to ATF compartment tests in 2018, ***EXCEPT:***

- PRG 320-18 compliant CLT
- Increased the amount of exposed mass timber

OBJECTIVES

Primary

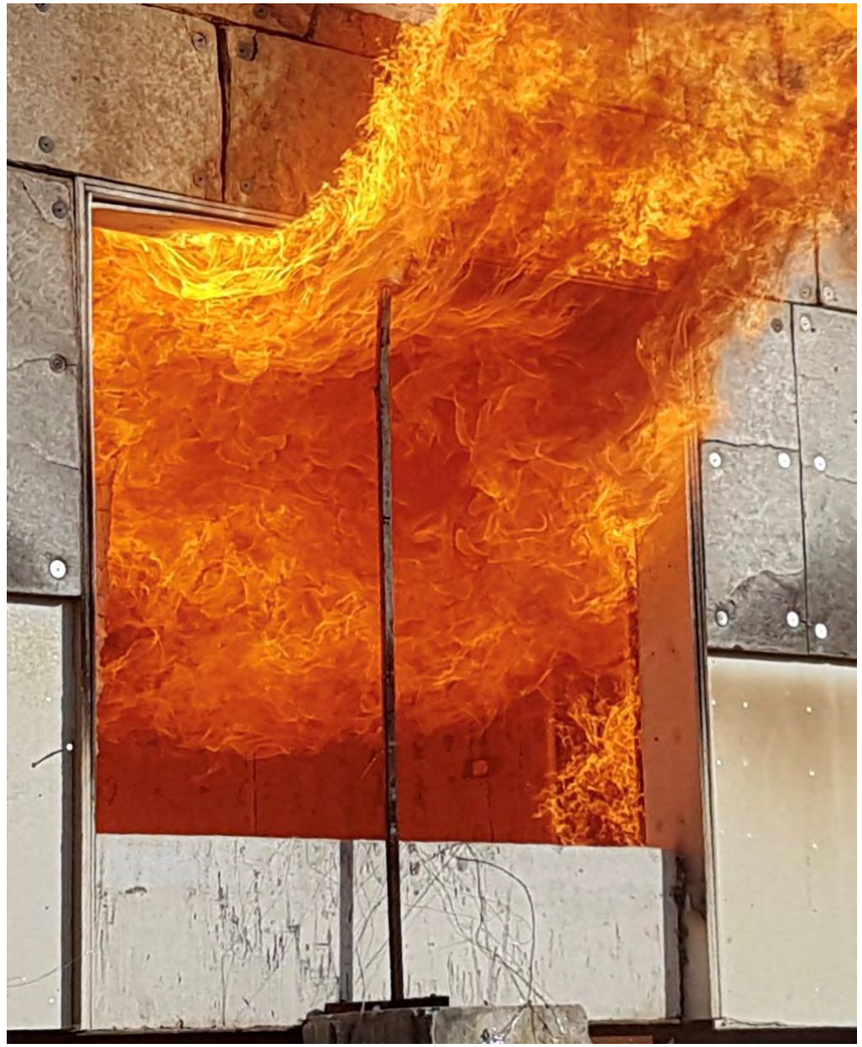
- Design and perform 5 compartment fire tests with PRG 320-2018 compliant CLT & varying amounts of exposed mass timber areas.
- Determine whether increased areas of exposed mass timber are justifiable using CLT compliant with PRG 320-18, based on performance criteria used in ATF tests

Secondary

- Design and test intersections between exposed mass timber members
- Record façade exposure allowing for comparisons with standard façade testing methods.
- Predictive modeling
- Case study for restoring exposed CLT members after a fire.

OUTLINE

- Development of New Mass Timber Construction Types
- Reason for Additional Testing
- Fire Testing Performed at RISE
- Applying What We've Learned



