MASS ENGINEERED TIMBER

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1.0 SCOPE

This data sheet provides recommendations on construction, fire protection and natural hazards for mass engineered timber buildings.

See Section 4.1 for other data sheets that provide design information and guidance for mass engineered timber.

1.1 Hazards

The use of mass engineered timber in construction is expanding and is considered a sustainable product. Mass engineered timber is constructed with smaller pieces of soft wood that are adhered into one piece to withstand structural loads. These mass engineered timbers perform well from a structural standpoint but pose unanswered questions in other areas that traditional noncombustible structural elements do not. These open unanswered questions are related to moisture concerns, understanding the criticality of the joints and assembly, transfer of fire through joints or fasteners and the ability to complete repairs.

Mass timber (large single pieces of wood) has been in use for hundreds of years. What is new is how small soft pieces of wood are adhered together to create a structural element and built to greater heights. The old mills that were built over 100 years ago used mass timber (solid wood, not adhered small pieces) and were typically less than 7 stories in height. Mass engineered buildings are now being constructed hundreds of feet in height, providing new challenges and unanswered performance questions. These concerns increase as the height and size of the buildings increase. The changes in height and size lead to new engineering designs, the need for individual component tests, and a lack of loss and repairability history.

Understand that mass engineered timber is wood and that wood burns. New areas should be considered when building with a combustible engineered building product, such as performance of the adhesives and the criticality of the joints and fasteners. There are longer term concerns related to the adhesive's performance with respect to moisture, both during and after construction. Little is known with respect to repairability of mass engineered timber. Repairs will utilize an engineered solution based on other materials, and concepts such as those used in lower mass timber buildings, or taller concrete and steel buildings. The concern becomes greater as mass engineered timber buildings are built taller with more creative, intricate designs and patterns.

1.2 Changes

April 2026. Interim revision. The following changes were made:

A. Updated information on cracking/checking.

B. Reduced acceptable moisture content.

C. Provided alternative to noncombustible requirements for fire ratings.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Construction

2.1.1 Moisture Protection of Roofs and Floors

2.1.1.1 Provide an FM Approved roof cover assembly for steel deck that includes an FM Approved pliable sheet and meets one of the following criteria:

A. Provides temporary protection from water intrusion and allows for drying by moisture vapor diffusion or:

B. Provides an ice-water protector (a.k.a. as separator sheet), such as one with a modified bitumen base sheet applied directly on top of the cross laminated timber deck.

Ensure both of the following during construction:

C. Prior to installing the FM Approved pliable sheet, measure the moisture content of the wood deck to ensure the moisture level is in accordance with Section 2.3.4.1 C. and

D. Apply the pliable sheet directly to the wood deck as soon as possible to protect the wood from moisture intrusion prior to installation of the final roof assembly products and cover.

2.1.1.2 An alternative to using a FM Approved roof assembly which includes a pliable sheet meeting section 2.1.1.1 is to provide an FM Approved active leak detection system per Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components.*

2.1.1.3 Seal splices, seams, joint or interfaces in cross laminated floors internal to the building structure as soon as possible during construction.

Manufacturers will recommend the type of sealing tape to be used. A tape is generally used for ease of installation. The sealing of these joints will help keep moisture out of the joints while under construction and prior to covering the floor deck with any barrier such as soundproofing, concrete or lightweight concrete.

2.1.1.4 Provide moisture protection between mass engineered columns and finished floors.

2.1.1.5 Provide a minimum roof slope of 1/4 in./ft (6.4 mm/304 mm) toward roof drains or building edge when constructed of mass engineered timber.

2.1.2 Vegetative Roofs Systems and Roof Mounted Solar Photovoltaic Panels

2.1.2.1 Install a noncombustible gypsum cover board or equivalent noncombustible material, such as mineral wool or expanded glass, directly below the roof membrane when installing a vegetative roof system or roof mounted solar photovoltaics on cross laminated timber roof decks or other types of mass engineered timber roofs. (See Data Sheet 1-15, *Roof Mounted Solar Photovoltaic Panels* or Data Sheet 1-35, *Vegetative Roof Systems, Occupied Roof Areas and Decks*).

2.1.3 Roof Assembly

2.1.3.1 Apply the following guidance for new roof assemblies:

A. Use a Roof*Nav* assembly designed for use on steel deck with appropriate ratings described in Data Sheet 1-28, *Wind Design*.

B. Apply Section 2.1.1.1 or 2.1.1.2, as applicable.

C. Conduct fastener pull-out tests per Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*, or complete calculations as indicated below.

If the facility is located in a tropical cyclone-prone region, see Data Sheet 1-28, *Wind Design*, and Data Sheet 1-52, *Field Verification of Roof Uplift Resistance*, for additional guidance.

D. Do not modify fastener spacing that is specified within the Roof*Nav* listing unless adequate wood screw resistance cannot be met following the guidance presented here. In this case, a tighter spacing can be utilized, and the analysis checked per the equations and limits specified in Table 2.2.3. However, the specified fasteners should be replaced with wood screws that have an equivalent head shape and size, regardless of spacing.

E. Calculate the required minimum penetration of the wood screws as presented within Table 2.2.3 without exceeding the upper resistance limit of the screw.

F. The penetration length of the wood screw must be less than the thickness of the cross laminated timber deck.

Table 2.2.3. Fastener Resistance

Wood Screw Size	*Required penetration of screw into Solid Sawn Lumber Wood Members (including CLT)*	*Upper Resistance Limit (Factored Load/ Fastener)*
#8	Req'd penetration [in.] = (1/115 * Rating * Trib Area) + 0.3 > 1 in.	Factored Load per fastener [lb] ≤ F_u/111
#10	Req'd penetration [in.] = (1/133 * Rating * Trib Area) + 0.4 > 1 3/16	Factored Load per fastener [lb] ≤ F_u/83
#12	Req'd penetration [in.] = (1/151 * Rating * Trib Area) + 0.4 > 1 5/16	Factored Load per fastener [lb] ≤ F_u/65
#14	Req'd penetration [in.] = (1/169 * Rating * Trib Area) + 0.5 > 1 1/2	Factored Load per fastener [lb] ≤ F_u/50

Notes:
The equations provided are based on the following:
- NDS equation 12.2-2
- NDS Appendix L wood screw dimensions
- Wood Specific Gravity value of 0.35 (conservative)
- For actual wood specific gravity > 0.5, a pilot hole is required
- Wood moisture content < 19%
- Wood not exposed to temperatures > 150°F [66°C] f for extended periods
- Load Duration Factor of 1.0 (conservative)
- Minimum wood screw penetration is 6 x screw diameter; this is depicted by the value on the right side of the inequality
- Required penetration includes the tapered end of the screw but not unthreaded portions. In other words, required minimum penetration is met with threaded portion of the screw only.

