



Video by Matthew Hoehler at NIST

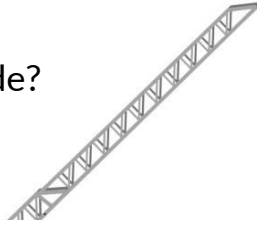
SFPE Expert middag Brandveilige Houten Gebouwen
Real Scale Fire Tests

Dr. Daniel Brandon

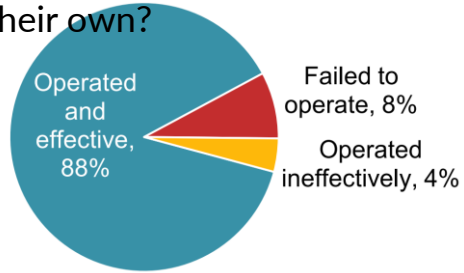
What if there are fires? Can we rely on:

The fire brigade?

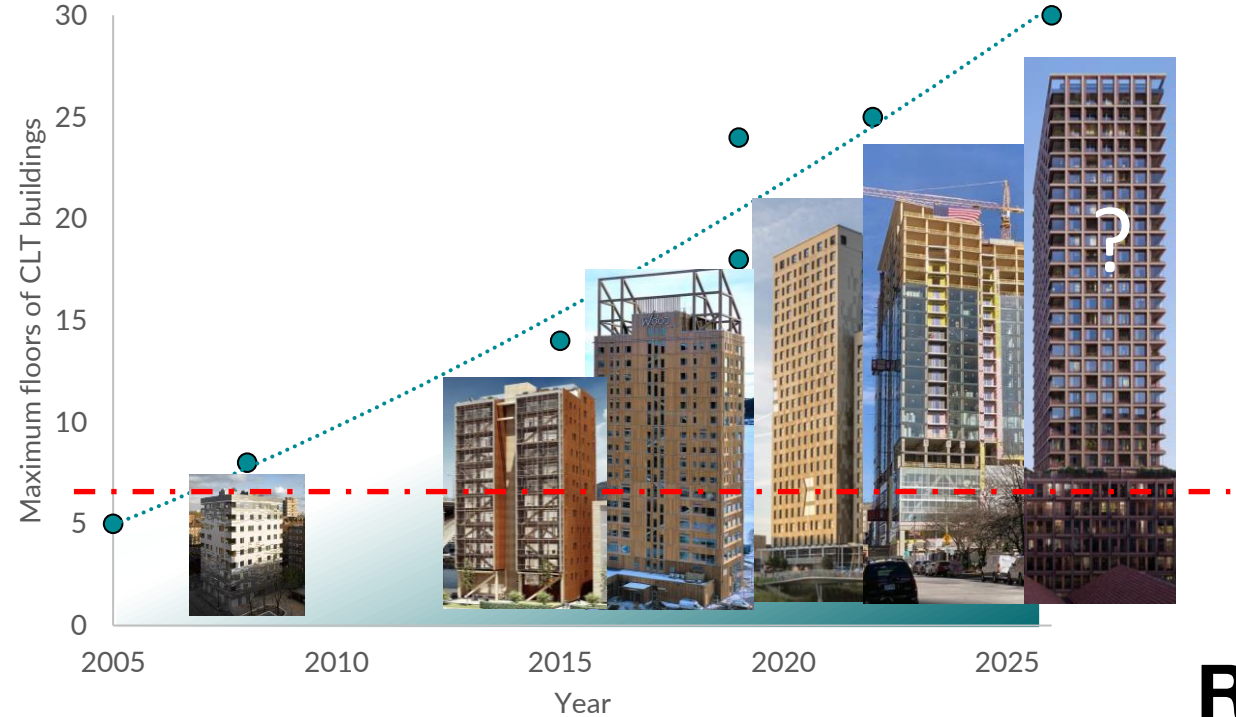
Sprinklers?



