

# Fire Safety of Multi-Storey Wood Buildings

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## Performance Approach to Fire Safety

Edmonton, AB  
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**Andrew Harmsworth**, M Eng, P Eng, CP

Principal, **GHL** Consultants Ltd

Email: [ah@ghl.ca](mailto:ah@ghl.ca)

- BAsC, Queen's University at Kingston, Civil Engineering
- M Eng, UBC's short lived Fire Science program
- 25 years' experience in Equivalencies and Alternative Solutions

# GHL Consultants Ltd

- Founded 20 years ago
- Building Code Consultants
- Fire Engineers
- Code reviews – both assisting clients and as Authorities
- No system design – won't sell you things you don't need

# About GHL

- “Code Consulting” firm
- Prefer “Fire Engineering”
  - Focus on Part 3
  - Fire hazard analysis
  - Fire risk analysis
  - Structural fire resistance
  - Heat transfer
  - Smoke control design

# 9 Principals + staff (total 21)



David Graham, P Eng, CP Principal



Andrew Harmsworth, M Eng, P Eng, PE, CP Principal



Teddy Lai, Architect AIBC, MRAIC, CP Principal



Khash Vorell, M Eng, P Eng Associate Principal



Adam Nadem, AT.AIBC, AScT Associate Principal



Frankie Victor, AScT, BCQ Associate Principal



Jeffery Mitchell, M Eng, P Eng, CP Associate Principal



Wendy Morrison, AScT, BCQ Associate Principal



K. M. Gary Chen, MAsC, P Eng Associate Principal

# Building Code Committee Work

- APEG Building Codes Committee (Khash Vorell / Andrew Harmsworth)
- BC Appeal Board (Frankie Victor)

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# Research Work

- BC Wood First Advisory Committee to Forestry Investment Innovations
- CAN 086 Task Group on Fire (Andrew Harmsworth)
- NEWBuildS Research Network (Andrew Harmsworth, Board of Directors) – 40 Master's and PhD Students
- Fire Risk Assessment for Alternative Solutions (Gary Chen)
- Effectiveness of Sprinkler Systems after an Earthquake.

# Research Work

- 6 Storey Group C (Residential) – Code Change (Andrew Harmsworth / Gary Chen, 2009)
- Group D (Office) Studies – 6 Storey Frame and 8 Storey Heavy Timber (HT)
- MSc Studies on Effects of Fire as a Structural Load (Gary Chen) - Current
- Lead Author, Tall Wood Guide with FP Innovations

# It's Been Done Before...

- Objective is to show that it can still be done TODAY



Kelly Douglas Building, Vancouver  
9-Storey Heavy Timber -1905



312 ft. (95 m) Sitka Spruce  
Canada

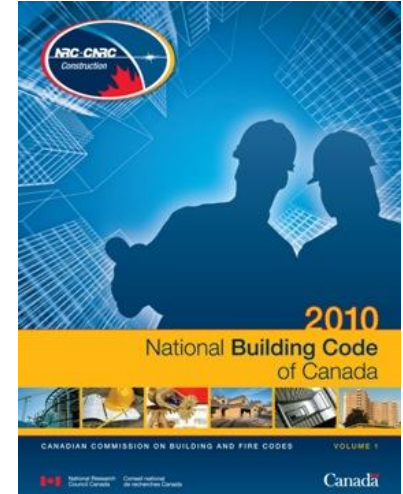
(Picture Courtesy of FPInnovations)

# National Building Code of Canada

All buildings are subject to risks:

- Code compliance  $\neq$  no risk.
- Code compliance = risks at acceptable level.

(see “Objectives” in Preface of NBCC, Vol.1)



Entering a building is just like getting into a car...  
...there is an acceptable level of risk.

