FiSAC

Fire Safety Asia Conference
Singapore 2014

FiSAC

Fire Safety & Emergency Management:
The Way Forward

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Fire Safety Challenges of Tall Wood Buildings

Agenda

- Overview and Background
- Building Regulations For Timber
- Timber Fire Performance
- Knowledge Gaps & Future Directions

Fire Protection Research Foundation

- Phase 1 Study – December 2013
- Recent architectural trends of increasingly tall buildings with timber
  - Components of laminated wood
    - Cross laminated timber (CLT)
    - Laminated strand lumber (LSL)
    - Glue laminated timber (Glulam)

Fire Protection Research Foundation

- Construction currently underway on buildings up to 10 stories
  - Australia, Austria, Canada, and Norway
- Motivation
  - Sustainability
  - Green approach



Fire Protection Research Foundation

- Origin and Development
  - Need exists to clarify building performance under credible fire scenarios
- Questions
  - Fire service operations
  - Interior/exterior flame spread
  - Structural stability
  - Fire exposure hazard



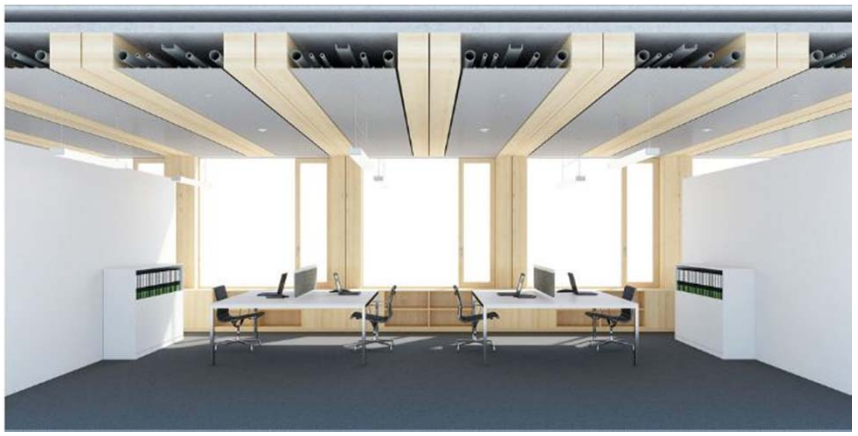
Fire Protection Research Foundation

- Project Scope and Tasks
  - Focus on buildings ≥ 6 stories
- Objectives
  - Characterize fire performance
  - Define requirements to achieve level of safety
    - Life
    - Property
  - Provide a guide for design professionals

Fire Protection Research Foundation







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Fire Protection Research Foundation



- Literature Review
  - Testing data
  - Ongoing research
  - Review of fire incidents
  - Review existing design guidelines
  - Global case studies of high-rise/tall timber framed buildings

