Mid-Rise Wood Construction
CASE STUDY

WAIKATO REGIONAL THEATRE

MID-RISE Wood Construction

RED STAG INVESTMENTS

Ministry for Primary Industries
Manatū Ahu Matua

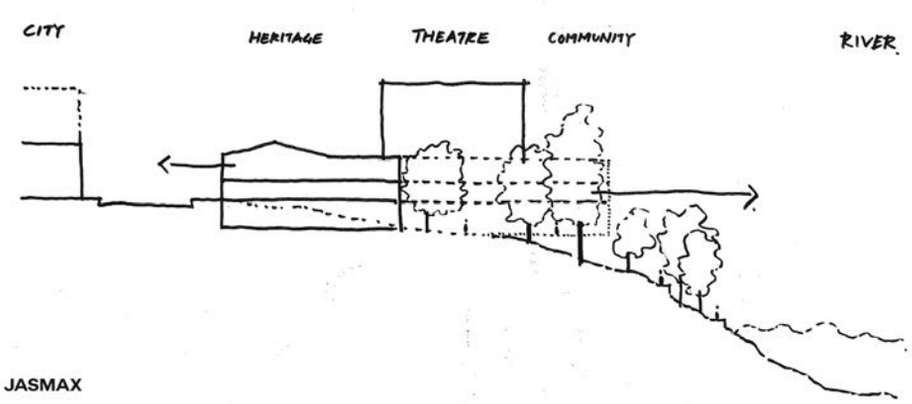

HAMILTON HOTEL

PROJECT BACKGROUND

The Waikato Regional Theatre (WRT) is an arts-led urban regeneration project for Hamilton which will form the civic heart of a riverfront cultural precinct. The new theatre is designed to be a destination for the community and tourism, and to inject new energy into the city. The mix of space includes an auditorium, flexible rehearsal and events space, gallery, hospitality venue on Victoria Street, and riverside café. The project includes restoration of the 100 years old heritage façade of Hamilton Hotel, retaining a key element of the site's history as a place of entertainment and vibrant creativity.

The theatre will provide citizens and visitors alike with majestic views of the Waikato River and is designed to accommodate a wide range of events and activities to celebrate the region's history and culture. At the centre of the project is a new 1,300-seat lyric theatre. The unique design will operate in theatre, concert, and orchestra modes, providing a world-class replacement for the 50-year-old Founder's Theatre.

The new theatre will sit behind the old Hamilton Hotel, which has a generous frontage onto Victoria Street. The hotel façade will be strengthened and restored to enhance street appeal and retain local history, and will provide access to a spectacular entry atrium featuring a sculptural stair descending to the theatre entry below.



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The wider project provides opportunities to reconnect the city with the river, a treasured taonga of Waikato-Tainui and Ngāti Tāwharetoa peoples. River views from the theatre foyer will be framed by striking blade walls positioned at right angles to the river. These are designed to emphasise the majestic proportions of this space and will also overlook a new riverside promenade incorporating indoor and outdoor courtyard spaces designed for smaller events and performances. The precinct will deliver a visitor experience that will be unique to Hamilton and in Aotearoa New Zealand, and will be a long-term asset for the community.

The WRT project has been realised through substantial community support, led by Momentum Waikato. The ambitious and complex development, which integrates new and existing heritage structures, has required careful planning, and necessitated innovative approaches to construction. A major redesign to meet Resource Consent conditions kickstarted a re-evaluation of the most efficient way to deliver the project, and it was at this stage that prefabricated mass timber, Cross laminated timber (CLT), was identified as a material that could offer multiple benefits and lead to substantial programme and cost savings.

Reasons for using engineered timber

Due to its function as a public building, WRT is designed as an IL3 building, with large volume spans necessitating a traditional structural steel and concrete primary structure. However, design changes arising from Resource Consent, combined with cost inflation resulting from the Covid 19 pandemic, contributed to the need to redesign key elements of the theatre. The option of using CLT was investigated by the design and construction teams because of the material's adaptability and the potential it offered for programme saving benefits.

CLT proved the most cost-effective solution by a substantial margin for the sub-structure of the new cantilevering blade walls which became a defining feature of the riverfront elevation of the theatre. Additional analysis led to CLT also being selected for the auditorium roof, catwalks and theatre bleachers. This is because design efficiency, programme reduction and buildability benefits including less material weight improving on-site handling and less crane time saved downstream cost.

In the case of the auditorium roof, CLT was selected as an acoustic material with inherent structural properties. The team realised that if the roof could be re-designed to be flat it, could reduce the additional bracing structure and be used as a safe working platform from which to install the remainder of the double skin warm roof assembly. Despite the reality that CLT will not be showcased, or even visible within the completed project, the acoustic performance of the material will provide unseen benefits, making the theatre a truly world-class venue for future generations.

GENERAL

Architectural design overview

Creating a strong connection between the city and the river was a driving concept for the design. The theatre experience starts at street level, with entry through the restored Hamilton Hotel and steps down into a majestic multi-level foyer which will bring visitors closer to the river.

The mixed-use brief for the whole project combines the bespoke theatre design with a range of complementary ancillary performance and entertainment spaces. The auditorium will achieve a world class standard of acoustic performance and enable a diverse range of performance types and scales. A key feature, locally quarried hinuera stone blade walls, frame views reinforcing the landmark site's connection with the natural environment and prominent location over the Waikato river.

