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# CLT Exterior Wall Assemblies Meet NFPA 285 Fire Test Standard

## Test Summary

The 2021 International Building Code (IBC) includes provisions for mass timber construction up to 18 stories and 270 feet. Cross-laminated timber (CLT) can be used as part of an exterior wall assembly in most construction types.<sup>1</sup> However, in Type IV projects (including A, B, C and HT), exterior walls greater than 40 feet may be required to pass the NFPA 285 *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components* fire test. Without the results of a successful test, a team seeking approval for a project that includes CLT exterior walls over 40 feet, whether load or non-load bearing, could be required to invest in their own testing—adding significant expense and uncertainty to the permitting process.

To remove this uncertainty, a project supported by a 2021 U.S. Forest Service (USFS) Wood Innovation Grant has demonstrated that a CLT-based exterior wall assembly can pass the NFPA 285 fire test. The project included the design of two CLT-based exterior wall assemblies that are appropriate for mid-rise and high-rise construction, and successful fire testing of these assemblies to the NFPA standard. By making the results publicly available, the intent is to provide a solution that any design team can replicate, both to remove a barrier to the use of mass timber for exterior walls and help others design safe and efficient mass timber buildings.

### **Project partners**

Timberlab (project lead), Arup, Mithun, SmartLam North America, Rothoblaas, ROCKWOOL North America, WoodWorks – Wood Products Council

### **Project funding**

2021 USFS Wood Innovation Grant 21-DG-11062765-735

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*Catalyst in Spokane, WA was among the first projects in the U.S. to include CLT exterior walls taller than 40 feet*

## **2021 IBC Requirements for Mass Timber Exterior Walls**

Where CLT and other mass timber panels are used as part of an exterior wall, the exterior wall assembly must be checked for compliance with a range of code sections.

For a CLT exterior wall assembly in Type IV-A, IV-B, IV-C or IV-HT construction, the IBC 2021 requirements are summarized in Table 1. While this introduces one possible code compliance path, each building situation is unique and the code path for one project may not apply to another. The type of exterior wall arrangement is also important—i.e., whether the wall is part of a balloon-frame solution (also referred to as a bypass or curtain wall) or a platform-frame solution (also referred to as an infill or window wall).

<sup>1</sup> CLT is approved in the IBC for use as part of an exterior wall assembly in Types IV-A, IV-B, IV-C, IV-HT, V-A and V-B buildings.

**TABLE 1:** Summary of IBC Requirements for Mass Timber Exterior Walls in Type IV Projects

Chapter 6	
<b>Table 601</b>	Sets a fire-resistance rating (FRR) requirement for exterior load-bearing walls, from no requirement for Type V-B construction to a 3-hour FRR for Type IV-A.
<b>Section 602.4</b>	Allows mass timber to be used in exterior walls in Type IV construction provided the requirements are met, including minimum dimensions for heavy timber in Section 2304.11 and the following:
<b>Section 602.4.1.1: IV-A</b> <b>Section 602.4.2.1: IV-B</b> <b>Section 602.4.3.1: IV-C</b>	Requires 40 minutes of noncombustible protection for the exterior face of the mass timber in exterior walls as determined per Section 722.7 and stipulates flammability requirements for the water-resistive barrier (WRB). The 40 minutes can be provided with one layer of 5/8-in. Type X fire-rated gypsum board. Requires all components of the exterior wall covering be noncombustible except WRBs meeting specified flammability requirements.
<b>Section 602.4.4.2: IV-HT</b>	Requires protection of the exterior surface of CLT in exterior walls in Type IV-HT construction of either 15/32-in. fire retardant-treated sheathing, 1/2-in. gypsum board, or any noncombustible material.
Chapter 7	
<b>Section 705.5</b>	Sets an FRR required of an exterior wall based on fire separation distance between the building and an adjacent lot line or another building. Also determines if the FRR is required for fire exposure from the exterior only or both the interior and exterior.
<b>Section 705.6</b>	Sets requirements for supporting construction of the exterior wall with different requirements for interior elements and exterior elements or within the exterior wall. Requires interior structural elements that brace the exterior wall but are not located within the plane of the exterior wall, to achieve the fire resistance required for that interior element in Table 601. Requires structural elements that brace the wall within the plane of the wall or exterior to the wall to achieve the FRRs of both Table 601 and Table 705.5.
<b>Section 715.4</b>	For balloon-framed (bypass or curtain wall) exterior walls, requires that any void between the exterior wall assembly and floor have a fire seal with an ASTM E2307 "F" rating consistent with the FRR of the floor.
<b>Section 722.7</b>	Where required in Type IV construction, defines how to provide the required noncombustible protection on the mass timber. Recognizes that 40 minutes of noncombustible protection can be provided with one layer of 5/8-in. Type X gypsum.
Chapter 14	
<b>Section 1402.5</b>	Any exterior wall with a combustible WRB greater than 40 feet tall in Type I through IV construction is required to pass a fire test in accordance with NFPA 285 <i>Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components</i> . Most, if not all, commercially viable WRBs are combustible.  The exceptions to this requirement are not applicable to exterior walls containing mass timber, as they apply when the WRB is the <i>only</i> combustible component in the exterior wall assembly.
<b>Section 1405.1.1</b>	In Type I through IV construction, exterior wall coverings of fire retardant-treated wood are not permitted to be more than 60 feet above the grade plane. Exterior wall coverings of other combustible materials are not permitted to be more than 40 feet above the grade plane.
Chapter 23	
<b>Section 2304.11.2.1</b>	Requires CLT in exterior walls of heavy timber (including Type IV construction) to be 4-in. minimum thickness.

