Correcting Misperceptions of CLT Fire Performance

Mid-Atlantic Wood Design Symposium

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ARUP

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

This presentation aims to answer questions commonly asked about CLT fire performance, including “delamination” and fire-resistance ratings, and how these issues related to low- and mid-rise buildings within the size limits of the current IBC vs. high-rise buildings.

Because CLT is relatively new in the U.S., designers often have to explain the fire design of their structure in much more detail than is required for typical construction materials, even for code-compliant buildings.

This session should equip designers with a better understanding of the code requirements, relevant and applicable CLT design methods, test standards and available testing related to CLT fire performance.

1. Review code-compliant applications of cross-laminated timber under the 2015 International Building Code (IBC).

2. Highlight available resources, including charring calculations and fire-tested CLT assemblies, to aid designers in exposed CLT building design.

3. Discuss the concept of CLT “delamination” under fire, related testing and recent changes to adhesive requirements that eliminate concerns.

4. Understand how various aspects of CLT fire performance apply (or don't) to code-compliant low- and mid-rise vs. high-rise buildings.


Lever Architecture

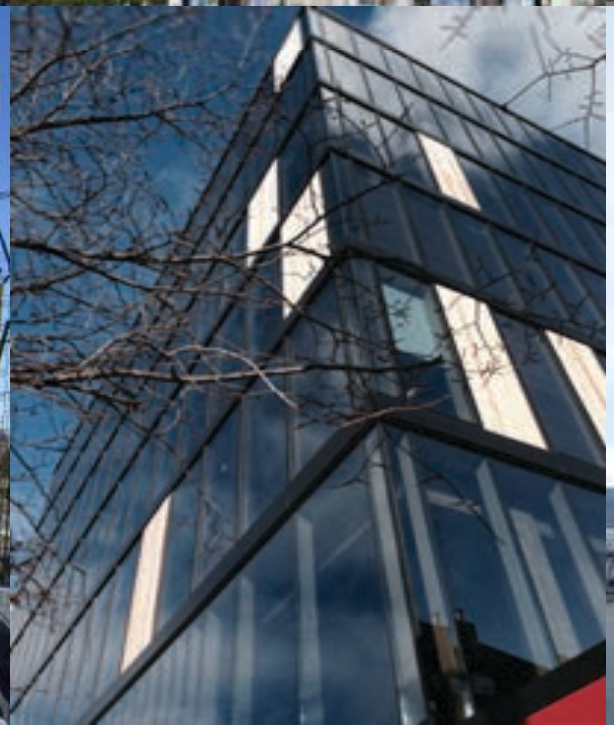

Nordic

Muhlweg Apartments, Austria

Svartlamoen, Norway



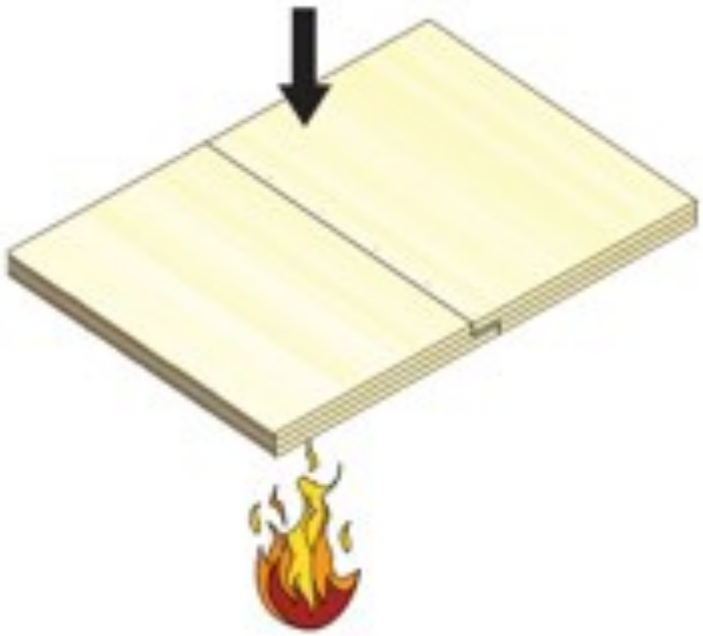


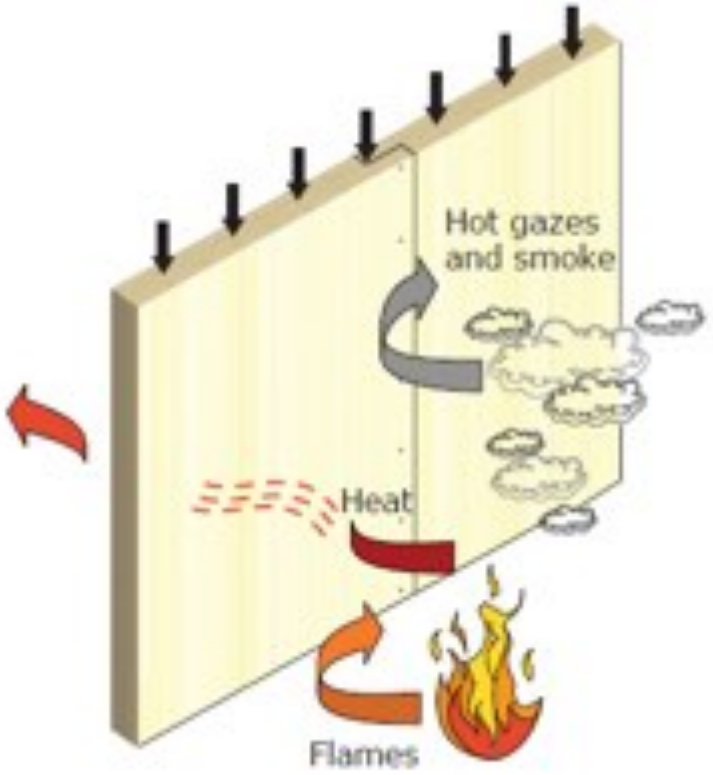
Mass timber and the IBC

Simple Banking HQ, Portland

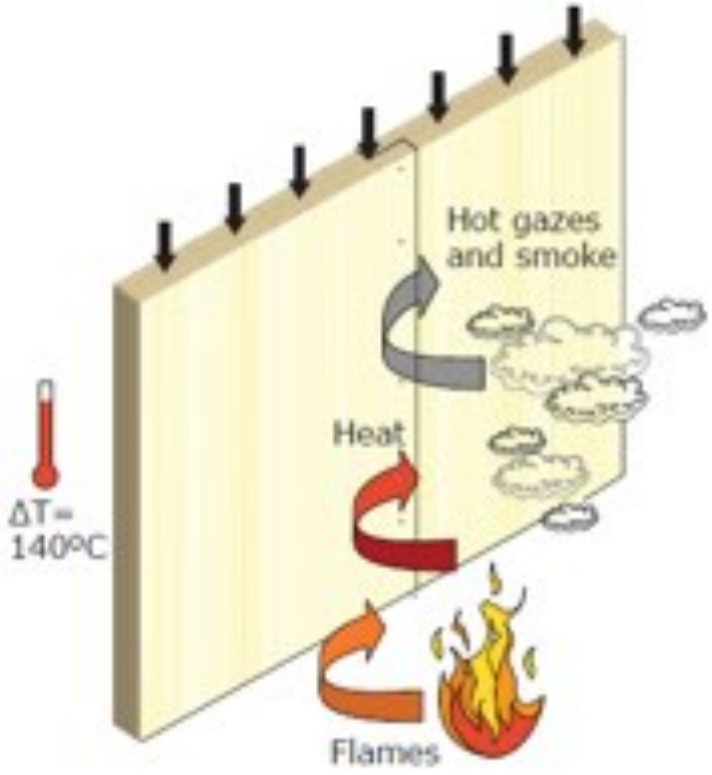
What is a Fire Resistance Rating (FRR)?



