Fire Safe Design of Exposed Timber in Mass Wood Buildings

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Wood Buildings

• Wood is new, again
Wood Buildings

- Perception of risk in model buildings codes
  - Construction based on combustibility, not fire resistance
  - Height and area limits wood use
Exposed Wood – What Architects Want

• Architects want exposed wood within their buildings
• Don’t we all !!!
• Limitations are based on fire safety, dealing with a new product (CLT) and general unfamiliarity with wood
Exposed Wood Fire Fundamentals

- Codes permit exposed wood as an interior finish
- Interior finish requirements are Class C to ASTM E84 (sprinkler protected building)
- Solid wood meets Class C (and some meets Class B)
- Exposed wood is not a new problem, it has just never been accounted for........
Exposed Wood Fire Fundamentals

- Exposed wood is now part of the load-bearing structure in mass wood buildings
- A new issue that needs to be addressed
- Exposed floors, columns, beams, walls:
  - Glulam is known, but not for high-rise
  - CLT is an unfamiliar product
- Fear of the unknown
Exposed Wood - Key Issues

- How does the exposed wood change the fire dynamics?

- Impacting on:
  - Fire duration?
  - Size of the fire? (heat release rate)
  - Fire temperature?

- And hence, the fire resistance ratings required to allow the building to withstand a full burnout?

- Interior wood finishes also impact on the above items...........

- Why aren’t steel and concrete buildings assessed for full burn out??
Exposed Wood Compartments – Recent Research


• McGregor “Contribution of Cross Laminated Timber Panels to Room Fires”, Carleton University, 2013.


• Medina Hevia “Fire Resistance Of Partially Protected Cross-Laminated Timber Rooms”, Carleton University, 2014


• Li, “Modeling of Barrier Failure and Fire Spread in CUrisk”, Carleton University, 2015
Exposed Wood Compartments—Recent Research

- Small ventilation controlled compartments, with real fuel loads (natural fires)
- Testing has ranged in type of exposed wood - walls, floors and ceilings
- Differing results provide difficulty in comparison, but trends are apparent

From Li, 2015

From Crielaard, 2015
Exposed Wood - Temperatures

From McGregor, 2013
Exposed Wood – Fire Size (HRR)

Temperature vs Heat Release Rate - Test 1

Temperature measured by the plate thermometer

Red dots represent estimated HRR

From Medina-Hevia, 2014
Exposed Wood – Fire Duration

Heat Release Rate Room Comparison

- Fully Unprotected Room (by McGregor)
- Fully Protected Room (by McGregor)
- Test 1
- Test 2
- Test 3

Two opposite walls exposed
Two adjacent walls exposed
One wall only exposed

From Medina-Hevia, 2014
Exposed Wood Compartments – Solutions

- Failure of the CLT through delamination is an expected mode of failure
- Delamination should not be feared, but accepted and engineered
- Exposed wood increases the fuel load within the compartment – but can be accounted for

From Medina-Hevia, 2014
From Crielaard, 2015
Exposed Wood Compartments – Solutions

• If multiple faces are exposed wood, re-radiation leads to continued burning after room combustibles have been consumed (so called “second flashover”)

• Exposed wood prolongs the fire duration – can be conservatively accounted for

• Direct impact on FRR

• How the compartment HRR decays is still yet to be fully determined when multiple faces are exposed

• More work is needed, but some reasonable correlations can be determined
Next Steps

- More testing is needed, especially with walls covered and ceiling exposed
- Continued testing by research consortiums, University testing
- Medium term - correlations and basic design rules to be developed
- Longer term – detailed analytical models
- Wood buildings will continue to receive significant scrutiny
Summary – Tall Wood Building & Fire Issues

• Fire risks are misunderstood and often misrepresented

• There is not enough accredited third-party fire testing carried out in the US:
  - ASTM E119
  - ASTM E84
  - Glulam connections

• Suppliers need to invest more in fire testing

• The lack of evidential fire testing is a significant barrier to approval