# National Building Code of Canada

**Building Code Compliance**

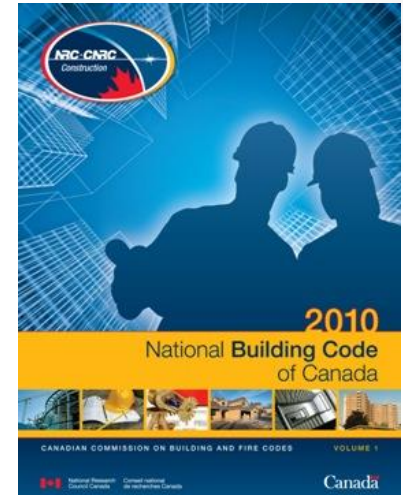
**Objectives and Functional Statements**

**Acceptable Solutions  
(Division B)**

- Deemed-to-satisfy solutions
- Establish level of performance

**Alternative Solution**

- Meet the objectives and functional statements
- Provide the *same* level of performance relative to objectives and functional statements



# National Building Code of Canada

## Objective OS1 “Fire Safety”

- Intent:

*To limit the probability that combustible construction materials within a storey of a building will be involved in a fire, which could lead to the growth of fire, which could lead to the spread of fire within the storey **during the time required to achieve occupant safety and for emergency responders to perform their duties**, which could lead to harm to persons.*

- Other *Provisions of the Acceptable Solutions* (Division B) are similarly worded.

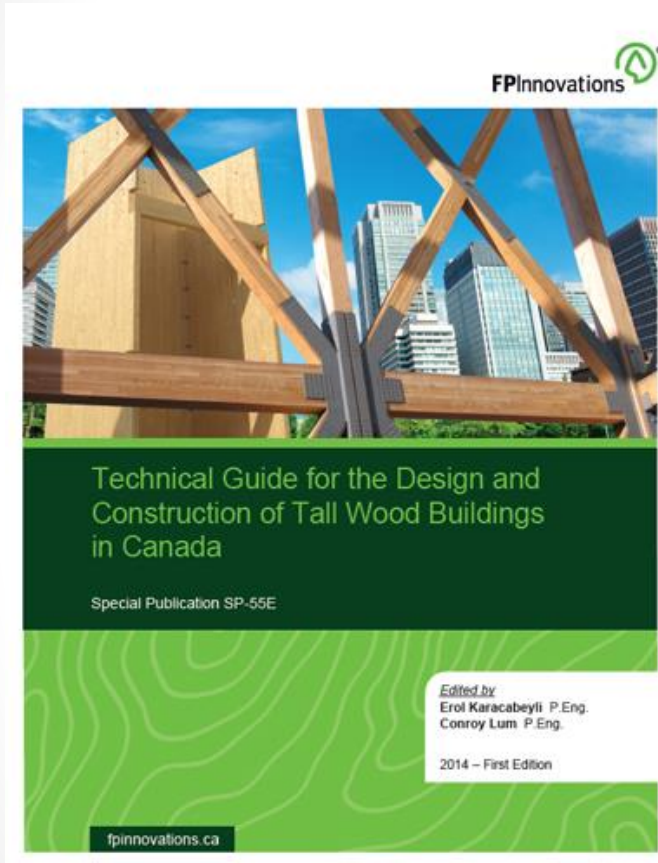
# National Building Code of Canada

- Design and Evaluation of alternative solutions should be based on science not emotion
- Level of safety need to balance risks

*Emotion prevails but let's apply science!!!*



# FPIinnovations Tall Wood Guide



FPIinnovations project funded by Natural Resources Canada (Federal Agency)

- 400 pages → 70 on fire safety
- Fire chapter is the first to provide comprehensive review of fire issues in tall wood buildings.



# FPInnovations Tall Wood Guide

- A guide to an alternative solution
- Intent was to demonstrate that it CAN BE DONE.
- Nationally acceptable risk tolerance.
- Took a conservative approach.

# FPInnovations Tall Wood Guide

- First to map out an alternative solution for Tall Wood on a national basis
- Chapter 5 of the Tall Wood Guide is on Fire Safety and Protection.
- Peer Reviewed

