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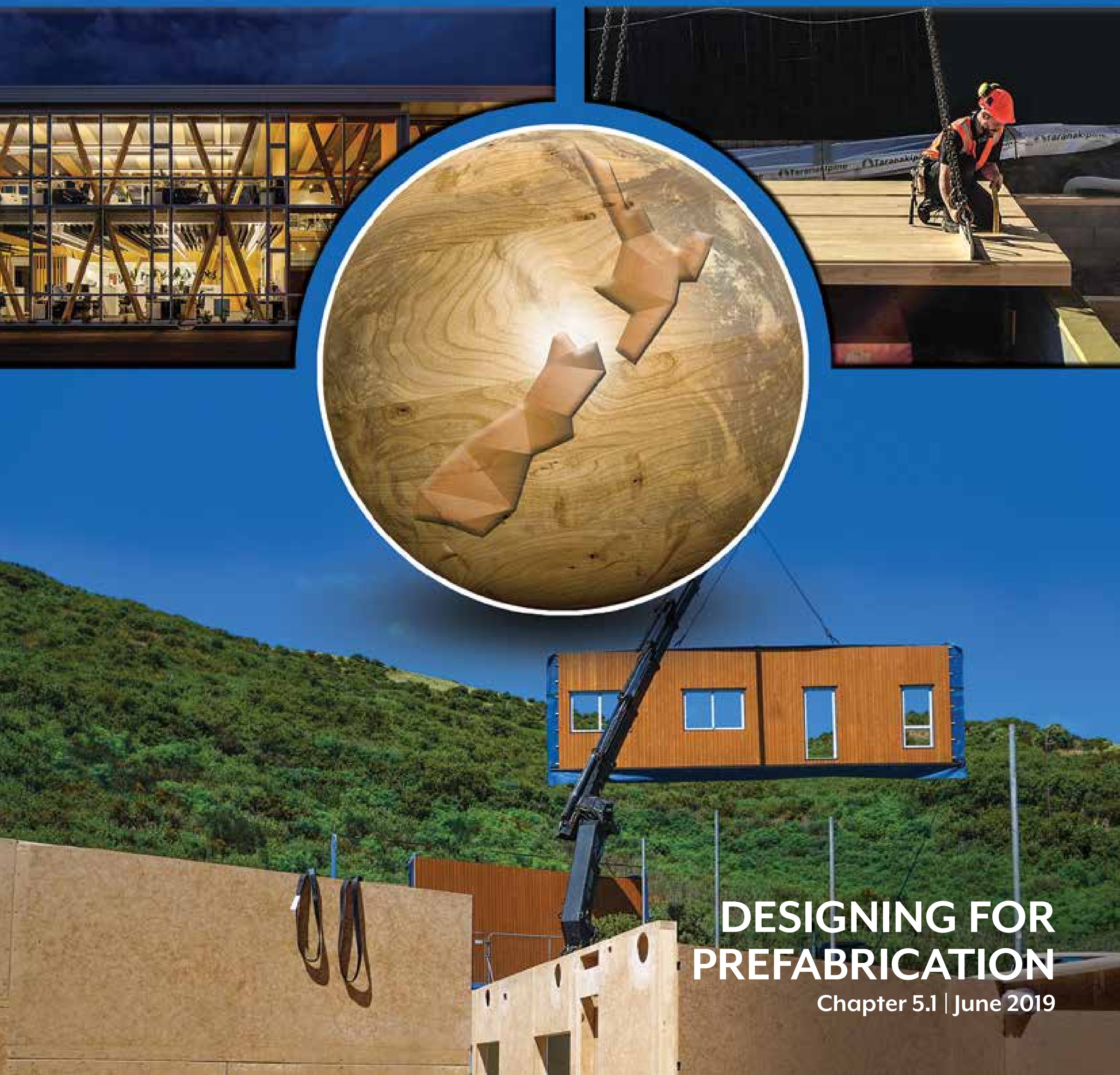
# NZ Wood Design Guides



# DESIGNING FOR PREFABRICATION

Chapter 5.1 | June 2019

Wood Processors & Manufacturers
Association of New Zealand

## NZ Wood Design Guides

A growing suite of information, technical and training resources, the Design Guides have been created to support the use of wood in the design and construction of the built environment.

Each title has been written by experts in the field and is the accumulated result of years of experience in working with wood and wood products.

Some of the popular topics covered by the Design Guides include:

- Quantity Surveying Guide for Timber Buildings
- Prefabrication Guidance for Specifiers
- Cassette Panels for Floors, Roofs and Walls
- Standard Connection Details
- Acoustical Design and Detailing
- Fire Safety Design in Timber Buildings

To discover more, please visit http://nzwooddesignguides.wpma.org.nz

NZ Wood Design Guides is an industry initiative designed to provide independent, non-proprietary information about timber and wood products to professionals and companies involved in building design and construction.


## ACKNOWLEDGEMENTS

Just like any successful prefab construction project, these guidelines too were a product of *collaboration*.

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# CONTENTS




*Funding for the NZ Wood Design Guides is provided by our partners:*


# 2 INTRODUCTION

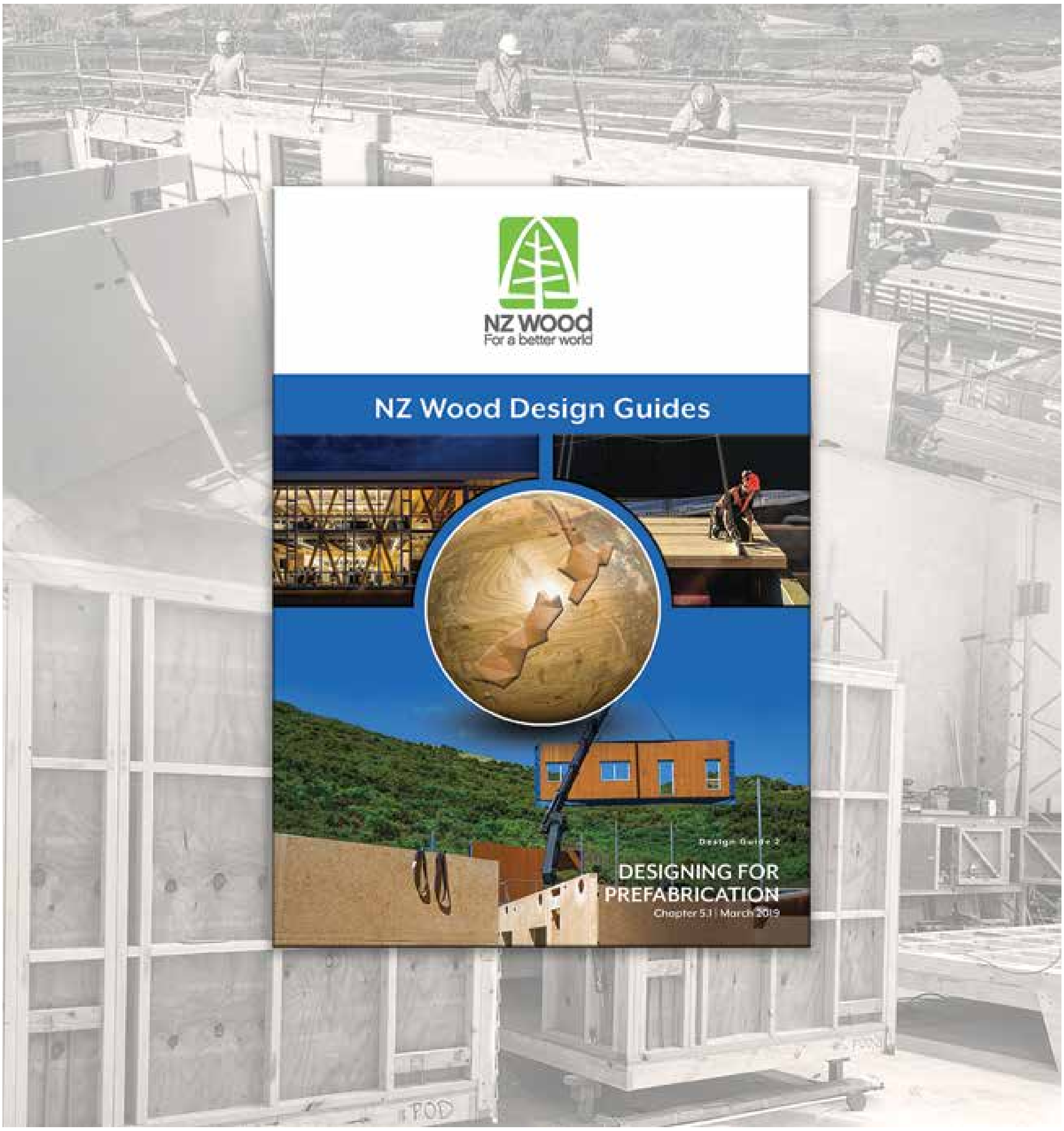
## 2.1 ABOUT THIS GUIDE

### 2.1.1 Use of terminology

Prefabrication, off-site construction, off-site manufacture (OSM), Modern Methods of Construction (MMC), pre-built construction, modular construction, manufactured building solutions are all terms that are used interchangeably in the industry, essentially describing building work being undertaken away from the final building site.

While not excluding any other terms describing this mode of construction, this guide is using the terms **Prefabrication**, **Prefab**, and **Prefab Construction**.
Aligned with resources published by MBIE on this topic, the term **Manufactured Building Solutions** is used with regard to compliance and the consenting process.

PrefabNZ provides useful resources on prefabrication, including a glossary around commonly used terms in prefabrication on their website: http://www.prefabnz.com/resources/



## 2.2 ARCHITECTURE AND CONSTRUCTION METHODOLOGY

Optimal project outcomes are dependent on choosing the best possible design and construction methods to achieve the client brief. Early decisions may be influenced by a variety of factors such as a tight project timeline, budget constraints, challenging ground conditions, specific site or climatic requirements, or urban context.

Essentially the question to be answered for the client is *"what is the most efficient way to realise the project"* given the project brief?

By better understanding prefabrication and the strengths of various timber systems on offer, designers and specifiers will be better equipped to come up with design solutions for their clients.

This Guide intends to achieve this in a two-pronged approach: Firstly, by educating readers about the most important prefabricated timber systems, their characteristics and applications, and secondly, by providing guidance on the collaboration and interaction between the various stakeholders throughout the prefab design and build process.

Rather than feeling constrained in their creative freedom by the thought of working within a system and an alternative approach to construction, designers will learn how to leverage proven systems and apply modern methods of construction to push the envelope of what can be built using wood, and how efficiently.

## 2.3 SPECTRUM OF PREFABRICATION

Prefabrication as a mode of construction is a relatively broad term and can refer to a whole spectrum of prefabricated components, from small individual components (pre-cut beams or posts), to closed wall or floor panels, to 3D volumetric modules or pods, through to completed prefabricated buildings or hybrids thereof (Refer Figure 1). This guide will be relevant to the entire spectrum of prefabrication with the intent to sharpen designers' understanding on what type of prefabrication is most relevant to their project.

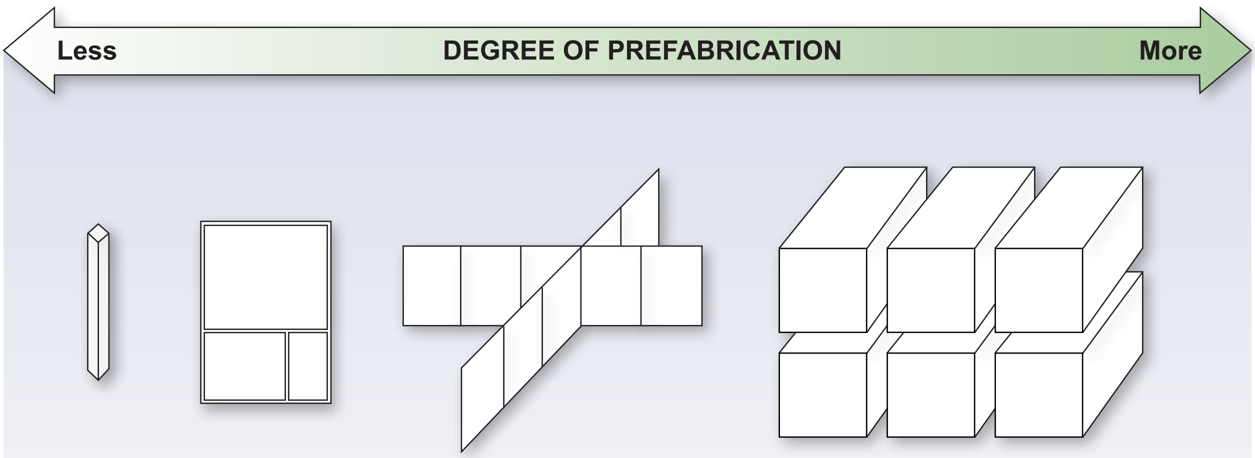



*Figure 1: Prefabrication can be classified by the extent to which elements are completed off-site. Generally, the benefits of prefabrication can be realised as projects move to increasing degrees of prefabrication.*
*(Source: Prefab Architecture, Ryan E. Smith).*

# 3 Prefabricated Timber Systems

## 3.1 BACKGROUND

Engineered timber is derived from the specialised processing of raw round logs. The word engineered in this context stands for the act of breaking down a log and reconstituting selected parts of it in a planned fashion using proven adhesives (and sometimes other additives) to achieve specific characteristics, for example structural, dimensional, thermal, appearance. Most engineered wood products can be categorised according to the size of the raw material input and by fibre orientation in the finished product, however hybrids do exist.

