Expert Tips

Fire Design of Gypsum Wall Board Over Mass Timber

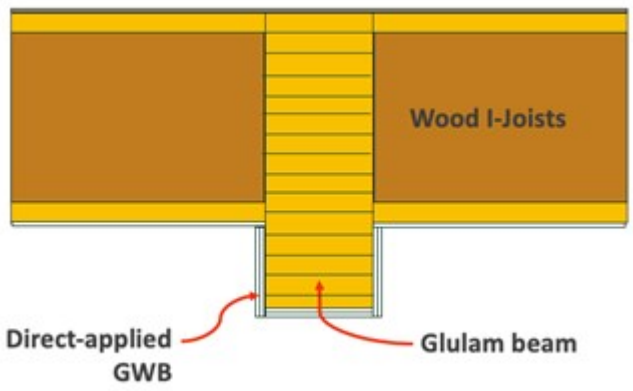
Fire-resistance ratings of mass timber members achieved by a combination of direct-applied gypsum wallboard and inherent timber char

Two-story mass timber vertical addition on existing three-story building at 69 A Street in Boston, MA / Margulies Perruzzi / McNamara • Salvia / Photo Greg

Mass timber's ability to remain exposed to the interior of a building while providing a 1- or 2-hour fire-resistance rating (FRR) can lead to reduced applied finish materials and enhanced aesthetics. Keeping mass timber structural elements exposed* is a must-have design component for many projects. However, in some circumstances, it may be necessary or desirable to apply noncombustible materials—commonly gypsum wallboard (GWB)—directly to mass timber members to add to or fully achieve the required fire resistance rating. This article describes the code path and design options for demonstrating FRR of direct applied GWB-covered wood members, where the FRR is obtained by a combination of the GWB and the wood char or solely with the GWB.

Some examples of when this might occur are:

- **Example 1:** Type III-A mass timber multi-family building using 3-ply CLT floors, requiring 1-hour FRR. Where CLT floors are not intended to be exposed as the ceiling surface, CLT is being used to enhance construction speed and thin the floor structure. GWB is directly attached to the underside of the CLT to achieve some or all the required 1-hour FRR of the floor/ceiling assembly. This application allows for the use of 3-ply CLT with GWB covering to replace a comparable 5-ply CLT alternative.
- **Example 2:** Type V-A mass timber office building using glulam beams and columns. Glulam columns may be covered with GWB to provide the required 1-hour FRR. GWB wrapped columns are only checked for structural loading requirements (i.e. not oversized for char) as the GWB provides the full 1-hour FRR.
- **Example 3:** Type V-A light-frame wood commercial/retail building. A 1-hour FRR I-joist floor assembly spans to an interior flush framed glulam beam. Where the depth of the beam is such that it extends below the ceiling, the portion of the glulam beam that extends below the I-joist ceiling is wrapped in GWB (see figure 1), maintaining the 1-hour floor assembly.



- **Example 4:** Type IV-HT mass timber institutional building using CLT shaft walls. Shaft enclosures require a 2-hour FRR since the building is four stories tall. CLT shaft walls are 3-ply, with two layers of GWB applied directly on each face.
- **Example 5:** Type IV-B mass timber hotel using 5-ply CLT floors. A 2-hour FRR is

required for the floor. A dropped ceiling is installed in bathrooms and kitchens to cover the congestion of mechanical and plumbing services. In these areas, direct applied GWB covers the underside of the CLT.

To better understand potential code paths for this GWB-over-wood fire design, it is helpful to first look at the options defined in the International Building Code (IBC) for demonstrating the FRR of members and assemblies. 2021 IBC Section 703.2 requires the rating to be determined by testing in accordance with ASTM E 119 (or UL 263) or via one of five alternatives listed in IBC Section 703.2.2:

> *The fire resistance of building element, components or assemblies established by an analytical method shall be any of the methods listed in this section, based on the fire exposure and acceptance criteria specified in ASTM E119 or UL263:*

1. *Fire-resistance designs documented in approved sources.*
2. *Prescriptive designs of fire resistance-rated building elements, components or assemblies as prescribed in Section 721.*
3. *Calculations in accordance with Section 722.*
4. *Engineering analysis based on a comparison of building element, component or assemblies designs having fire-resistance ratings as determined by the test procedures set forth in ASTM E119 or UL 263.*
5. *Fire-resistance designs certified by an approved agency.*

These alternatives are options when the exact assembly has not been tested per ASTM E 119 and a test report is therefore not available. They are all founded on ASTM E 119 testing.

