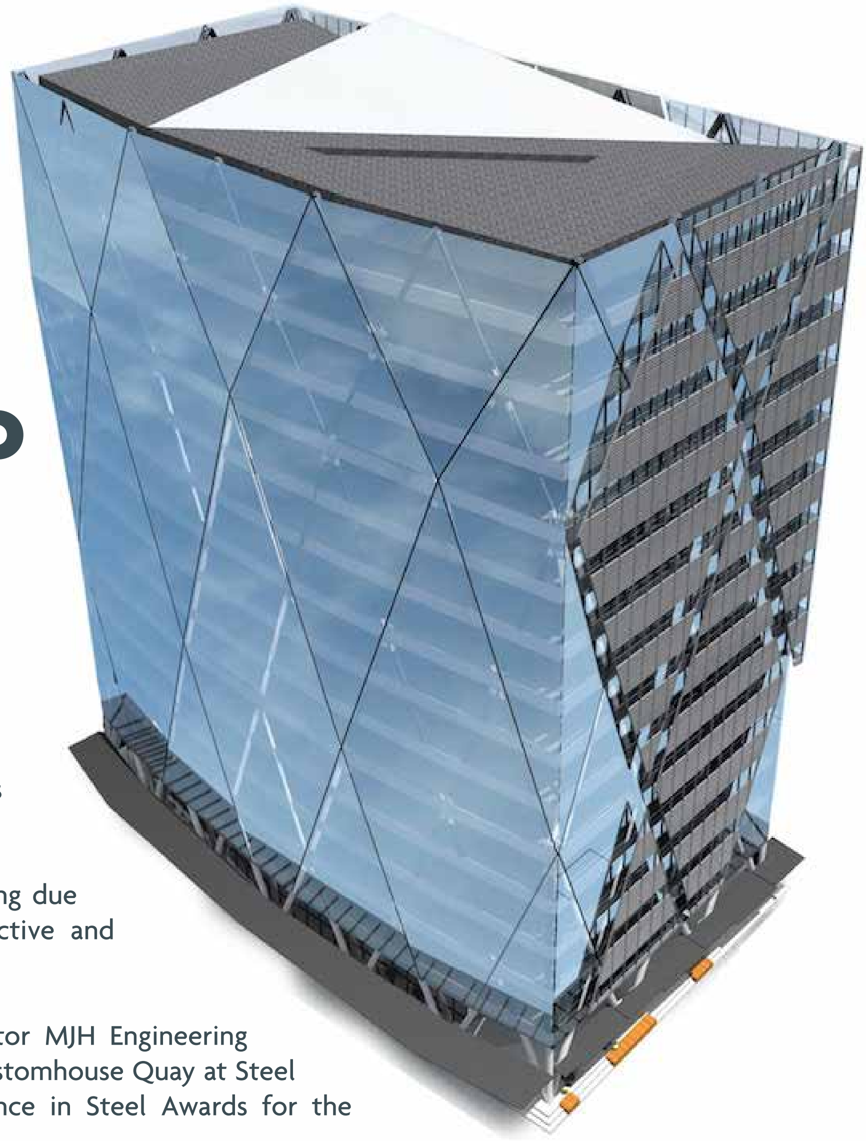
JULY 2019



ICONIC WELLINGTON BUILDING SETS NEW STANDARD FOR STEEL INNOVATION

20 Customhouse Quay is a new 14-level seismically advanced office tower on the site of the old BP House on Wellington's waterfront.

It has become an iconic Wellington building due to its prominent position, and its distinctive and innovative diagrid steel structure.

Wellington-based structural steel contractor MJH Engineering won the Overall Supreme Award for 20 Customhouse Quay at Steel Construction New Zealand's 2018 Excellence in Steel Awards for the project's outstanding execution.

Completed in mid-2018 following a 30-month construction, the New Zealand Green Building Council 5-star Green Star rated building is designed to minimise structural damage and reduce the potential for business interruption in the event of a one-in-500-year earthquake compared with a typical 100 percent NBS office building, which is only designed for a one-in-25-year event for the same damage limit. The building is estimated to meet up to 180 percent of the Building Code.

Notably, it is the tallest diagrid structure in New Zealand to be built on base isolators, which sit on top of new piles in the pre-existing BP House basement and isolate the building from ground movement. It is the building's structural steel diagrid frame that makes this approach possible.

