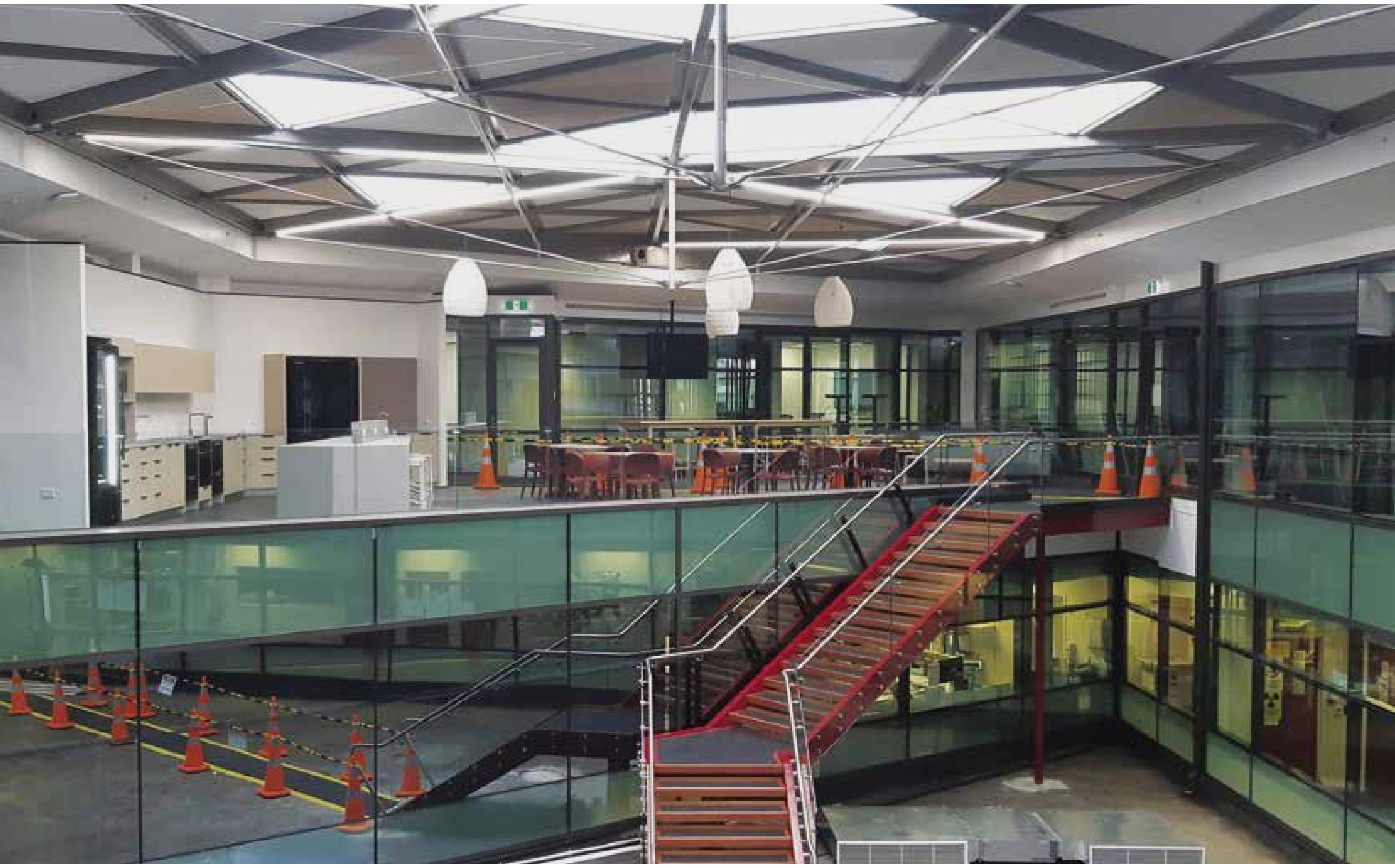
SEPTEMBER 2021



STRUCTURAL STEEL'S SEAMLESS AESTHETIC

Ask the project team what the key challenge was in delivering the atrium structure for NZ Blood's head office and a common theme emerges: working within an occupied building.

The atrium is the centrepiece of NZ Blood's new headquarters and part of a five-year project to consolidate the organisation's core operations under one roof.

Imagine a square internal courtyard, surrounded by offices on all four sides yet open to the sky. The job was to transform the large external area of the existing building into an internal space by covering it with a roof. The atrium was to become the heart of the building with branches leading away to the offices.