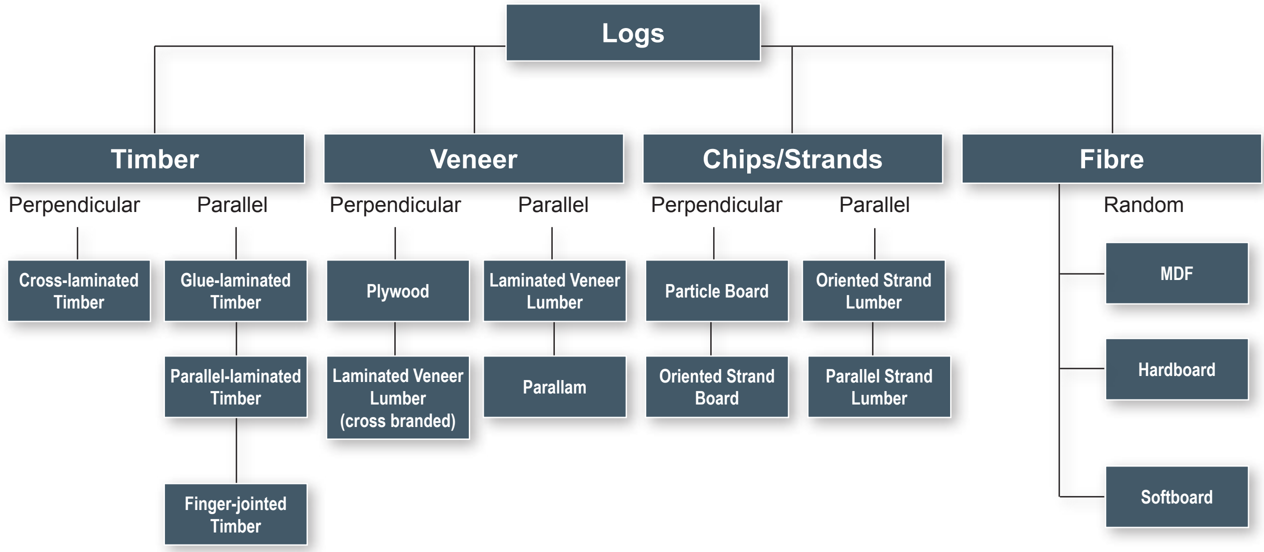



*Figure 2: Categorisation of engineered wood products depending on raw material input and wood grain orientation*

Engineered and solid wood products together with other non-wood products are then combined into a variety of prefabricated systems. These prefabricated systems can be categorised in terms of geometric size of individual modules and the level of fabrication achieved off-site (refer Figure 3).

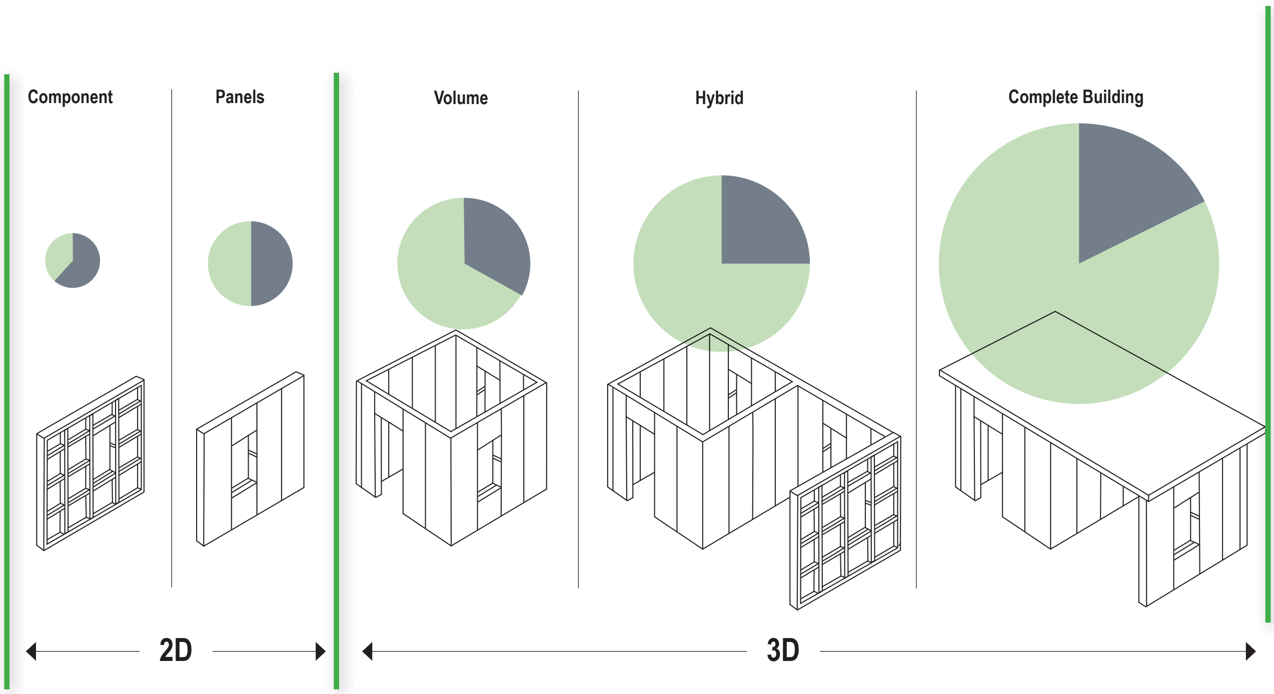



*Figure 3: Categories of Prefab Systems (Source: PrefabNZ Material Matrix 2018); The degree of prefabrication increases from Components (left) to Complete Prefabricated Buildings (right).*

## 3.2 PREFABRICATED TIMBER SYSTEMS

The range of timber systems available to designers today is wide and varied. Ongoing innovation in materials as well as manufacturing processes also means this range is evolving and new systems appear from time to time.

The following is an attempt to characterise the most important timber systems[1].

The member directories of the Wood Processors and Manufacturers Association (WPMA) of New Zealand and PrefabNZ provide directories of manufacturers and suppliers of engineered wood products and prefabricated (timber) systems.

Suppliers typically provide technical literature about their systems and offer guidance regarding the engineering, specification, standard details, and more.

### 3.2.1 Closed Light Timber Frame (LTF) wall panels

*LTF wall panel containing services. (Photo: Concision)*

*Closed LTF wall panels during installation. (Photo: Concision)*

#### DESCRIPTION

Closed wall panels made up of light timber framing (aligned with NZS3604) featuring studs, top and bottom plates. Depending on the desired level of prefabrication and the capabilities of the supplier, panels may be closed on one face only (e.g. with sheathing or rigid air barrier) or fully closed inside and out, pre-clad, including all services installed.

#### ADVANTAGES

- Speed of construction, especially for fully closed systems.
- Flexibility across a wide variety of wall assemblies (featuring a variety of claddings and linings, and for various levels of prefabrication.
- Suitable for carpentry and manual-style prefabrication as well as highly automated factory production.
- Closely aligned with timber construction as per NZS3604 which makes specification, construction on site, and compliance straight forward. Easily understood in design, construction, and compliance.
- Can accommodate a high level of thermal insulation.
- Easily specified, prefabricated, and installed as part of an all-of-house system made up of wall, floor, and roof panels.
- Light-weight.

#### DISADVANTAGES

- The level of prefabrication that can be achieved is typically lower than for 3D volumetric or pod construction.
- Has relatively low thermal mass, compared to solid timber or concrete systems.
- Being able to fully close floor cassettes and roof panels containing services requires a high level of detailing compatible with the prefabricator's capabilities and process. Also, early Contractor Involvement (ECI) is required from key service trades.

#### TYPICAL APPLICATIONS

- Self-supporting external and internal wall panels for detached dwellings.
- Closed façade panels designed for 'clipping on' to primary structure of multi-storey buildings for rapid weathertightness.
- Intermediate step in the prefabrication of 3D volumetric modules or pods.

[1]For more information on engineered timber products and prefabricated systems visit: WPMA website: http://www.wpma.org.nz
PrefabNZ website: http://www.prefabnz.com/

### 3.2.2 Light timber frame floor and roof cassettes

*Roof cassettes ready for transport to site. (Photo: Potius Building Systems).*

*LTF floor cassette during installation. (Photo: Potius Building Systems).*

## DESCRIPTION

Closed floor cassette and roof panels[2] made up of light timber framing (aligned with NZS3604) featuring joists, blocking, and usually at least one sheathing layer for bracing.
Depending on the desired level of prefabrication cavities can be left open to access structural fixings and for installation of services on site, or may be fully closed off-site.

## ADVANTAGES

- Speed of construction. Floor cassettes are one of the most efficient options to put down a platform for builders to work from.
- Very efficient use of material (e.g. joists) while being able to utilise cavities for services or insulation.
- Flexibility across a wide variety of floor and roof assemblies (catering for a variety of floor toppings and ceiling linings.
- Easy to combine with closed wall panels.
- Suitable for carpentry/manual-style prefabrication as well as highly automated factory production.
- Closely aligned with timber construction as per NZS3604 which makes specification, assembly on site, and compliance relatively straight forward. Easily understood in design, construction, and compliance.
- No propping of floors.

## DISADVANTAGES

- The level of prefabrication and finish achieved is typically lower than for 3D volumetric or pod construction.
- Being able to fully close floor cassettes and roof panels containing services requires high level of detailing compatible with the prefabricator's capabilities and process. Also, early Contractor Involvement (ECI) required from key services trades.

## TYPICAL APPLICATIONS

- Floor cassettes framed using either I-joists or other engineered wood products.
- Closed roof panels framed from rafters for mono-slope or simple pitched roofs.
- Stressed-skin panels, with enhanced structural properties due to composite action.

[2] 'Cassette' or 'panel' are two terms widely used in the industry for floor or roof elements built up from timber framing or trusses.

### 3.2.3 Solid timber panel wall, floor, and roof systems

*Honeycomb structures are well suited for CLT panel construction. (Photo: Xlam NZ Ltd).*

## DESCRIPTION

Most notably Cross-Laminated Timber (CLT) consisting of boards cross-layered and glued into large format panels, which are pressed and machined into bespoke elements (up to 17.5m x 4.5m size and more, depending on supplier) which can be used as pre-cut wall, floor or roof panels.
Another type of solid timber panel is Parallel-Laminated Timber (PLT) consisting of boards glued parallel to grain similar to a glulam beam used on its flat.

## ADVANTAGES

- Speed of construction due to large panel format and simple structural connections on site.
- Speed due to faster pace of follow on trades who typically find it easier working in with a solid timber system rather than steel or concrete.
- High precision, even for complex panel geometry and carpentry.
- Sustainable due to large amounts of stored carbon.
- Proven and predictable fire resistance due to charring (refer to Design for Fire Safety Guide published by NZ Wood).
- Higher thermal mass than lightweight systems.
- High strength to weight ratio, which makes CLT a great alternative to concrete precast at approximately 20% of the weight.
- Suppliers typically offer a range of structural and appearance grade panels.
- Easily combined with e.g. prefabricated wall panels from other systems.

## DISADVANTAGES

- Just like for other systems, intertenancy walls and floors typically require strapping and lining to meet acoustic and fire performance requirements.

## TYPICAL APPLICATIONS

- Honeycomb structures (apartments, multi-unit housing, aged care facilities, etc.) where internal and permanent walls act as primary supports for short to medium spans.
- Prefabricated solid timber stairs, e.g. cut from CLT.

### 3.2.4 3D volumes and pods

*Bathroom pods during manufacture and installation (Photos: Tallwood).*

## DESCRIPTION

3D volumetric modules or pods, typically made up of at least a floor and four walls. Floor and walls may be made up from traditional light timber framing (as per NZS3604) or from other timber systems, e.g. solid timber panels like CLT or Triboard.

The level of finish that can be achieved is typically higher than for panel construction since there are less joins to be made on site. Some examples of 3D volumetric/pod construction illustrate it is possible in some instances to achieve full finish of all internal surfaces prior to shipping.

## ADVANTAGES

- Very high degree of prefabrication and finish can be achieved (e.g. finished internal surfaces including carpets laid and curtains hung), harnessing many benefits prefabrication has to offer.
- Standardised size modules may be mass-customised and produced in a continuous process akin to an automobile assembly line.
- Pods/3D volumes typically are made up of 2D panels, which means 2D panelised construction can act as a stepping stone towards 3D volumetric construction.

## DISADVANTAGES

- Shipping of 3D volumetric modules by definition also ships empty space, i.e. air.
- Only suits certain types of building geometries, with loadbearing supports/walls not spaced any further than the maximum length and width of the volumetric module to be transported.

## TYPICAL APPLICATIONS

- Rooms or parts of a building with a high concentration of services, e.g. bathroom pods and mechanical plant rooms, etc. where factory prefabrication can dramatically simplify an otherwise complicated site-based construction process.
- 3D volumetric modules for buildings made up with repetitive modules, e.g. multi-storey hotels or student accommodation.

### 3.2.5 Panel and pod hybrids


*Bathroom pods combined with 2D wall panels to be installed on sole plates (Photo: Concision).*

## DESCRIPTION

A combination of pod construction coupled with flat panels, combining the advantages of both systems.

## ADVANTAGES

- Combines the best of 3D volumetric and 2D panelised construction.

## DISADVANTAGES

- Combining two systems may introduce interface issues without sufficient coordination, especially if 3D volumetric modules are sourced from a different supplier than the 2D (wall) panels.

## TYPICAL APPLICATIONS

- Bathroom pods combined with traditional site-based construction.
- Bathroom pods being installed within a multi-storey building (e.g. a hotel) which is being enclosed using 2D façade and floor panels.