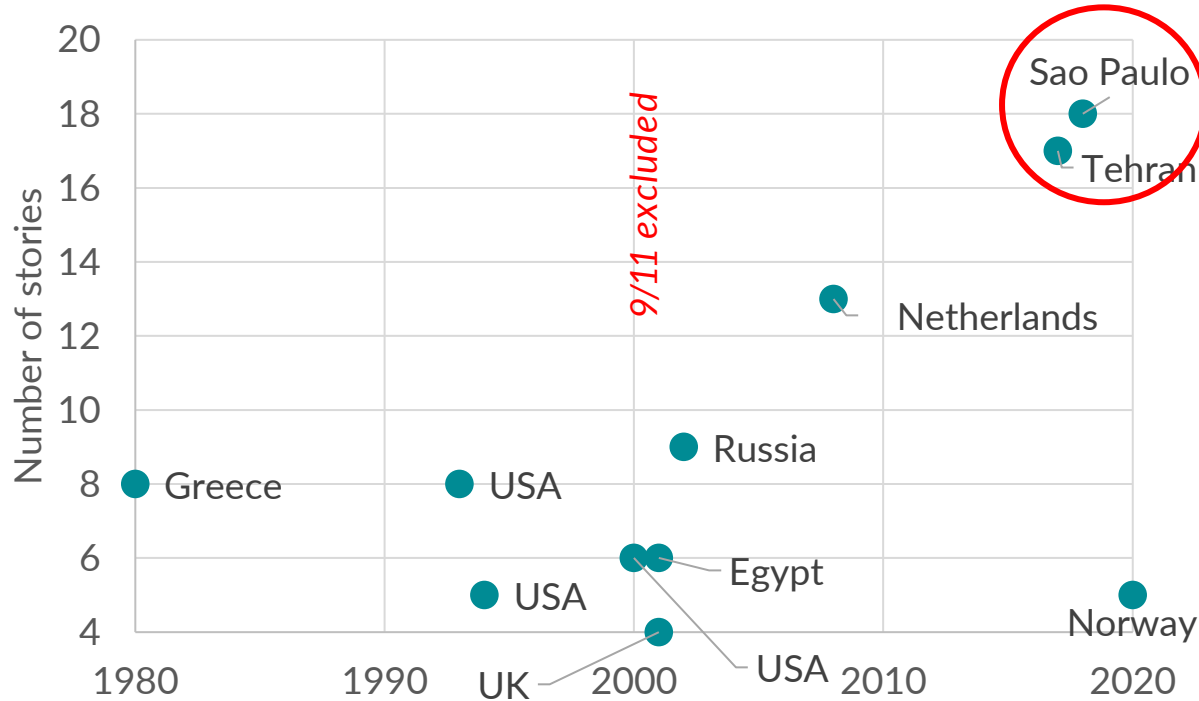
✓ Buildings surviving the fire on their own?



Tallest buildings



Progressive collapse by fire – multi storey buildings



Extraordinary
lack of
regulation
compliance

Extremely rare!

Coincidence?

From:

- Beitel and Iwankiw, 2008
- Brandon, 2018
- Fjellgaard Mikalsen, 2021

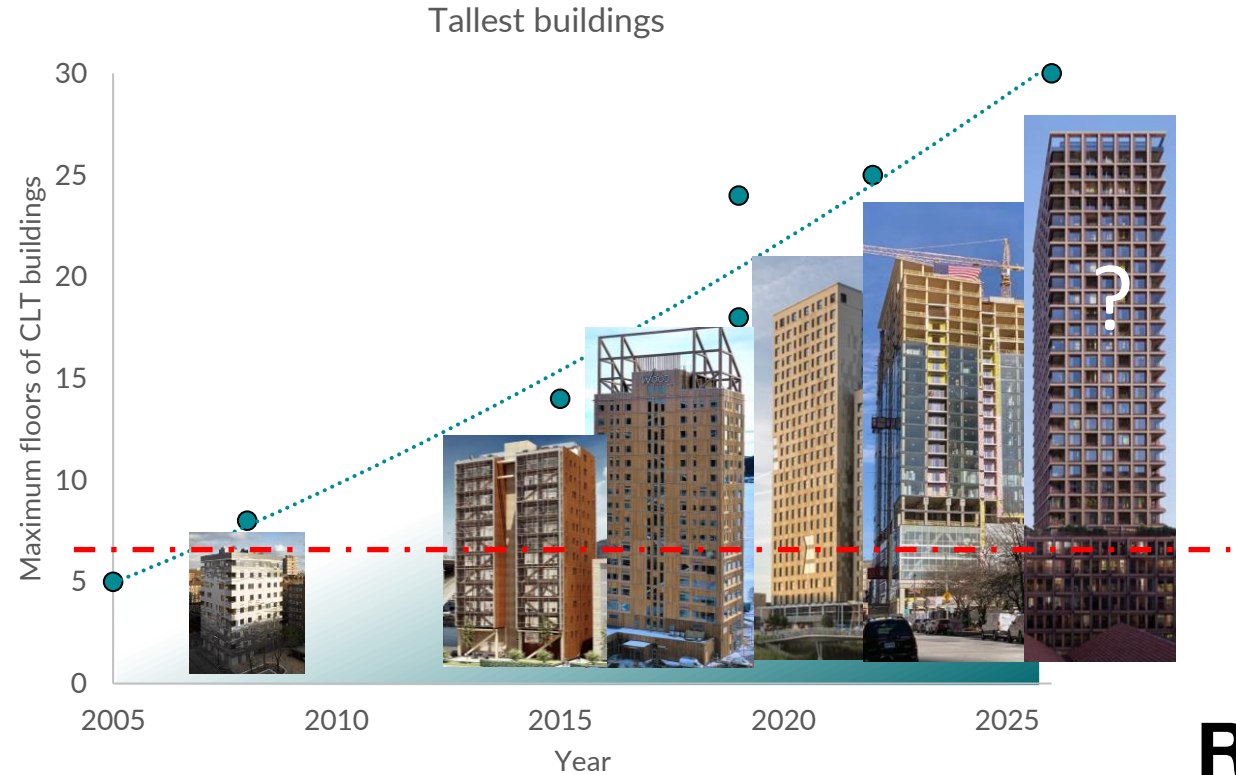
What if there are fires? Can we rely on:

The fire brigade?

Sprinklers?