## Summary of the Requirements

In all Type IV projects where CLT is being used with a combustible WRB (which is typical) in an exterior wall over 40 feet tall, the wall assembly is required to pass an NFPA 285 test. This is reiterated in *Mass Timber Buildings and the IBC 2021 Edition*, published by the International Code Council and American Wood Council, under Change Significance 602.4.1.1 Exterior Protection:

Buildings of Type IV-A, IV-B and IV-C construction will be subject to testing prescribed for exterior walls. Section 1402.5 of the IBC requires these walls to be tested according to NFPA 285. Nothing in this section is intended to preclude the test being applicable to these new types of construction. Even for wall assemblies passing the NFPA 285 test, all construction materials exterior to a mass timber wall, except the water-resistive barrier, must be noncombustible.

Mass timber used within exterior walls in Type IV-A, IV-B, and IV-C construction is required to be covered on the exterior side with a noncombustible material providing a minimum assigned time of 40 minutes of protection. A greater level of noncombustible protection may be needed if the exterior wall has an FRR requirement from the exterior greater than 1 hour. CLT-framed exterior walls in Type IV-HT projects have more flexibility in that the exterior protection can be 1/2 in. or thicker gypsum board, 15/21 in. or thicker fire retardant-treated wood sheathing, or a noncombustible material.

## Description of the NFPA 285 Fire Test

NFPA 285 specifies a fire test for an exterior wall assembly to determine the potential for flame spread vertically up the wall, laterally across the wall, and within the wall assembly. The fire test requires a two-story wall test assembly with a window opening in the lower room.

The test includes the use of two separate gas burners. One is located within the lower story room and ignites at the start of the test. This burner provides a simulated interior fire that replicates the ASTM E119 *Standard Test Methods for Fire Tests of Building Construction and Materials* fire curve that is used to determine fire resistance. After five mins of testing, a second gas burner is ignited outside the window to simulate large external flames. This protocol is to replicate a fire that starts internally, breaches a window or wall, and then grows on the exterior face of the building.

The test includes several criteria related to temperature and flame spread, all of which need to be met for the wall to pass the test. Temperatures are checked at various heights above the window, laterally away from the window, and within the wall. Flame spread height above the window is visually checked. A successful test demonstrates that the exterior wall assembly as a whole passes the test vs. any individual element.



**FIGURE 1:** NFPA 285 test showing exterior burner in position

## Exterior Wall Assembly Design and Fire Test Setup

The project team tested two CLT exterior wall assemblies. Both were designed to be applicable to a broad range of mass timber projects, and to reflect walls that are typical in parts of the country with a mild temperature and humidity range. The walls in both tests were assembled in a balloon-frame or curtain wall style of construction.

The assembly for Test 1 was designed based on the exterior wall requirements in the 2021 IBC for Type IV-A, IV-B, and IV-C construction. A single layer of 5/8-in. Type X fire-rated gypsum board on the exterior side of the CLT face provided the noncombustible protection required in Section 602.4.2.1.

The Test 1 wall assembly, from interior to exterior, was comprised of:

- 3-ply, 4-1/8-in.-thick (105mm) CLT
- 5/8-in. Type X gypsum board
- Combustible WRB
- 2 in. of 8 lb/ft<sup>3</sup> mineral wool batt insulation