## 3.2.6 Heavy post and beam

*Heavy Timber frame - Cathedral Grammar Christchurch (Photo: Patrick Reynolds).*

### DESCRIPTION

Systems of heavy timber posts and beams. Components may be designed and fabricated from solid timber or engineered wood products.

Posts and beams can be made up of composite cross-sections and typically form 3D frame systems that are either combined with bracing systems (e.g. shear walls) for lateral load resistance or the frames may be designed as self-bracing featuring moment joints.

### ADVANTAGES

- Ability to create large span, open plan, and multi-storey spaces that make efficient use of material.
- A large variety of systems and materials on offer, giving designers flexibility.
- Buildings feel light, airy, and transparent on the inside, due to plenty of flexibility regarding location and size of glazing and openings.
- Timber posts and beams including any joint details can form part of the aesthetics of the building where the structure remains on display.
- Any fire requirements can typically be satisfied with either of the following two strategies: a) oversizing members allowing for charring of the cross section, or b) encapsulating members with other materials.

### DISADVANTAGES

- None specifically.

### TYPICAL APPLICATIONS

- Multi-storey open plan office building: featuring façade panels and internal non-loadbearing partitions.
- Traditional post and beam style timber frame home expressing traditional mortise and tenon joints for architectural purposes.

## 3.1.7 Other (engineered) timber systems

The range of timber systems available to designers is wide and varied. Ongoing innovation in materials as well as manufacturing processes means this range is still evolving and new systems are being added. Other notable timber systems are:

- Timber trusses: from light timber (2x4 or similar) using nail plates to heavy timber with trusses often used as design feature.
- Portal frame structures.
- Pole structures.
- Timber-concrete composite floor systems.
- Post-tensioned systems
- Timber arches.

Please visit the websites of NZWood (http://www.nzwood.co.nz/) and the NZ Timber Design Society (http://www.timberdesign.org.nz/) for more information on timber systems available in New Zealand. Suppliers of timber systems typically provide technical literature about their systems and offer guidance regarding the engineering, specification, standard details, and more.

# 4 DESIGN FOR MANUFACTURE AND ASSEMBLY (DfMA)

## 4.1 DEFINITION, CHARACTERISTICS, ADVANTAGES

DfMA is the design and manufacture of discrete sections of a building which are fabricated off-site (typically in a factory for mass-production; sometimes in multiple locations) to then be transported to site for final assembly. DfMA coupled with Lean Manufacturing are fundamental principles that form the basis for successful prefab construction. It is also essential for all design disciplines to be coordinated well and any potential clashes to be resolved before manufacture and construction. Digital design and delivery tools should therefore be embedded to form a common infrastructure and language enabling project team communication and collaboration.

At the centre of the DfMA process is virtual reality modelling of the project which beyond 3D geometry, can contain meta-data (on programme, quality, environmental impacts, etc) and production information (components, panels, volumes/ pods; sub-systems).

## 4.2 DfMA PROCESS AND IMPLEMENTATION

DfMA relies on a collaborative design team, with direct input from main contractor, prefabricator, and key sub-trades such as building services as early as the concept design of the project. This front-loading of the design process is in direct contrast to the more linear and traditional procurement process of design-bid-build that usually does not consider construction and assembly until it is too late to optimise the design. (Refer Figure 4).

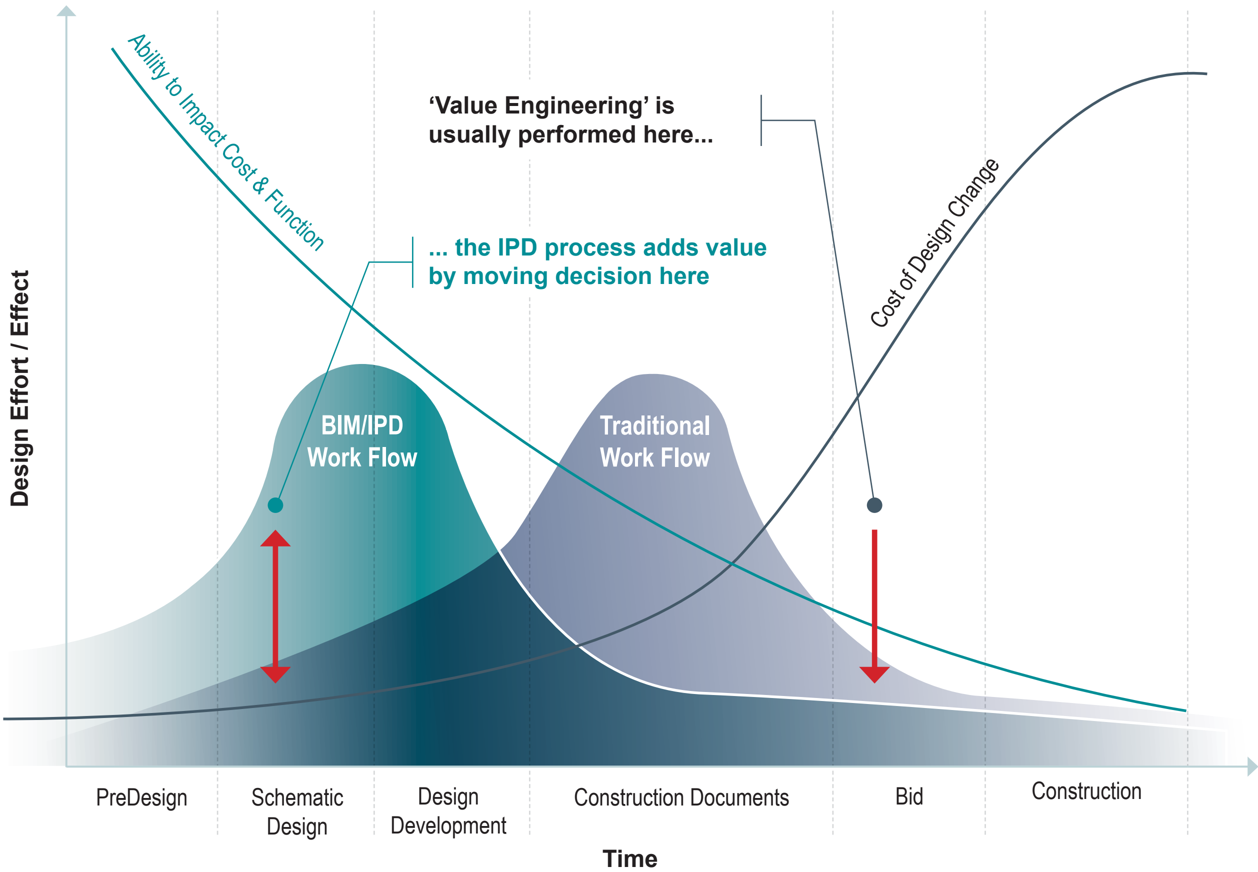



*Figure 4: MacLeamy Curve; This curve is famous among experienced prefabricators because it depicts the shift of effort which is often described as "front end loading" required for successful DfMA and Integrated Project Delivery (IPD). The justification for the shift is the fact that effort is moved to an earlier stage, when the cost impact (risk) of making design changes is less.*

A disciplined product development process with a DfMA methodology at the core of the process is required in order to support lean manufacturing resulting in successful prefabrication. This process guides the implementation of a project from client brief through conception to production and assembly. The DfMA process will be made more effective by taking the following[3] into account:

- Throughout the design phase, the designers should consider the full lifecycle process, including the manufacturing and assembly processes.
- Stakeholders should conduct collaborative DfMA and Lean Manufacturing workshops throughout the design phase to maximise production efficiency, reduce programme risk and minimise cost.
- Involved parties should seek to quantify the 'value add' in the off-site manufacturing process by creating preassembled elements; for example, facades, finished internal walls, and service cores.
- A continuous improvement process should be embedded in the development process to ensure issues are reported, recorded, and resolved.

## 4.3 COLLABORATION AND DOCUMENTATION

### 4.3.1 Early collaboration

A DfMA approach to construction requires close collaboration among all stakeholders within a project team from the very beginning. Early engagement will ensure the project is informed from all relevant angles -while the design is still somewhat flexible- ultimately to the benefit of the client. The goal of this phase of the project is to build a collaborative team from the start to be able to efficiently deliver the desired outcomes, from the start of concept design right through to construction.

Parties reasonably to be expected to take part and contribute (depending on size of project) when designing for prefabrication:

- Client/developer.
- Project/design manager.
- Architect/structural engineer/ other specialist designers e.g. acoustic and fire engineers.
- BIM (management) expertise.
- Main contractor and key suppliers, e.g. timber prefabricators.
- Quantity surveyor.
- Building Consent Authority(s) (BCA).
- Regulatory advisor.
- Others, as required.

[3]Source: Handbook for the Design of Modular Structures, Monash University, May 2017

Some prefabrication fundamentals to be discussed early among the project team:

| Topic | Aspects to be discussed |
|---|---|
| **Degree of prefabrication** | Consider complexity of the build and the best degree of prefabrication. |
| **The prefabrication processes and systems available** | Opportunity to learn more about relevant systems and design considerations for economy and efficiency of manufacture. *Refer Chapter 3: Prefabricated Timber Systems.* |
| **Importance of integrated design and BIM** | Encourage involvement in integrated/digital design which can provide efficiencies in streamlining the design process. Collaboration during the design phase is essential for prefabrication to be effective. *Refer following chapter 4.3.3* |
| **Engineering** | Scope requirements due to a prefabricated approach, e.g. temporary loads on components during fabrication, transport, storage, lifting, and assembly. |
| **Building services** | On-site vs off-site installation strategies. *Refer following chapter 4.4.5.* |
| **Timeline** | Prefab construction projects require a front-loading of the design process, shop drawings, and prefabrication, which is to be offset through speed of construction on site. *Refer Chapter 5: Procurement.* |
| **Finance** | Funding implications, particularly regarding lender requirements for manufactured components held off-site. |
| **Compliance pathways** | Robust QA systems and product assurance provided by the supplier will simplify the consenting process and minimise the BCA's need for decision making and site inspections. *Refer Chapter 5: Procurement.* |

## 4.3.2 Documentation and Prefabrication

The New Zealand Construction Industry Council (NZCIC) publishes Design Documentation Guidelines[4] (CIC Guidelines). These guidelines focus on defining the responsibilities of the parties involved in design and construction depending on the project phase. The 2016 version of the CIC Guidelines includes references to BIM suitable as high-level indicators on how BIM should be implemented on a project. The NZ BIM Handbook which has been coordinated with the CIC guidelines goes further and provides more detail and specific requirements around BIM.

Both documents are fundamental in outlining requirements around documentation when designing following a BIM-lead approach.

Documents specific to a prefabricated project can include:

- Specifications concerning the prefabrication, transport, storage and assembly of a timber system.
- Method statements and/or build manuals, e.g. covering temporary propping and temporary fixings.
- Factory shop drawings and QA documentation.
- Bill of Materials.

[4]Source: http://nzcic.co.nz/resources/guidelines/

### 4.3.3 Building Information Modelling (BIM)

At time of publication of this document the majority of prefabricated timber projects are still constrained to BIM maturity Level 0 - 1 (as defined by the NZ BIM Handbook 2019). This means there is currently very little integration between design disciplines and often BIM is limited to unmanaged CAD, usually in 2D format using paper (or electronic formats, e.g. pdf or dxf files) as the main exchange mechanisms, or exchange of separate 3D formats using a collaboration tool.

The above-mentioned CIC Guidelines also outline the responsibilities of the parties around BIM involved in design and construction depending on the project phase. Therefore, designers should familiarise themselves with BIM basics and how the BIM workflow can aid their project[5], since the BIM process is particularly applicable to prefabricated projects. Dedicated BIM software programmes aid in the design and drafting process, they decrease document errors, help to communicate more information among the project team, increase project certainty, and speed as well as accuracy of the build process. One of the key advantages of BIM software is that it facilitates collaboration between the various internal and external disciplines and project stakeholders. Indeed, for prefabricated projects, BIM and the Common Data Environment (CDE) created through it -literally and figuratively speaking- become the common language among the project team. (Refer Figure 6).
Especially for medium-sized to large prefab projects a BIM workflow and BIM approach to modelling and documentation are an essential prerequisite to successful project delivery. (Refer Figure 5)

BIM is usually not necessary for small scale residential projects with simply integrated prefab components (e.g. a cross-laminated timber floor only).

Prefab project teams are encouraged to work with and follow the NZ BIM Handbook as published by MBIE (Refer: https://www.biminnz.co.nz/bim-tools/).

Key documents in the BIM workflow are:

- Project BIM Brief.
- BIM Evaluation and Response template.
- Project BIM Execution Plan (Design & Construction).
- Model Element Authoring Schedule.

Refer to NZ BIM Handbook (latest edition) for further information.