- Lead Authors

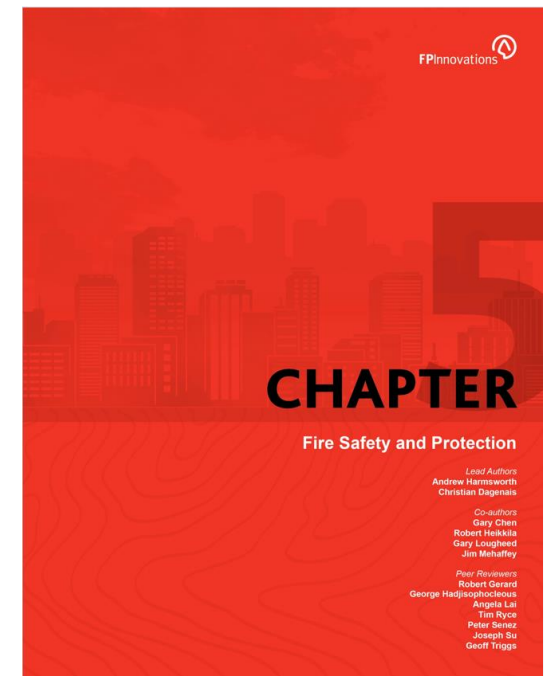
- *Andrew Harmsworth*
- *Christian Dagenais*

- Co-authors

- *Gary Chen*
- *Robert Heikkila*
- *Gary Loughheed*
- *Jim Mehaffey*

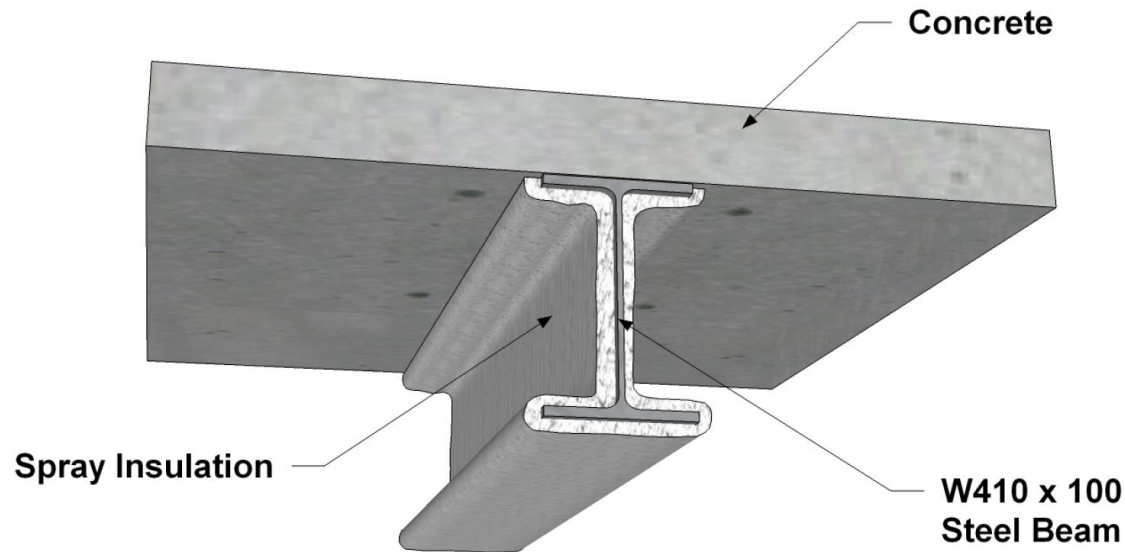
- Peer Reviewers

- *Robert Gerard*
- *George Hadjisophocleous*
- *Angela Lai*
- *Tim Ryce*
- *Peter Senez*
- *Joseph Su*
- *Geoff Triggs*



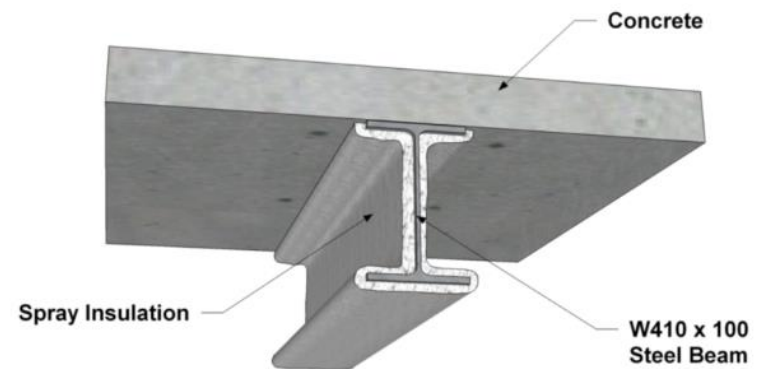
# Achieving Fire Performance using Encapsulation

