ADVANCED

TIMBER COMPOSITE

DESIGN

GUIDE

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Photographs and illustrations credit referenced in document.

The Advanced Timber Composite Design Guide is a technical document and that it is to be read in conjunction with the MASSLAM Design Guide, MASSLAM Coating Guide and MASSLAM Warranty.

Being owned and manufactured in Australia provides certainty in compliance and that our timber products are produced in accordance with the following Australian Standards and Laws:

i. AS 2796.1 Timber-Hardwood-Sawn and milled products, Part 1: Product specification.
ii. AS1604.1 Preservative-treated wood-based products, Part 1 Products and treatments –H3 treatment.
iii. Finger jointed or laminated to AS/NZS 1328.2 Glued laminated structural timber, Part 2: Guidelines for AS/NZS 1328: Part 1 for the selection, production and installation of glued laminated structural timber.
iv. Visually graded to AS 2082 Timber-Hardwood-Visually stress graded for structural purposes.
v. AS 4707 Chain of Custody of Forest and Tree-based Products – Requirements.

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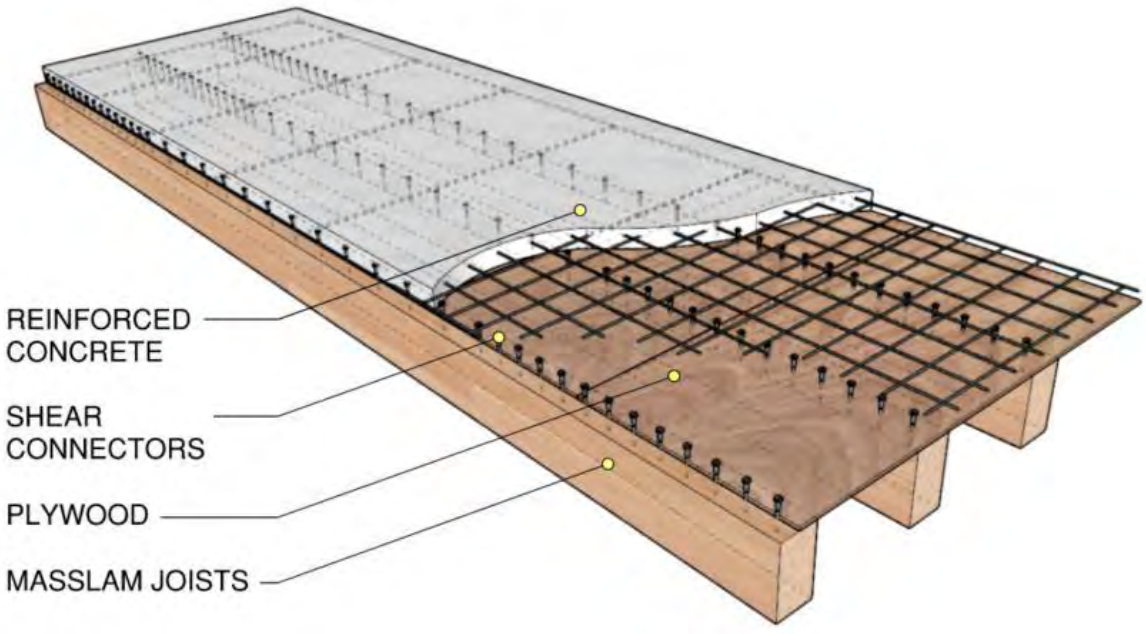
Introduction

Who is ASH?

Australian Sustainable Hardwoods (ASH) is a privately owned Australian timber mill and manufacturer. Established over 30 years ago, ASH has grown to become one of the largest hardwood mills in Australia; and Australia's largest hardwood timber manufacturer. Utilising automation and economy of scale, ASH operates 9 on-site manufacturing lines employing over 200 people locally to add value to our timber, from log to finished product. These include moulding, laminating, finger-jointing, deep splitting, set length docking, engineered flooring, by-product recovery and mass-timber production. Our range of timber species includes Australian Oak, Glacial Oak and Plantation Oak. Use of the Plantation Oak in the MASSLAM products allows fibre previously destined for pulp to be used to sequester carbon in a high value product, including the Advanced Timber Composite (ATC).

What is ATC?



MASSLAM Joists	200-450mm deep	Utilised in tension for MASSLAM's great bending properties at 800c/c to reduce overall fibre required at a visual grade quality.
Plywood	17-25mm thick	Sacrificial for fire, provides a working platform and formwork for the concrete pour with a visual grade exposed soffit.
Shear Connectors	-	Used to bring the concrete and timber together in composite action, increasing the strength of both.
Reinforced Concrete	60-120mm thick	Reduced thickness standard concrete slab for its excellent compression, durability, fire and acoustic performance.