Notes specific to the upper resistance limit:
- The value F_u is the tensile strength [psi] of the selected wood screw. If this is unknown, use 45 ksi as a conservative estimate.
- Upper resistance limit is based on allowable tension in screws per AISI S100-16, J4.4.3, Ωt = 3.00, and derivation based on tensile strength and net area calculated using root diameter (Dr) of wood screws in NDS Appendix L

Manufacturer's data, when available, may be used in lieu of the calculation for the upper resistance limit (Factored load per fastener must be less than ultimate strength). If the upper resistance limit is violated, either a larger screw size or higher-grade screw material should be used and the analysis checked per the equations and limits specified in the table above.

Note that although an FM Approved above roof deck assembly is used as the basis, the entire roof assembly will not be considered FM Approved.

2.1.4 Adhesives

2.1.4.1 Use mass engineered timber constructed with a heat resistant adhesive that meets ANSI/APA PRG-320 (2018 edition or later): *Standard for Performance-Rated Cross-Laminated Timber*.

2.1.5 Fire Ratings, Connections and Joints

2.1.5.1 Provide fire-resistant ratings using noncombustible materials when required by other FM Loss Prevention Data Sheets.

2.1.5.2 An alternative to using noncombustible materials, unless specifically required by other FM data sheet, is to encase the mass engineered timber fire-rated structural elements including, beam, column and connections.

Use 5/8-inch (16 mm) Type X gypsum board.

- For a two-hour rating provide three layers of gypsum board.
- For a three-hour rating provide four layers of gypsum board.

2.1.5.3 Provide FM Approved fire stopping material around any concealed joints that use metal in a fire-rated assembly. Seal all fire-rated penetrations.

2.1.6 Maximum Foreseeable Loss and Space Separation

2.1.6.1 Use noncombustible construction for maximum foreseeable loss (MFL) walls within mass engineered timber buildings.

2.1.6.2 Mass engineered timber is considered a combustible-exposing fire hazard for purposes of Data Sheet 1-42, *MFL Limiting Factors*.

2.2 Fire Protection

2.2.1 Provide automatic sprinkler protection in all mass engineered timber buildings in accordance with FM Loss Prevention Data Sheet 3-26, *Fire Protection for Nonstorage Occupancies*, or other applicable occupancy Data Sheet. Protect concealed spaces in accordance with FM Loss Prevention Data Sheet 1-12, *Ceilings and Concealed Spaces*.

2.2.2 An alternative protection is to provide an FM Approved water mist system for the occupancy in accordance with Data Sheet 4-2, *Water Mist Systems.*

2.3 Operation and Maintenance

2.3.1 Moisture Mitigation

2.3.1.1 When a mass engineered timber building is exposed to river, coastal or storm water, use noncombustible structural components, such as steel or concrete, for any level that may be exposed to river, coastal or storm water. The use of mass engineered timber, especially with end grain near the ground, will absorb water and could produce significant damage to the structure of the building.

2.3.2 Moisture Mitigation Planning

2.3.2.1 Develop and implement of a moisture management plan for mass engineered timber buildings under design and construction. The development of the moisture management plan is necessary at the architectural design level, which includes specifications. These documents ensure adequate steps are taken to prevent moisture and subsequent damage to the mass engineered timber.

2.3.3 Design Stage

2.3.3.1 Develop a moisture management plan during the design phase. If possible, the contractor should be included and understand their responsibilities and duties. The moisture management plan must indicate who is responsible for the implementation and actions of the moisture plan during construction. Include the requirements of the moisture management plan in the specifications for the general contractor and sub-contractors. Provide clear expectations that the plan is to be followed during construction and on weekends and holidays. Include the following, as applicable.

A. Install the wooden building components during the dry season.

B. Install a factory applied moisture resistant coating on the mass engineered timber prior to shipment.

C. Cover each panel individually prior to shipping with using taped and secured lumber wrap or a self-adhesive membrane.

D. Design the structure and each assembly to minimize the potential for trapped moisture and promote the ability of the wood to dry.

E. Include actions to be taken in the event of any delay in delivery or construction.

F. Install the façade and enclose the building as soon as possible.

2.3.4 Construction

2.3.4.1 During the construction phase include the following as part of the moisture management program as applicable:

A. Provide boards between the CLT panels or glulam beams for ventilation and to keep the wood off the ground during storage.

B. Provide an active water management team onsite with team members identified. Identify who will implement the moisture management plan (such as deployment of small tarps, leaf blowers, squeegees/ vacuums, etc.). Begin removing water as soon as rain or snow ends.

C. Measure the moisture content prior to the installation of any barrier such as soundproofing, roof covering, concrete, or lightweight concrete. Measure the moisture content of the wood in several places, including any available end grains. Measurements should be taken near any areas that appear wet, exterior openings, as well as interior locations, which have had recent moisture or possibility of moisture. The moisture content of each measurement must be below 15% prior to enclosure. Averaging moisture content is not acceptable. Any measurement greater than 15% must be dried out and moisture content remeasured to ensure it is below 15%.

D. Install an FM Approved membrane, which is part of an Approved roof assembly to serve as a temporary cover as soon as possible following the installation of the roof deck. If providing an FM Approved active leak detection system, provide a temporary cover to prevent moisture from penetrating into the wood and prior to the installation of the roof covering. Check for moisture prior to installing the roof cover. Complete the roof and enclosure as early as possible to protect the entire structure.