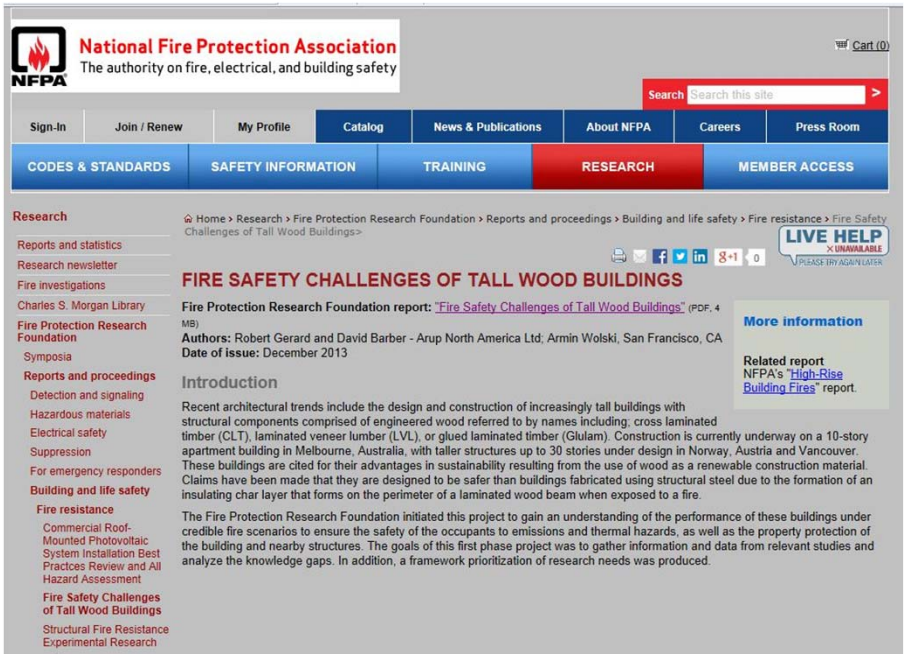
Fire Protection Research Foundation

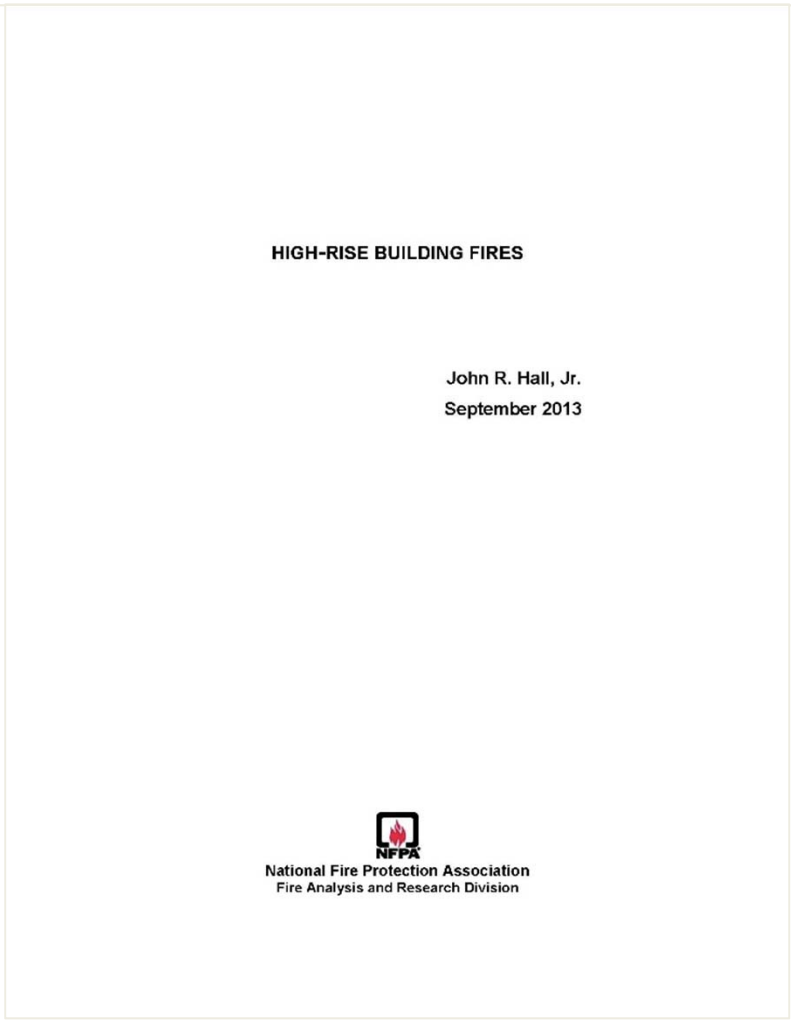
- **Gap Analysis**
  - Component and sub-system fire tests
  - Compartment fire dynamics
  - Environment
  - Economics
  - Society
  - Prioritization



