Modern Mass Timber Buildings: Design Skills for Architects & Engineers

Correcting Misperceptions of CLT Fire Performance

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Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.
Muhlweg Apartments, Austria

Svartlamoen, Norway
Mass timber and the IBC
What is a Fire Resistance Rating (FRR)?

- Structural resistance
- Integrity
- Insulation

What is Interior Finish Flammability?

Measure of flame spread and smoke development

Classes A, B and C
IBC limits for mass timber construction

Non-combustible construction – Type I, II
Combustible construction – Type III, IV, V

Mass timber - Code compliant use in Types III, IV, V

Type IV – Heavy Timber:
- Up to 6 floors (office) 5 floors (resi)
- Additional floors with “podium construction”
- 85ft in building height
Type III building

Podium construction with concrete to lower floors

Light frame floors and walls

Exterior walls are non-combustible, or wood covering (to 40ft) or FRT wood (to 60ft)

Up to 6 floors, with sprinklers
Type IV building

- Exterior walls are non-combustible, or FRT wood
- Timber beams, columns, floors, roof permitted
- Up to 6 floors, with sprinklers
- Code sets minimum dimensions for members
Modern Type IV building

Up to 6 floors, with sprinklers

Exposed mass timber

Glulam beams, columns; CLT floors and walls

Use of steel or concrete, where appropriate (hybrid construction)
<table>
<thead>
<tr>
<th>BUILDING ELEMENT</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
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<tr>
<td>Primary structural frame (see Section 202)</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<tr>
<td>Bearing walls</td>
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<tr>
<td>Exterior</td>
<td>3</td>
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<tr>
<td>Interior</td>
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<td>Nonbearing walls and partitions</td>
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<td>Exterior</td>
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<td>See Table 602</td>
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<td>Nonbearing walls and partitions</td>
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<td>Interior</td>
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<tr>
<td>Floor construction and associated secondary members (see Section 202)</td>
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<td>2</td>
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<tr>
<td>Roof construction and associated secondary members (see Section 202)</td>
<td>(1^{1/2})</td>
<td>(1^{b,c})</td>
<td>(1^{b,c})</td>
<td>0</td>
<td>(1^{b,c})</td>
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</table>
IBC: Heavy timber = mass timber

<table>
<thead>
<tr>
<th>MINIMUM NOMINAL SOLID SAWN SIZE</th>
<th>MINIMUM GLUED-LAMINATED NET SIZE</th>
<th>MINIMUM STRUCTURAL COMPOSITE LUMBER NET SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width, inch</td>
<td>Depth, inch</td>
<td>Width, inch</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>6 3/4</td>
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<tr>
<td>6</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>5 1/4</td>
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<tr>
<td>4</td>
<td>6</td>
<td>3 1/2</td>
</tr>
</tbody>
</table>

Solid or laminated timber (Chapter 23) – solid, LVL, glulam, CLT
Type IV – mass timber can be exposed (Chapter 8)
Type IV
- Max 85ft
- 5 floors
- Timber fully exposed

Type IV-C
- Max 85ft
- 9 floors
- Timber fully exposed
- 2hr FRR

Type IV-B
- Max 180ft
- 12 floors
- Timber partly exposed
- Protected timber shafts
- 2hr FRR

Type IV-A
- Max 270ft
- 18 floors
- Timber fully protected
- Concrete shafts
- 3hr FRR
CLT Resources - Fire
Schaffer, 1966, Forest Products Laboratory

\[ a_{eff} = 1.2 \beta_t t^{0.813} \]
1 hr exposure = 1.8 in/hr
2 hrs exposure = 1.58 in/hr

Original CLT depth

CLT structural capacity

CLT char depth

Strong

Strong

Strong

Original CLT depth
$a_{char} = 1.2 \left[ n_{lam} \cdot h_{lam} + \beta_n \left( t - (n_{lam} \cdot t_{fo}) \right)^{0.813} \right]$
Exposed CLT in high-rise buildings: what are the issues?
Fire Modelling – Exposed timber

Fuel load 500MJ/m²
Fire Modelling – Exposed timber

Fuel load 750MJ/m²
Fire Modelling – Exposed timber

Fuel load 1100MJ/m²
Fire Modelling – Exposed timber

Fuel load 1100MJ/m²
Delamination / Char fall-off
E119 test, CLT floor after 2hrs, with char fall-off

E119 test, CLT floor after 2hrs, with no char fall-off
For high-rise buildings:

Exposed CLT can be ok, in limited areas

Exposed CLT walls impact the fire dynamics less than ceilings

The adhesive used in the CLT is important (PRG-320 2018 update). Will allow more CLT to be exposed

Where the CLT is not exposed, the protection must prevent charring for the duration of the expected fire
Conclusions

For Type III, VI and V buildings (< 85ft), CLT is ok to be exposed

CLT manufacturers have interior finish and fire resistance testing reports

Connections have been fire tested and have ratings

IBC compliant calculation method for FRR

Char fall off / delamination – only an issue in high-rise resolved with new manufacturing standard
QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

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