- Steel and concrete assemblies



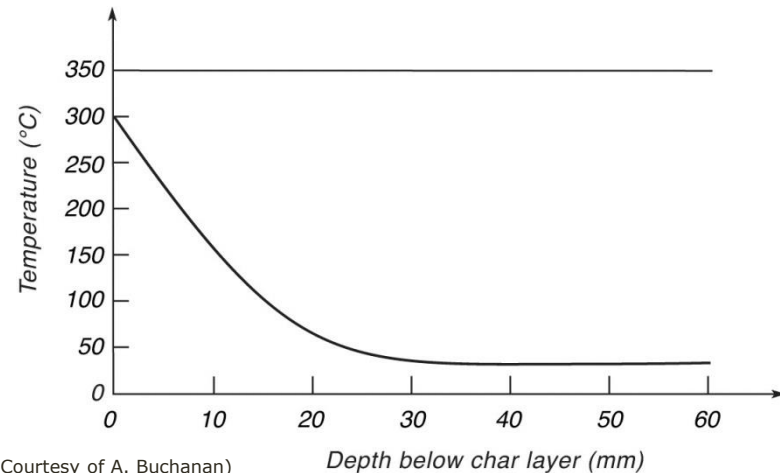
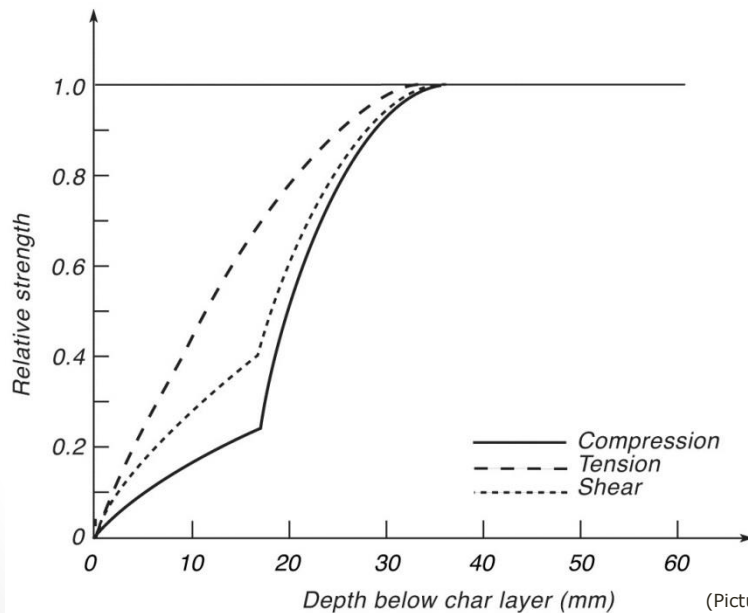
# Achieving Fire Performance using Encapsulation

- Steel is encapsulated for thermal protection
  - Performance criteria: limit steel temperature to 538°C (ULC S101)
- Reinforced concrete uses encapsulation to protect steel
  - Code provides minimum cover to protect reinforcement
  - Performance criteria: limit steel temperature to 593°C (ULC S101)
- Complete encapsulation would allow maintaining 100% strength



# Achieving Fire Performance using Encapsulation

- Mass timber
  - Charring can provide inherent fire rating
  - Zero loss of strength below char layer
  - Wood is combustible

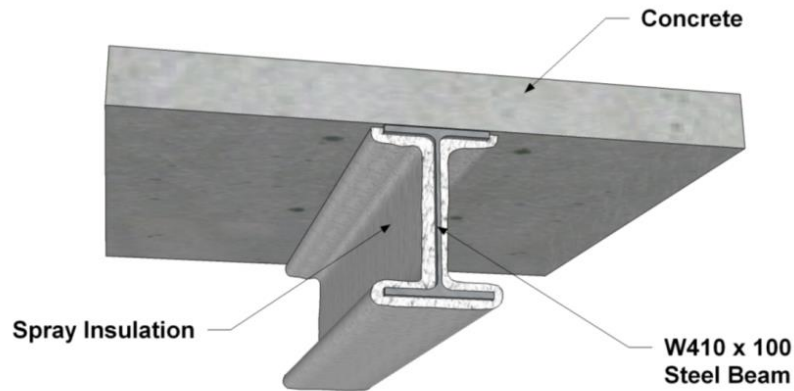


(Pictures Courtesy of A. Buchanan)