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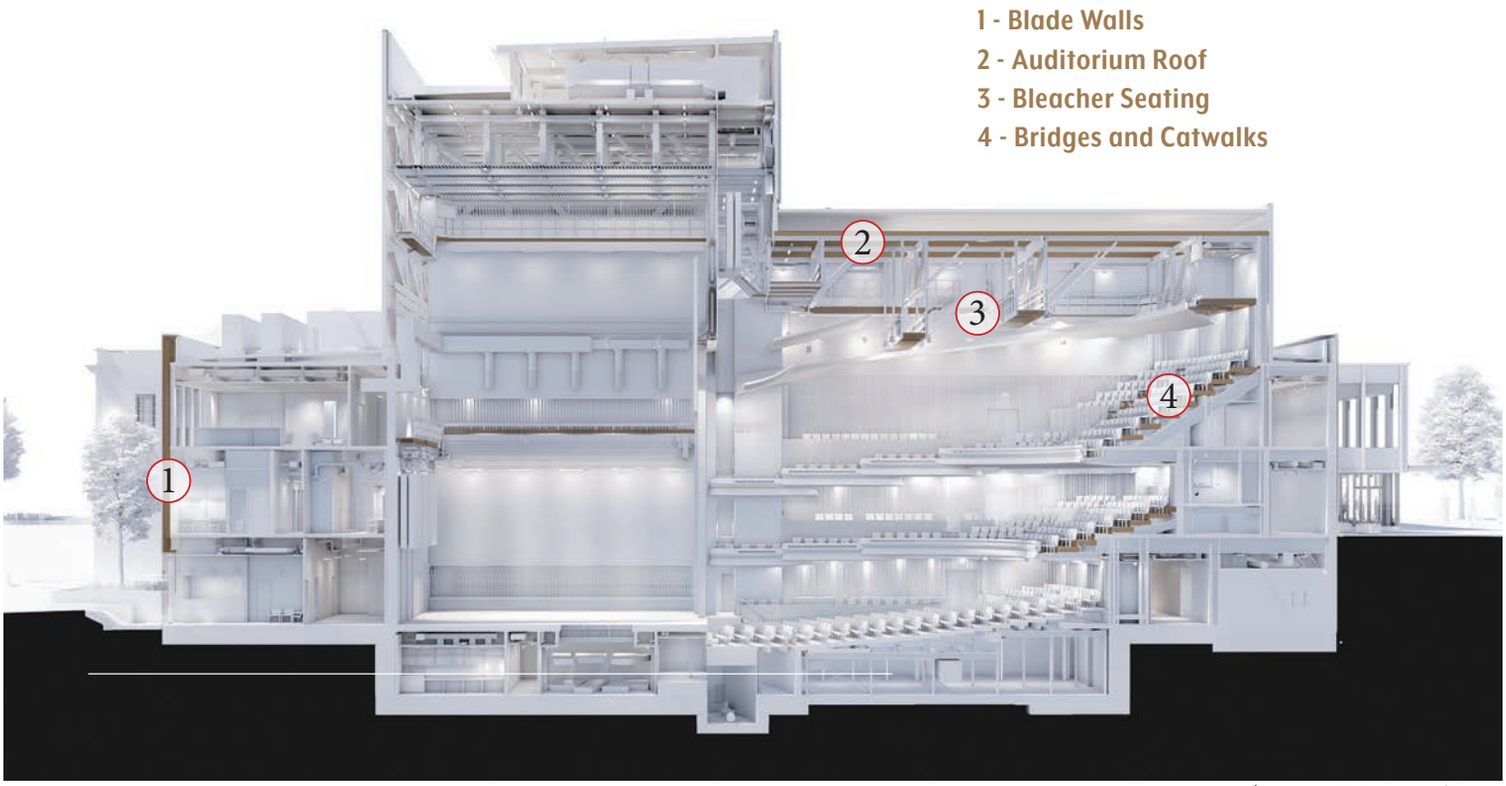
Engineering features

Steel and concrete provide the primary structure of the theatre and existing heritage buildings. CLT is used in secondary layers including enclosure and the internal floors supporting stepped seating bleachers.
CLT acts as structural substrate to the stone tile clad walls and simplified the tile rainscreen façade fixing. Rather than coordinating fixings with discrete framing elements, CLT allowed a lot more flexibility in fixing locations. The CLT auditorium roof acts as diaphragm reducing the total roof structure, with installation efficiencies resulting from reduced weight.



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KEY DESIGN CONSIDERATIONS (ranked):

1. Cost considerations and management:

A breakdown of project cost savings has been provided for each element where CLT was substituted for traditional materials and construction methodologies:

- **New Blade Walls - 118m³: Cost saving >13% for CLT.** Five fully costed options were developed for the construction of the new blade walls which are a key feature of the re-designed theatre. The CLT panels provide a structural substrate for the theatre's distinctive stone cladding. Although a precast option was also explored for these cantilevering elements, the two most feasible options were lighter in weight:

  Option 1: 400 centre timber frame stud wall with 2 x 25mm layers of H3.2 structural plywood
  Option 2: Hyspan/LVL studs and nogs with 90mm thick CLT panels. (During detailed design, the panel thickness was further reduced to 82mm)

- It was estimated that Option 1 would incur 3700 man-hours, whereas the Option 2 of CLT, with off-site prefabrication, would incur 1000 man-hours on site - a labour saving of 27%. Even once the cost premium for CLT was factored in, the overall cost saving for a CLT solution was estimated at 13%.

- The installation of the CLT panels has proved to be comparable to the estimate, with 100's of m² of CLT panels now installed – all within in a matter of days.

- The 13% additional cost saving does not take into account follow-on cost savings associated with a reduced number of fixings for the cladding brackets, or the simplicity of installing fixings directly to the CLT, when compared to framed plywood. Use of this methodology also achieved weathertightness far more quickly.