Supporting Information

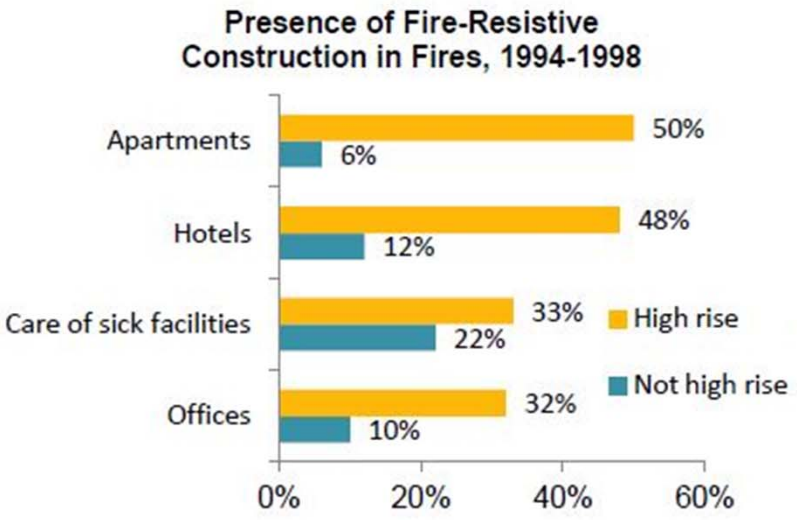
- Report: “High Rise Building Fires”
- Fire Stats on U.S. High Rise Buildings
- For 2007 through 2011

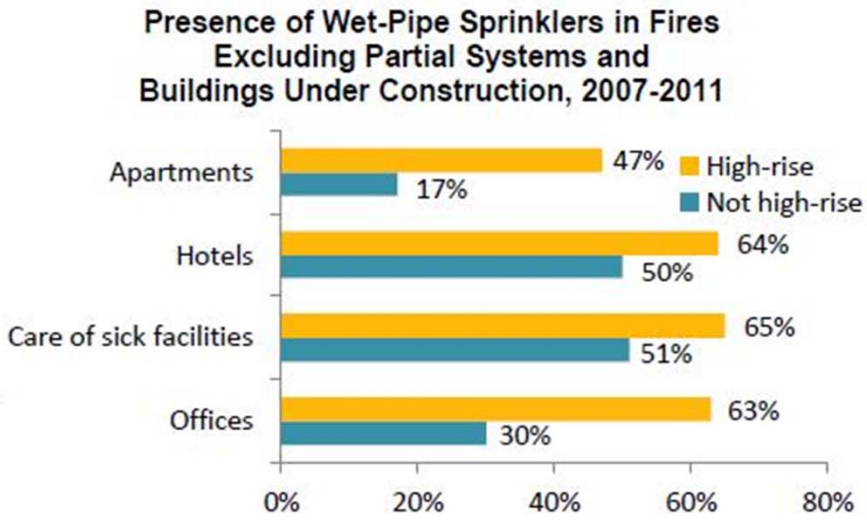




Supporting Information

- **Risk is lower in high rise buildings**





Timber Building Construction

EXAMPLES OF FEATURES AND CHARACTERISTICS

- Heavy timber frame products
  - Engineered wood products



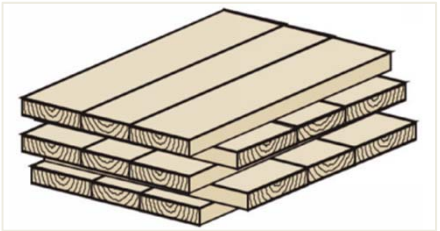
Glue laminated wood (Glulam)





Laminated Veneer Lumber (LVL)





Cross Laminated Timber (CLT)