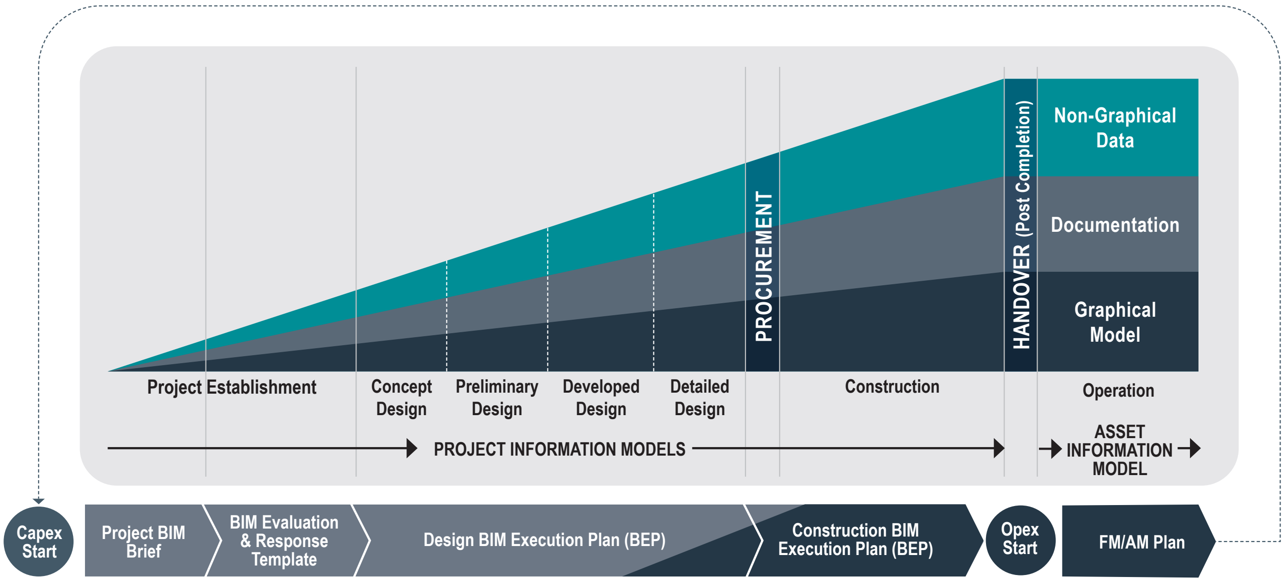



*Figure 5: The Information Delivery Cycle as per NZ BIM Handbook 2016 Edition.*

[5]For Benefits of adopting the BIM process, please refer to the NZ BIM Handbook, latest edition


*Figure 6: Model Federation Diagram. (Source: NZ BIM Handbook 2016 Edition).*

*The BIM Process allows for project stakeholders to collaborate on a federated information model throughout the lifecycle of building. Execution and responsibilities need to be specified carefully at the beginning of every BIM project.*

## 4.4 EARLY DESIGN CONSIDERATIONS

The following aspects should be considered early when designing for prefabrication:

### 4.4.1 Start with a system

Individual timber systems offer unique advantages and should therefore be chosen considering the specific requirements of the project. The technical literature provided by prefabricators can also provide guidance on the suitability and applications of their systems.

Once a system is chosen this has implications on architecture and structure (e.g. spans that can be achieved), transport and lifting methodology due to size of modules, etc. A careful weighing of pros and cons of relevant prefab systems within the project team is essential at an early stage of the design process. The system should be confirmed involving the entire project team.

Design grids can be a useful way to organise a desired floor plan into a system of standardised modules.

### 4.4.2 Logistics

Each prefab timber system poses logistical demands around transport and assembly on site.

The following factors need to be considered and carefully matched to project constraints early on:

- Size of prefabricated components.
- Transport distance to site.
- Site access available for delivery, lay down, and temporary storage.
- Craneage requirements and availability.
- Lifting methodology.
- Assembly/erection methodology to mitigate moisture and weather effects.

More information on prefab project logistics, refer Chapter 6. Transport, Storage, and Erection.

### 4.4.3 Standard details

The term ***standard detail*** here refers to any junctions between prefabricated components and junctions between prefabricated components and site-based structure in the case of hybrid construction.

When designing for prefabrication always consult with your preferred prefabricator about standard details first, including:

- Standard details (between prefab elements, and to site elements).
- Suitable fixing types and fasteners.
- Design for durability and maintenance.
- Typical tolerances to expect during on-site assembly.
- Specifications.

Experienced prefabricators will have a suite of standard details available supporting their systems. Unless for unique one-off projects, there is usually no need to design standard details from scratch. Where details have to be developed from scratch, standardisation and repetition of details, aligned with the prefabricator's capabilities is important to maximise efficiencies.

Where prefabricators offer a range of proven details these usually have shown to be most suitable for important reasons. If designers deviate this must be cleared by the prefabricator to avoid affecting the underlying economics of the prefab system and process.

Generally, standard details should be kept generic and need to be aligned with the prefabricator's capabilities. Advanced prefabricators will provide their own standard details including performance values for example for fire, thermal, and acoustic applications, based on testing conducted.

### 4.4.4 Structural engineering

Beyond the loads acting on the structure once completed, engineers may be called upon to design for stresses during prefabrication, lifting, and any temporary loading during erection.

Engineers should clarify early the scope of any input required around temporary loading during prefabrication, transport, and assembly stages. For highly standardised prefab elements, prefabricators have often covered these requirements for their system. For example, they may be using pre-engineered standardised lifting details.

In the absence of any guidance from the prefabricator (often the case for bespoke prefab systems of high complexity) engineers should provide input and design for:

- Lifting, stacking, and assembly methodology.
- Lifting points and temporary supports.
- Actions during assembly, e.g. weather events.

Construction sequence analysis and builder input during the design stage will help identify and address issues arising from temporary loadings early. Where design-based solutions are not available, the designer should clearly identify the issue and propose some form of construction stage solution on the drawings.

When in service, prefabricated elements by their nature not uncommonly feature some structural redundancy due to the self-supporting nature of individual elements.

In depth timber design guidance for structural engineers is available through NZ Wood and the NZ Timber Design Society.

## 4.4.5 Building services

The term ***building services*** in this document mainly refers to following disciplines:

- Mechanical (e.g. HVAC).
- Electrical (power and communication).
- Fire protection services (e.g. fire alarm systems, sprinklers).
- Plumbing.

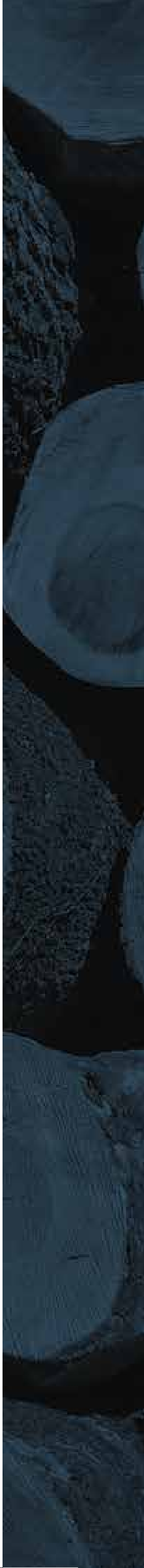
Designing for prefabrication in itself does not require qualitative different levels of specification or performance from the architectural demands required of the completed building, had it been constructed of the same materials traditionally in-situ. However usually when designing for prefabrication, designers have the opportunity to optimise their building services concept in collaboration with the prefabricator to ensure efficient installation, be it on or off-site.

Therefore, the main question arising is whether to install building services off-site in a factory (essentially contained in the prefabricated elements), or on-site after the assembly of prefabricated elements.

Before attempting to answer this question, designers should consult with their preferred prefabricator regarding a recommended strategy on how to deal with building services. Experienced prefabricators will be able to highlight any challenges and recommend solutions on how to best deal with installation of building services.

Depending on the project and the capabilities of the prefabricator there are three principal strategies on how to install building services:

| | |
|---|---|
| **On-site installation** | Any prefabricated elements required to take services are left open or accessible for building services to be installed in traditional fashion on site. E.g. light timber frame panels un-lined on the inside so cavities can be accessed for installation of electrical wires in situ.<br><br>**ADVANTAGES:** No or few extra requirements due to off-site approach.<br>**DISADVANTAGES:** Relatively lower level of prefabrication possible.<br>There is a risk that structural integrity of the product could be compromised by unauthorised on-site notching, chasing, etc. |
| **Off-site installation and on-site connection** | Building services are installed into prefabricated elements off-site and connected between elements on-site. Connections may be formed with traditional fittings or using plug-and-play type, depending on the design and any requirements.<br><br>**ADVANTAGES:** Very high level of prefabrication resulting in speed on site and other benefits associated with prefabrication. E.g. fully closed wall panels already containing any wiring and plumbing.<br>Makes sense as part of a highly standardised prefabricated system which is applied across many projects.<br>Possibility to eliminate wet trades from site.<br>**DISADVANTAGES:** Extra effort and level of detail required at the design stage. Designers must work closely with the prefabricator to achieve the complete off-site solution. Considerable R&D required by the prefabricator to develop standard details catering for a complete off-site solution. |
| **Hybrid options for installation** | Installation of some services (or conduit/draw cables) off-site, with a second fix and more complex services to be installed in-situ. E.g. drawing of power cables on-site, coupled with cavity access for installation of e.g. plumbing.<br><br>**ADVANTAGES:** Good compromise between on-site and off-site installation, delivering speed while saving the more complex installation for the construction site.<br>**DISADVANTAGES:** Not as fast as a complete off-site solution. |



Design ideas that can help make building service integration and installation more efficient:

| | |
|---|---|
| **Minimise pathways for building services** | **E.g. Orient bathroom and kitchens back-to-back to concentrate services and minimise reticulation of services.** |
| **Dedicated service cavities** | **Dis-entangling structure (durability 50 years) and services (typical durability 15 years) by physically separating them. e.g. introducing 45mm battened service cavities, false walls.** |
| **Prefabricated service cores, risers, or plant rooms** | **Dedicated (vertical) service cores to contain most important services with service-intensive rooms (e.g. kitchen/bathrooms) backing onto service core.<br>Makes particular sense for multi-storey buildings.** |

### 4.4.6 Other important early considerations

- Project timeframe.
- Early identification of prefabrication as option.
- Health and Safety.
- Early feedback on costings helps with design choices before too much time has been taken up.
- Site constraints (access, cranes, heavy equipment, ground conditions, storage).
- Logistic constraints (size, weights, fragility).
- Contractor or Supplier capabilities; equipment and labour constraints.
- De-constructability and adaptability of a design: timber systems, coupled with appropriate detailing, and use of mechanical fixings can allow for a design to be reconfigured, deconstructed, and recycled over time or at the end of its useful life.

# 5 PROCUREMENT

## 5.1 TRADITIONAL VS INTEGRATED

***Procurement*** in this Guide refers to the phase from engagement of a delivery team to delivery of a project to site, including client handover.

The traditional procurement process intends to create price competition by separating the design and construction of a project and awarding the construct-only contract to (usually) the lowest out of a number of bidders. This way, the traditional procurement model and traditional construction contracts introduce a significant gap between the various parties involved. This separation and traditional procurement methodology therefore are a major barrier to DfMA and integrated project delivery.

Opportunities for innovation and efficiencies in traditional procurement are severely limited through the contractual separation of design and construction.

## 5.2 INTEGRATED PROCUREMENT

As the name implies, an integrated approach to project delivery demands an integrated approach to procurement. Integrated project delivery and procurement require a high level of early collaboration and decision-making including contractors, prefabricators, and key suppliers. This front-loading of the design process typically requires more time for pre-construction activities. In return it encourages innovation in design and delivery resulting in tangible benefits through the DfMA approach, including alignment with manufacturer and contractor resources, speed on site, more efficient design solutions, etc.

Integrated procurement breaks down barriers between project stakeholders and therefore demands a clear definition and allocation of project risk, since problems are solved by the team, as opposed to silo-ed disciplines. In other words, alliancing is the most suited framework for integrated design and procurement on complex projects. (Refer Figure 7).

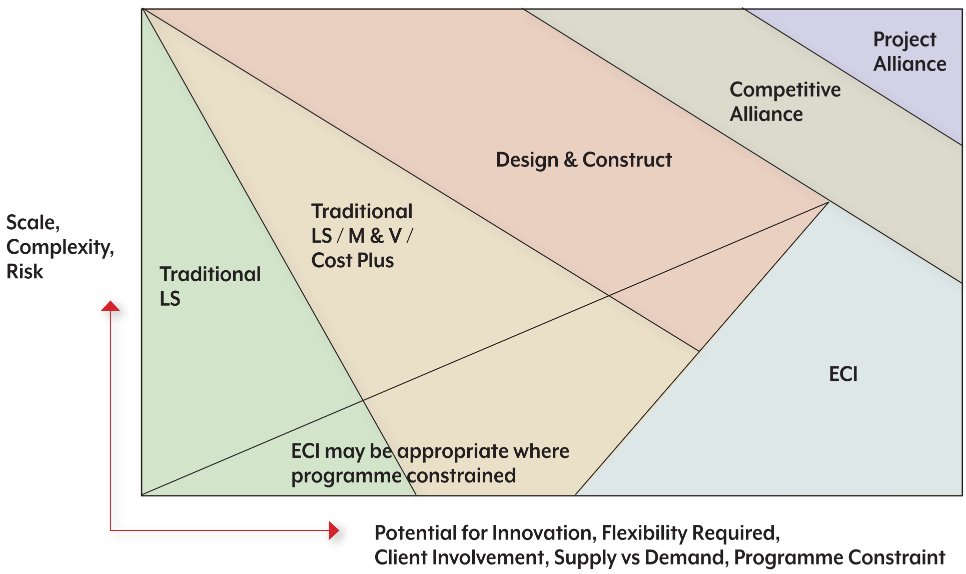



*Figure 7: NZTA Delivery model selection diagram. Source; NZTA.*
*LS = Lump Sum; M & V = Measure & Value; ECI = Early Contractor Involvement.*

### 5.2.1 Contractual management

#### 5.2.1.1 General comments

The level of prefabrication chosen can influence the type of construction contract most suitable for any given project.

