Hybrid Design - DfMA

DfMA Design for Manufacturing & Assembly

What is it? What does it mean?

DfMA Design for Manufacturing & Assembly

DfMA is a design approach, where the efficiency of the supply chains products & systems, and the construction methodology for those products and systems, is researched (in the context of a specific project), well understood, and this knowledge is then used to inform design decisions from **early** in the design lifecycle.

DfMA Design for Manufacturing & Assembly

Why is it important?

DfMA Design for Manufacturing & Assembly

The desired outcome of DfMA is a benefit to the project in both cost & time. Both are intimately linked, bothare equally important to enabling growth in mass timber construction, if we can embrace DfMA correctly, we can increase the uptake of mass timber in construction.

DfMA can help us overcome 2 of the main hurdles to increasing the uptake of Mass Timber

Cost

Through considered product selection & design we can lower supply and construction costs from the outset of design, giving timber a better chance of stacking up against other material types. Understanding the right material selection and cost of material and design options early can influence design decisions to ensure a project remains on budget and doesn't carry wasted costs.

Time

By decreasing the time required for manufacturing and the time to get to the point in design where manufacturing can commence, we can increase the output of suppliers. Productivity gains will lead to decreased costs through overhead reduction and more investment in production to keep up with a growing market. Reducing lead times and reducing supply risk (through gaining increased capacity) is vital to ensure developers have the confidence to choose timber options.

Surely designers already do this?

Yes, but….. Mass Timber is different.
It is more complex to design and understand than what we have traditionally used for structural systems.
We need to treat it differently to use it well.

Mass timber is a natural material, this paired with the fact that there are vast differences in supply chains and operational setups across manufacturers (compared with steel & concrete) means there is much more variability in the features and associated costs of the available products from one supplier to the next.

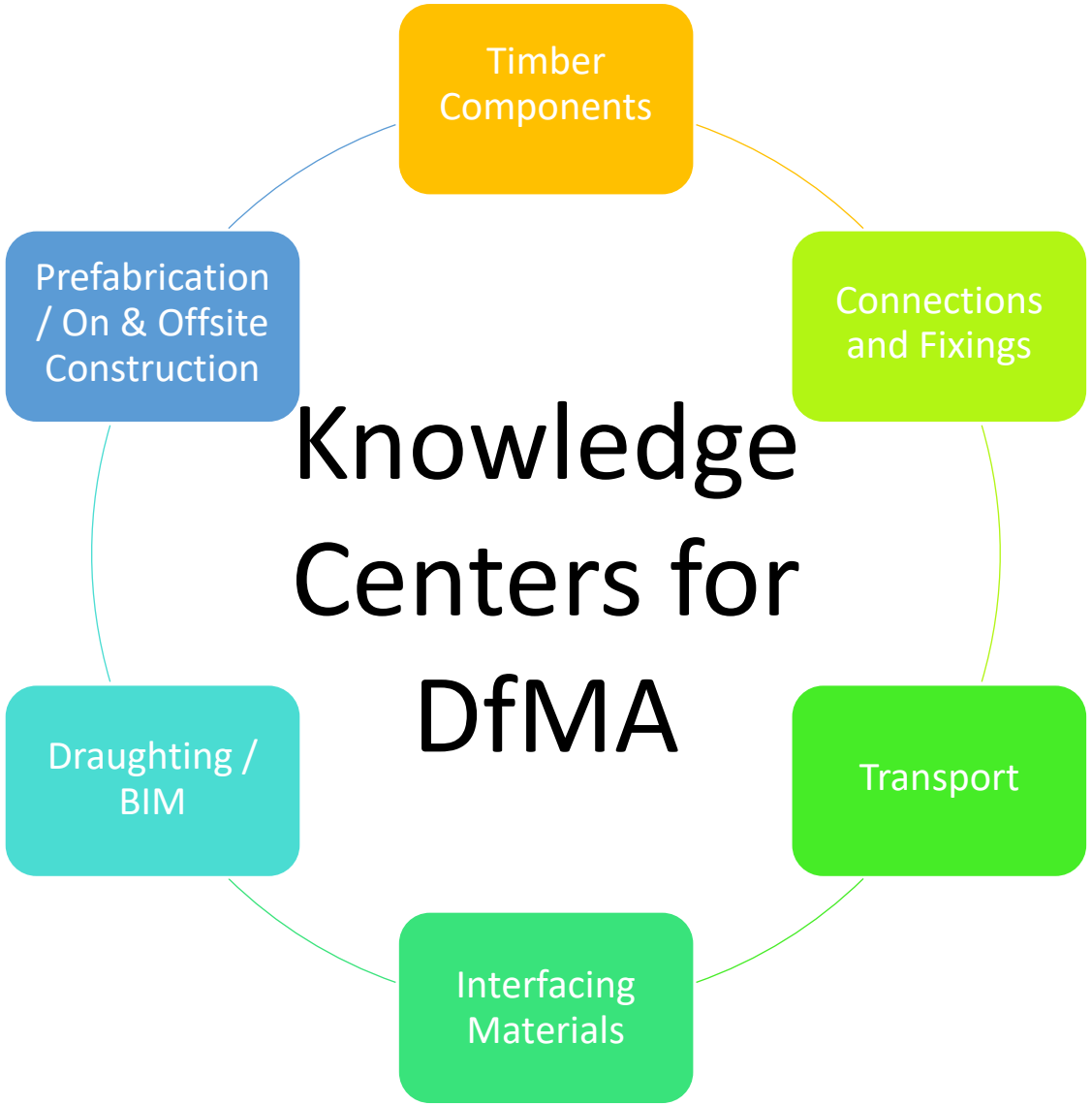
In NZ right now, you can purchase mass timber elements (just the timber, excluding connections & prefab etc.) from $1,500/m3 net through to $45,000/m3 net, compare that with structural steel which could typically range from $10/kg through to $30/kg, that's a 1:30 ratio in price options for mass timber vs 1:3 for structural steel, essentially timber is 10 x harder to design than steel in the cost consideration category alone.

