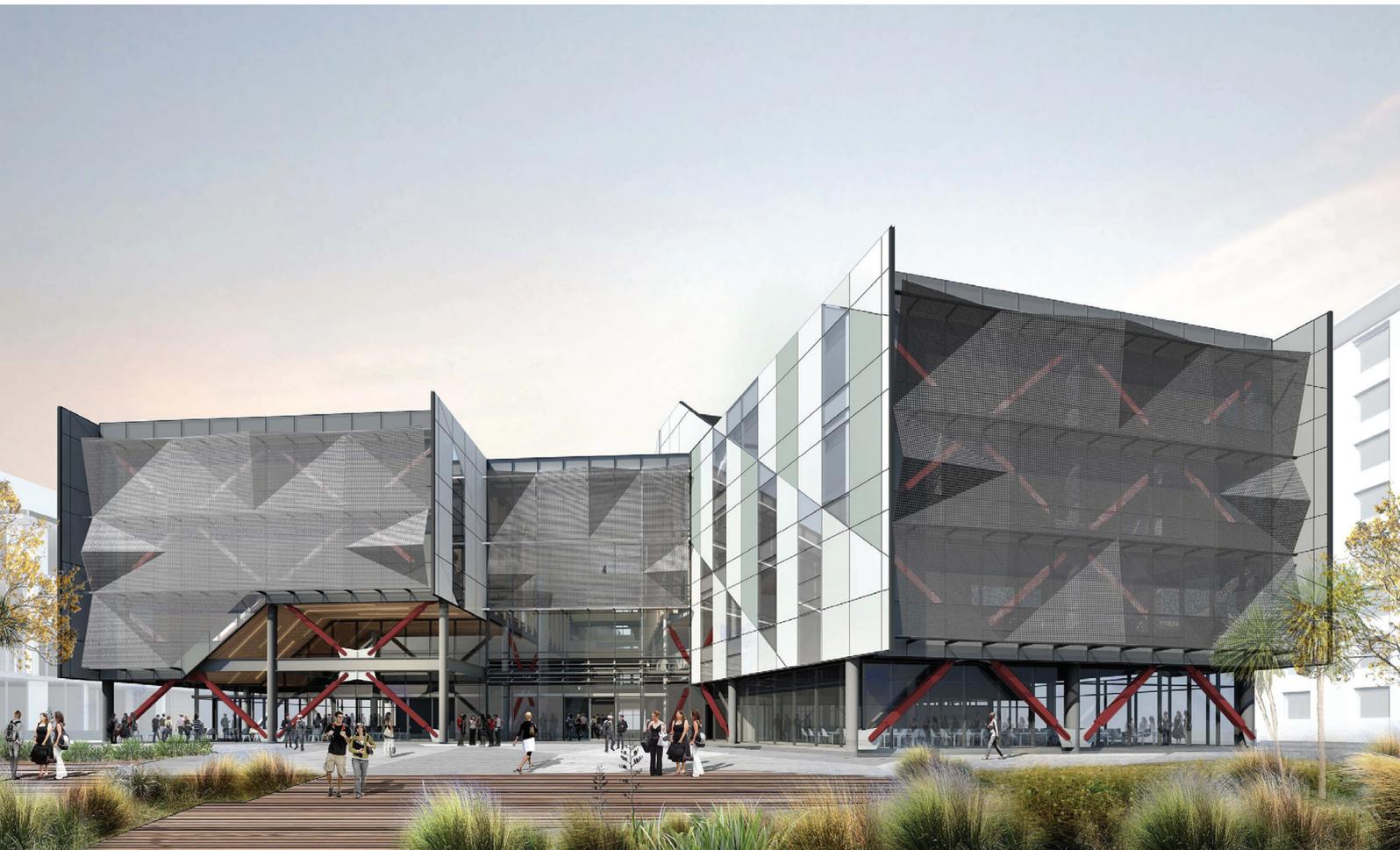


SEPTEMBER 2017



## STEEL : BUILT TO LAST

The \$216 million Rutherford Regional Science and Innovation Centre (RRSIC) will be the cornerstone of the University of Canterbury's Science Precinct. The state-of-the-art facilities will be a focal point for the University's science and innovation network and foster collaborative teaching, learning and research.