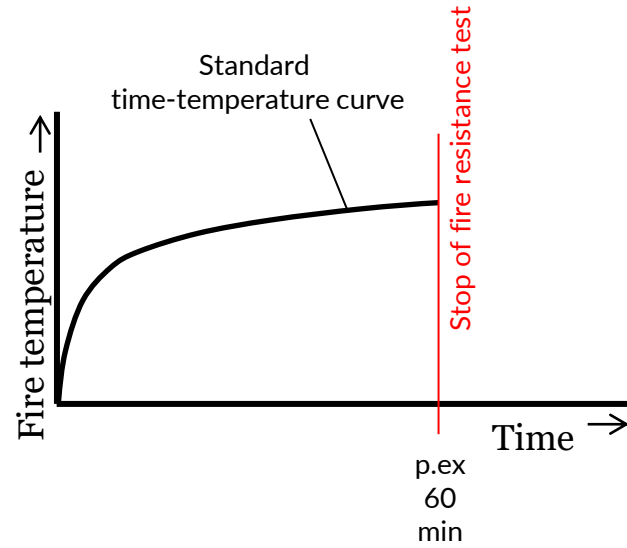
Buildings surviving the fire on their own?



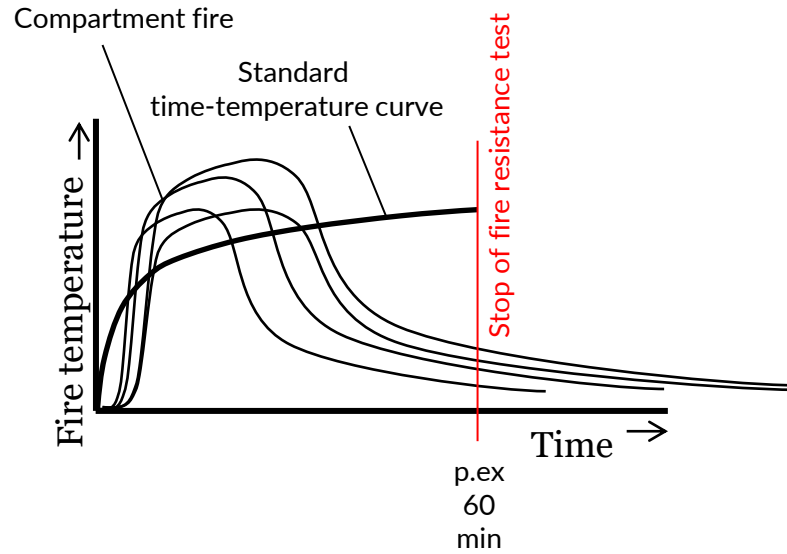
The Swedish Institute for Building Regulations:

” Building parts assigned to fire safety class 4 and 5 must in principle be able to withstand a complete natural fire scenario without collapse.”

	Option 1: brandmotstånd (min)			Option 2: mål
Brand-säkerhetsklass	Klassificering med normal brandbelastning $\leq 800 \text{ MJ/m}^2$	Klassificering med hög brandbelastning $\leq 1600 \text{ MJ/m}^2$	Klassificering med mycket hög brandbelastning $> 1600 \text{ MJ/m}^2$	Modell med naturligt brandförlopp
1	-	-	-	-
2	R 15	R 15	R 15	15 min
3	R 30	R 30	R 30	30 min
4	R 60	R 120	R 180	Fullständigt brandförlopp
5	R 90	R 180	R 240	Fullständigt brandförlopp med 50 % ökad brandbelastning



Is a building allowed to collapse after just 60 minutes in an unsuppressed flashover fire?



Is a building allowed to collapse after just 60 minutes in an unsuppressed flashover fire?

A real fire decays **once combustibles burnout**.
If the fire resistance requirements are conservative, collapse is unlikely

But what if the structure is combustible?