Why ATC?

The building and construction industries account for approximately 39% of energy-related carbon emissions. While we can't account for other sectors, there are several different ways designers and building professionals can significantly reduce carbon emissions in building materials whilst still catering for a growing population in need of places to live, work and meet. The first way is to incorporate low carbon materials that sequester carbon and the second is to use less material for the same outcome.

While making the shift from traditional construction to the bioeconomy is necessary to help meet Australia's climate targets, building differently can be perceived as a risk which comes at an unknown cost. The MASSLAM design team, with use of ATC, are able to bring certainty in supply, cost and assistance to help mitigate these perceived risks while the affiliated trades and contractors become familiar.

ATC build on the range of now readily available engineered wood products (EWPs) with the same concept, get the best out of the inputs with technology, manufacturing, and design to create the best possible solution and minimise waste by bringing together the advantages of each material used. It's about using the best materials in the best function in true composite action:

- sustainably sourced PEFC-certified local hardwood glulam for the joists,
- visual grade, structural plywood for construction stage and soffit finish, and
- green concrete for durability to the finished floor, removing material from low efficiency areas.

MASSLAM Visual Guide

Plantation Oak

Plantation Oak is ASH's unique brand of highly attractive plantation grown hardwood. Showcasing the best in Australian hardwood innovation, Plantation Oak is the responsible upgrade of plantation grown Shining Gum (Eucalyptus nitens), otherwise largely destined for export and wood chip applications.

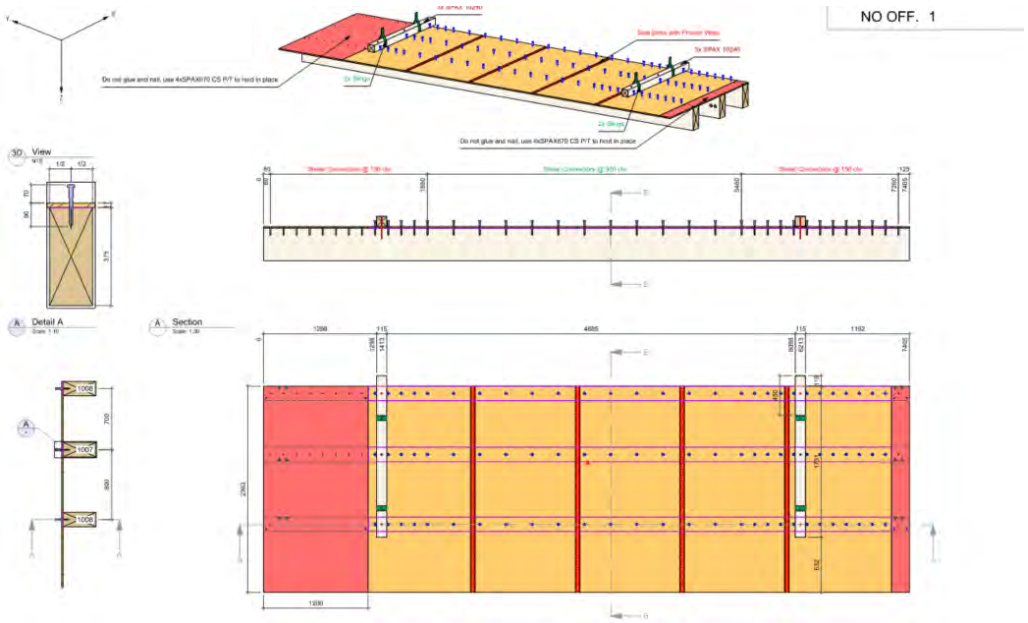
Plantation Oak is engineered to create an architectural timber with higher strength and improved appearance when compared to its unrefined counterparts. Like all species processed through our world class facility in Australia, Plantation Oak is straight line edged after drying, providing superior straightness. The result is a unique plantation hardwood with beautiful features and a consistent blonde to light brown colour. Plantation Oak is available in a Revit library for download on the ASH website in continuous render form.

