Mid-Rise Wood Construction

CASE STUDY

UPDATE

CLEARWATER QUAYS

CONTENTS

1. EXECUTIVE SUMMARY

This case study uses a five-level, luxury, residential apartment building to highlight the holistic benefits of engineered-timber construction compared with a traditional steel and concrete approach.

The Clearwater Quays Apartments has a total floor area of 2,130 m2 (including garages) with two open-plan apartments per level overlooking the lakefront of the prestigious Clearwater development in Christchurch, New Zealand.

Combining cross-laminated timber (CLT), laminated veneer lumber (LVL), glulam and panelised framing timber (e.g. structural insulated panels) creates a cost-effective, fast, resilient and sustainable system for mid-rise construction. Engineered timber is not only naturally beautiful but also provides a very strong, low carbon and comparably low-cost alternative to steel and concrete. It is easy to transport, relatively light, and has outstanding earthquake and fire resilience.

Cost comparisons for the Clearwater Quays project across three construction methods; concrete, steel and mass-timber, show that on a materials-only basis mass-timber had the highest cost. However, when the development impacts of the shorter construction programme were taken into account, the mass timber options became the least expensive by 6% compared to concrete and steel and 13% compared to the all-concrete option.

In addition to the financial advantage of mass-timber builds, this case study shows environmental benefits that cannot be ignored. For the Clearwater Quays project, the carbon calculator for the mass-timber building was a nett negative 87,500 kilograms. If the building were to be built in traditional steel and concrete, it would have resulted in 800,000 kilograms of carbon being released into the atmosphere, and over 950,000 kilograms of carbon if concrete alone had been used.

Throughout this document the following key learnings are discussed:

- The need for good communication
- When and how the team should be put together
- Where extra time is needed and where time can be saved
- Material transportation, protection and storage challenges
- The value of using Building Information Modelling (BIM)
- Compromises between fire safety and wood-exposure protection
- The comparison of carbon content between a mass timber build and concrete and steel builds.

2. INTRODUCTION

Mid-Rise Wood Construction is a partnership between the Ministry for Primary Industries (MPI) and Red Stag Investments Ltd.

The aim of this $6.75 million programme is to encourage widespread adoption of precision engineered timber in mid-rise building construction. Since its inception in 2018, the programme has assembled a pool of New Zealand professionals experienced in mid-rise wood building design and construction to help share and grow knowledge and expertise with the broader industry.

This case study showcases Clearwater Quays, a high-end residential development. The Clearwater Quays project is the first in a range of reference buildings of different types proposed under the Mid-Rise Wood Construction Programme.

This document has been designed to educate industry professionals about consenting, acoustic performance, fire risk, façade protection and durability, building envelope performance, cost management and analysis, fabrication and installation, environmental analysis and risk management. It is also intended to support architects, quantity surveyors, engineers, builders, project managers, property owners and developers considering a mass-timber build.

For ease, the document has been divided into four main sections that reflect the phases of a building project: General Considerations, Design, Construction and Learnings.

MID-RISE Wood Construction

RED STAG INVESTMENTS

Ministry for Primary Industries
Manatū Ahu Matua

1. ARCHITECTURAL

The attraction of a Mass Timber Project:

The construction industry contributes roughly 16% of New Zealand's greenhouse gas emissions. Trees sequester carbon as they grow and timber stores this carbon for the life of a building, making mass-timber structures a significant step towards a regenerative form of architecture and thereby reducing net emissions.

For architects, the attraction of working with timber goes beyond the environmental benefits of net-zero carbon buildings. There is a sensory connection to timber and a tactile experience with enduring appeal. Architects know that humans have an innate need to connect with nature, and timber construction plays a part in this connection. Revealing wooden interior surfaces is also a key biophilic design principle for Phillip Howard, the project's lead architect.

The Clearwater Quays Apartments:

The Clearwater Quays project was commissioned by a company with an interest in the timber industry. Showcasing timber both structurally and visually was a driving factor of the design brief.

The challenge for Mid-Rise Wood Construction was to maximise opportunities to highlight the aesthetic and structural quality of timber. This goal was achieved by incorporating dramatic, sculptural staircase structures projecting from the southern façade of each residential tower. These curvaceous forms create a counterpoint to the otherwise linear road-facing southern façade.

The spacious entrance lobby was designed to draw people into the building via a large portico structure. The apartment living areas face north with bedrooms and services areas orientated to the south.

The structural frame of each residential tower is entirely timber including CLT panel floors, and a lift featuring light-framed timber. The only non-timber elements to the structural system are the concrete slab ground floor, and footings. Mass-timber construction is very much the hero of this project.