- **Auditorium Roof - 106m³: Cost Savings >13% for CLT.** Fully costed options were not worked through for the roof because using 200mm thick CLT planks achieved so many buildability and performance design benefits. The auditorium roof was originally designed as a heavy warm roof with stone-wool insulation and a suspended GIB ceiling for acoustic performance. The primary driver for substituting CLT was that it **reduced** the total weight of the roof and enabled the deletion of the suspended triple-layered plasterboard to the underside for acoustic dampening, dramatically simplifying the roof design. This included removal of temporary works and scaffolding requirements to install the plasterboard.

- Additional benefits include improved safety through use of CLT as working platform, and **speed of** construction. As the bottom roof layer, CLT reduced requirements for working at height, although application of Intumescent coating will still require access at height.

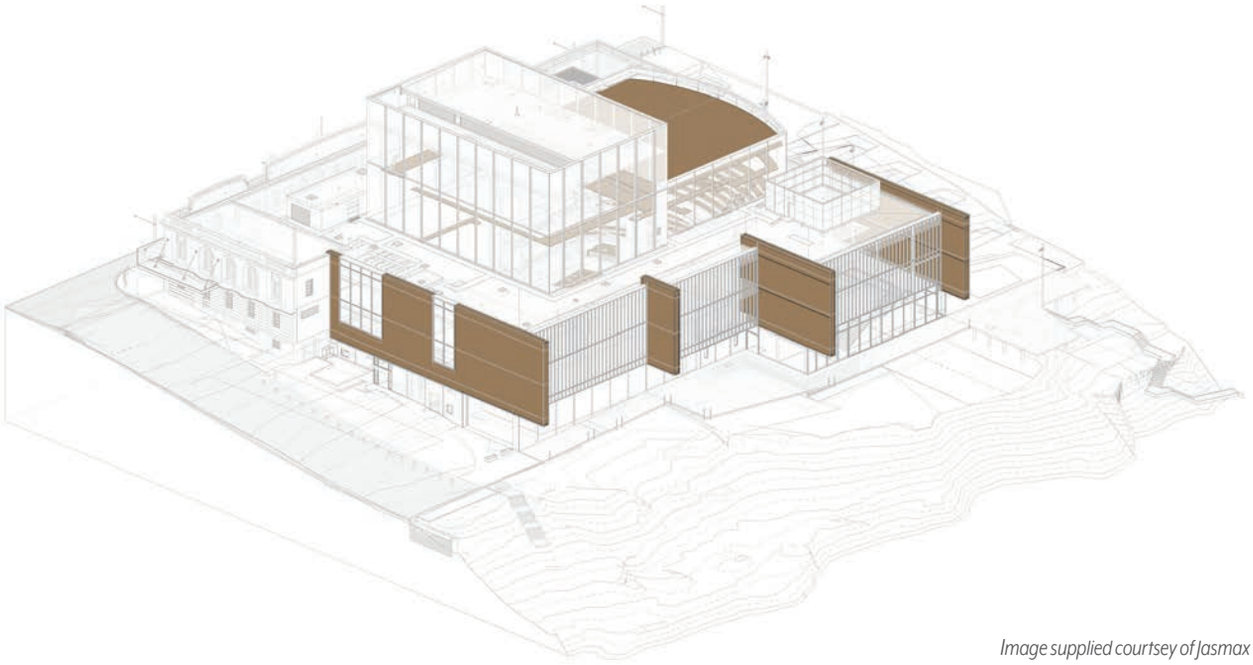
- Using CLT as a diaphragm also eliminated the need for steel cross bracing. As the roof design and installation was dramatically simplified through use of CLT, the cost saving for this component is estimated to exceed the % savings generated by the CLT blade walls.

- **Bleachers - 81m³: Cost saving >35% for CLT:** The initial cost comparison between using CLT rather than precast concrete bleachers produced an expected **saving of over 35%**. This saving didn't include the **reduction in weight** loads which also led to an optimized floor structure. The CLT also aided in reducing the temporary works, as the precast bleachers would have required greater co-ordination to install, due to weight. Being able to manufacture the CLT to the curved set-out removed extensive carpentry infill work which would have been required to form the complex curves and rationalise junctions at steps and row transitions for the beachers.

- CLT proved **more adaptable** to the curved seating geometry and achieved the complex shapes providing an homogenous substrate for finishing. Simplified structural connections, able to be installed with hand tools on site and use of self-tapping screws to connect CLT to the supporting structural steel substrate provides further efficiencies.

- Installing heavyweight precast bleachers would have absorbed cranage time and was on the critical path as the panels would have needed to be installed prior to enclosure of the roof. Because CLT panels are lighter than precast and can be moved across the floor on trolleys and lifted into position by small electrical hoists, this allowed the construction of the seating bleachers to be taken off the critical path.

- **Catwalks - 30m³:** Utilising CLT for the catwalks over the theatre came at a cost premium when compared to more traditional framing and plywood options, but significantly reduced the expected time working at height. Similar to the auditorium roof and bleachers, CLT provided additional acoustic reflection and ensured a consistent design across the exposed bridges above the seated areas and the CLT roof. CLT also allowed for removal of the timber framing and GIB acoustic layers to the underside of the exposed bridges above the seating area.



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2. Acoustic performance benefits of CLT

Inherent properties arising through the density and mass of CLT offer important acoustic advantages in theatre environments. Incorporation of CLT in the ceiling, bleachers and catwalks at Waikato Regional Theatre supports a more immersive auditory experience and reduced the need for secondary acoustic treatments.