Fire Safe Implementation of Visible Mass Timber in Tall Buildings

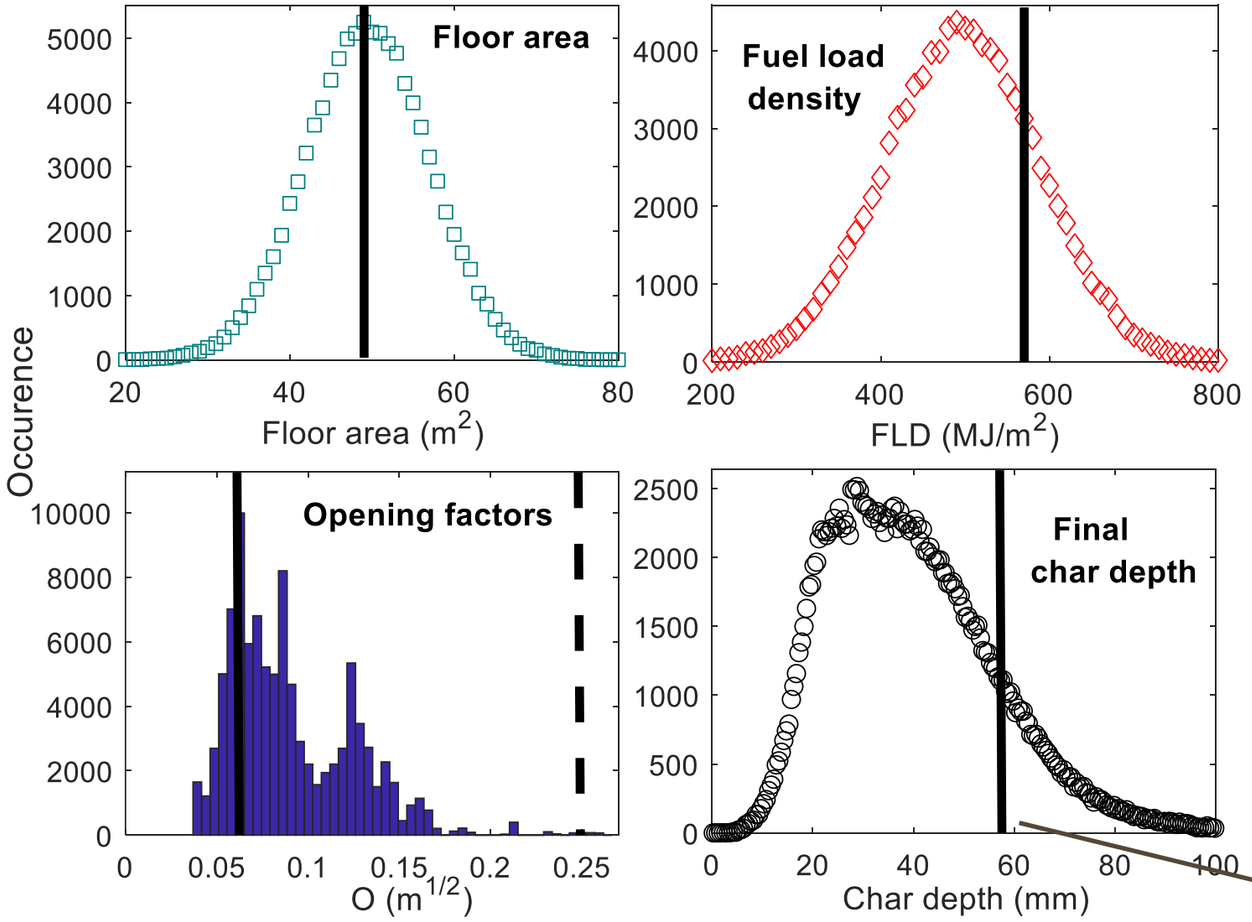
Project Team:

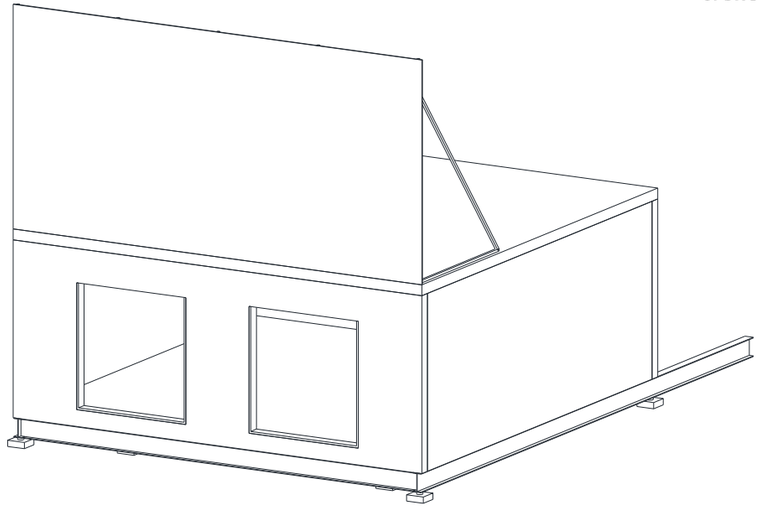
Daniel Brandon, Johan Sjöström, Alastair Temple,

Emil Hallberg, Fredrik Kahl

DESIGN VALUES – *SEVERE* BUT *REPRESENTATIVE*

For residential occupancy

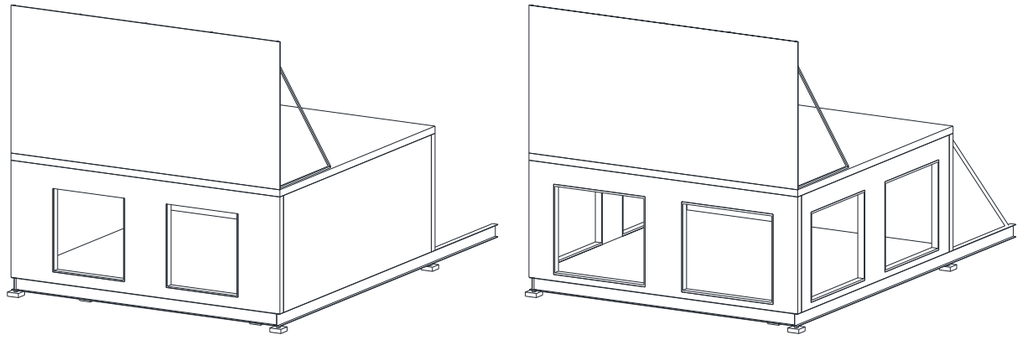




Small opening factor

- Floor area 49m^2
- Opening factor 0.062m$^{1/2}$)
- Fuel load density 560 MJ/m^2
- 85th percentile damage