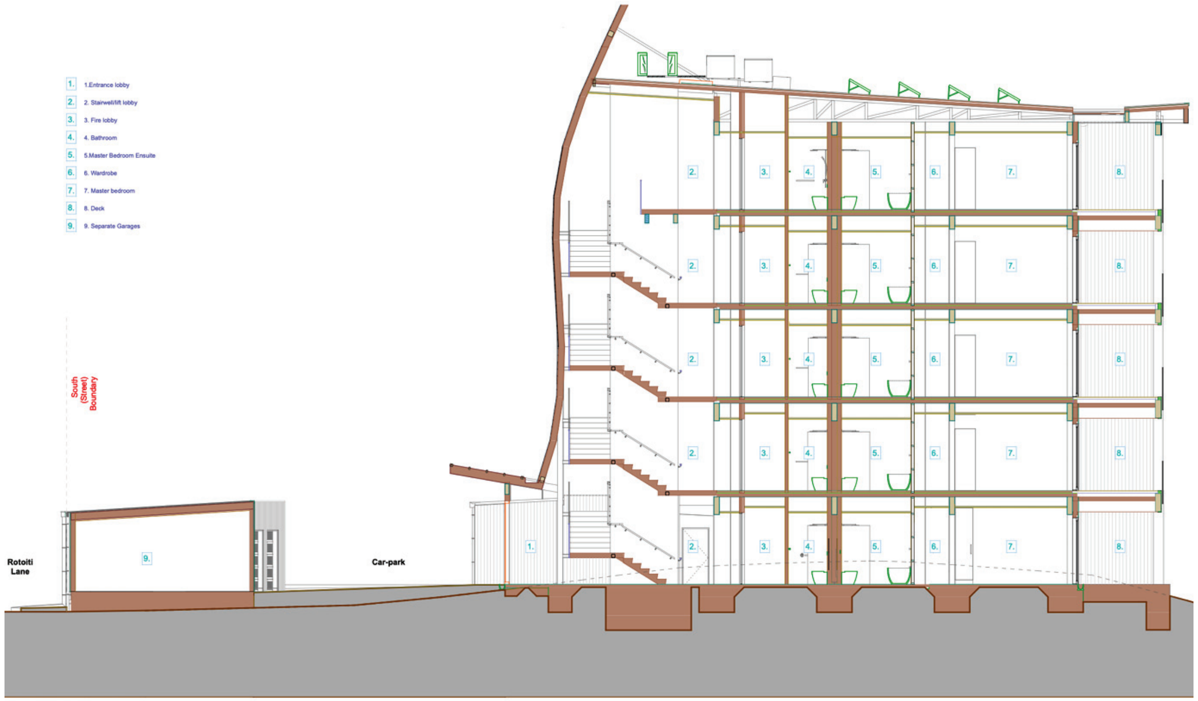
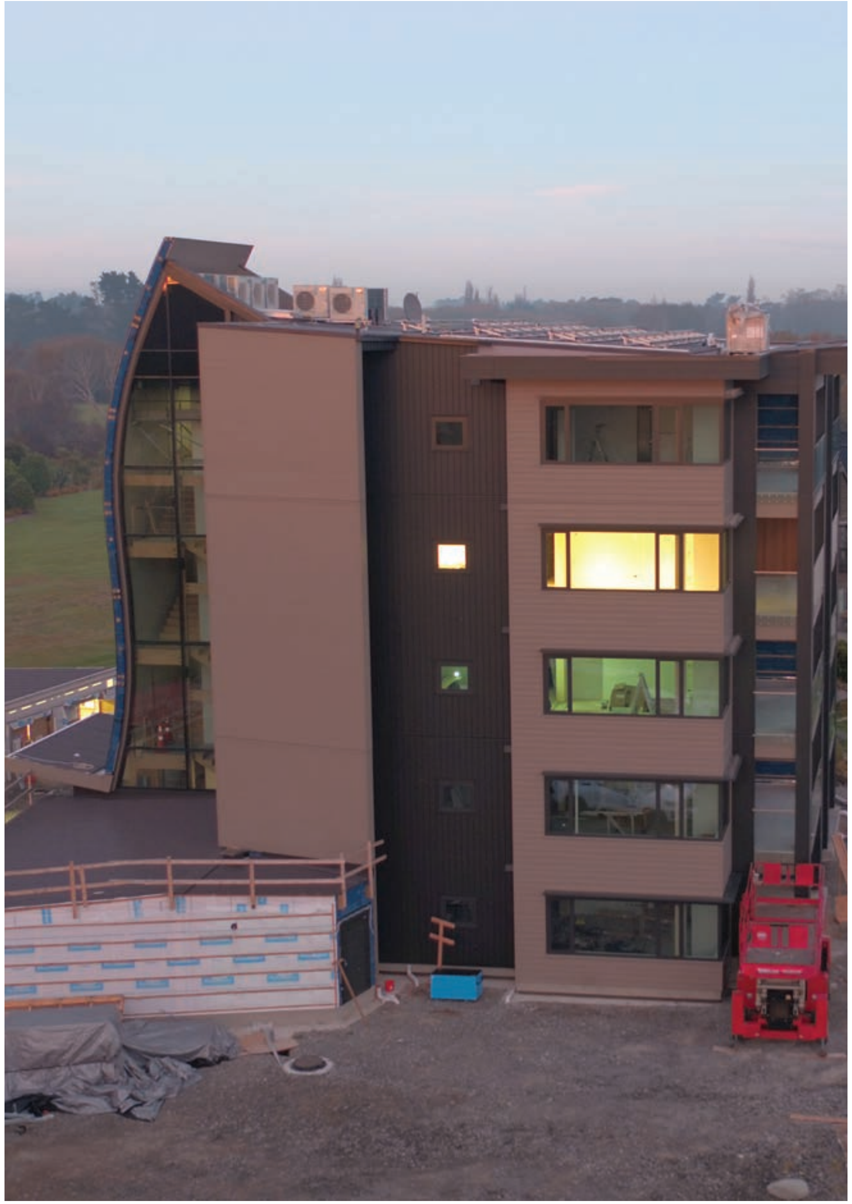


Fig. 1 - *Section through separate garages and apartment buildings*



Construction as of 03 May 2022

2. CONSENTING AND CODE COMPLIANCE

Design & Architecture

A pre-application meeting was held between key council staff, the architects, project manager and key engineers involved in the Clearwater Quays project. This meeting opened up early lines of communication so that contacts, approaches and expectations were set prior to the application for a building consent.

The consenting process for this project was split into two stages: (1) the floor slab and foundations; and (2) the superstructure. Stage 1 was very straightforward as it was a typical gravel raft and concrete construction.

Generating requests for information relating to architectural and structural items during the consent processing were also relatively straightforward although more drawn out due to the two-stage approach, some overlapping detailing between consultants that had to be worked through, peer review and Covid-19 lockdowns. The Council's focus was on the detail as expected considering the relatively unfamiliar primary structural system.

Engineering

The design of CLT is outside the scope of the verification method of NZS 3603:19921[1] under clause B1 of the New Zealand Building Code. Therefore, structural design of the CLT was an alternative solution under the Building Code. The CLT Handbook prepared by FPInnovations[2] was used to provide support for the design and construction of CLT as an alternative solution, and to provide technical information and structural analysis methods for CLT. Eurocode 5 (EC 5)[3] was also adopted to provide characteristic strengths and capacities for structural timber elements that use large-gauge screws and steel dowels, as these types of fasteners are also beyond the scope of the current verification method of clause B1.

Construction

As with a traditional build, the Council reviewed the consultants' site reports for the Clearwater Quays project and addressed any identified issues to ensure everything had been closed out by the consultants and the contractors on site. To date, Council inspections have been consistent with other projects, and the inspectors have been very interested to see how the structure has progressed during construction. The process has been a positive learning curve for everyone involved.

All documentation and requirements around the Code of Compliance remained the same for a mass-timber building as for a traditional steel building. Code compliance certification is no different from any other structure. The builders endeavour to continue to work with the inspectors to assess each apartment as they are finished for a code compliance certificate to help them understand the different type of construction and to develop confidence in the process. By allowing the inspectors to see each stage of the process, the final consent should be easier to obtain at the end with a focus on the main compliance issues rather than doing a final inspection for each apartment.

3. ACOUSTIC PERFORMANCE

DESIGN

Acoustic Engineering

Acoustic engineering is challenging because the human ear is so sensitive that sound must be reduced by 50% to make a noticeable difference. In fact, sound transmission must be reduced by five orders of magnitude to less than 0.001% to achieve the Building Code requirement of STC 55.

The heavy mass of concrete provides an effective barrier to sound so buildings made from heavy materials can be designed to give good sound insulation between dwellings using well-known techniques. There are standard solutions for most situations and, on the whole, acoustic design can be “added on” to the structural and architectural design process. Although acoustic design influences material selection, it does not need to be at the forefront of the design process.