Timber Building Construction

EXAMPLES OF FEATURES AND CHARACTERISTICS

- Heavy timber frame construction
  - Panelized construction







Timber Building Construction

EXAMPLES OF EXISTING TIMBER BUILDINGS

- Historical examples



Yiangxian Pagoda,
China, 1056



Urnes Stakirke,
Norway, 1132



Leckie Building,
Vancouver, Canada, 1908

Timber Building Construction

EXAMPLES OF EXISTING TIMBER BUILDINGS

- Contemporary examples
  - Post and beam construction



Life Cycle Tower One
Austria, 2012



Bullitt Center
Seattle, WA 2013



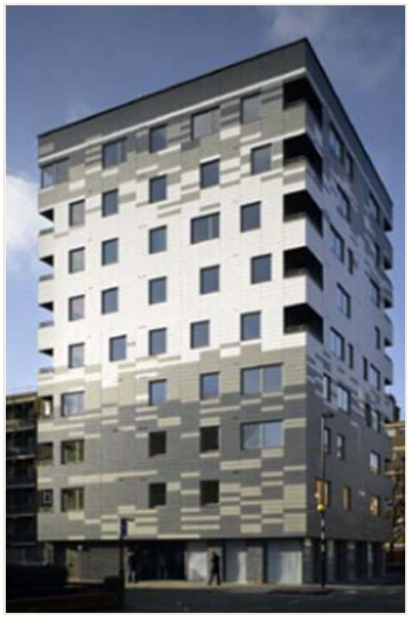


Wood Innovation Design Centre
Prince George, Canada, 2014

Timber Building Construction

EXAMPLES OF EXISTING TIMBER BUILDINGS

- Contemporary examples
  - Panelized construction



Stadthaus
London, UK 2009



Via Cenni
Milan, Italy 2013



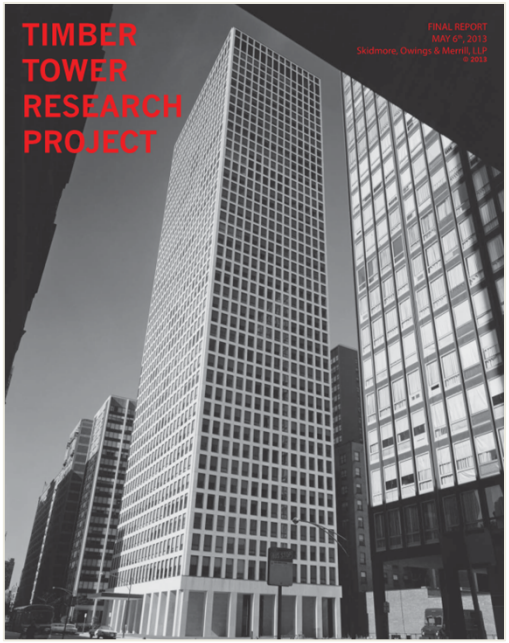
Forte Building
Melbourne, Australia 2013

Timber Building Construction

FEASIBILITY EXAMPLES OF TALL TIMBER BUILDINGS



40-story office building
CEI Architecture, 2013



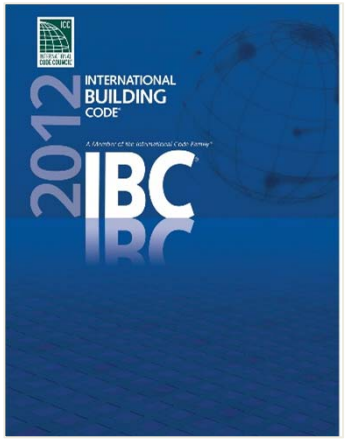
Timber Tower
SOM, 2013

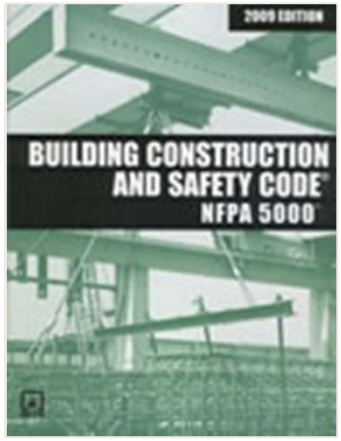


30-story high-rise
Michael Green Architecture, 2012

Building Regulations

U.S. Regulations





Applicable Building Code	Maximum # of Stories	
	Sprinklered	Unsprinklered
2012 International Building Code (IBC)	5*	4*
2012 National Fire Protection Association (NFPA) 5000	6*	5*
* Number of heavy timber stories permitted		