NFPA Fire Safety Challenges of Tall Timber Buildings



Tests performed at NIST



NRC-CMRC

NIST
National Institute of
Standards and Technology

**RI
SE**
Research Institutes
of Sweden

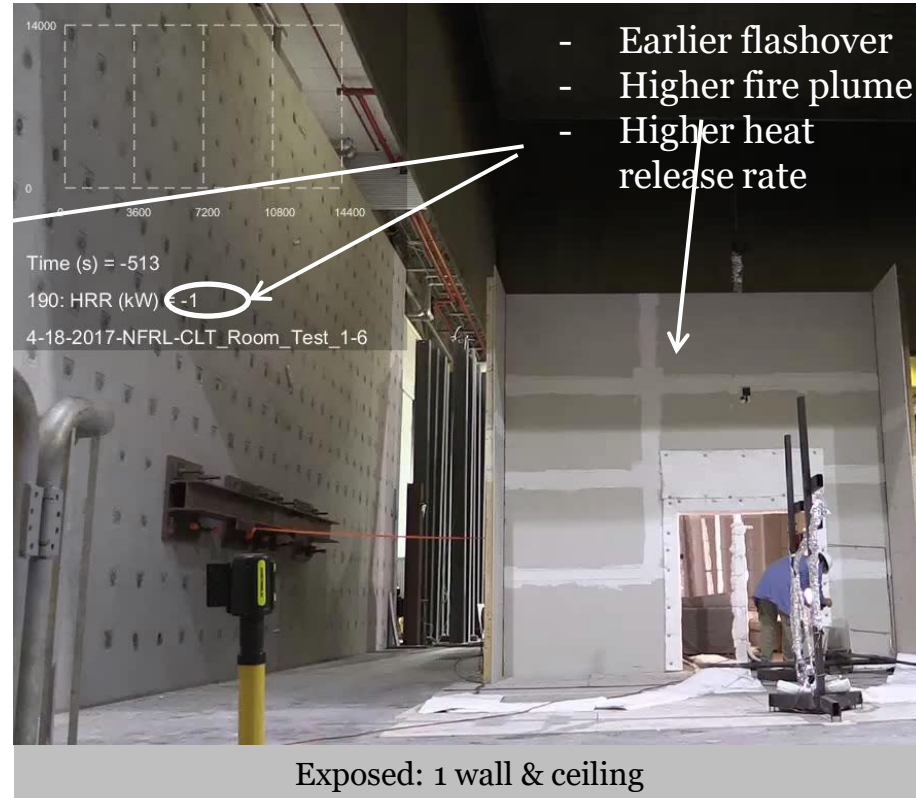
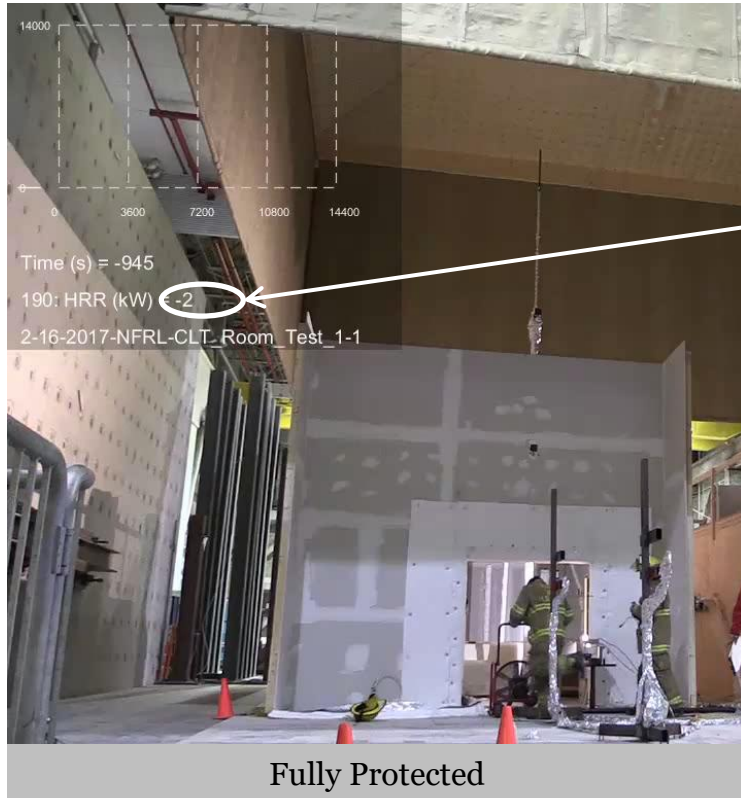
- Number of tests: 6
- Compartment dimensions:
9.2 x 4.6 x 2.7 m
- 175mm, 5-ply CLT
35-35-35-35-35 mm
- Fuel load density:
550 MJ/m² (Above residential average in
Canada)

