Tall Timber Buildings

The sky's the limit!

Ed Claridge - Principal Fire Engineer, Auckland Council

9th International Tall Building/High Rise Fire Safety Conference. Indianapolis, US I April 2025

Tall Timber Buildings

~~The sky's the limit!~~

Where is the limit?

Ed Claridge - Principal Fire Engineer, Auckland Council

9th International Tall Building/High Rise Fire Safety Conference. Indianapolis, US I April 2025

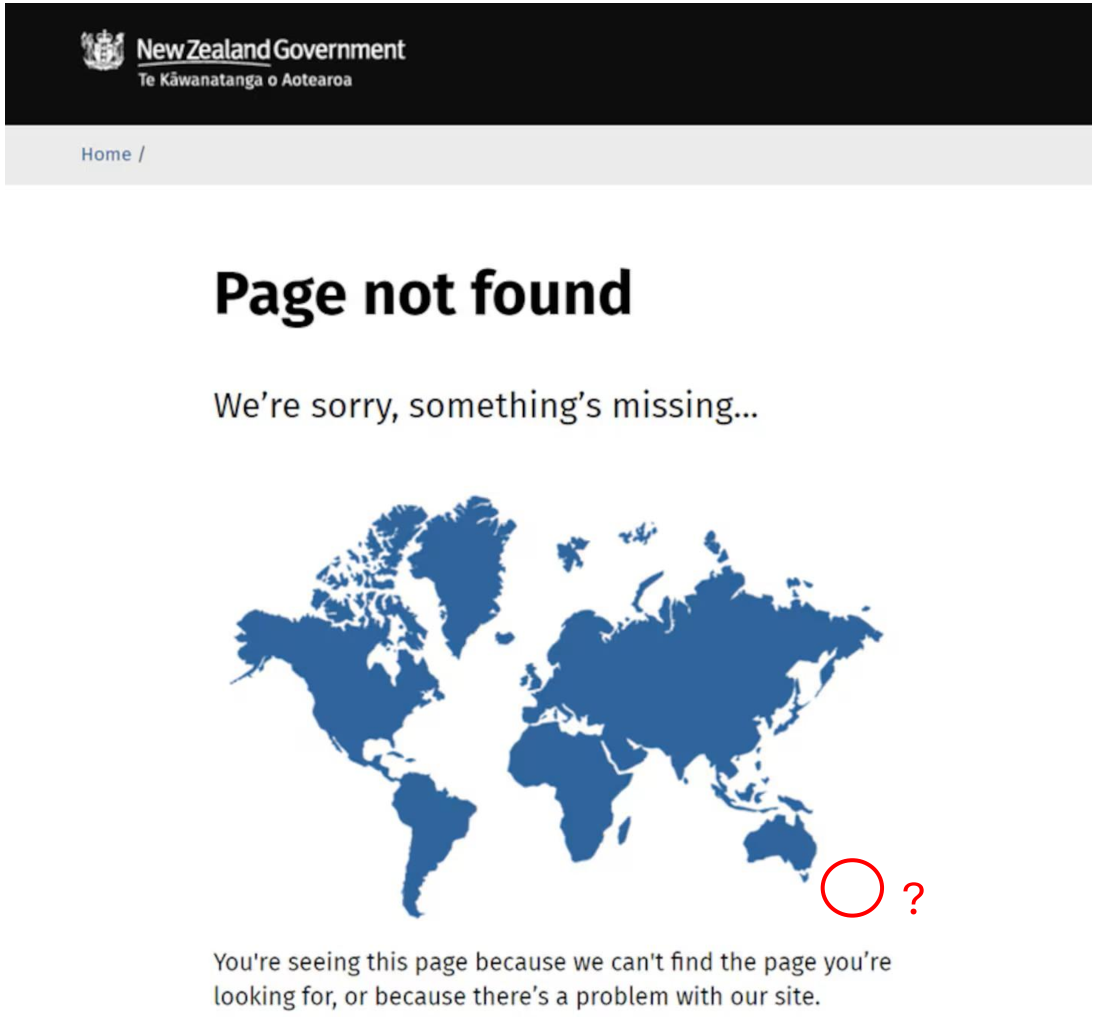

BLUFF
NEW ZEALAND
LATITUDE
LONGITUDE
168°21 min 26 sec
EAST
AA
NEW ZEALAND
LONDON 18958 km
15008 km NEW YORK
HOBART 1680 km
1401 km CAPE REINGA
SYDNEY 2000 km
6 km DOG ISLAND
WELLINGTON 784 km
21 km RUAPUKE ISLAND

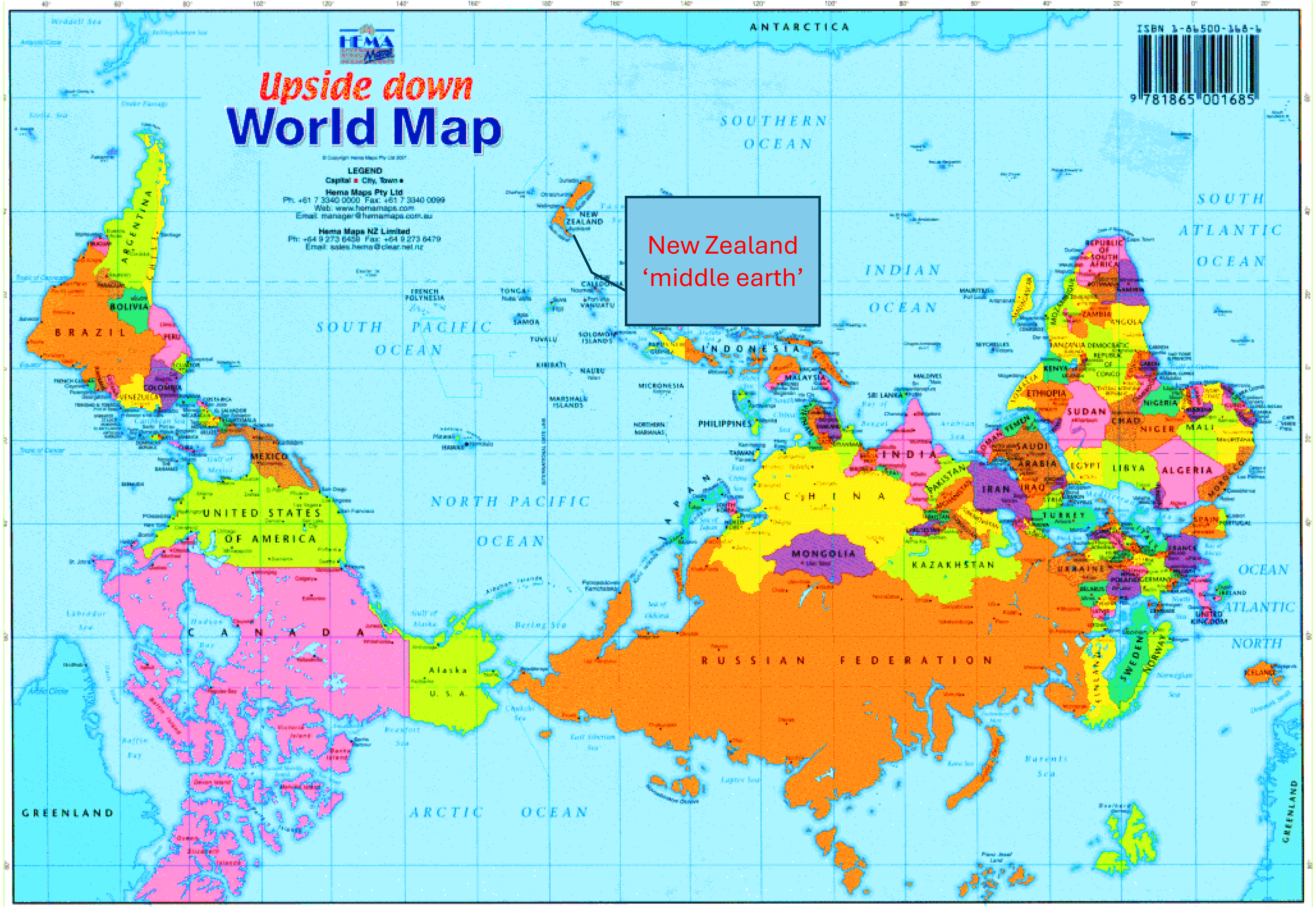
Aotearoa - New Zealand

Smithsonian Museum

Aotearoa - New Zealand

Smithsonian Museum




Upside down
World Map
LEGEND
Capital City, Town
Hema Maps Pty Ltd
Hema Maps NZ Limited
ANTARCTICA
SOUTHERN OCEAN
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
SOUTH PACIFIC OCEAN
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
ARCTIC OCEAN
NEW ZEALAND
New Zealand
'middle earth'
BRAZIL
BOLIVIA
ARGENTINA
CHILE
PERU
COLOMBIA
VENEZUELA
MEXICO
UNITED STATES OF AMERICA
CANADA
Alaska U. S. A.
GREENLAND
RUSSIAN FEDERATION
CHINA
MONGOLIA
KAZAKHSTAN
INDIA
INDONESIA
MALAYSIA
PHILIPPINES
JAPAN
IRAN
IRAQ
SAUDI ARABIA
TURKEY
UKRAINE
SUDAN
ETHIOPIA
KENYA
CHAD
NIGER
MALI
ALGERIA
LIBYA
EGYPT
NIGERIA
ANGOLA
ZAMBIA
REPUBLIC OF SOUTH AFRICA
MADAGASCAR
SPAIN
FRANCE
UNITED KINGDOM
IRELAND
SWEDEN
NORWAY
FINLAND
ICELAND
SOLOMON ISLANDS
MICRONESIA
MARSHALL ISLANDS
FRENCH POLYNESIA
TONGA
SAMOA
TUVALU
KIRIBATI
NAURU
Bering Sea
Barents Sea
ISBN 1-86500-168-6