Advantages of Advanced Timber Composite

Structural	Utilising the best properties of each material in composite action allows longer spans with less material required. Eliminate transfer slabs with larger grid spacings possible.
Fire	Validated performance pathway to Fire Design with timber joists and concrete covered in the NCC and full-scale fire testing completed and available to 120mins without supplementary fire protection.
Aesthetic	Visual grade hardwood timber with exposed soffit compliant with fire design and structural requirements (No additional soffit finishing required).
Prefabrication	Panels modelled, CNC'd, assembled and loaded on trucks in install sequence at ASH's Heyfield facility. Increased quality control associated with prefabricated modules in a controlled manufacturing environment.
Installation	Panels delivered to site in ready to lift modular form to replicate existing speeds with mass timber construction. Plywood as a working platform and a sacrificial formwork. Reduced on site team required at increased installation speeds.
Light Weight	Light weight in transport for reduced logistics and craneage costs as well as reduced footing requirements compared to conventional concrete structures.
Moisture Management	Continuous concrete topping slab avoids moisture management issues associated with exposed timber subject to the elements.
Sustainability	PEFC hardwood glulam and plywood uses sustainably managed trees at >2x the efficiency compared with CLT by operating in efficient structural zones. Green concrete able to be used as only 25MPa concrete properties required.
Vibration	Concrete slab along with high strength hardwood joists allow for increased vibration performance with less mass then a typical CLT design.
Acoustics	Increased acoustic performance through concrete properties. Additional floor buildups tested to suit a variety of building applications.
Certification Pathway	Validated performance pathway to structural, fire, vibration and acoustics all tested with flexibility in spans, applications and build ups.
Cost	Cost competitive with conventional construction with faster installation speeds.
Floor to Ceiling Height	Cost efficient floor to ceiling heights are achievable through reduced floor depths and acoustic build ups.
Eliminate Transfer Slabs	Large grids are possible without the need for transfer slabs to compensate for the change in column spacing to carpark areas below.

Design Process and Capability

The ASH Design Team

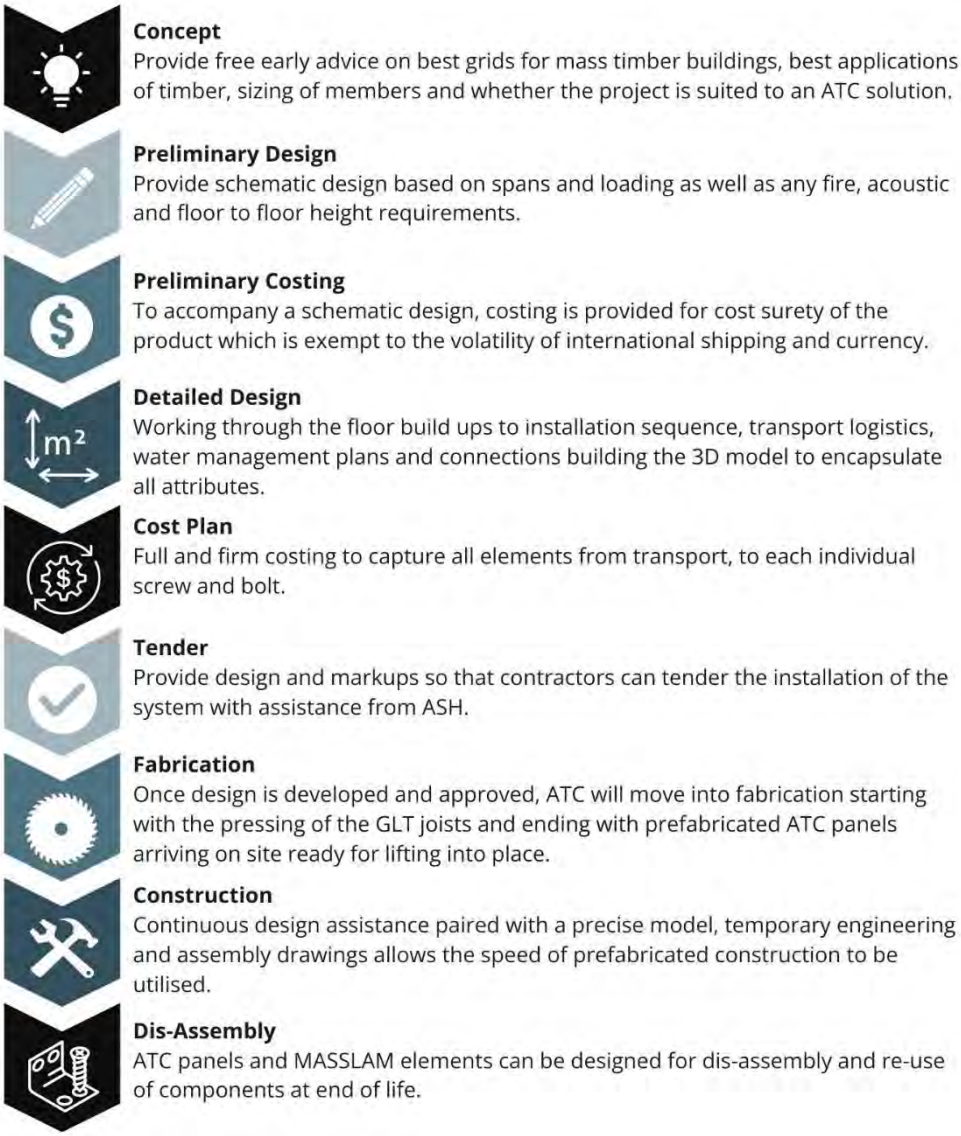


ASH has built up an experienced and versatile MASSLAM design team made up of timber design professionals from a range of consulting, manufacturing and construction backgrounds. The MASSLAM team can guide you right through the entire process of estimating, designing, documenting, fabricating, delivering and installing your mass timber project all in the one place. As with all design for manufacture and assembly (DfMA) projects, getting the MASSLAM design team in early has many advantages to the successful procurement and delivery of a project:

	Procurement Certainty	Booking a production slot early removes programme risk associated with procurement, providing a firm delivery to site date.
	Speed of Installation	If you are looking to reduce overhead costs and construction programme, early consultation will create an efficient DfMA project that will be fast to manufacture and faster to install.
	Cost Certainty	The MASSLAM design team can provide free design advice and cost estimates at an early stage to assess and give cost certainty to projects without the risk of volatile shipping and currency rates.
	Design Certainty	The entire project is 3d modelled with a set of installation drawings provided and approved ahead of fabrication allowing the project to be virtually built well ahead of arrival on site.
	Coordination of Services	Through clash detection and BIM coordination, the timber model can assist with the coordination of services to ensure the subsequent trades have the space required to continue their work.

Design Stages

The following diagram summarises the relevant assistance ASH can provide at every stage of design development.



Additional to assisting from design to delivery, the MASSLAM design team can also assist in a range of other roles throughout the process to ensure the project is delivered and installed on time, safely and with secure costing:

- Specialist timber advice and installation assistance
- BIM clash detection and model coordination with other trades and services
- Fastener and steelwork procurement
- Temporary engineering
- Project management
- Visualization aids
- Early consultant advice and service penetration coordination
- Water management advice
- Transport and logistic coordination

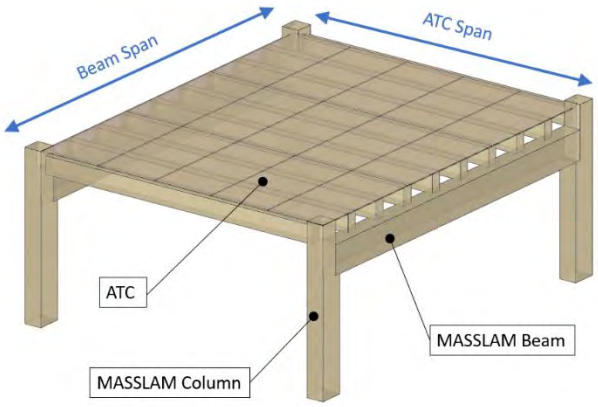
Preliminary Design

The following section provides quick-to-use design tables based off a defined set of assumptions for the early/initial design of an ATC floorplate using Plantation Oak, MASSLAM 38. For alternative sizes, species and spans, contact the MASSLAM design team.

Span Tables

Loading Assumptions

- Serviceability design is using long term combination G + 0.4Q at span/300 or max 25mm.
- All plywood to be 17mm thick F11 visual grade.
- Joists all MASSLAM 38 at 800c/c spacing.
- Concrete to be a minimum of 25 MPa.
- Shear connector design and spacing to suit loading requirements.
- Assumed construction loading from working platform and concrete pour of 1 kPa.
- FRL = 0/0/0: joist width 120mm, concrete slab 80mm
- FRL = 60/60/60: joist width 165mm, concrete slab 80mm
- FRL = 90/90/90: joist width 200mm, concrete slab 100mm
- FRL = 120/120/120: joist width 250mm, concrete slab 120mm



Typical Office Loading

Superimposed Dead Load: G = 1.0kPa
Live Load: Q = 3.0kPa, 4.0kPa
*8.4m+ span possible with increased joist width, contact MASSLAM Design Team.

	ATC Span (m)							
	FRL = 0/0/0		FRL = 60/60/60		FRL = 90/90/90		FRL = 120/120/120	
Joist Depth	Q = 3.0kPa	Q = 3.0kPa	Q = 3.0kPa	Q = 4.0kPa	Q = 3.0kPa	Q = 4.0kPa	Q = 3.0kPa	Q = 4.0kPa
200	4.6	4.5	3.9	3.7	3.1	2.9	2.9	2.8
270	5.8	5.7	5.3	5.1	4.4	4.2	4.3	4.2
330	6.6	6.5	6.1	5.9	5.7	5.5	5.7	5.5
370	7.1	7.0	7.1	7.0	6.5	6.3	6.5	6.3
410	7.7	7.6	7.7	7.6	7.3	7.1	7.3	7.1
450	8.4*	8.3	8.4*	8.3	8.2*	8.0*	8.2*	8.0*