**RI
SE**

NFPA Fire Safety Challenges of Tall Timber Buildings

Tests at

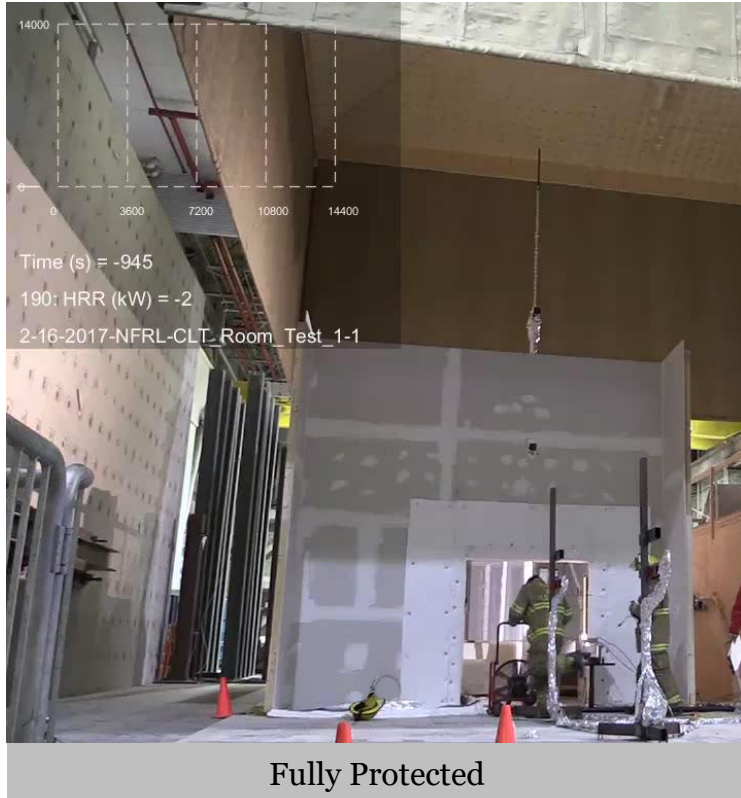
NIST
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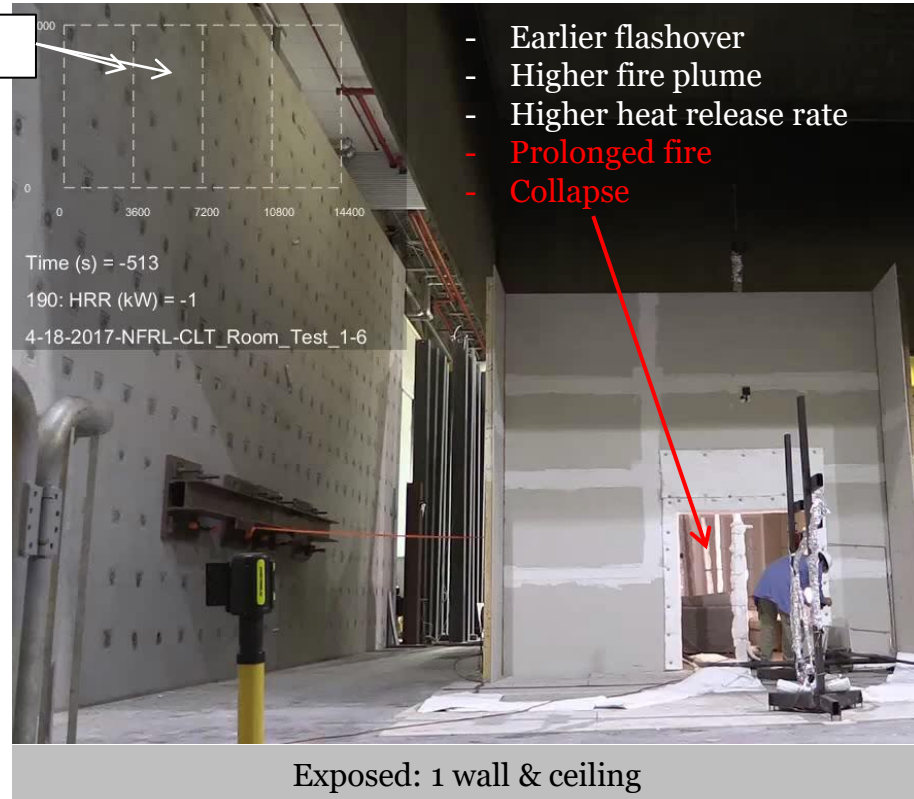
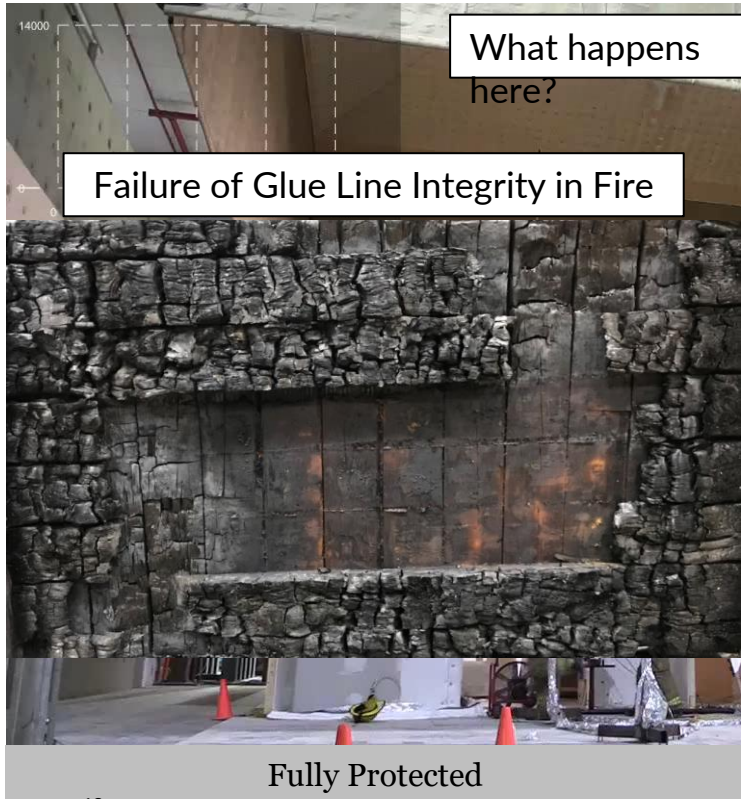
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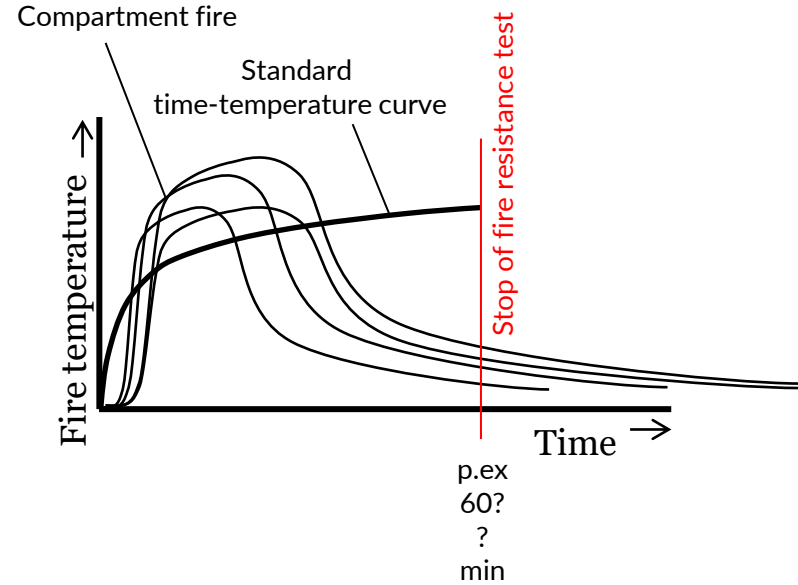
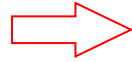
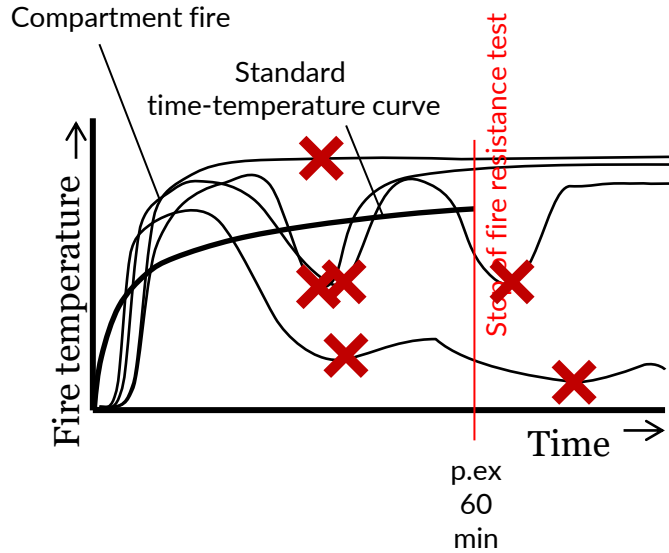