Structural resistance



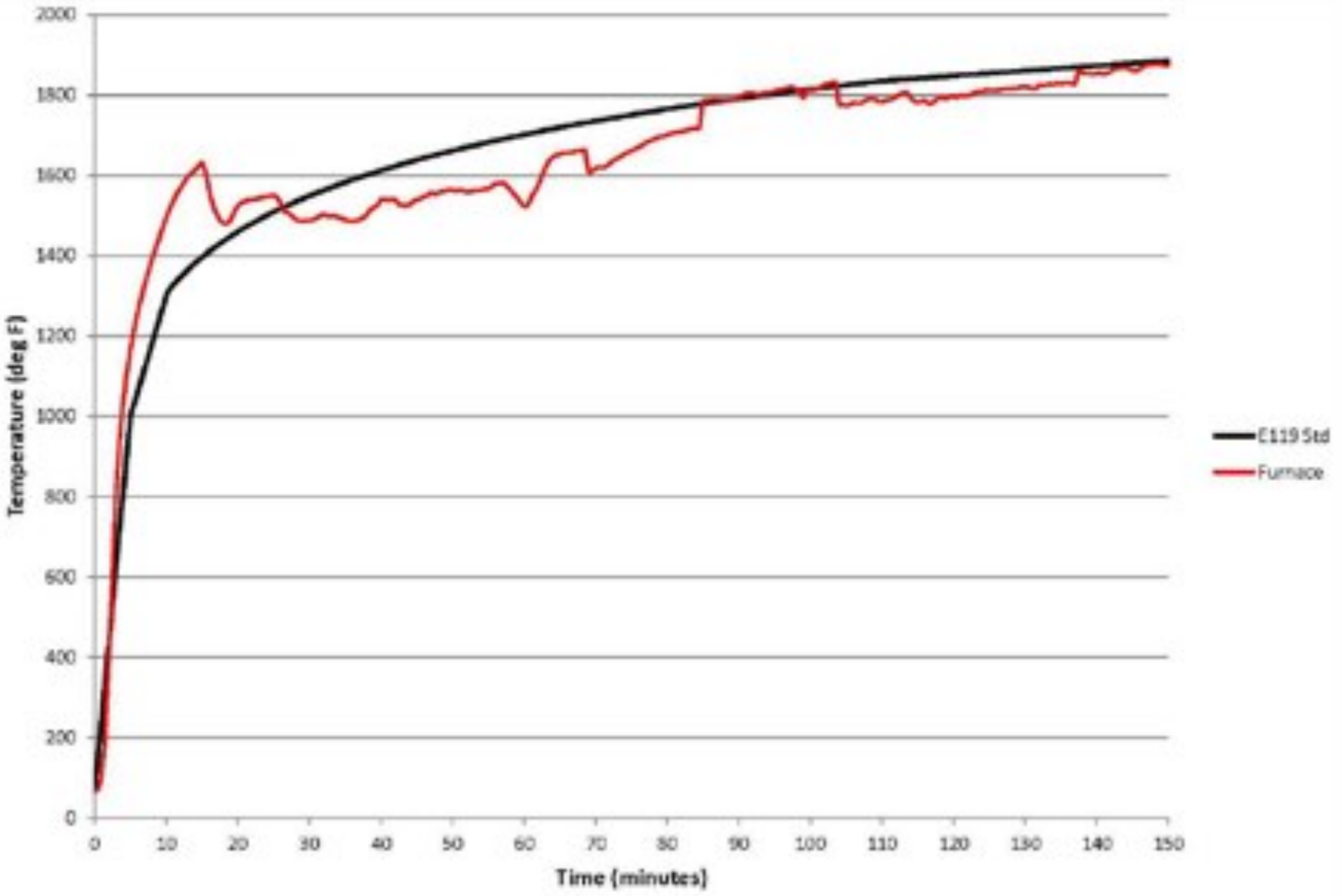
Integrity



Insulation

(from “CLT Handbook, US Edition”)

What is a Fire Resistance Rating (FRR)?




GAS


010105

What is Interior Finish Flammability?

Measure of flame spread and smoke development

Classes A, B and C

IBC limits for mass timber construction

Non-combustible construction – Type I, II

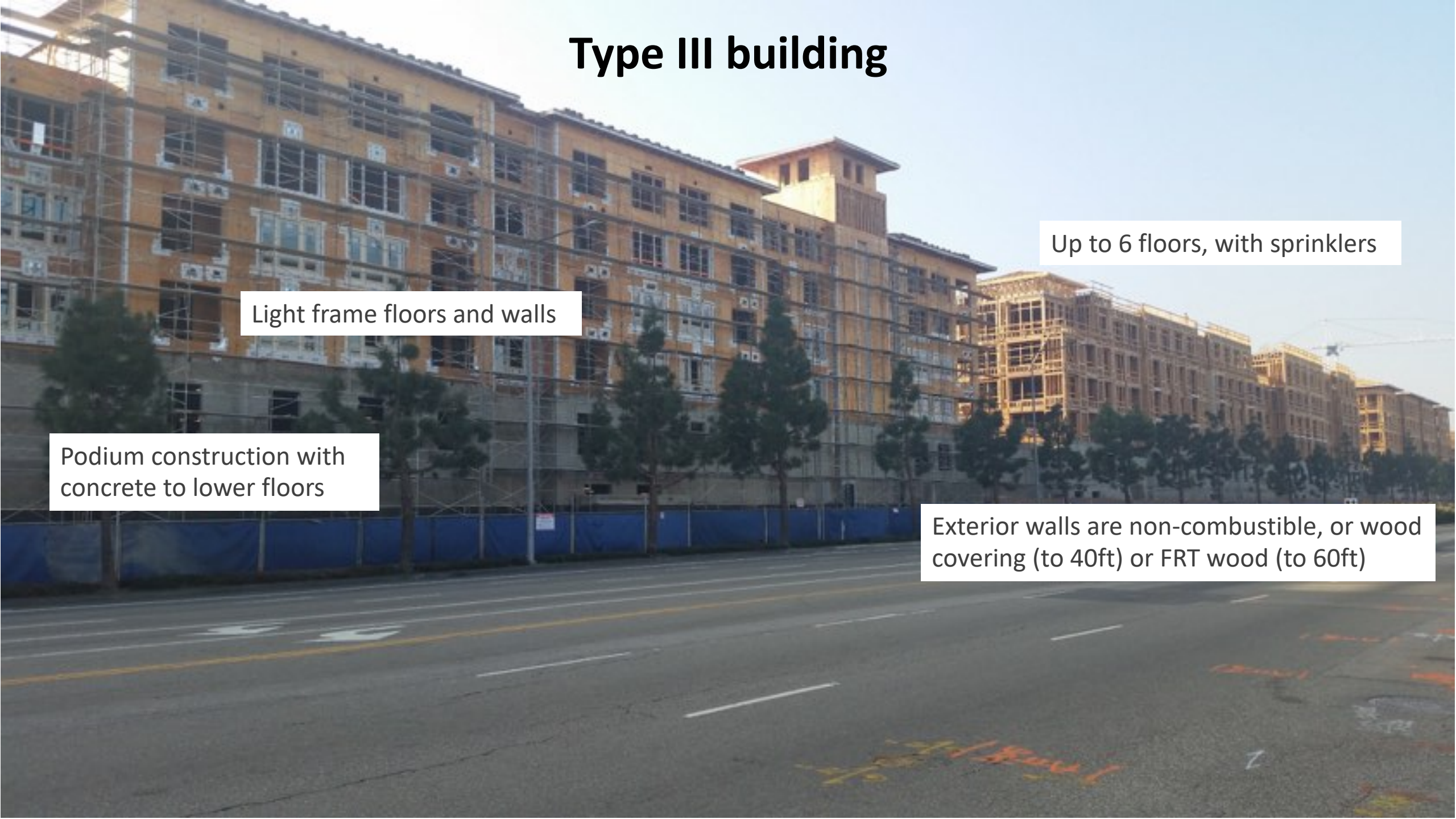
Combustible construction – Type III, IV, V

Mass timber - Code compliant use in Types III, IV, V

Type IV – Heavy Timber:

- Up to 6 floors (office) 5 floors (resi)
- Additional floors with “podium construction”
- 85ft in building height

