STEEL CONSTRUCTION NEW ZEALAND

CASE STUDY: PwC CENTRE, CHRISTCHURCH

STEEL ON DISPLAY

Image courtesy of Warren and Mahoney

The PwC Centre in central Christchurch, situated between the city and the Christchurch Botanical Gardens, inhabits a pivotal 'gateway'. The building is defined by the banks of the Avon River and its relationship with the Bridge of Remembrance. Its distinctive printed façade creates a striking landmark for Christchurch, both day and night.

The building has been designed to a high importance level, IL3, to create a safe working environment for tenants and visitors. The $30 million, five-storey office building is primarily a steel structure with a composite flooring system. The resilient, lightweight and economic building offers enhanced seismic performance with the use of buckling restrained brace (BRB) technology.

The project was highly collaborative – structural engineer Beca, architect Warren and Mahoney, builder Armitage Williams and structural steel fabricator Pegasus Engineering worked in close consultation with one another to create the signature building on the corner of Cashel Street and Cambridge Terrace.

Key Facts

- **Six-level building**
- **8,000sqm of office space**
- **Perimeter-based steel frame creates exoskeleton structure**
- **Columns anchored to 1,500mm-deep reinforced concrete raft**
- **900 tonnes of structural steel**
- **Substantial use of fillet-welded connections in lieu of bevel butt-welded connections**
- **BRB seismic technology features in the architectural finish**
- **Raft consists of 3,000cbm concrete and 420 tonne of reinforcing**
- **Superstructure isolated down to 65 production sequences**

The Team

Owner: Bridgewater Properties
Structural Engineer: Beca
Architect: Warren and Mahoney
Builder: Armitage Williams
Structural Steel Fabricator: Pegasus Engineering

Engineering

The original concept – a simple, cost-effective structural steel design using circular columns as braces – changed once the anchor tenant, PwC, came on board. It was PwC that requested the building code be exceeded. Resilience was crucial, ensuring the building remained safe and operational. The change represented a significant challenge for the design team: how to modify the structural design to meet the higher demands, keep it cost effective and limit any impact on the programme.

Steel's inherent design flexibility allowed the team to adapt the concept to meet the new needs. The structural perimeter-based strategy, with the BRBs placed on the outside to create an 'exoskeleton', allowed the team to move things around on the inside; stair cores and lift shafts, for example, were easily and swiftly relocated.

"AFTER THE EARTHQUAKE IT MADE GOOD SENSE TO USE STEEL: IT IS FAIRLY COST EFFECTIVE, AND EASY AND FAST TO BUILD WITH."

SAMIR GOVIND, TECHNICAL DIRECTOR, BECA

Innovative elements of the structural design include:

- the main building columns are anchored using conventional steel shear studs to a 1,500mm-deep reinforced concrete raft, which allowed the first floor structure to be built prior to the ground floor raft. The concrete raft has been designed to control differential settlement effects should liquefaction occur during an earthquake
- a novel bracing arrangement, which was architecturally pleasing yet structurally efficient; it also allowed the main building columns to be designed efficiently
- modified web cleat slotted through the main building columns in two directions were designed to avoid cutting the column
- fillet-welded connections, wherever possible, in lieu of full-strength welding, which reduced both the time needed to complete the structure and the level of weld testing

Steel's light weight allowed a lighter foundation structure. Anchoring the columns to the raft enabled part of the steelwork to be erected early with minimal construction tolerances allowed. The anchored detail, which is embedded into the concrete raft with conventional steel shear studs, is an idea that Beca derived early in the design process. It offered a number of programme benefits to the builder that would not otherwise have been possible.

BRBs have the ability to yield the internal steel core, both in tension and compression, with the outer steel casing preventing the internal steel core from buckling. The brace has a flat plate running through the centre, which is encased in concrete and then sheathed in steel. Arranged in simple lines on each building elevation, the BRBs reduce the overall demand on the collector beams and column elements.

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. Following an earthquake the brace can be easily removed and replaced.

The building uses steel pipe columns filled with self-compacting concrete reinforced with steel fibres to provide a 60-minute fire-resistant rating on the braced floor levels.

The design-build team – engineer, architect, fabricator and builder – were all using the same building information modelling (BIM) platform, Revit. It allowed the seamless transfer of design and detailing between all parties. The building was digitally designed in 3D from the ground up.

Architecture

By integrating the architecture and engineering structure the PwC Centre is lightweight but strong. Warren and Mahoney created a distinctive printed façade for the PwC Centre, which controls glare and solar gain, and balances outlook and daylight considerations at its northern face.

On the interior, the architect employed steel as part of the building's architectural statement. The exposed BRB structure works aesthetically as well as functionally, blending seamlessly into the interior architectural form. The lines of force running through the building are clearly, and deliberately, on display.