Most strikingly, perhaps, is the seamless aesthetic on show inside the atrium. Looking up from ground level, the view is of an intricate latticework of steel triangles. Connections for the architecturally exposed structural steel feature hidden bolts so that all the joints appear slick. A portion of the services are fed through the interior of the rectangular hollow section members to contribute to the clean aesthetic.

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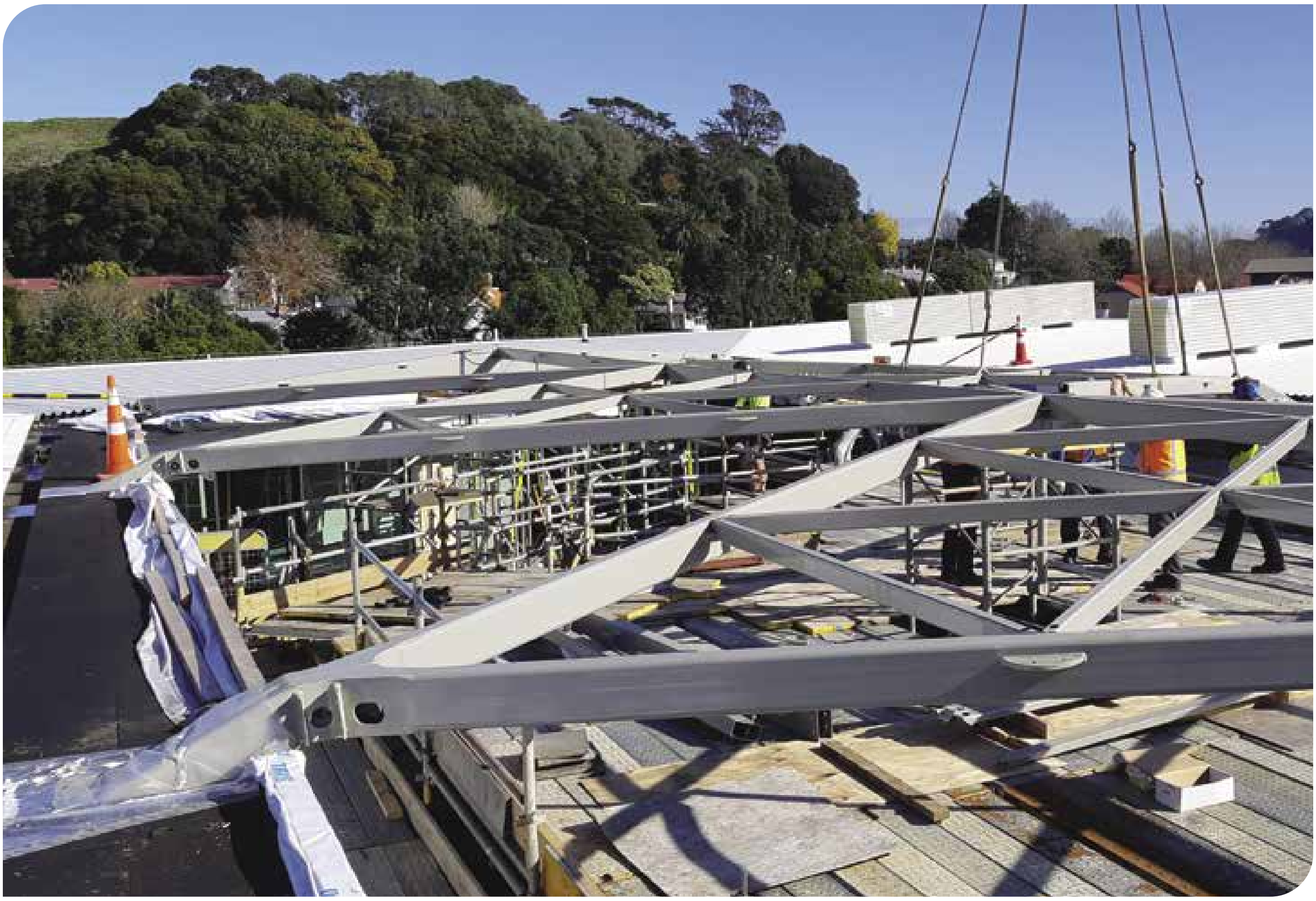
THE FACTS

- 24 tonnes, design mass of main structure
- 1,500 pieces of steel
- 13 major assemblies
- 443kg, the heaviest single atrium assembly
- 2 tonnes of strengthening steel around perimeter
- 517kg, heaviest strengthening beam manhandled into place
- 130 tonne mobile crane

ENGINEER GHD **ARCHITECT** GHD WOODHOUSE **STEEL CONTRACTOR** GLOBAL ENGINEERING **BUILDER** Q INTERIORS



ENGINEER

When the architects presented GHD with the conceptual render for the project, the question was, how close could the engineering design get to the concept. It got very close and the successful scheme was developed hand in hand with the architect.