Type III building



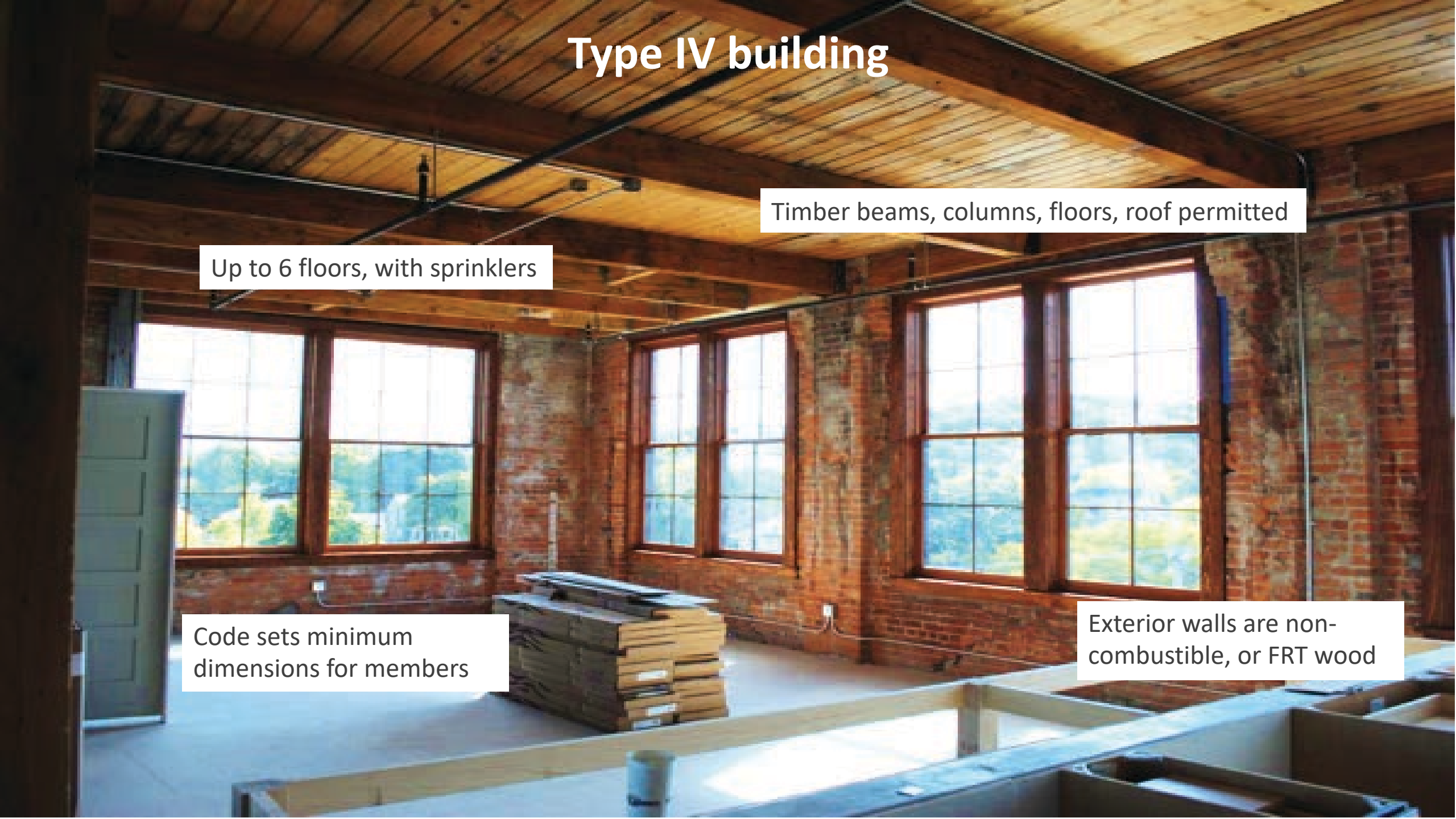
Up to 6 floors, with sprinklers

Light frame floors and walls

Podium construction with concrete to lower floors

Exterior walls are non-combustible, or wood covering (to 40ft) or FRT wood (to 60ft)

Type IV building



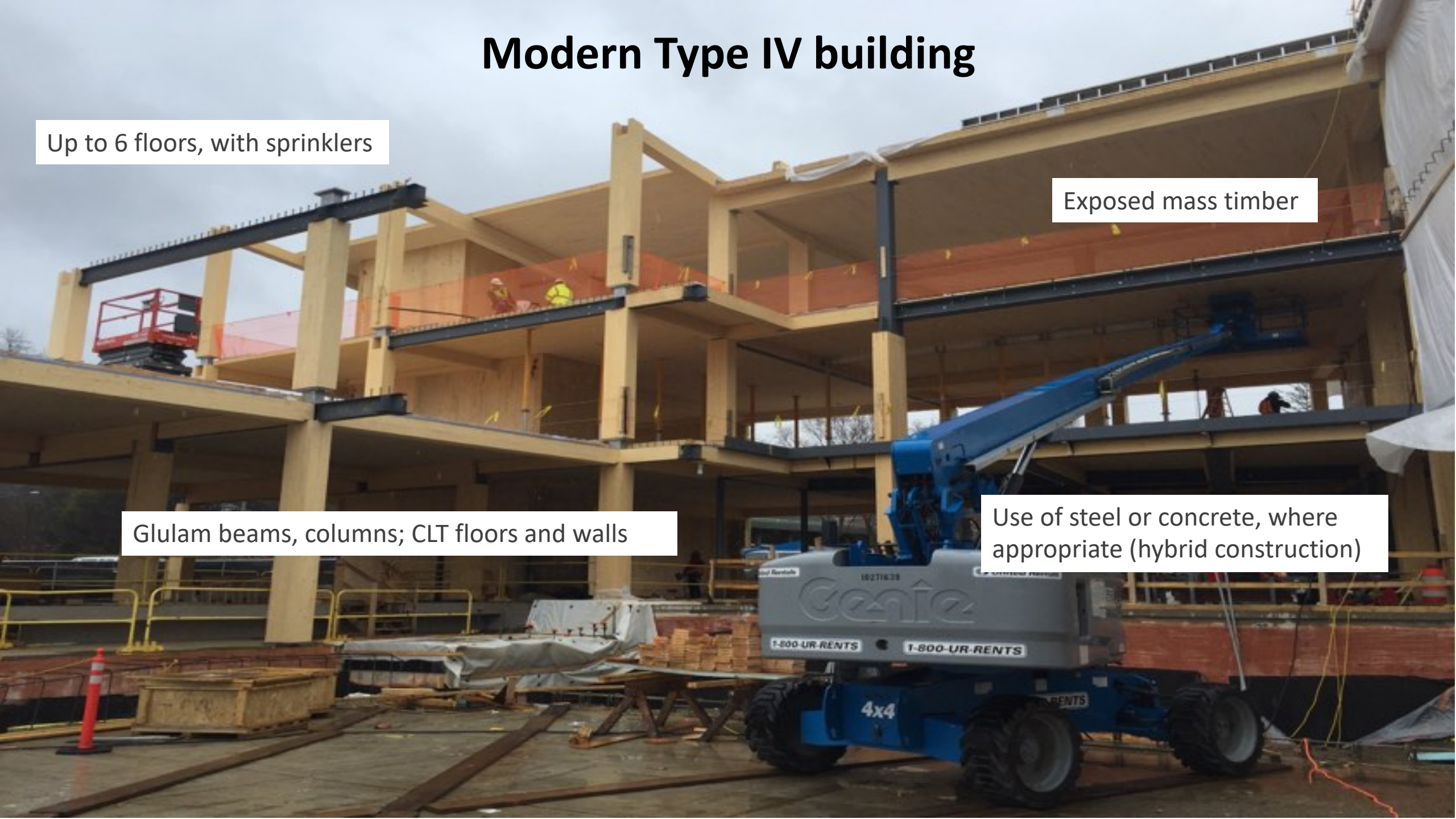
Timber beams, columns, floors, roof permitted

Up to 6 floors, with sprinklers

Code sets minimum dimensions for members

Exterior walls are non-combustible, or FRT wood

Modern Type IV building



Mass timber construction

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A	B	A	B	HT	A	B
Primary structural frame[f] (see Section 202)	3[a]	2[a]	1	0	1	0	HT	1	0
Bearing walls									
Exterior[e, f]	3	2	1	0	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	$1^{1}/_{2}$[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1[b,c]	0