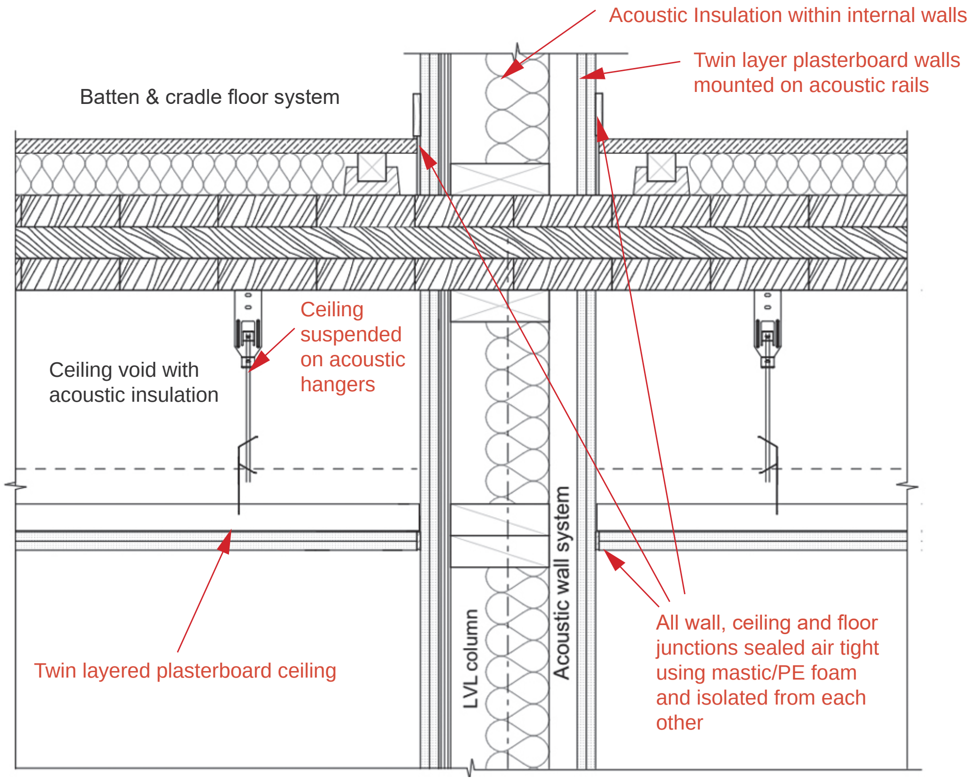


Fig .2 - *Typical Intertenancy Wall with central CLT panel and lightweight linings*

Unlike concrete, wood is light and stiff – ideal properties for converting vibration into sound. Therefore, mass-timber construction needs a quite different noise-control approach, as acoustic considerations must be tightly integrated with the whole structural, thermal, fire protection and architectural design process rather than being added on at the end. It is very important that the structural engineer and the acoustic engineer work together early in the design process and develop the basic building structure with a thorough understanding of each other's constraints.

Wall linings such as plasterboard over an air gap are required to reduce the direct sound transmission through walls and floors. Unfortunately, this approach clashes with architectural desires to expose the natural beauty of timber.
In certain situations, some direct exposure of timber is achievable, but it must be carefully planned. There is also a requirement to control impact sound such as footsteps and likewise a single layer of timber, even one 200 mm or thicker, is not adequate on its own to achieve the Building Code requirement of IIC 55 for impact sound.

Fortunately, considerable research both in New Zealand and overseas (in Canada, in particular) has been done recently into the design of walls and floors using mass timber that will achieve good airborne and impact-sound insulation. As this form of construction becomes more common, further research will focus on optimising designs to achieve Building Code requirements in different situations. However, good walls and floors by themselves are not sufficient.

A more challenging aspect to achieving good acoustics is to limit flanking sound transmission, i.e. the sound that travels between apartments indirectly as, for example, through a continuous floor platform.

Sound will be transmitted into the floor of one apartment, travel underneath the separating wall and re-emerge from the floor of the second apartment. No matter how good the wall, it will be short circuited by the flanking path. For this reason, close cooperation between the structural and acoustic designers is required to achieve optimal outcomes so that transmission paths are interrupted by resilient materials, or such paths are shielded by wall or floor linings. Various types of wall/floor junctions can block or attenuate sound transmission and, by understanding how effective these are, the structural requirements can be achieved together with the acoustic requirements.

The Clearwater Quays project is an example of such integrated design with structural breaks incorporated into floor panels to reduce flanking sound transmission and with double-stud, timber-framed walls that will achieve design ratings of STC 58 and comfortably exceed the Building Code requirements of STC 55 for design and STC 50 for the finished building. The walls incorporate ply in an innovative way to achieve structural and acoustic requirements at the same time, with the same materials, rather than the acoustic design coming at a later stage and being laid over top of the structural design.

Accommodating acoustic requirements in the floor design for Clearwater Quays is more complex than for the walls. A floating floor is required on top of the CLT floor plate to reduce both the impact sound to the apartment below, and the flanking sound to the adjacent apartment. As noted before, a continuous CLT floor plate could reduce the noise-control performance to the adjacent apartment to less than STC 40 and a single CTL floor panel would achieve well below IIC 50 to the room directly below. The solution for the Clearwater Quays build was to install a separate floating floor in each apartment that was sitting on recycled rubber blocks. This approach attenuates sound transmission into the main CLT floor and so controls both impact to below and flanking to adjacent apartments at the same time. A suspended ceiling also provides not only sound insulation in the vertical direction but also reduces flanking sound horizontally.

3.1 DEVELOPMENT'S ACOUSTIC DESIGN CRITERIA

Protection from internal noise

The Clearwater development has been designed to have an enhanced performance above the standard of the NZBC, see T+T design report. The performance criteria for the development are included in Table 4.1. The field or on-site requirement (FSTC) was specified to be 5 points better than the minimum performance standard of Clause G6 (i.e, 55 rather than the Clause G6 minimum of FSTC no less than 50).