Tests at

NIST
National Institute of
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Is a building allowed to collapse after just 60 minutes in an unsuppressed flashover fire?

Mass timber performance



Methods

- 1) Eurocode 5 (2025)
- 2) Thicker lamellas? → Be careful!! Does not always work



Engineering methods:

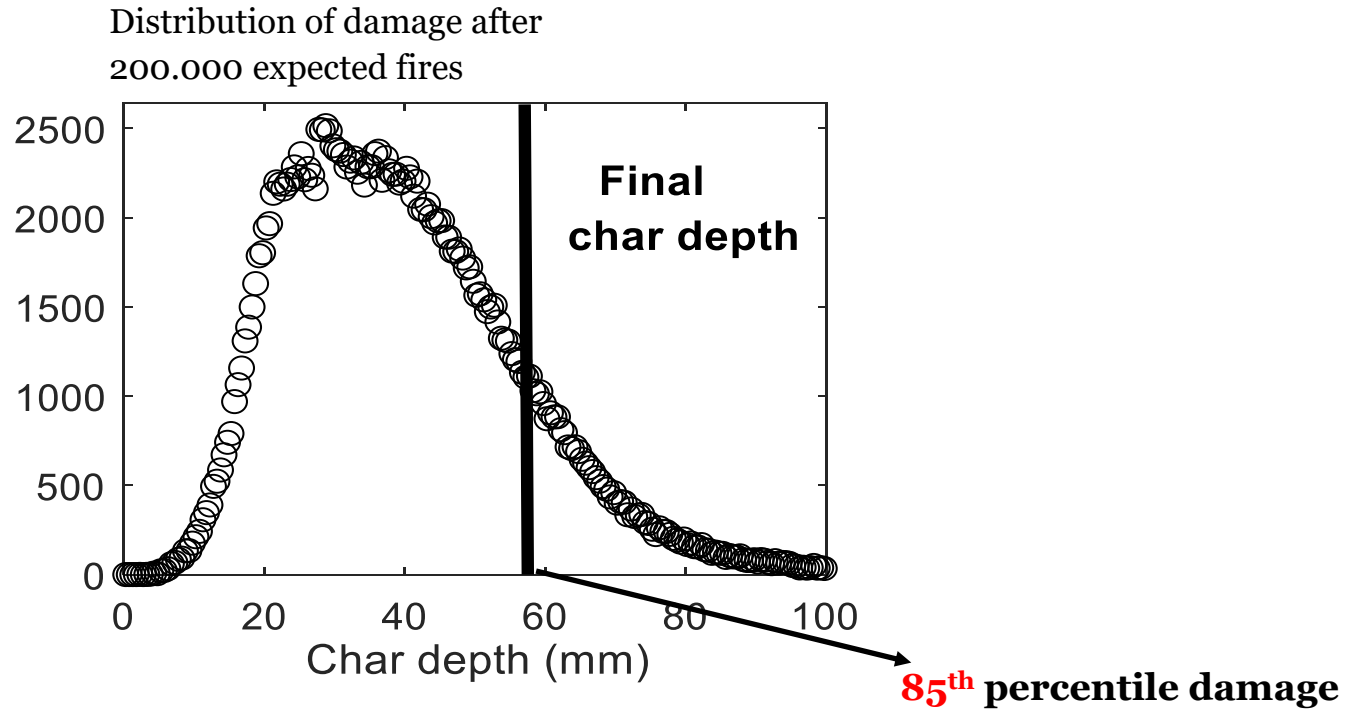
- 1) <https://www.nfpa.org/News-and-Research/Data-research-and-tools/Building-and-Life-Safety/Fire-Safety-Challenges-of-Tall-Wood-Buildings-Phase-2>
- 2) <https://www.ri.se/en/what-we-do/projects/fire-safe-implementation-of-mass-timber-in-tall-buildings>