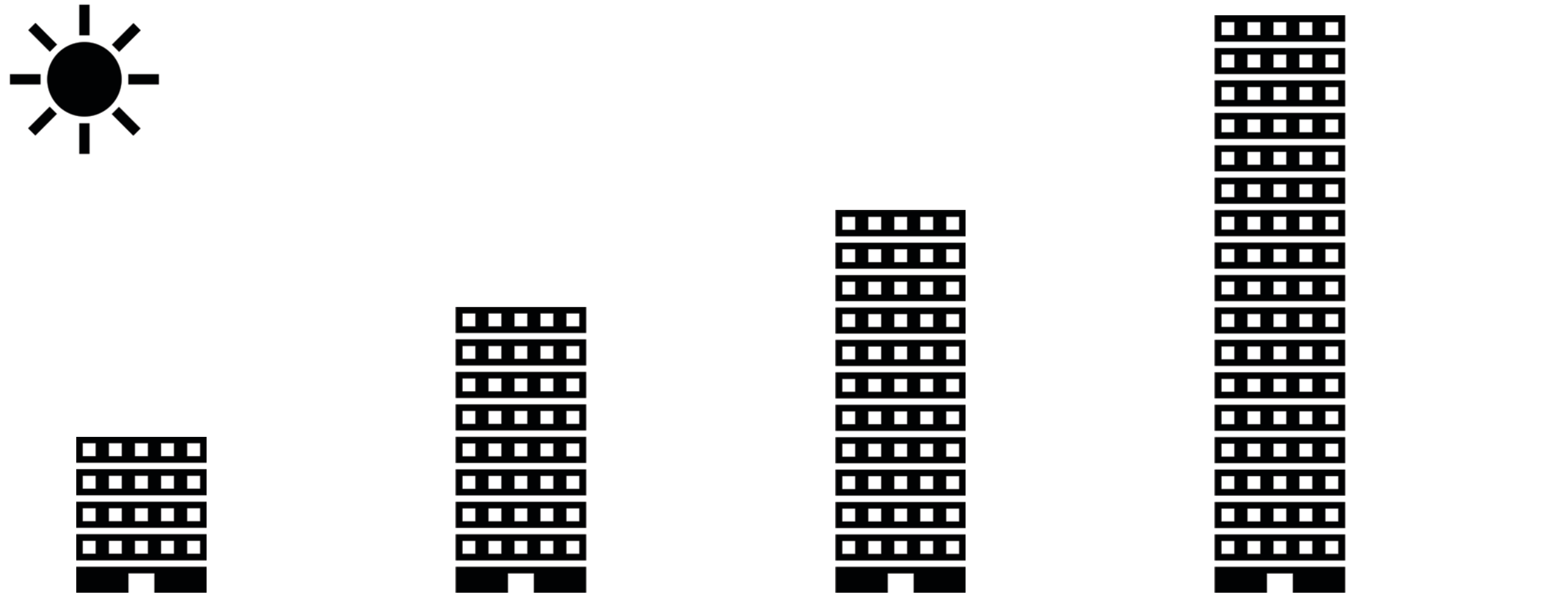
IBC: Heavy timber = mass timber

TABLE 602.4
WOOD MEMBER SIZE EQUIVALENCIES

MINIMUM NOMINAL SOLID SAWN SIZE		MINIMUM GLUED-LAMINATED NET SIZE		MINIMUM STRUCTURAL COMPOSITE LUMBER NET SIZE	
Width, inch	Depth, inch	Width, inch	Depth, inch	Width, inch	Depth, inch
8	8	$6^{3}/_{4}$	$8^{1}/_{4}$	7	$7^{1}/_{2}$
6	10	5	$10^{1}/_{2}$	$5^{1}/_{4}$	$9^{1}/_{2}$
6	8	5	$8^{1}/_{4}$	$5^{1}/_{4}$	$7^{1}/_{2}$
6	6	5	6	$5^{1}/_{4}$	$5^{1}/_{2}$
4	6	3	$6^{7}/_{8}$	$3^{1}/_{2}$	$5^{1}/_{2}$

Solid or laminated timber (Chapter 23) – solid, LVL, glulam, CLT

Type IV – mass timber can be exposed (Chapter 8)



Type IV
- Max 85ft
- 5 floors
- Timber fully exposed

Type IV-C
- Max 85ft
- 9 floors
- Timber fully exposed
- 2hr FRR

Type IV-B
- Max 180ft
- 12 floors
- Timber partly exposed
- Protected timber shafts
- 2hr FRR

Type IV-A
- Max 270ft
- 18 floors
- Timber fully protected
- Concrete shafts
- 3hr FRR

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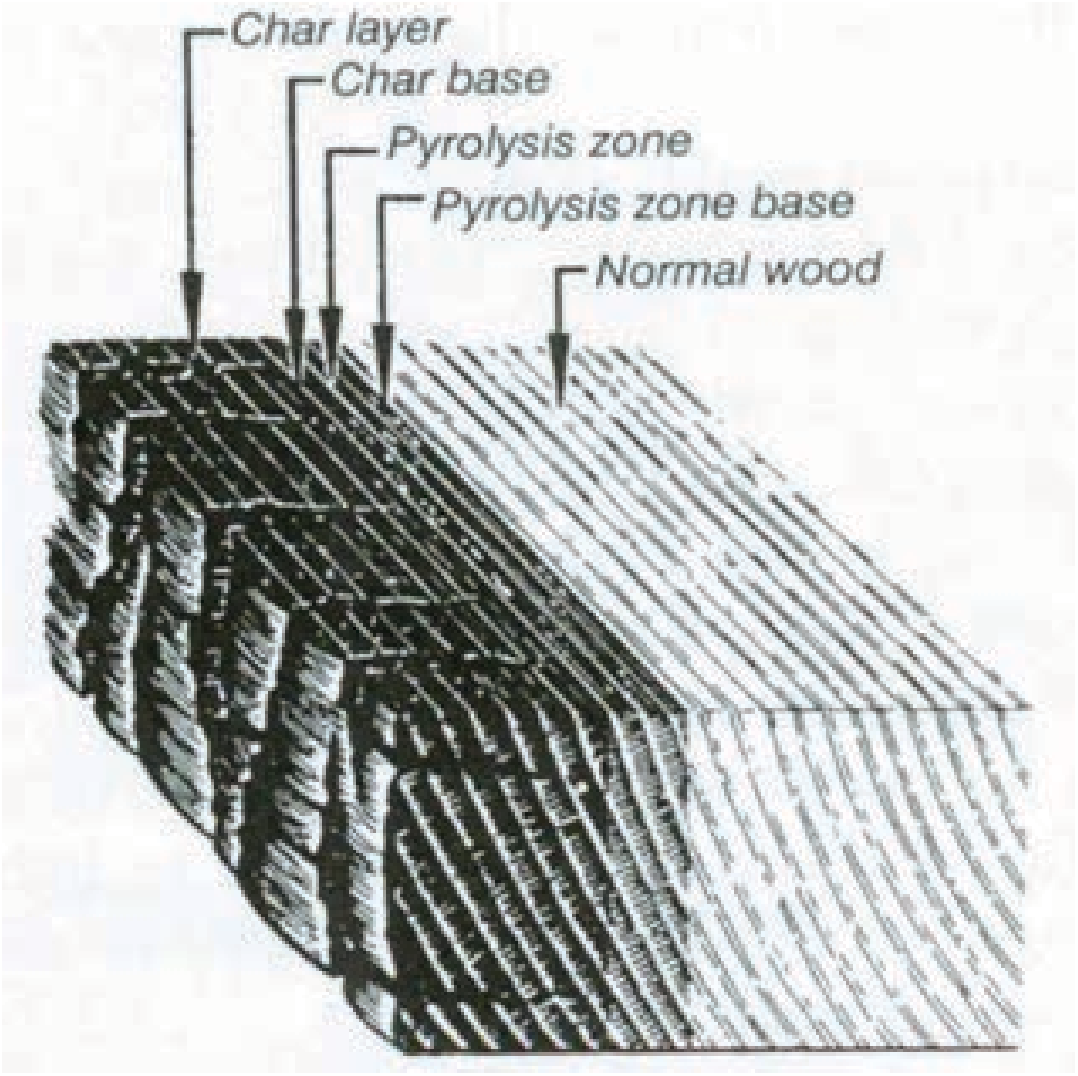
CLT Resources - Fire