Given the complexity of this project, early engagement and collaboration between parties was essential to overcome challenges and develop innovative solutions.

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THE FACTS

- 15-level base-isolated building
- Unique steel diagrid structure
- 3m-high ceilings
- 17,500m^2 gross floor area
- NZGBC 5 Star Green Star rating
- Designed to survive a one-in-500-year earthquake
- Estimated to meet up to 180 percent of the Building Code
- Used a Hololens to ensure fabrication accuracy
- More than $10 million of structural steel used

STRUCTURAL STEEL CONTRACTOR: MJH ENGINEERING **ARCHITECT:** STUDIO PACIFIC ARCHITECTURE **ENGINEER:** DUNNING THORNTON
BUILDER: SCARBRO CONSTRUCTION

A standout feature of this building is the steel diagrid superstructure, essentially a series of versatile, diagonal columns inside the façade.

"THIS WAS VERY MUCH A WELLINGTON-LED PROJECT, WITH MUCH OF THE TEAM BASED IN THE CITY, AND THE INNOVATIONS WE DEVELOPED CAME DOWN TO OUR CLOSE-KNIT TEAM APPROACH."

– CHRIS SPEED, ASSOCIATE, DUNNING THORNTON

ENGINEERING

From the outset, the aim was to create a highly resilient, seismic-resisting and aesthetic structure.

To achieve this, the base of the building uses a system of base isolators – rubber devices with a lead core that absorb the majority of the movement in an earthquake, rather than the building itself. For this approach to succeed, the building's structure needed to be strong yet lightweight – structural steel ticked those boxes, and more.

A standout feature of this building is the steel diagrid superstructure, essentially a series of diagonal columns inside the façade. The diagrid is versatile and can be moulded into almost any shape, allowing the building to take on the subtle curve of the building's façade. The result is a complex geometry, which had to integrate with the existing basement, fitting together like a Meccano set.

"The perimeter diagrid structure and composite steel construction allows for large, open floor areas. The diagrid structure is efficient – it uses about 20 percent less steel than conventional building designs – and limits the need for interior seismic structure so internal columns planning could be optimised.

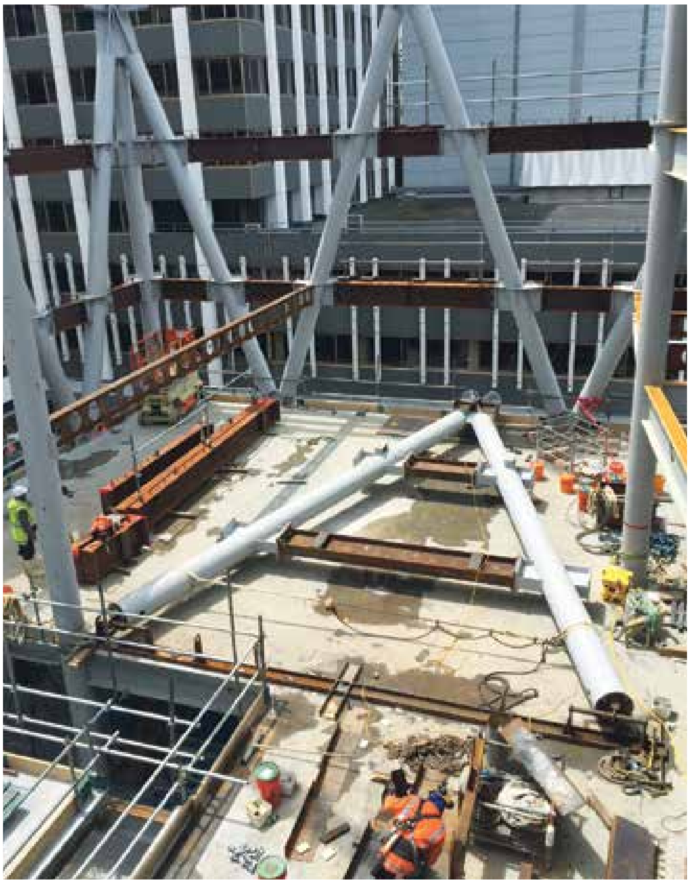
The diagrid A frames were assembled on site and then 'hinged' into position. The team painstakingly machined all of the mating faces between the diagrid nodes and the circular hollow section braces to make them perfectly flat, and ensure that correct dimensional and geometrical tolerances were achieved.