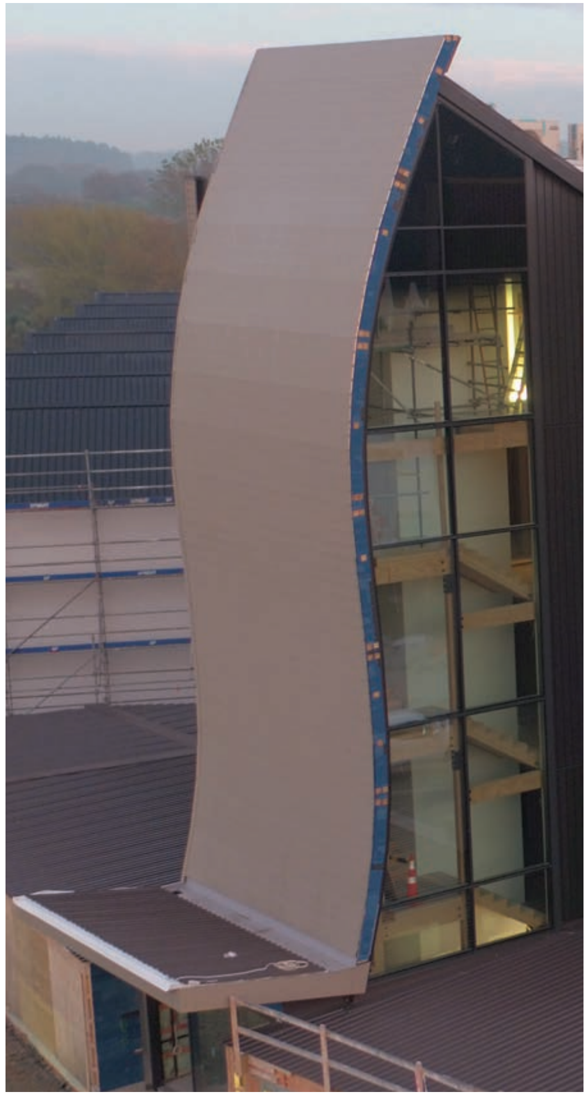
Table- *Development design criteria and minimum requirements for field measurements - acoustics*

Element	Location	Design	Field (on-site)	Verified in this report?
Airborne sound insulation	Walls from common areas to apartments (stairwell) and IT walls	STC 58	FSTC 55	Yes
	Enhanced IT walls	STC 63	> FSTC 55	Yes
	Floors between apartments	STC 60	FSTC 55	Yes
	Floors between apartments (enhanced)	STC 62	> FSTC 55	Yes
Impact sound insulation	Hard floor covering between apartments	IIC 58	FIIC 55	Yes
	Hard floor covering between apartments (enhanced)	IIC 61	> FIIC 55	Yes
Rain noise (40mm/hr)	Apartments	NC 35	NC 40	No
HVAC	Bedrooms	NC 25	NC 40	No
	Living / dining areas	NC 30	NC 35	No
Plumbing noise	Bedroom	30 dB $L_{Aeq\ (10s)}$	35 dB $L_{Aeq\ (10s)}$	No
	Living / dining areas	35 dB $L_{Aeq\ (10s)}$	40 dB $L_{Aeq\ (10s)}$	No

For rain-noise, HVAC and plumbing noise, the criteria are based on acceptable levels of internal noise as established from AS/NZS 2107:20167 and best practice.

Construction as of 3 November 2021

Curved wall to curtain wall interface



UPDATE: Construction as of 05 May 2022


UPDATE: Construction as of 05 May 2022


SMITH

4. COST MANAGEMENT AND ANALYSIS

The cost of a mass timber build compared to concrete and steel

INTRODUCTION

Mass-timber building using LVL, glulam and CLT is a relatively new method of construction. In the past decade, the building industry has seen an increase in interest, due to awareness of climate change and the need for sustainability leadership. This type of interest means that most mass-timber builds have been "passion" projects or statement buildings that have been developed to show the possibilities as well as the direct and indirect benefits of this type of building. The construction of many bespoke mass-timber buildings has involved a steep learning curve for the industry. Most buildings have been architecturally and structurally different and built to stand out as exemplar projects so extracting meaningful cost data from such projects can result in a wide range of information. Using such data can result in invalid comparisons with traditional construction methods, and many projects have defaulted to traditional builds due to this lack of validity.

More recently, the costs of mass-timber builds have been affected by increased industry experience, methodology developments, refined prefabrication techniques and greater competition among suppliers. These factors, combined with more accurate cost estimation software, better understanding of both programme savings and capital return durations, have resulted in more informed cost comparisons. Increasing both the quality and type of information available to developers will continue to increase the uptake in mass-timber builds.

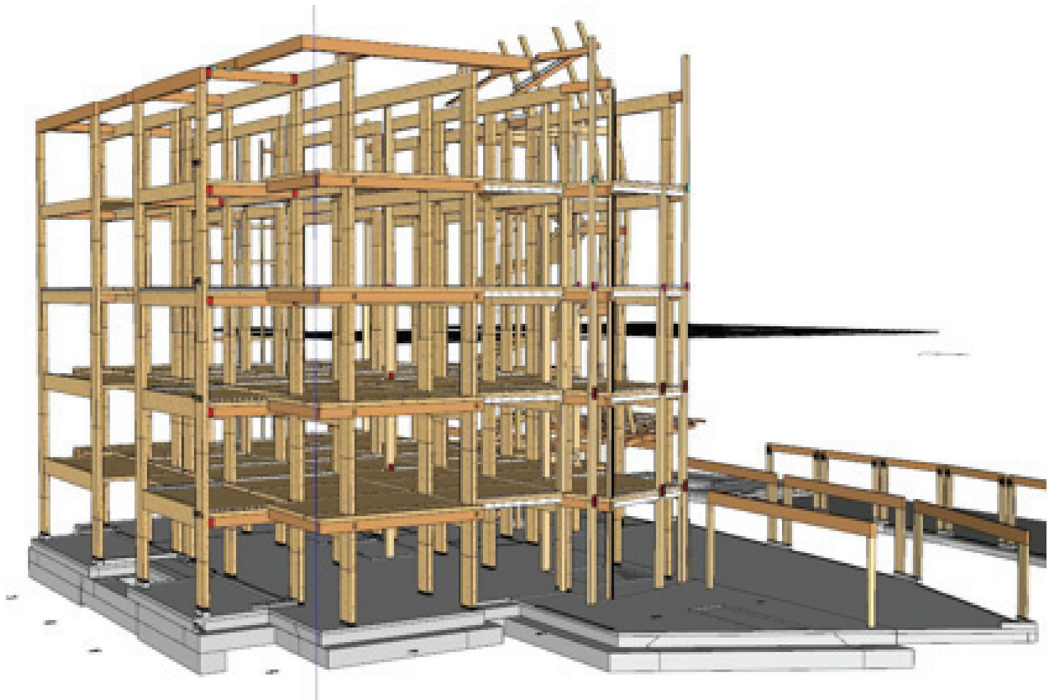


Fig. 11 - *Mass Timber Elements*

ESTIMATION METHODOLOGY

At the outset of this project, the quantity-surveying team built a 'Digital Twin' cost model for the Clearwater Quays development. (A digital twin in construction, engineering, and architecture is a dynamic, up-to-date replica of a physical asset or set of assets). The structural engineer developed alternative designs to sufficient detail for the construction manager to be able to estimate the build programme time and for the QS to be able to price the structure and foundations, and estimate the cost implications of the time saving from constructing in mass timber. The alternative designs were in:

1. Steel frame & concrete floors
2. Full in-situ concrete

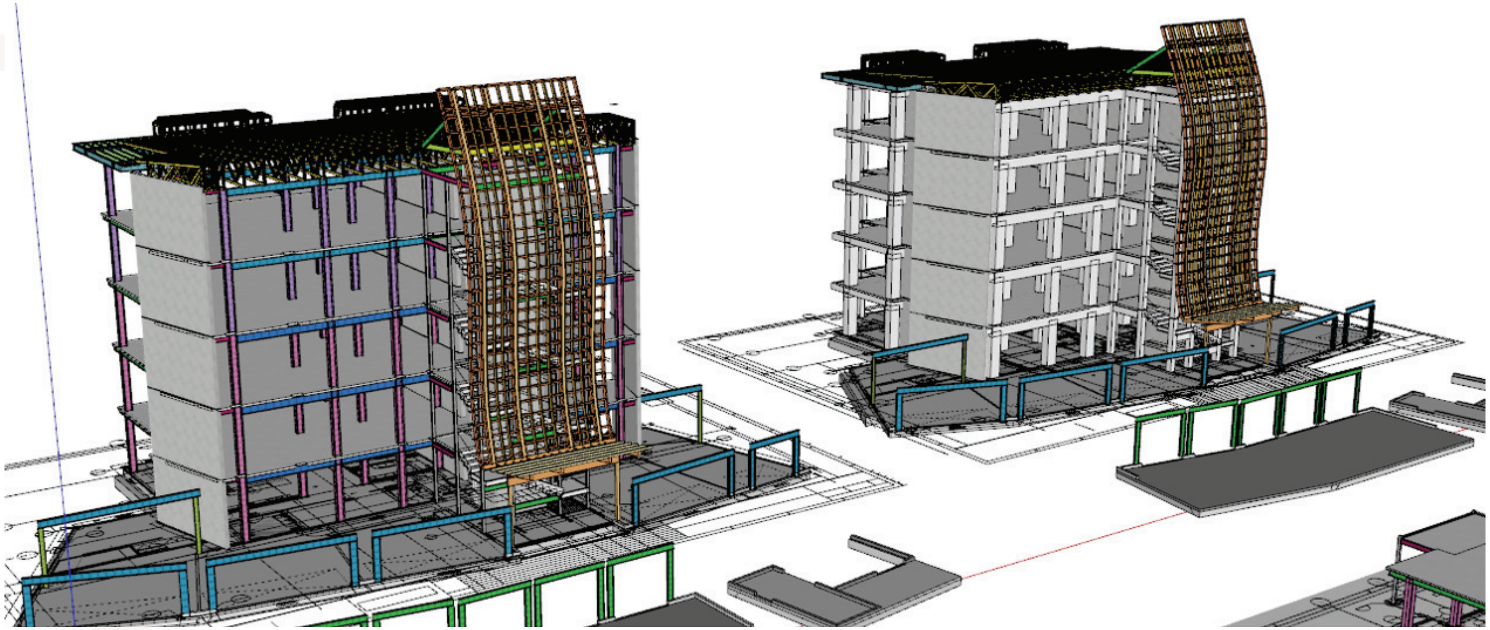


Fig. 12 - *Left: Steel frame & concrete floors Right: Full In-Situ Concrete*

Building digital twin models for the structures was the next best option to constructing these on site. Within these models, design elements were incorporated that would be associated with these build methodologies. For example, CLT floors would require acoustic cradle and batten flooring where concrete floors would not. Mass timber-builds would typically have lighter foundations than other methodologies. The various approaches and considerations of structure, acoustics and fire across each design were addressed and incorporated into the cost estimates.

Utilising a building information modelling (BIM)/virtual design and construction (VDC) approach increases accuracy, and allows cost findings to be communicated in a language that clients and design teams understand. All elements are quickly interchangeable and can be fed back into build budgets. Back and forth discussions with the engineer refined these structures and increased the accuracy of cost estimation.

To fully understand any cost comparisons, there must also be a consideration of intangible inputs within the comparisons. Often such inputs are overlooked or there is simply not enough knowledge or expertise to inform feasibility investigations/comparisons. These are:

- Reduced construction durations
- Development cost - Market risk
- Development cost - Carrying costs
- Development cost - Completion settlement

Typically, the longer it takes to deliver the project, the higher the non-productive costs are. This is true for the construction programme but is also relevant to the developer's capital investment and financing. To put it simply, the longer it takes to complete the project the longer it will take the developer to return capital investment. It leads to longer finance carrying durations, increased risk, and can delay further opportunities to invest in the next project.

FINDINGS

Utilising the above digital methodology has enabled a more robust and detailed cost estimation to be developed than could previously be completed without physically constructing each design. The results of these feasibility investigations are valid at the time of this case study (September 2021). Since September 2020 the cost of concrete and steel has increased relative to mass timber materials, improving the cost advantages of mass timber. The chart below contains typical cost-data comparisons for different types of construction materials.