Building Regulations

INTERNATIONAL REGULATIONS

Country	Applicable Building Code	Maximum # of Stories	
		Sprinklered	Unsprinklered
Australia	2013 Building Code of Australia (BCA)	3	3
Austria	Austrian Building Codes	8 (*72 feet)	3
Canada	2010 National Building Code of Canada (NBCC)	4	3
Germany	2012 Federal Building Code	8 (*59 feet)	3
Sweden	2013 Planning and Building Act	8	2
United Kingdom	2010 Building Regulations	5**	4**

* Indicates a height limit in addition to a maximum story limit

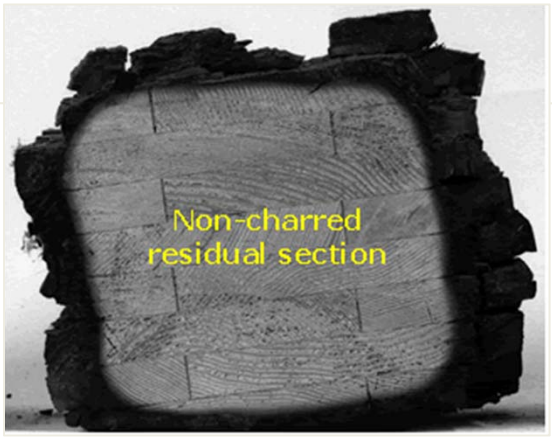
Building Regulations

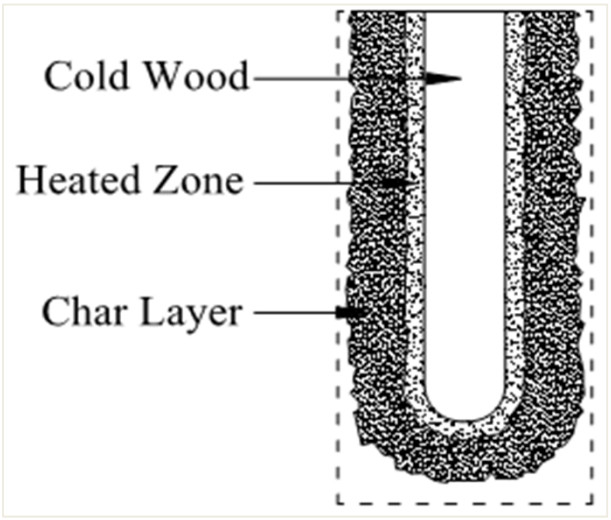
- Annex D – NFPA 5000
  - Building height is a life safety restriction
    - Use *NFPA 101* height limits based upon occupancy
  - Building area is replaced with compartment areas
- Performance Based Codes
  - Workshop on Friday

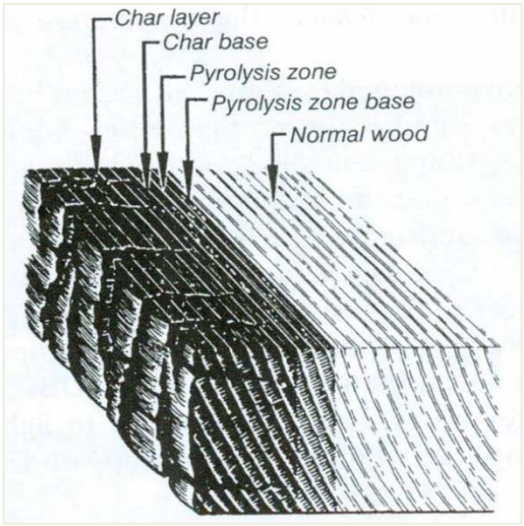
Timber Fire Performance

CHARRING

- Well understood…
- Predictable…
  - ~0.7mm/min (0.03 in/min)



