Fire Safety Challenges of Tall Wood Buildings

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Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.
Wood Buildings

- Wood is new again
Wood Buildings

- Wood is combustible – how much of a barrier is this?
Wood Buildings

• Perception of unacceptable risk in model buildings codes, for tall wood building, hence height and area limits

• There is a significant barrier to the use of wood by regulation and code
Tall Wood Buildings – No Stick Framing

• Light wood is excellent for low-rise developments
• Light wood is fire protected through encapsulation only
Tall Wood Buildings – Mass Wood

• Heavy / massive wood frame products
  - Sawn wood
  - Engineered wood products

Glue laminated wood (Glulam)  Cross Laminated wood (CLT)
Wood – Fire Fundamentals

• Fire performance
  – Light wood vs. heavy wood
Wood – Fire Fundamentals

Not all wood is the same
Wood – Fire Fundamentals

Wood burns – how it burns is important:

• Fire performance of wood is very well studied – with research dating back to 13th century
• Solid wood has highly predictable performance in fire
• Variability between countries and in species type is known
• Knowledge = data = confidence
Wood - Fire Fundamentals

• Wood has inherent fire protection – no additional passive protection is needed

Sacrificial char layer

Solid “cold” wood carrying applied loads
Wood – Fire Fundamentals

Charring protects wood:

• Natural protection for wood
• Allows for continued, but diminishing strength during a fire
• Predictable at 0.025 in/min [0.7mm/min]
• Different wood – different char (due to density and water content)
• Wood has an inherent FRR – which increases as size increases and can be more than 2 hrs
Wood Fire Performance – Recent Research

- Charring of single elements
- Understanding if wood behind gypsum increases hazard in compartments (light wood framing)
- Natural fire testing
- Frame elements and joints
- CLT compartment tests (natural fires)
- CLT – exposed vs. gypsum lining
- Composite actions (concrete wood)
- Innovative wood products

Research has been European and Canadian led
Wood Fire Performance – Recent Research

• Wood Frame 2000
  – Cardington, UK
  – Fire resistance of a mid-rise wood building
Wood Fire Performance – Recent Research

- CLT fire testing:
  - Natural fires
  - CLT exposed vs. gypsum lining
  - Sprinklered vs. non-sprinklered
  - Frangi and Fontana, 2005

Combustible lining

Gypsum board lining

Sprinkler protection
Wood Fire Performance – Recent Research

• CLT assemblies:
  – Charring rate consistent with wood
  – Predictable behavior
  – Improved performance with gypsum board protection
  – Osborne, Dagenais, Benichou, 2012
Wood Fire Performance – Recent Research

• CLT assemblies:
  – Understanding how compartments with fully exposed CLT behave
  – McGregor, 2013; Medina, 2014
Wood Fire Performance – Recent Research

• CLT assemblies:
  - NewBuildS tests on CLT floors (Aguanno, 2013)
  - FP Innovations CLT fire tests (2012)
  - Understanding how floor – ceiling assemblies fail
  - CLT char fall off – is this an issue?
  - Will CLT ceilings be exposed in buildings?

<table>
<thead>
<tr>
<th># of Plies</th>
<th>CLT Thickness (mm)</th>
<th>Gypsum Board Protection</th>
<th>Load (kPa)</th>
<th>Load Ratio (%)</th>
<th>Failure Mode</th>
<th>Fire Resistance (min)</th>
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<td>77 *</td>
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<td>101</td>
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</tbody>
</table>
Wood Fire Performance – Recent Research

- Issues being addressed through research and testing include:
  - Contribution of wood to room fires (McGregor, 2013)
  - Charring inconsistency through laminations
  - Self-extinguishment (?)
  - NewBuildS research
Wood Fire Performance – Recent Research

- Composite members
  - Wood concrete floors
  - Up to 2 hrs
  - Developing design tools
- STiC (UC, UTS, 2012)
Wood Fire Performance – Recent Research

• Wood assemblies - CLT box beams
  – Over 2-hour ratings for assemblies
  – STiC, NewBuildS
Wood Fire Performance – Recent Research

- Composite wood products – post tensioned beams, floors, walls
  - STiC, 2013
Wood Fire Performance – On-going Research

• Fire protection for connections
Wood Fire Performance – On-going Research

- Prefabrication – floors, walls
  - Sealing of joints, concealed spaces, continuity issues
Wood Fire Performance – Research?

- Fire stopping of penetrations
  - More work needed
Fire Performance – Why The Barriers?

• Education is needed (substantial)

• Perception of risk
  – Improved understanding of fire performance of wood needed across the construction industry

• AHJ involvement (and support)

• Code revisions required – based on science, not perception

• Any material that meets FRR and surface spread of flame, should be acceptable
Fire Performance – Why The Barriers?