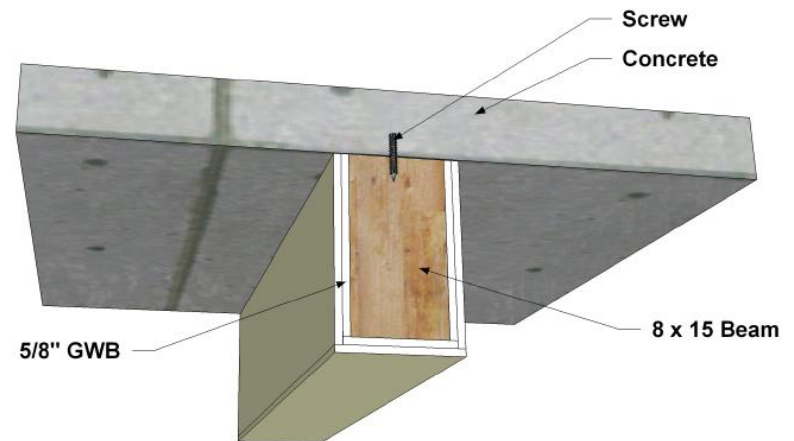
# Achieving Fire Performance using Encapsulation



What is the difference?



Encapsulating  
for Strength



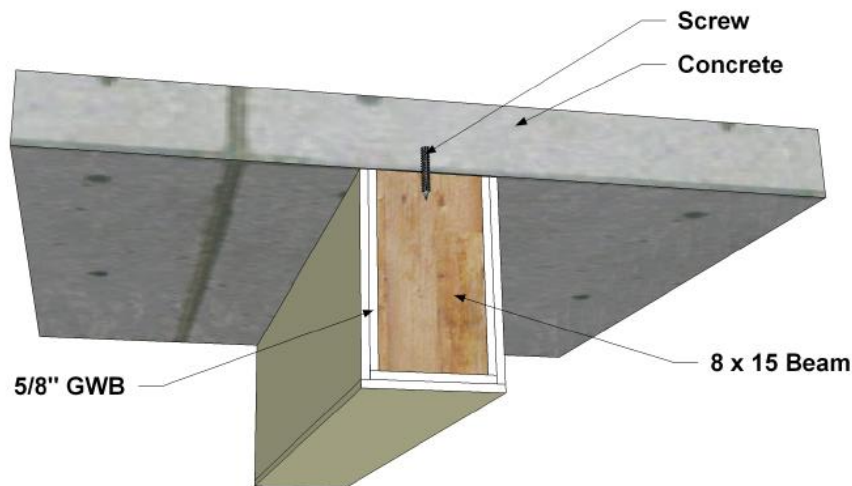
Encapsulating for  
Combustibility

# Complete Encapsulation

- Wood not affected by the fire for expected duration (2h).
- Wood does not contribute to the fire for expected duration.
- 3 or 4 layers of Type X gypsum board.
- Makes the point that it CAN BE DONE.

