Timber Rocks

The new Carterton Events Centre is a building that will be able to rock and roll with the land if it shakes, then spring back into place. It is half way through construction and already attracting attention.

Six years ago Carterton District Council commissioned Opus International Consultants to design the Events Centre, giving the company carte blanche. Opus came up with a timber building and an innovative seismic system that has been used only once before.

Colin Wright, the Council's Chief Executive, says the town needed a multi-purpose events centre where activities were integrated and interconnecting. The Council had originally considered using two older buildings – a concrete structure used as a Scouts' den built in the 1970s, and the historic Category 2-listed timber library, built in 1881. Eventually a new centre incorporating the two buildings was planned to provide facilities for community groups, attract events and bring new life to the region.

The $6 million Events Centre is the first civic building to be built in Carterton for more than 100 years. The structure has to be seismically resilient (the Wairarapa is a high seismic zone with a history of large earthquakes) and able to be used as an emergency welfare centre. The Council didn't specify the kind of construction or materials to be used in the building – it simply told the consultants what uses the building was intended for. Together, the Principal Architect Bruce Curtain, Senior Structural Engineer Dave Dekker and their team developed the concept and structural elements.

Timber was their preferred material and they considered seven structural options – heavy and lightweight, elastic and ductile structures and envelopes – to a point where costs and performance could be compared. When taking acoustic requirements into account, one option was to use concrete walls around the 300-seat auditorium; however, this option would have been heavier, required more seismic design and affected the architectural finishes.

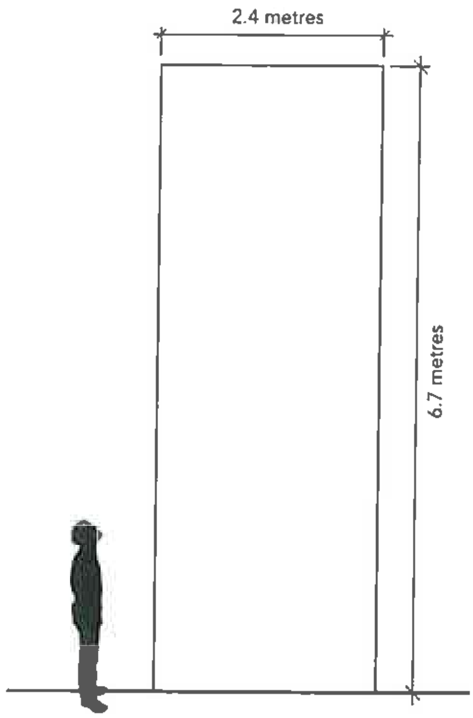
"There was a good level of trust between us as a team," Mr Curtain says. "That allowed us to go off and explore a bit more and come back with some alternatives."

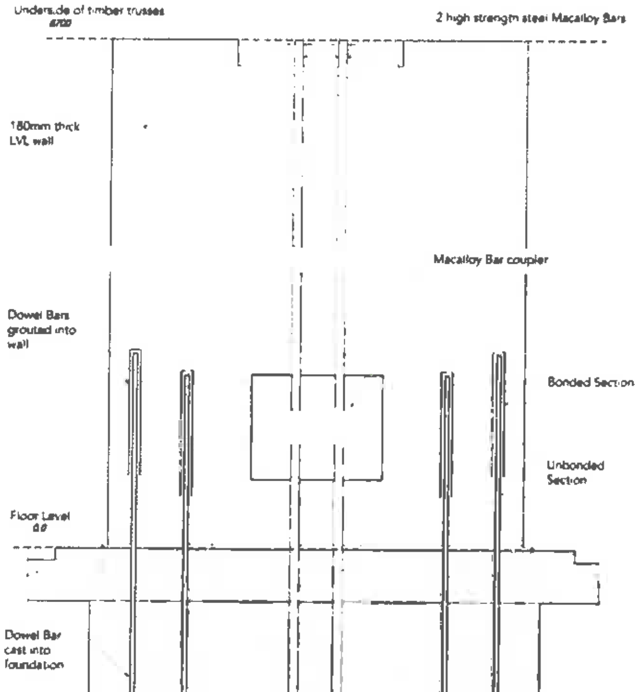
A graduate of the University of Canterbury College of Engineering, Mr Dekker was familiar with the Pres-Lam structural system developed there in 2005. Pres-Lam adapts the hybrid structural system developed by the Precast Seismic Structural Systems programme in the United States for concrete, combining it with engineered Laminated Veneer Lumber (LVL). The Pres-Lam system incorporates large timber structural frames or walls, constructed of LVL, with longitudinal unbounded post-tensioning and grouted in (or composed of external mild steel) energy dissipation devices.

