THE LIVING PĀ

TE HERENGA WAKA – VICTORIA UNIVERSITY OF WELLINGTON

CASE STUDY

WEB VERSION

MIDRISE Wood Construction

Ministry for Primary Industries
Manatū Ahu Matua

RED STAG TIMBERLAB

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INTRODUCTION

The Living Pā project, situated at Victoria University of Wellington's Kelburn campus, serves as a remarkable example of how mass engineered timber construction can significantly reduce carbon emissions while providing an inspiring environment for learning. In this case study, we will explore the sustainability achievements of the Living Pā and emphasize its role as a pioneer in high performance building, with deep-rooted connections to Māori values.

OVERVIEW

The Living Pā project represents an ambitious endeavour to transform Te Herenga Waka Marae, located on Kelburn Parade at Victoria University of Wellington, into one of the world's most environmentally responsible hubs. Spanning 3000sqm the project will extend the marae's capacity to bring people together to learn, live and share a sustainable future. It will be a space not just for the University, its staff and students, but for the wider community.

Full International Living Futures Institute's® Living Building Challenge® (LBC) certification is a central goal for the project. 'Living' LBC certification means that the Living Pā must not only be energy, carbon, water, and waste positive but also actively contribute to the local ecology and community across a wide comprehensive range of imperatives. LBC compliance significantly dictates materials selection for projects. For the pā's structure this means widespread use of timber, including a mass timber structure and timber piles.

The primary objective of the project is to challenge and elevate our understanding of what can be achieved in design, construction, education, and life. By intertwining Māori values and LBC principles, this endeavour calls on all participants to:

- Prioritize Papatūānuku (earth Mother) and the importance of nature to humans.
- Actively seek innovative solutions and push the boundaries of good practices.
- Tackle complex issues by considering them in the context of their system, so encompassing interacting elements, such as, community, equity and inclusion, history, economic models, and ecosystem health.
- Advocate for transformative change in all aspects of the project.

Practical completion is scheduled for October and the building will be opened on the 6th of December 2024. This case study aims to highlight a range of exemplary approaches and processes employed in this ground breaking project.

DESIGN AND CONSTRUCTION TEAM

Client

Te Herenga Waka Marae (client)

Rider Levett Bucknall, Tennent Brown Architects, Dunning Thornton Consultants, 335 Building System Engineers, Wraight and Associates, Tonkin and Taylor, The Building Intelligence Group, Oculus, Morphum Environmental, Holmes Fire, Protech, LT McGuinness.

KEY FEATURES

Project Phase: Construction

At a glance

This initiative involves the redevelopment of a pan-tribal, university-based marae, which already includes an existing wharenui, Te Tumu Herenga Waka. The expansion encompasses a new 3000sqm mid-rise structure characterized by a low-impact engineered timber framework, a photovoltaic array with a capacity of 220kW, an intricate closed-loop water management system, a plan for ethnobotanical planting, and an increase in marae engagement and teaching spaces.

Site Considerations

The project is situated in a high-profile urban location with a 980sqm land area. It occupies a mixed-use site on challenging, steep terrain. The building's foundations rest on variable geological conditions, and it is adjacent to several multi-story institutional buildings, which restricts solar access. The site is a major thoroughfare for campus arrivals and departures, as well as a key access route to the city.