DfMA for Hybrid Structures

In reality, most mass timber buildings are hybrid designs, with at the least a significant portion of metalwork for connections, but often a mixture of mass timber types being used or paired with structural steel or precast walls/frames and of course a concrete slab or podium.

So, what do we need to consider to get the best out of mass timber in hybrid designs.

DfMA is very similar to many other design philosophy's, in that it revolves around using knowledge to enable a considered and holistic approach to form a response.


Timber Components
Connections and Fixings
Transport
Interfacing Materials
Draughting / BIM
Prefabrication / On & Offsite Construction
Knowledge Centers for DfMA

Cardinal Rules!

Use timber where timber is suited, square peg in round hole (that's the point of hybrid)

Don't design timber buildings from a concrete or steel design (changing the colour on the drawings to brown doesn't make it a timber design).

- The second rule above, is what typically forces designers to grapple with the first rule.

Timber Components

- Mass timber types – CLT/Glulam/LVL/Hybrid solutions, each have their own strengths and weaknesses (major & minor axis strengths, durability, ability to be used in varying geometries, machining suitability)
- Within the above types, **section size has the largest impact on cost per m3 to produce**, varies amongst suppliers and products, biggest cost risks are, Panel thickness for CLT, member width for Glulam, member depth and width for LVL as well as billet utilization. Getting this wrong will sink a job financially at concept.
- Geometry of elements, curved/twisted/tapered/turned, all are possible, but most have large cost implications over straight/std product. Very important if designing curves to understand the step changes in laminate sizes for curving laminates. Even single curved items can cost 3-5 more/m3 than straight elements.
- Repetition of members to reduce number of bespoke members, every one-off member decreases output of a manufacturing facility.
- Consider the use of cheaper product types (such as CLT) for use in non-traditional forms, post and beam/portal frames (even if you use more volume of product, it can still be more cost effective).
- Specify correctly and in a detailed way, be careful of blanket specs that influence costs over all components on a job.

Connections and Fixings

- Steel distortion and warping from welding needs to be considered when detailing close fit tolerance items, large & thin knife plates or plates that are expected to bear against timber surfaces, particularly important for visual connections.
- AESS categories for exposed connections when connecting to exposed timber, adds significant cost (specific specifications to nominate different AESS categories for items at different view heights can save big on costs).
- Coatings, consider thickness if part of a tight tolerance fitting, durability for install (paint/powdercoat systems are difficult to keep intact during install) to avoid excessive remedial.
- Predesigned solutions / off the shelf (can provide a large reduction in Draughting time & RFI's), custom/one off brackets are costly to produce.
- Countersinking both sides of a piece of timber is costly (flip on CNC or CNC + manual), consider smooth dowel in place of bolts. Avoid square corners in pockets, will be detailed with a router
- Pilot holes for screws often can't be CNC completed (drill length to diameter ratio not suitable), a lot of manual labour to complete.
- Understand CNC tooling, limitations and cost efficiencies

Prefabrication / On & Offsite Construction

- Consider cost of factory vs site labour, factory labour has large overheads compared with site labour, could be double the hourly rate.
- Real Estate on site, laydown areas need to be checked and aligned with connection and prefab methodology.
- Lifting/Access limitations, crane reach, limiting working at heights.
- If all prefabricated consider making ahead and stockpiling, needs to be planned for in design and shop drawing timing. A fully prefabricated frame can be built faster than can be manufactured.
- Not everything has to be prefabricated or factory completed, most mass timber in NZ is softwood, its easy to work with on site. For every item detailed in factory it needs to be consultant drawn, shop drawn, approved for manufacturing, manufacturing files created and finally detailed. There is a cost, both in money and time to every detail.