E. Sealing any splice, seam, joint and interface as soon as possible following panel installation to prevent trapped moisture.

F. Provide tarps if rain, snow or ice is forecast including prior to night or weekend weather events.

G. Update the moisture management plan with the owner, contractors and design team throughout the construction. Complete updates after each moisture event. Modify the moisture management plan as needed.

2.3.5 Remediation

2.3.5.1 During construction moisture will enter the building. Long term leaks must be resolved and repaired upon detection. During the remediation phase include the following as applicable:

A. Dry wetted wood (e.g., CLT and joint splines areas) before they are sealed, covered or enclosed. Dry wood with mechanical ventilation. Verify moisture content is below 15% prior to covering with roof cover, concrete, lightweight concrete or other materials.

B. When the ambient environment is not ideal for drying or needs to be accelerated, recommend drying by fans or dehumidification.

C. Remove any non-structural components such as drywall, insulation, and other coverings that have been installed to verify and ensure there is no trapped moisture.

2.4 Human Factor

2.4.1 Conduct infrared thermography of the roof cover and deck every three years. Conduct infrared thermography of walls constructed of mass engineered timber every three years.

2.4.2 Develop a three-year frequency cycle after completing the initial infrared thermography, based on the following:

A. One year after construction is complete

B. One year after any roof work has been completed that has the potential to introduce moisture within the building

C. One year after any wall or component of a wall constructed of mass engineered timber has had work completed that has the potential to introduce moisture within the building

2.4.3 Determine the source of moisture found during infrared thermography. Hire a structural engineer to review the area affected by moisture and determine if the structure is capable of carrying the original structural design loads safely. If not, develop a repair plan. Plan to repair the structure back to the original design requirements. Conduct repairs to eliminate the source of moisture, repair any damaged material and ensure the woods moisture content is less than 19% prior to re-covering.

2.4.4 If the roof is protected with an FM Approved ice-water protector or FM Approved active leak detection system, the infrared thermography of the roof cover and deck can be conducted every six years.

2.4.5 Avoid hot work. Where it cannot be avoided, hot work involving a mass engineered timber building should be considered high-risk. Recommend the appropriate precautions as outlined in Data Sheet 10-3, *Hot Work Management*, and use the FM Hot Work Permit System.

2.4.6 Do not use torch-applied roof systems. See Data Sheet 1-0, *Safeguards During Construction*, for further loss prevention guidance during construction.

2.4.7 Monitor the mass engineered timber for excess checking. If excess checking is observed, engage a structural engineer to review the ability of the mass engineered timber to still meet the design load, including safety factors. (See Section 3.0 for additional support information.)

3.0 SUPPORT FOR RECOMMENDATIONS

General

Engineered timber is a wood product that is manufactured by binding or fixing small pieces of wood with adhesives or other methods, such as dowels or nails. It is referred to as mass engineered timber when it meets minimum dimensional sizes in accordance with building codes. It has become popular for several reasons including sustainability, lighter weight and lower overall cost compared to traditional construction. One of the biggest cost savings is the reduction in labor to construct a mass engineered timber building. The ability to construct and transport pieces for just in time installation and the speed of installation is beneficial in congested areas.

Mass Engineered Timber Building Design Approaches

The design approaches are provided for information. The client, in conjunction with the design team, will decide which approach is best for their project. Recognize that in mass engineered buildings, the majority of the work is completed at the beginning of the process, including coordination and cutting of all penetrations at the factory. This requires significant coordination of the architect, structural engineers, mechanical, electrical and plumbing trades. Design changes are very unlikely after the design is completed due to the upfront coordination work. It is imperative that FM be involved in the design at the onset of a project.

There are four different mass engineered timber design approaches. Understanding the different design approaches greatly affects the ability to impact changes during the design. The first two designs identified below rely heavily on upfront planning. In these designs, months are spent on the layout of mechanical, electrical and plumbing to be pre-cut at the factory during manufacturing. Once completed, any changes to the design are unlikely or, at best, very difficult to affect. The sprinkler protection layout and design have been completed as well. Companies may refer to these approaches differently, but the goals of each are similar. All four designs have the delivery of the mass engineered timber as part of the service. The design approaches are as follow:

Design and Supply – The manufacturer has the ability to provide full engineering and partners with the architect to retain the original intent while maximizing the mass engineered timber elements and members. Complete detailing and CAD services are provided. This service includes coordination and pre-drilling for mechanical, plumbing and electrical.

Manufacturing Design Assist – The mass engineered timber manufacturer will assist the engineer of record and architect on the design to achieve cost optimization. Complete detailing and CAD services are provided. This service includes coordination and pre-drilling for mechanical, plumbing and electrical.

Traditional Bid – The engineer and architect of record will complete the design and drawings as they normally would for any project. The mass engineered timber manufacturer then provides complete detailing and CAD services.

Fabrication Only – The mass engineered manufacturer provides the supply of mass timber per single piece drawing or possibly fully detailed 3D model and delivers to the site.

All manufacturers offer a pre-staging service for mass engineered timber. This service allows for coordinated delivery and installation. This is common in congested areas where the mass engineered timber arrives by truck in the order in which it is to be installed.

3.3 Material Optimization and Service Integration

Involving the manufacturer as early as possible in the design allows for optimization of the mass engineered timber (column and beam spacing). The manufacturer will work on the layout of columns, beams and cross-laminated timber (CLT) flooring to minimize panel thickness, increase the span of the columns, save materials and minimize waste.

One benefit of using mass engineered timber and the Design and Supply or Manufacturing Design Assist options is the ability to pre-cut all penetrations in the mass engineered timber. This requires a lot of coordination up front with the different trades. Determination of how best to run the mechanical, electrical and plumbing is done well in advance. This will ensure the penetrations are engineered in the wood and eliminate the need for onsite work, thereby reducing the cost of the material and labor. As with any building project, changes will be needed and may require unanticipated penetrations and further review.

Many times, a concrete or lightweight concrete is installed on top of cross laminated timber floors for vibration control or as part of the sound proofing. It is important that the cross laminated timber moisture be measured prior to the installation of the concrete or lightweight concrete. Trapping additional moisture may lead to deterioration of the soft wood.