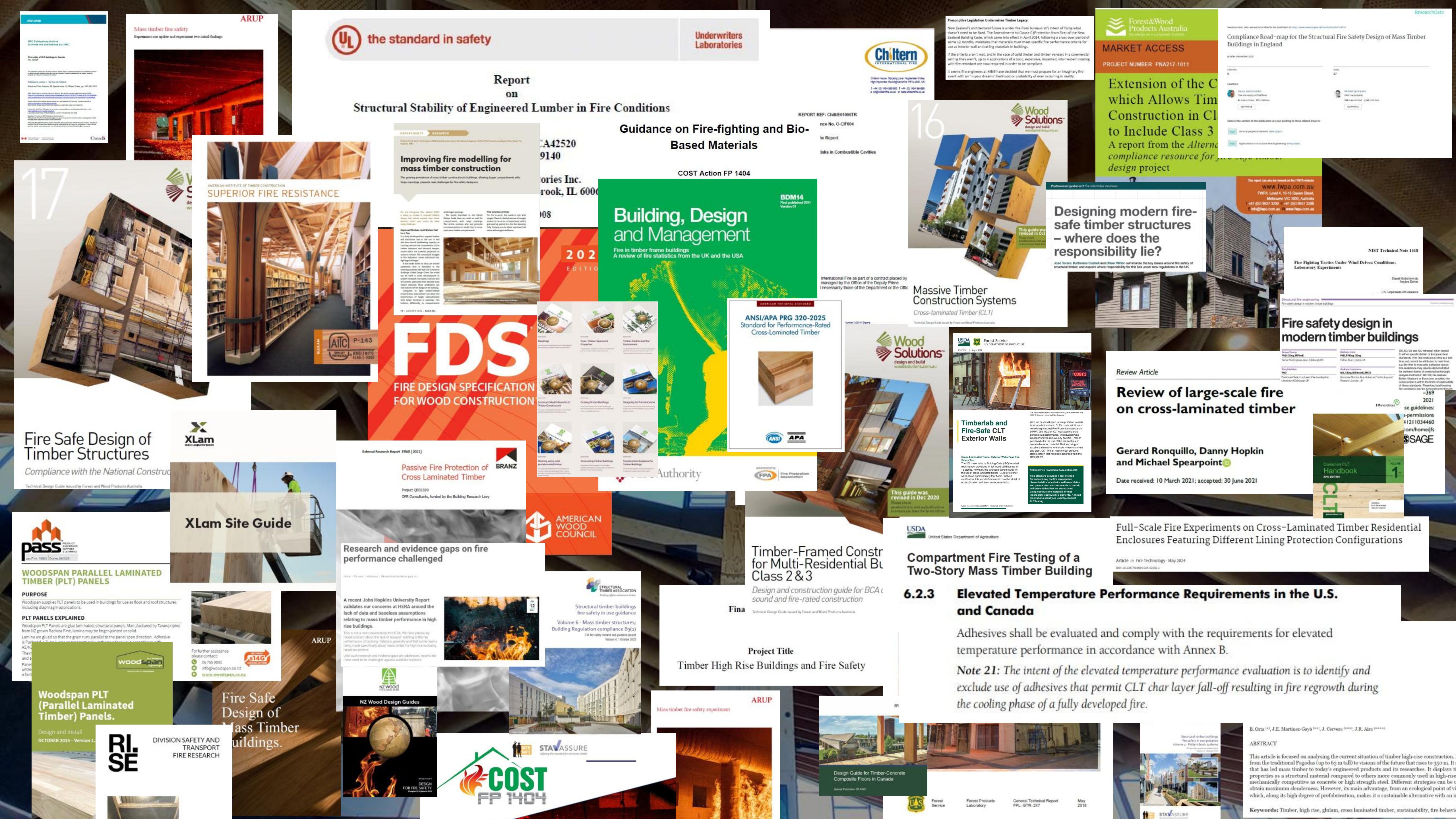
Auckland Council

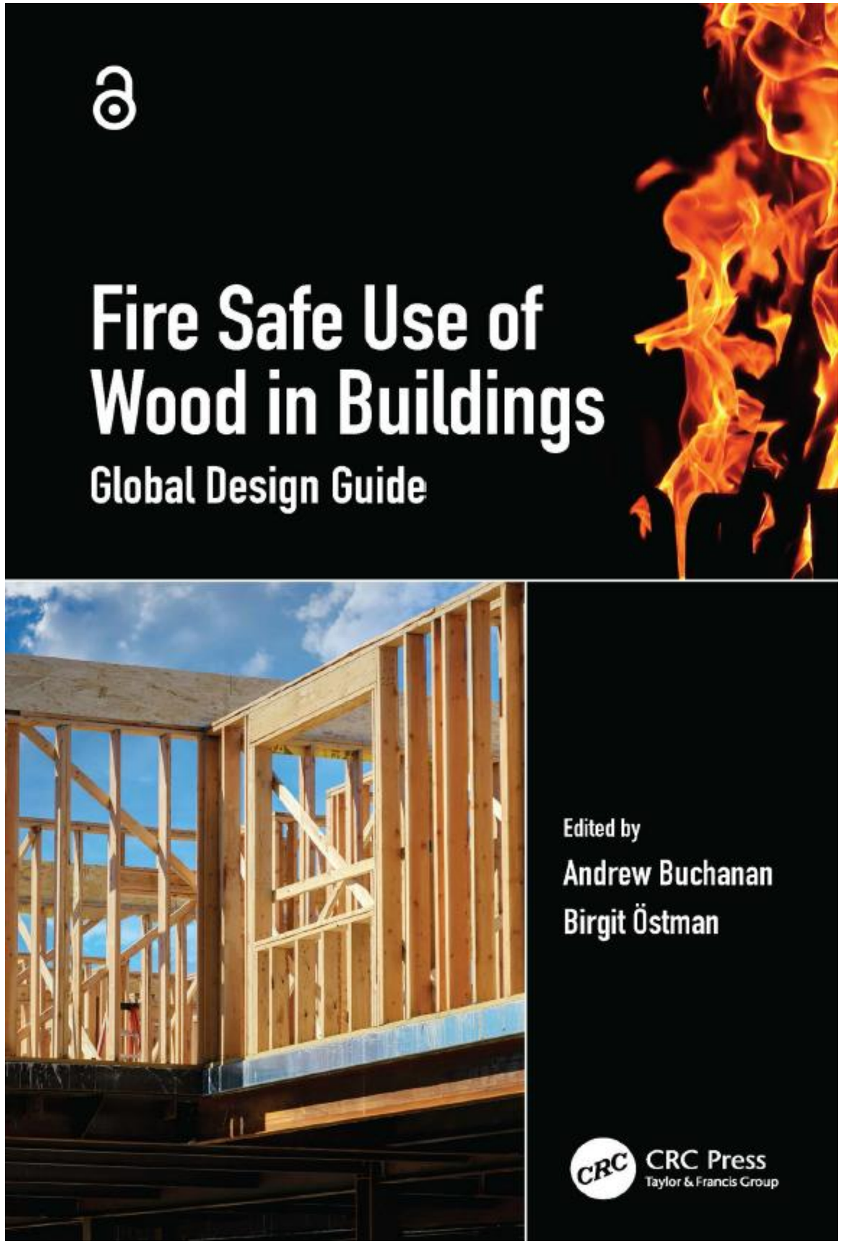
- largest local government council in the Southern Hemisphere
- largest approval authority - approximately 40-60% of all New Zealand's building approvals
- team of >250 building surveyors, code compliance assessors and building warrant of fitness officers (fire systems auditors)
- Annually
  - approvals for approx. 24,000 building consent applications
  - conduct 225,000 building inspections
  - issue 16,000 CCCs
  - 17,000 BWOFs


Cambourne Rd
MILES
HAZARD AREA
KATO

- Concrete?
  - basement/podium only
- Timber
  - stairs and risers shafts
  - lift shafts
  - external walls etc.

Guidance, guidance everywhere, but!