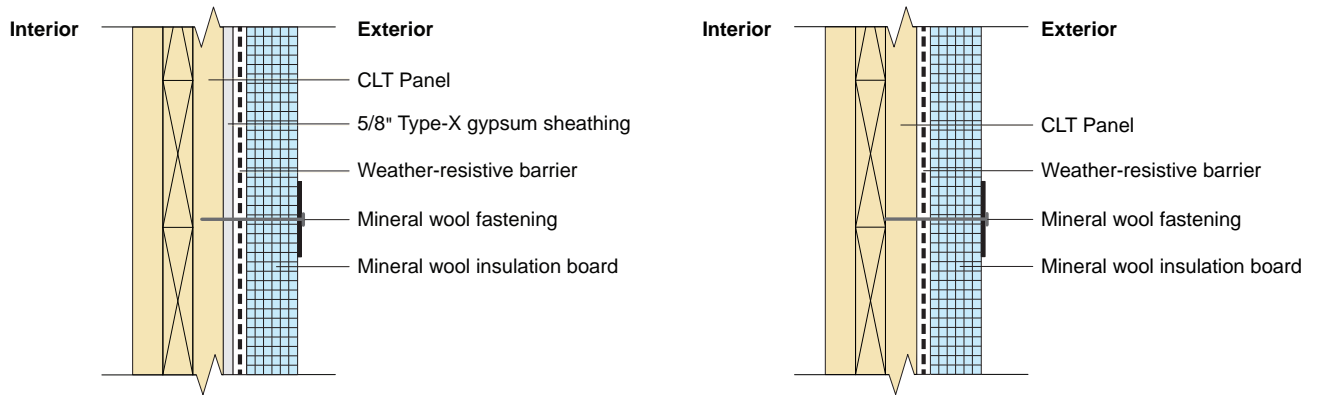
The Test 2 assembly was similar but without the Type X gypsum board. It included, from interior to exterior:

- 3-ply, 4-1/8-in.-thick (105mm) CLT
- Combustible WRB
- 2 in. of 8 lb/ft<sup>3</sup> mineral wool batt insulation

The components of the wall assemblies are shown in Figure 2, and additional details are as follows:

- The CLT panels were manufactured to ANSI/APA PRG 320-2019 *Standard for Performance-Rated Cross-Laminated Timber*. The interior face of the CLT was not covered.

- The gypsum board used in Test 1 is a commonly available exterior grade fiberglass mat gypsum sheathing meeting the requirements of Type X special fire-resistant gypsum board.
- The WRB was selected based on commercial availability and applicability for moisture control in a CLT exterior wall assembly. However, the WRB does not meet the flammability criteria within Sections 602.4.1.1, 602.4.2.1, 602.4.3.1 or 1402.5 Exception 2. This decision was based on the limited supply and high cost of WRB with very low flammability.
- The insulation is 2-in.-thick noncombustible mineral wool insulation board. A typical building in most U.S. climate regions will have thicker mineral wool to meet energy performance objectives. Thicker mineral wool would perform equally as well or better than the thickness used in the test.
- The window jambs, sill, and header were carefully detailed as these areas often fail to meet the NFPA 285 test. A window-frame product was not included. For actual projects, the expectation is that the window will positively fasten to the CLT edges at the opening.
- The interior face of the CLT was left exposed because this is often a desirable architectural solution. This added combustible fuel to the test as the CLT interior face combusted and charred.
- The CLT-based exterior wall assemblies were tested with no exterior facing rain screen or wall covering. This allowed additional noncombustible coverings to be directly fixed on the exterior face of the assembly without detrimentally impacting the test results.



**FIGURE 2:** Tested wall assemblies

See Figures 3 to 8 for photos of the Test 1 wall during construction.



**FIGURE 3:** Test 1 setup – CLT wall completed in frame (left); installation of fire-rated gypsum board (right)





**FIGURE 4:** Test 1 setup – Installation of WRB (left); installation of mineral wool insulation (right)



**FIGURE 5:** Test 1 setup – Close-up of gypsum board to window edge and WRB wraparound



**FIGURE 6:** Test 1 setup – Installation of window frame surround and sealing tape prior to mineral wool overlay



**FIGURE 7:** Completed wall setup prior to testing

## Fire Test Results

Testing was conducted by the Southwest Research Institute, which determined that both assemblies met the NFPA 285 criteria and passed the test.

### Test 1 Summary

Test 1 occurred on April 28, 2022. The assembly met all the test criteria with no temperatures exceeding the failure criteria of the standard or the flame extension limits related to height and lateral spread.

The following observations were made during the test and when the panel was subsequently disassembled:

- Interior face of the CLT was visibly flaming throughout the test, as expected
- Interior CLT face exposed to the test burner was charred
- Mineral wool was heavily scorched but still provided protection to the underlying CLT, preventing flame spread
- WRB had significant heat damage directly above the window, but this was limited in height to about 24 in.
- Window surround suffered damage but remained in place throughout the test

The uncovered interior face of the CLT-based exterior wall assembly was exposed to the gas burner, resulting in charring to the CLT in the interior of the lower room.