For example, on projects with a relatively low level of prefabrication (e.g. pre-nail frames only) the main contractor is likely to also act as installer of the prefab system and cover these items with their contract. In contrast, for projects featuring a relatively high level of prefabrication (e.g. a fully closed panel system containing services) a design-install contract with the main supplier may make more sense, this way clearly delineating responsibilities and warranties around the installation and performance of prefabricated elements.

Early Contractor Involvement (ECI) may be considered during the design phase where contractor input is desired however the actual contractor has not been appointed yet. ECI therefore is a means of involving a preferred contractor early to help inform a design, with potential compensation for the contractor in return.

#### 5.2.1.2 Contracts supporting Integrated Procurement

The basic principle of integrated procurement is the client establishes a contract with a single party (ideally a designer/contractor consortium) which assumes the full responsibility for both design and construction. Through early contractor involvement the client grants the freedom to the contractor (or consortium) to propose and realise an innovative design, including the use of new materials, production and assembly techniques. The main requirement is that the design meets the client's functional elements.[6]

The key factor to success is the presence of a well-defined project brief which is clear on the outcomes sought by the client.

This type of negotiated contract provides more flexibility breaking down barriers and allowing everyone to work together in a performance-based approach, instead of the often counter-productive constraints of a prescriptive brief. In particular the contract needs to facilitate the integrated nature of the project team plus free information sharing so information can transition into shop drawings.

The contract should also spell out the documentation infrastructure, shared software and interfaces enabling the actual information sharing.

### 5.2.2 Timeline and Sequencing

The timeline of prefabricated projects (including resulting implications on procurement) are best understood working backwards in time from the assembly of prefabricated elements on site.

The critical path of a project emerges by carefully matching design, production, and supply of resources to the assembly process on site. (Refer Figure 8).

[6]Handbook for the Design of Modular Structures, Monash University, May 2017

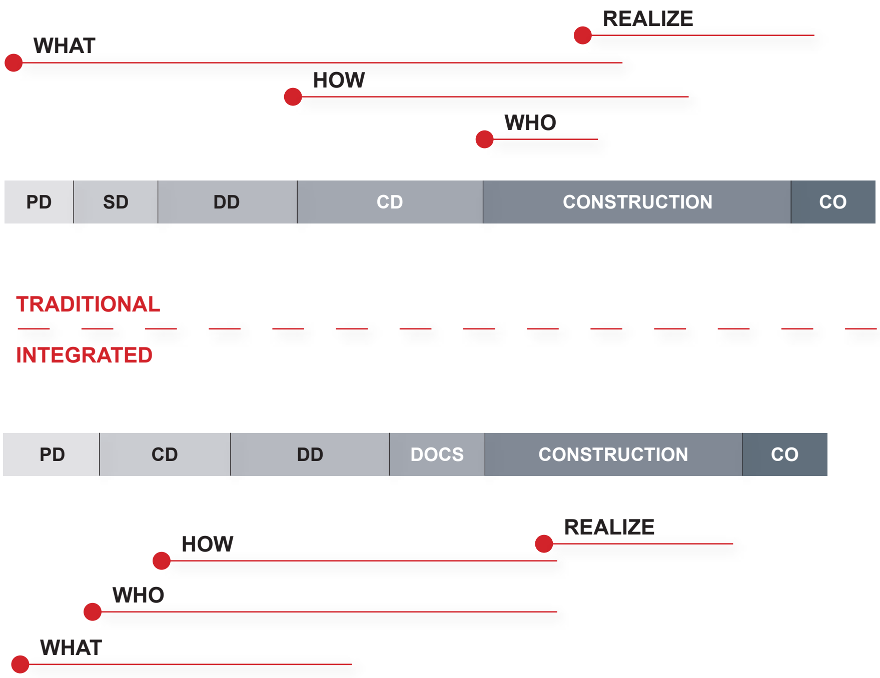



*Figure 8: Project timeline comparing traditional and integrated project delivery. (Source: Prefab Architecture, Ryan E. Smith, 2010).*

The project flow from pre-design (PD) to closeout (CO) in an integrated delivery is different from the traditional method in that it does not use the conventions of schematic design (SD), design development (DD), and construction documents (CD) which tend to create workflow bar-riers. These phases of a traditional design process do not encourage collaboration. Integrated project delivery suggests the identification of project goals early, so that decisions regarding production methods are considered from the beginning. The "what", "who" and "how" are integral to the design process and involve not only owner and architect, but also contractor and key subcontractors such as prefabricators who will have a major stake in the project delivery. Because the project is coordinated to a high degree before the construction phase begins, off-site fabrication and on-site assembly are more efficient and provide a shorter construction period. (Source: Prefab Architecture, Ryan E. Smith, 2010).

### 5.2.3 Design Freeze and Late Changes

As designers work through a project collaboratively, involving contractor and fabricators, the concept of *Design Freeze* will be useful. The intent is to lock down certain aspects of a design among the team at an agreed point in time, so the project can move to the next stage with confidence.

For small projects this could simply be the milestone after completion of all detailed design and prior to start of any fabrication. For larger and more complex projects design freeze can be applied at several points throughout the design process (e.g. Grid lines, RLs, floorplans, window and door rough openings, etc).

Formal review and approval of 3D fabrication models and/or shop drawings by designers is encouraged and can act as design freeze prior to manufacture. Essentially the prefabricator must have full and final dimensions and construction details, service penetrations, etc finalised prior to prefabrication commencing in the factory. Review responsibilities should be defined and rest with the relevant team members – the design consultants and the contractor (for sequencing and buildability), and other stakeholders as relevant (e.g. the client).

Design freeze should be mutually agreed among the team and the implications of late changes must be understood by all. While late changes -at least in theory- are always possible, the cost of late-changing a design usually increases exponentially throughout the project duration, particularly once fabrication in the factory and construction on site have commenced.

Late changes to a design are fundamentally against the nature of DfMA and have the potential to erode any cost benefits the prefabricated approach may have to offer.

## 5.3 OTHER IMPORTANT CONSIDERATIONS

| | |
|---|---|
| **Lead times** | Purchase of supplies with long lead times, including from overseas, e.g:<br>• Screws, finishes, connectors, claddings, etc.<br>• Elevators for multi-storey buildings. |
| **Early engagement** | Suppliers, DfMA/ Shop Drawing Consultant, and Erection Specialist. |
| **Skills requirements** | In factory/production, and on-site during assembly. |
| **Just in Time (JIT) vs site storage** | *Refer Chapter 6:* Transport, Storage, and Erection. |
| **Installation** | Depending on the timber system and the level of detailing, installation of services on site can be very fast. Follow on trades can move progressively and more quickly compared to traditional construction. Typically, less rework and waste. |
| **Pre-construction activities** | Allow extra time for:<br>• off-site coordination involving other trades;<br>• review and sign-off of shop drawings, including definition of milestones |
| **Site measure** | Against the fundamental nature of DfMA and should be avoided, unless working around existing structures, early point clouds, etc. |
| **Regulatory matters and quality assurance** | Clear articulation of any requirements to provide documents etc. required for compliance purposes.<br>Specification of the standard and nature of any QA systems. |

# 6 TRANSPORT, STORAGE, AND ERECTION

## 6.1 GENERAL COMMENTS

Efficient transport, storage, and erection of prefabricated building components requires a cohesive methodology driven by the manufacture and installation of elements on site, rather than traditional construction. Therefore, the three main topics covered in this chapter are presented as one, even though they cover a lot of ground within the prefabricated design and build process.

A successful plan maximising the efficiencies across all three phases needs to consider:

- Collaboration and involvement of all stakeholders early.
- Load sizes, transport route and road rules for (oversized) transport, site access, space allocation on site.
- Delivery strategy: Just In Time (JIT) vs storage on site.
- Risk management: Minimising risk through a detailed risk management approach.
- Protection of prefab elements during all three phases.
- Crane size, reach, and availability.
- Availability and skill of site workforce.
- Planning erection around site constraints, Health and Safety, progressive trade activities, and protection.

## 6.2 TRANSPORT

Sooner or later the prefabricated elements will need to be transported to site for assembly and erection. The New Zealand Transport Agency (NZTA) clearly defines road rules, vehicle (over)dimensions and mass allowed on New Zealand roads.

Prefab elements are most economically transported if they do not require a special permit, pilot vehicle or road closure. However, the most efficient transport strategy for a project needs to also be informed by a detailed assessment of erection strategy, as well as consideration of available lay down and storage area on site. Depending on the project, transport of fewer oversized loads to site can be justified if enabling more efficient erection on site.

It is therefore impossible to prescribe an ideal transport strategy for prefab construction projects in general. The best possible strategy for a given project can only emerge in a collaborative DfMA process with main contractor and prefabricator(s) helping to inform the design early.

Generally, timber systems (panelised and 3D volumetric) are sufficiently flexible in design to comfortably fit within the constraints encountered on New Zealand roads. Formulating a transport strategy during the design stage is key to avoiding late changes to a design (or worse, to prefabricated product) due to limits encountered during transport.

Structural engineers may be called upon during this phase to investigate the structural aspects of transport and their impact on the prefabricated elements.

## 6.3 PROTECTION

A lot of value has been added to prefabricated elements up to the time of despatch from the factory. It therefore is paramount for prefabricated elements and their value to be adequately protected during the phases of transport, storage, and erection.

Detailed risk assessment for these phases of construction will help to identify hazards and how to protect against them.

While most protection will be built into the actual transport, storage and erection processes, design solutions may exist and should be considered at design stage to help protect prefabricated product.

For Example: application of overlay finishing layers on site, reduces the level of protection required for (otherwise finished) surfaces until after installation.

### 6.3.1 Moisture control

Just like natural wood in general, engineered wood products and timber systems respond to moisture changes in their environment with shrinkage and expansion[7]. An understanding of the effects of moisture on wood along the supply chain and in service is important and must be considered during design, supply, and installation. This is important not only to protect wood products, but also other materials forming part of the prefabricated system, e.g. plasterboard and insulation.

Prefabricated elements are most vulnerable to potential exposure to the elements during transport, storage, and erection. Managing moisture through adequate protection during these phases and maintaining sufficiently dry conditions is of utmost importance ensuring the quality of the finished building.
Generally, the climate encountered by prefabricated elements after leaving the factory should be as close to the climatic conditions the elements will be exposed to once in service.

Product stored on or near the ground will pick up moisture at the bottom of a pack. A layer of polythene or storage indoors will help. Top panels in a stack are vulnerable allowing panels to sweat or -if wrapping is split- allowing moisture to penetrate.

Where timber systems have been exposed to moisture and expansion has occurred, panels must be allowed to return to an equilibrium moisture content (EMC) between 12-15% before the timber panels are closed in.

For small projects (e.g. family home) this requirement for weather protection can be addressed with increased prefabrication to minimise the time during which a project is left exposed. Advanced prefabricated systems can be lockable and weathertight in a day for a typical family home.

*Unprotected end grain taking up ponding water. Photo: (Xlam NZ Ltd).*


*Self-adhesive weather protective membrane . (Photo: Xlam NZ Ltd).*

[7]Generally, cross-plied engineered wood products like cross laminated timber or plywood are somewhat more dimensionally stable (compared to engineered wood products with all grain running parallel) since the cross-plied direction of wood grain stabilises naturally occuring shrinkage and expansion, at least to some extent.

Options of protection of timber systems against moisture in order of efficacy:

1. Mechanical: e.g. use of moisture resistant wrapping during transport; tarping; construction under cover or tent on site.
2. Spray or paint on surface protection: e.g. hydrophobing agents slowing moisture uptake.

*Movable tent/roof covering a prefabricated construction.*

*Movable tent from inside including an integrated gantry crane (Source: Svensktträ, Design of Timber Structures - VolI, 2016).*

### 6.3.2 Visual surfaces

Because of their very design intent visual timber surfaces of prefabricated elements deserve particular attention and protection.

Examples of how visual surfaces can be affected during transport, storage, and erection:

| DEFECT | CAUSE | PROTECTIVE MEASURE |
|---|---|---|
| Metal-stained surface | Moisture and contact of temporary fixings/props. | Insert inert separators between timber surface and metal fixings. |
| Scratched/ scuffed surface/ disfigurement | Poor handling. | Care on site. |
| Scratch/scuff marks | Forklift prongs. | Use packing to avoid direct contact with prongs. |
| Differential ageing of the natural wood surface. Natural wooden surfaces naturally darken/change colour after exposure to daylight/UV | UV Effect. | Cover visual surfaces until the building is closed in. Choose UV-resistant final finishes where there will be high incident natural light. |
| Water stains, roughened surface. Timber swelling | Wet timber surfaces/ standing water. | Factory or site-applied temporary sealing. Design junctions to keep timber (especially end grain) away from ponding water. |
| Rounded edges, marked surfaces | Use of non-suitable lifting ties, e.g. chains, steel cables. | Use edge protectors in conjunction with slings. |
| Colour staining or mold growth due to water damage | Excess water over prolonged periods of time. Sweating/humid timber under plastic wrap. | Keep wood products dry Use breathable water-resistant wraps. |

Visual surfaces are vulnerable until the last trade has left the construction site and the building has been handed over to the client. After erection of the prefabricated timber elements it is important follow up trades are managed working around visual surfaces.

Access to already finished parts of a building should be restricted where possible.

