Woodsolutions – Structural Design of Mid-Rise Timber Buildings

“What is DFMA and why should I care?”

16th May 2019
What is DFMA and why should I care?

• So you’ve started to design your mass timber building, what’s next?
• How do you make it a cost effective structure to manufacture?
• How do you make it easy to build?
• How do you detail it?
• How do you document it?
DFMA stands for Design for Manufacture and Assembly. DFMA is the combination of two methodologies; Design for Manufacture, which means the design for ease of manufacture of the parts that will form a product, and Design for Assembly, which means the design of the product for ease of assembly.
Balancing competing demands
Tips for a cost-effective mass timber building
Top tips

1. Understand the manufacturing process
2. Design to the material not try to fit the material to the design
3. Keep it simple
4. Minimising material volume may not be cheaper option
5. Understand where focus is – design or assembly?
6. Consider pre-assembly
7. Speak to the manufacturer/fabricator
CLT Manufacturing Process

1. Computerised crosscutting
2. Fingerjointing
3. Planing to size
4. Layup & pressing
5. CLT ready for machining
XLam Supply Capability

Manufacturing Capability
• Max billet size: 16m x 3.4m x 350mm thick
• Min billet size: 2.4m x 6m x 60mm thick

Transport Capability
• 12m x 2.5m – relatively simple to most mainland sites
• 16m x 3.5m – possible under special escort
• 12m x 2.2m – for shipping containers

For other manufacturers refer to their specific guidance
Model to Panel Process
Step 1: Model and Panelise

• Reverse engineer model to individual panels (panelisation)
Step 2: Installation sequence to panels

• Give panels an install sequence panels based on delivery and site conditions
Step 3: Nesting and Arrangement

• Nesting individual panels onto sequential billets based on type, thickness and grain direction
• Arrange billets into deliveries
Step 4: Create Detailed Delivery and QA Drawings

Please note: smaller panels must be stacked on top of larger panels despite installation sequence.
Step 5: Machine Tool Assignment

• Billets moved from CAD software into CAM/CNC software
• Tools and process order assigned for most efficient production
Step 6: Processing (under supervision)
CNC Machining
The right tool for the right job

100 x 100 x 10000mm Halflap cut

Please note: this table if for comparison and is not a true reflection on overall tool efficiency, as some tools are better suited for different processes.

<table>
<thead>
<tr>
<th>Tool</th>
<th>Timing on Machine (mm:ss)</th>
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<tbody>
<tr>
<td>Universal Mill 1</td>
<td>05:26</td>
</tr>
<tr>
<td>Universal Mill 2</td>
<td>12:47</td>
</tr>
<tr>
<td>40Ø Finger Router 1</td>
<td>44:01</td>
</tr>
<tr>
<td>40Ø Finger Router 2</td>
<td>07:50</td>
</tr>
<tr>
<td>22Ø Finger Router</td>
<td>32:40</td>
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<td>03:35</td>
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<tr>
<td>800Ø Circular Saw</td>
<td>02:58</td>
</tr>
<tr>
<td>1000Ø Circular Saw</td>
<td>02:37</td>
</tr>
</tbody>
</table>
Rule of Thumb

If it’s difficult to draw, it’s likely to be difficult to manufacture, transport and assemble
Examples
Simplify panel thicknesses

Less different panels = better chance of minimising waste + simpler detailing and construction process
Residential CLT Design

Small and angled panels should be avoided in design or charged accordingly
Complicated Nesting

3 hours of processing time!
60% processing on machine, 40% on manual handling and rework
Simple Design

- Small panels avoided
- Less angles on panels
More 1 and 2 Complexity, less 4 and 5
Wall – single panel vs multiple

- Two wall panels made in different ways, which one will be the cheapest...?
Wall – single panel vs multiple

- **Solid panel**
  - 28m² timber
  - 9m² waste

- **Multiple panels**
  - 20.5m² timber
  - <1m² waste
Wall – single panel vs multiple

- **Solid panel**
  - 13mins CNC time
  - 2 crane lifts
  - Single panel QA check

- **Multiple panels**
  - 30mins CNC time
  - 14 crane operations
  - 7 panel QA checks
Wall – single panel vs multiple

Solid panel
• XLam cost = approx. $3400
• Site install – allow 1 lifts at 15mins = 15mins

Multiple panels
• XLam cost = approx. $3800
• Includes additional fixings
• Site install – allow 7 lifts at 10mins each + 15mins additional fixings = 85mins

It may depend on: site access, transport and crane capacity; but smaller panels in general will be more expensive
Detailing Examples
Alternative connection solutions

- Less processing
- No flipping required
Avoid the need to flip a panel

The blue lines indicate where the saw cuts will be made. This process will require flipping of the panel.