Mass timber fire safety
ARUP
the standard in safety
Underwriters Laboratories
Report on Structural Stability of Engineered Lumber in Fire Conditions
Chiltern International Fire
Prescriptive Legislation Undermines Timber Legacy
Forest & Wood Products Australia
MARKET ACCESS
PROJECT NUMBER: PNA217-1011
Compliance Road-map for the Structural Fire Safety Design of Mass Timber Buildings in England
Improving fire modelling for mass timber construction
Guidance on Fire-fighting and Bio-Based Materials
COST Action FP 1404
SUPERIOR FIRE RESISTANCE
AMERICAN INSTITUTE OF TIMBER CONSTRUCTION
Building, Design and Management
Fire in timber frame buildings
A review of fire statistics from the UK and the USA
BDM14
Wood Solutions
Massive Timber Construction Systems
Cross-laminated Timber (CLT)
Designing modern fire-safe timber structures – where does the responsibility lie?
NIST Technical Note 1618
Fire Fighting Tactics Under Wind Driven Conditions: Laboratory Experiments
Fire safety design in modern timber buildings
Fire Safe Design of Timber Structures
Compliance with the National Construction Code
FDS
FIRE DESIGN SPECIFICATION FOR WOOD CONSTRUCTION
ANSI/APA PRG 320-2025
Standard for Performance-Rated Cross-Laminated Timber
Timberlab and Fire-Safe CLT Exterior Walls
Review Article
Review of large-scale fire on cross-laminated timber
Gerard Ronquillo, Danny Hopkin and Michael Spearpoint
Date received: 10 March 2021; accepted: 30 June 2021
Canadian CLT Handbook
XLam
XLam Site Guide
Passive Fire Protection of Cross Laminated Timber
BRANZ
AMERICAN WOOD COUNCIL
WOODSPAN PARALLEL LAMINATED TIMBER (PLT) PANELS
Research and evidence gaps on fire performance challenged
Timber-Framed Construction for Multi-Residential Buildings Class 2 & 3
Compartment Fire Testing of a Two-Story Mass Timber Building
Full-Scale Fire Experiments on Cross-Laminated Timber Residential Enclosures Featuring Different Lining Protection Configurations
Structural timber buildings fire safety in use guidance
Volume 6 - Mass timber structures; Building Regulation compliance B3(1)
Project Title
Timber High Rise Buildings and Fire Safety
6.2.3 Elevated Temperature Performance Requirements in the U.S. and Canada
Adhesives shall be evaluated and comply with the requirements for elevated temperature performance in accordance with Annex B.
Note 21: The intent of the elevated temperature performance evaluation is to identify and exclude use of adhesives that permit CLT char layer fall-off resulting in fire regrowth during the cooling phase of a fully developed fire.
Woodspan PLT (Parallel Laminated Timber) Panels.
Fire Safe Design of Mass Timber Buildings.
RISE
DIVISION SAFETY AND TRANSPORT
FIRE RESEARCH
NZ Wood Design Guides
COST FP 1404
STAVASSURE
Mass timber fire safety experiment
Design Guide for Timber-Concrete Composite Floors in Canada
ABSTRACT

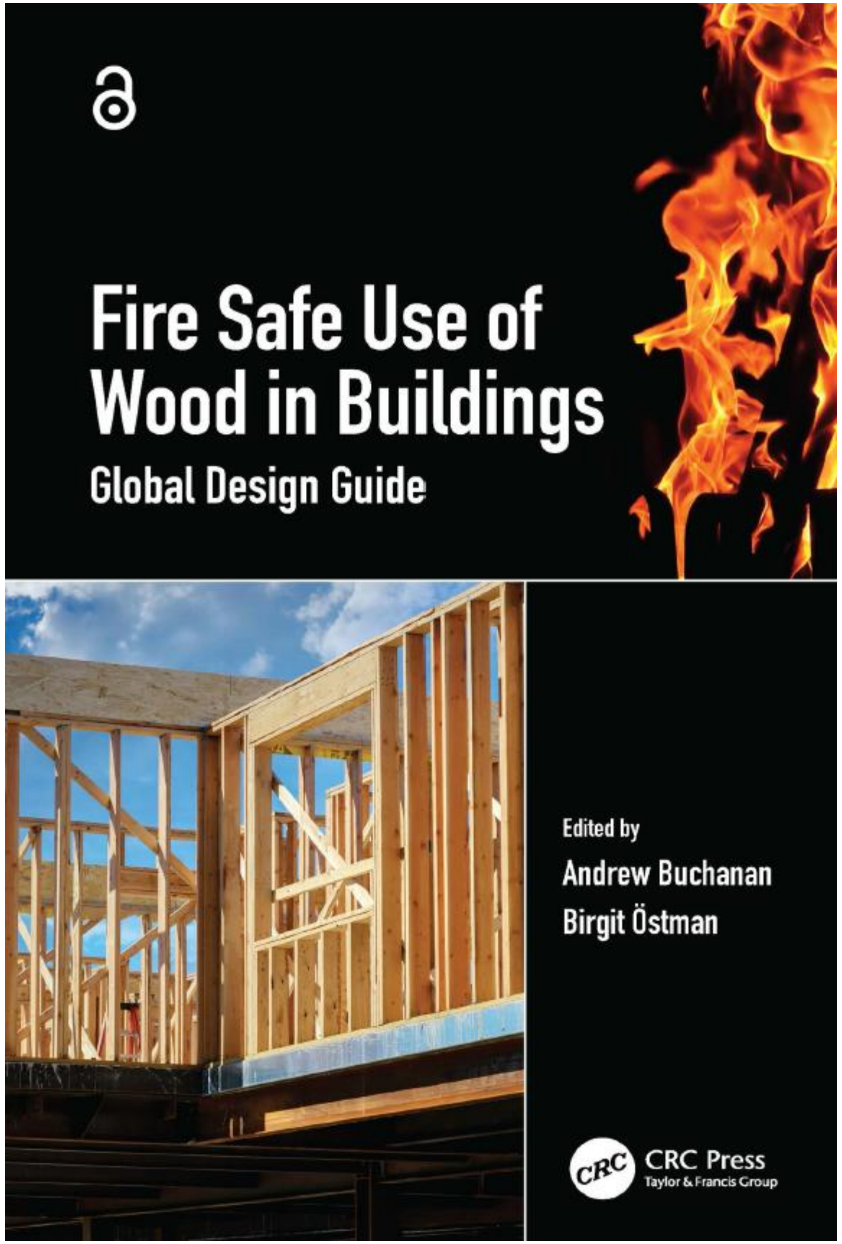


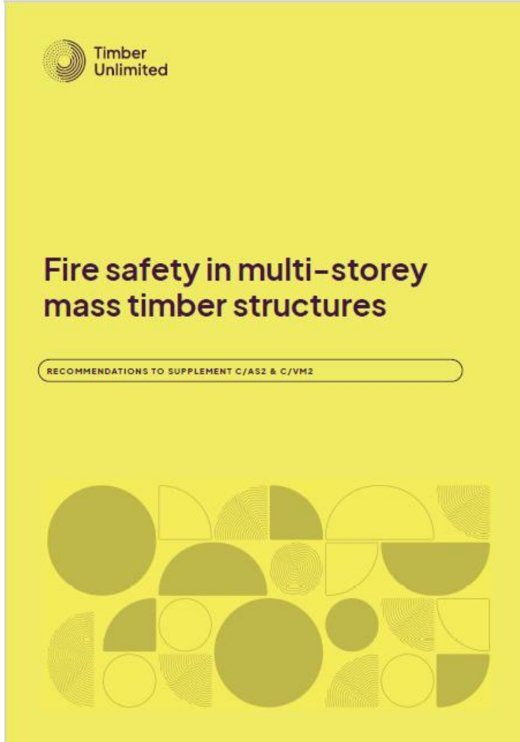
FIRE SAFE USE OF WOOD IN BUILDINGS – GLOBAL DESIGN GUIDE

Christian Dagenais*, Andy Buchanan, Birgit Östman, Michael Klippel,
David Barber, Ed Claridge, Andrew Dunn, Paul England, Marc Janssens,
Alar Just, Esko Mikkola, Colleen Wade, Norman Werther

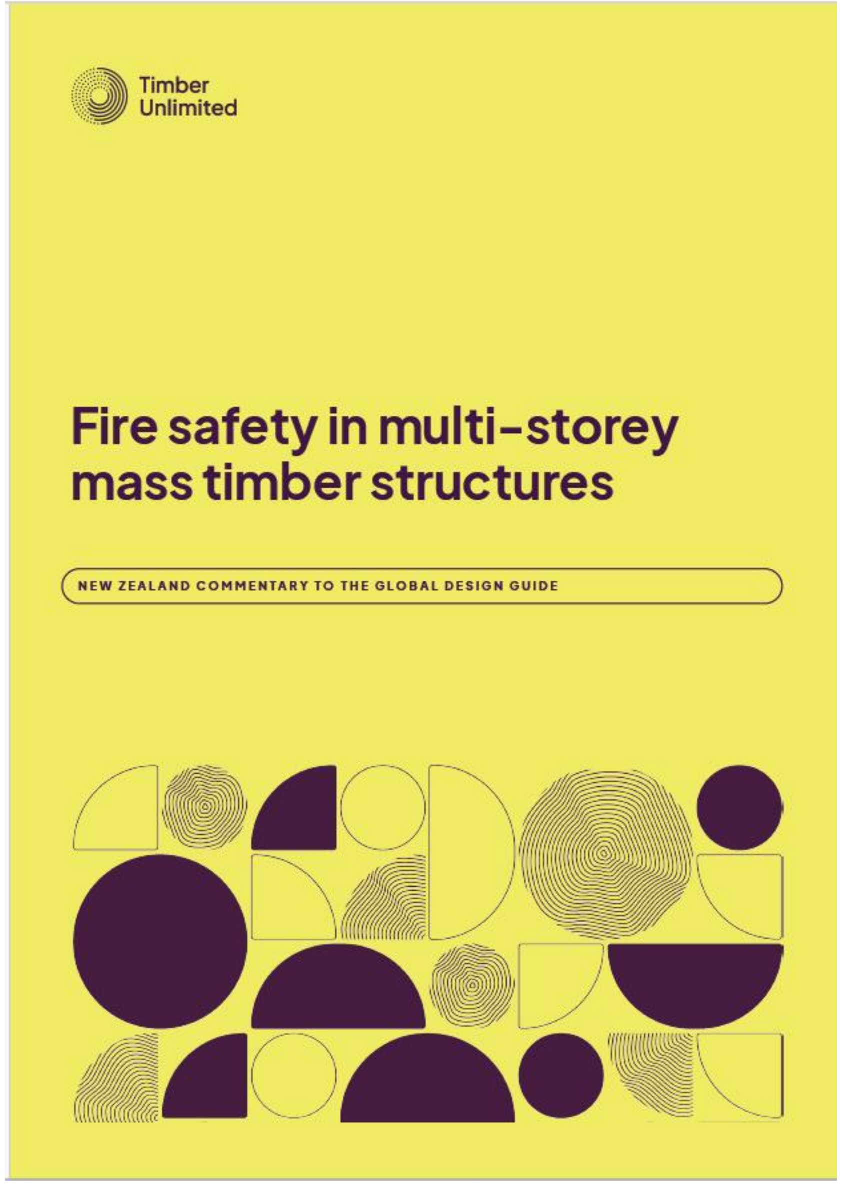
FPInnovations

World Conference on Timber Engineering Oslo 2023


Fire Safe Use of Wood in Buildings
Global Design Guide
Edited by
Andrew Buchanan
Birgit Östman
CRC Press
Taylor & Francis Group