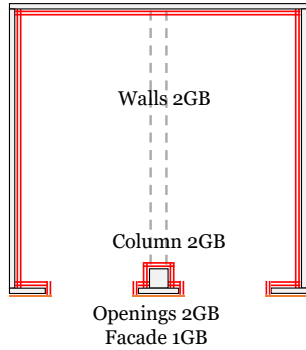
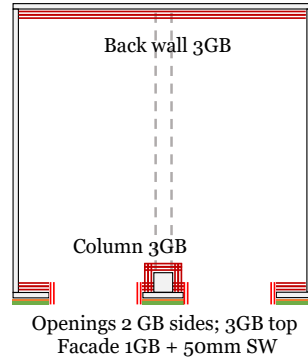
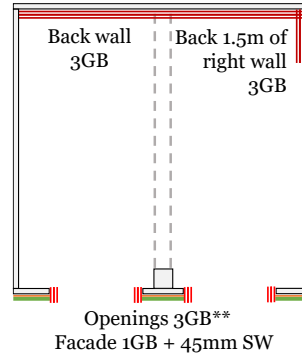
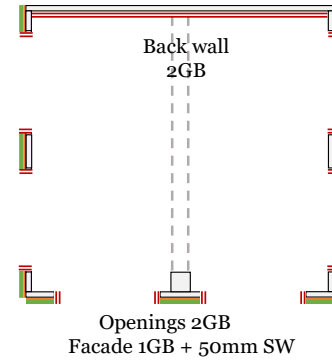
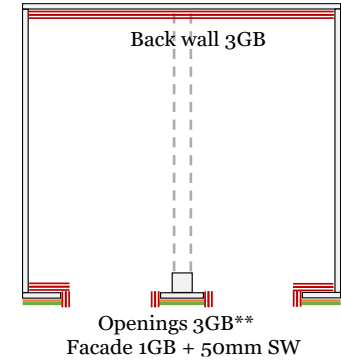
Fire Safe Implementation of Visible Mass Timber in Tall Buildings



- Number of tests: 5
- Compartment dimensions:
7.0 x 6.9 x 2.7 m
- 175mm, 5-ply CLT
35-35-35-35-35 mm
- Fuel load density:
560 MJ/m²
(Above residential average in Canada)

Design values – *Severe* but *representative*



Test 1**Test 2****Test 3****Test 4****Test 5**

Configurations based on a combination of:

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



Setup & Fuel load





Test 1 - Exposed timber: 53.8 m²



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 1 - Exposed timber: 53.8 m²



Test 2 - Exposed timber: 91.2 m²



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Test 4 - Exposed timber: 77.9 m²

