The use of mass timber – an update

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Abstract

Outside of Europe, the recent rise in the application of a relatively new engineered wood product, cross-laminated timber (CLT), has come at a time when its sustainability properties make it an attractive choice for commercial and residential building construction. From the perspective of building industry professionals who have gained experience with this option, it brings considerable advantages. Internationally, the attributes of CLT and related products in mitigating climate change continue to broaden its appeal. Now a growing number of building professionals in New Zealand are using CLT positively in a range of building projects.

Introduction

The market for mass timber (or engineered wood) products in New Zealand is a small but growing part of residential, multi-residential and commercial building sectors, e.g. the new Nelson airport terminal described in the November 2018 issue of this Journal (Novak et al., 2018). Growth in this market has been constrained by material supply, wood design engineering capacity, the perceptions of developers, and to a lesser extent by misconceptions of material performance in commercial building.

Mass timber is currently a rapidly growing trend making headway for commercial construction in many countries. Cross-laminated timber (CLT) is the most often cited material for what some converts are calling a 'tall wood' revolution. However, it is only one of many engineered wood products helping bring positive change and environmental, construction phase and built-environment advantages to commercial building.

Mass timber describes a building material type characterised by the use of large solid wood panels for wall, floor and roof construction. It includes innovative building forms and non-building structures comprising solid wood panels or structural wood component framing systems of large dimensions. The basic elements of engineered wood products are most often common sizes of structural timber (e.g. 4 x 1 or 4 x 2) used to make CLT or plywood veneers for laminated veneer lumber (LVL). LVL is an engineered wood product that uses multiple layers of thin wood assembled with adhesives. CLT is layers of timber that are glued perpendicular to their adjacent layers – cross-lamination. Both LVL and CLT can be sawn to the desired dimensions. Large post and beam elements are also included, known as glue-laminated timber (GLT).

LVL has been around for some time but it is only in recent years that it has been sawn to specifications (e.g. 90 x 45 mm) to compete head on with sawn lumber, while CLT is relatively new to the New Zealand market. According to BRANZ, over the past 20 years there has been some remarkable progress in the technology using LVL and CLT in building structures (see https://nzier.org.nz/publication/plantation-forestry-statistics-contribution-of-forestry-to-new-zealand).

Internationally, timber for commercial building is undergoing a renaissance, as leading architects and individual developers begin to recognise the combined benefits of wood as a natural material for creating a user-friendly work environment and for decarbonising the building materials used.

Timber engineering specialists in New Zealand have built a long-standing reputation for designing and building uniquely exquisite buildings in wood. However, it is European manufacturers who have led the way with CLT globally. Germany, Austria and Switzerland have been the driving force in CLT development, not only as the originators of CLT products, but also as the leading CLT producers and exporters. As the biggest producer of CLT over the past 20 years, Austria leads the world in production and consumption.

The growth in the use of CLT in commercial buildings has also accelerated quickly in Canada and the US in the past five to 10 years. Both countries have been proactive in promoting the use of wood in building through local and federal governments offering grants and subsidies. This has boosted building starts with a focus on tall wood buildings. The most iconic of these has been Brock Commons, an 18-storey student apartment building on the campus of the University of British Columbia in Vancouver (Pilon et al., 2018). Similarly, in the US, the western states have been the area of greatest interest and activity for CLT buildings, with Portland in Oregon a hive of activity.

Both government and industry in North America have been proactive in promoting wood in commercial building through the use of subsidies, free design services and extensive wood promotion programmes. Timber-specific design software has been developed to nurture interest and expertise for all of the related disciplines of architecture, engineering, design, specification and quantity surveying.

Australian perspective

In Australia, the change to engineered wood in building has been driven by committed and focused companies in both the residential and commercial building areas. Worldwide developer, Lendlease, has been a leader in tall timber buildings in Australia, with a focus on commercial buildings that are attractive for their focus on sustainability and enhanced work environments from wood interiors.