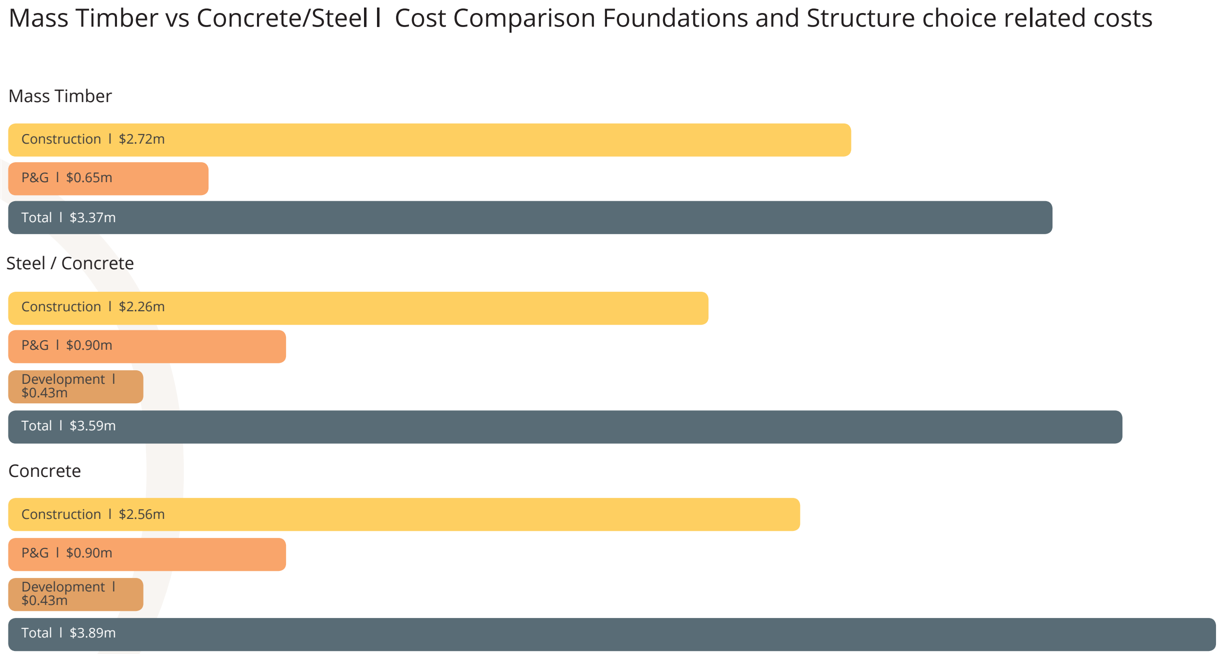


Fig. 13 *- Cost Comparison of Mass Timber, Steel/Concrete and Concrete Options*

Comparisons for the Clearwater Quays project across the three construction methods examined show that on a materials-only basis the mass timber had the highest cost. However, once Preliminary & General were factored in, all-concrete options were the most expensive. When the development impacts of the shorter construction programme were taken into account, the mass timber options became the least expensive by 6% compared to concrete and steel and 13% compared to the all-concrete option.

The development items are made up of the following being applied to each week saved or delayed:

- Market Risk – Adverse property market move risk of 5%/year on a $18m value development
- Carrying cost impact – Carry cost of $3m land, design/consent fees $2m and head office overheads $1m. Total $6m at 5%.
- Completion settlement/redeploy profit – Assume developer re-deploys $2.7 (15%) profit in their next development worth $6.75m at 15% profit in the next year.

It is important to note that development costs will be subject to the developers' own financing model, capital & investment structure, and contractual exposure to market risk. The referenced figures are based on internal calculations for this project provided by Clearwater Development Ltd

The length of time it takes to build a mass timber build compared to concrete and steel, and where savings can be made

Every project has different infrastructures and demands on programme deliverables. Preliminary & General items will usually include project costs that will not physically be left on site, e.g. professional supervision, site fencing, utility costs, insurance etc. On a typical medium sized contract of $10m, the expectation would be for a $30,000 monthly average spend on preliminary and general.

For this project, the Clearwater Quay's construction manager developed alternative delivery programmes for steel & concrete and full concrete structures, and compared these with the known mass-timber programme. (It is worth noting here that the construction manager's background and experience prior to this project had been in traditional building methods, and no allowance was made within the mass-timber programme for efficiencies associated with the learning curve required or lessons and skills attained).

The results of the comparison show that the mass-timber build had a programme saving of 2.5 months. These 2.5 months were saved during what would have been the critical frame-installation process where costs exceeded the average $30k spend and were closer to $70k. Theoretically, savings during this period would have been $175k when compared with an alternative build method.

Less time on site has many positive benefits in addition to the financial benefits discussed above. Using mass-timber construction for the Clearwater Quays project has reduced disruption to neighbouring properties and generated interest that has resulted in positive engagement with the local community. Contractors working on site have noted the positive effects of a cleaner site and floors, reduced construction risk and an enclosed weathered environment earlier in the programme.

In summary, mass-timber builds can be cost effective when compared with other construction method but many factors need consideration to ensure comparisons are fair.

5. ENVIRONMENTAL IMPACT ANALYSIS AND CO_2 CALCULATOR

Design & Architecture

The most sustainable aspect of the building is the carbon sink of the building's structure.

The living spaces are heated via reverse-cycle heat pumps, negating the need for a central heating system. Natural ventilation has been used for cooling in lieu of an artificial system and trickle vents were also introduced to provide make-up air (with acoustic baffles to control exterior noise). Low-E glass was originally to be used just for the bay windows as these have the greatest potential for overheating, but following an upgrade from the glass supplier, all windows will now be double-glazed. Low E. Solar panels will supply the electricity demand to the majority of the common area (lobby and stairwell).

Environmental benefits

The Clearwater Quays project promotes environmental benefits in several different processes. These include:

Carbon – the processes of manufacturing building materials such as concrete and steel produce far more carbon than mass timber. In fact, there is more carbon already efficiently and safely stored within the timber material than produced during manufacture.

Mass timber is a carbon-negative material so using it results in carbon being extracted from the atmosphere and stored in the building material. That carbon storage can off-set the impact from other materials used in the building process, such as steel fixings, cladding systems and foundations.

Wastage – lean construction and minimal waste is synonymous with off-site construction. The core structure of the Clearwater Quays Apartments can be categorised into three main elements: (1) CLT floors replace concrete and steel floors; (2) structural steel is replaced with LVL columns and beams to support these floors; and (3) there are the panelised/prefabricated timber frames. These components have all been manufactured off site in controlled manufacturing environments that utilise technology to control and minimise wastage, which substantially reduced on-site waste output. The Clearwater Quays site was striving to be as close to zero-waste as practicable with all material being sorted before leaving the site. Materials that could be recycled were diverted to the correct facilities.

The use of a QS 3D BIM cost model added significant value in this area. The model not only replicated the construction build and every element, it also accurately quantified every piece of timber, every bolt and tape etc. The model contained information on material specifications, such as sheet sizes, timber supply lengths etc so was able to provide accurate order quantities by unit supply and could produce cutting lists for trades. This process provided key site performance information that encouraged efficient material ordering and use on site.