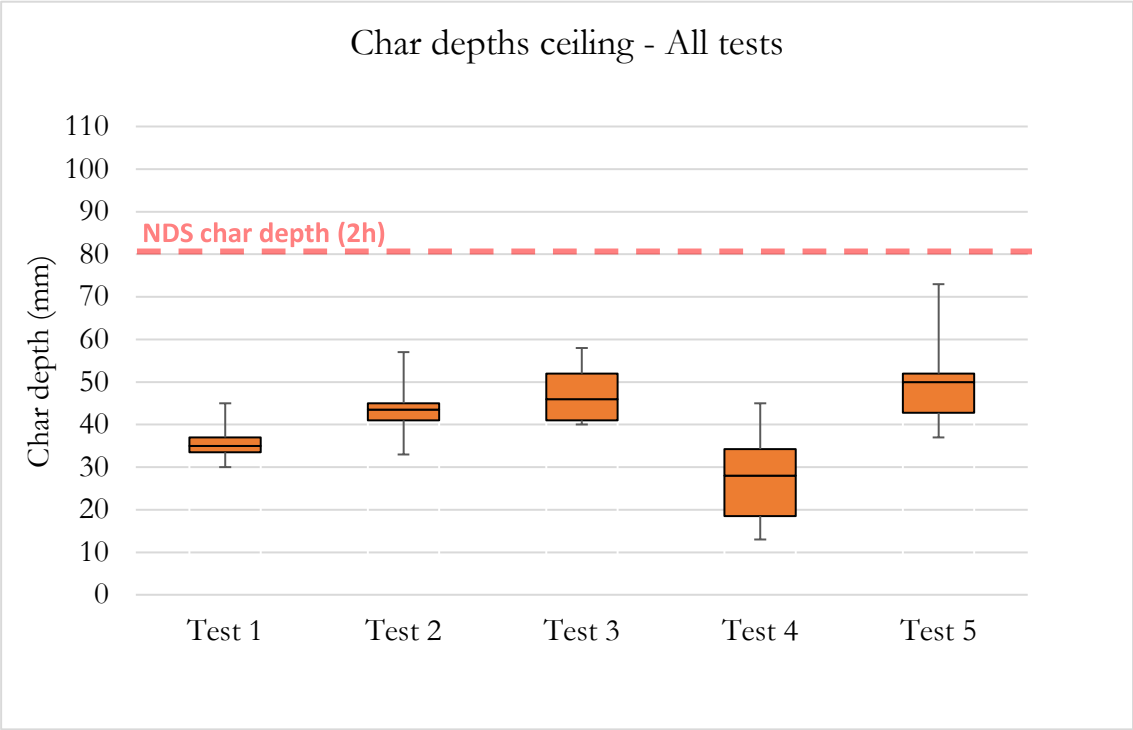


Test 5 - Exposed timber: 97.2 m²

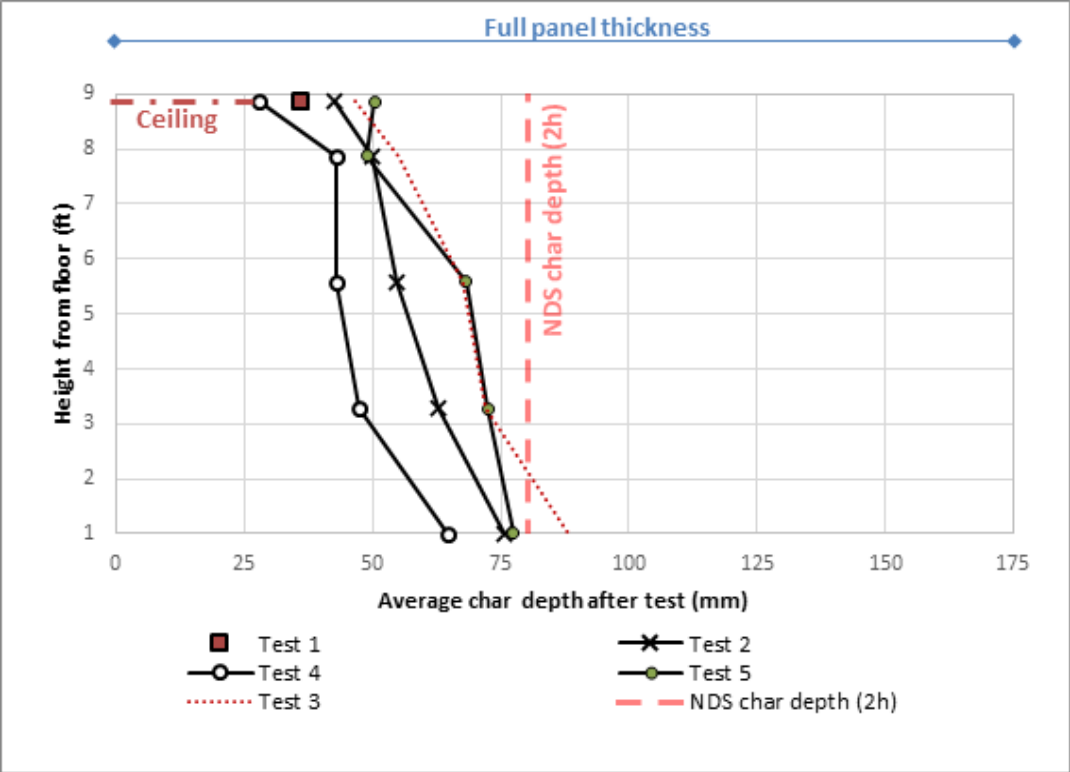


Reference without PRG320(2018)
compliance - Exposed: 67 m²

Fire test results – char depths



Fire test results – char depths



Conclusions (general)

- Glue line integrity failure of mass timber, gypsum board fall-off and charring behind gypsum boards, or any other phenomenon that increases the fuel load during the fire can compromise full fire decay
- Compartment fire tests, where these phenomena were avoided, with substantial amounts of exposed CLT have led to fire decay.

Conclusions for tested compartments

- The fire in the compartment with the ceiling exposed and walls protected with 2 layers type-X gypsum boards, decayed at least up to 4 hours after ignition.
- 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.
- In compartments without intersecting exposed CLT walls in a corner the char depth after the full 4-hour fire duration was in general (but especially in the ceiling) less than the char depth for 2 hour fire resistance. In compartments where exposed walls met in corners, the char depth exceeded this value in some locations in the bottom of the corner.



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