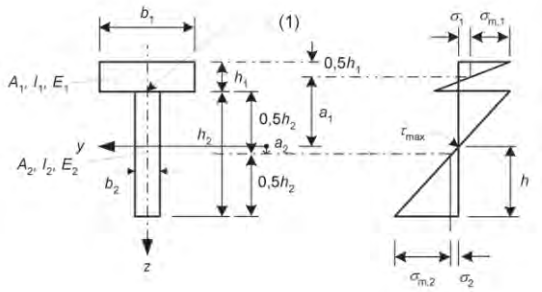
Typical Residential Loading

Superimposed Dead Load: G = 1.0kPa
Live Load: Q = 2.0kPa
*8.4m+ span possible with increased joist width, contact MASSLAM Design Team.

	ATC Span (m)			
Joist Depth	FRL = 0/0/0	FRL = 60/60/60	FRL = 90/90/90	FRL = 120/120/120
200	4.7	4.0	3.3	3.0
270	6.0	5.4	4.6	4.5
330	6.8	6.7	6.0	5.9
370	7.4	7.4	6.7	6.7
410	7.9	7.9	7.5	7.5
450	8.4*	8.4*	8.4*	8.4*

Detailed Design

Composite Certification Pathway



Detailed design of ATC is done using the Euro Code 5 gamma method to calculate stresses and deflections of the individual materials and the effect of the composite action. This method has been verified with extensive structural testing which is available in the appendix if further information is required. Using this framework, the common standards used by design and building professionals can be utilised the same as with typical mass timber or concrete construction.

An example calculation using the Euro Code 5 gamma method is available in the appendix resources.

Relevant Standards

Component	Relevant Standard	Relevant section(s)
Composite Action	EC5	***Gamma Method:*** Annexe B
Concrete Slab & Reinforcing Mesh	AS3600	***ULS/SLS:*** Section 3.1, Section 8 ***Penetrations:*** Section 9.2 ***Fire:*** Section 5.5
GLT	AS1720	***Beam ULS Design:*** Section 3.2 ***SLS:*** Section 2.4.1.2, Appendix B ***Fire:*** ASH NATA Fire Reports, AS1720.4 Section 2.5
Shear Connectors	AS1720	***ULS:*** Section 4.5
	EC5	***SLS:*** Annexe B.5
Plywood	AS1720	***ULS:*** Section 5

Mechanical Properties

LABEL	MASSLAM 38
	Equivalent GL15
Species	Plantation Oak
Bending Strength	F'b = 38MPa
Tension Strength	F't = 19MPa (parallel)
	F'tp = 0.5MPa (perpendicular)
Shear Strength	F's = 5.0Mpa
Compression Strength	F'c = 38MPa (parallel)
	F'cp = 10MPa (perpendicular)
Bearing Strength	F'l = 45MPa (parallel)
	F'p = 10MPa (perpendicular)
Modulus of Elasticity	E = 14500MPa
Modulus of Rigidity	G = 960MPa
Joint Group	JD4
Design Density	Mean = 600kg/m3, Design = 500kg/m3
Service Class	1 & 2 only
Adhesive	Externally rated, high temperature PUR
Formaldehyde Emissions	None (E-0)
Certification	PEFC
Char rate	*0.7mm per min
Movement in Service -Axial	0.02% per 1% change in MC
Movement in Service – Radial	0.20% per 1% change in MC
Movement in Service – Tangent	0.31% per 1% change in MC

*Warrington Fire NATA lab according to AS 1530:4 **Calculated according to EN384:2004.
Other species available upon request.

Shear Mechanism

The shear mechanism is a critical component to the effectiveness of the ATC composite action. In the ATC panels, this is ensured using shear screws which, when embedded into the timber joist, form the shear and slip resistance required to allow composite action of the timber joist in tension below, and concrete in compression above.