The RRSIC project is two buildings, the first of which is being built by Fletcher Construction and is a 25,000m<sup>2</sup> seismically engineered steel structure that includes specialist teaching and research laboratories for physics, astronomy, chemistry, geology, geography and biological sciences.

The development is part of a \$1.2 billion capital works programme that is progressively transforming the University campus with state-of-the-art teaching, learning and research facilities. A further \$1.2 billion in developments out to 2045 has been identified in a recently released Campus Master Plan.

The design team describes the first building of the RRSIC project as a "collegial effort". The team's attitude was to solve issues together, which was central to overcoming the many challenges the job threw at them.

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### ➔ THE FACTS

- Six-storey building
- 25,000m<sup>2</sup> gross floor area
- BRB seismic technology is a visible architectural feature
- \$216 million budget for the entire Science Precinct upgrade, which includes two buildings
- 31,000 bolts
- 1,643kg, weight of heaviest baseplate
- 8,525kg, weight of U frame
- 967kg, weight of heaviest HD bolt assembly



**“WORKING CLOSELY WITH THE LOCAL FABRICATOR WE WERE ABLE TO ADJUST DETAILS TO INCORPORATE BUILDABILITY AND OFFER SAVINGS TO THE CLIENT. DRIVING DOWN THE ROAD TO BRAINSTORM A BETTER WAY IS FAR MORE PRODUCTIVE THAN NUMEROUS PHONE CALLS, EMAILS AND SKETCHES WITH PARTIES THAT ARE NOT FAMILIAR WITH CONSTRUCTION PRACTICES IN NEW ZEALAND.”**

– ANDRE KIRSTEIN, TECHNICAL DIRECTOR - STRUCTURAL ENGINEERING, BECA

Structural steel fitted perfectly with the desire to incorporate buckling restrained braces (BRBs) as the main lateral-resisting system for the building. This seismic engineering technology enables buildings with this technology to operate soon after post-earthquake inspections are completed. If damaged, BRBs can be easily removed and replaced.

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## ENGINEERING

During the concept design phase a number of structural solutions were considered. Other than the foundations and floor slabs, the entire structure is fabricated steel and is the main material in both the gravity and seismic members.

Structural steel was chosen due to its ability to deliver on a range of key design points: it is cost efficient; allows large open spaces in line with modern teaching environments; has sufficient strength and stiffness to minimise total building deflections and inter-storey drifts; and offers a flexible and adaptable framing system, particularly salient given the extensive building services.

A building of this nature needs to almost be designed around the services rather than trying to fit the services into the building. The steel members can accommodate numerous and large penetrations that perfectly fit the building services ducts and pipes without forcing higher floor-to-floor dimensions.

Design changes during construction are inevitable with the number of end users in an educational building of this size and

complexity. Fortunately, steel is relatively forgiving and allows simple modification as required on site.

Most important, perhaps, is that structural steel fitted perfectly with the desire to incorporate buckling restrained braces (BRBs) as the main lateral-resisting system for the building. This seismic engineering technology enables buildings with this technology to operate soon after post-earthquake inspections are completed. If damaged, BRBs can be easily removed and replaced.

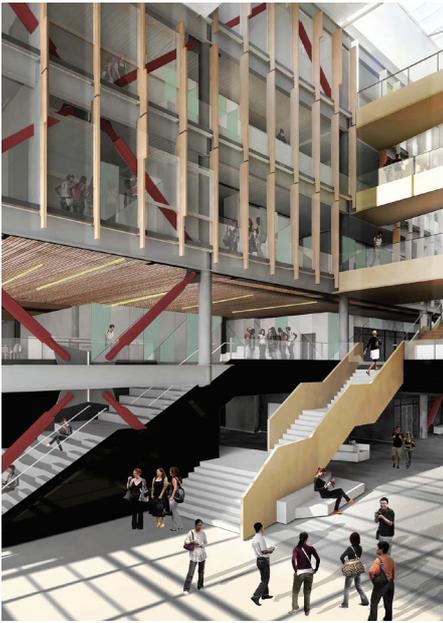
BRBs perform consistently in both compression and tension. A flat plate, which passes through the centre of the brace, is enclosed in concrete and then sheathed in steel. The outer steel casing prevents the internal steel core from buckling. As the building moves during an earthquake, it yields the piece of flat steel inside the brace, which absorbs the energy of the quake. The concrete case retains the plate and stops it from seriously deforming.