Timber Unlimited
Fire safety in multi-storey mass timber structures
RECOMMENDATIONS TO SUPPLEMENT C/AS2 & C/VM2

Oct 23

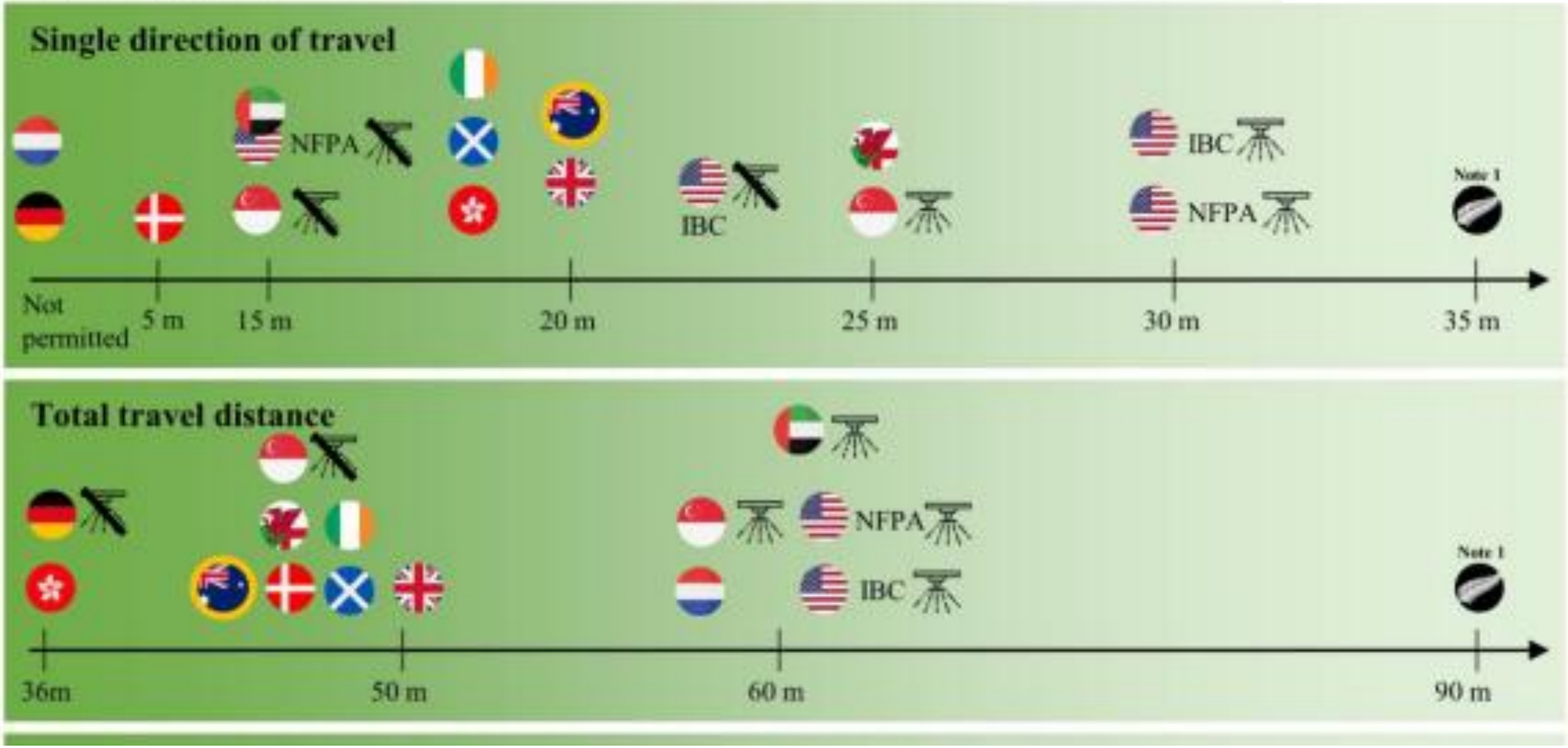

Timber Unlimited
Fire safety in multi-storey mass timber structures
NEW ZEALAND COMMENTARY TO THE GLOBAL DESIGN GUIDE

Aug 24

So how does NZ compare?

Out of date?

World leading?



https://www.abcb.gov.au/sites/default/files/resources/2024/296877-ABCB-ARUP-Fire-safety-in-carparks.pdf

Storeys	New Zealand		USA		Australia		Canada		England**	
	With sprinklers	Without sprinklers	With sprinklers	Without sprinklers	With sprinklers	Without sprinklers	With sprinklers	Without sprinklers	With sprinklers	Without sprinklers
20	30		180		90		120		120	
19	30		180		90		120		120	
18	30		180		90		120		120	
17	30		180		90		120		120	
16	30		180		90		120		120	
15	30		180		90		120		120	
14	30		180		90		120		120	
13	30		180		90		120		120	
12	30		120		90		120		120	
11	30		120		90		120		120	
10	30		120		90		120		120	
9	30	60	120		90		120		90	
8	30	60	120		90		120		90	
7	30	60	120		90		120		90	
6	30	60	60		90		60		60	
5	30	60	60		90		60		60	
4	30	60	60		90		60		60	60
3	30	60	0*		90	90	45	45	60	60
2	30	60	0*		90	90	45	45	30	30
1	0*	0*	0*	§	0*	0*	0*	0*	0*	0*
	FRR	FRR	FRR	FRR	FRR	FRR	FRR	FRR	FRR	FRR

§ International Residential Code can be used for one and two-family dwellings and townhouses up to 3 storeys without fire sprinklers.
* FRR may be required to protect tenancies and egress routes, or to limit fire spread across boundaries.
** Approved Document B only applies to 'common building situations' and may not apply to some buildings with a combustible structure.

Key:

- Combustible materials generally permitted.
- Fire-protected timber (typically requires two layers of fire grade plasterboard).
- Fire-protected timber (limited areas of wood can be exposed on walls and ceiling).
- Non-combustible materials required.
- Primary structure can be combustible, except external wall
- Primary structure can be combustible except external wall.

There are three choices for modelling the full *burnout design fire*:

a) Use a time-equivalent formula to calculate the equivalent *fire* severity and specify *building elements* with a *fire resistance rating* not less than the calculated *fire* severity. In this case, an equivalent *fire* severity of $\boxed{\text{20 minutes}}$ shall be used, if the calculated value is less.

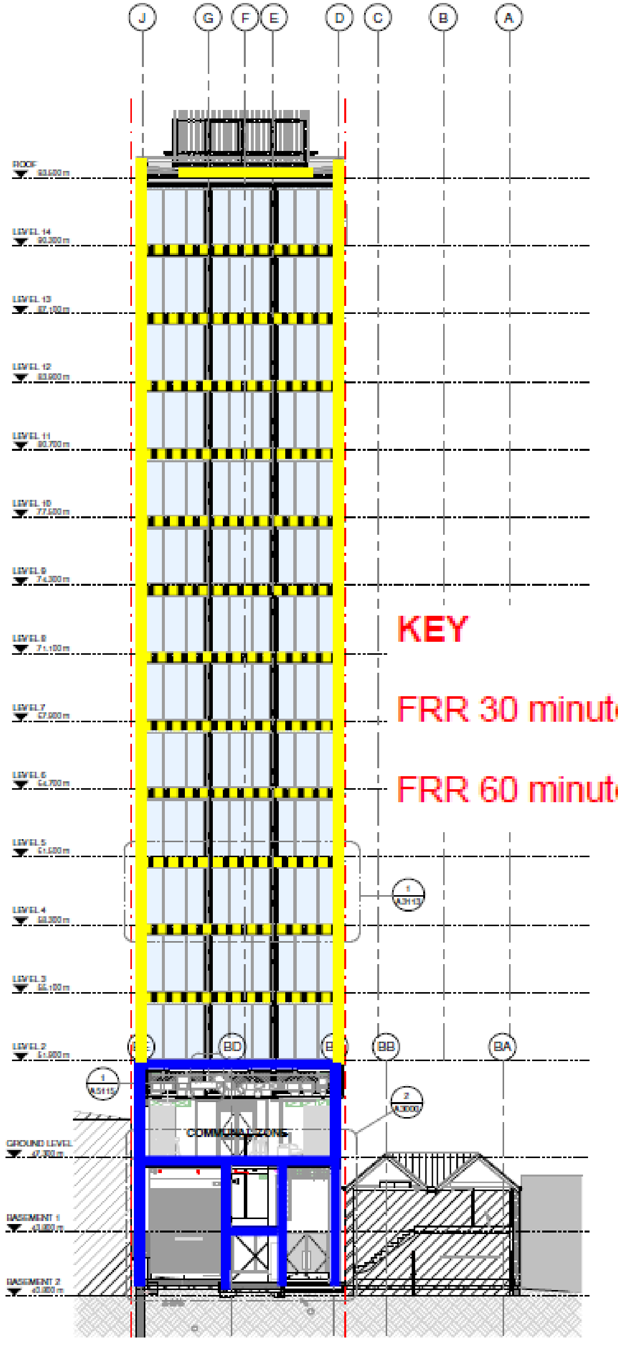
Worst case apartments — FHC = 1
(typical floor, Apt b, c, d, e, h, i, j or k)

k_b = 0.065
Firecell height = 2.4m
A_f = 36.5sqm
A_h = 0.0sqm — A_h/A_f = 0
A_v = 9.1sqm — A_v/A_f = 25%