# Limited Encapsulation

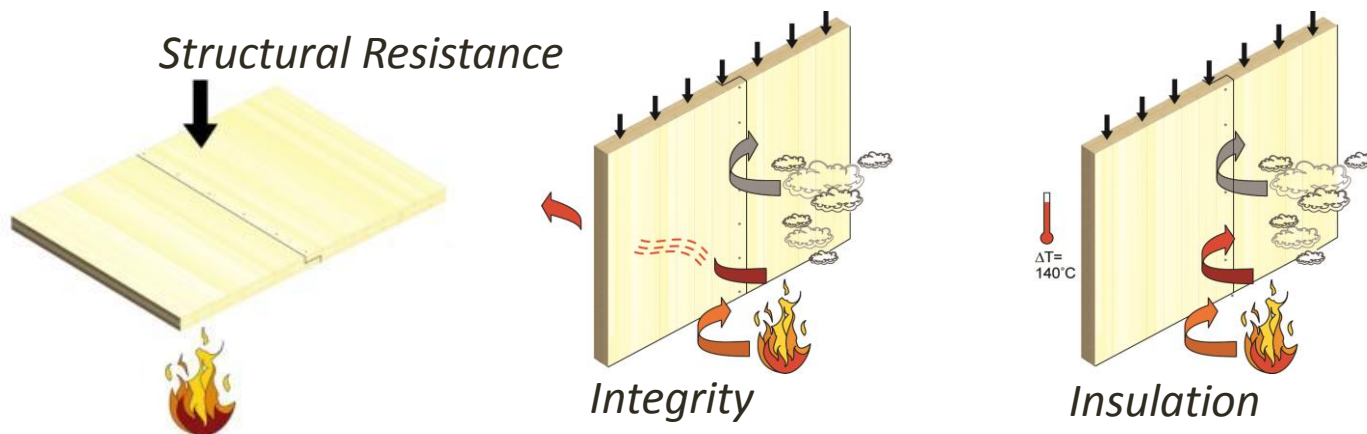
- Prevent wood from contributing to fire severity for “*time to achieve evacuation and FF response*”
- 1 to 2 layers of Type X gypsum board
- Prevent possibility of “re-flashover”





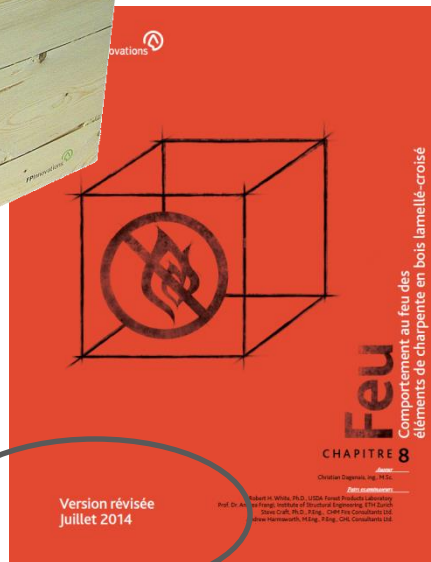
# Fire Resistance

- We can start with full encapsulation and peel off layers
- Code indicates some exposed wood panelling is acceptable
- “Burnout with all systems failed” is not appropriate
- Continued charring is acceptable, Re-flashover is not