Tested Assembly Method

There are successful examples of fire-tested assemblies consisting of GWB direct applied on mass timber. WoodWorks' *Inventory of Fire Resistance-Tested Mass Timber Assemblies and Penetrations* (companion to *Fire Design of Mass Timber Members: Code Applications, Construction Types and Fire Ratings*, noted above) includes several examples of CLT floor/roof assemblies with direct applied GWB, and CLT/NLT/DLT wall assemblies with direct applied GWB on one or both faces. An example is as follows:

Fire-Tested CLT Floor/Roof Assembly:

- 3-ply CLT (4.133 in, 105 mm)
- CLT Grade: SPF #1/#2
- Ceiling Protection: 1-layer 5/8" Type X Gypsum
- Panel Connection: Half-Lap
- Floor Topping: None
- Load Rating: 75% Moment Capacity
- Fire-Resistance Achieved: 1-Hour

Previous fire testing and reports on wood members with direct applied protection are further discussed in the U.S. Forest Service, Forest Products Laboratory publication, *Fire Resistance of Wood Members with Directly Applied Protection*.

Calculation Design Method

Component Additive Method (CAM) of IBC 722.6

If the fire-tested options don't provide the specific solution a project needs, one alternative could be to use calculations (see item 3 from IBC Section 703.3, noted above). IBC 722.6, often referred to as the component additive method, provides a calculation-based method of assigning a fire-resistance rating time to a given assembly by adding together the ratings of the individual components of that assembly. As noted in the IBC Commentary to 722.6: *the fire resistance rating is equal to the sum of the time assigned to the membranes, the time assigned to the framing members and the time assigned for additional contribution by other protective measures, such as insulation. The membrane on the unexposed side is not included in the calculations.*

While this design method is typically applied to light-frame wood assemblies rather than a solid mass timber panel, some building designers have applied the principles and data presented in IBC 722.6 for GWB over mass timber design scenarios. For example, IBC Table 722.6.2(1) assigns a time of 40 minutes to a single layer of 5/8" Type X gypsum board. Using the design scenario presented in Example 1 above, a single layer of 5/8" Type X GWB applied to the underside of the CLT panel could achieve 40 minutes of the required 60-minute FRR. The remaining 20 minutes of FRR required could be obtained by demonstrating that the CLT panel itself can achieve 20 minutes, using the calculations presented in Chapter 16 of the American Wood Council's National Design Specification® (NDS®) for Wood Construction. Note that IBC 703.2.2 item 3 permits calculations in accordance with IBC section 722 as a viable means of demonstrating the fire-resistance rating of members and assemblies, and IBC section 722.1 references the NDS for the fire design of exposed wood members and assemblies. For additional information on the char calculation method from NDS chapter 16, including structural analysis under fire-design conditions, see the WoodWorks publication *Fire Design of Mass Timber Members: Code Applications, Construction Types and Fire Ratings*. If exploring this design approach, the building designer should discuss this with the applicable Authority Having Jurisdiction (AHJ) to determine its acceptability. Also, note that the CAM method of IBC 722.6 is limited to a 1-hour maximum FRR, as stated in IBC 722.6.1.1.

CAM of IBC 722.7

The 2021 IBC introduced three new construction types, permitting mass timber buildings of up to 18 stories and 270 feet. One of the new provisions introduced along with the suite of new tall mass timber options was IBC Section 722.7, which notes: *The fire-resistance rating of the mass timber elements shall consist of the fire resistance of the unprotected element added to the protection time of the noncombustible protection.*

While this section is specifically called out for Type IV construction, it is notable as it is the first time the IBC has prescriptively recognized this method of a net FRR of mass timber members by summing the timber's FRR and the direct applied noncombustible protection's FRR. For additional information on the fire design of mass timber members, specifically in these three new construction types, see the WoodWorks publication *Demonstrating Fire-Resistance Ratings for Mass Timber Elements in Tall Wood Structures*. For additional information on tall mass timber projects, design topics, and other resources, visit WoodWorks' Tall Mass Timber webpage.

AWC's Fire Design Specification (2024 FDS) Method

Similar to the CAM from IBC 722.6, AWC's Fire Design Specification discusses the fire design of wood members and assemblies. Section 3.4.2 of this document discusses the contribution of gypsum board when added to wood members and assemblies. Specifically, section 3.4.2.2 states:

> *3.4.2.2 Gypsum panel membrane: Where Type X gypsum panels are used as a membrane to protect the entire wood member or assembly, the protection time, tp, provided by each layer of Type X gypsum panels shall be in accordance with Table 3.4.2.1.*

Table 3.4.2.1 notes that each layer of 5/8" Type X gypsum provides 40 minutes of protection.

* *For additional information on the fire design of exposed mass timber members, see the WoodWorks publication Fire Design of Mass Timber Members: Code Applications, Construction Types and Fire Ratings*