SEVERE BUT *REPRESENTATIVE* – OPENING FACTOR

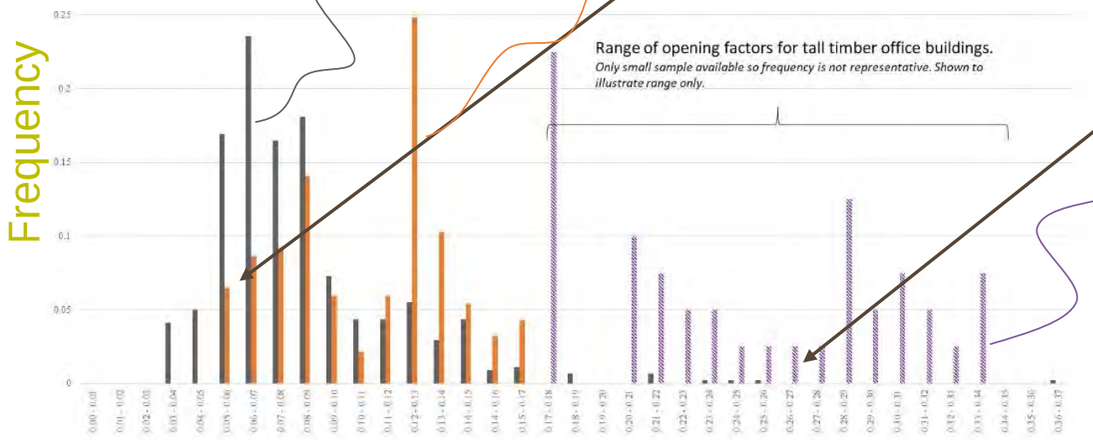


Test 1, 2, 3 and 5

Test 4

Multi-storey residential compartments (non-timber)

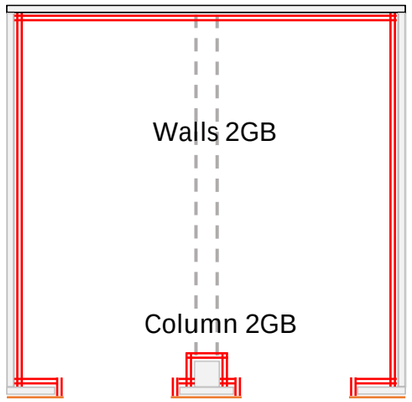
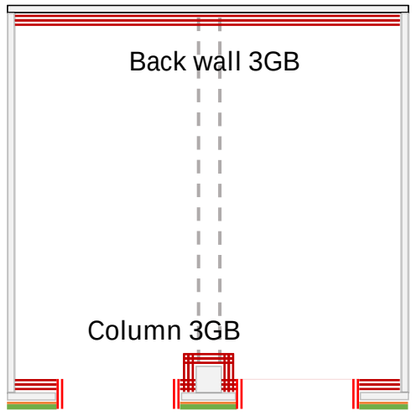
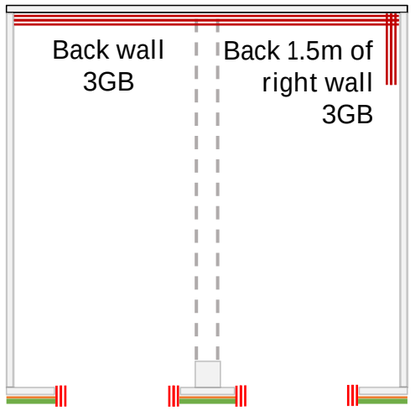
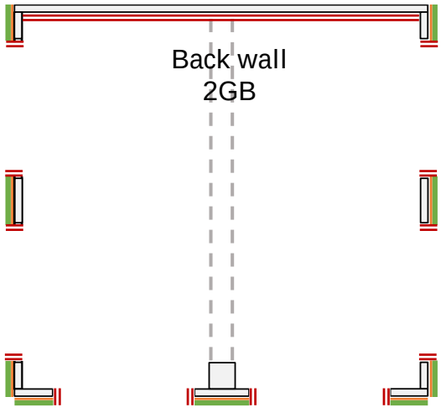
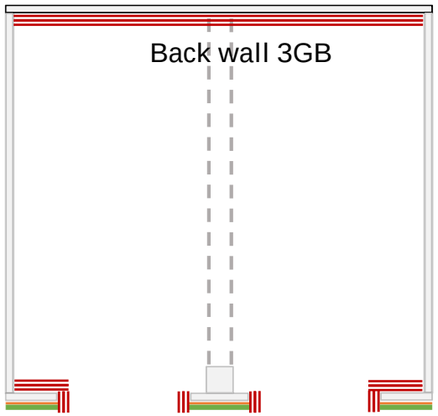
Multi-storey residential compartments (mass timber)



Multi-storey business compartments

Increasing opening factor

TEST CONFIGURATIONS

Test 1	Test 2	Test 3	Test 4	Test 5
				
Openings 2GB Facade 1GB	Openings 2 GB sides; 3GB top Facade 1GB + 50mm SW	Openings 3GB** Facade 1GB + 45mm SW	Openings 2GB Facade 1GB + 50mm SW	Openings 3GB** Facade 1GB + 50mm SW

Configurations based on a combination of:

- Performance of the previous test
- Modeling predictions
- Opinion of the steering group