**FIGURE 8:** Test 1 underway (left); flames impinging on mineral wool above window (right)



**FIGURE 9:** Test 1 completed – Window burner extinguished with ongoing flaming within test room (left); damage to assembly layers with mineral wool manually removed (right)





**FIGURE 10:** Test 2 underway – Flames extending above window (left); post-test showing damage to layers after mineral wool manually removed (right)

## Test 2 Summary

Given the successful results of Test 1, the CLT-based exterior wall assembly was modified for Test 2 to exclude the single layer of 5/8-in. Type X fire-rated gypsum board on the exterior face of the panel. Instead, the exterior face of the panel relied on the mineral wool to provide the protection against fire spread. The Test 2 assembly was tested by the Southwest Research Institute on May 4, 2022 and also met all NFPA 285 test criteria. The following observations were made:

- Similar charring to the panel as in Test 1
- Similar damage to the mineral wool and window surrounds as in Test 1
- More heat damage to the WRB, with damage extending up the face behind the mineral wool approximately 36 in. and across the width of the window opening
- Overall temperatures and flame heights similar to Test 1

## Discussion

Two successful NFPA 285 fire tests have been completed for a CLT-based exterior wall. Each test can be used as the basis for design of exterior walls required to meet the NFPA 285 standard.

In Test 1, the Type X gypsum used on the exterior wall provided the 40 minutes of noncombustible protection required in IBC Section 722.7.1 for a CLT-based exterior wall. As such, it prescriptively meets the minimum noncombustible protection requirements for exterior CLT walls in Type IV-A, IV-B, IV-C and IV-HT construction. While the WRB used does not meet the quantitative fire-performance requirements for WRBs in IBC Sections 602.4.1.1, 602.4.2.1, 602.4.3.1, the fact that the assembly as a whole successfully passed the NFPA 285 fire test suggests that its design meets the intended performance of the IBC for exterior flame propagation and flame spread.

Test 2 did not include gypsum board to provide noncombustible protection to the exterior face of the CLT. However, protection provided by the mineral wool alone was sufficient to pass the NFPA 285 test. While mineral wool is not prescriptively recognized as providing noncombustible protection in IBC 2021 Table 722.7.1(2), it is expected that time contributed to the FRR by mineral wool used as noncombustible protection can be established through testing in accordance with IBC 703.6. (Justification for the level of noncombustible protection provided by mineral wool is outside the scope of this project.) As mineral wool qualifies as a noncombustible material, the Test 2 wall assembly meets the exterior protection requirements of Type IV-HT construction in IBC 602.4.4.2.

The test setup for both walls was based on a design that replicates a typical project, but many different types of CLT exterior walls could be constructed. While the tests demonstrated that these specific assemblies pass the NFPA 285 test, an assembly with any of the following changes can be expected to also meet the NFPA 285 criteria:

- CLT as a load-bearing wall: The tested wall assemblies had no load applied during the test, as NFPA 285 does not specify any applied load. Using the wall as load bearing is not expected to impact the NFPA 285 results.
- Increase in CLT depth: A thicker CLT panel can be used with no detrimental impact on the outcomes of the test.
- Increase in mineral wool thickness: Installing a thicker layer of similarly attached mineral wool of similar material properties can be used with no detrimental impact on the outcomes of the test.
- Addition of a noncombustible exterior wall covering: A noncombustible exterior wall covering with no vertical voids or airspaces directly fixed to the exterior face of the mineral wool is not expected to negatively impact the results.
- Addition of an interior covering to the CLT: The NFPA 285 tests had the CLT exposed on the interior side (facing into the occupied area). The results would not be negatively impacted if the CLT was covered with a noncombustible covering.

The change of any material from the tested assemblies is subject to approval of the Authority Having Jurisdiction. This may be permitted based on justification provided from a licensed design professional. Materials being substituted would need to perform as well as or better than those tested.

## Conclusion

With funding from a USFS Wood Innovation Grant, the partners in this project have successfully demonstrated that a CLT-based exterior wall assembly is a viable option in applications greater than 40 feet in Type IV projects. In addition to verifying that a CLT-based exterior wall assembly can meet the NFPA 285 standard for exterior wall fire propagation, the results provide clarity regarding a potential IBC compliance path for the use of mass timber within exterior wall assemblies, and two design alternatives. With these fire test results, the tested assemblies can be replicated for future multi-story mass timber building projects.

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## Available Documents Related to the NFPA 285 Fire Test

Construction documents for the tested assemblies and test reports developed by the Southwest Research Institute are available from WoodWorks at <https://www.woodworks.org/resources/nfpa-285-fire-test-report/>.

### Additional WoodWorks Resources

[Exterior Walls in Mass Timber Buildings – Part 1: Code Requirements and Commonly Used Materials](#)

[Inventory of Fire Resistance-Tested Mass Timber Assemblies and Penetrations](#)

[Fire Design of Mass Timber Members: Code Applications, Construction Types and Fire Ratings](#)

[Demonstrating Fire-Resistance Ratings for Mass Timber Elements in Tall Wood Structures](#)

[Key Design Considerations for Mass Timber Projects](#)



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