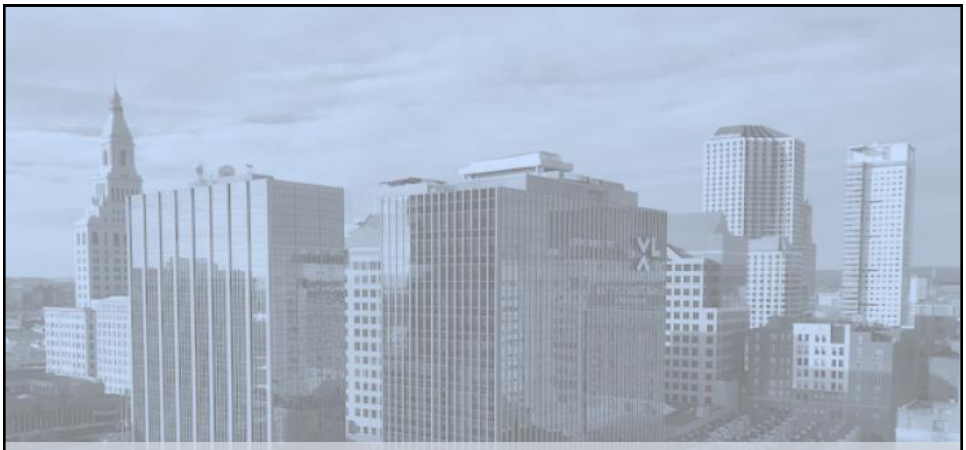

Tall Wood Buildings for Local Code Officials

Spring 2019 Career Development Series – January

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DAS Office of Education and Data Management

Objectives

- This class will look at the recent phase 1 and 2 research studies conducted by the Fire Protection Research Foundation
- This is not an NFPA or FPRF sponsored or promotional class
- It is a look at the current state of tall wood buildings in testing, research, and construction

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Advisory Panel

- Representatives of lumber industry, U.S. Forestry Service, insurance industry, engineering firms, and the fire service
- Panel was a sounding board for the FPRF staff and the selected research facility
- Panel reviewed proposal, had an opportunity to observe tests, and comment on findings

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Phase 1

- A research study of prevailing literature including testing, rereading of published studies

Phase 2

- Analysis of Phase 1 found gaps in technical knowledge, developed and implemented a testing procedure

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Lots of Questions

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When is a tall wood building at greatest risk of fire?

During Construction

What are the concerns?

- Access
- Water Supply
- Exposed lumber piles
- Delayed reporting

What can we in the local office do?

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Points of View of Others

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CT Concrete Promotion Council

- No Complete testing
- Wood lacks resilience and fire protection of non-combustible alternatives
- No wind component in testing
- Adhesives not standardized
- Major organizations do not support

"Allowing wood structures to be built above the level of FD access is a serious mistake"

email 10/18/18

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Firehouse.com

- Tall wood buildings are really tall mass timber buildings
- Tall mass timber buildings are not stick built of dimensional or lightweight wood products
- Tall mass timber buildings are built of large, pre-manufactured panels
  - CLT-Cross Laminated timber
  - GluLam-Glued laminated timber
  - SCL-Structural composite lumber
  - CNT-Cross nailed timber
- No elements less than traditional heavy timber

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Firehouse.com, continued

- Tall mass timber buildings start in mid 1990s
- Addressed by Chapter 1 of IBC
  - Section 104.11 "Alternative means and Materials"
- Strong supporter of fire resistance ratings, automatic sprinklers, 2 sources of water

December 2015 ICC established an ad hoc committee

- Committee said, "Proposals recommended would provide life safety protections to the public and first responders that are equal to or greater than tall buildings that are made of steel or concrete"
  - Raymond O'Brocki 6/11/18

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The BDC Network says…

5 Myths of CLT
1. It is not in the building code
2. Is a wood product and easily catches fire
3. You need specialized crews to install
4. Not good for the environment
5. CLT is expensive

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Phase 2

- Task 1 Literature Review
- Task 2 Test plan, modeling
- Task 3 CLT Compartment Fires

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A Finding

"the contribution of encapsulated timber to a compartment fire can be non-existing or insignificant"

BUT

"…failure of the encapsulation…can lead to the involvement of timber in the fire…eventually lead to a second flashover"

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Other Factors

- Fuel load in the space
- Impact of ventilation

Finding:

"…in under-ventilated fires the contribution of unprotected timber can lead to significant flaming combustion outside of ventilation openings, such as windows"

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What does this mean?

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Finding:

"The contribution can, but does not always, lead to a delayed decay of fire…"

What does this mean?

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Why even study?

- CLT, LVL, GluLam
  - Cited for their advantages in sustainability resulting from the use of wood as a renewable construction method

BUT

- Concern that timber elements could contribute to
  - Increase in fuel load
  - Increase initial fire growth rate
  - Compromise fire protection systems
  - Cause more severe conditions

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Who or what is impacted by more severe conditions?

- Occupants
- Firefighters
- The building
- The neighbors

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Based upon Literature

- McGregor 2013
  - Furniture fueled fires
  - Max HRR achieved in +1-5 minutes
  - Cooling at 10 minutes
  - HRR rebuilds as CLT contributed to the fire
  - Exposed CLT seemed to delay the temperature drop or decay of the fire

If 2 unprotected walls are opposing vs. adjacent, which leads to higher HRR?
Why?