CONSTRUCTION

FURNISHINGS

TEST VIDEOS-DURING

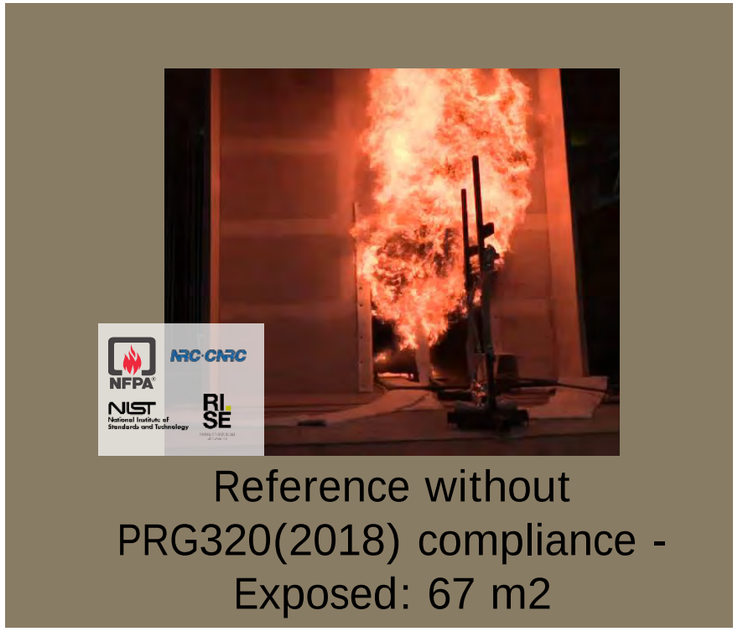
Test 1 - Exposed timber: 53.8 m^2

Test 2 - Exposed timber: 91.2 m2

Test 3 - Exposed timber: 96.2 m2

Test 4 - Exposed timber: 77.9 m2

Test 5 - Exposed timber: 97.2 m2



Reference without PRG320(2018) compliance - Exposed: 67 m2

TEST VIDEOS-AFTER

Test 1 - Exposed timber: 53.8 m^2

Test 2 - Exposed timber: 91.2 m^2