Vibration

Mass engineered timber can be used in areas of vibration concern. Several options exist to deal with vibration; but typically, a concrete or lightweight concrete is added on top of the CLT floor is used. Generally, a soundproofing material or mat will be installed beneath the concrete or lightweight before covering the CLT floor.

Charring Effect

Charring is typically used as a method of fire resistance in mass engineered timber construction. The column, beam or member is designed to char for a specified duration (wood is consumed); such that after the specified fire resistance time, the remaining wood (uncharred) is able to carry the design load. To achieve this, the original member is over-designed to account for charring, while maintaining the anticipated loading. Charring is generally calculated at .02 in/min (.65 mm/min). This equates to about 3 inches (76 mm) on all sides to achieve a two hour fire resistance rating. See Section 3.2.1 for additional information on fire resistance testing.

3.1 Loss Experience

At the time of publication, there were two known losses involving mass engineered timber.

3.2 Mass Timber Construction

This is a relatively new type of construction in which the majority of structural elements are fabricated from small pieces of wood adhered and engineered to develop a mass timber wood product. It was first seen in the 1970s in Europe and Canada. It became more common in Europe in the 1990's and is now becoming common in the United States. Mass engineered timber is seen as a means of sustainable construction, protecting communities from wildfire and providing jobs. This data sheet focuses mainly on cross laminated timber at this time but includes other types of mass engineered timber such as nail laminated timber (NLT), glue laminated timber (glulam), laminated veneer lumber (LVL), dowel laminated timber, timber-concrete composite, and post-tensioned timber.

Mass engineered timber is considered sustainable and a highly desired carbon sequestration tool. Mass timber is considered an environmentally friendly construction approach, because the use of prefabricated materials can expedite construction time and reduce material waste. Like traditional wood construction, mass timber is combustible. Metal connections can make this construction susceptible to heat, as with standard steel construction. The use of glue creates unique challenges (such as potential delamination during fire and water exposure) that are not fully understood and subject to ongoing research.

Mass engineered timber construction uses a category of engineered wood products of a large size for columns, beams, roof, floor and wall panels. Mass engineered timber wood products are engineered for high strength, comparable to steel and concrete, but are lighter in weight. A building is considered mass engineered timber when the majority of the vertical and horizontal structural framing system is comprised of engineered mass timber wood products. (See Appendix C for examples.). Mass engineered timber can be a hybrid with other materials, such as heavy timber, steel and concrete. Mass engineered timber wood products are comprised of multiple wood pieces laminated (glued with adhesives) or nailed together to form larger, stronger members which can be used for columns, beams, roofs, floors, walls, etc. They are typically built off-site.

3.3 New Construction

3.3.1 General

The use of CLT is increasing due to the sustainability of the product. Glulam and other engineered wood products have been available for decades. In all engineered wood products, the largest risk is wetting of end grain boards. The end grain is more water absorptive than face grain. Water can be trapped in lamination gaps and splines at joints. If the boards are exposed to water at the end grains, swelling is expected parallel to the wood. Cross laminated timber makes swelling more difficult due to the adhesives and alternating layers of wood.

Wood can generally be dried once the moisture source is removed. Moisture evaporation can occur in warm, low-humidity and ventilated environments. Drying may take weeks or longer when moisture has penetrated deep in a large member. Drying will become extremely slow or even impossible if the members are covered with low vapor-permeance materials.

The majority of cross laminated timber is used in residential and office buildings. Cross laminated timber can be used in many other ways or occupancies. Some known uses are:

- For shear walls and diaphragms. See DS 1-2, *Earthquakes for additional guidance*.
- Sometimes used to meet requirements for both vapor retarders and vapor barriers in walls and roofs.
- Starting to be used in place of concrete tilt up walls and for manufacturing and warehouse facilities, although all fire testing has been geared towards office and residential settings.

There are no FM Approved roof assemblies for cross laminated timber. To determine the fastener spacing, pull-out tests and calculations will need to be completed.

Mass Engineered Hybrid Timber Buildings

A mass engineered hybrid building is one in which mass engineered timber is combined with steel or concrete. This is generally done to obtain larger spans between columns.

3.3.2 Fire Tests

The National Fire Protection Association, Fire Protection Research Foundation conducted testing on compartmented units constructed of cross laminated timber. Six tests were conducted in a compartment size of 30 ft x 15 ft x 8.75 ft (9.1 m x 4.6 m x 2.7 m). These tests were conducted using 5-ply CLT with polyurethane adhesives, not meeting the ANSI/APA PRG-320: *Standard for Performance-Rated Cross-Laminated Timber*. The compartment fuel size was 550 MJ and contained two ventilation configurations and various amounts of gypsum board. The testing showed that the adhesives delaminated during the fire, adding more fuel to the fire load.

The International Code Council in conjunction with Alcohol, Tobacco and Firearms (ATF) conducted compartment fire tests similar to the arrangement conducted by the Fire Protection Research Council. These tests were designed for a typical residential unit. The compartments were two stories and used adhesives complying with ANSI/APA PRG-320: *Standard for Performance-Rated Cross-Laminated Timber*.

The conclusion was that heat resistant glues did not delaminate during the test. From these tests for a residential unit the wood remained in place and did not delaminate for four hours. The fuel load was consumed, and the mass engineered timber did not contribute to the fire. Heat resistant adhesives allow the timber to remain in place during a fire and char in order to limit contribution to the occupancy fuel load. Without heat resistant adhesives, the timber falls off adding additional fuel to the fire.

Fire testing has identified a possible issue related to exposed glulam columns. These columns when exposed to a standard room temperature test continue to smolder after the fire is out. This smoldering is known as a thermal wave. This thermal wave continues to allow for heat to be transferred throughout the column. Testing has shown these columns collapsing prior to their reported fire resistance. There is inadequate information at this time to require recommendations.

Table 3.3.2 provides information and effects on the design based upon exposed fire temperatures. This table is provided for information only and shows the importance of properly installed sprinkler systems in mass engineered buildings.