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McGregor, 2013 continued

Findings:

- Once the gypsum board failed the CLT increased the intensity of the fire and a 2nd flashover occurred

AND

- Delamination of the CLT led to a 2nd flashover

Why does this occur?
What does this mean to us?

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Highlights of Complications

Tests by Hakkarainen, Frangi, Fontana, McGregor, Li, et al.

- Intensity of the fire outside the compartment
- Falling gypsum board
  - Extraction and calorimetry
  - Loss of data
  - Failure of steel frame reference tests
- In a real fire these are real complications

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Phase 2

- Lack of sprinklers
- Not an ok to not install sprinklers
- Was to allow fire to develop through all stages
- Ventilation
  - Open voids vs. panels
  - Size of openings
  - How to simulate doors

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Phase 2 Tests

- Quantify contribution of CLT building elements to compartment fires
- Characterize the effect of gypsum board on delaying or preventing involvement of CLT under varied ventilation conditions

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Phase 2 Tests

- Six compartments assembled
  - Used prefab CLT panels
  - Each panel 2 plies of 35mm thick lumber
  - Polyurethane adhesive used
  - Wall 2 (front) had opening of 1.8m x 2.0m in 4 tests, 3.6m x 2.0m in 2 tests
  - Interior lined with 15.9mm thick Type X gypsum board
  - Real residential furnishings

Test 1 – 3 layers of Type X No exposed CLT
Test 2 – 3.6m x 2.0m opening
Tests 3 and 5 – Wall 1 exposed
Tests 4 and 6 – Exposed ceiling and wall with an opening of 1.8m x 2.0m

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Videos

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The Tests: What Was Learned?

6 compartments

- 9.1m x 4.6m x 2.7m
- 175mmthick 5 ply CLT structural panels using 2 x 4 spruce-pine-fir lumber
- Glue was a polyurethane adhesive
- Movable furniture typical of a residential studio apartment
- No sprinklers
- No manual firefighting

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The Tests: The Findings

- Sprinklers would have operated at <5.8 minutes, limiting fire to the first item ignited
- Ventilation conditions had significant impact on the fire development
- Larger openings increased the peak release rate but reduced the fire challenges to the CLT
- CLT contribution to the fire increased with increasing exposed surface area of the CLT
- There is a need to use better heat resistant adhesives in CLT for exposed CLT applications to minimize delamination

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About Ventilation

- Tests 1-3 with a wide opening the delamination in the exposed wall does not prevent the fire from continuing to decay

BUT

- Tests 4-5 with a narrow opening the delamination of the plies led to a runaway growth of the fire

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What do these findings mean to use as code officials?

- Plan review, careful attention to specs
- Frequent inspections during construction

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Computer Modeling

There was a need to quantify the contribution of CLT

How?

- Charring rate
- Visibility
- Temperature
- Toxicity

How to do this?

- By the use of parametric fires
  - What is a parametric fire?
    - A simple design method to approximate a post flashover compartment

Will firefighters most likely arrive **pre** or **post** flashover?

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Computer Modeling, continued

- A parametric fire represents the most severe flashover fire which is possible in a compartment if all combustible material is ignited at once
- But there are limits
  - Max compartment size of 500m^2
  - Max height of 4m
  - Roof without openings
  - Mainly cellulosic type fire loads
  - Compartment linings have specified thermal inertia

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Test Criteria

- Assumes temperature is uniform within the compartment within the compartment
- Considers compartment size, fuel load, ventilation conditions, and the thermal properties of compartment's walls and ceilings

What part of the compartment is not being considered?

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Who is saying what?

Search Tall Wood Buildings
Search CLT and similar

- ICC
- Architect
- WoodWorks
- Disastersafety.org

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Who is saying what?

ICC Committee Action Hearings

- To allow mass timber technologies up to 18 stories

Architect Magazine

- Most U.S. fire codes limit wood frame to 4 to 6 stories
- Early 1900's up to 8 stories
- Sees IBC allowing in 2021 ed.
- 15% of North American market means 2.4 billion board feet of wood annually

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Who is saying what?

WoodWorks by Wood Products Council

- IBC 2012 and 2015 ed.s allow up to 6 stories and 85ft
- IBC Sec. 510.2 Horizontal Building Separation Allowance
  - Allows 2 vertically stacked sections of a building to be considered as separate and distinct buildings, provided:
    - Separation is 3-hr rated
    - Building below is Type 1A and protected by sprinklers
  - No limit on the number of stories below the separation

Disastersafety.org

- Cites a pagoda in China built in 1056 AD and 221ft tall

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Additional Tools/Resources

NFPA

- High Rise Buildings with Combustible Exterior Wall Assemblies
  - Fire Risk Assessment Tool
- Research Roadmap for Smart Firefighting

NIST

- Fire Risk Reduction in Buildings Program

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What The Foundation Did Not Study

- Multi-story construction methods
- Resulting and necessary interstitial spaces
- Connectors and connections
- Design and Engineering needs
- Ability of local code officials to exercise sufficient due diligence

What does this mean for us?

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Questions?

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