Test 3 - Exposed timber: 96.2 m^2

Test 4 - Exposed timber: 77.9 m^2

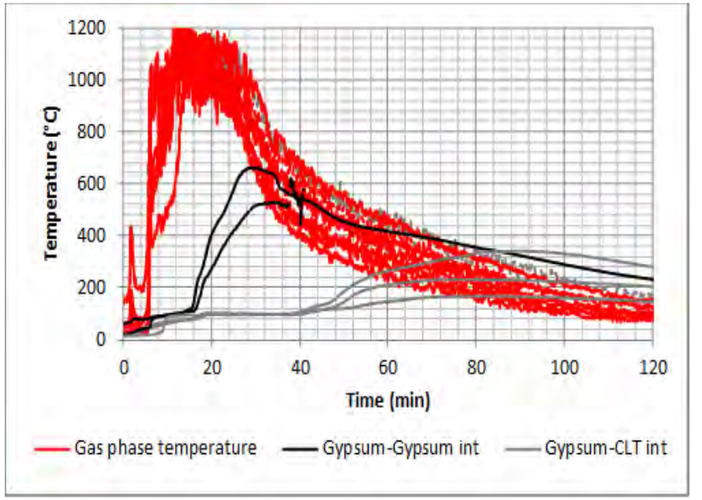
Test 5 - Exposed timber: 97.2 m^2

Reference <u>without</u> PRG320(2018) compliance - Exposed: 67 m^2

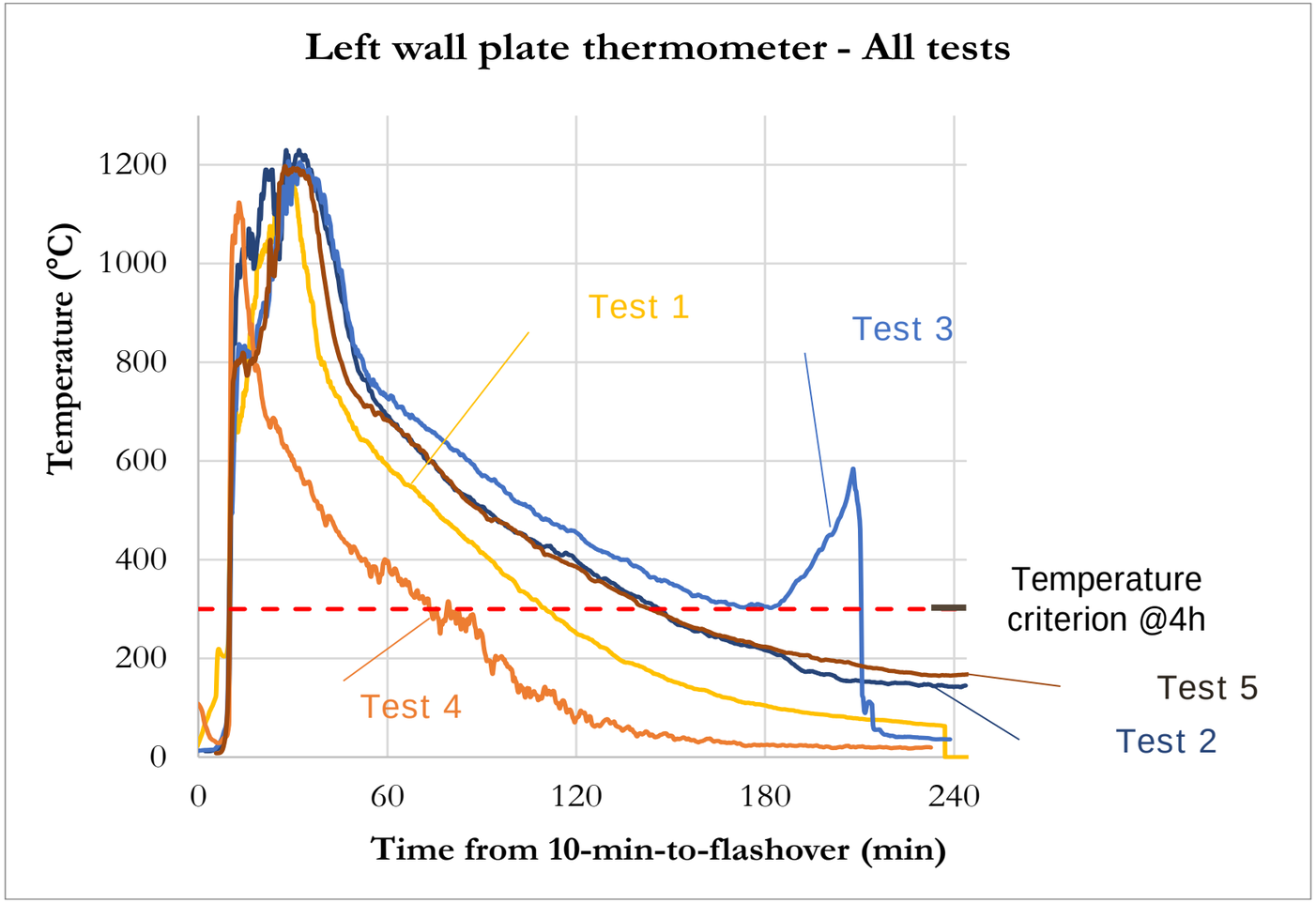
RESEARCH AT RISE

Objective:

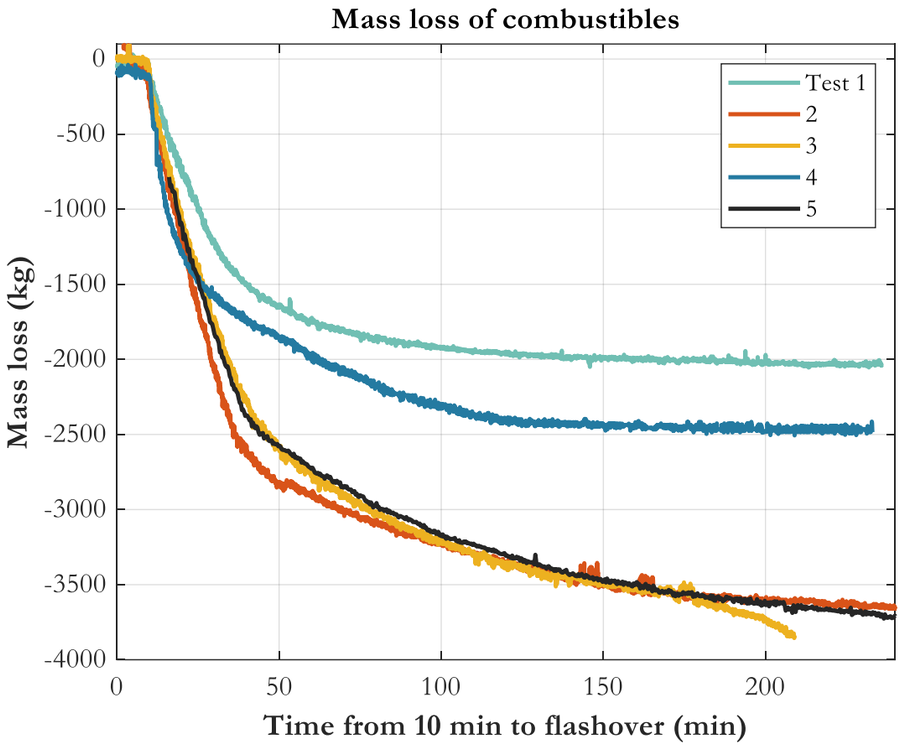
- Determine whether increased areas of exposed mass timber are justifiable using CLT compliant with PRG 320-18