*Marked surface due to forklift prongs. (Photo: Xlam NZ Ltd).*

*Physical protection of finished surfaces in high traffic areas. (Photo Xlam NZ Ltd).*

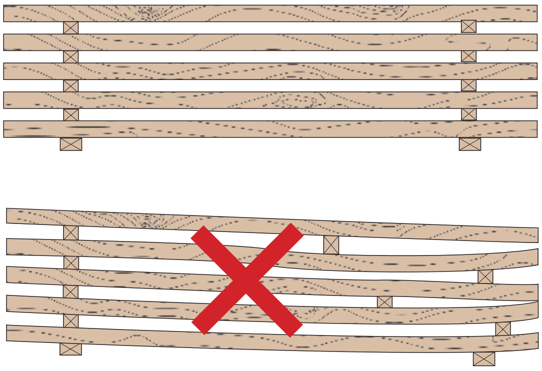

*Metal props packed off the finished surface of a timber panel. (Photo: Xlam NZ Ltd).*

## 6.4 DELIVERY AND STORAGE

The prefab element delivery sequence should be planned and arranged at time of order to match the intended lifting program on site.

Ideally a timely and sophisticated delivery strategy will help to achieve prefabricated elements are delivered, lifted, and installed seamlessly from the delivery truck. This should also include the correct loading sequence and loading plans for elements to avoid double-handling on site, as much as possible. Double-handling, whether on-site or at off-site storage, may affect the loading and delivery sequence.

Where intermediate storage is necessary, elements must be stored dry and level on suitable supports. Engineers may be called upon to design supports or temporary works.



*Store prefab product dry, level, evenly supported, and off the ground.*

As an example, depending on panel thickness, solid timber panels may be stored dry, level, and at least 100mm off the ground on bearers spaced at 2m max c/c.

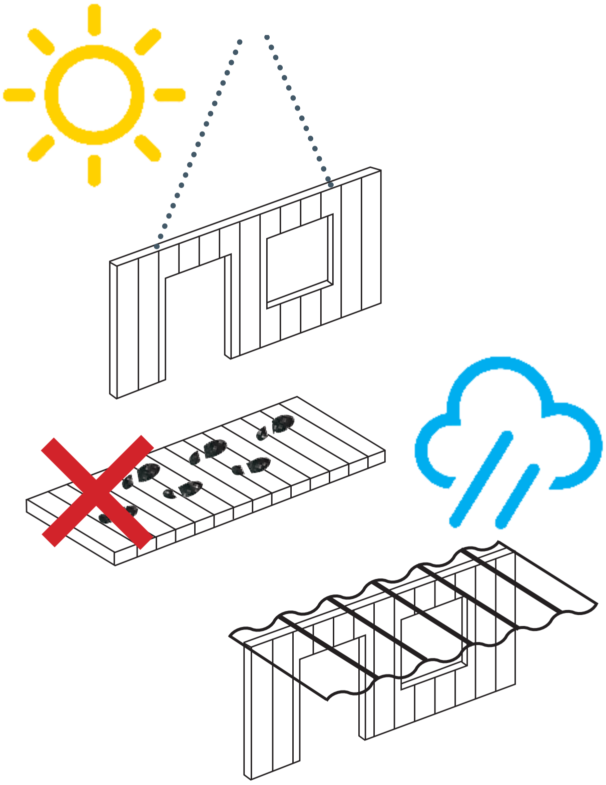
Off-site storage and the associated logistics may need to be considered in case of large volumes or construction sites constrained by lack of space.

## 6.5 ERECTION

### 6.5.1 General comments

Efficient erection of prefabricated elements and systems on site is the result of a well-planned supply chain from the factory to assembly on site. Following are some key points to be considered:

- Health and Safety procedures.
- Sequence/programme.
- Hybrid Construction where prefabricated elements connect to other components on site.
- Lifting and positioning.
- On-site Modifications.



*Assemble during favourable weather conditions (top)*
*Avoid marking/damage of prefab elements on site (middle)*
*Protect prefab elements from weather events (bottom).*

### 6.5.2 Sequence

Prefab element delivery sequence should be planned and arranged to suit the intended lifting programme on site to minimise handling and storage requirements.

3D BIM models of sufficient Level Of Detail (e.g. LOD = 400) can be very useful for analysing the sequence and logistics required on site. Sophisticated models for large projects may include crane movements and trace the route of individual elements to their final destination. This 4D time-analysis of the assembly process has the potential to pre-empt logistical issues, optimise the process, and this way dramatically increase the efficiencies on site.

Designers, prefabricators, and contractors are strongly encouraged to collaborate and combine their expertise around a central 3D BIM model when analysing build sequence. Having planned deliveries in detail their arrival on site should be highly predictable and installation efficient.

Accessibility e.g. for inspections or other trades is an important consideration when planning the sequence and timing of assembly and closing in.

### 6.5.3 Hybrid Construction

Where prefabricated elements are to integrate with other elements on site, early considerations around the hybrid nature of construction are very important.

In general, the following can be said about hybrid construction:

- The interface between on- and off-site construction is an opportunity for dimensional (and other) issues to crop up and needs to be managed carefully.

  **ISSUE:** Slab penetrations for pipes to connect to prefab elements above are in the wrong place.
  **DESIGN SOLUTION:** Carefully coordinate slab penetration set out and diameter among designers and suppliers using one central BIM model.

- Off-site elements are typically relatively dimensionally accurate (millimetres) with tight tolerances compared to site construction (centimetres).

  **ISSUE:** perfectly square prefabricated wall panels to millimetre tolerance to be installed on a concrete slab of, for example +- 2cm tolerance.
  **DESIGN SOLUTION:** Introduce a 'sole plate' which is to be laser levelled, packed out, and installed prior to prefab wall panels arriving on site. Alternatively tighten the dimensional tolerances permitted for the concrete slab.

- Integrating other/site-built elements into prefabricated elements comes at the expense of speed on site.

  **ISSUE:** Integrating structural steel posts, beams, and portal frames on site into light timber framed wall panels, which need to be left open and accessible for installation.
  **DESIGN SOLUTION:** Design and specify posts, beams, etc made from engineered wood product instead. These are easier to integrate off-site into a timber system.

Designers of off-site systems need to understand site build tolerances and issues such as practicality of component placement and fixing before proposing solutions. Prefabricators should be consulted on their typical product dimensional tolerances. Critical elements and critical dimensions need to be identified early.

*Rework delay due to insufficient tolerances. (Photo: Xlam NZ Ltd).*

| CRITICAL ELEMENT | CRITICAL DIMENSIONS |
|---|---|
| Concrete slab/foundation to receive prefabricated elements. | RLs, out of level, etc. |
| Structural steel (posts/beams/portal frames/etc). | RLs, column set out in plan, tag/weld/splice plates. |
| Precast concrete wall panels/stairs. | RLs, Out of plumb. |
| Position of site-cast slab penetrations/pipes/sockets. | Set out relative to grid and diameter in plan. |
| Alignment of vertical shafts/risers (incl. lift shaft) through basement and timber superstructure. | Set out and dimensions in plan; RLs for structural connections. |
| Services connection points between/to/from elements. | Set out and dimensions/diameter, relative to gridlines. |

**MATERIAL COMPATIBILITY:**

When integrating off-site elements with site-built elements the compatibility of materials brought together needs to be considered at design stage and communicated to the interfacing trades.
This includes the durability of any fixings and connections.

Examples of compatibility issues for some materials:

| MATERIAL COMBINATION | POTENTIAL COMPATIBILITY ISSUE |
|---|---|
| Different metals. | Galvanic action. |
| Fixings into treated timber. | Potential corrosion. |
| Paint systems. | Non-compatibility of e.g. primer and top coats. |
| Timber bearing on porous material, e.g. concrete. | Wicking of moisture into wood. |

### 6.5.4 Lifting and positioning

Depending on the type of timber system, the preferences of the contractor, and other factors, a variety of lifting systems are available. Systems of slings, spreader bar, plus a crane are a common system employed for vertical lifting and positioning of timber panels.

Depending on the prefabricated element, the lifting system, and other influences temporary stresses may be acting on the prefabricated elements. Standard lifting details and a method statement for the lifting and positioning process may need to be designed, unless these are supplied by the prefabricator and approved by designers.

Experienced prefabricators will be able to contribute pre-engineered and proven lifting procedures and lifting details. In the absence of any lifting solution provided by the prefabricator, engineers may be called upon to design a suitable lifting system and conduct checks on elements resulting from temporary stresses during the lifting process.

Consideration needs to be made regarding lifting axis (strong or weak axis, i.e. panel on edge or on flat) with clear instructions as part of a lifting method statement if necessary.

For example, a 140mm solid CLT timber panel of 10m length (2.8m wide) weighs approximately 2000kg. Lifting of the panel on flat (i.e. weak axis) without consideration of number and location of lifting points may compromise the structural integrity and cause damage.

To aid the (lifting) contractor, shop and assembly drawings for prefabricated elements should clearly identify, as a minimum.

- Overall dimensions.
- Weight of the module.
- Centre of gravity.
- Lifting points and lifting system to be employed.
- Method statement.

**SLINGING USING WIDE LIFTING TIES:**

- Approved wide lifting ties only. Edge protection, especially for finished and visible product, is important. Where a gentle rounding of the corner of the raw material does not matter timber panels can be lifted with wide lifting ties.
- Ties with round cross-section (e.g. chains, rope, synthetics) should not be used.

*Reusable wide lifting ties.*

*Lifting anchors used in combination with self-tapping screws, for lifting of solid timber beams or panels.*

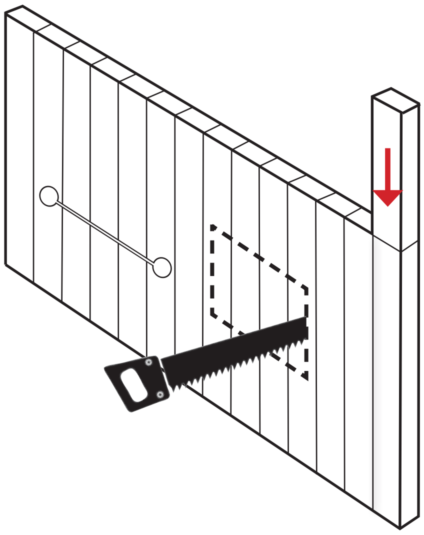
## 6.5.5 On-site modifications

All site modifications of prefabricated timber systems need to be reviewed and cleared by the designers. Just like Late Changes in general, on-site modifications are often a symptom of lack of early collaboration and planning and should be avoided since they may contribute to the erosion of any efficiencies offered by a prefab approach to construction.

Typical on-site modifications of timber systems include:

| MODIFICATION | AUTHORITY REQUIRED | POTENTIAL IMPACT |
|---|---|---|
| *Rebates*, e.g. for services | Structural engineer and Architect; Mechanical/Services engineer. | • Reduced structural strength<br>• Cutting timber exposes wood grain with no or lesser treatment. |
| *Penetrations* through panels or structural members (e.g beams and posts) | Structural engineer (and Architect). | • Structural integrity of the member is compromised.<br>• Cutting timber exposes wood grain with no or lesser treatment. |
| *Additional loads* | Structural engineer. | • Member is undersized for additionally imposed load. |

Where site modifications involve cutting or machining treated timber, any site-cut surfaces may need to be site-treated to the required hazard class with a compatible treatment system.



# 7 COMPLIANCE: THE CONSENTING PROCESS[8]

## 7.1 GENERAL COMMENTS

The terms **consenting** or the **consenting process** in this guide cover the stages from applying for consent through to issuing a Code Compliance Certificate for a project containing prefabricated building components. This includes the compliance, inspection, and verification requirements of a prefabricated design and its construction.

Generally, the NZ regulatory systems are flexible and able to cater for innovative designs and alternative delivery models as required for prefabricated timber systems. Making use of this flexibility requires thinking strategically about compliance and taking appropriate advice early[9].

The ultimate goal of the consenting process is to ensure the building owner, the Building Consent Authorities (BCAs), and other project team participants can be satisfied all obligations have been met and the project is compliant as per the consented design and specifications.

In line with other guidance documentation available on this topic prefabricated building systems are referred to in this chapter as **Manufactured Building Solutions** and these two labels are treated as synonymous for the purpose of this guide. Manufactured Building Solutions may vary in size and complexity, from individual components, to open or closed panels, to pods or panel and pod hybrids, or even completed buildings.

Regarding compliance, manufactured building solutions differ from traditional site-based building work mainly in following ways:

- The prefabricated components are manufactured in a factory or a similar controlled environment by workers undertaking specified tasks.
- This manufacturing tends to follow a documented, process-driven approach.
- There are usually strong production controls and quality assurance systems in place.

[8]This chapter is based on material published by MBIE: https://www.building.govt.nz/projects-and-consents/apply-for-building-consent/support-your-consent-application/offsite-construction/, and the Guide to Manufactured Building Solutions written by John Gardiner (Building Confidence Ltd) published in 2018 by PrefabNZ as part of the Good Offsite Guide.
NZWood are working on a separate Guide called "Consenting Process for Timber Buildings" which will be available for public download late 2019.
[9]For more complex projects, a regulatory advisor can assist to develop a regulatory risk plan and identify ways to mitigate any risk. They could also help manage the relationship between the Building Consent Authorities as well as the regulatory aspects of the work of design professionals and prefabricators.

## 7.2 HOW THE CONSENTING PROCESS WORKS

### 7.2.1 2-step process

Building consents are issued by BCAs, in essentially a two-step process:

1. **Getting Consent:** The test for a consent is whether the "Building if constructed in accordance with the plans and specifications" will comply with the Code. If yes, a consent is granted.
2. **Code Compliance Certificate:** The second step is establishing if the constructed building complies with the consent (the plans and specifications). If this test is met, then the Code Compliance Certificate is issued.

It is important to recognise that it is when granting the consent (Step 1) that the BCA decides how to gather the evidence that what has been constructed complies with the designers' plans and specifications.