Currently, the New Zealand Building Code does not include specific design provision or guidance for BRBs, so US design guidance was adapted for use here. Early agreement on the

design methodology with a structural peer reviewer and the local territorial authority allowed agreement on design principles throughout the design process.

The use of BRBs enabled the team to design a structure that limits lateral movement, giving the façade greater protection from earthquakes than specified in the Building Code. BRBs also provided a very cost-effective façade system as it could be fabricated with simplified waterproofing details to joints, and without the need for complex movement details or support systems.

A stiff building does, however, pose other challenges. The impact of this approach was that the large over-strength forces had to be absorbed in the foundation raft design. Coordinating column hold-down bolts and holding them in position while also feeding the foundation reinforcing around the bolts is a common challenge on projects. But when you have a 1.5m-deep foundation raft, numerous layers of closely spaced 32mm-diameter bars and need to install 64mm-diameter holding down bolts, it requires some thought. Working closely with the contractor the issue was eventually resolved



The structural steel provided a quick, lightweight and clean framework from which other elements could hang. What's more, the steel is integral to the building's architecture and aesthetic, both internally and externally.

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**“THE PRECISION THAT STEEL OFFERED THIS PROJECT WAS PIVOTAL TO ITS SUCCESS – THE STRUCTURE WENT TOGETHER VERY WELL. DIFFERENT FABRICATORS WORKED TOGETHER ON THIS JOB TO ENSURE QUALITY AND EFFICIENCY – THE DELIVERY AND QUALITY WAS SEAMLESS. SUCH A HIGH-QUALITY OUTCOME WOULD BE DIFFICULT TO OBTAIN FROM AN OVERSEAS SUPPLIER.”**

– CHRIS BOSS, ASSOCIATE PRINCIPAL, JASMAX

by installing specially designed steel ‘tables’ that formed a template to support the bolts, shear key anchors and reinforcing.

Prefabricated steel formwork, which looked like inverted tables, was placed within the foundation to which the hold-down bolts were fixed and the reinforcement was threaded through. It allowed the contractor to hold all of the components in place with precision while the concrete was poured.

Structural steel's light weight reduced the impact on the design of the foundation raft. The ground underneath one building in particular has very soft layers. The design team's solution was to ‘float’ the building on top of the stiffer upper soils. The heavier the building, the further the load must be spread to limit settlement to a level that the building can accommodate. The steel made it easier to distribute those loads over a small area.

Another feature of the project was an existing underground service tunnel. The tunnel couldn't be moved without disrupting all services to the entire university. As such the engineers had to incorporate the tunnel into the design of the raft.

The design required the supply of very thick

plates, up to 150mm. Working with the fabricator the engineer was able to source higher grade steel allowing for thinner plates to be used. In addition, some circular hollow section columns required wall thicknesses of up to 32mm. Again working with the fabricator, the engineer rationalised the column design such that very little waste was incurred. Working with offshore fabricators would not offer this service easily and waste would have been seen as just part of the cost.

## ARCHITECTURE

The building's architecture is a symbol of its cultural and aspirational context. The ‘tree of knowledge’ design begins with the atrium, which serves as a wayfinder and encourages movement up through the levels of the building, from the undergraduate spaces below to the post-graduate areas above. The stairs evoke the spider webs of Ruahinematamorari that the Maori mythical hero Tawhaki used to climb to the heavens on his search for knowledge.

During construction, the structural steel provided a quick, lightweight and clean framework from which other elements could hang. What's more, the steel is integral to

the building's architecture and aesthetic, both internally and externally. For example, structural steel rods are used to support a glass balustrade, and the façade design follows the diagonal bracing system of the BRBs – glimpses of the structure can be seen at different points through the glazing.