- **Reducing external sound transmission**

  The natural density and mass of CLT provides excellent insulation, making it ideal for acoustically isolating the theatre, protecting performances from outdoor noise interference, like rain. CLT will also reduce sound transmission, containing the sound of performances within the auditorium.

- **Vibration dampening**

  CLT's layered construction helps dampen vibration. It will reduce structure-borne noise generated by footsteps and other impact sounds, making the most impact in the circle and balcony seating areas, where the CLT beachers will prevent noise disturbance during performances.

- **Low-frequency sound absorption**

  Compared to traditional materials like plasterboard and timber framing, CLT absorbs less low-frequency sound. This feature is crucial for preserving the rich, resonant quality of orchestral music in the theatre, where over-absorption of bass frequencies can dull the acoustic performance of a space. CLT will help maintain a natural balance, ensuring that low-frequency sounds are neither excessively absorbed nor too prominent.

- **Reflectivity**

  CLT retains strong reflective qualities at mid- and high-frequencies, enhancing clarity in spoken word and musical performances by reflecting sound back into the auditorium for a more immersive auditory experience.

3. Building Envelope (connections/ seismic)

- **Temporary weather protection of CLT elements**

  As all of the CLT was to be enclosed it required temporary weather protection. Slopeshield was pre-installed on exposed timber auditorium roof elements. Vaproshield was installed on wall planks.

- **Seismic**

  Inter-storey movement was able to be accommodated with the unitised construction.

4. Fire design

CLT was not typically used in separation of fire cells and treatment of openings and joints has not required detailing for fire protection.

Where CLT atypically spanned fire cells, it was overclad in fibre cement board. Intumescent coating was required for the underside of the exposed CLT auditorium roof.

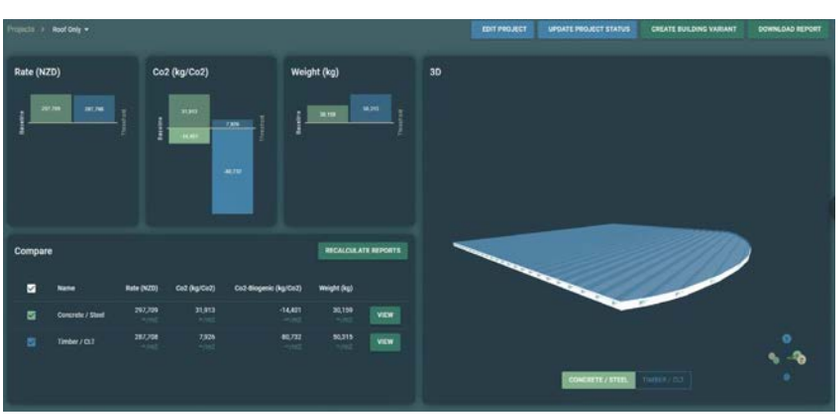
Reliance on the inherent fire resistance of the CLT bleachers meant no added fire rating material was required for this element

5. Building for climate change

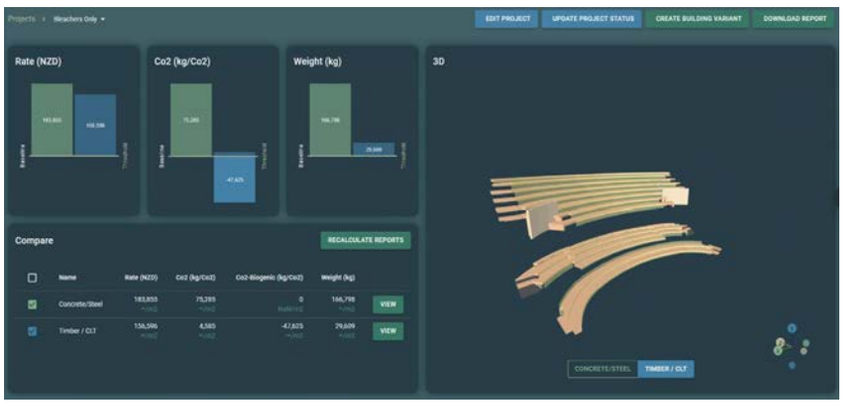
Whilst reducing carbon was not the primary driver for this project, the substitution of CLT provided a total up-front carbon reduction of 3% for the project.

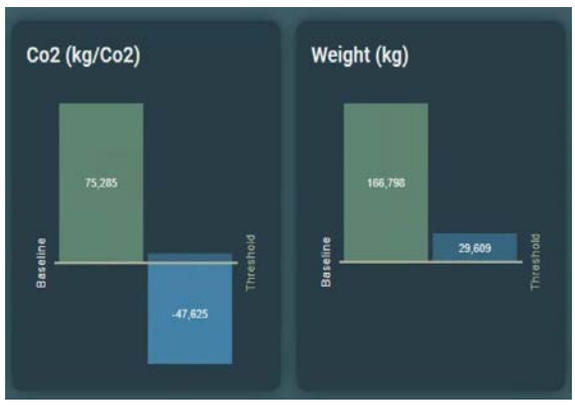
The following section provides a detailed carbon analysis of three key structural elements of the Waikato Regional Theatre: the Roof, Bleachers, and Blade Walls. Each of these elements was assessed based on their environmental impact, comparing traditional concrete and steel materials to engineered timber, specifically Cross laminated timber (CLT). The analysis highlights the significant carbon reductions and other benefits that CLT provided in these areas. This section serves to illustrate the environmental advantages gained through the use of CLT, supporting the project's broader goals of sustainability and innovation in construction.