$S = kt_e$ = 10 minutes — $\boxed{S = \text{10 minutes}}$

10 minutes for 30 stories!

https://www.buildmagazine.org.nz/articles/show/fire-safety-in-multi-storey-apartments

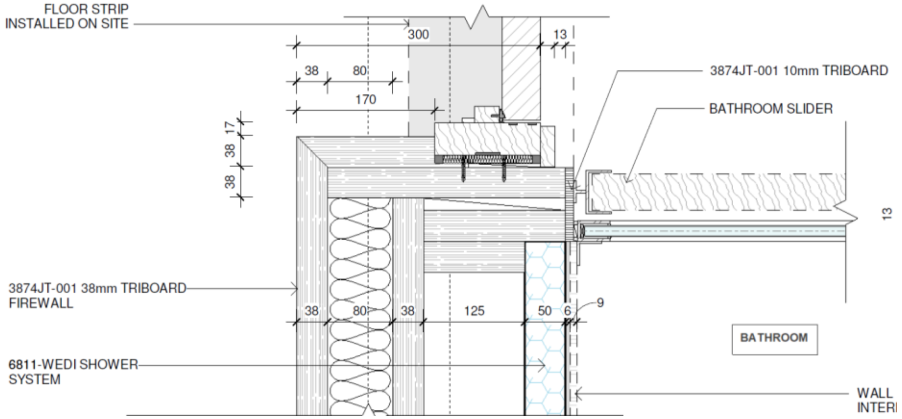


CROSS SECTION A1

16 storeys, +roof

30 minute fire rating provided by 38mm thick wood strand core panels

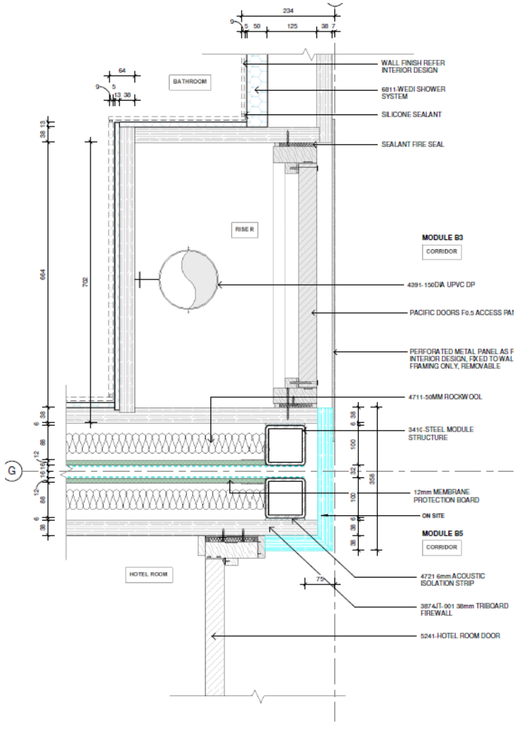
Modular construction, incl floors, ceiling, walls, risers etc.



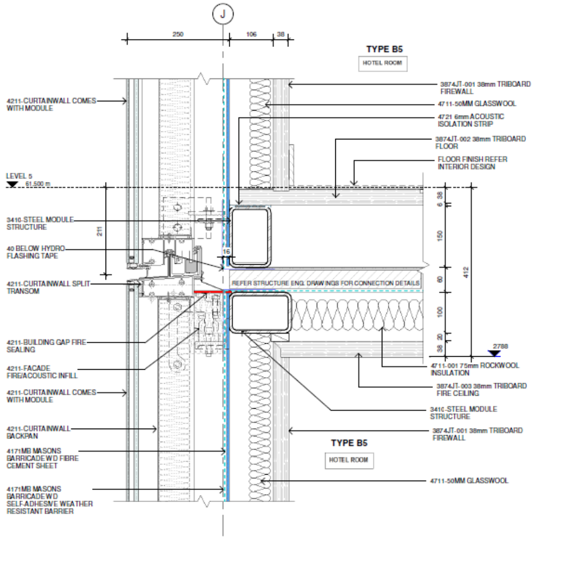
KEY

FRR 30 minutes

FRR 60 minutes



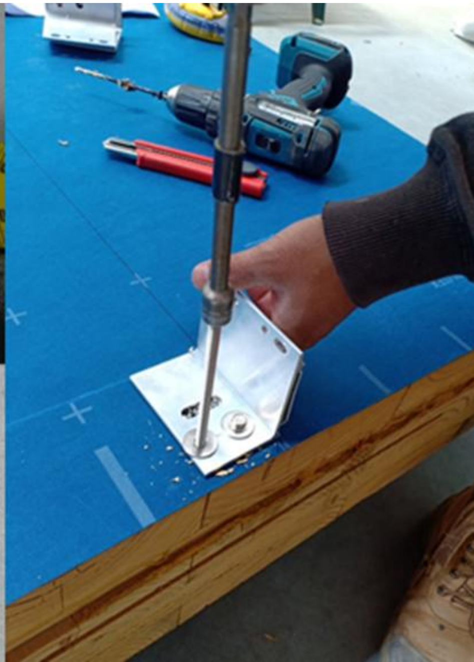
LEVEL 4-13 (TYPICAL) - FLOOR REFERENCE PLAN - TYPE B3 / B5



FIRE RATED CURTAIN GLAZING SECTION DETAIL

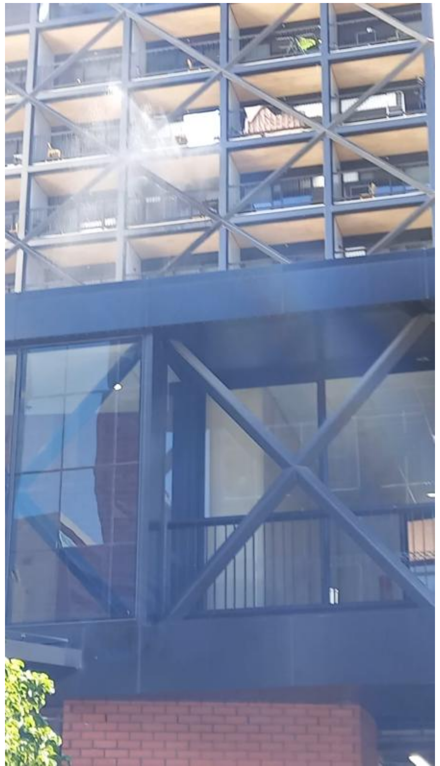
Mass timber learnings

- Construction



Mass timber Learnings

- Construction
- Moisture control – sprinklers?