Originally planned as a timber structure, the design changed to structural steel. The team had to choose between either using timber and changing the aesthetic, or changing the material and keeping the aesthetic. It came down to material properties.

Timber would have required large member sizes, which would have altered the aesthetic substantially. By using steel sections, the design could achieve the required strength and stiffness, and retain the look and feel of the original concept.

The use of steel allowed the team to achieve the atrium's complex geometry, which consists of contorted load paths. The biggest challenge for the team was trying to thread through the structure's hidden supports.

There were very narrow architectural envelopes to get to the existing structure, so all of the exposed steelwork had to be as thin, and look as clean and simple, as possible. The most difficult thing was working to strict height limits and trying to find a solution where the steelwork could all be threaded through without letting on that it was actually supported further out.

About 25 percent of the support structure is hidden in the existing gutter islands, which form part of the existing structure. A 1.5m 'eyelid' wraps all the way around the building, as the gutter is artificially wide for aesthetic purposes. The structural steel supports drop down inside the eyelids, out to the main grid lines where the primary steel for the main structure is.

Where the steel goes down through the eyelids, there is a structural depth of only 200mm – trying to slot down inside that was quite challenging.

The existing building envelope was neither plumb nor square. To address this, additional tolerances were built into the structure. The engineers also worked closely with the structural steel contractor. They exchanged the fabrication model dozens of times to ensure that any changes between the as-built drawings and the physical building were accounted for before fabrication started.

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Having a local structural steel contractor on board allowed the engineering team to respond fluidly to issues as they arose, and working with locals meant that the team could visit the factory during the fabrication process. Structural steel contractor Global Engineering conducted a trial assembly of the atrium in its workshop and the engineering team was able to inspect the subassemblies – specifically a couple of the centre nodes – before they were welded onto the main members. With an overseas' supplier, there would not have been an opportunity to check the product and make sure that each party had understood the other correctly.

"I LIKE STEEL'S CLEAN, PRECISE LOAD PATHS AND ITS UNIFORM PROPERTIES; IT IS A LOT LESS AMBIGUOUS THAN OTHER MATERIALS."

RICHARD ENGLISH,
STRUCTURAL ENGINEER, GHD

BUILDER

Not only was the team working in a live site, it was a highly sensitive medical environment. They all had to coexist. It was critical that construction didn't interrupt NZ Blood's operations and the business was protected from any construction contamination.

Accessing the site was a challenge. The build team couldn't just walk in materials off the street. To get to the atrium it had to go down through the basement, up the back stairs and follow a maze of accessways. Builder Q Interiors likens it to an island at the centre of the building and getting materials to the island was hard.

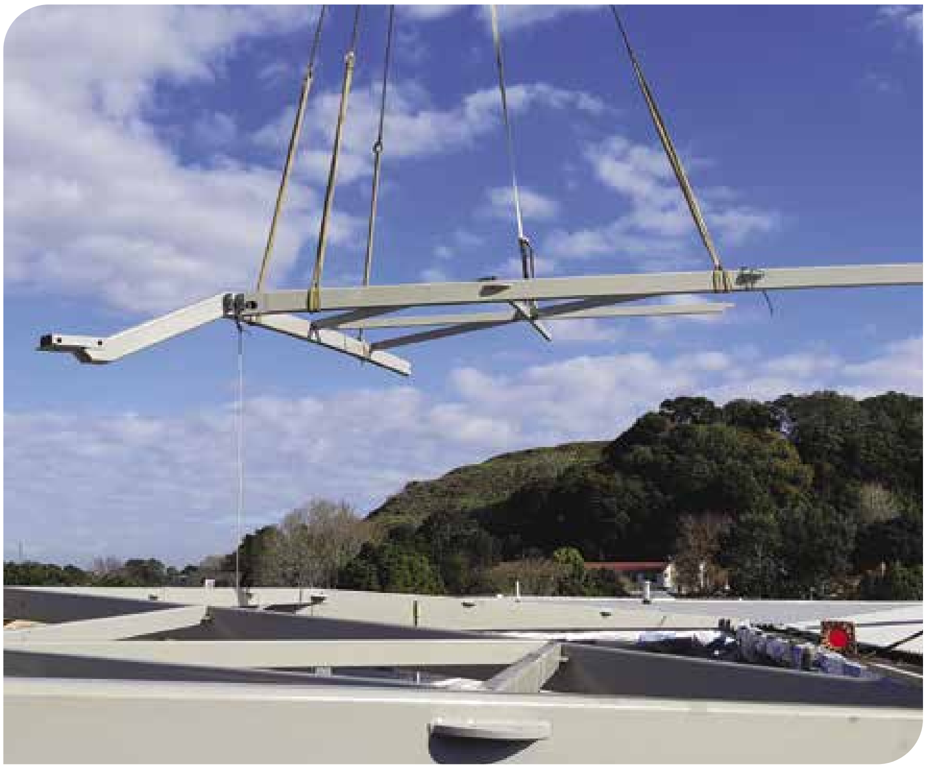
The team brought some things in through the bottom and up, a scaffold was constructed on the outside of the building so other materials could go up and over, and a mobile crane was used to lift framing and plasterboard into the work site.