WRT - ROOF ONLY	NETT RESULTS	Concrete/Steel	Timber/CLT
	C02 (kgc02eq)	17,512.00	-72,770.00
	Weight kgs	30,159.00	50,315.00

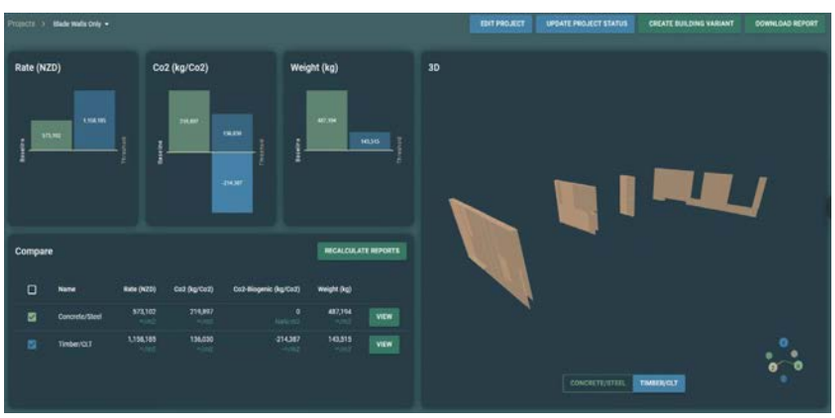


WRT - BEACHERS ONLY	NETT RESULTS	Concrete/Steel	Timber/CLT
	C02 (kgc02eq)	75,285.00	-43,040.00
	Weight kgs	166,798.00	29,609.00

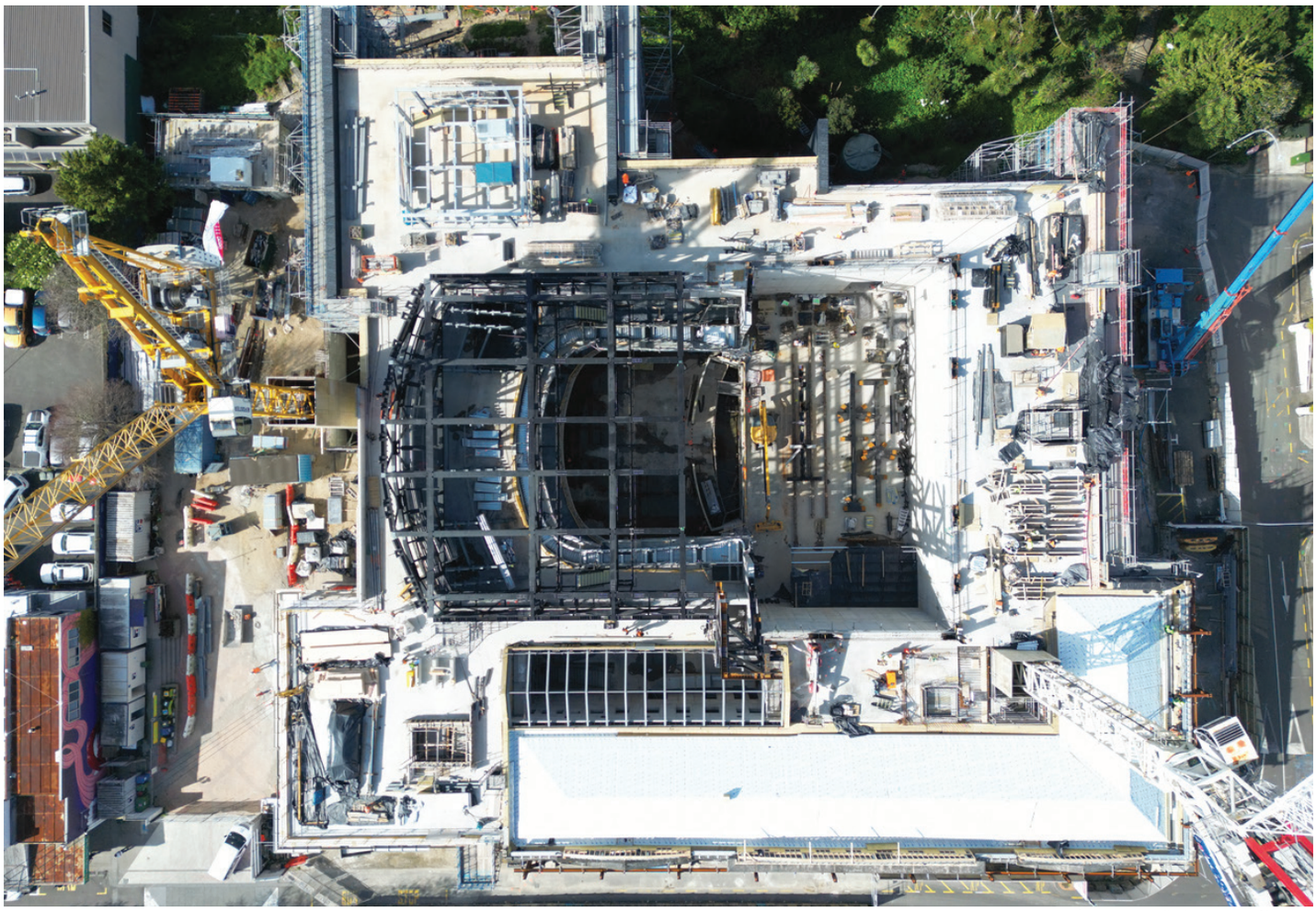




WRT - BLADE WALLS ONLY	NETT RESULTS	Concrete/Steel	Timber/CLT
	C02 (kgc02eq)	219,897.00	-78,357.00
	Weight kgs	487,194.00	143,515.00