Table 3.3.2. Heat Effects on Mechanical Properties

Temperature	*Effect on Mechanical Properties*
212°F (100°C)	Compression
392°F (200°C)	Shear
482°F (250°C)	Tension

3.3.3 Introduction of PRG 320

The tests conducted by Fire Protection Research Foundation and ATF resulted in the development of ANSI/APA PRG-320-2018: *Standard for Performance-Rated Cross-Laminated Timber*. Mass engineered timber used for construction in North America is required to meet this standard.

This standard was released in 2018. Mass engineered timber produced after 2019 will probably meet this standard. This test used a prescribed fuel load controlled by gas. The CLT adhesive qualifies under ANSI/APA PRG-320: *Standard for Performance-Rated Cross-Laminated Timber Annex B* if the temperature measured within the compartment stays below 950°F (510°C) during the last 90 minutes of the test. This test is designed to ensure no delamination and fire regrowth occurs during the decay phase of the FPRF fire test.

Heat resistant adhesives for use in cross laminated timber were introduced in 2018 in North America. Assume buildings made prior to 2019 were constructed using non heat-resistant adhesives.

3.3.4 Fire Design

Two options are commonly available to achieve fire resistant ratings when using mass engineered timber. These are referred to as encapsulation and charring using sacrificial layers of wood. Sometimes these options are combined to create the fire resistance rating. Tall mass engineered timber buildings (greater than 12 stories) in North America are required to use a combination of the two methods to achieve the fire resistance rating.

Cross laminated timber is often referred to as fire resistant, pointing to its ability to char. The manufacturer's marketing specifically avoids the term "burn" and some market it as being equivalent to or better than steel or concrete. There are positive and negatives to each of the construction products. Ultimately, mass engineered timber is wood; and wood is combustible and burns. Charring is part of the burning process. The standard for mass engineered timber is its ability to pass the same ASTM E119 test. Passing this test provides a fire resistance rating. For purposes of mass engineered timber, it means the product can maintain its structural strength while being exposed to an increasing temperature for up to the time tested. The same criteria are used for steel and concrete. However, many buildings do not require fire resistance ratings at all.

3.3.5 Moisture

Moisture is the enemy for soft woods. Soft woods are utilized in mass engineered timber. Soft woods are susceptible to decay during a wet-dry cycle. This decay is common when there are roof or cladding leaks. These leaks are typically hidden until severe decay has already occurred.

A moisture management plan is critical during the construction of a mass engineered timber building. Due to the potential for severe decay, which can be hidden, yearly infrared thermography image is recommended for the exterior of a mass engineered timber building to provide for early detection and repair.

3.3.6 Biophilic Design

Mass engineered timber is marketed not only as sustainable but has the ability to promote better overall health for people living and working in the building. This is known as biophilic design. The architects look to design and incorporate more natural features in the building. The mass engineered timber is one part; but live trees, living walls and other natural environments are being introduced. The goal is to increase the natural plantings (trees and living walls, etc.) and to the use mass engineered timber to provide an outdoor feeling. Several biophilic studies associated with the use of mass engineered timber and the inclusion of natural features show a positive health effect.

3.3.7 Cracking or Checking of Mass Engineered Timber

3.3.7.1 Glulam beams and cross-laminated timber (CLT) are commonly used today. Both these products are made from soft pine wood. As the wood dries out, especially in conditioned buildings – checking (a.k.a cracking) is common and expected. Wood checking is not an indication of delamination or a concern in most cases. With delamination, the surface of thelamination at the opening is smooth. Checking is separation of the wood fiber itself and is not smooth. Checking should not occur at a glue line. Separation at a glue line is a sign of delamination.

Figure 3.3.7.1-1 shows a typical glulam beam and its layers of construction. The number of layers is dependent upon the design.

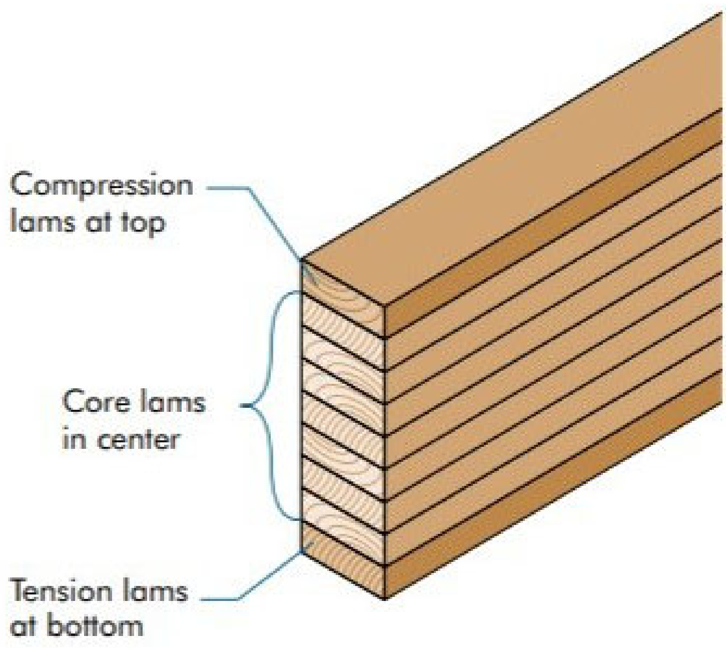

Fig. 3.3.7.1-1. Typical glulam beam. Courtesy of APA – The Engineered Wood Association

Figure 3.3.7.1-2 shows a typical glulam column. The size is dependent upon the design. The column on the left shows checking in a portion of the column, which is generally considered normal. The column on the right shows checking running the entire column length, which can be of concern.