The steel was installed on site using a jump floor process, where three floors of the structure were installed at a time, followed by the next three. This construction process allowed for greater efficiency and created safer work areas to install Comflor on the floors below the jump.

ARCHITECTURE

The client wanted an iconic commercial Wellington building, and 20 Customhouse Quay is just that – a dark, structurally strong building in a high-profile position on Wellington harbour.

The site was a challenge as there were three prominent façades to design and the need for the building to stand out from a distance. From the outset, a base-isolated building was



Diagrid A-frame section assembled on the slab in a hinge frame, ready to be lifted.

A-frame section of diagrid, upright and about to be released from a hinge frame and craned into position.

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"IT WAS INVALUABLE FOR US TO BE ABLE TO INTERACT WITH THE LOCAL STRUCTURAL STEEL FABRICATORS AND SEE THE MANUFACTURING OF THE STEEL FIRST-HAND, TO OVERCOME THE CHALLENGES TOGETHER AS A TEAM."

– BRUCE GREEN, SENIOR ASSOCIATE, STUDIO PACIFIC ARCHITECTURE

a requirement so the architecture needed to drape around this. There were many different design exercises carried out to determine the façade treatment.

The distinctive steel diagrid structure was adopted as the design's DNA, influencing many of the architectural decisions. It was faceted to create a subtle curve on the building's eastern face. A super-grid of geometric diamonds references the diagrid and breaks the façade into three main sections, giving scale and a vertical proportion.

The faceted curve animates the façade, with changes in angle creating different reflections of the harbour and city in the tinted glass.

Architects Studio Pacific Architecture considered two options to work with the base-isolated system: having a panel around the building that would lift in a seismic event or having the building move across the top of the footpath in a seismic event.

The prospect of no obvious moving joints made for a crisp design and hidden features, and dictated the type of movement system used. In this case the ground floor had to be above the level of the footpath so the decision was made to use a stone plinth rather than having the building flush with the ground.

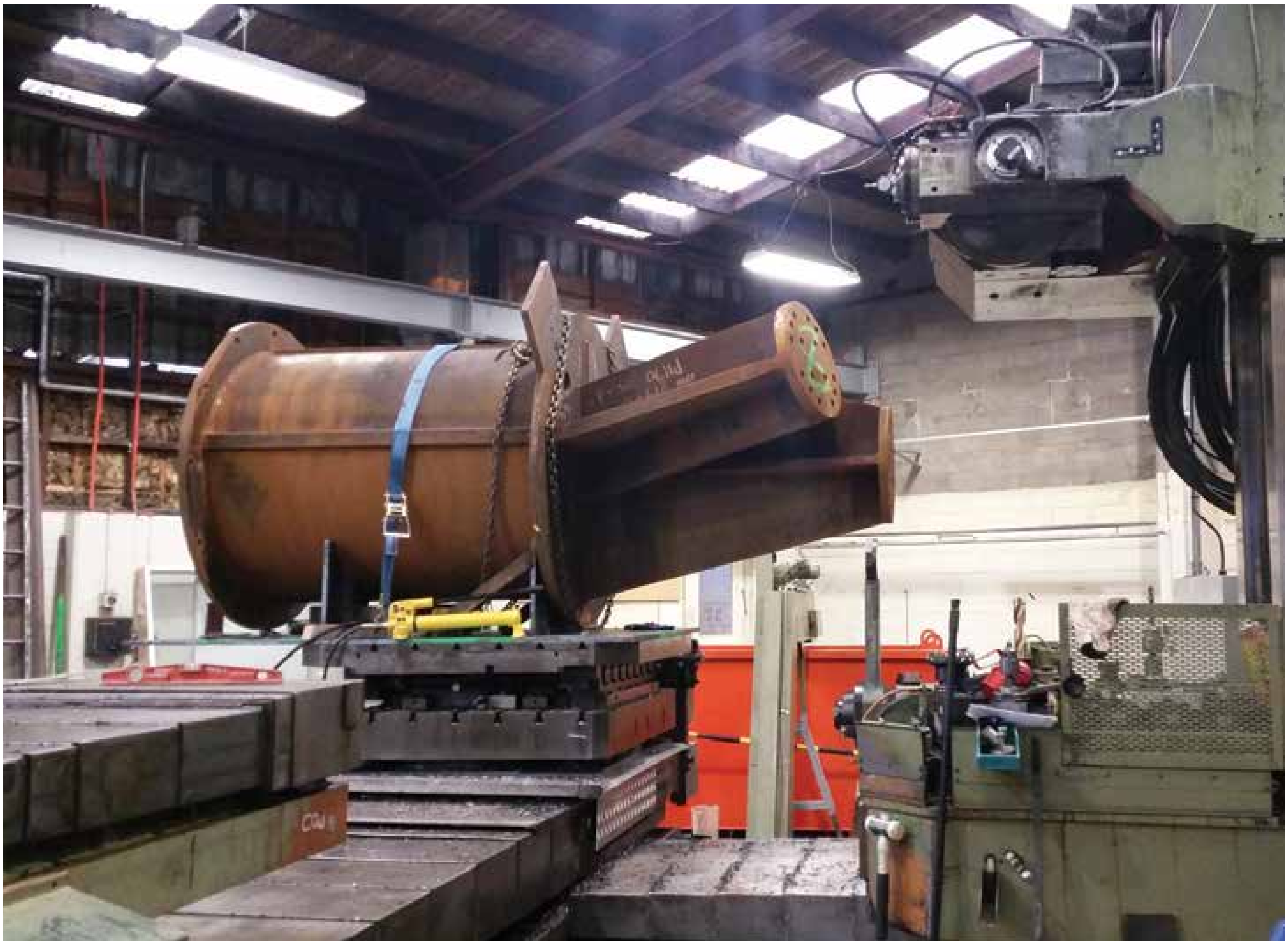
As well as being seismically advanced, the building is environmentally sustainable with external louvres on the north and west façades, which help to prevent solar gain and reduce the amount of energy required for cooling.