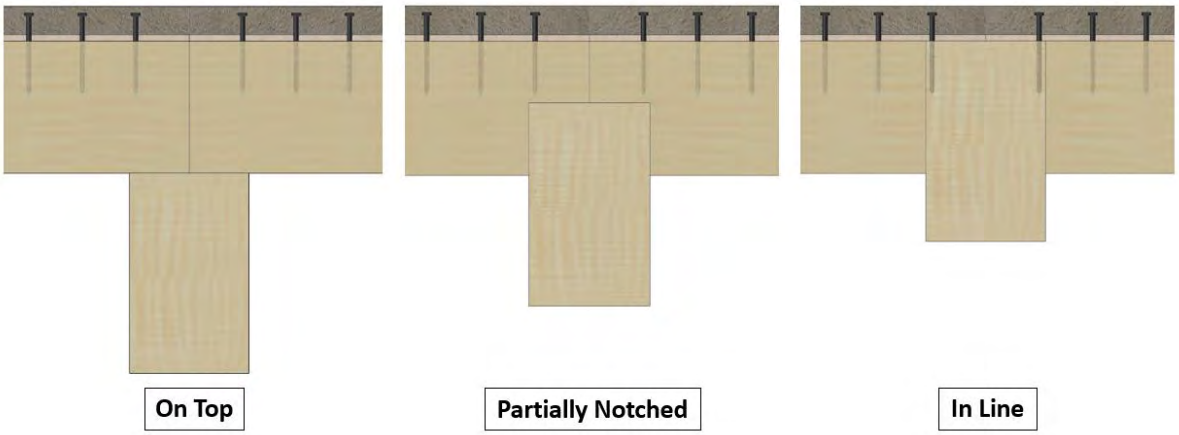
Several shear mechanisms have been considered and tested for flexibility of design, manufacture, and assembly. The most common and practical is the coach screw as it's commonly available, easy to install, and has strong structural properties with MASSLAM.

Structural Plywood

In the ATC system the structural plywood:

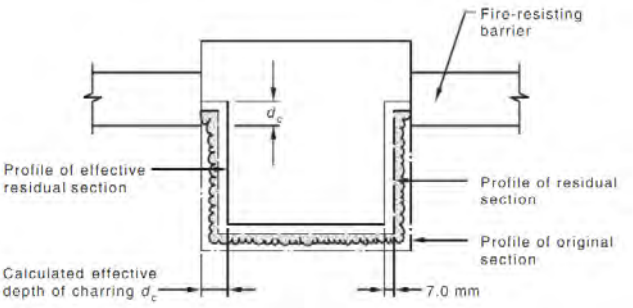
- Provides a sacrificial working platform for the concrete pour, based on construction loading.
- Sacrificial in a fire scenario (assumed to provide no additional protection to the slab).
- Provides a validated performance pathway visually exposed soffit to the underside of the ATC panel.

Connections



ATC has several options for connections to a typical mass timber post and beam system, with pre-attaching of connections possible within the production line to speed up install works on site. ATC panels can be placed on top of the primary beam, partially notched or in line with the top if height is an issue.

Fire Design



Design and certification for mass timber buildings concerning fire is a traditionally difficult space to navigate due to CLT not being recognised in the NCC as a deemed-to-satisfy approach for fire design. One of the key advantages of ATC is that it is a validated performance pathway flooring solution, thus avoiding the need for performance-based solutions.

ATC uses components that are already covered in the NCC and common place in building design. MASSLAM joists are designed using hardwood's low charring rate, plywood is used as a sacrificial visual grade formwork, and concrete slabs have a long history and wealth of typical construction details used in reinforced concrete fire design.

As a composite system, full scale fire tests have verified the structural performance under load and fire conditions through extensive testing undertaken at Warrington Fire's NATA accredited laboratory up to 180 minutes. The MASSLAM design team can help navigate the process of certifying ATC for mass timber projects with the project fire engineer using our extensive fire testing as a base.

Penetrations for Service Reticulation

ATC presents opportunities in services reticulation and concealment between joists. Early planning and involvement of the MASSLAM design team can help to avoid or reduce penetrations but sometimes with the building geometry and service requirements penetrations are required. Penetration types fall into 3 distinct categories:

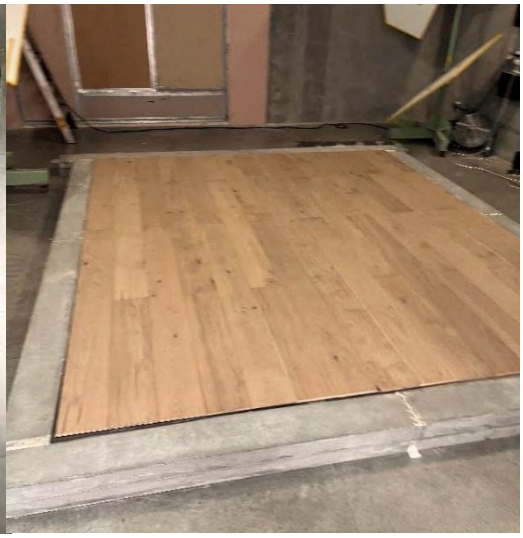
- **Through the floor:** This type of penetration is relatively straight forward with existing guidelines on penetrations through concrete slabs able to be used and variety of fire collars readily available.
- **Parallel to the joists:** If ATC is placed on top or partially on top of the primary beam services can be easily run alongside the MASSLAM joists with no penetrations required.
- **Through the joists:** If possible, coordination in service highways, use of bulk heads or cable trays avoid the need for penetrations but if not possible speak to the MASSLAM design team about options that can be CNC'd ahead of arriving on site.