Images supplied courtsey of Fosters Construction



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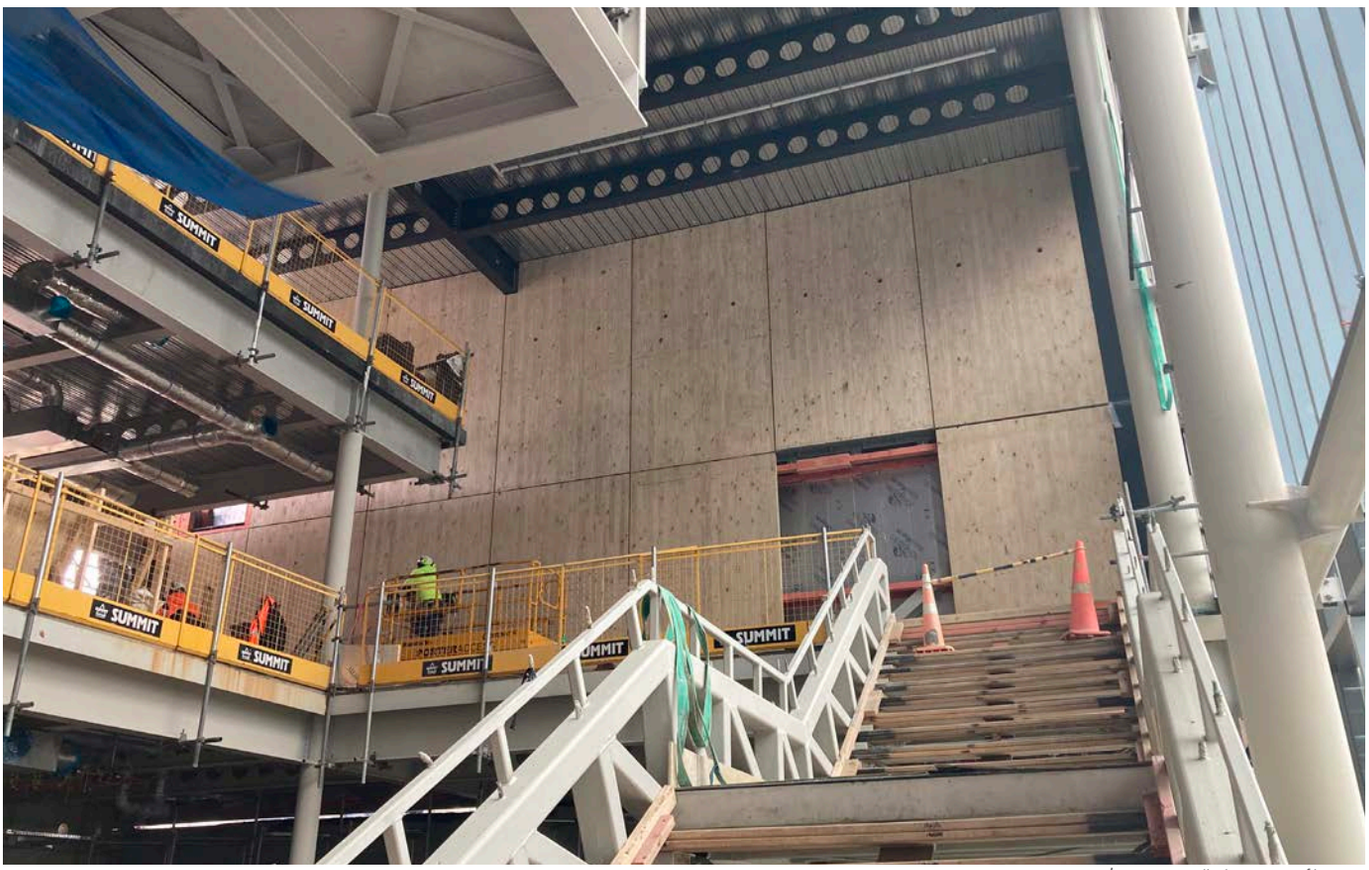