The eleven Pres-Lam walls are 2.4 metres wide and 180 millimetres (mm) thick. They are constructed of glue-laminated panels of 45 mm-thick LVL. A 600 mm by 90 mm-slot runs full height through the centre of the wall and houses two high strength Macalloy Bars. The bars are cast into the foundation and provided with a coupler just above floor level and a large anchor plate at the top of the wall. The solid end regions of each wall contain two grouted Grade 300 reinforcing bars with a de-bonded length to provide the yielding element active in both tension and compression. The Macalloy Bar size and spacing, and the dissipater bar size, spacing and yielding length, are different for the walls in each direction. They are designed to tune the wall to the desired response. Mr Dekker says this significantly reduces the amount of movement and damage to a building during an earthquake, meaning fewer repairs are required after a large quake.

"While the post-tensioning provides a desirable re-centering characteristic, the dissipation devices provide energy release from the system," Mr Dekker says.

During an earthquake, a controlled energy dissipating rocking motion, characterised by flag-shaped hysteresis behavior, occurs at the beam-column, column-foundation or wall-foundation connection.





The Pres-Lam walls were designed using displacement-based design principles for a maximum drift of one per cent. They were no more costly than the other systems evaluated – including ductile plywood sheathed shear walls – yet provided a structure with a design drift of 60 per cent less than the maximum allowed in the Building Code. The walls also provide support to the LVL roof trusses.

The Events Centre walls were modelled to design the loads and energy dissipation in the steel bars. A team headed by Dr Alessandro Palermo, University of Canterbury Senior Lecturer in Structural Engineering, undertook a peer review of the design.

"As this is relatively new technology, we wanted the Council to be assured the design was correct and in accordance with the *Building Code* and design standard," Mr Dekker says.

The review included refining and improving the design of the connection detailing in Phase One, which is now complete. Computer analysis to confirm the expected behavior of the auditorium is now being conducted by Dr Palermo.

"As usual, the devil's in the detail and there was minor tweaking – the size and spacing of the bars and a few other details we modified on their recommendation. They have done additional analytical modelling and time-history analysis to verify how the walls will behave in strong ground shaking, similar to what could happen in the Carterton area, and are finishing that off now," Mr Dekker says. "This analysis will confirm a lot of aspects of the wall design, including re-centering, damping and energy dissipation."

Following a major earthquake an assessment may recommend the dissipater bars be replaced. The embedded bars can be simply cut and new external dissipating elements provided at the ends of the Pres-Lam walls, as the walls are fully enclosed in the auditorium linings.

Mr Dekker says the LVL system has many benefits over structural steel and concrete. It's comparatively lightweight, holds up and springs back into place in an earthquake and uses a renewable resource. The project received considerable support from Juken New Zealand (JNL), which supplied locally-grown wood through the Carterton factory. This made timber a cost-effective choice.

Other ways to use JNL's LVL and plywood were explored. As a result, between 60 to 70 per cent of the walls and roof framing is LVL, and there are plywood bracing and diaphragms throughout the structure.

The use of timber for the roof trusses is also innovative, Mr Dekker says, as are the connections to the trusses, based on a design from the University of Auckland.

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"Instead of using heavy steel plates and lots of bolts, we are using 'riveted' connections that use much thinner, smaller steel plates and nails, so it is cheaper and you can barely see it."

The auditorium roof trusses span up to 20 metres over the stage, and the walls are double-skinned and incorporate acoustic and thermal insulation. Some laminated beams and posts will be exposed in the foyer. All the Pres-Lam walls, LVL roof trusses and Glulam beams were fabricated by McIntosh Timber Laminates.

"It [LVL] has been a fantastic solution both in the design and suitability for the Centre. Right through the construction process it's gone really smoothly."

The system was tested two years ago using a two-thirds scale, two storey building constructed in a laboratory at Canterbury University. The model used the Pres-Lam wall system in one direction and in the other, a frame system, adopted for the Nelson-Marlborough Institute of Technology's Arts and Media Building. And the system is flexible. "We have used single walls but you can double them up and put additional dissipating systems between two adjacent walls."

Another advantage of the design, Mr Dekker notes, is that large pieces of timber stand up well to fire, as the outside chars and insulates the rest of the wooden structure. The LVL shear walls are encased within the plasterboard lining, which would help prevent destruction in a fire. A sprinkler system will also protect this community and heritage facility.

Finally, in the context of recent seismic activity, Pres-Lam offers a viable structural option. Mr Dekker sees potential for use in Christchurch in medium-rise residential and commercial buildings.

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