A privately-held company, building contractor Strongbuild, has been leading the Australian building industry in the development of multi-residential wood buildings. They set a new paradigm:

- In Sydney, with Macarthur Gardens providing 101 apartments using 2,600 m^3 of CLT
- At Aveo Bella Vista Norwest in Sydney where they have completed a 10-storey retirement village complex comprising 131 luxury retirement units over two towers using 3,000 m^3 of CLT
- Phoenix Apartments, Rouse Hill, NSW has 134 apartments over six storeys. This build combined lightweight LVL timber-framed walls with CLT floors, the roof and core using 2,650 m^3 of CLT.

Strongbuild had an exclusive partnership with Austrian company Binderholz to bring its product into the Australasian market. The prefab components were built in Strongbuild's 8,000 m^2 manufacturing facility, an extremely precise, automated panelisation facility in Baulkham Hills. Keeping the entire design and build process in-house provides control over price, quality and timing, another advantage of prefabrication.

Architectural perspective

James Whetter, architect, leads the residential team at Jasmax, a New Zealand architecture and design firm. He has had a significant role to play in promoting the increased use of engineered timber in New Zealand, both through projects at Jasmax and in his role as the NZ Institute of Architect's representative in the Timber Design Society. Jasmax have led the way in multi-residential buildings in New Zealand with several large-scale CLT projects.

Whetter says there are three key reasons why he is an advocate for mass timber in buildings:

- The carbon capture is number one – the figures are powerful when you look at the science
- This technology supports local industry, providing local products and local jobs
- Finally, there is the undeniable speed of building on the site.

Jasmax designed one of Auckland's first CLT multi-storey buildings, the Merchant Quarter apartments in New Lynn. The project used CLT as the primary structure for the 25 apartment building. The building needed to be lightweight to sit on top of an existing concrete carpark, plus it had an accelerated building programme. Using CLT allowed it to achieve both requirements.

The Beatrice Tinsley Building at the University of Canterbury under construction. An academic support building in the new Rutherford Regional Science and Innovation Centre, it uses LVL and is a Jasmax large-scale timber project. Photo courtesy of Jasmax

Completed in 2018, and designed by Jasmax, Ara Institute of Canterbury's Kahukura building is one of the country's first built examples of a large-scale (three-storey and 6,500 m^2) timber construction building. Lightweight construction and a significant gesture to environmentally sustainable design, and the use of innovative wood technologies such as CLT in this building, positions New Zealand in line with countries worldwide who are using this design and construction method on a mass scale.

Engineering perspective

Andy Lind is a Director at Engco, Consulting Engineers (Christchurch, Queenstown and Auckland), where a team is passionately leading the way in the design of engineered timber structures. He says, 'We've been busy in the last few years writing the only New

Inside view of Arvida Living Well Park Lane retirement village in Christchurch. CLT panels make for a very natural look inside a building, emphasising the sustainability of the materials used. Photo courtesy of Jasmax

Bealey Lodge, Christchurch, under construction. The speed and accuracy of CLT buildings becomes very visually apparent when the buildings go up much faster than traditional materials in commercial buildings. Photo courtesy of Engco

Zealand design guide for the use of CLT and investing in the testing of timber products. This will assist the engineering and architectural community in the mainstream use of timber for larger and more ambitious projects.'

From the inception of Engco, the team have consistently looked to take a leading role in the structural use of engineered timber, evidenced in designing the Bealey Lodge Backpackers in Christchurch. This was recognised with a Timber NZ Award in 2017 for the first major commercial use of CLT. Engco provided the structural design for the Arvida retirement village where they worked closely with the architect, fire and acoustic engineers. The result has been a lightweight multi-storey structure, with reduced foundation costs, that exposes elements of the timber structure to enhance the quality of life for the residents and the community through the drive towards sustainability.

It is an exciting time of growth for the timber industry. While long being the staple construction material for residential construction, timber has only recently become generally recognised in New Zealand as an alternative material able to achieve the higher strength required for multi-storey and commercial structures. Its use is, however, still hindered by a deficiency in the codified engineering guidance available for practising engineers. With an in-house team of timber specialists, Engco are trying to redress this. The focus is very much on giving cost-effective designs, which means attention to connection detailing and maximising the efficiency of the structural layout during concept design.

