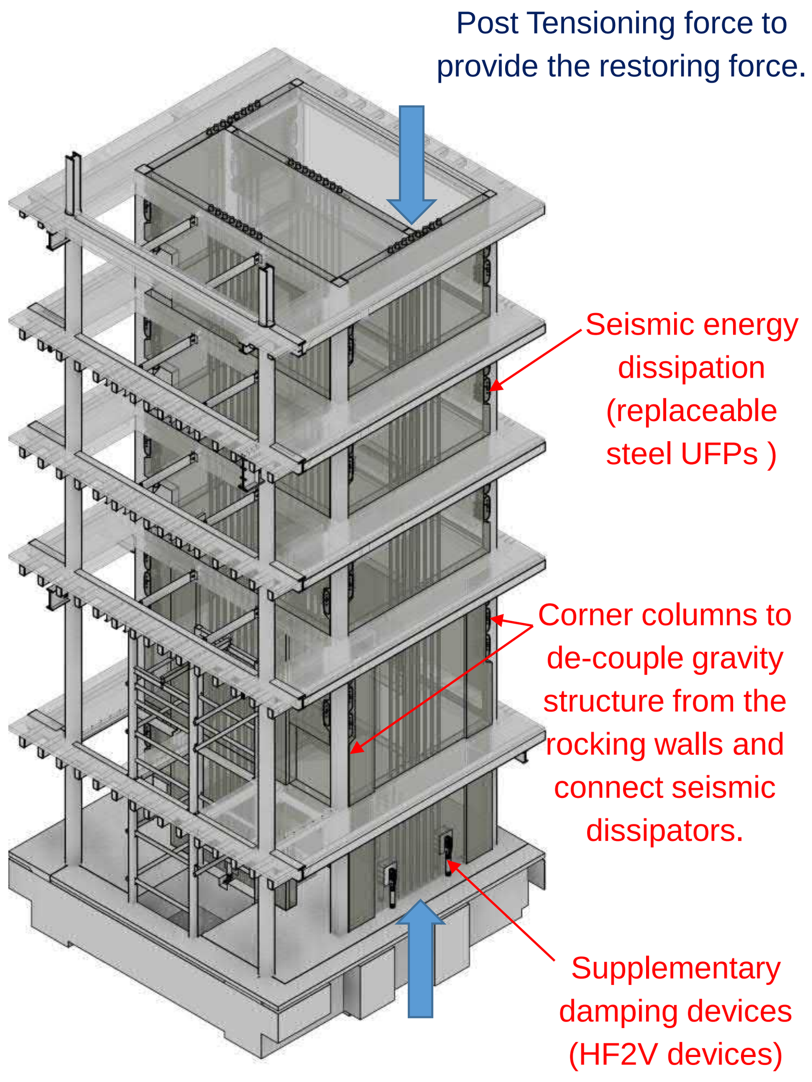
TŪRANGA
Christchurch, New Zealand

lewis bradford
CONSULTING ENGINEERS

New Central Library, 60 Cathedral Square, Christchurch
Opened October 2018

Structural Engineer:	Lewis Bradford Consulting Engineers
Architect:	Architectus + Schmidt Hammer Lassen
Owner:	Christchurch City Council
Contractor:	Southbase Construction
Project Peer Reviewer:	Ruamoko Solutions
Building Services Engineer:	Powell Fenwick Consultants
Geotechnical Engineer:	Tonkin and Taylor
Site Specific Hazard Analysis:	Professor Brendon Bradley
Specialist Peer Reviewer: Of Hybrid Walls	Professor Stefano Pampanin
HF2V Damper Designer:	Dr. Geoffrey Rodgers