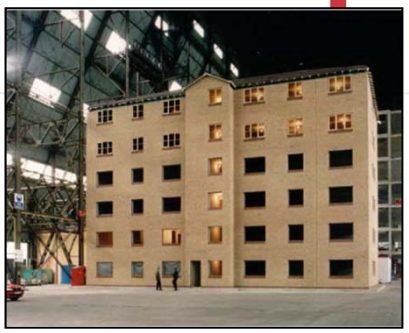


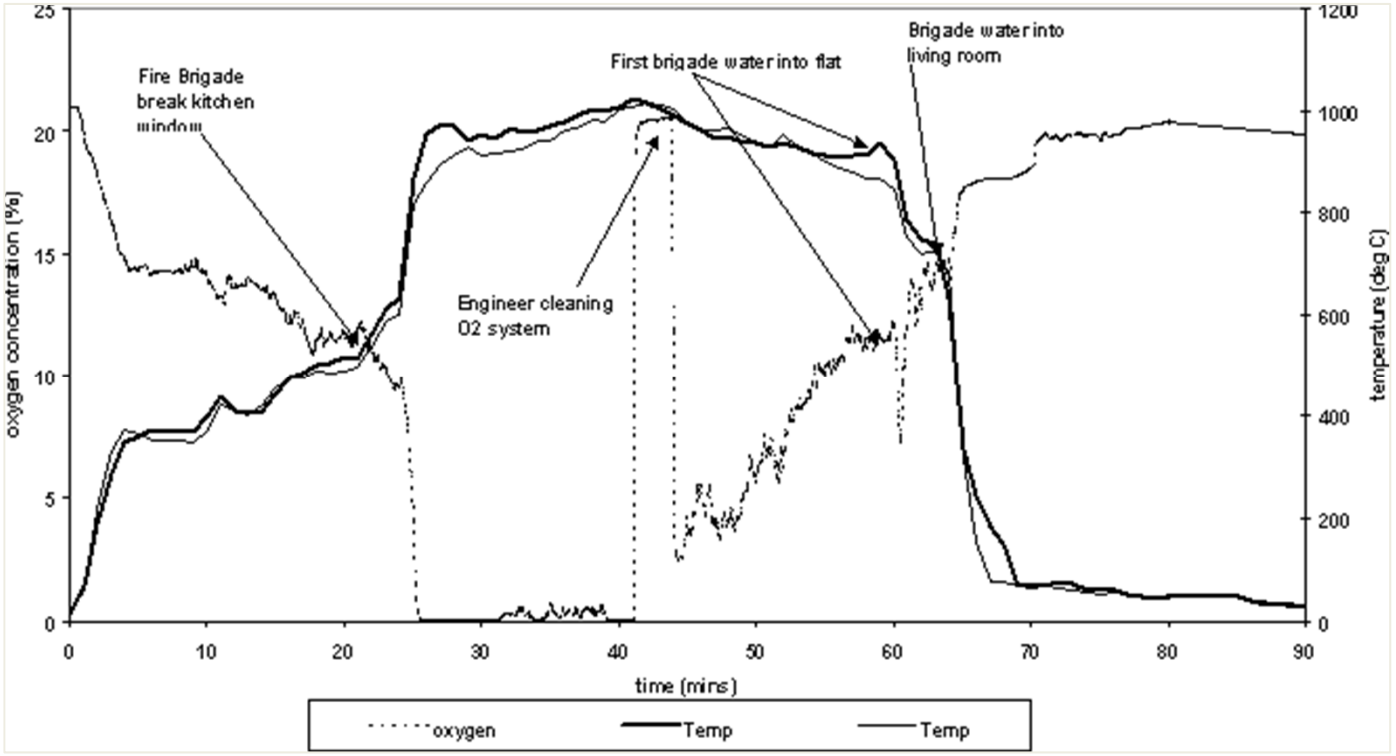


Timber Fire Performance

EXAMPLES FROM LITERATURE REVIEW

- Timber Frame 2000 (TF 2000)
  - Cardington, UK, 1999
  - Fire resistance mid-rise timber building