# Fire Resistance

- CLT Handbook – Chapter 8 (2014 Edition)
- CSA O86-14 – Annex B



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Engineering design in wood

## *Annex B (informative)*

### ***Fire resistance of large cross-section wood elements***

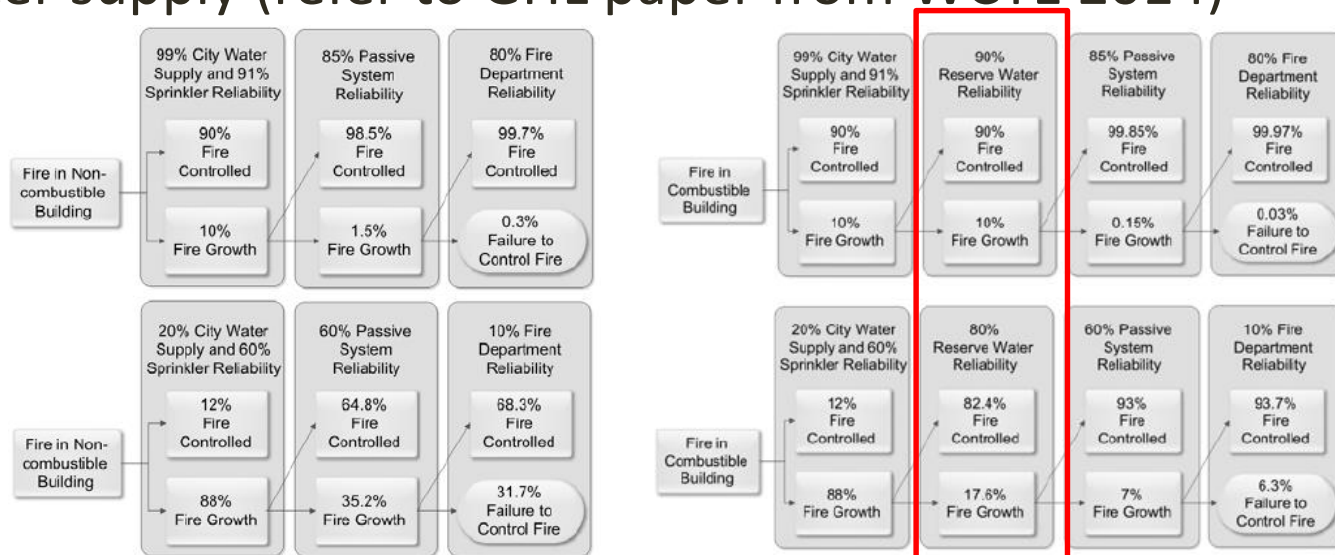
#### **Notes:**

- (1) This informative (non-mandatory) Annex has been written in no where users of the Standard or regulatory authorities wish to ac Standard.
- (2) When this informational (non-mandatory) Annex is not otherv as additional requirements to this Standard, the methodology users of the Standard in the development of a proposal for an National Building Code of Canada (NBCC).



# Fire Resistance

- Analysis shows that at least one wall can be exposed
- Two basic approaches
  - Complete encapsulation with city water supply
  - Limited encapsulation with some walls exposed with backup water supply (refer to GHL paper from WCTE 2014)



# Other Considerations

- Connections



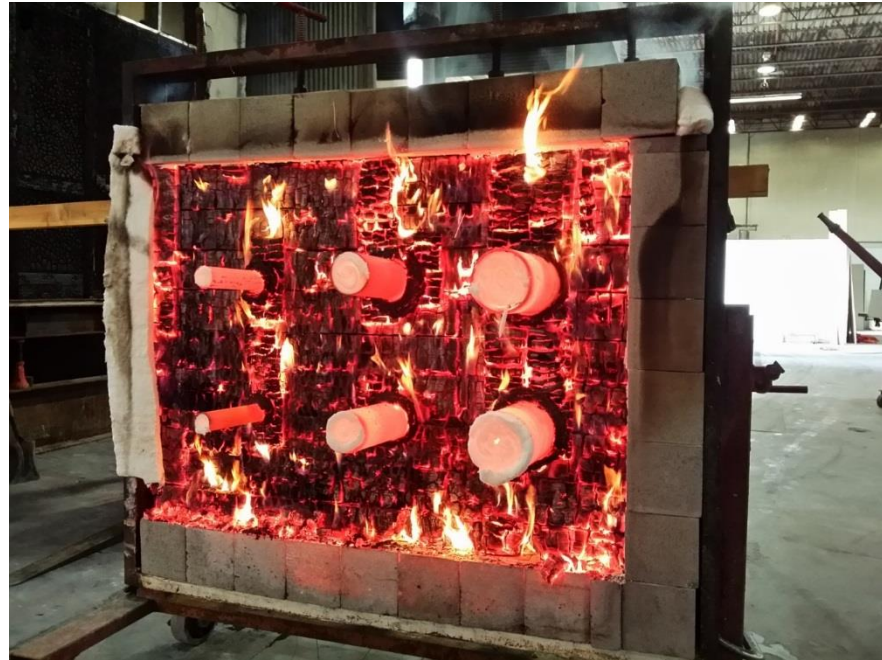
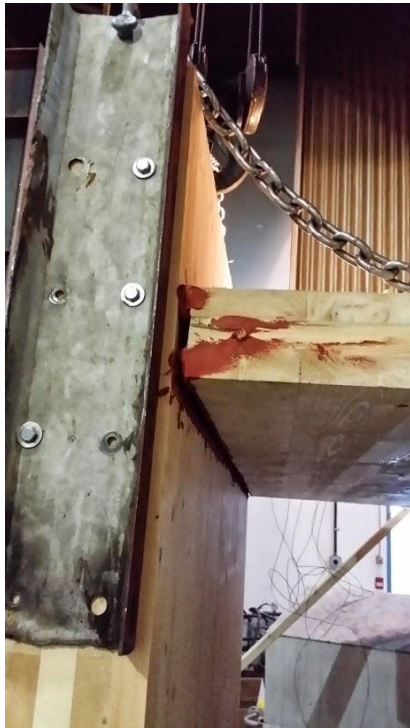
2h Fire Rated Connection  
The Landing, Vancouver