A talking building

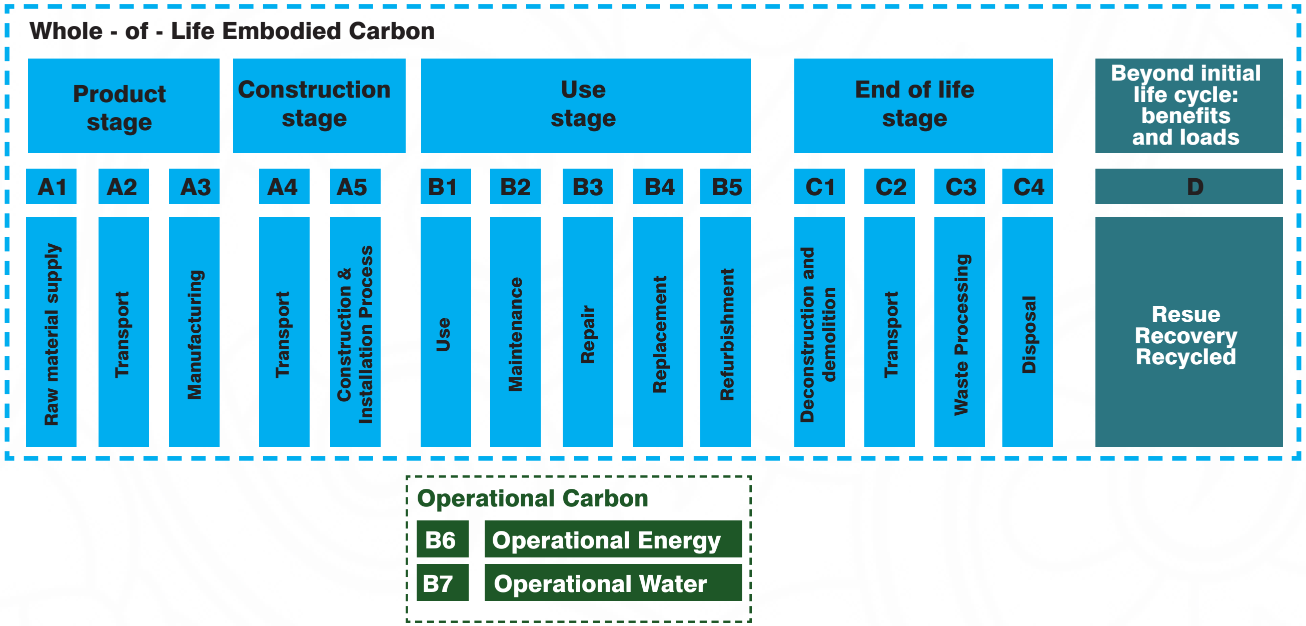
The central ethos of the project is to infuse the foundational principles of Te Herenga Waka Marae, meaning 'the gathering of canoes', into its tangible existence through both the construction process and its future operation. This undertaking serves as a unifying force fostering innovation and research through a building that engages in a meaningful dialogue with its inhabitants - the things we are care and talk about will be clearly manifest for people as they walk through the building. The over arching goal is to function within and across multiple systems, with a core commitment to kaitiakitanga (guardianship) being inviolable.

Sustainability and Carbon

Almost all human activity either directly or indirectly contributes to the climate crisis and it has been estimated that buildings are directly and indirectly responsible for 20% of New Zealand's greenhouse gas emissions, and contribute to a web of significant interconnected problems, such as, persistent toxins in the environment, strains on water systems, habitat loss and more.

It is now widely accepted, the "business as usual" approach to the design of buildings needs to change to address the crisis, and this is done by addressing both embodied and operational carbon through the specification of low carbon materials, minimising waste reduction and using more energy efficient and renewable building systems. Designs however need to extend past carbon and reflect the changing climate by ensuring buildings are resilient and inclusive to the surrounding community that may need to lean on a new building as their surroundings and way of life change in response to a changing climate.

Constructed from CLT and LVL, and with limited steel and concrete, the Living Pā is a carbon store. The project completed a life cycle assessment (LCAs) to ensure carbon savings over the entire life cycle of the building. The building's carbon ratings for everything, from structural materials to the building envelope, services and internal walls, showed emissions of 421kgCO^2 e/m^2 over the building's life or carbon modules A–D in Figure 1. This can also be understood as a 42 percent reduction in embodied carbon impacts and 61 percent reduction in whole of life carbon impacts.



The Living Building Challenge

To reduce the climate impacts of buildings there are several building certification programmes that projects can commit to that will take the client, the design team, the contractor and the end users on a journey to creating a lower impact building. One of these certification programmes is the Living Building Challenge (LBC) and it is considered as one of the most rigorous sustainability standards. This endeavour presents a multitude of unique challenges, each contributing its distinctive complexities.

Living certified projects necessitate significant achievements across seven performance categories and 20 imperatives, each with its own set of requirements. While certain categories, such as energy, water, and materials, focus on technical aspects, others delve into a deeper understanding of place, health, happiness, equity, and beauty. The categories and imperatives are intricately interconnected, and their impact on the community and the environment cannot be overlooked.

The driving theme behind LBC is regenerative design - a whole living system approach that works to mimic, and work with, the surrounding ecosystem. In the case of the Living Pā this has been approached in several ways. From embodied and operation carbon perspectives, it has been designed to be carbon negative using a mass timber superstructure and completely self-sufficient in both water and energy consumption through the use of water retention, on site wastewater treatment and solar power generation. To address the wider impacts of construction and the materials that the building uses, 90% of waste needs to be diverted from landfill and all products need to be verified against the ‘Red List®’. The ‘Red List’ is an ever-growing list of chemicals found to have short and long term negative environmental impacts. Finally, LBC looks to better the project’s impact from cultural and economic perspectives, by focusing on the end user experience through biophilic design, air quality and ensuring the building is equitable to all that use and live around the building.

