FIRE PERFORMANCE OF TIMBER-CONCRETE COMPOSITE FLOORS

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OBJECTIVE

Investigate the fire performance of timber-concrete composite floors under service loading conditions for both cross-laminated timber (CLT) and nail-laminated timber (NLT).

BACKGROUND AND MOTIVATION

North America is rapidly adopting the use of mass timber products in mid- and high-rise building construction, especially CLT, which lends itself to:

- Offsite prefabrication,
- Greater precision in production,
- Decreases construction time,
- Provides for lighter foundation systems, and
- Reduced seismic demands.

In many mass timber buildings, floors are constructed with a concrete topping to improve the acoustic, vibration, or fire performance. Engineers have begun to design mass timber floors to be composite with a concrete topping to span longer distances.

Mass timber high-rise building construction is currently hindered by the confines of the building codes10. The timber-concrete composite systems have an improved fire performance as compared to the timber only floor systems. This improvement could lead to taller code-allowed mass timber buildings.

STATE-OF-THE-PRACTICE

Currently, mass timber construction is categorized as combustible. This limits the height of a timber building11.

- Timber construction is categorized as Type III, IV, and V construction in the International Building Code12.
- Types III and IV construction can have a maximum height of 85 ft with an increased level of fire protection and structural performance11.
- For high-rise mass timber structures to be characterized as Type I category, the primary structure must be non-combustible, and therefore requires an alternative engineering approach to structural fire engineering11.
- Type I construction represents a large market for the Oregon timber industry. This research project will reduce the burden on project teams and facilitate the use of timber in many more projects around Oregon and the United States.

TIMBER-CONCRETE COMPOSITE FLOORS

- Composite action achieved through mechanical connections
- Can increase the stiffness and strength of the timber floor systems
- Gap in knowledge of the fire performance of composite floor system results in conservative design, not accounting for the addition of concrete

TESTING METHODOLOGY

- Testing occurred in a gas-fire furnace at the National Research Council in Ottawa, Canada
- Heating procedure adhered to the ASTM E119 standard fire curve, shown in Figure 6
- Service loading conditions was applied with hydraulic rams simulating a distributed loading
- Temperature distributions through the cross-section were measured with Type K thermocouples
- Panel ends were simply supported by rollers during testing
- Failure was defined as the loss of load carrying capacity

RESULTS

<table>
<thead>
<tr>
<th>Location</th>
<th>Charring rate (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLT</td>
<td>1.16</td>
</tr>
<tr>
<td>NLT</td>
<td>1.15</td>
</tr>
<tr>
<td>2.75</td>
<td>1.89</td>
</tr>
<tr>
<td>4.15</td>
<td>1.42</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thickness at end of test (in)</th>
<th>CLT</th>
<th>NLT</th>
</tr>
</thead>
<tbody>
<tr>
<td>105 min</td>
<td>187 mm</td>
<td>105 mm</td>
</tr>
</tbody>
</table>

APPLICATIONS

Experimental tests are essential for demonstrating the fundamental behavior of timber-concrete composite systems. These tests demonstrated that timber-concrete composite floor systems can have significant fire resistance. Future work to be done includes a series of push-out tests to quantify the force-slip behavior of the composite connections used in these tests. The compiled results of both tests will be a cohesive package of data demonstrating the performance of TCC systems.

ACKNOWLEDGEMENTS

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REFERENCES