• Where is the innovation?

• North America – Code requirements and permissible construction

• NFPA Fire Research Foundation – leading from the front with Phase 1 study

• Phase 2 will involve full scale CLT testing in 2015, as the basis for future change

• Need for coordinated support for code revision by all wood industry partners

• We can have safety and sustainable design
Tall Wood Buildings?
Tall Wood Buildings

- Mass wood frame construction
  - Column and beam construction
  - Glulam
  - Concrete core
Tall Wood Buildings

• Mass wood frame construction
  – Panelized construction
  – CLT as floors and walls, all load-bearing
Tall Wood Buildings

- Fire protection strategies
  - Passive
    - Encapsulaton (?)
    - Compartmentation
    - Egress
  - Active
    - Sprinklers
    - Detection and alarm
Recent Examples – Panelized Construction

Stadhaus, London, UK, 2009

Forte, Melbourne 2013
Recent Examples - Post and Beam Construction

Life Cycle Tower One, Austria, 2012

Wood Innovation Design Centre, Prince George, 2014
Contemporary Examples

**Europe**
- Svartamoen Trondheim Norway - 5 Residential 2005
- MFH Holzenhausen Steinhausen Switzerland - 6 Residential 2006
- Lagerhuset Eslov Sweden - 10 Residential 2008
- Limnologen Vaxjo Sweden - 8 Residential 2008
- E3 Berlin Germany - 7 Residential 2008
- Bad Aibling, H8 Bad Aibling Germany - 8 Mixed 2011
- Grün Berlin Germany - 5 Residential 2011
- Life Cycle Tower One Dornbirn Austria - 8 Office 2012
- Via Cenni di Cambiamento Milano Italy - 9 Residential 2013
- Studentenwohneim Oslo Norway - 8 Residential 2013
- House of India Paris France - 7 Residential 2013
- WHA Wagramerstrasse Vienna Austria - 7 Residential 2013
- Panorama Giustinelli Trieste Italy - 7 Residential 2013
- Tamedia Zurich Switzerland - 6 Office 2013
- Merina Verde Caorle Italy - 6 Hotel 2013
- Woodcube Hamburg Germany - 5 Residential 2013
- Illwerke Zentrum Montafon Dornbirn Austria - 5 Office 2014
- Rundeskogen Sandnes Norway - 8 Residential 2014
- St. Dié-des-Vosges St. Dié-des-Vosges France - 8 Residential 2014
- Bergen Norway - 14 Residential 2016

**United Kingdom**
- Svartamoen Trondheim Norway - 5 Residential 2005
- Waterson Street Hoxton United Kingdom - 5 Residential 2006
- Stadhaus, Murray Grove London - 8 Residential 2009
- Bridport House London - 8 Residential 2011
- 52 Whitmore Road London United Kingdom - 6 Mixed 2012
- Banyan Wharf London United Kingdom - 10 Residential 2014

**North America**
- UBC Earth Sciences Vancouver Canada - 5 Education 2012
- Bullit Centre Seattle United States - 6 Office 2013
- District 03 Quebec City Canada - 6 Residential 2013
- WIDC Prince George Canada - 6 Office 2014

**Australia**
- Forte Living Melbourne Australia -10 Residential 2012
Fire Safe Solutions – Performance Design

• Alternative approach or Performance route
• Many tall wood structures to date – UK, Australia, Europe, Canada
• Up to the discretion of the approval authority
• Technical justification for safety
• No different to any other innovative building solution
• AHJ and Fire Marshal dependent
Fire Safe Solutions

• IBC allows alternate means to proving an FRR (cl. 703.3)

• IBC References National Design Specification for Wood Members (NDS)

• Methods to be used are either:
  – Encapsulation
  – Charring

• Proven methodologies for glulam and CLT

• Steel structures are based wholly on encapsulation – wood solutions should also be accepted
Next Steps

• Address the issues of fire risk during construction
  – Builders following same techniques for steel construction, which put the building at risk

• Combustibility of the load-bearing structure is a “hill too hard to climb” for some

• Need to educate that steel structures rely wholly on passive protection (or are engineered); timber structures have inherent FRR and can be made more fire resistant due to additional passive protection

• Tall timber buildings will not be constructed by lightweight timber
Summary

• Wood is the oldest building material
• Wood has excellent inherent fire resistance
• The FRR is well understood, predictable and well proven
• Wood buildings are efficient and sustainable
• Fire risks are misunderstood and often misrepresented
• Combustibility of primary structure is not a significant safety risk and can be accounted for
• Wood buildings continue to be built higher
• USDA and SLB are offering $2m first prize for the first US wood building over 10 stories