Low Damage Features

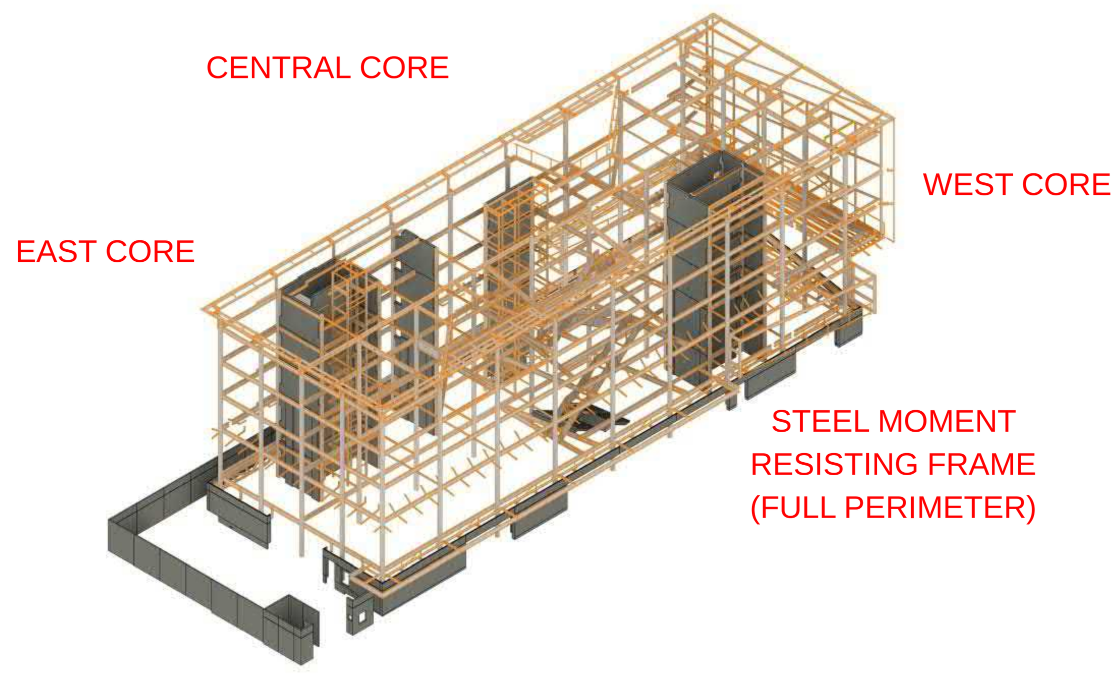
Hybrid Walls (Column-Wall-Column System)

A key feature of the structural design of Tūranga was the incorporation of a dual seismic resisting system primarily consisting of an integrated, self-centering mechanism in the form of Hybrid Concrete Shear Walls that can rock to isolate the building from peak earthquake accelerations. Each wall has high tensile, post-tensioned steel cables that clamp the wall to the foundations with approximately 1,000 tonnes of force per wall. When the walls rock, the stretch of these cables further increases the restoring force and returns the building to its original position after an earthquake.

On the corner of each core arrangement, a vertical column provides support for gravity floor beams and also provides the connection points for seismic dissipators called U-Shaped Flexural Plates (UFPs). This column-wall-column arrangement is a relatively novel approach to a rocking wall system, however it allows the high performance aspects of the self-centring hybrid wall system to be integrated into the stair cores. Utilising the cores is also ideal from an Architectural and Building Services perspective. Thanks to the post-tensioning, seismic energy absorbing devices (called high force to volume lead dampers or HF2V dampers) attached to the wall bases and the steel UFPs at each end of the walls; the rocking motion occurs in a controlled manner.

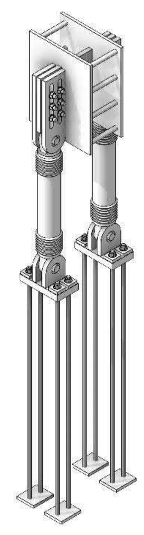
The second component of the seismic resisting system is the steel moment resisting frame around the full building perimeter with rocking connections at the base. These frames further enhance the building performance, and provide the added assurance of a building with two independent seismic resisting systems acting together.

The combination of the dual system, replaceable energy absorbing devices and the self-centering mechanism of the building provides a seismically resilient structure – delivering the performance level required and the property protection that the city deserves.



The UFPs installed between the walls and columns maximise damping by being located in the highest movement regions of the walls. The UFPs are "plug and play" elements i.e. they can be easily removed and replaced after a large seismic event. HF2V Devices provide additional supplementary damping (approx. 700kN per device) and are located each face of wall bases as close as practicable to wall ends. These devices consist of a steel piston pushing through a lead core. Full scale prototype testing was undertaken at Victoria University to confirm design parameters and velocity dependence of these devices. The restoring force is provided by post tensioned cables cast into the foundation, and anchored at the top of the wall. These provide approximately 25 MN.m of restoring force per wall at maximum drift.