Engineered timber provides a high level of robustness and accuracy in the product dimensions, but it remains a 'living' material and requires a greater understanding of durability, long-term creep and response to moisture than is demanded by more sterile materials. While these characteristics require more design thought, the reward is a lighter material that is easier to work with and which champions a greener and more sustainable construction industry.

Project manager and contractor perspectives

The project manager for our southern-most and largest volume CLT building, Otago Polytechnic Student Village (OPSV), was Logic Group. Director Sam Cadden summarised key advantages of working with CLT as:

- Improved collaboration in the early phases and better coordination
- Improved cost estimation
- The contractor takes more ownership
- Value engineering from the outset.

Through the experience of this large CLT building, Cadden confirmed that they expect to be able to deliver this type of project even more cost-effectively in the future through:

- More prefabrication
- Pre-nailed and pre-lined internal walls
- Panelised external walls
- Elimination of scaffolding
- Building the roof on the ground
- Better staging.

He adds that beyond the potential advantages of constructing buildings with CLT there are further intrinsic values, saying, 'We know that workers are less stressed and more productive, students learn better, patients heal faster, and people are generally happier and calmer in indoor areas which contain wooden elements.'

Director of the lead electrical contractor for the OPSV build was Paul Parsons of the Aotea Electrical Group. He noted these issues:

- Early engagement would have been advantageous due to scope and design changes
- Cable access and main routes would have been drilled off-site
- There was no internal scaffolding allowing for clear access
- Fixings for services into wood saved considerable time
- Penetrations through wood made it easier and more efficient
- The building is dry/warm/enjoyable/tidy
- There was pride and passion in the project due to the design and outcome.

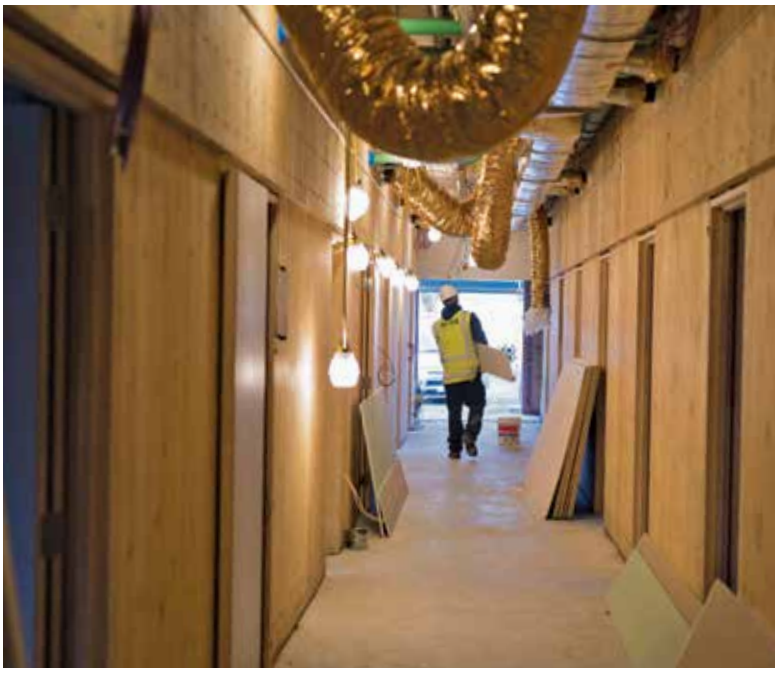
Furthermore, Parsons summarised what is possible when the project manager invites early contractor involvement and engagement: 'If this approach was used on the OPSV, it could potentially have saved 10-15% productivity as planning and coordination in the design phase would have resulted in all trades hitting the ground running.'