Schaffer, 1966, Forest Products Laboratory

$$a_{eff} = 1.2\ \beta_t t^{0.813}$$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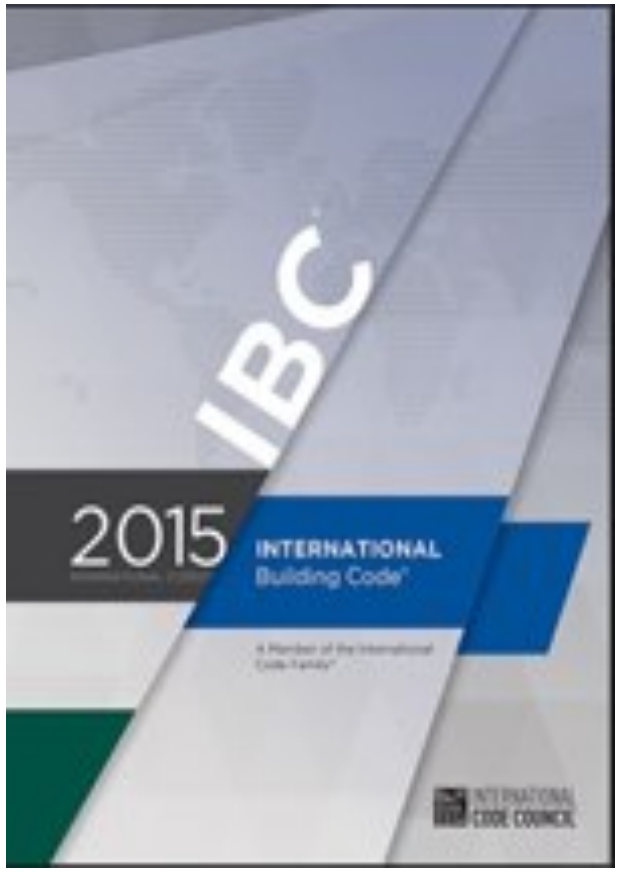
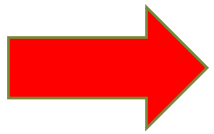
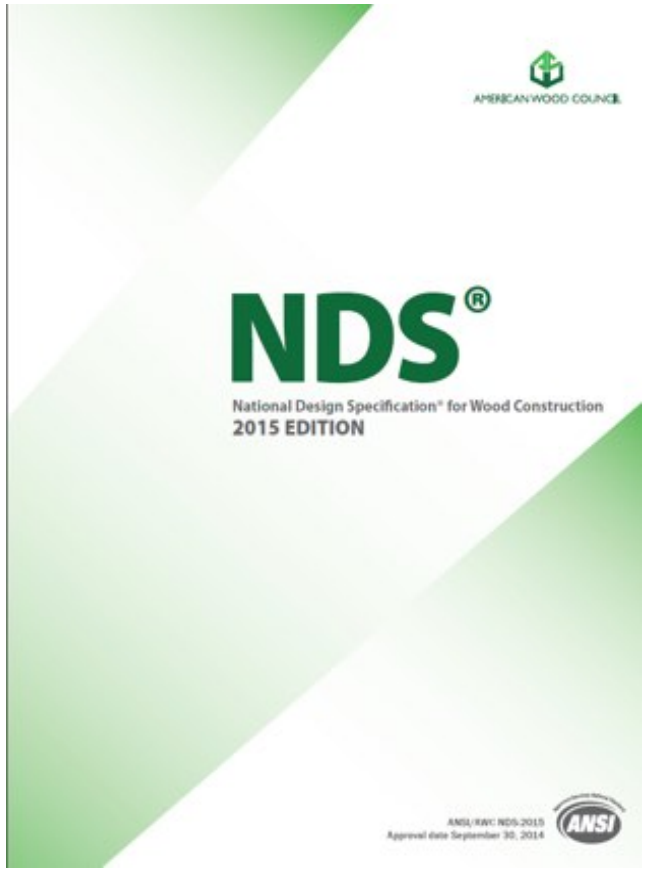
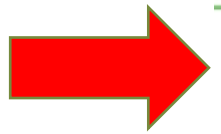
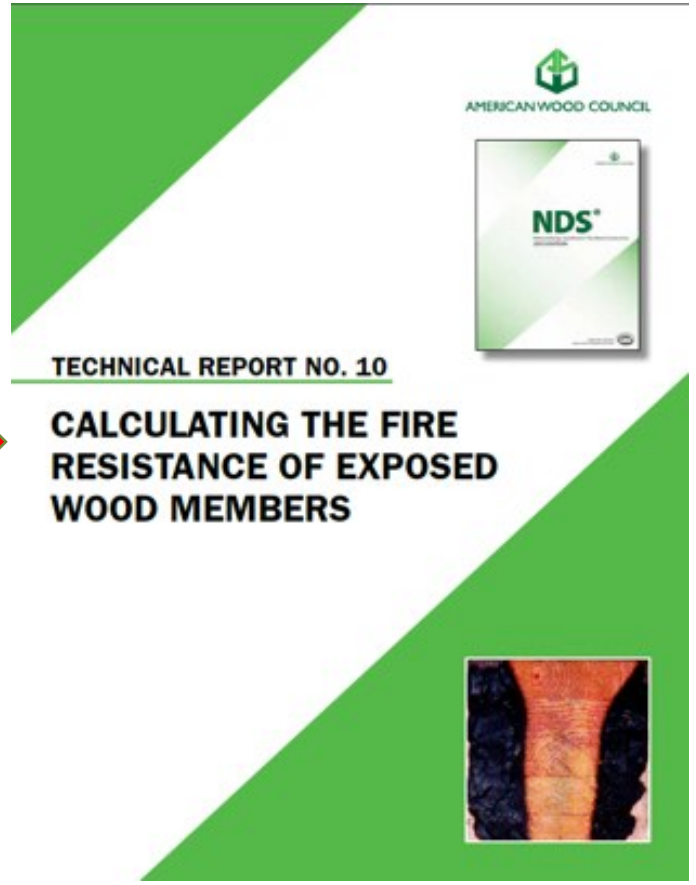

IBC
2015
INTERNATIONAL
Building Code®
INTERNATIONAL CODE COUNCIL




AMERICAN WOOD COUNCIL
NDS®
National Design Specification® for Wood Construction
2015 EDITION
ANSI




AMERICAN WOOD COUNCIL
NDS®
TECHNICAL REPORT NO. 10
CALCULATING THE FIRE RESISTANCE OF EXPOSED WOOD MEMBERS

DR Johnson

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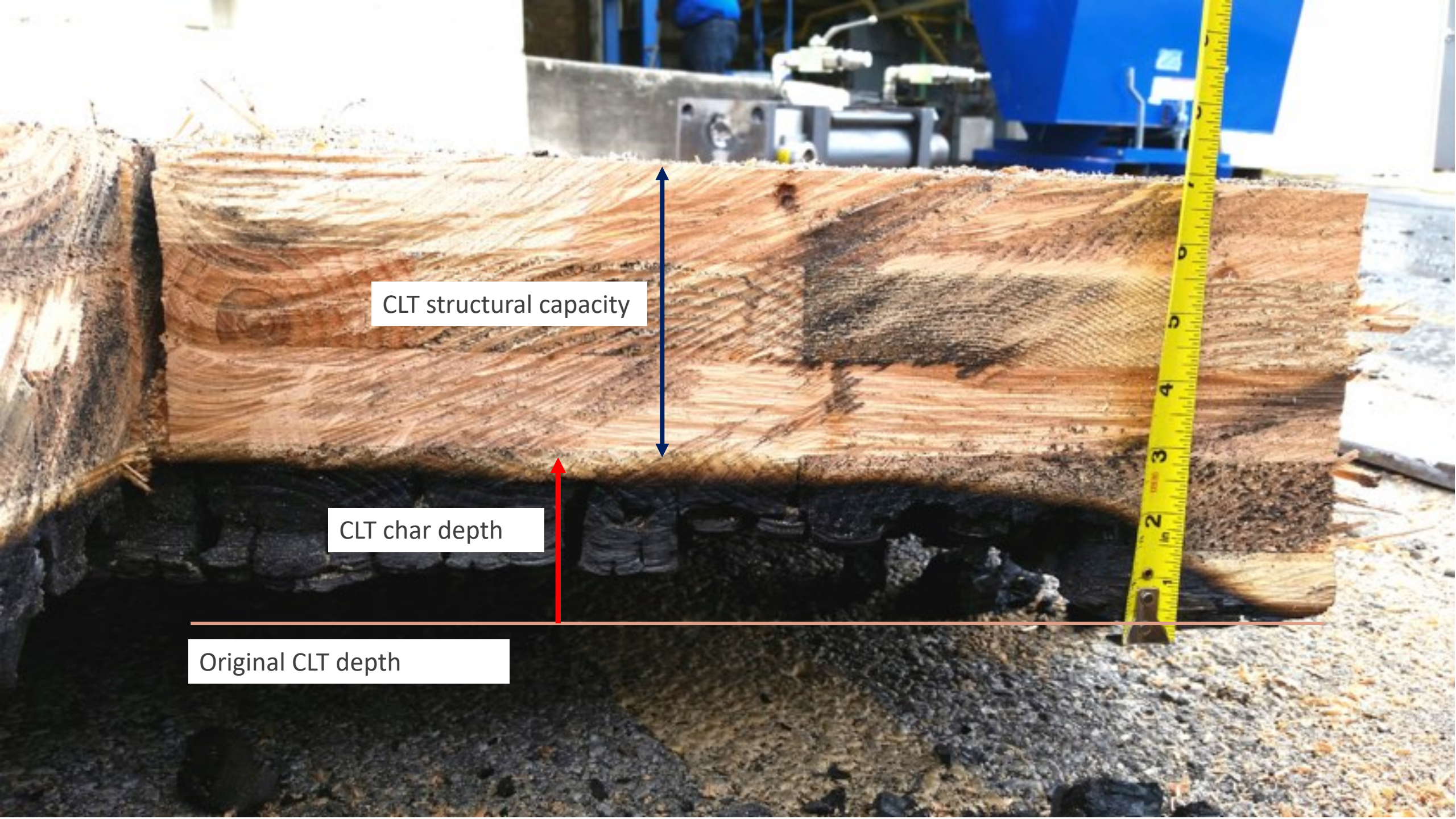
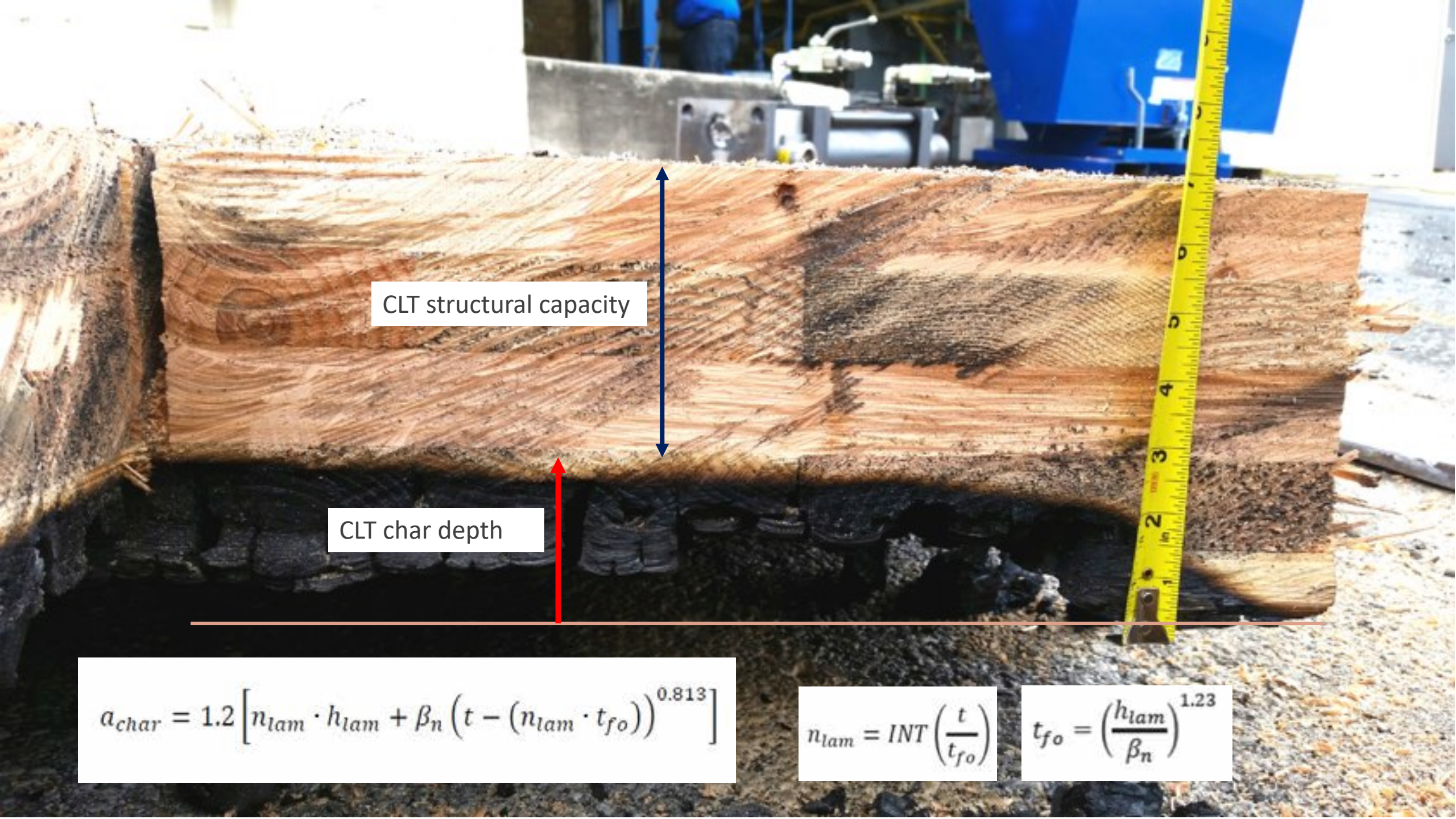