Environmental Impact & Acoustics

Embodied Carbon

Mass timber alongside ATC is a great structural component to assist with achieving high Green Star, NABERS and other industry recognised sustainable building ratings. Alongside MASSLAM's existing carbon storage calculator and timber regeneration timeline, ATC panels can also be assessed based on an assumption of 200km transport from the ASH Heyfield facility to site (Melbourne CBD as base level). The appendix contains a link to the ASH online calculator which can assist with understanding the balance of embodied carbon in manufacture and transport along with the carbon sequestration in the PEFC certified hardwood timber.

Acoustics



The composite buildup of ATC provides significantly improved acoustic performance compared to timber-only structural solutions, which can prevent the need for further build ups in typical environments. In more sensitive applications such as residential buildings, extensive full scale acoustic insulation testing has been performed in collaboration at CSIRO's laboratory to better understand the airborne and impact acoustic behaviour of ATC panels with acoustic dampening floor build ups.

This information was then used with Marshall Day's INSUL software to assess acoustic performance of different buildup and ATC combinations and form an accurate depiction of acoustic results. A variety of floor buildups to achieve the projects target rating are provided below to identify required build ups.

Class of Building	**Minimum Sound Insulation Rating**		
	Airborne[1]		**Impact[3]**
	R_w[2]	**$R_w + C_{tr}$**	**$L_{n,w}$**
Class 2 or 3 (Apartments)	None required	Not less than 50	Not more than 62
Class 5 (Offices)	None required	None required	None required
Class 9c (Residential Care)	Not less than 45	None required	None required

[1] The larger the number, the better airborne sound insulation achieved.
[2] For Class 9c buildings only (e.g., floors separating sole-occupancy units in residential care facilities).
[3] The smaller the number, the better impact sound insulation achieved.

	ATC Floor System and Surface Treatments	System Acoustic Performance			Tested System Illustration
		Airborne		Impact	
		R_w[1]	$R_w + C_{tr}$	$L_{n,w}$	
1	80 mm bare concrete slab	48	44	87	
2	80 mm concrete slab plus 7.5 mm carpet tile (no underlay)	48	44	56	
3	80 mm concrete slab plus 2 mm foam underlay plus 14 mm floating timber flooring	50	47	63	
	120 mm concrete slab plus 2 mm foam underlay plus 14 mm floating timber flooring	54	50	59	
4	80 mm concrete slab plus ASP™ IconX Access Floor	50	43	62	
5	80 mm concrete slab plus ASP™ IconX Access Floor plus 7.5 mm carpet tile (no underlay)	50	43	54	
6	80 mm concrete slab plus Batten & Cradle™	57	52	51	
	120 mm concrete slab plus Batten & Cradle™	60	54	48	
7	80 mm concrete slab plus Batten & Cradle™ plus 7.5 mm carpet tile (no underlay)	57	52	45	
8	80 mm concrete slab plus Batten & Cradle™ plus suspended 13 mm plasterboard ceiling	67	58	45	
9	80 mm concrete slab plus Batten & Cradle™ plus 7.5 mm carpet tile (no underlay) plus 13 mm suspended plasterboard ceiling	67	58	40	

[1] For Class 9c buildings only (e.g., floors separating sole-occupancy units in residential care facilities).

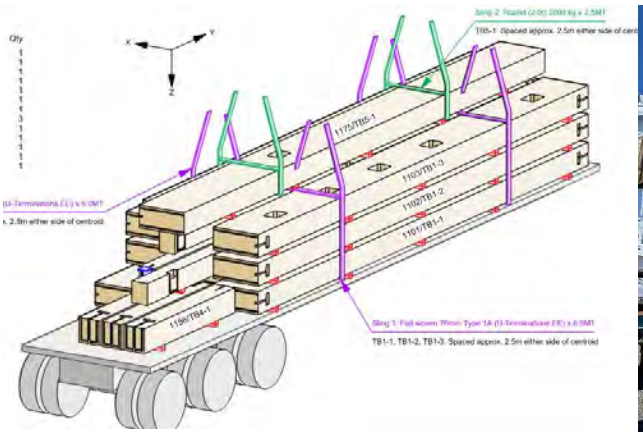
Installation

Tolerances & QC

Width	± 2mm
Depth	± 2mm
Squareness	± 2mm per 300mm depth
Length ≤ 6m	± 2mm
Length > 6m	± 0.05%
Spring/Straightness ≤ 6m	± 6mm
Spring/Straightness > 6m	± 0.1%

In addition to the BIM, clash detection and shop drawing approvals, each ATC panel is assessed through MASSLAM's quality control system at both an individual component stage post-CNC and as a panel system with tags attached providing component attributes for identification on site ahead of lifting into place. ATC panels follow the same tolerance criteria as MASSLAM components utilising the mm accuracy of the CNC machine with DfMA principles to deliver a product that can be lifted into place with minimal work on site. ASH are also third-party certified to PEFC, RW, ISO14001 and ISO 45001.