The decision to pursue Living Building certification fundamentally influenced the design and pre-construction phases of the Living Pā. Given the inherent intricacies of this certification, the project embraced an integrated design process and early contractor involvement as essential strategies. The consenting and construction phases are highly collaborative and demand considerable dedication and resources to address intricate interdependencies, straying from conventional linear construction approaches. Furthermore, the project compels all stakeholders to advocate for change rigorously, supported by empirical evidence. The entire project lifecycle, from initiation to design, construction, and post-occupancy maintenance, requires effective change management practices.

The enticement of the Living Building programme, best sits along Māori whakapapa (relational) approaches to kaitiakitanga (guardianship) responsibilities, and it represents a legitimate endeavour to elevate the bar in the realms of construction, education, occupation, and maintenance. The LBC framework fosters expansive thinking and encourages critical examination of established models, assumptions, and attitudes. Conversely, it urges the abandonment of systems or processes that perpetuate degradation or inequity, promoting values that are both pro- planet and pro-human. By compelling action, the LBC framework serves as a catalyst for market advancement.

Architecture

Architecturally the LBC is a primary focus understood through a te ao Māori lens. In terms of architectural form, the building fills the site, wrapping right up to the Glasgow St retaining wall. Timber as a structural material is embraced, rather than fought. Mass timber is inherently large, and this is celebrated with much exposed timber in finished building. Openness to promote engagement in learning is a key principle, and this is carried through into the interplay between structure and architecture.

The building integrates with the existing wharenui, itself a focus of the project, and the values it represents. Open and interconnected spaces throughout the Living Pā promote engagement in teaching and learning.

Services

Functionally, the building is very ambitious. It is largely passively ventilated, collects its own water, generates all its own power and processes its own waste. Large water storage tanks sit to the west of the building, the roof (and beyond) is covered in solar panels, and a 5-tank wastewater treatment plant sits to the north of the building. The work and collaboration of the client, consultant team, and contractor to realise this vision is very significant.

Mass Timber Structure

The design brief, the sustainability imperative, and the architecture are major drivers of the building structure. Mass timber is used extensively throughout the building, with relatively small amounts of concrete used in the foundations, and steel for connections and heavy structural elements.

Mass timber can have many advantages over reinforced concrete. Because it is light, it is easily transportable, and as it can be easily machined, it can be easily prefabricated. This makes offsite manufacture attractive, and therefore speeds up site installation.

The CLT 'double tees' are a good example of this – a CLT floor with CLT beam webs. They have been prefixed together in the Red Stag factory in around 7.2 x 3.0m panels. They can be easily dropped into place to provide an instantly trafficable floor.

The CLT TTs then typically span onto CLT/ glulam box beams. To give the desirable open spaces through the building, these span nearly 9m, which is high for timber and these beams have significant load. To save time and cost of developing the full shear flow with screws, these have been glued together with epoxy. A half box beam was manufactured and tested to verify the creep properties of the beam. This performed very close to the expected behaviour, with 8.0mm initial and 14mm final deflection predicted, and 7.0mm and 13.5mm observed.

Figure 2: Test beam setup

The box beams then span onto large prefabricated LVL T columns made by Nelson Pine. The columns are made from two 12m tall, 1.2m wide and 300mm thick LVL panels that are held together with 1088 screws. These are the largest elements ever made by Nelson Pine and form part of the seismic system, as discussed below.

Connections between gravity elements generally rely on either bearing, diagonal screws, or both. Corbels and bearing notches have been commonly seen in carpentry and timber construction for a very long time. Diagonal screws are a modern invention- they use large, fully threaded engineered screws, commonly up to 13mm in diameter and 1.0m long. Providing they are correctly orientated on an angle to the shear plane, they will be primarily in tension, and capacities of around three times the direct shear capacity are possible.

To connect with nature, particularly the vegetation to the west side of the building, large glulam planters are suspended at the building second floor. These are hung from large steel tubes at roof level and CLT spandrels at the façade. They laterally brace themselves as a horizontal moment frame.