One of the first things craned in was scaffolding. Q Interiors used it to build a large birdcage scaffold inside the atrium space and loaded essential plant, materials and equipment onto it from afar. It had a working platform at about six-metres high so that when the roof was on the team had a platform underneath from which it could fit lights, sprinklers and all the steel components.

The sequencing was pivotal towards the end of the project when the roof was on and the build team had boxed itself in. It couldn't go over the top or through the middle, so it had to have everything there in advance and carefully work its way through the building as required. It was a daily challenge – the team had to be absolutely precise about what it brought to site and when.

The very nature of refurbishment work means that existing buildings are never as they seem. The design team used the 20-30 year-old drawings as a starting point to model the design but when the team arrived on site, little was as it should have been. The building was out of square and out of plumb. 'Quirks' of the building were uncovered by the team as it went and it had to be dealt with in real time.

The project team worked together to address the problems and find solutions. A lot more surveying of the existing site was required than originally envisaged to create a workable model. The steel fabrication shop drawings, in particular, needed to reflect the actual on-site situation.



Global Engineering's role was critical as the steelwork had to work within very precise construction tolerances while trying to "shoehorn a square peg into a round hole". There were a few choice words used throughout the project but the team got there.

The design of the atrium structure was such that the entire roof 'floated', unfixed, on the strengthened existing structure until such time as all roof fixtures were installed. So, for a large part of the project this huge structure was just floating there, which was a challenge in itself because there were considerable propping, bracing and temporary works required to accommodate it.

"THE TRIANGLE-SHAPED STEELWORK FITTED TOGETHER LIKE A JIGSAW, IN A SPECIFIC ORDER. WORKING WITH A LOCAL STRUCTURAL STEEL FABRICATOR, WE KNEW WE COULD GET WHAT WE NEEDED, WHEN WE NEEDED IT, TO MEET THE CRITICAL SEQUENCING."

GRANT BROWNE, DIRECTOR, Q INTERIORS

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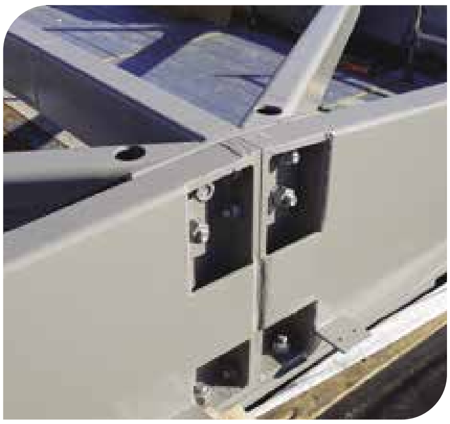


FABRICATOR

Working in the middle of an occupied building without direct external access was challenging. Global Engineering had to conduct much of the preliminary strengthening works after hours as it involved cutting and welding to the existing steel structure. The team found a few "gremlins" when the existing steel was exposed, but these are expected on refurbishment jobs.