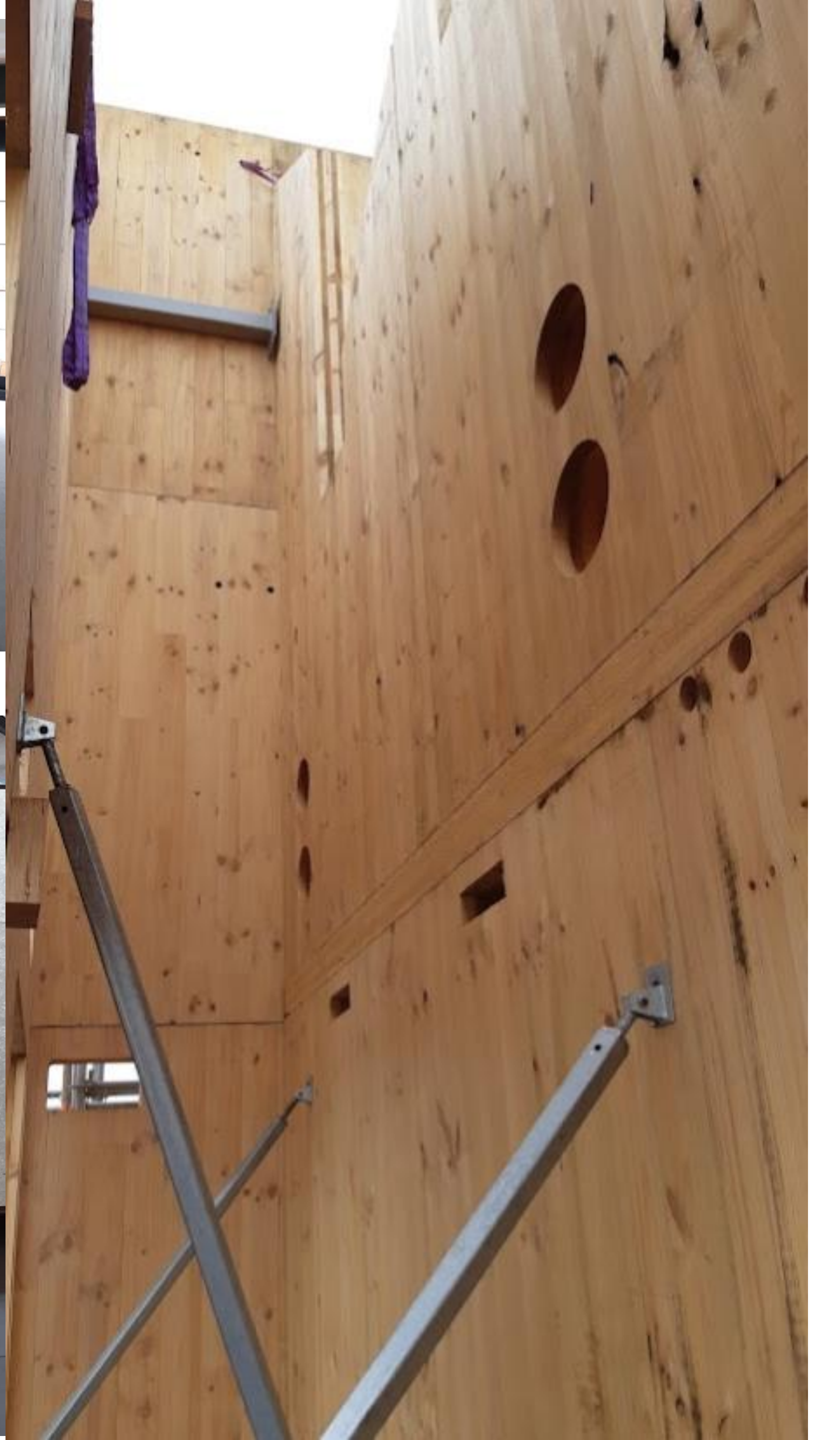


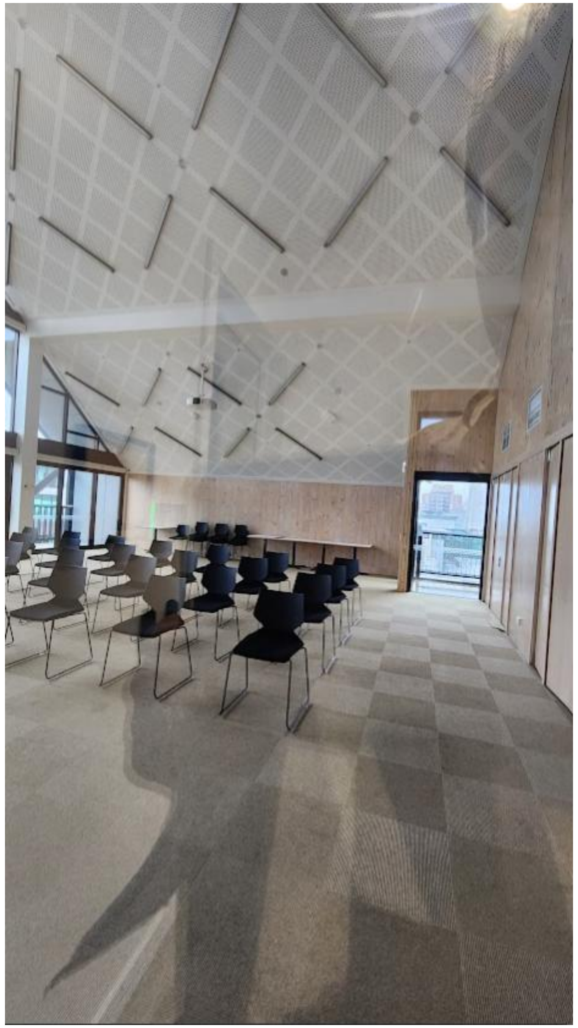
Mass timber Learnings

- Construction
- Moisture control
- Splits and gaps

Mass timber Learnings

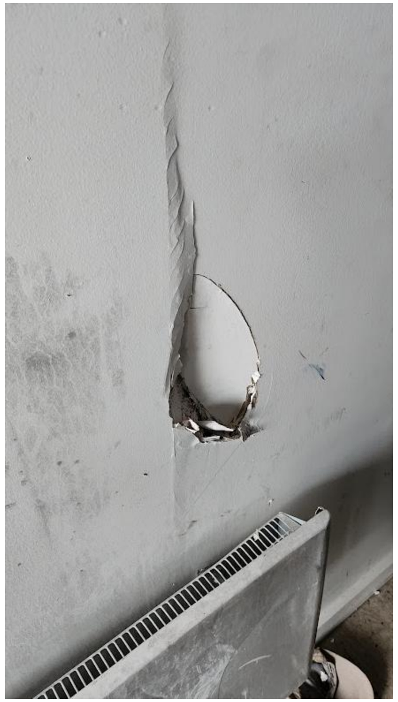
- Construction
- Moisture control
- Splits and gaps
- QA auditing and Onsite QC





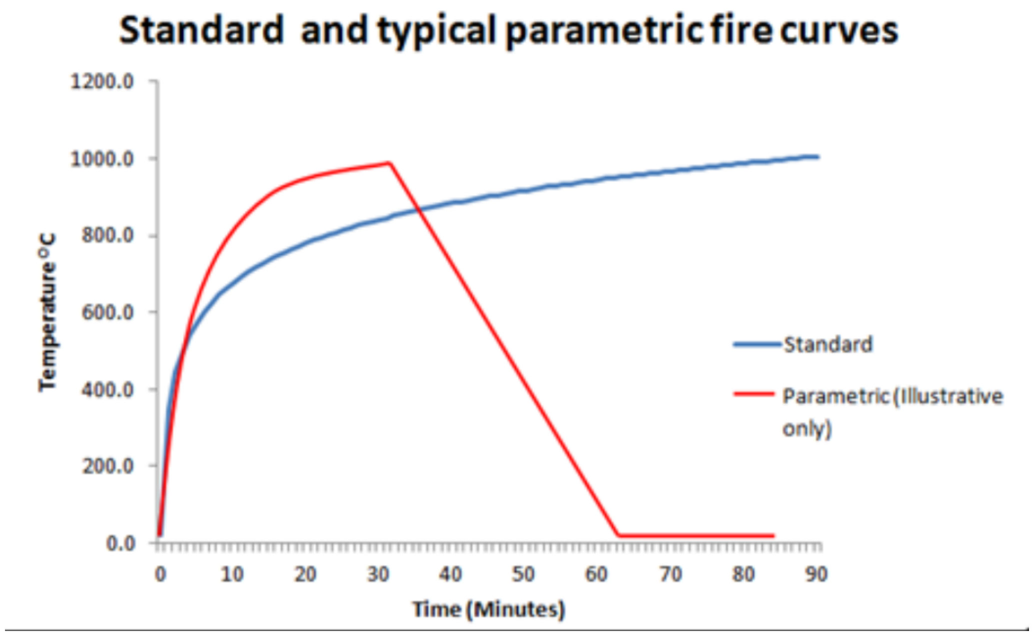
19

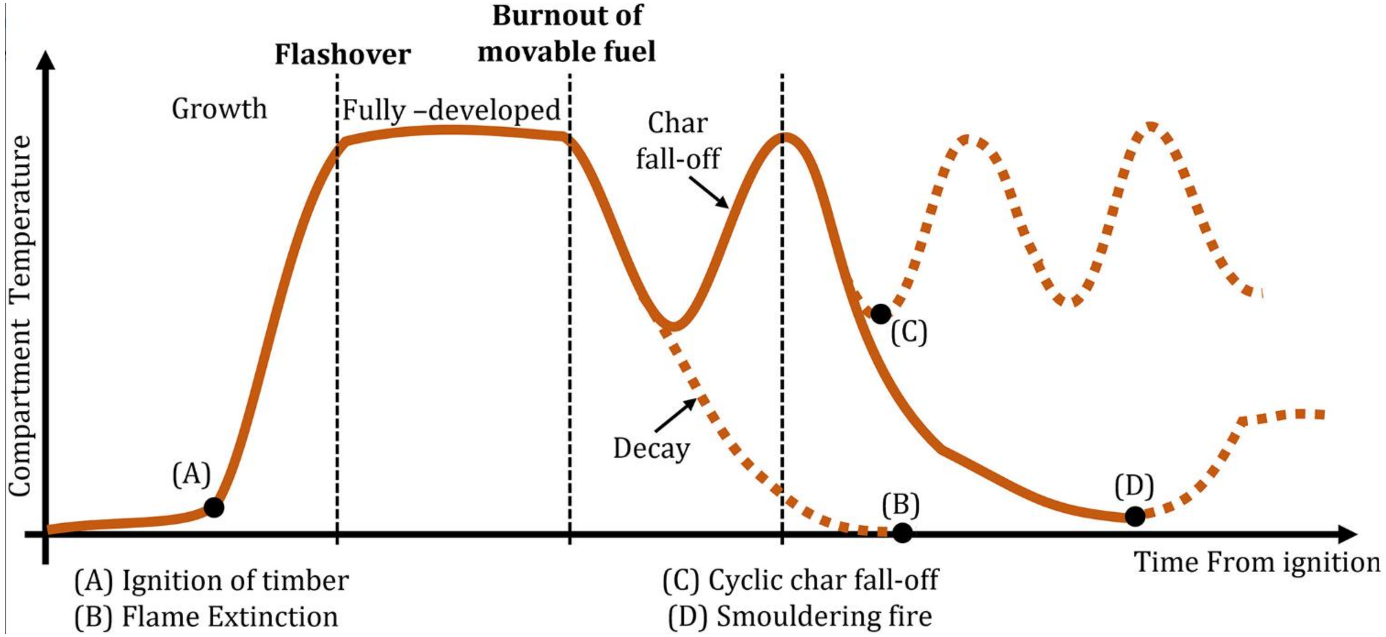
No standing, no storage
No storage




5
North Stair

Standard fire resistance testing





Time temperature curve for periods of fire development

* **Review of fire experiments in mass timber compartments: Current understanding, limitations, and research gaps**
https://doi.org/10.1002/fam.3121

New-York Tribune.