Seismic Structure

The main lateral bracing structure is a two-way timber moment frame, with bespoke buckling restrained steel dampers as yielding elements. Transversely, there are 2 half portal frames, with a damper providing a moment connection into the LVL T columns, and a pin at the outer column. Dampers run vertically, which essentially makes the beam simply supported with a point load, and a large 'beam column' joint shear at the column. It effectively applies a point moment to the column through a bearing block at one end and a large steel dowel at the other. Longitudinally, dampers run horizontally, with corbels and angled screws into the column.

Timber is strong longitudinally; around 30-40MPa in tension for LVL. Perpendicular to the grain, it is brittle, and much weaker, with around 0.5-1.0MPa in tension – the direction you split timber with an axe. Where seismic forces are present, particular with moment resisting beam column joints, forces tend to be significant and in non-ideal directions. The steel dampers are necked to control forces entering the timber, which is capacity designed. To ensure reliable strength and deformation capacity, as well as controlling the damper overstrength, these were extensively tested. In the case of the LVL T column's 1088 screws, these were designed to stop any cracks forming in the timber, , generally running perpendicular to grain. These are up to 20mm in diameter and 1.1m long.

Timber Superstructure

The Living Pā is the first mass timber building that L.T. McGuinness has constructed and as such the construction planning focused heavily on minimising and managing the existing documented risks associated with such a structure. Some of the key challenges and advantages experienced during the superstructure erection phase are outlined below.

Model coordination and tolerance management - Tennent Brown Architects, Dunning Thornton and L.T. McGuinness worked with the mass timber and structural steel suppliers Nelson Pine, Red Stag and MJH Engineering to coordinate the superstructure through the shop drawing stage in Revit and through intensive shop drawing checks, testing tolerances and constructability considerations before the timber went in to fabrication. Physical models of the building were also made to test erection methodologies. An example of this process working well was the successful install of the 1.8m long, 150mm diameter solid steel pins that were hydraulically pumped through five layers of ~300mm thick LVL with only 2mm of tolerance in the hole. All pins were installed successfully and with no onsite remediation required to get the pins through.

Speed of erection - when Wellington wasn't blowing a gale and the tower crane could operate for a full week, a complete grid of the building could be erected and in the case of the lift shaft, a full lift shaft could be installed in a day. The prefabrication of the timber and repeatability of the general structure allowed for quick install times that could also be refined throughout the project. It was made apparent early however that "just in time delivery" was not a realistic methodology and instead the timber was stored offsite locally and brought to site on an "as required" basis.

Moisture management - one of the biggest lessons learnt on the project, with the methodology being regularly adjusted throughout the project. Dunning Thornton and L.T. McGuinness have worked closely together to refine the process and to ensure regular monitoring of the timber is carried out so that any significant moisture issues could be addressed quickly and before there are any long-term negative effects. The project has used wireless 24/7 moisture meters, handheld moisture probes, fans and vacuums as the primary tools to both monitor and manage moisture build up. The structural specification allows for the timber to exceed 15%MC, but at closing in, the timber needs to be at 15%MC or below. At the time of writing the timber is typically at 15%MC or below which is critical for the intumescent coating on the timber to be applied and therefore all following on fit out stages of the project.

Figure 3: 150 diameter steel pin installation

Southern structure - the southern end of the building was the last section to be erected and differs greatly from the rest of the building requiring a completely revised erection methodology. The advantages of prefabrication were not totally lost, but the speed advantages gained with the repeatability of the structure north were lost, significantly reducing erection speeds and requiring temporary propping not previously required.

WORKING WITH TIMBER

Mass timber is being increasingly used in building construction in New Zealand, and around the world, for its carbon sequestration, desirable aesthetic, strength, and ease to work with. For the Living Pā, Living Building Challenge requirements and an ambitious design brief drove the use of timber in both the gravity structure as well as the seismic structure. For the former, this is common and fairly routine. For the later, highly variable forces push timber to extremes not usually seen in its natural state, therefore additional requirements are needed. Here, ductile steel elements are used to protect the timber, and significant reinforcing is required to protect the timber in its weaker directions, leading to complex joints, such as the one in Fig 4.

Timber is light and stiff and strong when used correctly. It is also very easy to machine and to work with making it an ideal material for offsite construction. Despite its unique structure and highly bespoke design, this building has good examples of this. While complex and labour intensive, the seismic structure is highly repeated, and can be made factory made. The columns, where the seismic force is concentrated, are all nearly identical. Manufactured in Nelson, where special jigs could be made, and quality assurance levels can be very high. Once crafted the columns were shipped to site and erected quickly.