CLT structural capacity
CLT char depth
Original CLT depth



$$a_{char} = 1.2\left[n_{lam} \cdot h_{lam} + \beta_n \left(t - \left(n_{lam} \cdot t_{fo}\right)\right)^{0.813}\right]$$

$$n_{lam} = INT\left(\frac{t}{t_{fo}}\right)$$

$$t_{fo} = \left(\frac{h_{lam}}{\beta_n}\right)^{1.23}$$


A-13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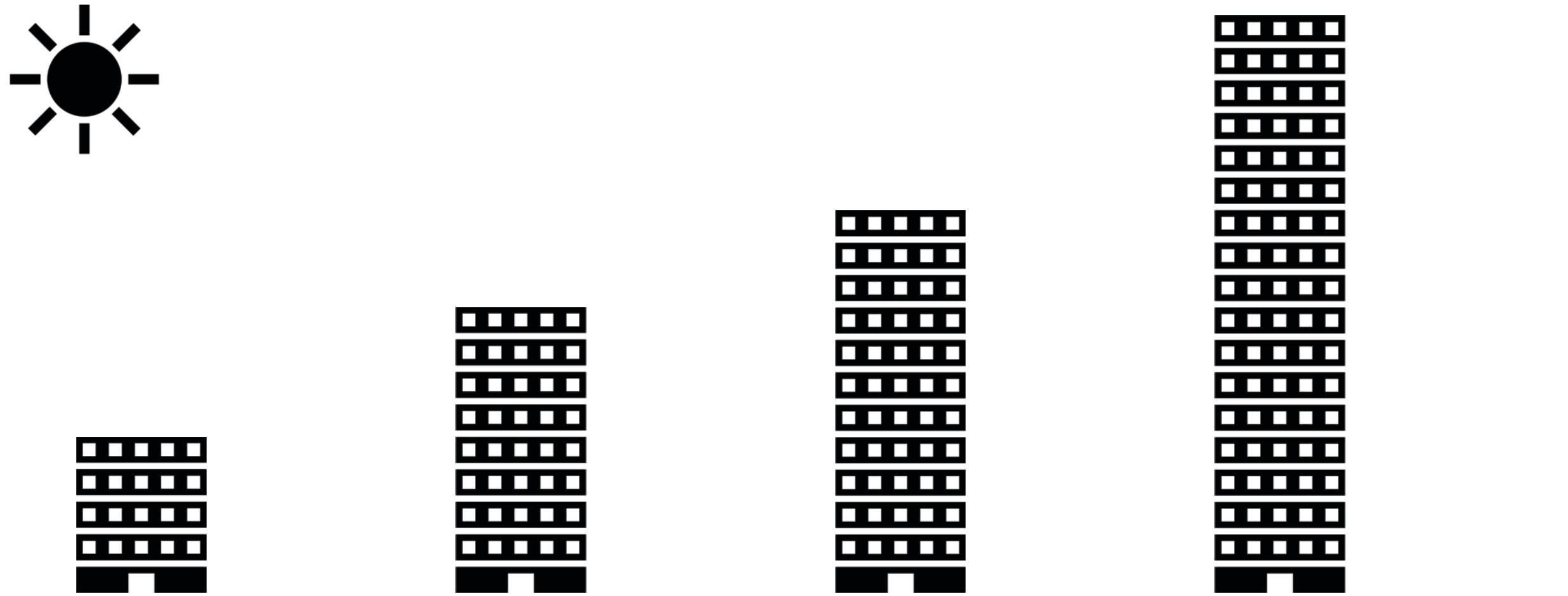
Exposed CLT in high – rise buildings what are the issues?