SUNDAY, OCTOBER 19, 1902.

"Fireproof wood," he said recently, "is really a misnomer. It should rather be called fire resisting wood" P. M. Stewart 1902

"when fearful consequences may result from a failure of a structure due to fire, no test is too severe which reasonable care and expense in construction can resist" Ira Woolson 1902

Building department experts applying the fire test to alleged fireproof building materials

Standard fire testing Hybrid/composite construction?

"it always must be borne in mind that in a strict sense standard fire (testing) is not a measure of the actual performance of an element in fire, and, furthermore, that it is not even a perfect measure for comparison"

Harmathy and Lie 1970

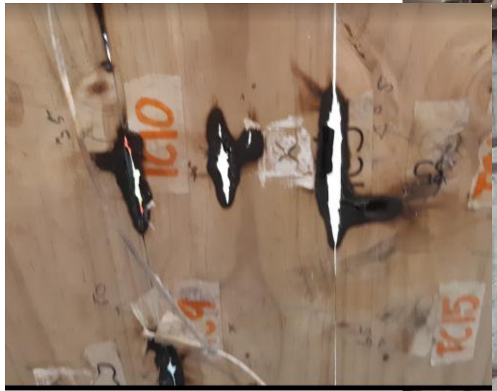
The structural fire engineering community is now waking up to the pitfalls of using standard fire testing and the opportunities that a more rational approach might present. A gradual shift in testing philosophy to large scale non-standard fire testing using real fires, rather than standard temperature-time curves, seems now to be underway, and a fire testing renaissance is occurring aimed at not merely capturing the comparative structural performance of isolated materials, but at rationally defining the full suite of interactions to be expected in real buildings in real fires.

Gales, J., Maluk, C., and Bisby, LA . Structural fire testing- where are we, how did we get here, and where are we going. 15th International conference on experimental mechanics: Fire symposium. 2012

Charring rates

- NZ typically uses a design value of 0.65mm/min
- AS/NZS 1720.4 does not apply to CLT
- Numerous NZ tests show charring rates far greater - 2.3mm/min and more!
- Idealised testing, not representative and no agreement!
- Charring is burning

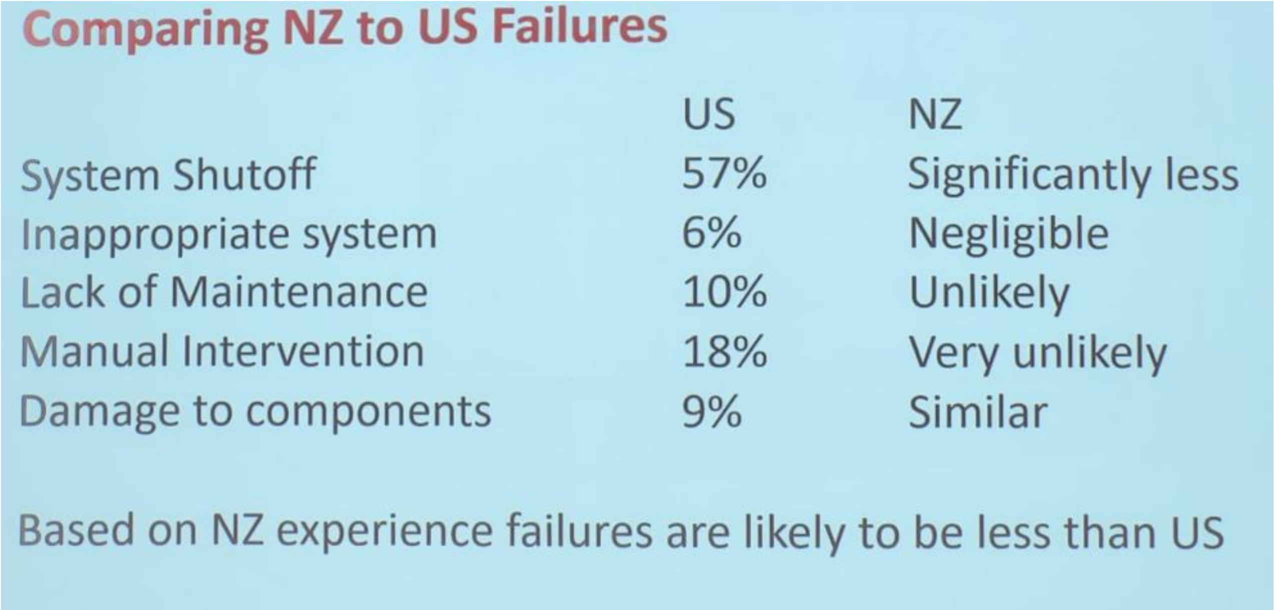
"the location of mass timber elements within a compartment was found to have a significant impact on the charring behaviour. Exposed timber ceilings were found to have charring rates on average 16% lower than exposed timber walls in the same experiment. Furthermore, charring rate is predominantly driven by ventilation conditions and movable fuel load density, with average charring rate decreasing as the proportion of timber surface area to opening surface area increases. However, the influence of key compartment design parameters on timber charring rate requires further understanding to progress the current understanding of compartment fire dynamics." *



Char fall off and burn through

Sprinklers

- 99.996% reliable?
- "Belts and braces"
- Construction, demolition, maintenance, repair, replacement, earthquake, stupidity…



Comparing NZ to US Failures

	US	NZ
System Shutoff	57%	Significantly less
Inappropriate system	6%	Negligible
Lack of Maintenance	10%	Unlikely
Manual Intervention	18%	Very unlikely
Damage to components	9%	Similar

Based on NZ experience failures are likely to be less than US

Cladding compliance

USDA | Forest Service
U.S. DEPARTMENT OF AGRICULTURE

FS-1161(r) | August 2022

The two-story testing wall exposed to flaming at temperatures over 1600 °F. Courtesy photo by Erika Edwards.

Timberlab and Fire-Safe CLT Exterior Walls

Cross-Laminated Timber Exterior Walls Pass Fire Safety Test

The 2021 International Building Code (IBC) included exciting new provisions for tall wood buildings up to 18 stories. However, the language lacked clarity for the use of cross-laminated timber (CLT) for exterior walls above approximately four floors. Without clarification, this wonderful material could be at risk of underutilization and even misrepresentation.

With too much left open to interpretation in each local jurisdiction due to CLT's combustibility and no existing National Fire Protection Association (NFPA) 285 tests for CLT wall assemblies to demonstrate performance, this situation was an opportunity to remove any barriers—real or perceived—for the use of this renewable and sustainable wood material. Besides being an excellent alternative to emission-heavy concrete and steel, CLT, like all mass timber products, stores carbon that has been absorbed from the atmosphere.

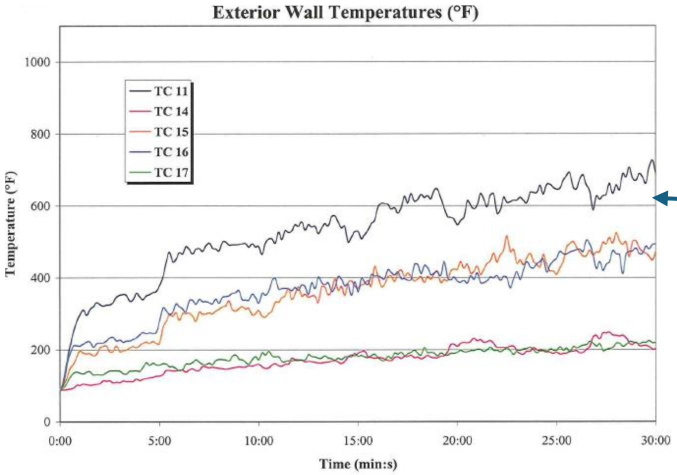
National Fire Protection Association 285:

This standard provides a test method for determining the fire propagation characteristics of exterior wall assemblies and panels used as components of curtain wall assemblies that are constructed