Similarly, the 'double T' CLT panels greatly speed up construction. These were glued and screwed together in the Red Stag factory in Rotorua. They were then trucked to site, where they could be very quickly erected. Once

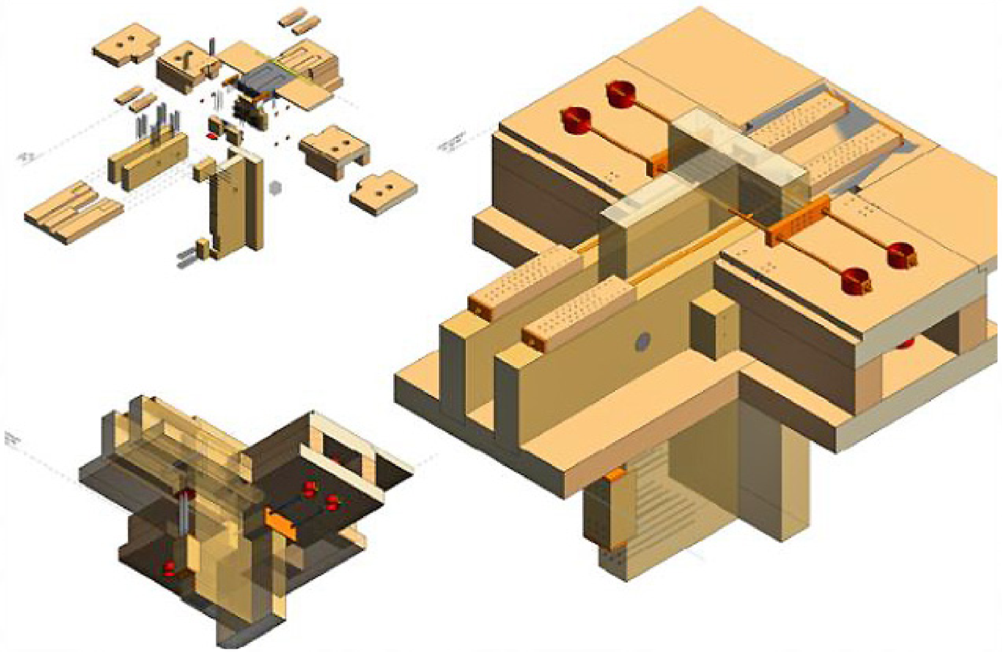


Figure 4: The typical 2-way beam column joint

installed in place, they were instantly trafficable without propping. This is a significant advantage over traditional concrete floor construction, which generally takes days to cure.

By contrast, where building elements are irregularly shaped and non-typical, significant propping is required. This requires significant work from the site team, and significant oversight from the engineer to ensure details are followed.

Figure 5

5. RENDERS

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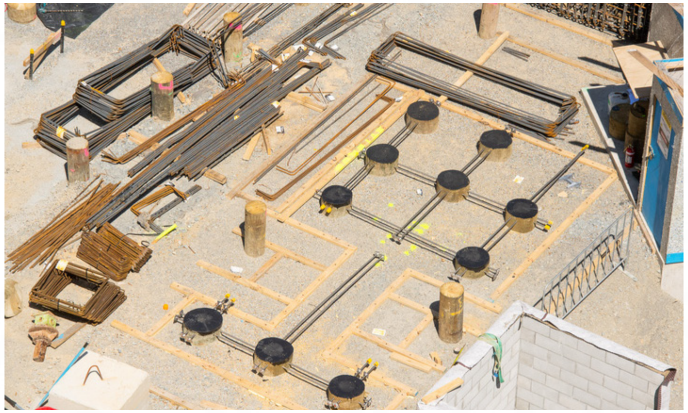
6. CONSTRUCTION



6. CONSTRUCTION

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SUMMARY -TIMBER CONSTRUCTION INSIGHTS

Advantages / Opportunities

- Mass timber is a fledgling industry in New Zealand, but one which is poised to grow at a rapid rate. Careful stewardship is required for growth and innovation to be realised.
- Prefabrication has made erection relatively quick, compared with concrete. This did require some up-front work from Main Contractor to make sure assembly was possible. It is beneficial not having to wait for curing times for slabs. While this is more relevant to taller buildings where slabs need to be at strength to do the next lift, it is great to be able to use the floors immediately following install
- Further to above, greater understanding of CNC functionality would aid designers
- Strategic use of steel helps design, e.g., dampers, outriggers etc.
- Timber is a very easy material to work with, e.g., onsite hole coring might be a good idea in future
- Compared with a steel and concrete site, working conditions are far cleaner and quieter.