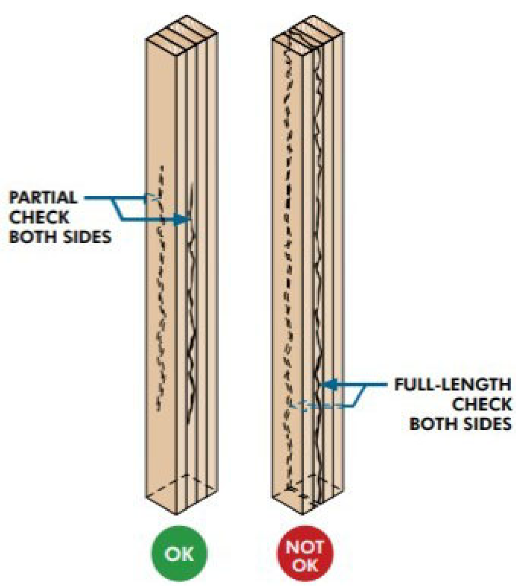

Fig. 3.3.7.1-2. Typical glulam columns showing cracking/checking. Courtesy of APA – The Engineered Wood Association

A glulam beam or column generally shows less checking than a solid piece of wood, as the wood pieces used to make the glulam beam or column were all dried in a kiln prior to assembly. Drying is an important step to help the adhesives stick properly and achieve the desired strength. Figure 3.3.7.1-3 shows additional examples of checking.

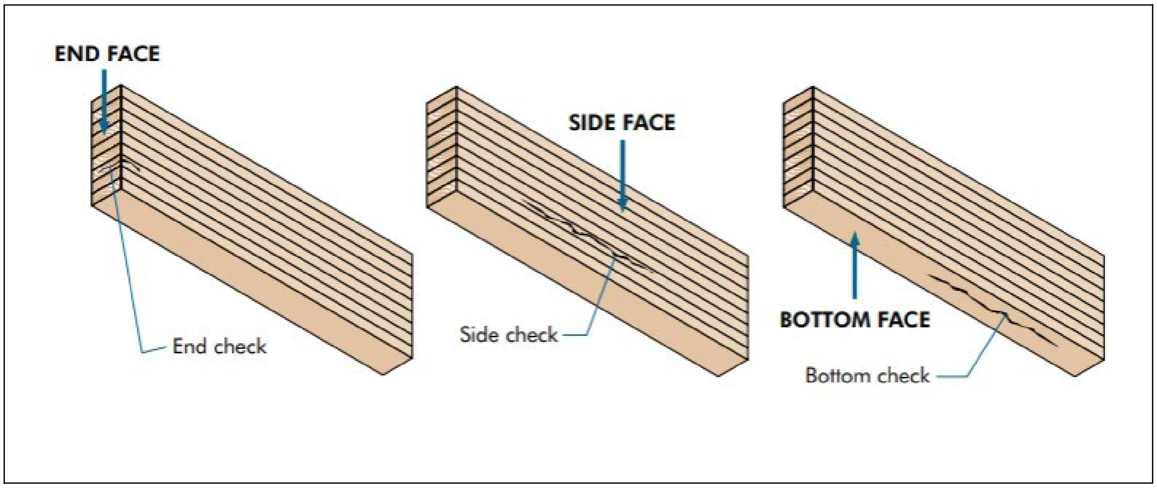

Fig. 3.3.7.1-3. Glulam beam showing different types of cracking/checking. Courtesy of APA – The Engineered Wood Association

Wood used in the manufacturing process is generally dried to an average moisture content of 12 percent. In bending members (beams, rafters, girders, etc.), checks are commonly observed on the face of the bottom lamination, on the side of the members and at the end of the members (Figure 3.3.7.1-3).

Side checks that are no greater than one-third the width and one-third the length of the glulam beam typically have a negligible effect on the structural performance of the bending member. Side checks can appear at any depth of the beam.

Checks that are parallel to the natural grain of the lumber are not considered to be of structural significance, even if they span the full depth of the face lamination. For a glulam column or post, a crack/check becomes a structural concern if it develops into a full-length split extending the entire length and on both sides of the glulam as shown in Figure 3.3.7.1-2 on the right column. In this very unusual case, the length-to-depth (or L/d) ratio used in the design of columns will change; and the resulting structural capacity of the column should be confirmed by a qualified design professional. A partial check, as shown on the left column in Figure 3.3.7.1-2, is not a structural concern.

Figure 3.3.7.1-4 is a guideline published by the Engineered Wood Association. It provides more guidance on when checking is a concern and when to recommend a structural engineer be retained to review and evaluate the checking.