Estimated time to flip and two cuts: 22mins

which adds up to a cost of: $250

No flipping required!
Wall – CNC Castellations vs proprietary brackets

Lots of castellations, rebates and drillings = long time to fabricate
Wall – CNC Castellations vs proprietary brackets

Limited fabrication requirements, simpler to install

I am aware that these solutions have very different capacities...
Wall – CNC Castellations vs proprietary brackets

Castellation
• CNC time = over 2 hours!
• Cost = expensive!

Proprietary brackets
• CNC time = approx. 10mins
• Cost = cheap!
How to document a mass timber building?
Example documentation – typical plan

Panel sizes and spans called up

Treatment under wet areas

Connections referenced on plans (or elevations)
Example documentation – typical details

Revit families and typical details available from XLam!
Example documentation

• Major characteristics like panel thicknesses and span directions
• Any locations where panels must (or must not) be split
• Limits on sizes of panels noted
• **DO NOT** fully panelise
• Detail locations drawn on plans and referenced
• Typical details for all junctions provided
DFMA in action
Iron Creek Bay, Sorrell, Tasmania (15mins from Hobart Airport)

Private developer

3 mass timber buildings
  3 backpackers cottages
  15 three and five bed holiday units
  1 two-storey restaurant and cellar door building

Collaboration with architect and builder from day 1
DFMA Case Study
Holiday Units
Simplest construction option

NOT FOR CONSTRUCTION

Floor material cost: approx $46,000
Transport costs: $8250 (approx 1.5
mucks)
Panel lifts: 15
Max panel weight: 1.75T (1.2T at max
radius)

Pros:
- Simplest construction. Floor spans
over steel beams to give solid working
platform

Cons:
- Least materially efficient in terms of
CLT
- Heaviest lifts

Project: Iron Creek Bay
Sketch Title: SK02 - Pavilion Floor Plan - Option 1
Date: 18/10/18
By: NH
Minimum material option

Floor plan - Option 2

- Propping needed for corner segments until walls and roof are all tied in (or steelwork extends to support it)

- Main support lines from steel beams shown only

- Could we build the sawtooth "wedges" on the ground and lift into place as one unit? Would need propping until it can be tied into the roof as it will rely on this for stability

Project: Iron Creek Bay
Sketch Title: SK03 - Pavilion Floor Plan - Option 2
Date: 18/10/18
By: NH
Final model

- Saved more than 1 day per unit – 4 weeks saved from overall programme
- Beams on top of roof for clean soffit below
- Roof shape simplified for increased efficiency
Backpackers Cottages
DFMA Case Study

- Roof pitch reduced by 1°
- 3 wall panels became 1 – slightly more material but savings on fixings
- 2 days saved per building
Restaurant
Original Restaurant Roof Concept

- Coffer roof worked structurally but was not materially efficient
- Required a lot of construction on site to minimise lifting
- Off-site production at XLam meant a lot of air was shipped and increased costs
XLam’s Proposed Roof Solution

- Roof orientation even improved solar panel efficiency!
- Folded plate minimised material by using the structure’s overall geometry to do the work
- Geometry allowed all columns on the balcony to be removed for unimpeded views

Roof orientation even improved solar panel efficiency!
Case Study Summary

- Timber structure engineered and certified by XLam
- Over $500k (10%+) reduced timber costs from original concepts
- Overall more than 2 months reduced from construction programme
- First buildings on site in May 2019
- Early engagement has allowed the design to be tuned to deliver true DFMA benefits and savings to the client
Summary

• If a panel looks complicated, it is probably expensive to manufacture
• Understand relative requirements for manufacture and assembly and balance as necessary
• Engage early with fabricators to understand the whole process
• Please come and visit our factory (or another mass timber provider) to learn more!
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XLam

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