Design Guide
Mass Timber Construction

Mass Timber has become increasingly popular in the construction industry, with some of the most iconic Australian projects in the past decade, such as International House Sydney, 25 King Street, La Trobe University student accommodation, garnering recognition for their design, sustainability and innovation. FIREFLY has partnered with top industry professions in Sydney and Melbourne to deliver high profile projects including Macquarie Law School's Michael Kirby Building, The Bond, 36 Wellington and Barker College's Math and Senior Studies Hub, among others.

What exactly is mass timber and how did it originate?

Mass timber, also known as "Massive Timber," refers to various forms of engineered wood products that serve as structural elements. These products replicate the durability and strength of traditional sawn timbers commonly used in post-and-beam and timber frame construction for centuries. Iconic examples include Scandinavian Stave churches, which have stood the test of time, with some lasting over 700 years.

The development of engineered mass timber technology began in Europe and quickly gained global acceptance as a superior and environmentally friendly structural material. Embracing mass timber offers a range of advantages, including:

- Faster construction time with potential for cost savings
- Increased protection against fire
- A renewable resource due to regeneration. Is reusable, recyclable and 100% biodegradable
- Reduced carbon emissions; retains embedded carbon through life-cycle (carbon sequestering)

Types of mass timber products

Cross laminated timber (CLT): CLT panels are widely used for walls, roofs, floors, and ceilings. These panels consist of an odd number of layers of two-by dimensional lumber, with each layer oriented at a 90-degree angle to the adjacent layer. Strong adhesives chemically bond the layers together, resulting in a robust wooden material.

Glue laminated timber (GLT): Also known as Glu-lams, GLT utilizes 2x4 or 2x6 pieces of lumber. The individual pieces, or laminations, are aligned parallel to the member's length and bonded together with a durable moisture-resistant adhesive using a hydraulic press. Glu-lams are commonly used for beams, girders, and strong column structures.

Dowel laminated timber (DLT): DLT panels are composed solely of wood. Softwood layers are held together by friction-fit hardwood dowels, creating a strong and durable construction material. These panels are frequently used for floors and roof decks, serving a purpose similar to CLT.

Nail laminated timber (NLT): NLT is suitable for building walls and floors. It involves placing wood planks on their sides and securing them with nails or screws to create panels. This method allows for the use of widely available, standard-sized wood planks without the need for specialised production facilities.

Laminated veneer lumber (LVL): LVL is produced by bonding thin layers or veneers of wood together. Similar to glulam, the veneers are oriented in the same direction and joined using pressure, heat, and adhesive. LVL is commonly used for beams and columns due to its strength and versatility.

Parallel strand lumber (PSL): PSL is created by gluing together parallel strands of wood. These long, thin strands are subjected to high pressure, producing a material with exceptional strength. PSL is typically used for long-span beams or columns that need to support heavy loads.

Fire resistance of mass timber

In Australia, building construction is required to meet the prescriptions in the NCC which may also call upon various standards to ensure minimum standards for livability and building safely. One important aspect of the NCC is to ensure fire safety for occupants within a building. Apart from employing different active fire safety measures, the building code also incorporates fire resistance levels for structural elements within a building.

Fire resistance is the ability of a building or its elements to withstand fire for a duration prescribed in minutes within the NCC.

Depending on the type and class of a building, fire resistance may be required for the structural elements throughout the entirety of the building or within a specified area in a building.

The three components the determine the required fire resistance level or FRL are structural adequacy, integrity and insulation which are depicted in minutes for example – 120/120/120 or -/120/60.

Structural adequacy provides the duration in minutes through which the structure or a building element can maintain its stability and load bearing capacity during a fire.

Integrity provides the duration in minutes until which the structure or building element is able to resist the passage of flames and hot gases during a fire.

Insulation provides the duration in minutes until which the structure or building element is able to maintain a temperature on the surface not exposed to flames below the limits specified in the relevant standard.

NCC 2022 in Specification 1 Fire-resistance of building elements, sets out the procedures for determining the FRL of building elements. These include performing a standard fire test on the element as per AS1530.4 2014 or using AS/NZS 1720.4 2019 to determine fire resistance for structural adequacy and insulation of timber elements.

Reaction of mass timber to fire

Mass timber possesses unique characteristics that influence its reaction to fire in a consistent and predictable manner. The process of charring, which occurs when mass timber is exposed to fire, plays a crucial role in enhancing its fire resistance. Here's a breakdown of how mass timber typically responds to fire:

When subjected to fire, the outer layers of mass timber begin to burn and form a protective layer of char. This porous and insulating char layer develops at a relatively even rate. By acting as a shield, the char layer slows down the transfer of heat and fire into the core of the wood. This insulation effectively reduces the combustion rate of the inner wood, prolonging the timber's strength and durability. This slow-burning process significantly contributes to the fire resistance of mass timber.

Throughout the charring process, mass timber retains a significant portion of its structural integrity. Unlike materials such as steel that rapidly weaken at high temperatures, mass timber maintains its load-bearing capacity for an extended period due to the insulating effects of charring. In some cases, the char layer can even create a barrier that restricts the oxygen supply to the burning wood, leading to self-extinguishing within the charred layer itself. This attribute aids in containing the fire.