North American perspective

The process for mass-timber-construction permitting is about to become streamlined thanks to changes to the International Building Code (IBC) set to be released in 2021. In December 2018, the International Code Council passed 14 code changes relating to mass timber construction that would be included in the 2021 IBC. Among the changes is the creation of three types of construction that set new allowable heights and fire safety ratings for wood buildings.

The current code sees buildings in mass timber, including CLT, as outliers from existing categories, and requires performance-based design for permitting processes. The proposed changes would both define mass timber construction and create three new categories for it, dealing with mass timber that is protected with non-combustible materials, partially exposed, and unprotected, with maximum heights of 18, 12 and nine storeys, respectively.

Thomas Robinson, founder of Portland, Oregon based LEVER Architecture, explains the potential of these code changes from his office in a mass-timber building his firm designed, Albina Yard. He says, 'With this new code, you could say, "If I follow these guidelines, I'm pretty confident that I'll be able to get a permit." That has a huge impact on how owners will



Left: Construction of ground floor structural elements at Otago Polytechnic Student Village. Right: Under construction – many of the sub-contractors commented on the clean and quiet environment, which made their job more pleasant. Photos courtesy of Logic Group

think about investing in these types of buildings, and on strengthening the national supply chain, because people will be comfortable investing in technology and in building new [mass-timber] plants.'

Robinson and his team at LEVER are well versed in timber construction, as co-winners of the US Tall Wood Building Prize for their 12-storey project, Framework. The LEVER team conducted around 40 tests for fire safety, acoustic performance and structural performance to gain permitting for Framework, which was the first wooden high-rise to win such approval in the US. Robinson says his firm's work highlights the opportunity that code changes present to architects who will no longer face the same rigours of testing his team encountered.

What is clear is that the US demand for wood buildings is there. The country's largest producer of CLT, SmartLam, has experienced such rapid growth since opening six years ago that it is building a new headquarters in Columbia Falls, Montana. SmartLam is also planning a second facility in Maine to supply what the industry thinks will be an influx of mid-rise construction in New York and other cities along the Eastern Seaboard.

'The expansion here is simply driven by need,' says SmartLam CEO, Casey Malmquist. 'There's always been a grassroots support for CLT in the US and a recently increased interest in research and testing. But now we're no longer speculating about whether it will work – it's going mainstream.'

While similar Pacific Northwest companies like DR Johnson and Katerra, as well as firms such as LEVER Architecture and Michael Green Architecture, have long led the field, production is growing in uncharted territories across North America. Pioneering European companies, which have historically dominated the market and supplied American developers, are now putting down roots in the US. Austrian giant mass timber producer KLH is partnering with International Beams in Alabama, supplying it with glulam blanks.

Finished project showing exposed wood features and entrance into one of the many student accommodation rooms. Photo courtesy of Logic Group

Mass timber – an efficient solution

In addition to the structural, aesthetic, and environmental advantages, mass timber can be an efficient and practical solution to design challenges.

With prefabricated panels, mass timber construction is fast – approximately 25% faster than concrete. It also results in 90% less construction traffic and 75% fewer workers on the active deck, making it well-suited to urban infill sites.

Because mass timber is lighter than steel and concrete, it can be a good solution for sites where poor soil is an issue.

There is also a trend toward the integration of services into prefabricated elements, such as panels and trusses. The fact that the labour is done off-site means greater quality control and a less hectic job site.

These investments show that the race to build such production facilities is vital to the US market becoming competitive with other countries. However, many experts say we need to increase cultural acceptance of mass timber as well as get investors on board before the industry starts churning up a sizable profit.

'The real strategy is that the big manufacturers in Europe are focused on making franchises here,' says Alan Organschi, Principal of Gray Organschi Architecture in New Haven, Connecticut. 'They can produce higher quality products cheaper, even with overseas shipping, than manufacturers can in the US and Canada.'