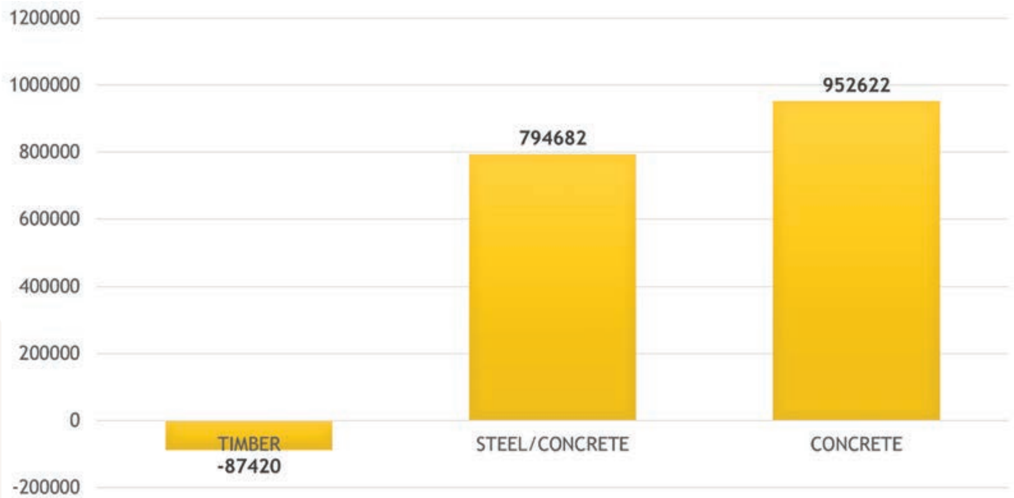
Traffic – Most heavy traffic on site was generated from the movement of material. The biggest saving to time and cost of a mass-timber build is through the use of CLT floors, but this has other positive benefits too. Construction of a concrete suspended floor requires delivery and installation of several individual elements. These include steel decks, timber formwork, steel reinforcing, and of course concrete. All this requires multiple truck deliveries arriving and moving on site. A typical CLT floor level at Clearwater Quays can be delivered to site and installed in less than one day.

CARBON CALCULATION

As discussed above, alternative design methodologies were completed for concrete and steel construction. Using BIM 5D Cost modelling technology, the QS team explored various build options and demonstrated some significant findings regarding carbon footprints. The metadata now stored in the 3D geometry is typically used for cost calculation, but also contains embodied carbon data. Carbon calculation is becoming a major consideration in building projects and can now be automated allowing for quicker and more flexible comparisons across build options. The results allow the client to understand the environmental impacts of their materials choices in conjunction with cost data allowing for more informed decision making.

This system has been refined in house and automated for completing carbon calculation assessment at feasibility/concept design stage. The models can be generated quickly by focusing on the variable core structures only, while the advanced parametric capability allows for quick conversion to the alternative material choice. Live data feedback with referenceable 3D-model information allows for in-depth analysis of different building and elemental options. which facilitates identifying and understanding the sweet spots between cost and carbon results in cost effective sustainable buildings.

For the Clearwater Quays project, the carbon calculation for the mass-timber building was nett negative 87,500 kilograms. If the building were to be built in traditional steel & concrete, it would have resulted in 800,000 kilograms of carbon being released into the atmosphere, and over 950,000 kilograms of carbon if concrete alone had been used.



CO_2	Option Carbon Results
Option	**Upfront Carbon**
Timber Option	-87,420
Steel Option	794,682
Concrete Option	953,622

Fig. 22 - *Carbon released into the atmosphere for Timber, Steel and Concrete builds*

6. PROJECT LESSONS LEARNT

Design & Architecture

Working closely with the structural engineer at the start of the project means that the design process becomes more holistic and symbiotic, whereby innovative structural solutions can help inform design. Ideally this collaboration would extend further with all design consultants, by engaging a contractor early on to facilitate a truly integrated design process.

Many mass-timber construction advocates promote the advantages of a shorter construction programme. This relates to actual construction time on site. However, time in the design process needs to account for the need to produce more detailed construction drawings. With earlier provision of more detailed design documents then the shop drawing process would be as per traditional contract procedures and be part of the contractor's tender.

The design and manufacture of this type of building and material at this stage of its development in the industry is too specialised to allow any subcontractor to just put their design around it. It needs to be designed using early contactor engagement and then tendered.

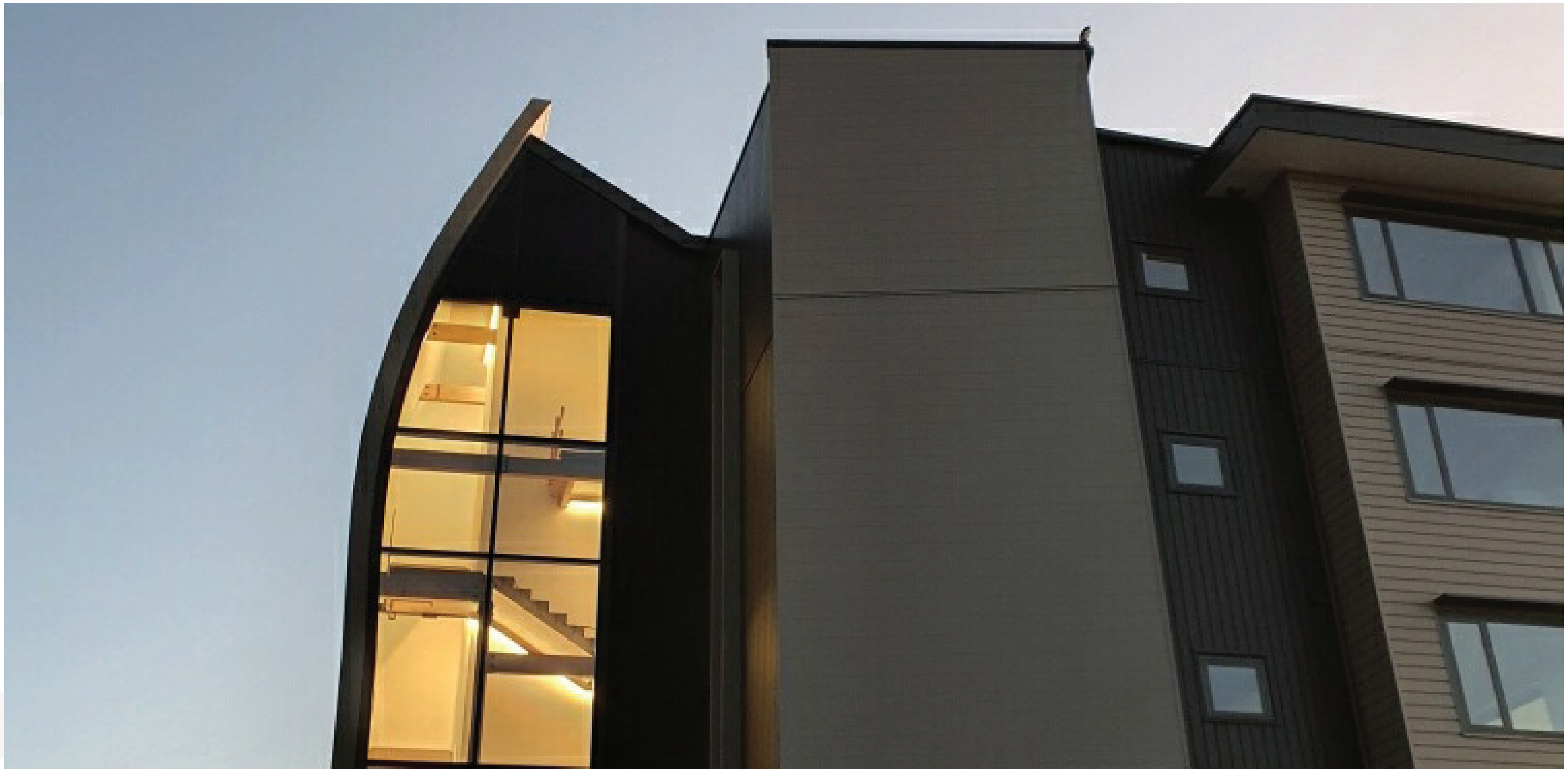
Construction

There is no doubt that competitive supply options in the marketplace mean that mass-timber buildings have a place in today's construction environment and will become more and more popular as they become more mainstream. This is the way of the future. There is still a lot to learn, but good transparency and sharing of information will help.