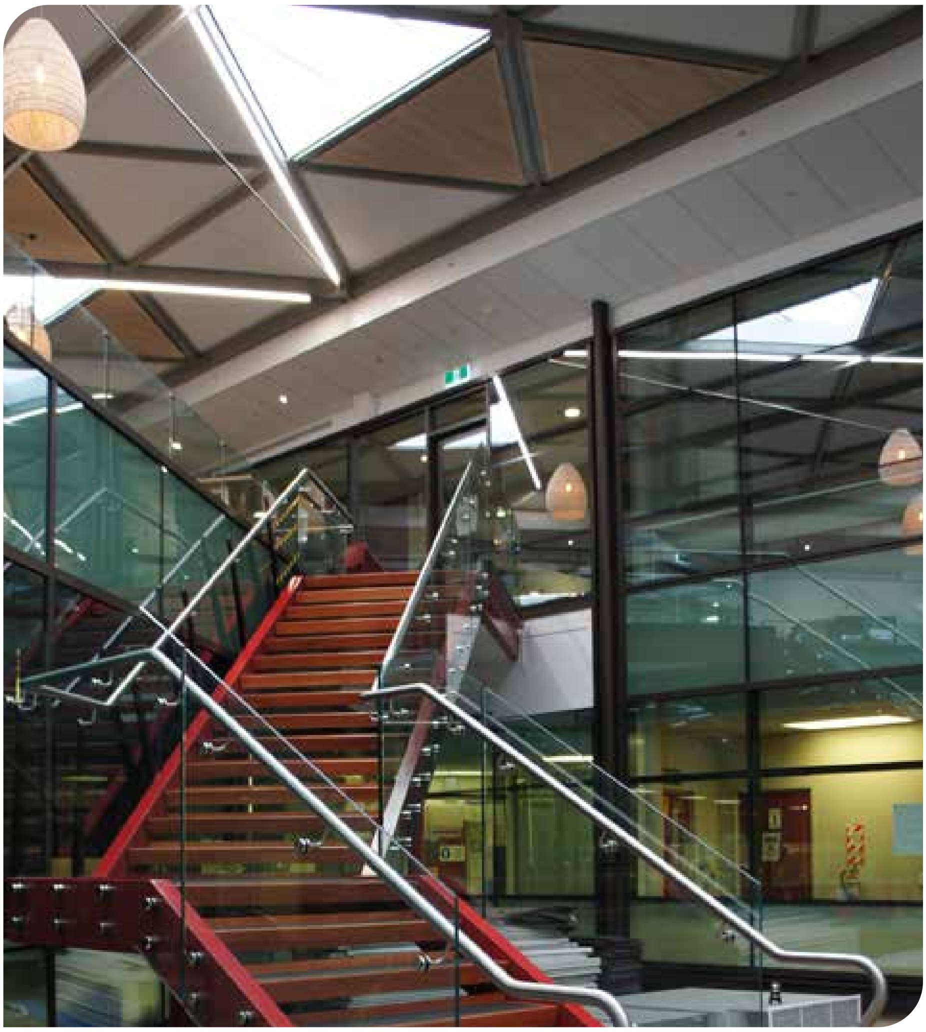
All of the strengthening steel was manhandled around the building on trollies and lifted into place with manual mechanical lifts, then temporarily held in place with bracing while welding was conducted.

A crash deck (birdcage) was installed to work from, which included rated load towers that the steel frames sat on while assembly occurred. Once the main work started, the team had to arrange cranage to lift it over the building into the atrium void.

The complex and close-tolerance connections were tricky to fabricate and required delicate and careful on-site assembly, all while working on the suspended birdcage outside the crane's line of sight. Radio contact between the steel erection team and the crane operator was crucial for the delicate operation. Success came down to the steelwork being well made in the workshop so that it fitted perfectly on site.

Pre-cambers were designed into the steelwork to allow for 90mm deflections on installation. The team needed to start with it out of plumb and account for the building not being square to start with. Effectively, the team built the structure lopsided so when it finished it was straight. When two pieces of steel are butting up against each other, once it sags that joint will want to open up so the team built it with the top joint open to produce a nice straight joint when finished.

The steel frame of small triangle shapes fitted together in a particular order and each triangle was as important as the next. Together, they support each other so one can't be removed without destabilising the whole structure. The team couldn't deviate from the installation sequence. The frame was built first, followed by the roof, and installation of the sprinklers, lights and windows that hung off it.



Looking up from ground level, the view is of an intricate latticework of steel triangles. Together, the triangles support each other so one can't be removed without destabilising the whole structure.

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Only then could the tension rods be adjusted and load towers lowered for the full load to transfer to the main building. This was because the entire structure was effectively self-supporting in tension.

Next, the deflections were checked and further adjustment of the tension rods made. That's when all the careful engineering calculations and the manufacturing accuracy came into play – getting all of the deflections accurate ensured that when the load came on all of the pre-cambered steel straightened. Once the engineers were satisfied, the team permanently bolted the structure to the strengthened building.

"WHEN YOU PUT IN THE EFFORT AT THE BEGINNING TO UNDERSTAND HOW YOU'RE GOING TO DO IT, THEN IT GETS EASIER FURTHER ON. ECI HELPED, WE HAD THAT COHESION AND WE WERE WORKING TOWARDS A COMMON GOAL."

MARK DUXFIELD, PROJECT MANAGER, GLOBAL ENGINEERING

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