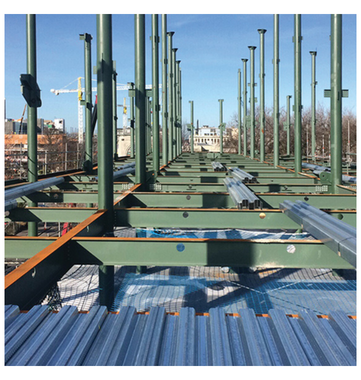
With all the steel on show, it was important the finish of the steelwork look the part. Stitch welds on column undersides were ground and polished to a perfect finish, leaving no evidence of process marks.

The architectural brief also called for modern, flexible workspace configurations. The steel exoskeleton allows a relatively open plan layout, comprising a series of steel columns that support the steel beam and concrete slab floor structure.

"IT'S COMING OUT OF THE GROUND VERY QUICKLY WITH STEEL. THE PROJECT LEAPT FROM THE RAFT TO THE COMPLETE BUILDING SKELETON IN LESS THAN THREE MONTHS, IT WAS GOBSMACKINGLY FAST."

JONATHAN COOTE, PRINCIPAL, WARREN AND MAHONEY

Fabrication



Steel fabricator Pegasus Engineering was invited to work with the engineering team at an early stage. Structural engineers don't typically get an opportunity to work with the fabricator, due to procurement challenges. The building owners saw the benefits in doing so for this project. Working collaboratively with Pegasus, Beca developed distinctive, cost-effective and pragmatic details. This allowed the 900-tonne steel structure to be fabricated and installed easily, while achieving the high performance required by the code. Collaboration also made it easier to determine the 'buildability' and incorporate novel ideas; issues were identified and resolved before they became a problem.

Pegasus worked particularly closely with Beca to refine some of the welded connections and fabrication techniques applied to the building. Considerable economies were introduced by reducing fabrication time, particularly the welding component; it meant that less labour went into the building, and less cost.

Steelwork is one of the critical paths of the project; by being involved early on any cost-saving changes were included in the design before the council consent process. Normally this would happen after consent, which then slows the process and creates additional cost for all by having to revisit the design. The erection methodology, for example, was factored into the design so there was no need to revisit this step after consent was granted. It meant less consultant time was required, freeing up the consultants to focus on other trades and any buildability issues.

Images courtesy of Beca

"WE WERE INTRODUCED TO THE PROJECT AT AN EARLY STAGE, WHICH HELPED TO DRIVE ECONOMIES INTO THE DESIGN USING DIFFERENT WELDING AND FABRICATION TECHNIQUES. BEING LOCAL ALSO ALLOWED US TO COLLABORATE WITH THE CLIENT'S TEAM AS AND WHEN REQUIRED DURING THE FABRICATION AND ERECTION."

SIMON WILLIAMSON, GENERAL MANAGER, PEGASUS ENGINEERING

State-of-the-art workshop technology was used to achieve the high levels of accuracy required. Applying Tekla shop drawings to complicated connections in the roof and structure highlighted any of the clashes before approval stage. Pegasus coordinated the engineering and architecture models into one to make sure the building could be built. The process highlighted any clashes, which Pegasus then problem solved with the two consultants so that both parties were satisfied with the final design.

A key challenge for the fabricators was to manage the flow of work. There was no storage or laydown area on site so sequencing was critical. Pegasus broke the project superstructure down into 65 sequences for the main floor structure to produce the right steel at the right time, as per a programme communicated and agreed with the builder. Pegasus' logistics team had to programme the deliveries by the truckload. The team used a software package called FabSuite to monitor and report on logistics.

Construction

Steel's light weight, speed of erection and off-site fabrication played a key part in the material's selection for this project.

A key challenge for builders Armitage Williams was the site itself – the building occupies the entire footprint. Bound by street frontages on two sides and hard up against neighbours on the other, there is little working or storage space. So off-site fabrication was a real benefit. Considerable thought went into the logistics: sequencing of steelwork production, truck loading and delivery to site. Construction began at one end and moved west to east across the 90m long, 40m deep site.

"THERE ARE REAL ADVANTAGES TO WORKING WITH A LOCAL FABRICATOR. NOTHING BEATS SITTING DOWN ACROSS A TABLE AND THRASHING OUT THE ISSUES; YOU GET ON TO PROBLEMS ASAP."

GRAEME JONES, SENIOR PROJECT MANAGER, ARMITAGE WILLIAMS

Off-site production and the speed with which steel is erected minimised time spent on site. The steel bolted together quickly and easily on site. Less time spent on site increased the cost effectiveness of the project.

Having the fabricator involved early on in the project led to the whole steel process getting underway sooner: detailing, shop drawings and steelwork production. It aided a smooth, uninterrupted supply to the build site.

Construction began with the raft followed by the building's steel 'skeleton', which was characterised by tall, slender columns. The floor slabs were filled in later, floor by floor. This approach allowed construction to move at a considerable pace.

Steel Construction New Zealand Inc. L2, 17-19 Gladding Place, P.O. Box 76403, Manukau City 2241, New Zealand
Phone: +64 9 263 5635, Fax: +64 9 263 5638, Email: info@scnz.org