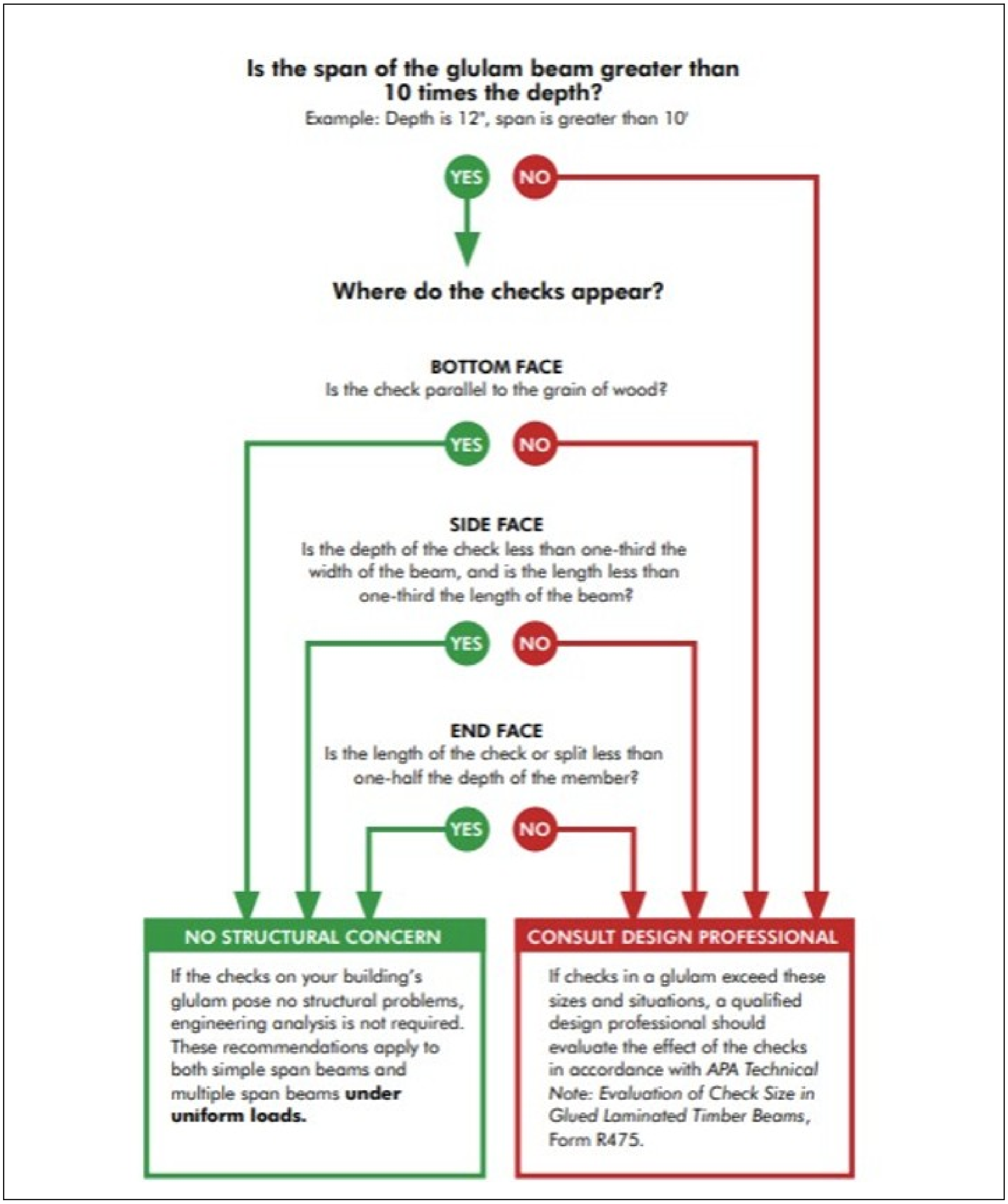

Fig. 3.3.7.1-4. Guidance on when to be concerned with cracking. Courtesy of APA – The Engineered Wood Association

3.3.8 Fire Testing of Connections

3.3.8.1 Recent testing completed by an independent group indicates that per the US International Building Code, a 2-hour rated, column-to-beam connection (including a metal connection) is not possible without additional protection measures. This same series of reports indicates that the beam-column connection, as well as the PRG-320 test, should be reviewed further.

North American standards allow for gaps or voids between the wood pieces (caused by imperfect wood used to create the member). These gaps should be no greater than 0.25 in. (6 mm) when used to cover the full width, and no greater than 0.4 in. (10 mm) for members more than 8.85 in. (225 mm) wide. Where multiple laminations are not edge glued (vertically glued on the ends) but only glued on the plane (horizontally), excessive gaps or voids can lead to connection failure; if fasteners are placed directly into, or close to, a gap or void. The European standards do not provide guidance on gaps.

3.3.9 Fire Resistance Ratings

3.3.9.1 Tests are available that have determined the fire resistance rating of mass engineered timber. The mass engineered timber should be tested in accordance with ASTM E119, *Standard Test Methods for Fire Tests of Building Construction Materials.* This test is designed to expose materials to a constant and rising temperature. Originally designed for noncombustible materials, this test is referenced throughout the codes. The standard time-temperature curve is below.

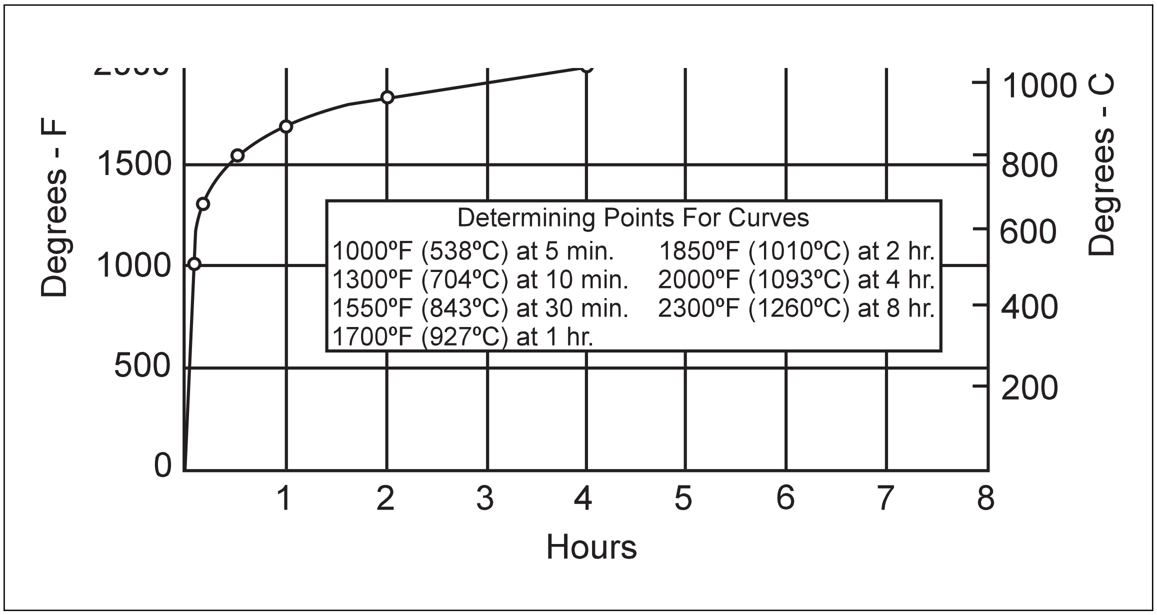

Fig. 3.3.9-1. ASTM E119 standard time-temperature curve

With the introduction of engineered wood into the code and the ability to create taller wood buildings than in the past, fire-resistance ratings are required in many jurisdictions. ASTM E119 and ISO 834 are test standards prescribed in many building codes. These tests have been historically applied to noncombustible materials, such as concrete and steel. Due to concerns with the application of these tests to wood products, encapsulating any critical structural elements is recommended to mitigate damage that may occur during a real fire event.