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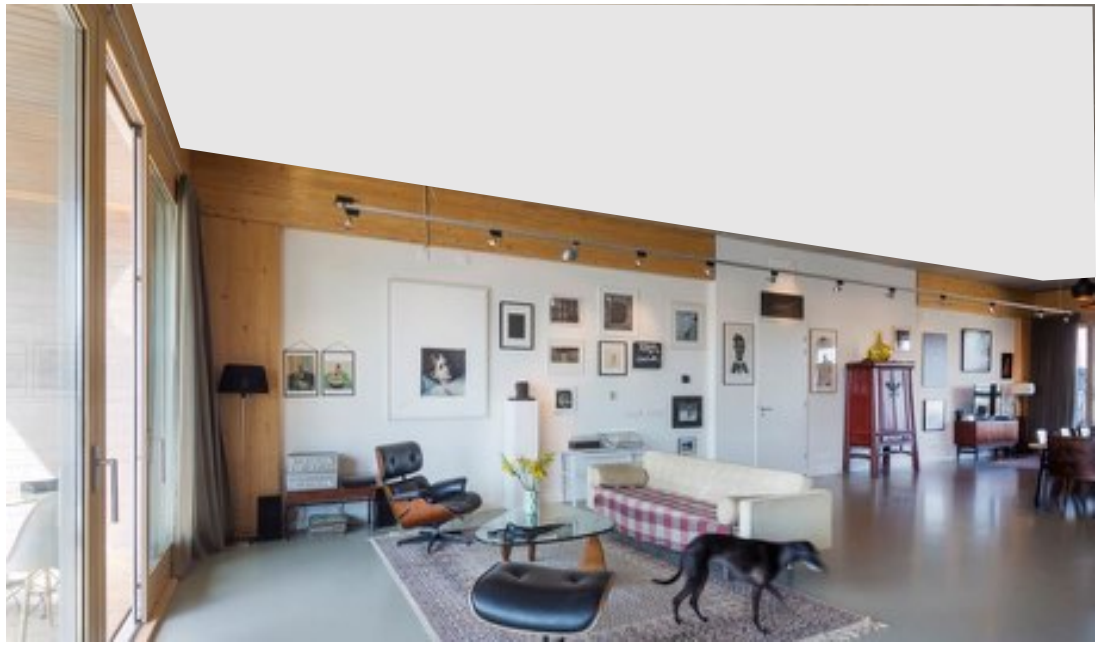
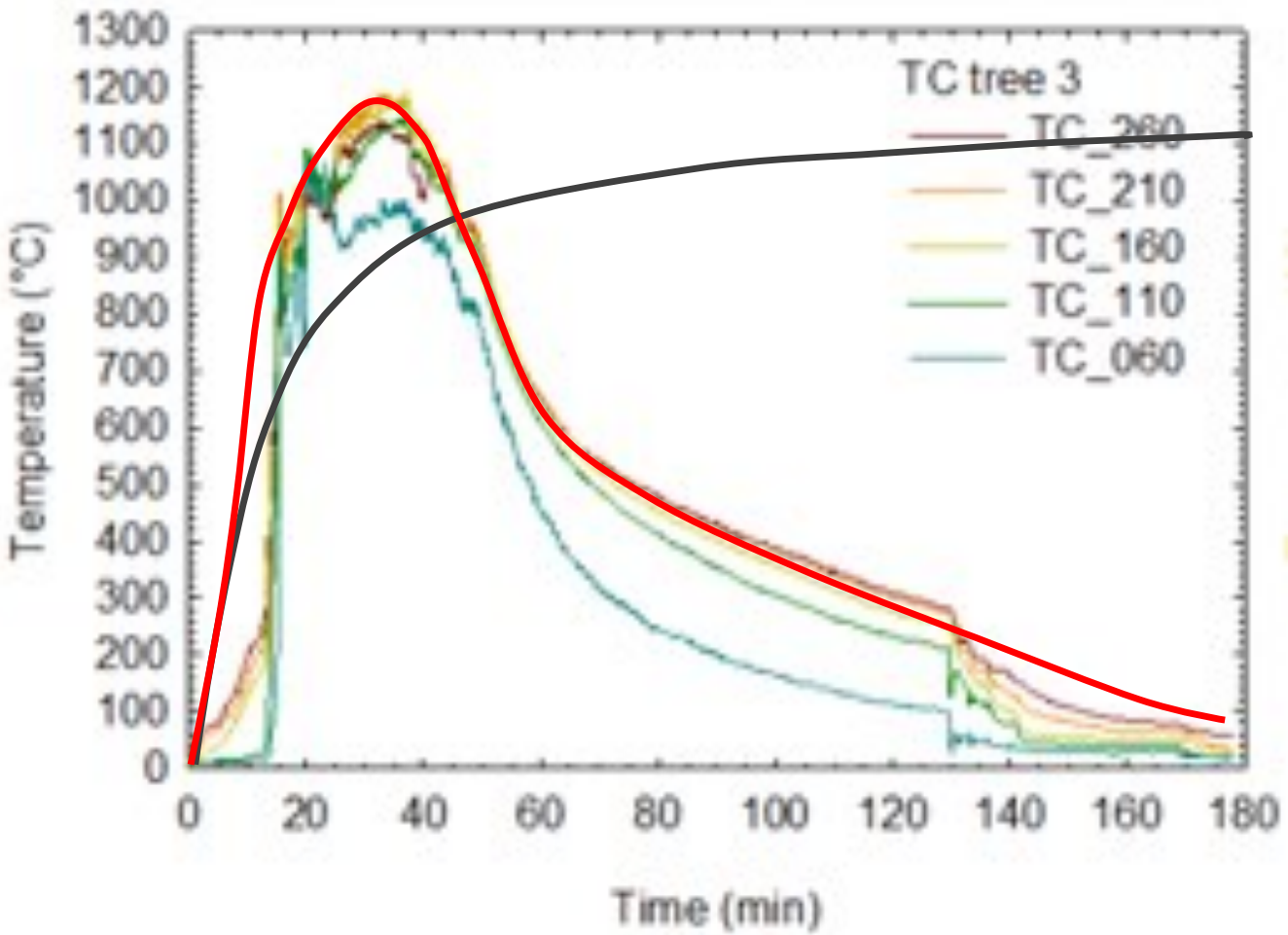
I WANT TO
BELIEVE