The global climate change perspective

In 2015, world leaders meeting in Paris agreed to move towards zero net greenhouse gas emissions in the second half of this century. That is a tall order, and the building industry makes it even taller. Cement-making alone produces 6% of the world's carbon emissions. Steel, half of which goes into buildings, accounts for another 8%. If you factor in all of the energy that goes into lighting, heating and cooling homes and offices, the world's buildings start to look like a giant environmental problem.

Governments in the rich world are now trying to promote greener behaviour by obliging developers to build new projects to 'zero carbon' standards. From 1 January 2019, all new public sector buildings in the European Union must be built to 'nearly zero energy'

standards. All other types of buildings will follow in January 2021. Governments in eight further countries are being lobbied to introduce a similar policy.

These standards are less green than they seem. Wind turbines and solar panels on top of buildings look good but are much less productive than wind and solar farms. Also, the standards only count the emissions from running a building, not those belched out when it was made. These extra emissions are thought to account for between 30% and 60% of the total over a structure's lifetime.

Buildings can become greener. They can use more recycled steel and can be prefabricated in off-site factories, greatly reducing truck journeys. However, no other building material has environmental credentials as exciting and overlooked as wood.

The energy required to produce a laminated wooden beam is one-sixth of that required for a steel one of comparable strength. As trees take carbon out of the atmosphere when growing, wooden buildings contribute to negative emissions by storing the stuff. When a mature tree is cut down, a new one can be planted to replace it, capturing more carbon. After buildings are demolished, old beams and panels are easy to recycle into new structures. Also, for the retrofitting of older buildings to be more energy efficient, wood is a good insulator. A softwood window frame provides nearly 400 times as much insulation as a plain steel one of the same thickness and over 1,000 times as much as an aluminium equivalent.

A race is on to build the world's tallest fully wooden skyscraper. However, such edifices are still uncommon. Industry fragmentation, vicious competition for contracts and low profit margins mean that most building firms have little money to invest in greener construction methods beyond what regulation dictates.

Governments can help nudge the industry to use more wood, particularly in the public sector – the construction industry's biggest client. That would help wood-building specialists achieve greater scale and lower costs. Zero-carbon building regulations should be altered to take account of the emissions that are embodied in materials, which would favour wood as well as innovative ways of producing other materials.

Growing the market in NZ

Beyond the individual business-to-business marketing and information campaigns there are a number of industry-wide efforts that are building awareness among architects, engineers, specifiers, quantity surveyors and developers. These include:

- WPMA design guides – using groups of industry experts, a full set of engineered wood design guides are being created. The first one of these relates to the most sensitive area – fire design
- Red Stag Group – a combined industry/government-funded project to build apartments using CLT at Clearwater in Christchurch and a multi-storey commercial building in Auckland. The project is led by chairman Marty Verry, whose company also plans to build a CLT manufacturing plant in Rotorua. It has gained government funding through the Sustainable Food and Fibre Fund
- WoodWorks – this industry-funded technology transfer service started in 2016 with an annual technical conference entitled 'Changing Perceptions'. From 2019, the WoodWorks service will also provide monthly industry updates on mass timber projects and technical information. This service will gather information from a range of sources, including industry design guides and Red Stag's government-supported building development at Clearwater in Christchurch, amongst others.

Role of government

While not yet resulting in any confirmed policy, there are strong industry efforts to make a change in government policy akin to incentives and requirements implemented in British Columbia, Canada where it is know as a 'Wood First' encouragement policy. Industry leaders are working with the Labour Party and caucus members to gain acceptance for a set of 'Wood Preference' policies. As the previous government signed the Paris Agreement there could be a win-win result if future government-funded buildings were constructed using mass timber produced in New Zealand.

The last word – a tree-hugger's perspective

The last word on CLT timber at this early stage of its development goes to a popular blogger and self-titled 'tree-hugger', Lloyd Alter (www.treehugger.com), a leading Canadian commentator on mass timber trends. He says, 'If you write out the basic facts of trees, but framed as technology, it sounds like impossible sci-fi nonsense. Self-replicating, solar-powered machines that synthesise carbon dioxide and rainwater into oxygen and sturdy building materials on a planetary scale.'

References

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