For designers and prefabricators this provides the opportunity to collaboratively propose and inform the procedure for gathering this evidence, as part of the preparation of a building consent application. This is essentially the time for a design team and the prefabricator to think about how to provide evidence to support Steps 1 and 2; e.g. by using the prefabricator's Quality Assurance (QA) system, etc.

The Building Act and the regulatory system also provide a number of tools by which applicants for building consent can prove compliance with the Code (Step 1) and in some cases compliance with the plans and specifications (Step 2).

### 7.2.2 The Tools

For a Consent (Step 1), these may include:

- Compliance with an acceptable solution or verification method.
- A product certification (CodeMark).
- A Multiple Use Approval (Multi-proof).
- An evaluation of compliance using expert opinion and independent testing (often called Alternative Solution)

For the Code Compliance Certificate (Step 2), these may include:.

- A Product Certification (Code Mark).
- Use of a formal Quality Assurance system by the prefabricator.
- Evidence provided by the prefabricator, e.g. photographs, invoices, delivery dockets.
- Inspection of the building by BCA staff (the "classic" model).
- Site observation by design professionals.

## 7.3 IMPLICATIONS FOR DESIGNERS

At time of writing of this guide the demand for prefabricated solutions in New Zealand is outstripping knowledge readily available around design as well as consenting of prefabricated building solutions. Designers, prefabricators, as well as Building Consent Authorities are constantly learning.

Following chapters contain advice helping designers to navigate the consenting process when pursuing a prefabricated approach to building work.

For the purpose of this guide all off-site construction and prefabrication is assumed as "building work" as defined by the Building Act.

### 7.3.1 Early involvement

Early involvement of the BCA will help pre-empt issues and questions otherwise only picked up after the application for consent has been lodged. For large or complex projects this can be facilitated by a Regulatory Advisor.

Designers should endeavour early to understand the BCA requirements, arising from the prefabricated approach and collaboratively with the prefabricator develop a strategy to satisfy these requirements. For example, clarify questions on whether a peer review will be required, e.g. of fire or acoustic designs.
Early involvement is an opportunity to establish common language and understand what is required from each other.

### 7.3.2 Choose robust Quality Assurance (QA) systems

Robust quality assurance is integral to successful prefab construction. Ultimately so the building owner, the Building Consent Authority (BCA), and everyone else involved in the design and build process can be satisfied all obligations have been met and the project is compliant as per the consented design and specifications.

When identifying and selecting suitable prefabricated solutions, designers are encouraged to look for prefabricators with robust QA systems and product assurance in place. While the QA for the work undertaken is ultimately for the prefabricator to demonstrate, being able to demonstrate robust QA systems and product assurance at time of consent application will aid BCAs in minimising, or ideally preventing, their need to inspect the prefabricated building work to be undertaken. In other words, robust quality and product assurance (particularly such as product certification) will help to minimise the decision-making role and ultimately the inspections BCAs would require in the absence of structured and robust QA regimes.

By better understanding a prefabricator's product assurance and QA systems, designers and applicants for building consent are better positioned to pick suitable solutions and demonstrate compliance to BCAs.

### 7.3.3 Application for consent

A *Design Supplement* (prepared by the designer based on information compiled by the project team) outlining the prefab design, performance, and how the system and QA will help to collect evidence during prefabrication and assembly, will go a long way to answer the BCA's questions regarding the use, suitability, and specification of innovative materials, systems, and construction methods.

In order to get a prefabricator's quality assurance systems included in the compliance pathway for a building consent, the applicant needs to include information about these systems in the building consent application. The Building Act allows this information to be included as part of the building plans and specifications. If the BCA disagrees with the proposal without good reason, building consent applicants can apply to the Ministry for a 'Determination'.

## 7.4 IMPLICATIONS FOR PREFABRICATORS

### 7.4.1 Use good quality assurance systems[7]

In inspecting, the BCA is establishing that the building work complies with the consent and the Building Code. Most good quality assurance systems are doing just that. For a prefabricator of manufactured building solutions their in-house quality assurance systems can therefore help minimise, or ideally prevent, the need for the BCA to inspect any manufacturing that is building work.

Quality assurance systems of the prefab factory generally have the following attributes which are then integrated into a document called a quality manual by the prefabricator:

- A quality policy setting out the general quality-based objectives of the prefab organisation, the broad allocation of quality related responsibilities and the target level of quality.
- The specific organisation structure and responsibilities.
- Key processes including controls over purchasing and task allocation.
- Regular reviews or audits to make sure quality policies are being followed (these can be done by internal and/or external parties), and
- Mechanisms to record quality problems and to analyse these and change processes, tasks or materials as appropriate.

MBIE's product assurance guidance to prefabricators highlights further ways to demonstrate prefabricated products and systems comply with the performance requirements of the Building Code. Product assurance options[10] for prefabricators include:

- Summarising key features of a manufactured building solutions in a product technical statement.
- Membership of a relevant industry association and evidence of compliance with any testing standards or quality measures this association may have
- Independent testing or appraisals
- Product Certification (CodeMark) for building products or methods (note that BCAs must accept a product certificate as evidence of Building Code compliance)
- Developing good quality assurance systems for manufacturing,
  or
- A combination of these approaches to suit the project's compliance needs.

By using good quality assurance systems and generally providing good quality information about their product, prefabricators make it easier for the consent applicant and the BCA to collect all relevant evidence required for the successful completion of the consenting process.

Rather than viewing QA merely as a business overhead, successful prefabricators establish and use robust QA systems and product assurance as quality mark to more efficiently navigate the consenting process, while also marketing the associated benefits (quality) to customers.

## 7.5 COMPLIANCE - CONCLUDING COMMENTS

New Zealand's regulatory systems are flexible and able to deal with innovative designs and delivery systems. Quality and easy decision-making by BCAs are enabled by quality information.

Early engagement and open communication between BCA and consent applicant are essential for a smooth and efficient consenting process. Lack of understanding of each other's requirements are typically a symptom of lack of early collaboration with the potential to diminish efficiencies of the prefabricated approach.

The future will be a digital and consistent approach to consenting.

[10]Source: Guide to Manufactured Building Solutions by John Gardiner (Building Confidence Ltd) published as part of The Good Off-site Guide (PrefabNZ; 2018).

# 8 PROJECT SNAPSHOTS[9]

## 8.1 Oakura House

| | |
|---|---|
| Location: | Oakura, Taranaki |
| Client: | A & K Hinton |
| Main Contractor: | Chris Bell Construction |
| Architect: | Boon Modular |

| | |
|---|---|
| Engineer: | BCD Group |
| Completion date: | December 2018 |
| Prefabricator: | Woodspan Ltd |

**DESCRIPTION:** The Integration of 3D design technology with off-site prefabrication utilising Woodspan PLT mass timber floor and roof systems and the efficiencies this enabled around design, onsite accuracy and speed of build meant this residential dwelling for a local family was delivered by the team from Chris Bell Construction within a tight timeframe, significantly faster than traditional build methods. *(Photos: Woodspan Ltd)*

## 8.2 STRONSAY LANE

| | |
|---|---|
| Client: | Private owner |
| Main Contractor: | Spanbild Projects Ltd |
| Architect: | In-house design |
| Engineer: | In-house design |

| | |
|---|---|
| Completion date: | May 2018 |
| Construction time: | 9 months |
| Prefabricator: | Concision |
| Prefabrication cost: | $110k |

**DESCRIPTION:** This project was an in-house designed 90m2 residential dwelling for a hill-side section on the Port Hills in Christchurch. The design focused on thermal efficiency and air-tightness to create a year-round comfortable indoor climate.

The dwelling consisted of 5 floor panels, 3 external deck panels, 17 wall panels and 3 roof panels. The panels were fabricated including insulation, air-tightness membrane, wall cladding, modular electrical wiring, plumbing and recessed uPVC windows. Fabrication took 9 days and installation on-site was completed in 2 days. *(Photos: Concision)*

## 8.3 LEMONWOOD GROVE PRIMARY SCHOOL

| | |
|---|---|
| Client: | Ministry of Education |
| Main Contractor: | Southbase Construction |
| Architect: | Stephenson & Turner |
| Engineer: | Lewis Bradford |
| DfMA Consultant: | Offsite Design |

| | |
|---|---|
| Completion date: | End 2016 |
| Construction time: | 9 months |
| Prefabricator: | Concision |
| Project Cost: | $6.5mio |
| Prefabrication Cost: | $1.1mio |

**DESCRIPTION:** This project was part of the MoE innovation tender. The design & build project covered a 2000m² school, which included 3 learning hubs, a hall, library and admin area.

Early design involvement resulted in the project being optimised from the out-set for manufacture and assembly with typical panel length of 12.0m. The project is made up of 68 closed warm wall panels and 140 warm roof panels, which were fabricated and installed in just under two months.

The use of prefabrication meant the school managed to meet an ambitious deadline and was able to open at the start of 2017, a requirement by the Ministry of Education. *(Photos: Concision)*

## 8.4 CARTERTON DISTRICT COUNCIL

| | |
|---|---|
| Client: | Carterton District Council |
| Main Contractor: | Holmes Construction |
| Architect: | Opus Architecture |
| Engineer: | Opus International Consultants |

| | |
|---|---|
| Completion date: | October 2010 |
| Manufacturer: | Juken New Zealand (LVL) |
| Prefabricator: | Timberlab Solutions |

**DESCRIPTION:** The Carterton Events Centre is the first civic building to be built in the town for more than 100 years, and incorporates an innovative blend of old and new – the refurbished, heritage Public Library building built in 1881, and a new modern 'Town Hall'.

The Events Centre is located on Holloway St as part of a civic precinct gifted to the town by its founderCharles Rooking Carter. Designed to meet both the current and future needs of the Carterton community and wider Wairarapa region this new facility has been delivered for the Carterton District Council through extensive consultation with over 80 different local community groups.

The auditorium's innovative Pres-Lam system uses locally grown and manufactured LVL as large vertical shear walls held in place with internal post-tensioned high-strength steel rods. The walls rock in an earthquake, absorbing earthquake energy as they move and return the building to a near-vertical position once the shaking stops. LVL is also utilised for 20m span auditorium roof trusses.

The use of locally sourced timber extends throughout the Centre with the majority of the timber structure and finishes coming from nearby Wairarapa forests. (Timber Design Awards 2011; Engineering Excellence; Highly commended)
*(Photos: Jet Productions)*

## 8.5 MINOR DWELLING INFILL PROJECT

| | |
|---|---|
| Location: | Napier, New Zealand |
| Main Contractor: | Stanley Construction |
| Architect: | Sam Curtis Architects |
| Engineer: | Dunning Thornton |

| | |
|---|---|
| Client: | Housing New Zealand |
| Completion date: | June 2018 |
| Prefabricator: | Tallwood |

**DESCRIPTION:** This project had 19, two-bedroom houses constructed in 17 weeks, from site establishment to all houses ready to live in. Bathrooms were prefabricated as pods and finished off site by Tallwood, including any subtrades, e.g. plumbing, electrical, and floor coverings.

Use of defined factory processes in a controlled environment meant quality as well as timeline were able to be tightly controlled and therefore predictable. *(Photos: Tallwood)*

## 8.6 UNIVERSITY OF CANTERBURY – STUDENT ACCOMMODATION (DOVEDALE CAMPUS)

| | |
|---|---|
| Client: | University of Canterbury |
| Main Contractor: | Naylor Love Construction |
| Architect: | Stufkens + Chambers |
| Engineer: | Spanbild Projects Ltd |
| Completion date: | End 2017 |

| | |
|---|---|
| Construction time: | 5 months |
| Prefabricator: | Concision |
| Project cost: | $ Unknown |
| Prefabrication cost: | $2.6mio |

**DESCRIPTION:** This project was a design & build project for 15 two-storey student accommodation units (90 beds). It used prefabricated timber closed wall and mid-floor panels, Metrapanel ceiling, steel trusses and fully prefabricated bathroom pods. The design and build project meant the requirements for efficient manufacture and assembly were able to be incorporated from the outset. Use of off-site componentry meant the contractor was able to meet tight project deadlines set by the client. The first block of units was fully enclosed while the foundations of subsequent blocks still had to be poured. *(Photos: Concision)*

## 8.7 PLANT AND FOOD RESEARCH CENTRE

| | |
|---|---|
| Location: | Nelson, New Zealand |
| Main Contractor: | Scott Construction |
| Architect: | Jerram Tocker Barron Architects |

| | |
|---|---|
| Engineer: | Sylvester Clark Engineers |
| Completion date: | 2017 |
| Prefabricators: | XLam NZ Ltd, Nelson Pine Industries, Potius Building Systems |

**DESCRIPTION:** Nelson's Plant and Food Research Centre houses varied research functions across the seafood value chain, and provides staff with a connective, open environment that promotes collaboration and innovative thinking.

Innovation starts with the building itself. The site on waterfront reclaimed land required a light construction solution, timber being an obvious choice. Apart from 15 m long piles penetrating the old seabed to support a concrete ground floor, all main components are wood. The structural design hinges on the use of locally manufactured, light weight prefabricated engineered timber components. The two-storey offices and administration building incorporates a blend of products from XLam, Nelson Pine Industries and Potius Building Systems.

The main structural support and shear walls comprise XLam CLT panels rising full height of the building. The walls were rapidly installed, and wrapped against weather until the building was enclosed. The CLT walls support a Potius floor fabricated from Nelson Pine Industries LVL, while bracing to the open south wall is provided by elegant LVL cross columns.