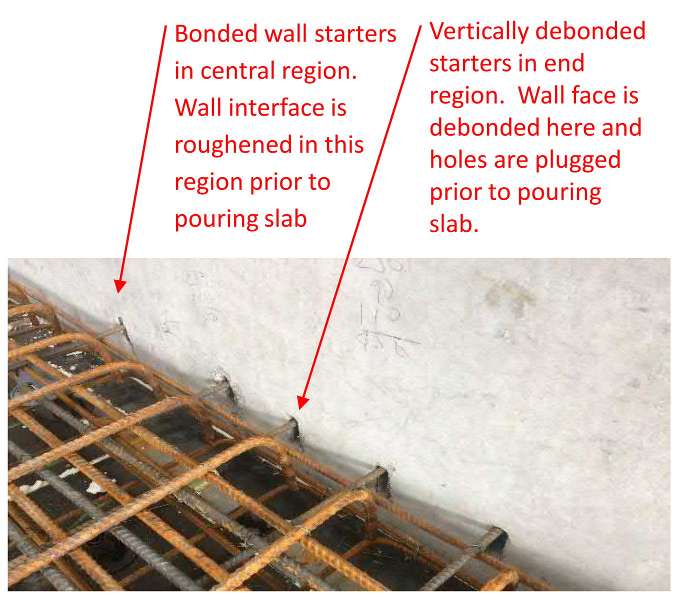

Steel UFPs


HF2V Device


Post tension anchors in foundation pockets at the base of the wall

Wall to Slab Interface

One of the greatest challenges of low damage rocking wall structures is allowing for vertical movements at the wall to slab interface, particularly at the ends of the walls. Here we developed a slight twist on conventional shear wall detailing to find the best possible balance between low damage design and overall structural robustness that is provided by well tied together conventional reinforcing detailing.



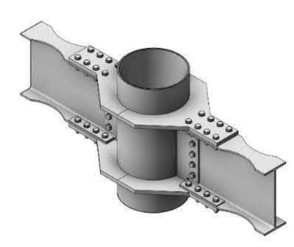
The end regions of the walls (higher movement regions) are vertically de-bonded from the slabs with RHS sections and carefully located compressible fillers. Conventional bonded wall to slab starters are provided in the middle region of the walls (the lower movement regions), allowing full shear transfer under seismic loading. Simple, but effective at minimising damage to floor slabs under seismic movement.

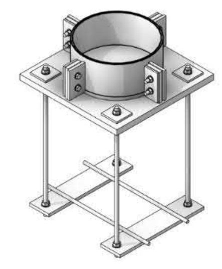
Analysis and Foundation System

The incumbent structural design by a different engineering firm included a basement and deep pile foundations. We shifted the plantroom to the roof and founded the building instead on a robust near surface gravel layer, deleting the requirement for piles.
A sensitivity analysis was undertaken on soil flexibility to assess variations in bearing pressures and foundation demands. Foundations were designed to ensure even bearing stresses under each of the rocking walls, to minimise the potential of differential performance of the foundations and flow on effects on the superstructure.

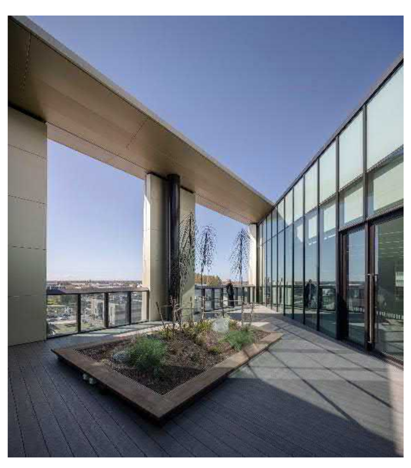
Steel Moment Resisting Frames

The steel moment resisting frames provide approximately 25% of the overall seismic resistance of the building. They help to limit building movement and therefore damage by providing high torsional resistance due to their position around the perimeter of the building. The steel columns are 507mm diameter Circular Hollow Sections (CHS's) concrete filled with steel collar joint connections. The perimeter beams have reduced beam sections adjacent to the collar joints to provide a ductile fuse element with controlled yielding outside the collar joints.





The deformation compatibility of the steel frame movements with the walls has been maintained at ground floor by providing rocking connection details at the column bases. These connections have vertically slotted holes with friction grip connections to allow the column bases to rock whilst the axial force in the columns provides an additional restoring force to minimise residual displacement.



Architectural Features

- Folded, perforated aluminium veil covering sections of glazed façade designed to mirror the Southern Alps and harakeke flax plants
- Long span floor system and central feature atrium stair
- Clean unencumbered elevations with no diagonal braces thanks to the use of hybrid shear walls in the stair cores
- Cantilevered glazed western end
- External roof terraces facing areas of importance to Iwi: Maukatere/Mt Grey to the north, Aoraki/Mt Cook to the west and Banks Peninsula to the south.

Building Services and Non-Structural Elements

- The broad range of technical skills at Lewis Bradford Consulting Engineers was also applied to bespoke fit-out elements such as the Imagination Station Lego Wall, the Book Tree, the playground and the touch screen wall.
- Accelerations from the Non-Linear Time History Analysis were used for the design of non-structural components.
- Since the building services were being fed from the plant deck at roof level, the services did not cross the 'rocking plane' at the ground floor level (the base of the hybrid walls). Rigid body motion of the hybrid walls in turn limited any requirements for special detailing of the building services to accommodate differential movement.
- In a few instances where services had to pass through a rocking wall, flexible hose joints were used.