AMERICAN WOOD COUNCIL

Fire Testing on Full-Scale Mass Timber Building Will Inform Code Changes

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DES603-A Fire Testing on Full-Scale Mass Timber Building Will Inform Code Changes

Description:

Heavy timber construction (Type IV in the International Building Code) is one of the oldest building types used in the United States. There are efforts by underway to expand the use of heavy timber construction through the International Code Council (ICC) Ad-hoc Committee on Tall Wood Buildings (TWB) utilizing mass timber construction. This article covers a brief history of heavy timber construction and the progress of the TWB that researched tall mass timber construction and performed testing to help inform code change recommendations which ensure life safety and property protection in tall mass timber buildings.

Learning Objectives:

- Cite reasons for growing in heavy timber construction.
- Restate goals and objectives of work groups and committees interested in mass tall timber construction.
- Summarize the findings of the 5 fire tests conducted at the U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives Fire Research Laboratory.
- Formulate own thoughts regarding safety and property protection based on fire test data and code change recommendations.

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FROM THE PUBLISHER OF FIRE PROTECTION ENGINEERING MAGAZINE

Fire Testing on Full-Scale Mass Timber Building Will Inform Code Changes

ICC Ad Hoc Committee on Tall Wood Buildings Studies Promise Full-Scale Fire Test Results

By Carl Baldassarra, P.E., FSFPE and Kenneth Bland, P.E.

Heavy timber construction (Type IV in the International Building Code) is one of the oldest building types used in the United States. The use of massive wood structural elements and solid wood floor assemblies has been satisfactorily demonstrated in thousands of buildings over the last two centuries, with many of them still in use today.

The heavy timber building was originally conceived as a multi-story structure, designed and used primarily for industrial and storage purposes. In recent years, however, this type of construction has gained popularity among designers for adaptive reuse in many cities, as well as a variety of new low- to mid-rise building types, such as assembly, mercantile and mixed-use buildings.

Among the innovations further expanding what's possible in this category is the development of new manufacturing, connection and construction technologies using mass timber, which present significant opportunity for wood buildings — including high-rise applications. These new structural systems in wood represent the first serious challenges to traditional high-rise construction in more than a century. The main barriers to broader acceptance in the United States are current height and number of story limitations set by the International Building Code (IBC): 85 feet and six stories tall, respectively.

As interest mounts in finding safe, sustainable and resilient alternatives to incumbent structural materials of the urban world, several other countries have realized the benefits of tall mass timber building construction. With this in mind, the International Code Council (ICC) formed the Ad-hoc Committee on Tall Wood Buildings (TWB) in 2016 to "explore the building science of tall wood buildings with the scope being to investigate the feasibility of and take action on developing code changes for tall wood buildings."

This multi-year effort is supported by numerous work groups of the Committee involving stakeholders, design professionals, code officials, fire officials and other interested parties who looking into developing code changes for using mass timber in taller or "beyond current code" buildings. One such work group is dedicated to addressing fire safety.

As part of this work, the American Wood Council (AWC) and U.S. Forest Service Forest Products Laboratory collaborated with the TWB to conduct research and testing necessary to understand the performance and validate the fire safety of mass timber buildings. Over the summer, five fire tests were completed in a full-scale, multi-story mass timber apartment building with extremely promising results. The layout included two identical one-bedroom apartments with various arrangements of exposed and unexposed cross-laminated timber (CLT) and open doors between living and bedroom.

The TWB identified the following five test scenarios (see Table 1), which were intended to test the performance and fire resistance of a building with exposed mass timber:

- Test 1: A mass timber structure fully protected with two layers of 5/8" Type X gypsum wallboard subjected to a large furnishings and contents fire with a fuel load density of approximately 570 MJ/m^2. The test ended when the entire fuel package completely burned out after three hours without any significant charring on the protected mass timber surfaces of the structure, as observed after removing the gypsum wallboard.
- Test 2: In this test, 30 percent of the CLT ceiling area in the living room and bedroom was left exposed. The test ended after four hours, providing additional time to determine whether there would be any significant fire contribution from the exposed CLT. Notably, once the furnishings and contents had been consumed by the fire, the exposed CLT essentially self-extinguished due to the formation of char that protected the underlying mass timber.
- Test 3: Parallel CLT walls, separated by a distance of 30 ft, were left exposed, one in the living room and one in the bedroom. Similarly to Test 2, once the apartment furnishings and contents had been consumed by the fire, during which a protective surface char formed on the CLT, the mass timber surfaces essentially self-extinguished.
- Tests 4 and 5: This test examined the effects of sprinkler protection. For both tests, all mass timber surfaces in the living room and bedroom were left exposed. Test 4 demonstrated that under normal operating conditions, a single sprinkler easily contained the fire. For Test 5, the fire was allowed to grow to flashover in the compartment (about 23 minutes) before water was supplied to the sprinklers, which quickly controlled the fire.