Floor levels are linked by XLam CLT stairs which provide a strong design feature to the double height entry. Much of the mass timber is clear-finished, delivering warmth and ambience to the interior.
*(Photos: Xlam NZ Ltd - top left and right. Jason Mann Photography - bottom left and right)*

## 8.8 MOTAT AVIATION DISPLAY HALL

| | |
|---|---|
| Client: | Museum of Transport and Technology (MOTAT) |
| Main Contractor: | NZ Strong |
| Architect: | Studio Pacific Architecture |

| | |
|---|---|
| Engineer: | Holmes Consulting |
| Completion date: | September 2011 |
| Manufacturer: | Futurebuild LVL |
| Prefabricators: | Carters Manufacturing |

**DESCRIPTION:** The Aviation Display Hall is a major new museum facility for MOTAT's collection of historic aircraft.
At over 3000m2, the new building has ample space to accommodate the aircraft and is located on a closed landfill, meaning that it is effectively built on recycled land. Using the unique capabilities of massive LVL (laminated veneered lumber) box beam portal frames, it spans 42 metres, encompassing the great wingspan of the aircraft. The design is a timber interpretation of the hangar form, wrapping meaningful interior spaces within an exterior that provides visual expression and interest from the street. The Display Hall is also designed to function as an education area, incorporating reception areas for students, classroom provision and provision for other specific student needs.
From the outset, sustainable design measures have been an integral part of the overall design approach. The building utilises a ventilation strategy that favours natural ventilation in conjunction with a 'heat chimney' on the north of the building and requires only a low provision of mechanical heating. Glazing to specific areas of gallery space also maximises natural light where appropriate. (Timber Design Awards 2011, Sustainability, Clever Wood Solutions) *(Words: Studio Pacific Architecture)*

*(Photo: Patrick Reynolds)*

*(Photo: Matt Wilmott)*

*(Photo: Patrick Reynolds)*

## 8.9 TE PĀ TAUIRA - OTAGO POLYTECHNIC STUDENT VILLAGE

| | |
|---|---|
| Location: | Union Street East, Dunedin, NZ |
| Client: | Otago Polytechnic |
| Main Contractor: | Naylor Love Construction |
| Architect: | Mason and Wales |

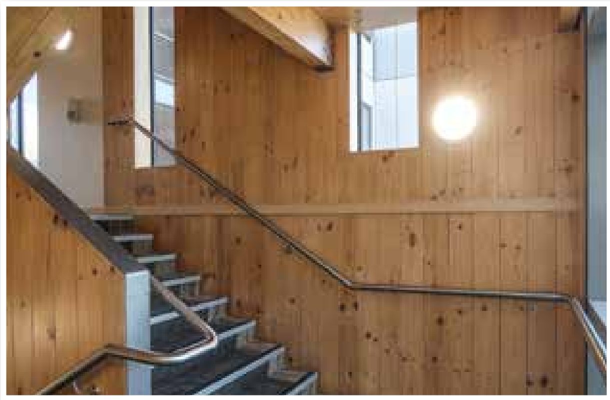
| | |
|---|---|
| Engineer: | Kirk Roberts |
| Completion date: | February 2018 |
| Prefabricators: | XLam NZ Ltd,<br>Nelson Pine Industries |
| Project Manager: | Logic Group |

**DESCRIPTION:** At its completion Otago Polytechnic's student village was NZ's largest mass timber building, with a total floor area of 6000 square metres over 4 and 5 storeys. Building occupancy for the following study year dictated a short construction timeframe which could only be achieved by using off-site manufactured prefabricated structural components to streamline operations on site.

All of the primary structure is XLam CLT, with some additional columns, beams and bracing elements in LVL. Te Pa Taūira entailed a high level of early collaboration between XLam and the project team. CLT panels were trucked to the site in batches to match assembly requirements. The contractor's site team were able to assemble each floor in a matter of days, and completed the construction program in an impressive 15 months.

The Polytechnic also wished the building project to exemplify sustainability to its students and building occupants. Within the budget limitations, the architects adopted the philosophy of the Living Building Challenge, an internationally recognised standard for achieving sustainable construction. The selection of a CLT structure, exposed wherever possible, was central to this approach.

Judges for the 2018 NZ Wood-Resene Timber Design Awards posited this building will help to shape the attitude of a new generation towards timber, citing the modular layout, efficient off-site prefabrication, significantly reduced construction time, minimised waste and reduced cost. *(Photos: Xlam NZ Ltd)*



## 8.10 PARK LANE RETIREMENT VILLAGE

| | |
|---|---|
| Location: | 35 Whiteleigh Avenue, Christchurch, NZ |
| Main Contractor: | Armitage Williams |
| Architect: | Jasmax |
| Engineer: | Engco |

| | |
|---|---|
| Client: | Arvida |
| Completion date: | July 2018 |
| Prefabricators: | XLam NZ Ltd |
| Project Manager: | The Building Intelligence Group |

**DESCRIPTION:** This first of a two stage Arvida rest home facility comprises 29 apartments spread over two to four storeys, offering independent living in a socialised environment including a café, lounge and library within a landscaped setting. The building comprises two linked wings of three and four storeys in a concrete and timber hybrid design comprising concrete up to first floor level and CLT above. As with many mass timber buildings, sustainability and healthy living have been aspirations for the client. The use of XLam CLT as a locally sourced and sustainable material was a critical choice.

The "honeycomb" nature of repetitive residential apartments separated by permanent structural internal walls offered the optimal scenario for economic CLT construction. Other than some light timber framed infills and internal partitions accommodating services, the primary wall and floor structure from first floor up is entirely XLam CLT, making for a highly cost-effective building structure.

Inter-tenancy wall panels are acoustic-battened and gib-lined to achieve sound insulation. Elsewhere, sprinkling the building has allowed visual grade CLT panels and stairs to be exposed and clear-finished as a strong design feature.
*(Photos: Xlam NZ Ltd)*

## 8.11 NELSON AIRPORT TERMINAL

| | |
|---|---|
| Location: | Nelson, New Zealand |
| Main Contractor: | Naylor Love Construction |
| Architect: | Studio Pacific Architecture |
| Engineer: | Dunning Thornton |
| DfMA Consultant: | Offsite Design |

| | |
|---|---|
| Client: | Nelson Airport Ltd |
| Completion date: | 2019 |
| Prefabricators: | Naylor Love (roof panels) |
| | Nelson Pine Industries (LVL) |

**DESCRIPTION:** : Once finished this new airport terminal will measure 105m by 36m and will be part of a relatively small number of airport structures worldwide featuring exposed timber as primary structural material.

The structure consists of 37 laminated veneer lumber (LVL) columns, LVL façade mullions, topped with a total of 56 roof triangles forming an origami-like folded plate roof structure. Rafters and roof beams too are made from locally produced LVL. Custom made and perforated 25mm plywood acts as appearance ceiling and diaphragm bracing of individual roof triangles. The terminal building features an open and transparent façade with the entire building being braced by the LVL columns, with the help of energy dissipating devices to cater for seismic events, in combination with a roof diaphragm.

Individual roof triangles measure up to 19m x 9m each and were prefabricated on the ground using custom jigs in an adjacent empty aircraft hangar which had been repurposed by the main contractor as prefab factory for the duration of terminal construction. The LVL and the custom-made plywood were supplied by Nelson Pine Industries, who were using a state-of-the-art CNC beam processor to precut all LVL components.

Naylor Love led the design and assembly of the various prefabricated components (LVL, perforated plywood, posi-struts, additional roofing layers) into the finished roof triangles before lifting these into place. Gibbons Construction was one of the key partners in the assembly and installation process. *(Photos: Naylor Love Construction)*

## 8.12 CATHEDRAL GRAMMAR JUNIOR SCHOOL

| | |
|---|---|
| Location: | Christchurch, New Zealand |
| Main Contractor: | Contract Construction |
| Architect: | Andrew Barrie Lab, Tezuka Architects |

| | |
|---|---|
| Engineer: | Ruamoko Solutions |
| Client: | Cathedral Grammar School |
| Completion date: | 2017 |
| Prefabricator: | Timberlab Solutions |

**DESCRIPTION:** Cathedral Grammar stands out as an example of what can be achieved with effective collaboration and innovative use of timber design, material selection, fabrication and construction technologies. The expression of the structural LVL frames at a human scale is inviting and invites tactile engagement from the young occupants. (Timber Design Awards 2017, Winner: Commercial Architectural Excellence; Judges comments)

*(Photo below: Patrick Reynolds)*

## 8.13 WELLINGTON INTERNATIONAL AIRPORT TERMINAL

| | |
|---|---|
| Location: | Napier, New Zealand |
| Main Contractor: | Hawkins Group |
| Architect: | Warren and Mahoney |
| Engineer: | BECA |

| | |
|---|---|
| Client: | WIAL |
| Completion date: | June 2018 |
| Prefabricator: | Techlam NZ |

**DESCRIPTION:** Techlam built and fully assembled the curved glulam columns off-site. The controlled environment ensured precision and pre-fitting of joints, allowing transport to site fully finished for final assembly. Using prefabricated components helped to reduce project cost by minimising construction time, and crane time enabling the client to re-open with minimal disruption.

With the construction site located on a working airport the hours available for site-based construction were severely limited which in turn suited a prefabricated approach to construction.

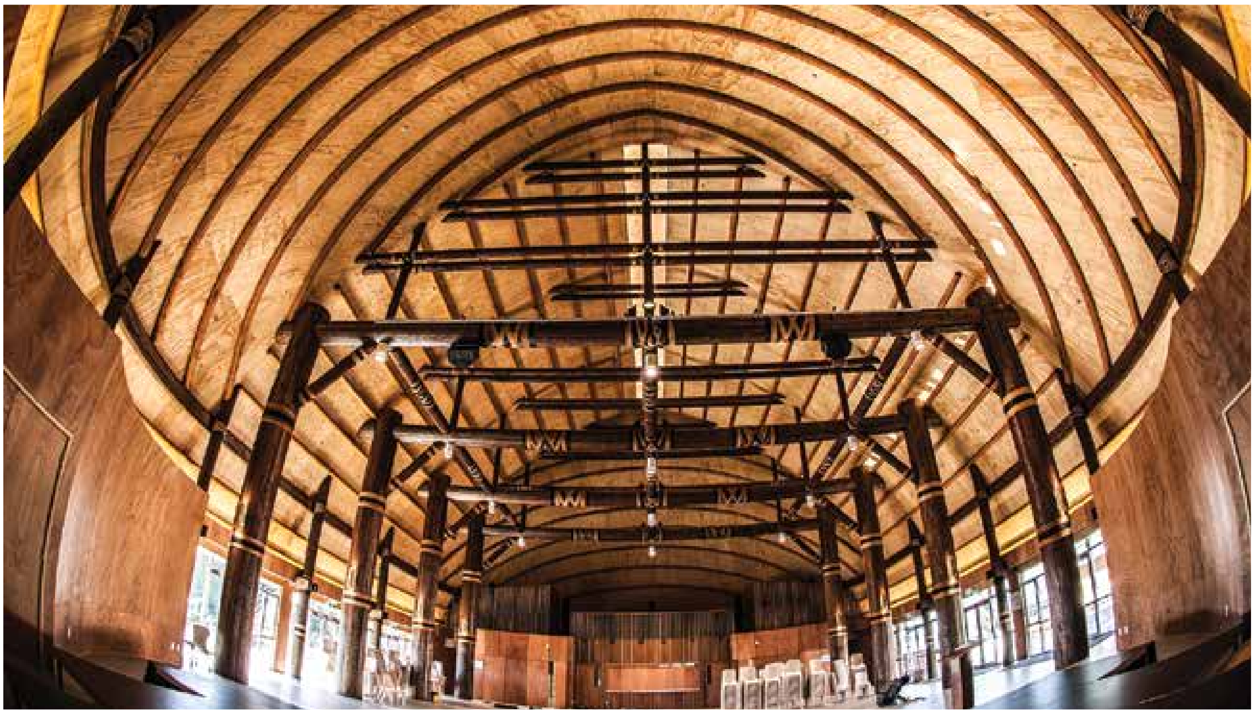
Final assembly on site was seamless enabled by an integrated approach to design and delivery. *(Photos: Techlam NZ)*

## 8.14 THE GOVERNMENT OF SAMOA FALE

| | | | |
|---|---|---|---|
| Location: | Mangere, Auckland, NZ | Client: | Government of Samoa |
| Main Contractor: | Haydn & Rollett | Completion date: | 2017 |
| Architect: | Walker Community Architects | Prefabricator: | Timberlab Solutions |
| Engineer: | Markplan Consulting | DfMA Consultant: | Offsite Design |

**DESCRIPTION:** Traditional building methods have been scaled-up to make a large community space while maintaining the sense of enclosure and detail. Great richness is derived from the shaped and honed timbers with traditional bound joints (tafa). The large and elegantly curved and lathed Glulam rafters suggest traditional fale construction while demonstrating the use of advanced timber machining technology. (Timber Design Awards 2017; Winner: Interior Innovation; Judges comments)

*(Photos: Milti Stefadouros)*



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## ABOUT THE AUTHOR

**Johann Betz** has a degree in timber structure engineering, design, and prefabrication from Rosenheim University in Germany. He also holds a Masters of Engineering in wood technology focusing on the industrial engineering and optimisation of timber prefab operations.

In New Zealand Johann has worked as structural timber engineer and has advised a number of start-up and established companies on their prefab systems and prefab factory operations. His unique background combines structural timber engineering and design expertise with practical and theoretical experience on how to prefabricate in a factory.

Johann is Founder and Principal of Offsite Design Ltd (www.offsitedesign.co.nz), a consultancy providing design and engineering services supporting the delivery of prefabricated timber buildings.

*Top Photo: Bealey Lodge*
*Backpackers Hostel - Xlam NZ Ltd*

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