Timber Fire Performance

EXAMPLES FROM LITERATURE REVIEW

- Natural fire testing, Frangi and Fontana, 2005
  - CLT structure
  - Sprinklered vs. non-sprinklered
  - Exposed wood vs. gypsum lining



Sprinkler protection



Gypsum board lining



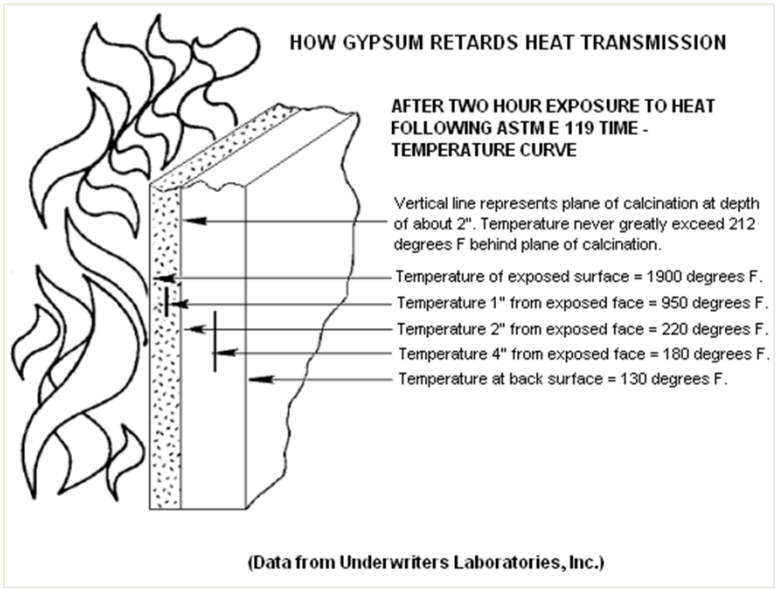
Exposed CLT

Timber Fire Performance

EXAMPLES FROM LITERATURE REVIEW

- Light timber assemblies
  - Improved fire resistance with gypsum board layers and thickness
  - Design equations (Just, Schmid and Konig, 2010)

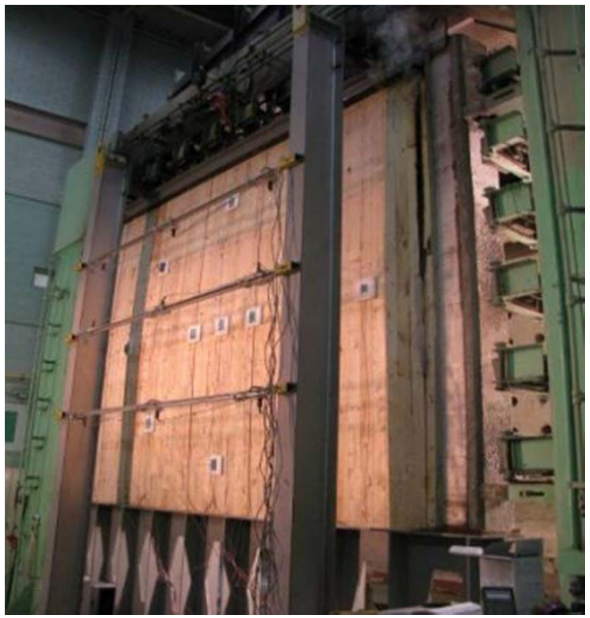




Timber Fire Performance

EXAMPLES FROM LITERATURE REVIEW

- CLT assemblies (Osborne, Dagenais, Benichou, 2012)
  - Charring rate consistent with wood (~0.7 mm/min [0.03 in/min])
  - Predictable behavior
  - Improved performance with gypsum board protection