Lessons Learnt:

- Put the team together from conception.
- Design/Manufacture/Protection/Stacking/Transportation.
- Site set out/handling on site/installation sequencing - The base plate connections to concrete floors are areas that need extra attention paid to.
- Gear/lightweight propping/specialised tooling and gear.
- Correct Gear – Specific impact drivers, drills and batteries are required.
- Specialist fixing suppliers.

- Factory environment - More can be done in the factory environment to reduce time on site like intumescent paint, spring washers or lock nuts, all pre-torqued.
- Lifting plan for LVL 'H frames' - There should always be a lifting plan in place for all mass-timber projects. Although mass timber is relatively lightweight (20% the weight of concrete), the elements are still very heavy. When lifting frames, care must also be taken to have a lifting plan that avoids any twisting as the connections are generally weak in the out-of-plane orientation. The Clearwater Quays project team would always recommend an engineered solution for lifting elements on a building site.



LEARNING

7. FREQUENTLY ASKED QUESTIONS

How difficult is it to get building permission for mass-timber buildings?

The consenting process for the Clearwater Quays project was relatively straight forward. The design of CLT is out of scope of the verification method of NZS 3603:1992[1], so the CLT Handbook, prepared by FPInnovations[2], was used to provide support for the design and construction of CLT as an alternative solution, as well as to provide technical information and structural analysis methods for CLT. Long before the consenting application, a pre-application meeting was held between key designers and key Council staff to set expectations and to open up communication channels. For this particular project, the Council staff have been proactive in learning about the system, including by attending the open days.

To date, the Council inspections have been as per any other project.

Can noise transfer risks be eliminated for multi-residential occupancies?

Yes, noise transfer risks can be mitigated for multi-residential occupancies by implementing the following:

Wall linings: Wall linings, such as plasterboard, over an air gap are required to reduce the direct sound transmission through walls. As this can clash with architectural desires to expose the natural beauty of timber, it is important to plan carefully, so that some direct exposure is still achievable.

Resilient materials: Close cooperation between the structural and acoustic designs is required to achieve optimal outcomes so that sound transmission paths are interrupted by resilient materials, or that such paths are shielded by wall or floor linings. Various types of wall/floor junctions can block or attenuate sound transmission.

Floating floor: A floating floor is required on top of the CLT floor plate to reduce both the impact sound to the apartment below, and the flanking sound to the adjacent apartment.

Suspended ceiling: A suspended ceiling also provides sound insulation not only in the vertical direction but also reduces flanking sound horizontally.

How does the design tackle fire concerns?

It proved impossible to use timber cladding up the entire height of the tower due to fire/spread of flame restrictions. Instead, the Clearwater Quays project opted to use Vulcan timber cladding from Abodo within the deck/balcony areas with CLT floors acting as the fire separation, and for the ground-level garaging and separate garages. The remainder of the wall cladding was extruded aluminium Dualbord and Euro-suite Flashclad products from Flashman Flashing Systems installed in both vertical and horizontal orientations.

As required by NZBC and the Fire Engineering Report, the suspended CLT floors were required to be fire rated for 30 minutes for a fire-sprinklered apartment. The required fire resistance rating for the intertenancy floors was achieved by the fire-test data from the CLT manufacturer.

LVL beams and columns were designed for charring to support the floor during the fire load case. Bolts that were used to transfer the vertical shear from the beam into the column for the fire load case were countersunk up to steel internal gusset with a 30-mm ply plug and were therefore protected from charring of the timber. A 25-mm min plywood sacrificial layer was also provided around the bottom edges of the steel gusset to prevent heating during a fire. Where edges were exposed and not protected from charring, they were intumescent coated.

How does the design tackle moisture concerns?

The external envelope for the Clearwater Quays project was designed to ensure a weathertight system keeping the internal space dry and free from external moisture.

The principle of the aluminium clad façade system was that of a sealed system with a drained cavity. The sealed system (Rigid Air Barrier and Adhesive Wrap) is a solar-sensitive product, so was overclad with an aluminium rain screen to provide protection to the Rigid Air Barrier and Adhesive Wrap. The aluminium rain screen also provides a cavity to the sealed system, that allows for wind-driven rain to get into the system, but also to let it safely drain out without compromising the sealed line. This is in line with good-practice principles used by the industry to prevent water from entering the internal spaces.

Aluminium is a product which is inherently durable and widely used in the industry. It includes bespoke jamb head and sill flashings around the windows to carry the principle of a drained cavity described above through the windows. These have been tested to AS/NZS4284 to ensure they are suitable for use in high-rise spaces.

The fixings of the façade elements were specified to be stainless steel to ensure that they are compatible with the timber substrate and are resistant to rust and corrosion so that the overall system meets load and structural capacity requirements.

What does it cost compared to concrete and steel?

For the Clearwater Quays project, initial comparisons across the three construction methods (timber, steel & concrete, and concrete) examined showed that using a mass-timber method will cost 5% more than steel & concrete when the build cost is considered in isolation. However, this extra cost drops to 1.5%when programme and P&G savings are added. When realised development costs are added, mass timber construction offers a saving of 2.4% over steel & concrete or concrete methods alone.

Is a mass-timber build faster than a traditional build?

For the Clearwater Quays project, the mass-timber build had a saving of 2.5 months compared with steel & concrete. These 2.5 months were saved during what would have been the critical frame-installation process where costs were close to $70k a month. Theoretically, savings during this period would have been $175k when compared with a traditional build.

How does wood compare environmentally?

For the Clearwater Quays project, the carbon calculator for the mass-timber building was a nett negative 87,500 kilograms. If the building were to be built in traditional steel & concrete, it would have resulted in 800,000 kilograms of carbon being released into the atmosphere, and over 950,000 kilograms of carbon if concrete alone had been used.

UPDATE: Construction as of 05 May 2022

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Mid-Rise Wood Construction: https://midrisewood.co.nz/ **WPMA:** https://www.wpma.org.nz/timber-design-guides.html