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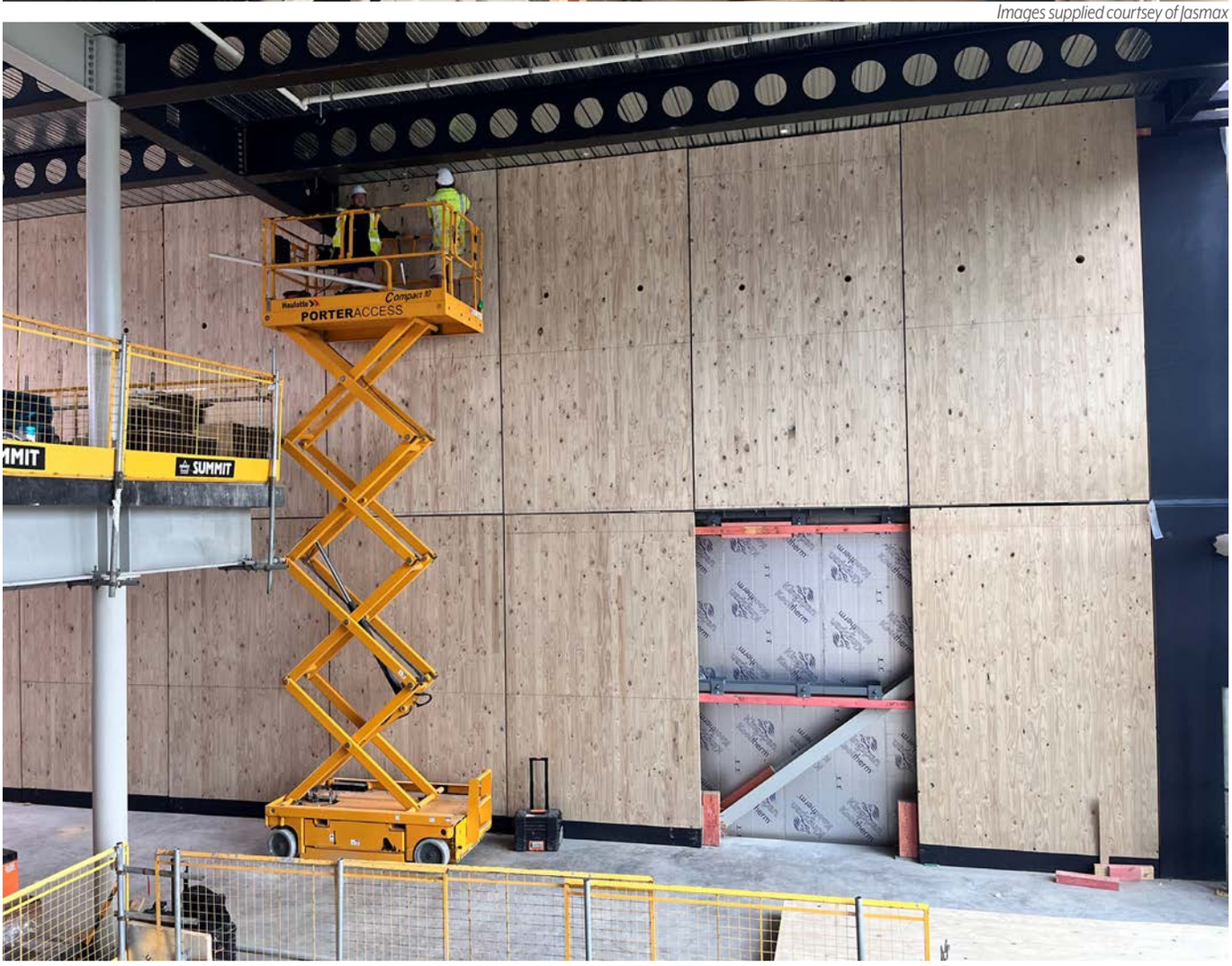

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CONSTRUCTION

Advantages of Engineered timber

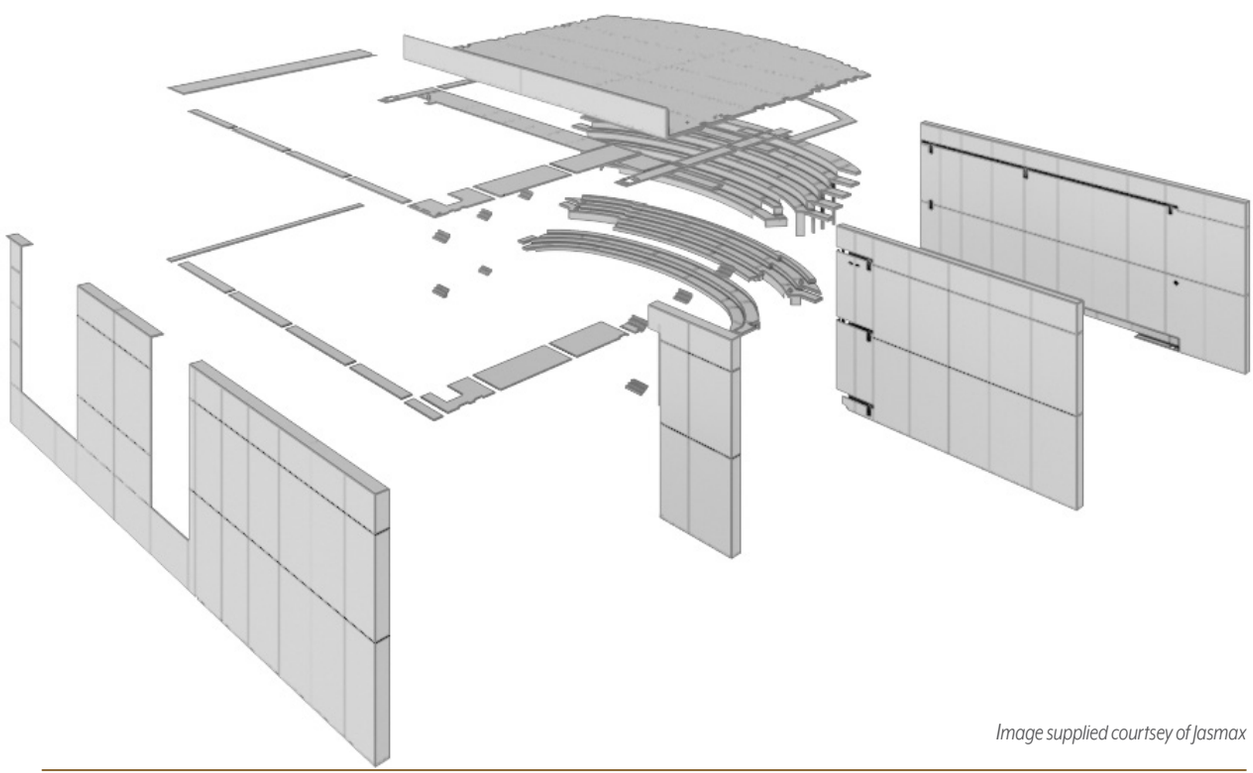
CLT provided the most multi-functional and effective sub-structural solution for key areas of the new Waikato Regional Theatre, significantly reducing project risk and cost. Key benefits included:

- Design and delivery certainty enabled through off-site pre-fabrication.
- Programme savings significantly outweighed the material cost premium (compared to standard construction methods).
- Enhanced site safety, especially working at height.
- Material properties of CLT highly suited to stringent acoustic requirements for performance venue.
- Ability to perform as structural diaphragm and light weight of CLT reduced size and cost of other structural elements.
- CLT resulted in upfront carbon reduction (compared to standard construction methods).