While the braces look the same, they are exposed to different loads throughout the building. The south end is the heaviest part of the structure. At this point the braces use stronger pins rather than bolts to hold them in place.

The mechanical services in the RRSIC are massive and it was crucial to get this aspect underway as early as possible to ensure the project was completed on time. The structural steel solution offered phenomenal accuracy and early access for the multiple trades. Importantly, the material also allowed deeper ceiling voids and castellated beams to accommodate the services.

The building has also been designed with environmental sustainability in mind, with a specific focus on limiting energy use, maximising access to natural light and ventilation, and reusing existing materials wherever possible.



**“MEETING THE PROGRAMME IS EVERYTHING. OUR HIGHLY AUTOMATED TECHNOLOGY MEANS THINGS ARE MUCH MORE PREDICTABLE. WE CAN PLAN TO A HIGH LEVEL OF DETAIL, GIVING CONSULTANTS AND BUILDERS FULL CONFIDENCE IN THE PROGRAMME.”**

- WAYNE CARSON, GENERAL MANAGER, D&H STEEL

The fabricator coordinated the detailed design phases with the builder as a way of managing the limitations inherent in a compact site. The building was constructed in two vertical phases: up to level four, then a second jump up to the top-most level.

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## FABRICATION

Joint venture partners D&H Steel and John Jones Steel supplied and installed the structural steel for the project. D&H Steel looked after the high productivity, easy-to-transport components from its Auckland base, while John Jones Steel managed the more difficult, “big and ugly” elements as they were close to the construction site.

In addition, D&H Steel was tasked with the design and supply of the BRBs. D&H Steel is the exclusive New Zealand agent for US company Star Seismic, one of only three companies internationally offering the BRB solution. Star Seismic developed the design and D&H Steel manufactured the BRBs on the ground in New Zealand.

As the fabricator responsible for both, D&H Steel seamlessly coordinated the BRBs and the structural steel. There is a series of intricate connections between these elements – up to 30 for each BRB, of which there are 120 reaching diagonally from the floor to the ceiling.

BRBs are essentially highly specialised shock absorbers – the piece in the core is the magic. Having the same fabricator for the structural steel and the BRBs meant the fabrication

tolerance and buildability risks for the builder were significantly reduced.

The fabrication processes use highly advanced machines. Half of the components are produced using automated CNC technology. It allows precise and rapid repetition of the elements compared with manual operations.

The nature of the project, as both a science and an architectural building, meant there was considerable complexity. There were multiple services to be accommodated including air, water, data, gas and air conditioning. Also, much of the structural steel is exposed so a high level of architectural coordination was required – the finish and the alignment must be precise to create the desired aesthetic.

The fabricator, engineer, builder and architect worked together closely. There was ongoing dialogue and information was shared via 3D building information modelling (BIM). The fabricators worked from the architect’s model, which saved considerable effort when it came to the secondary steel. BIM replaced traditional shop drawing from a set-out perspective – bracket placement, for example. The 3D model went straight to the CNC machine so the final product was precise and without human error.

As part of the seismic design, the hold-down

bolts for the foundations were massive. Typically a manual process, for this project the bolts had to be craned into place as the complete assembly weighed over a tonne. By working closely with the builder in the planning stages, the fabricator identified a way of making the assembly simpler and also suggested an alternative baseplate shear connection detail, shaving \$300k off the cost in the process.

The six-storey high, 600mm-diameter columns provided some challenges. There are a large number of attachments inside the column along its length, as well as reinforcing steel. To manage the attachments the fabricator cut the columns into sections then welded them back together in the workshop. Getting them from the workshop to the site was a logistical feat. Having John Jones Steel’s workshop on the ground near the site was a real advantage to the programme.

The fabricator coordinated the detailed design phases with the builder as a way of managing the limitations inherent in a compact site. The building was constructed in two vertical phases: up to level four, then a second jump up to the top-most level. The fabricator sequenced production of the steel structure to sync with the construction phases.