Arrival On Site



ATC panels arrive on site in trucks ready to lift in reverse installation sequence according to approved loading plans. Panels are accompanied by a set of marking plans highlighting their position within the build, assembly drawings to see the connection details, and individual shop drawings to nominate lifting and weight of panels.

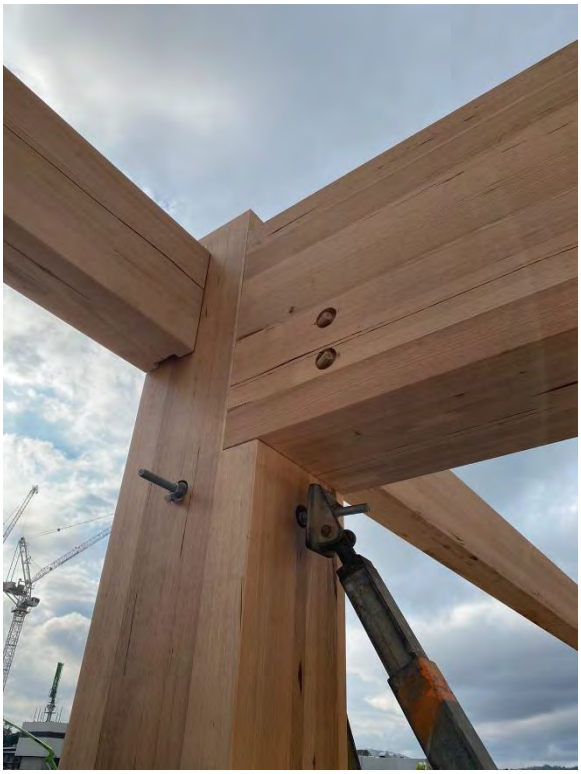
Temporary Works & Lifting

The MASSLAM design team can assist with in-house temporary engineering and lifting to suit project geometry and site constraints. Broadly these can be divided up into a few key areas:

- **Panel Lifting:** ATC panels can be lifted with either pre-attached lifting screws to suit standard lifting clutches or soft slinged. In some cases, additional blocking at end and mid spans will be provided to stiffen the panel during the lifting process.
- **Formwork for concrete pour:** The plywood is designed to provide both a sacrificial formwork for the concrete pour, safe working platform and visual grade soffit (no need to remove formwork). Additional side formwork for slab edges can be provided in edge panels.
- **Propping at midspan:** may be required for some longer spans or where loading dictates that the short-term serviceability deflection needs to be countered. The

MASSLAM design team can assist with temporary works to understand and plan for floor cycle times.

- **Fall Protection:** can be pre-attached on site prior to the lift the same as conventional CLT products by fixing into the perimeter joist with coach screws or pan head timber screws.



Moisture Management

Prevention of water ingress and management of water on construction sites should be a significant consideration during design and construction planning. Managing water ingress can help avoid issues like increased moisture content, water staining, mould, and exacerbated shrinkage/swelling. Remediation for such issues has proven to be costly.

ATC offers a solution to these issues in the form of the continuous and impermeable surface – in the concrete slab – that has well understood, proven and viable water management properties. The durability of concrete facilitates the protection and visual appeal of the MASSLAM soffit, once again demonstrating a hybrid system that utilises the best material for the best application.

Ahead of pouring the concrete topping slab, the MASSLAM cassettes (joists and plywood) and MASSLAM primary structure have typical temporary protection measures applied to mitigate water ingress. These include taping/sealing joints, flashing around the base of columns etc. As is the case for all mass timber buildings, it is important that the building envelope is installed as soon as possible so that the building is watertight and final coatings and finishes can be applied – the speed of assembly of ATC and MASSLAM product ensures this can be achieved.

Appendices

1. NIFPI Report: Fire, Acoustic and Structural Performance of Prefabricated Plantation Shining Gum Advanced Timber Composite (ATC) Floor Systems – FWPA & TPC Solutions

2. Fire Report: Assessment of Advanced Timber Composite (ATC) floor systems – Warrington Fire

3. Acoustic Report: Acoustic System Test Reports – CSIRO

4. Acoustic Modelling Report: Modelled Acoustic System Performance Report – Marshall Day Acoustics

5. Design Examples: ATC Floor System Design Examples – TGA Engineers

6. ATC Carbon Calculator

7. Downloadable 3D Model of ATC System

8. Typical Architectural Details