The behavior of mass timber in a fire is relatively predictable. Engineers can calculate the rate of charring and the corresponding decrease in strength over time. This predictability allows for the selection of thicker beams to compensate for any loss in thickness due to fire and still maintain the required structural adequacy and insulation.

Passive fire protection solutions for mass timber, compliant with AS 1540.4 and AS 4072.1 standards, have been developed by FIREFLY in collaboration with leading experts in the mass timber construction industry. These solutions cater to a range of scenarios, ensuring the safety and fire resistance of mass timber structures.

Protection of Connectors

Similar to other forms of construction, the joints and connectors are typically the weakest points in the structure as they bear the load transfer between different elements. Therefore, it is crucial to protect these connection points from fire.

To safeguard the connectors, a metal plate made of steel or aluminium is used to form the connection between walls, columns, beams, and girders. It is essential to install this connector at a specific depth within the element to shield it from direct exposure to flames. However, there is still a potential for heat to access the connector through the gap between the building elements at the point of connection.

Steel, for example, is a material that weakens as its temperature increases. It begins to lose strength around 300 °C, and this loss accelerates after reaching 400 °C. At 550 °C to 600 °C, steel retains only 50% to 60% of its strength at room temperature. If left unprotected, steel can lead to structural damage or even failure. On the other hand, aluminium, with a melting point around 660 °C, performs even poorer than steel in high-temperature environments.

FIREFLY has developed two solutions to address this concern and protect the connectors within Engineered Mass Timber.

1. Using FIREFLYMastic HP
   A 10mm bead of FIREFLYMastic HP, when installed around the perimeter of the connector and on all sides of the beam was able to maintain the structural adequacy of the element with an established FRL

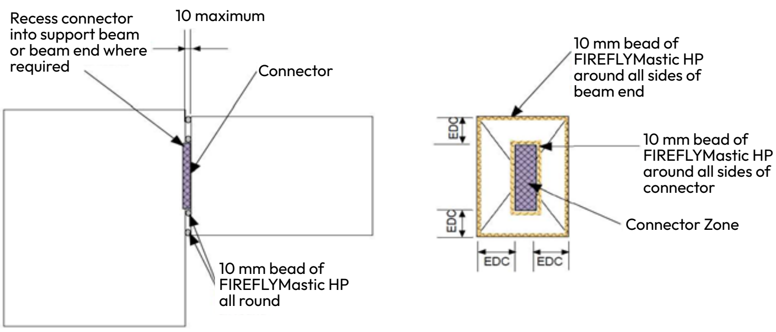

Figure showing connector protection with FIREFLYMastic HP (10mm bead internal and external edges)

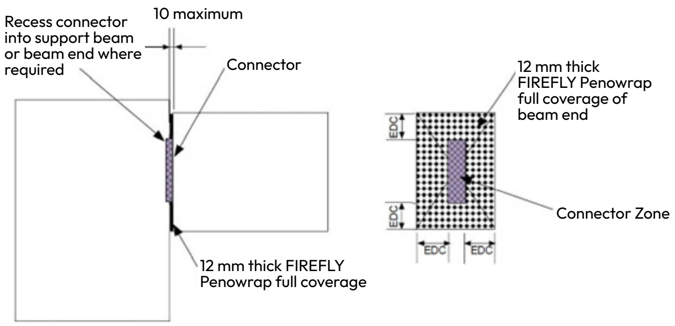

Figure showing connector protection with FIREFLY Penowrap (12mm thick, full coverage)

2. Using FIREFLY Penowrap
   FIREFLY Penowrap is a thin and lightweight wrap, measuring 12mm in thickness, that offers exceptional fire and thermal resistance. By fully covering the ends of the beam with FIREFLY Penowrap, it effectively prevents any compromise to the structural integrity of the element

Protection of services through core holes

FIREFLY has thoroughly tested various building service penetrations in mass timber structures and offer a range of solutions to meet different fire resistance levels (FRLs).

Our systems provide protection for electrical, communications, mechanical, fire & security, plumbing & hydraulic, and wet fire service penetrations that pass through CLT floors and walls.

These solutions cover a broad range of FRLs, including up to -/120/120, ensuring effective fire protection for service penetrations.

- Linear gap seals in walls
- Fire alarm cable bundles
- Circular power cable
- PEX pipes
- Steel Pipes
- Control joints in floors
- TPS cable bundles
- Air conditioning bundles
- uPVC pipes
- Multiple service bundes

Protection of large openings

In cases where multiple services need to pass through a fire wall or a fire-rated floor, a dedicated opening is created to accommodate these services.

FIREFLY has developed tested systems specifically designed for such situations. Our durable FIREFLYBatt has undergone testing in CLT floors and walls, achieving an impressive fire resistance level (FRL) of up to -/90/90. It effectively covers a wide range of large services, including cable trays, pair coil bundles, busducts, and even linear seals.

All solutions mentioned in this guide are NCC 2022 compliant and have been tested in accordance with AS1530.4 2014 and assessed in accordance with AS4072.1 2005. They are available in Warringtonfire Reports FAS190234 RIR, FAS190235 RIR and FAS190236 RIR.

For further details regarding our solutions or copies of our test reports, or to discuss your mass timber project contact us on 02 8004 3333 or sales@tbafirefly.com.au.