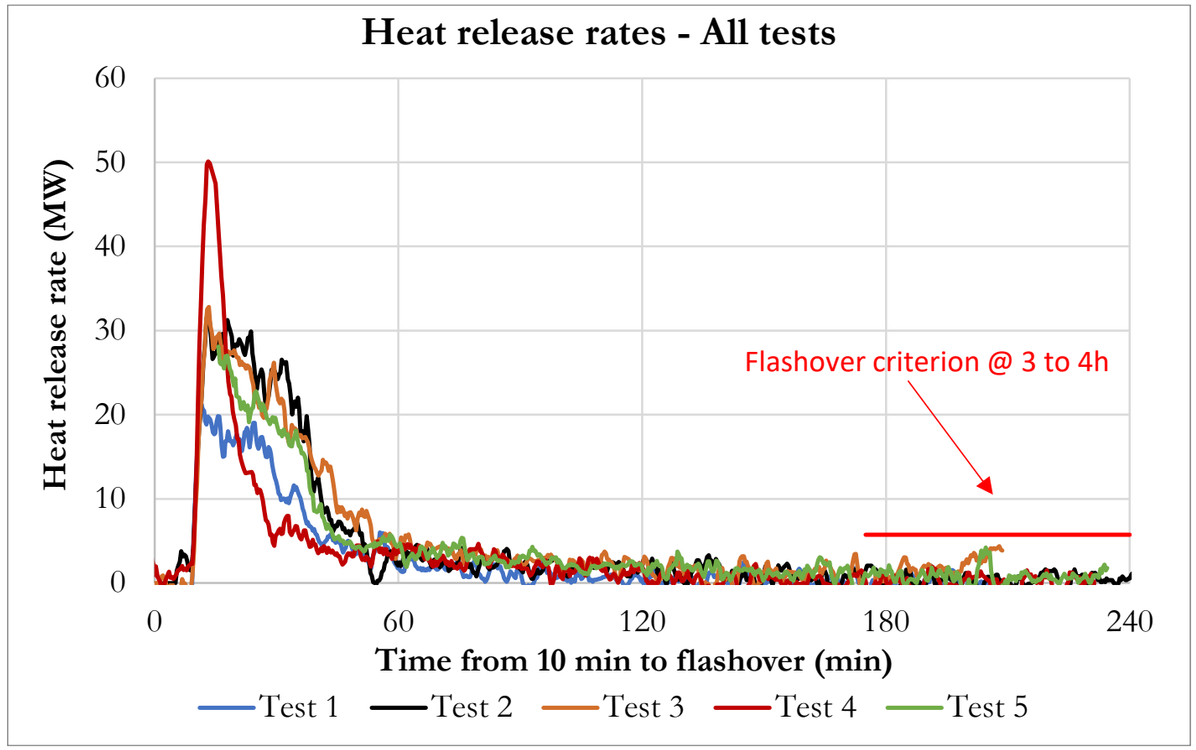


FIRE TEST RESULTS

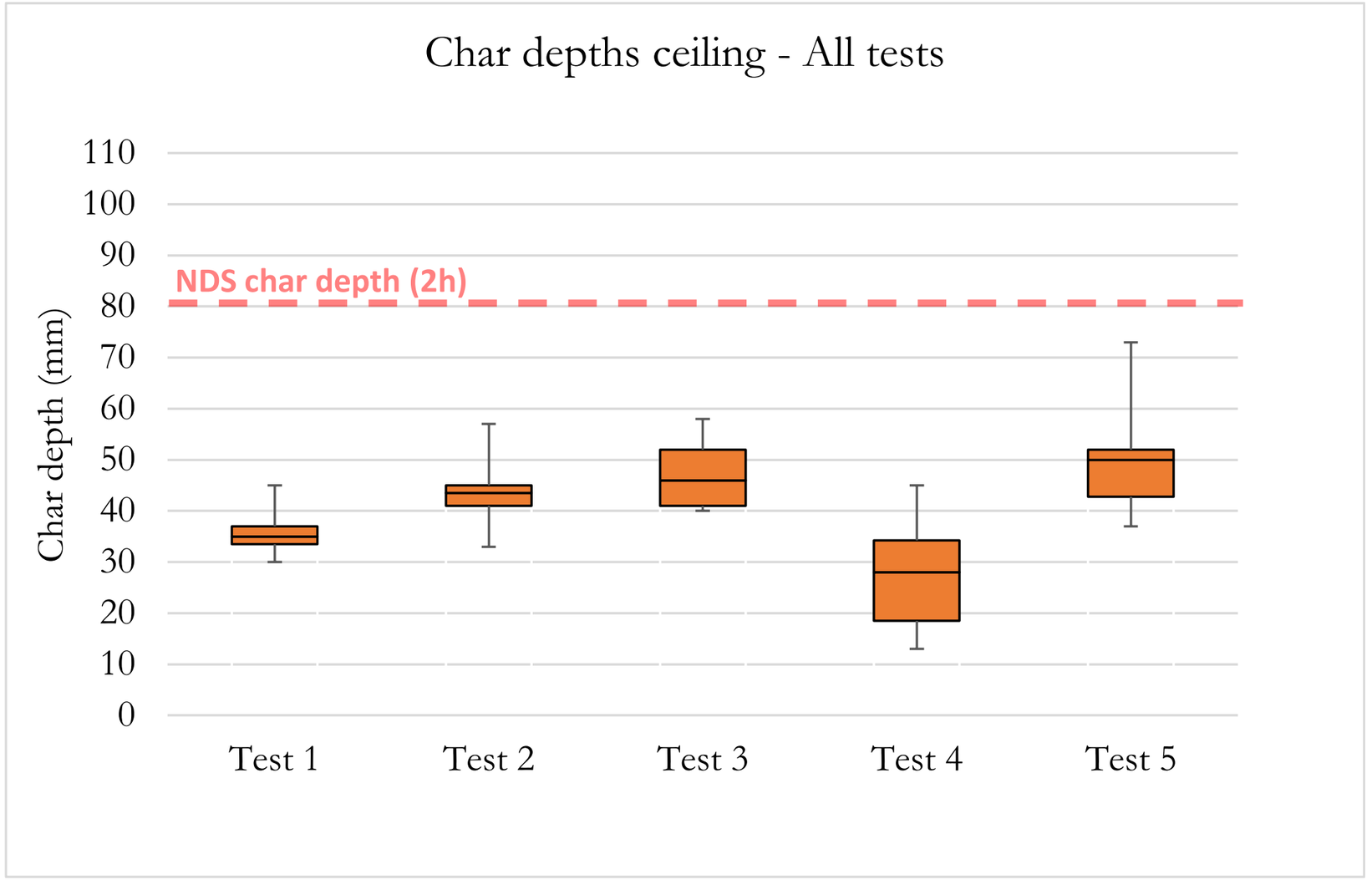


FIRE TEST RESULTS

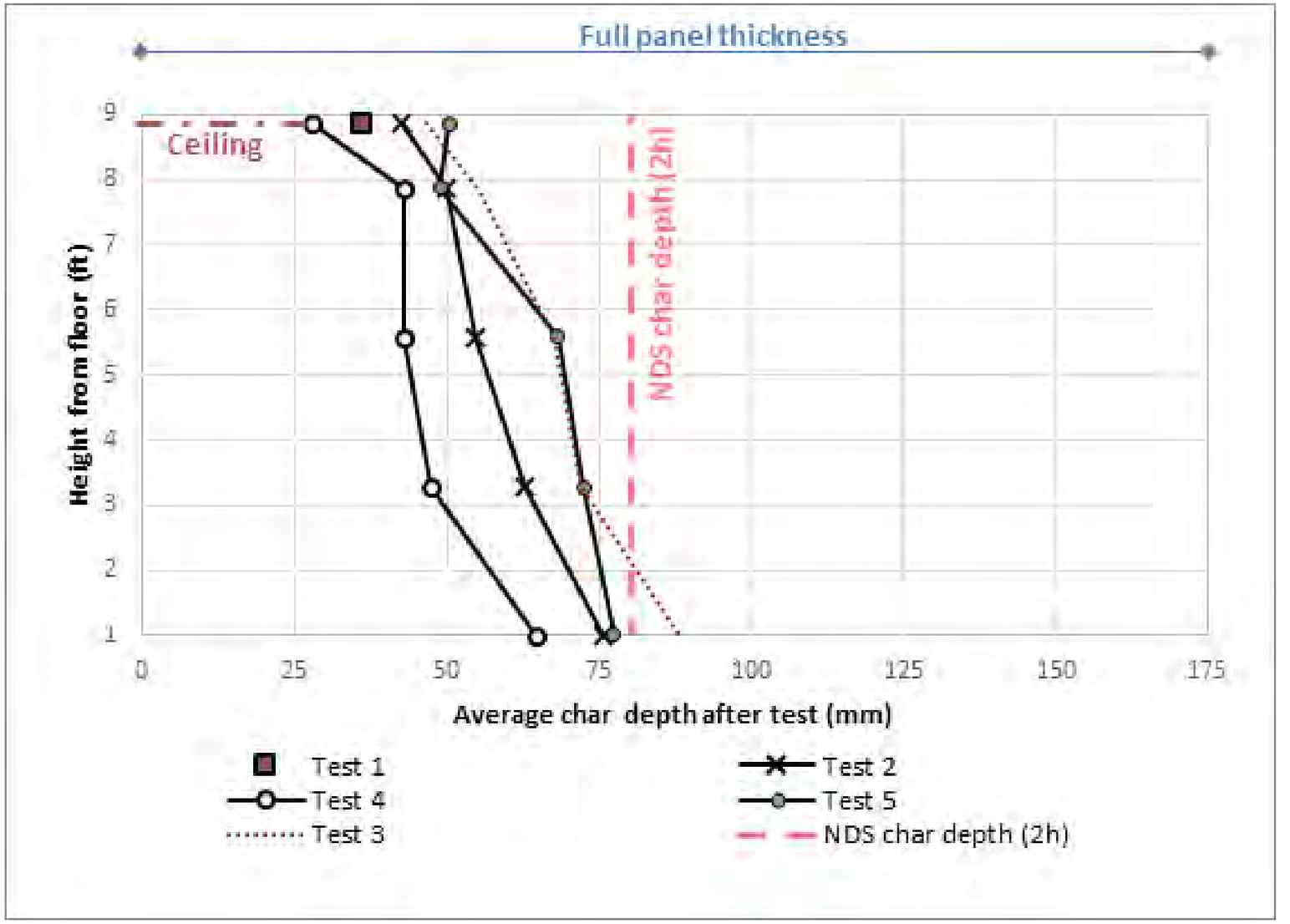




FIRE TEST RESULTS – CHAR DEPTHS



FIRE TEST RESULTS – CHAR DEPTHS



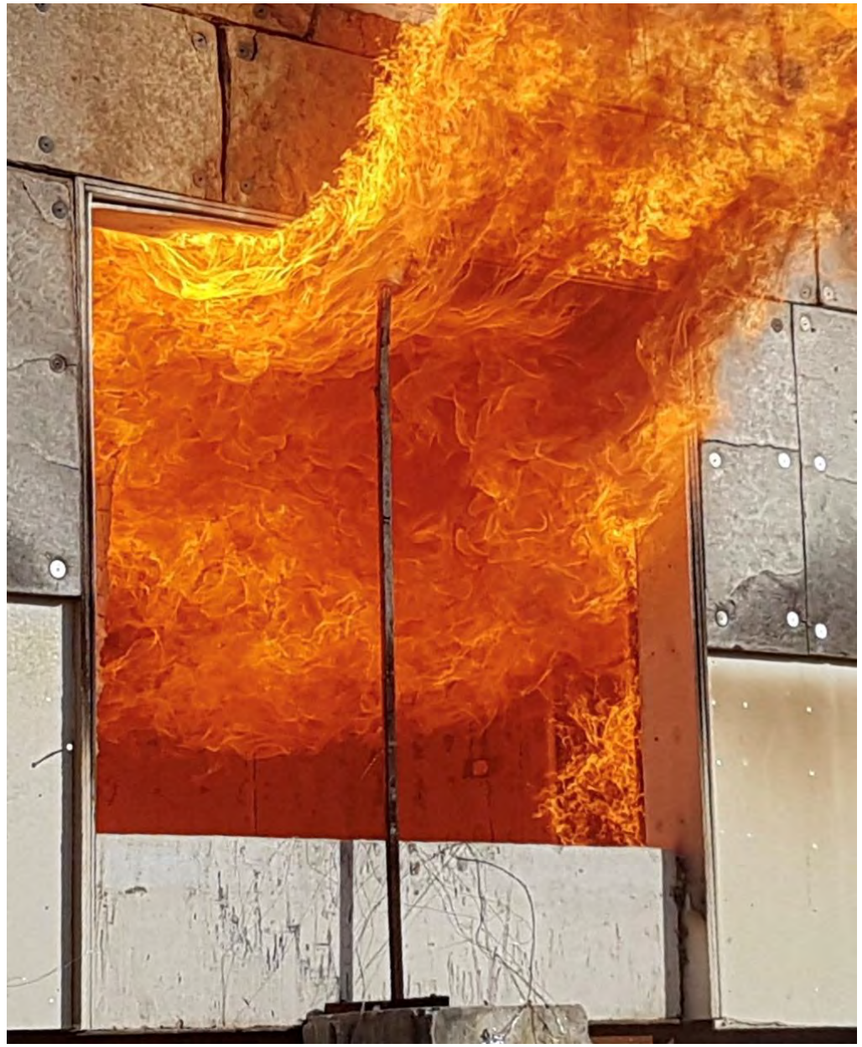
PRIMARY CONCLUSIONS

- The fire in the compartment with the ceiling exposed and walls protected with 2 layers type-X gypsum boards, decayed to the end of the 4-hour test.

- Fires in compartments with significant areas of additional exposed wall surfaces, decayed at least up to 4 hours after ignition, with one exception where exposed wall surfaces intersected in corners and increased damage in the bottom of corners was observed.

OUTLINE

- Development of New Mass Timber Construction Types
- Reason for Additional Testing
- Fire Testing Performed at RISE
- **Applying What We've Learned**



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APPLYING WHAT WE'VE LEARNED

Code Change Proposal Based on RISE Research:

G147-21

- Proposed by several former members of the ICC-TWB Committee
- Submitted January, 2021
- Recommended for approval at ICC Committee Action Hearings in April 2021 & PC hearings in October 2021
  - Proposal is justified by findings from RISE research