Three primary concerns have emerged. First, many existing tests on wood products have not been properly conducted with the elements under a structural load. Second, deep charring after the test can continue to degrade the structural element, causing premature structural failure. Third, the prescribed standard time-temperature curve used in the tests will exceed the autoignition temperature of most wood products. As a result, the exposed wood surfaces become part of the fuel source; in a noncombustible test, the material is not involved. The control system used to produce the required time-temperature within the furnace typically requires a reduction in the fuel oxygen mix to compensate for the contribution from the ignited wood. This compensation may result in a lower fire exposure for wood products compared to noncombustible products and effectively reduces the fire resistance rating for wood products.

3.3.10 Reparability

3.3.10.1 Ongoing, worldwide research continues to demonstrate that repairs after a fire or moisture event are feasible, but that remains to be validated.

4.0 REFERENCES

4.1 FM

Data Sheet 1-0, *Safeguards During Construction, Alteration and Demolition*
Data Sheet 1-4, *Fire Tests*
Data Sheet 1-12, *Ceilings and Concealed Spaces*
Data Sheet 1-20, *Protection Against Exterior Fire Exposure*
Data Sheet 1-28, Wind Design
Data Sheet 1-29, *Roof Deck Securement and Above Deck Roof Components*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 3-26, *Fire Protection for Nonstorage Occupancies*
Data Sheet 10-3, *Hot Work Management*

4.2 Other

American Wood Council (AWC). The 2018 National Design Specification (NDS) for Wood Construction.

American Iron and Steel Institute. AISI S100, *North American Specification for the Design of Cold-Formed Steel Structural Members*.

APPENDIX A GLOSSARY OF TERMS

Biophilic Design: A concept used in the building industry to increase the occupant connectivity to the natural environment. Biophilic design incorporates natural light, ventilation and landscape. It is thought to create a healthier and more productive environment.

Conventional Light-Frame Construction: Construction whose primary structural elements are formed by a system of repetitive wood-framing members. (Typically used in residential construction.)

Cross Laminated Timber: A prefabricated, engineered wood product consisting of not less than three layers of solid sawn lumber or structural composite lumber where the adjacent layers are cross oriented and bonded with structural adhesive to form a solid wood element. To be considered mass engineered timber, the floors are a minimum of 4 in. (101 mm) and roofs a minimum of 3 inches. Exterior walls a minimum of 4 in. (101 mm).

Dowel-Laminated Timber (DLT): Similar to NLT, but the laminations are held together with wood dowels to form a wood panel.

Engineered Wood: Wood products that are manufactured by binding or fixing the strands, particles, fibers, veneers or sawn lumber together with adhesives or other methods, such as dowels.

Finish Rating: Refers to a fire resistance rating that is achieved by applying a noncombustible material, such as gypsum board, to a mass engineered timber element.

Fire Resistance Joint System: An assemblage of specific materials or products that are designed, tested and fire-resistance rated in accordance with either ASTM E1966 or UL 2079 to resist the passage of fire through joints in or between fire-resistance-rated assemblies for a prescribed period of time.

Fire Resistance Rating: The period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or methods based on tests based on ASTM E119 or UL 263.

Hardboard: A fibrous-felted, homogeneous panel made from lignocellulosic fibers consolidated under heat and pressure in a hot press to a density of not less than 31 pcf (497 kg/m^3).

Gypsum Board: The generic name for a family of sheet products consisting of a noncombustible core primarily of gypsum with paper surfacing.

Laminated-Veneer Lumber (LVL): Multiple layers of thin wood (veneers) stacked in parallel and bonded with adhesives to form beams or headers.

Ice and Water Shield (Protector): A waterproof underlayment membrane designed to protect the roof from ice and water damage. It is typically made with a polymer-modified bitumen designed to seal penetrations, such as those from screws or nails installed as part of the roof membrane (cover), after installation.

Mass Engineered Timber: Engineered wood meeting minimum sizes established by codes or regulations. Generally, the minimum component size is 6 in. (152 mm) in width and 8 in. (203 mm) in depth or greater.

Mass Timber Construction: Consists of structural elements used in building construction, primarily of solid, built-up, panelized or engineered wood products.

Nail-Laminated Timber (NLT): Multiple laminations of lumber stacked on edge and successively nailed perpendicular to the face to form a wood panel.

Particleboard: A generic term for a panel primarily composed of cellulosic materials (usually wood), generally in the form of discrete pieces or particles, as distinguished from fibers. The cellulosic material is combined with synthetic resin or other suitable bonding system under heat and pressure.

Post-Tensioned Timber (PTT): Engineered wood beam or column used in combination with steel post-tensioning cables to place the member in a state of precompression, increasing the load carrying capacity.

Prefabricated Wood I-Joists: Structural member manufactured using sawn or structural composite lumber flanges and wood structural panel webs bonded together with exterior exposure adhesives, to form an I-shaped cross-section. See ASTM D 5055.

Solid Sawn Lumber: Timber cut from a single log.

Structural Composite Lumber: Structural member manufactured using wood elements bonded together with exterior adhesives. See ASTM D 5456.

Structural Glued-laminated (glulam) Timber: An engineered, stress-rated product of a timber laminating plant. It is composed of assemblies of specially selected and prepared wood laminations in which the grain of all laminations is approximately parallel longitudinally, and the laminations are bonded with adhesives.

Glulam beams can be bonded in shapes for architectural design while providing structural support. Glulam can be manufactured to 60 in. (1.5 m) deep and 100 ft (30 m) or greater in length. (ANSI/AITC A 190.1 or ASTM D3737).

Timber-Concrete Composite (TCC): CLT, DLT or NLT panels with poured in-place concrete slab on top, connected with metal screws or dowels to form a roof or floor.

Wood Structural Panel: A panel manufactured from veneers, wood strands or wafers, or a combination of veneer and wood strands or wafers, bonded together with waterproof synthetic resins or other suitable bonding systems.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

April 2026. Interim revision. The following changes were made:

A. Updated information on cracking/checking.

B. Reduced acceptable moisture content.

C. Provided alternative to noncombustible requirements for fire ratings.

July 2023. This is the first publication of this data sheet.