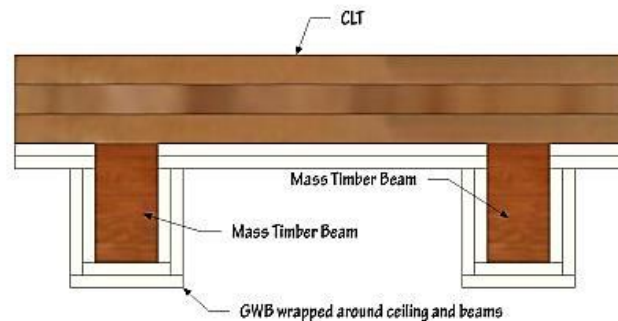
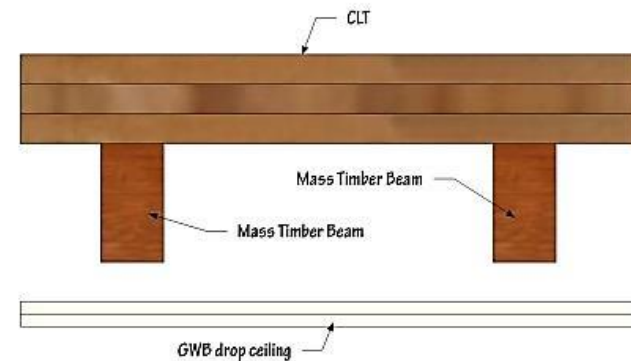
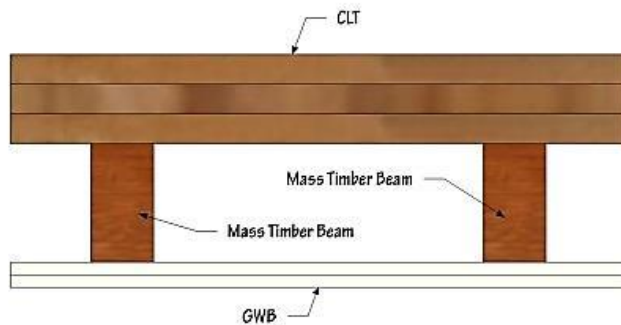
# Other Considerations

- Firestopping



# Other Considerations

- Protection of concealed spaces



# Other Considerations

- Construction fire safety



Laminated 2x6 elevator shaft

# Future Editions

- First edition needed to capture all the issues.
- Next edition needs to:
  - Edit out some issues
  - Look more at the solutions
  - Consider newer materials
  - Look at where appropriately protected light timber may be acceptable...  
...provided it is fully encapsulated (thus does not need to be mass timber)
  - Address quality control
  - Firefighting assumptions



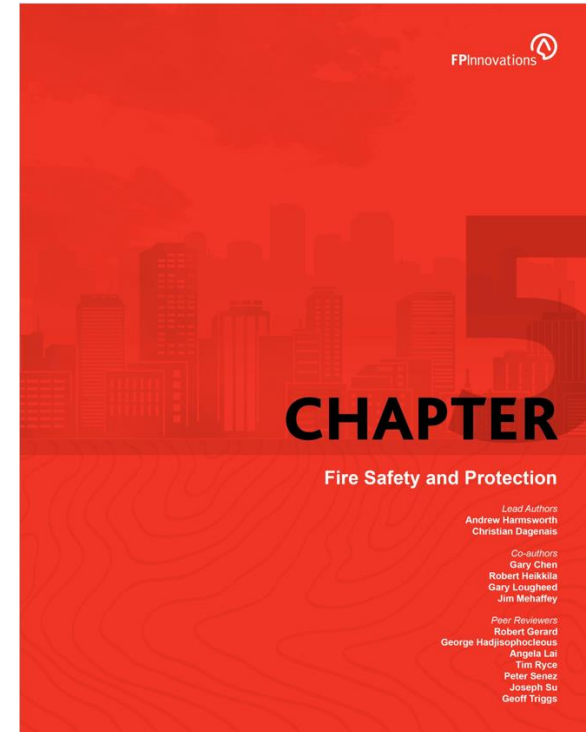
# Acknowledgments

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# Questions?

# Thank You

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