APPLYING WHAT WE'VE LEARNED

Excerpt from G147-21:

602.4.2.2.2 Protected area. Interior faces of mass timber elements, including the inside face of exterior mass timber walls and mass timber roofs, shall be protected in accordance with Section 602.4.2.2.1.

Exceptions: Unprotected portions of mass timber ceilings and walls complying with Section 602.4.2.2.4 and the following:

1. Unprotected portions of mass timber ceilings and walls complying with one of the following:

   1.1. Unprotected portions of mass timber ceilings, including attached beams, shall be permitted and shall be limited to an area less than or equal to ~~20~~ 100 percent of the floor area in any dwelling unit or fire area.

   1.2. Unprotected portions of mass timber walls, including attached columns, shall be permitted and shall be limited to an area less than or equal to 40 percent of the floor area in any dwelling unit or fire area.

   1.3. Unprotected portions of both walls and ceilings of mass timber, including attached columns and beams, in any dwelling unit or fire area shall be permitted in accordance with Section 602.4.2.2.3.

2. Mass timber columns and beams that are not an integral portion of walls or ceilings, respectively, shall be permitted to be unprotected without restriction of either aggregate area or separation from one another.

APPLYING WHAT WE'VE LEARNED

Excerpt from G147-21 (continued):

602.4.2.2.4 Separation distance between unprotected mass timber elements. In each dwelling unit or fire area, unprotected portions of mass timber walls ~~and ceilings~~ shall be not less than 15 feet (4572 mm) from unprotected portions of other walls ~~and ceilings, measured horizontally along the ceiling and from other unprotected portions of walls~~ measured horizontally along the floor.

APPLYING WHAT WE'VE LEARNED

Code Change Proposal Based on RISE Research:

G147-21

- All other provisions regarding noncombustible protection in Type IV-B remain in-place:
  - ✓ Minimum 15' separation between exposed areas on walls
  - ✓ Limit on combined areas remains unchanged
- Conservative relative to tested conditions in RISE tests

PASSED! ICC OGCV 11/24/21 2024 IBC

POLLING QUESTION

What is the production standard for CLT that is manufactured with fire-resistant adhesives per the 2021 IBC?

a) DOC PS1

b) AWPA U1

c) ANSI 117.1

d) ANSI/APA PRG 320-18

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AMERICAN WOOD COUNCIL

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THANK YOU! Questions? mhunter@awc.org