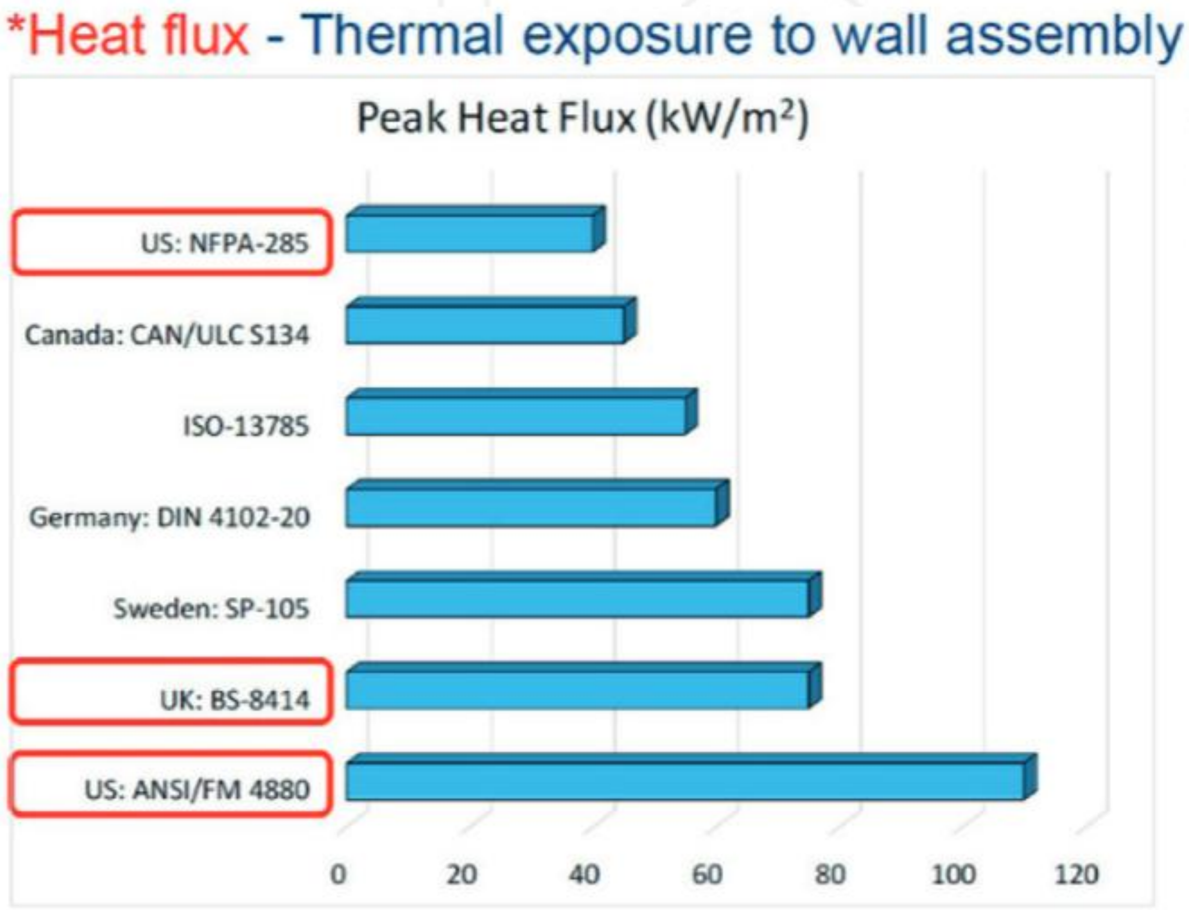
Figur

The two-story testing wall exposed to flaming at temperatures over 1600 °F.

NFPA 285 – good enough?



600^{O}F



Nguyen (2024) - Fire Performance of Open-State Cavity Barriers for Ventilated Façades

NFPA 285 – good enough?

Future research - NZ

This research will address these challenges by investigating the **whole-structure** performance of hybrid timber structures in **realistic fire scenarios**. Key focus areas include:

- **Charring rates** under <u>varying fire intensities and durations</u>
- **The hot-knife effect** and mitigation strategies
- **The fire dynamics** in hybrid timber buildings and differences with non-combustible construction with a particular focus on <u>the effect of ventilation and the decay phase of the fire</u>
- **Behaviour of loaded structural timber elements** <u>through all stages of realistic fires</u>
- **Whole-structure performance** throughout all stages of realistic fires, including the interdependent load-effects
- Improvements to hybrid structure performance in fire as well as earthquakes, cost, efficiency and other non-fire requirements
- Toxicity exposure from fires in hybrid timber buildings and how it differs from fires in conventional buildings
- **Fire-resistant treatments**, their influence on hybrid system integrity and their potential negative effects on the environment

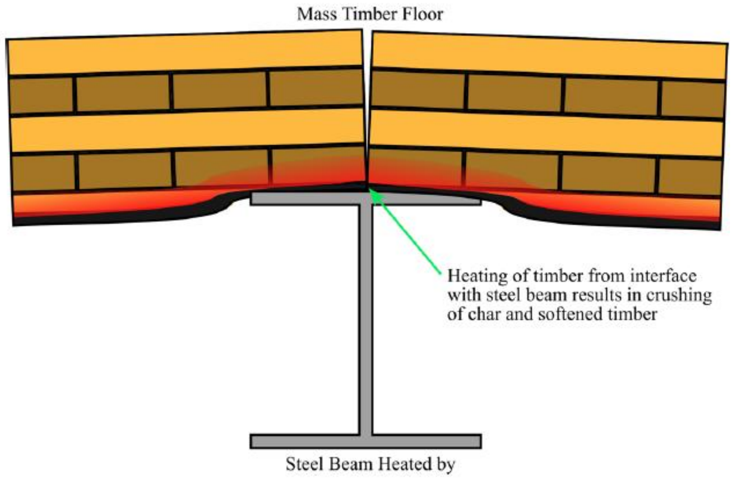
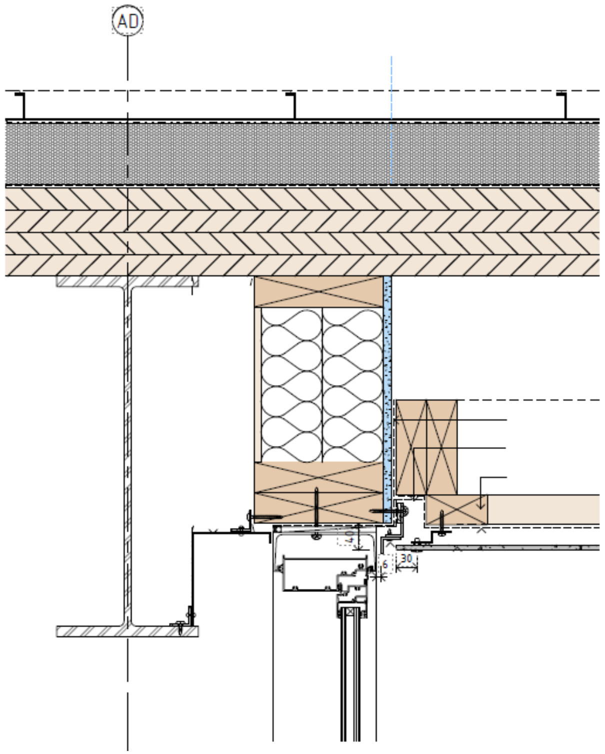


Figure 1: Illustration of interaction between timber floor and steel beam



Some thoughts on the Challenges

- Engineered and mass timber now allows us to build buildings that were not possible or feasible before
- *Timber buildings are becoming mainstream, we have moved past this being a specialist discipline*
- *Industry does not want any limitations to the use of timber*

- *"Mass-timber is an indispensable way for New Zealand to produce a higher value product from its plentiful forestry resources to yield the benefits of timber buildings"*

- *The timber industry will win the '<u>political justification</u>' but what about the '<u>technical justification</u>'?*

- The research and understanding of the complexity of timber construction is not yet there
- Current 'code compliance' is based on standard fire tests, which do not fully reflect real fire conditions, particularly during the decay phase when structural timber elements can fail even though the fire is out

Some thoughts on the Challenges

- Specific concerns expressed by firefighters:
  - Faster fire growth and greater total heat release rates
  - Earlier flashover, including the possibility of multiple flashovers
  - Increase in fuel load producing longer duration fires
  - Increased fire fighting water demands
  - Greater requirements for resources inside the building, including access above the fire floor
  - Hidden fire spread in voids and ongoing combustion behind encapsulation
  - Increased severity of external flaming from windows and openings
  - Increased chance of fire spread to adjacent buildings
  - Greater reliance on fixed fire protection systems
  - Increased production of carbon monoxide due to ongoing smouldering combustion as well as other volatiles/smoke
  - Increased influence of wind-driven fires

Figure 14.1 Firefighter team during the timber fire test scenario at the Technical University of Munich, 2021.

- We need to consider the ‘Life of a building’, construction, demolition and during use when systems are not available
- Education is key

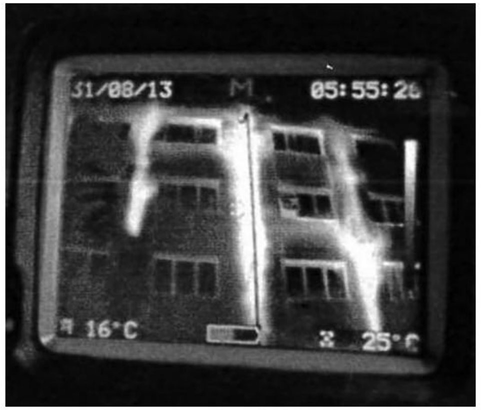


Figure 14.12 Thermal imaging used to identify the extent of fire travel within voids in a burning building (Björkman, 2013; Östman and Stehn, 2014).

Large timber buildings are now a fire service issue?