Fire Modelling – Exposed timber

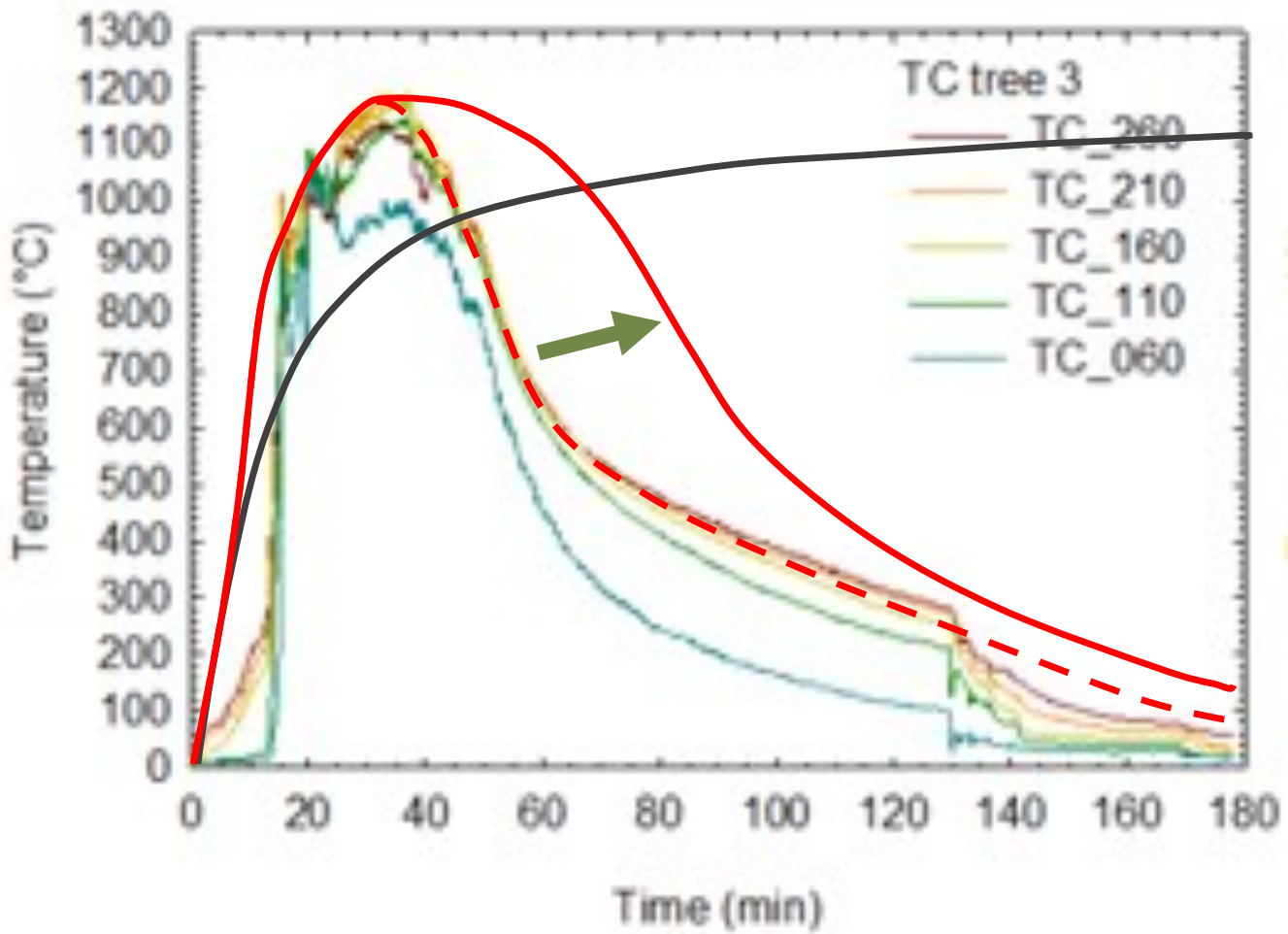


Fuel load 500MJ/m²



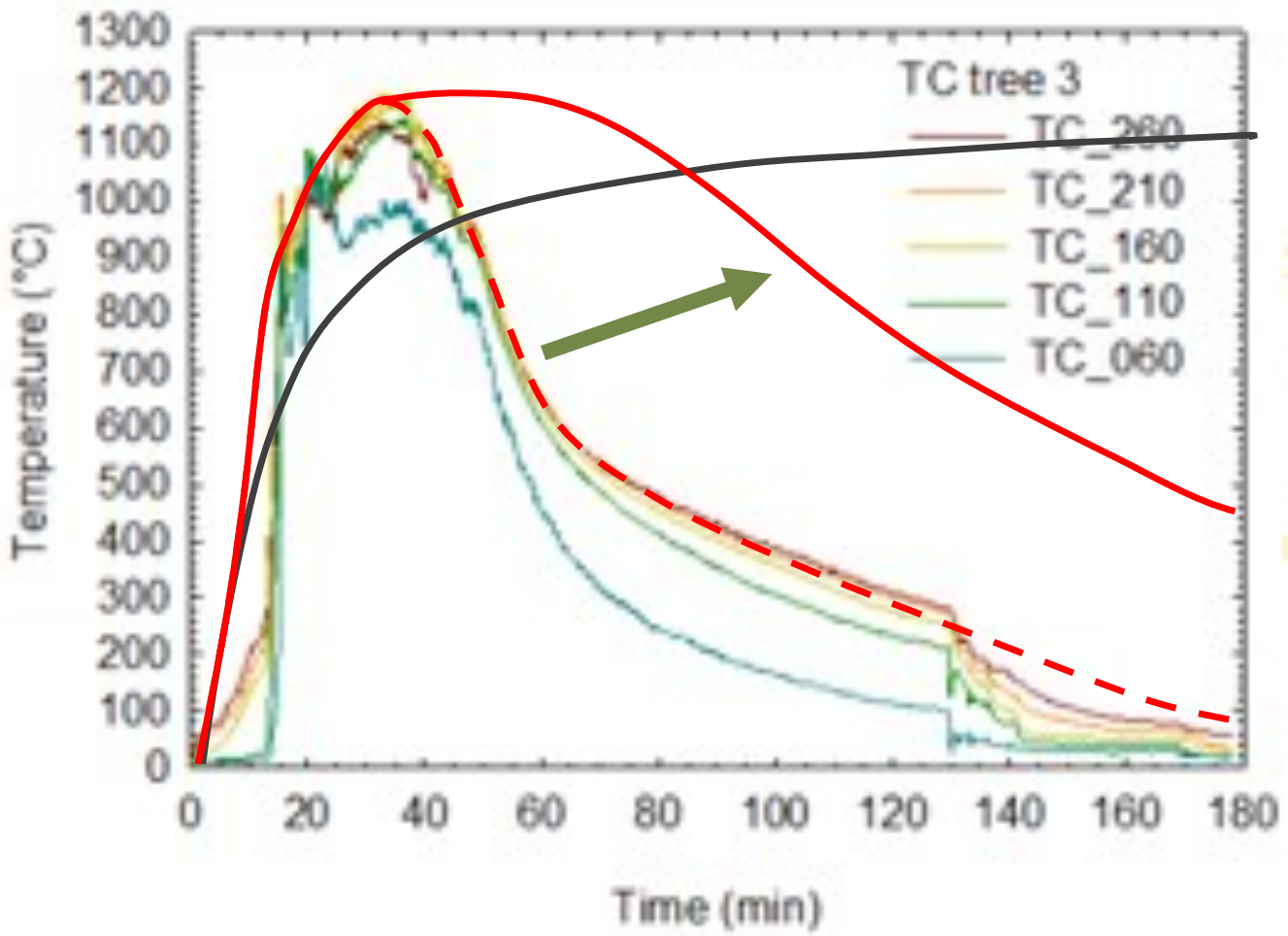
Fire Modelling – Exposed timber

Fuel load 750MJ/m²



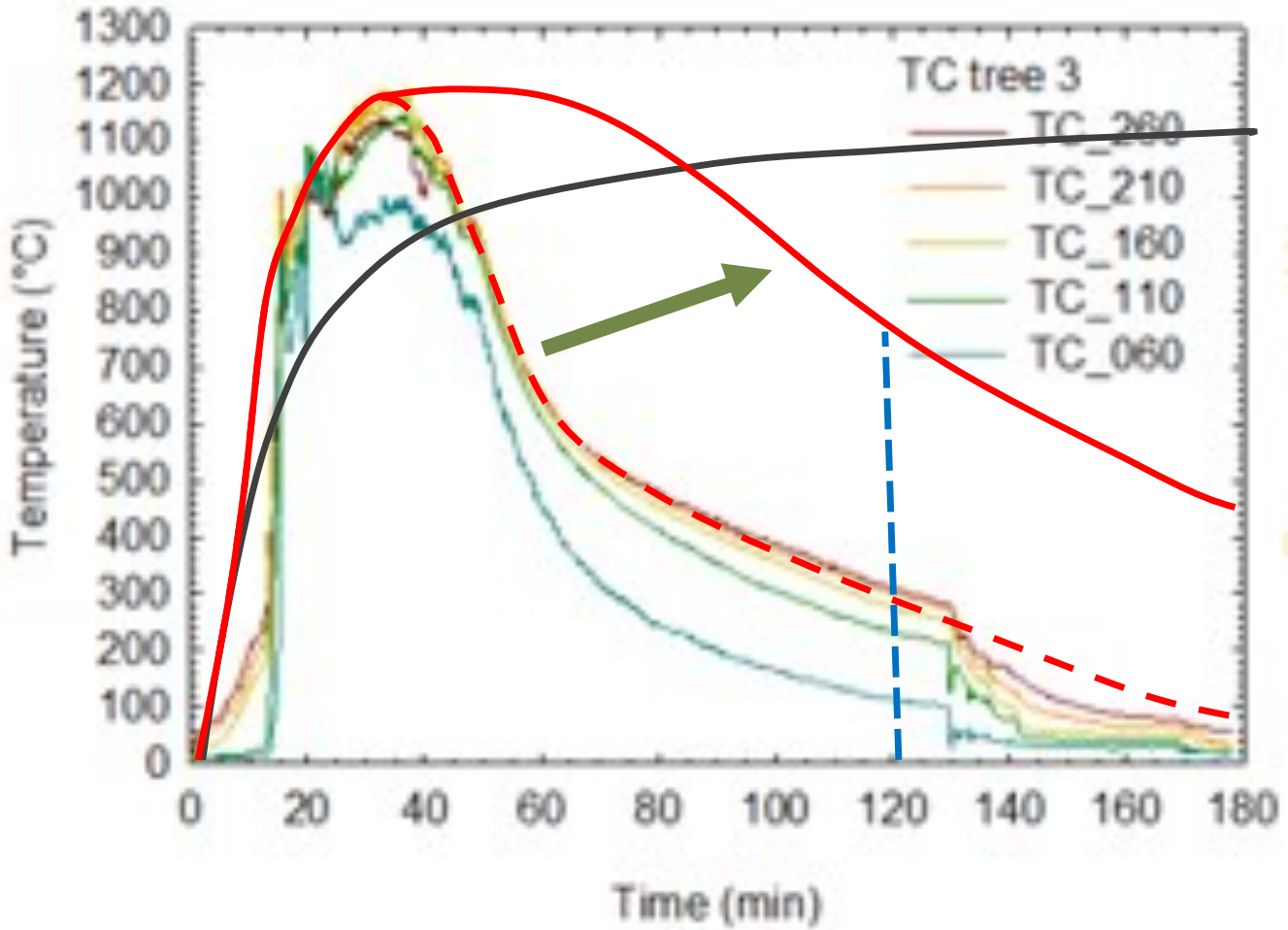
Fire Modelling – Exposed timber

Fuel load 1100MJ/m²



Fire Modelling – Exposed timber

Fuel load 1100MJ/m²



E119 test, CLT floor after 2hrs, with char fall-off

E119 test, CLT floor after 2hrs, with no char fall-off


Crielaard


15757


20707


2:14 16

For high-rise buildings:

Exposed CLT can be ok, in limited areas

Exposed CLT walls impact the fire dynamics less than ceilings

The adhesive used in the CLT is important (PRG-320 2018 update). Will allow more CLT to be exposed

Where the CLT is not exposed, the protection must prevent charring for the duration of the expected fire

Conclusions

For Type III, IV and V buildings (< 85ft), CLT is ok to be exposed

CLT manufacturers have interior finish and fire resistance testing reports

Connections have been fire tested and have ratings

IBC compliant calculation method for FRR

Char fall off / delamination – only an issue in high-rise resolved with new manufacturing standard

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

Please contact me with any mass timber fire questions:

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