In recognition of the building's prime waterfront location, its contiguous floor plates have been designed to support modern flexible workplace planning and take advantage of views to the sea, down the quays and back to the city. Ample natural light is provided by floor-to-ceiling glazing and a three-metre internal ceiling height.

FABRICATION

The importance of early contractor involvement in the success of the building can't be underestimated. From the beginning, MJH Engineering worked closely with engineer and architect teams, and trust and confidence in each team's abilities was established. This collaborative approach identified potential buildability issues and resulted in a number of innovative ideas employed in the project.

The key challenge was the complexity of the connections required to build the iconic



Large five-tonne, ground-level fabricated node section on machine table, about to have diagrid face plates machined.

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"THIS WAS A HIGH-PROFILE JOB IN WELLINGTON, AND MANY CONTRACTOR EYES WERE ON US DURING THE BUILDING PROCESS. IT IS CERTAINLY A SHOWCASE FOR STRUCTURAL STEEL. WE ENJOYED WORKING OUT THE COMPLEXITIES OF THE PROJECT WITH THE REST OF THE TEAM."

– MARK SHIRTLIFF, PROJECT MANAGER, MJH ENGINEERING

diagrid structure. On a conventional building, vertical columns would support the structure, however, with this building the columns were on a 60-degree angle. To ensure precision, MJH invested in a five-axis CNC milling machine previously used in the US aerospace industry (for machining jet engine turbines) that could machine the steel to precise dimensions.

This specialised technology was able to machine large componentry – up to 12 tonnes. There are only a few of this size machine available in the world. The milling machine uses data extracted from the 3D model to achieve the flawless, highly complex geometric structures. It also supported face-to-face movement and end-joint tolerance without any corrective alignment shimming required.

MJH used its augmented reality device, Hololens, to view and interact with the 3D model and check for any potential design issues. The use of smart cell beams increased efficiency and the large circular holes in the beams allowed for easy integration with other services.

MJH also created a design for nut encapsulation – a method of restraining the nuts to allow them to align themselves as the bolts were tightened.

In conjunction with Dunning Thornton, MJH integrated a risk-based assessment for weld testing which was essential for a project of this nature with a significant volume of deep-penetration welds.

Using local steel fabricators who have Steel Fabrication Certification (SFC) meant that a robust quality assurance process was assured – each part of the project is carefully monitored providing peace of mind that a quality structure is provided. On a major project such as 20 Customhouse Quay, these assurances before arriving on site were pivotal to ensuring the build went smoothly and remained within budget.