BIM coordination

The Waikato Regional Theatre BIM model is an exemplar for how a fully integrated BIM environment can be beneficial on complex projects necessitating design changes and extensive detailed coordination requirements. Jasmax led and managed incremental updates to the project geometry through extensive coordination and ensured the BIM model met accuracy requirements for shop drawings and coordination. The 3D model continues to provide significant benefits to the contractor during construction as the information is highly developed.

The unitised CLT system allowed for precision in set-out and interfaces, providing more certainty on site. In addition BIM coordination supported clash detection and resolution and coordination with structure and services, resulting in penetrations being installed prior to delivery of theCLT to site. The BIM model was also used as the base for blade wall shop drawings with accurate dimensions and set-outs.



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Site considerations

- **Storage and Delivery:** CLT panels are simple to deliver, offload and store on site, reducing temporary site prep necessary for storing precast concrete panels.

- **Moisture Management Plan (MMP):** For Waikato Regional Theatre the MMP was extensive and detailed. A key priority on site was maintaining the specified moisture content throughout delivery, storage and install, until the product was fixed and protected necessitating frequent moisture testing (daily).

- **Techniques for managing moisture:** CLT is delivered to site sealed and this must be protected until the product is installed. Once installed, polythene sheeting with battens beneath maintained airflow evenly on both sides of the product. Minor cupping of panels caused by temperature/ atmospheric moisture differential between each panel face proved temporary once the product was installed. Once completed, a 20m long wall only had 4mm deflection. Fans were also used to maintain airflow.

- **Fixing processes:** More efficient than fixing to a typical plywood wall.

- **Improvements in sequencing and critical path:** Once the CLT roof diaphragm was installed, the steel roof trusses were then used as support from which to winch lower panels (theatre bleachers) into place, taking these off the critical path as they could be loaded in after the roof was constructed. This meant the costly crane time was used where most needed (on roof construction and installing precast cladding elsewhere).

  The use of CLT on the auditorium roof removed the need for scaffolding and other working at height requirements which would have been needed to install a GIB acoustic ceiling within the 5-storey auditorium void.

PROJECT LEARNINGS

Project lessons learnt:

- **Programme Acceleration:** The programme acceleration possible through use of CLT had a domino effect with knock-on cost savings accruing as a consequence of reduced programme. In addition, a significant reduction in time working at height was a major benefit to site safety for the theatre.

- **Simplification on site:** Coordination of services was simplified, and storage and handling of CLT was greatly simplified compared to precast panels.

- **Importance of shop drawings for CLT:** To support ease of coordination with structural steel trade; traditionally CLT follows the steelwork so timing works well to achieve seismic tolerance.

Barriers to engineered timber to overcome:

- **Contractual:** While some terms in Engineered Wood Products supply contracts have historically been seen as unfavourable, recent adjustments, such as reduced deposits tied to shop drawing deliverables and more flexible payment schedules, have provided more favourable terms for constructors..

- **Compliance:** Whilst the industry is becoming more accepting of CLT, there is no NZ Standard for this material. CLT is viewed either as an alternative solution under the NZ Building Code or an engineered timber solution, attracting additional design costs to demonstrate performance. As there are no national standards for local manufacturers to meet, our industry relies on complying with a variety of different international standards, for which there is no like-for-like comparison. As a result, the products produced by each supplier (XLam and Red Stag Timberlab) are not simply interchangeable, and producer statements for each are sufficiently unique that it is not easy to compare alternatives or cost check without incurring additional investigative and design costs. This can leads to a lack of transparency and lack of competitiveness in the market.

- **Cost of Moisture Management:** Cost for wraps were higher than expected.

- **Shop Drawing Delays:** Delays producing shop drawings slowed the time to manufacture the CLT panels. The shop drawings for the blade walls took 6 weeks. Being faced with an estimate of 4 weeks for the catwalks, the team modelled these inhouse, completing shop drawings in 1 week.

- **Shop Drawing and Coordination Costs:** These are significantly higher for CLT, so project budget's need to anticipate this at an early stage. Sequencing and coordinating dimensions and junctions between CLT steel and other structural elements can be complicated. (Noting WRT is a highly complex building with atypical design elements.)

Team member commentary:

Waikato Regional Theatre was procured under a Design Build contract, and the project has benefitted from a 'one team' approach from the outset. Fosters Construction, Jasmax, Charcoal Blue and Holmes Group have combined their expertise to achieve a 'best-for-project' philosophy, with the design team embracing the substitution of CLT for the multiple project benefits it provided.

The design team were excited to maximise the opportunity for greater use of CLT providing early design sketches and information for QS to measure and cost, anticipating and elevating potential challenges and mitigating obstacles.
The design team also maintained a comprehensive understanding of the design and performance requirements throughout the evolution of the project, through to its final resolution.

The building design is of a very high quality and all delivery partners have worked to ensure the Waikato Regional Theatre will be a valued asset for the community and a magnet for creative endeavour.

- "CLT has proven a good material to work with. The programme and other benefits we hoped for have been proven to be real." *Tim Strawbridge, Commercial Director, Fosters*
- "I would like to build a whole building in CLT now." *David Middlemiss, Site Manager, Fosters*
- "The versatility of CLT enabled us to apply it in many creative ways on this complex project and is delivering a lower cost and reduced carbon outcome." *Nathan Groth, Project Architect, Jasmax*

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