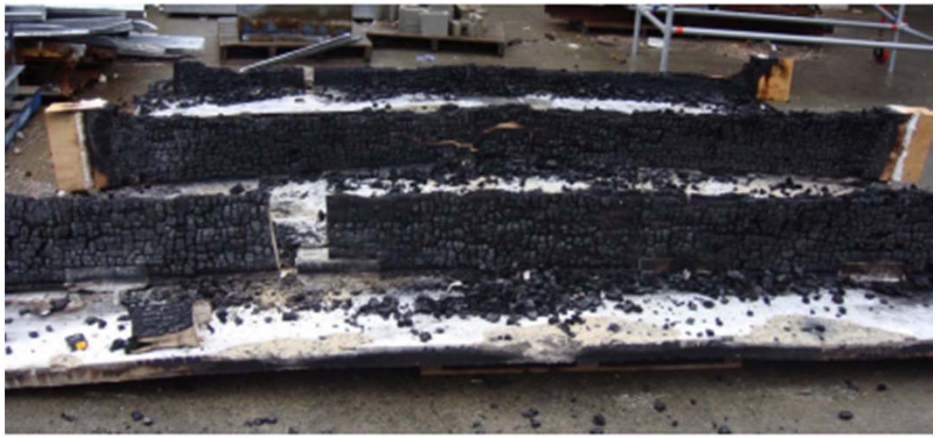


Timber Fire Performance

EXAMPLES FROM LITERATURE REVIEW

- Timber composite assemblies (O'Neill, 2012)
  - Fire performance based on testing
  - Up to 2-hour ratings for assemblies





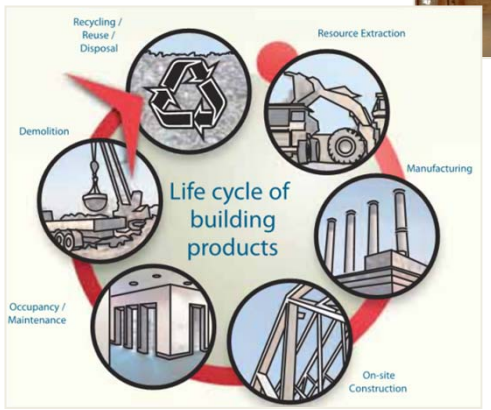
Gap Analysis

TOPICS BEING CONSIDERED

- System level testing
  - e.g., with exposed steel
  - Wood contribution to compartment fire
- Composite assemblies
- Connections
- Delamination
- Penetrations & firestopping
- Economics
  - Fire protection
  - Life cycle costs









Gap Analysis

- Impact of automatic sprinkler protection
  - Sprinklers in concealed, combustible spaces
    - NFPA 13
      - Combustible loading
      - Practicality of installation
      - Risk mitigation by other means
    - Height of the concealed space

Gap Analysis

- Concealed, combustible spaces
  - Fires challenge fire suppression personnel
    - Difficult to access
    - Delayed time to detection
  - Use of “draftstopping” to subdivide space
    - Effectiveness of draftstopping
    - Reliability of draftstopping

Gap Analysis

BUILDINGS UNDER CONSTRUCTION

- Additional challenges...





Gap Analysis

RECOMMENDATIONS FOR FUTURE RESEARCH

1) Fire testing of new and innovative timber and hybrid solutions;
2) Full-scale / large-scale fire testing of mock up tall timber frames;
3) Natural fire testing in full-scale / large-scale tall timber frames;
4) Economic analysis to quantify construction, operation and costs of tall timber buildings; and
5) Emphasis on effective risk communication and education



Questions/Discussion



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