<table>
<tr><th>No.</th><th>Test Floor / Construction Type</th><th>Wall A</th><th>Wall B</th><th>Wall C</th><th>Wall D</th><th>Floor/Ceiling</th><th>Interior Partition</th><th>Active Protection</th></tr>
<tr><td>1</td><td>1st / IV-A</td><td rowspan="3">60% openings with 2 layers Type X GWB elsewhere</td><td>2 Layers Type X GWB</td><td>2 Layers Type X GWB</td><td>2 Layers Type X GWB</td><td>Floor: 2 layers cement board
Ceiling: 2 layers GWB</td><td rowspan="5">Non-fire rated ½" GWB on each side</td><td rowspan="3">None</td></tr>
<tr><td>2</td><td>2nd / IV-B</td><td>2 Layers Type X GWB</td><td>2 Layers Type X GWB</td><td>2 Layers Type X GWB</td><td>Floor: 2 layers cement board
Ceiling: 2 layers GWB with 30% in LR & BR</td></tr>
<tr><td>3</td><td>2nd / IV-B</td><td>Livingroom: Exposed CLT
Kitchen: 2 Layers GWB</td><td>2 Layers Type X GWB</td><td>Bedroom: Exposed CLT
Bathroom: 2 Layers Type X GWB</td><td>Floor: 2 layers cement board
Ceiling: 2 layers GWB</td></tr>
<tr><td>4</td><td>1st / IV-C</td><td rowspan="2">60% openings with glazing with exposed CLT elsewhere</td><td colspan="3" rowspan="2">Exposed CLT</td><td>Floor: 2 layers cement board
Ceiling: Exposed CLT</td><td>NFPA 13, Ordinary Hazard</td></tr>
<tr><td>5</td><td>1st / IV-C</td><td>Floor: 2 layers cement board
Ceiling: Exposed CLT</td><td>NFPA 13, Ordinary Hazard with 23-minute activation delay</td></tr>
</table>

Table 1: Details Outlined in Tests 1 Through 5

The tests were conducted at the U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives Fire Research Laboratory, the world's largest research laboratory dedicated to fire scene investigations, with funding provided by AWC and the Forest Products Laboratory. While the data are still being analyzed, the initial results indicate that mass timber provides the level of fire safety performance that should warrant its use in larger buildings and even expand the option for exposed mass timber structure in smaller projects. A General Technical Report FPL-GTR-247 with the full fire test data will be available from the Forest Products Laboratory in the coming months.

Figure 1: Test 1 Shortly after Ignition. Photo credit: Laura Hasburgh (FPL)

In the meantime, the TWB will continue to study the findings, which will ultimately help inform its code change recommendations, to be available for public review later this fall on the ICC cdpACCESS website. The change proposals provide a comprehensive set of code requirements to ensure an abundance of life safety and property protection in tall mass timber buildings. A thorough review of the entire IBC was undertaken to capture any provision that may affect taller Type IV buildings. Non-structural provisions for the 2021 code cycle will be submitted for consideration during 2018, and structural provisions will be submitted for review and approval during 2019, in accordance with the ICC schedule for code development.

Figure 2: Test 1 Shortly after Flashover. Photo credit: Laura Hasburgh (FPL)

The code changes will help create a prescriptive path for designing mass timber buildings taller than 85 feet or six stories, beginning with the 2021 edition of the IBC. Until then, more performance-based research, testing and demonstration projects are needed to help industry professionals understand the possibilities of building with mass timber and encourage further development of this emerging construction technology. To learn more, visit www.awc.org/tallwood.

Carl Baldassarra, P.E., FSFPE, is with Wiss, Janney, Elstner Associates, Inc. and Kenneth Bland, P.E., is with the American Wood Council (AWC)