Transport

- Wide loads/over dimensional, cost analysis required early in design for transport cost vs site efficiency (may have an impact on time-of-day deliveries can be made)
- Prefab can increase transport costs due to inefficient stacking
- Additional transport costs to consider if going to an offsite/storage facility or prefab y

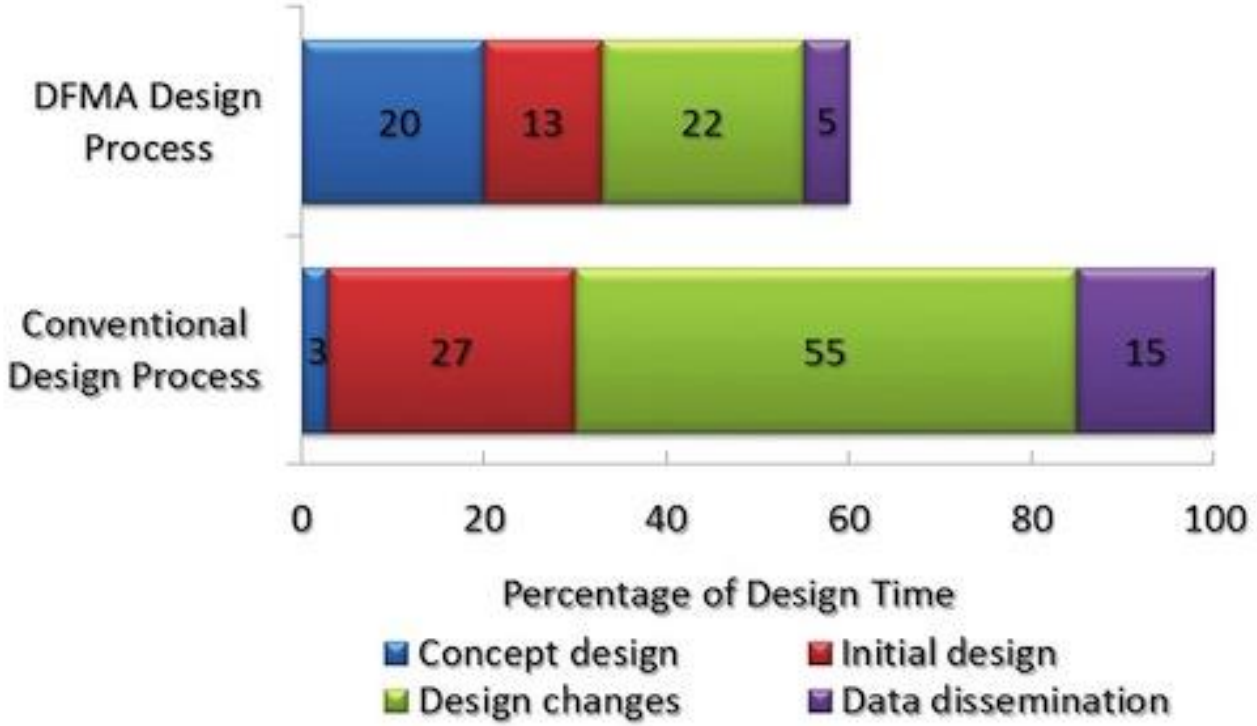
Draughting / BIM

- Roles and responsibilities, design coordination, clash detection, head contractor's role, consultant's role, set the expectations early in a BIM & Drawing plan. Include software platforms/technology that will be used for coordinating and sharing, naming conventions.
- Which trade takes a lead in design and approvals for hybrid buildings? Make a plan based on procurement
- Consider who should model connections in a hybrid building, and how the coordination will happen. Bracket modelling and shop drawing can be as much or more than the timber components on some Hybrid projects. Mass timber teams traditionally aren’t steel experts, a good compromise can be timber team model, but steel fab shop draws from the modeled elements.
- A DfMA and or BIM consultant is a good option for smaller head contractors.
- Amount of unique items has a huge bearing on time and cost for draughting, particularly when considering manufacturing files.
- Designers LOD, completeness and coordination directly relates to manufacturing shop drawing time, manufacturing can only begin after drawings are approved.

Interfacing Materials

- Having exposed timber structures can lead to increased finish quality requirements for the timber and for other materials, not all timber has to be exposed.
- Design for variable movement from moisture and thermal movement between different products, especially important at splices/interfaces & over long structures that involve structural steel.
- CLT, Glulam & LVL will move differently when affected by moisture.
- Carefully detail interfaces with concrete, the tolerances typically can be large.
- Base setout for lowest level of columns is the best place to deal with site tolerances, consider drossbachs's, site welded plates, self drilling dowels or site drilled plates to deal with all 3 axis being misaligned.

Most designs suffer from time constraints, to get the most out of DfMA, do it early!



Front load the design thinking, don’t rush to get a concept out.


Timber
Unlimited
NEW ZEALAND TIMBER DESIGN SOCIETY
Thank you