Challenges

- *Seismic* - Bracing structure is difficult to design and make work in pure timber in Wellington above 4 stories (diaphragm building are difficult in many regions). The Living Pā is aiming at a very high level of environmental protection. Intermediate hybrid solutions are used elsewhere, e.g., with steel frames.
- Tolerances should be well defined. The Living Pā has some tight tolerances, which have worked well.
- *Moisture management* - There is little in the way of consistent advice on how to best manage moisture on site and perspectives can vary significantly, for example, to wrap or not wrap. For the pā some items that have worked well, such as the column 'shower caps'. It's also difficult to cost moisture management as it's dependent on conditions during construction, environmental standards, client appetite for risk (based on consultant and contractor advice of course), erection methodology. Standardised %MC ranges would make management easier, but again this can vary and is difficult to know.
- Multiple subcontractors make coordination challenging during drawing, and allowance needs to be included for extra model coordination costs and setting an early an 'lead' to take responsibility for the model. In terms of the pā this has been LTM, however a sub would be a preferred alternative.

- The design process for timber is different to other materials. CIC guidelines are less applicable, and connections should be designed first. Maximising the advantages of timber, such as, CNCing of service penetrations, means the typical design process needs to be flipped somewhat. A good example, services need to be shop drawn first or in parallel to be confident in CNC penetration placement.
- *Fire* - This is an important topic of conversation, and more research and discussion are required to get a good balance. This building is designed as a single fire cell, with 2 escape stairs. Timber members are designed to char in a fire, but still retain sufficient strength and stability. Critical fixings are recessed into the timber, so they do not get hot enough to lose strength.
- *Acoustics* - The Living Pā is a complex space acoustically. Timber is light and stiff, so transmits sound easily. To provide separation between floors a raised floor is used. To absorb sound acoustic panelling is installed below the floors. Some designated quiet spaces use traditional gib linings.

Production Process

- *Understanding of scope/production ability* - Designers need to engage timber suppliers early to ensure their designs can actually be built with the equipment available (talking with respect to other timber jobs we have coming up). Suppliers require high levels of detail to ensure that they know what they are signing up to well in advance of production, and to avoid last minute changes to design.
- *Peer review* - This is a difficult process in mass timber. Details are often novel, codes foreign, and new research is often used, for example. Peer review needs to happen well in advance of shop drawings to avoid delays and changes late in the piece. Many suppliers are now indicating that they won't start shop drawing until peer review is completed. Councils also need to be up with the play of the peer review process to avoid items being produced before production begins.
- *Production process* - Important to understand how the CNC batching process works and how late design changes will impact fabrication and therefore programme.
- *Screw supply* - Important to understand production cycles and screw options. Not all screws are made at the same time, and the screws used on pā are made in Italy and shipping can be problematic if not forecasted with all fabrication variables considered.

SUMMARY

The Living Pā project has been an educational journey, particularly concerning the demanding process of LBC certification. Bridging the gap between standard building codes and Living certification represents a substantial leap. As an experienced design and construction team, the project commenced with an awareness of the challenges in advancing benchmarks. However, as the project unfolded, a deeper appreciation has emerged for the secondary mission of the LBC framework, which requires teams to actively advocate for good, instead of less harm. This proposition fosters a demanding mindset.

At the time of writing this case study, the Living Pā project is past the construction phase midpoint. Innovation has come with complexities and challenges, nevertheless, the project team is buzzing with newfound knowledge and a determination to make regenerative building the norm. By embracing Māori values and undertaking the rigorous journey toward Living certification, this project exemplifies the potential for sustainable building practices to lead us into a regenerative future—one where human well-being and environmental health are at the forefront of architectural and construction endeavours. It demonstrates that by thinking about environment degradation in their wider system, and thinking about the needs of the people, and advocating for change, we can pave the way for a sustainable tomorrow.

ABOUT THE MID-RISE WOOD CONSTRUCTION PROGRAMME

Mid-Rise Wood Construction is a six-year 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.

Engineered timber is not only naturally beautiful but also provides a very strong, low carbon and comparably low-cost alternative to steel & concrete. It is easy to transport, relatively light, and has outstanding earthquake and fire resilience. The use of prefabrication can decrease construction time by as much as 30 percent, and reduces costs compared with traditional building methods. Combining cross-laminated timber (CLT), laminated veneer lumber (LVL), glulam and panelised framing timber creates a cost-effective, fast, resilient and sustainable system for mid-rise construction.

For more information go to **www.midrisewood.co.nz**
or **scan the QR Code link below**

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