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MANUKAU INSTITUTE OF TECHNOLOGY BUILDING CASE STUDY

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ABSTRACT

Phase 1 of the Manukau City Centre Tertiary Campus and Transport Interchange integrates three operational elements: a teaching and learning facility for Manukau Institute of Technology, a new Auckland Transport railway station, and a bus interchange. The first structure of the proposed 65,000sqm campus is comprised of three seismically separated buildings, which rise to six storeys and are constructed around and over the fully operational train station. MJH Engineering was the lead steel constructor and completed the on-site erection. This presentation will discuss the many challenges of the project, including the exposed raking column steel frame, a key feature of the facade that required close integration of the architectural and structural design.

Introduction and Description of Project

Phase 1 of the Manukau City Centre Tertiary Campus and Transport Interchange integrates three operational elements: a teaching/learning facility for Manukau Institute of Technology (MIT), a new Auckland Transport railway station and a bus interchange. The first structure of the proposed 65,000m2 campus is comprised of three seismically separated buildings; they are constructed around and over the fully operational train station and rise to six storeys.

Figure 1. *An artist's rendering of the East facade and main entrance as shown from the bus interchange. Image courtesy of Warren and Mahoney Architects*

1. Managing Director of MJH Engineering, First appeared in Building Today November 2012 and written by Roy Kane

Principal Blair Johnston of architects Warren and Mahoney says the central, enclosed atrium space "creates a common campus heart that signifies the moment of arrival for students and commuters alike. . . It reflects MIT's desire for 'a highly efficient, open and interconnected learning landscape'. . . The teaching floors have classroom spaces around the perimeter of the building, with open flexible learning spaces and break-out areas located around the atrium edge."

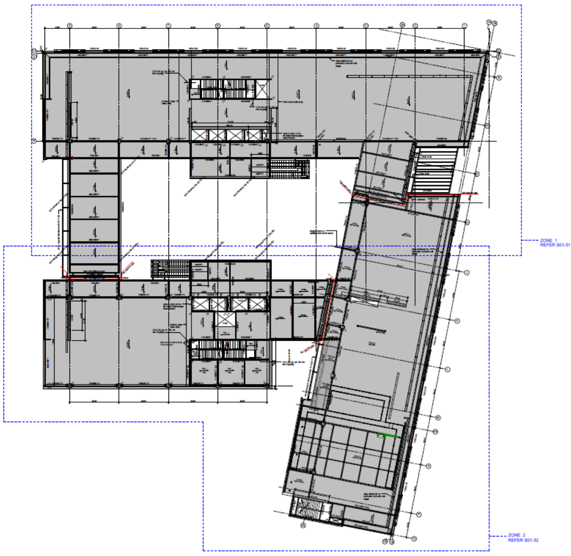

Figure 2. Holmes Consulting Group's plan.

An exposed raking column steel frame on the north and east elevations is the key feature of the exterior appearance of the building and required close integration of the architectural and structural design. Project Director Jeremy Austin for Holmes Consulting Group explains: "Because of their geometry and their position outboard of the main structure, the raking frames bear high axial and torsional loads. The raking frame members are welded box sections connected by three types of nodes: Y-nodes at the base, X-nodes at mid height, and inverted V-nodes at the top. Since the nodes are exposed in the finished facade, their design had to be simple and neatly detailed. Full penetration welds of the 40mm plate steel were needed to ensure adequate transfer of the forces. All welds were ground flush to provide a high level of finish. The connections are fully bolted site connections; site welding was avoided for durability and aesthetic quality reasons. Full tension friction bolts were secured to captured nuts inside the box sections.

Figure 3. *Construction of the diagrid, which extends five levels to roof height*.

Figure 4. O*ne of the 15 “X” nodes, a centre-point of the diagrid. D&H Steel also fabricated 18 “Y” nodes for the bottom points and 16 “V” nodes for the top points.*

“The steel beam that supports each floor is set inboard of the raking columns. The twisting caused by this eccentricity is resisted by minor axis bending in the braces. The interior sides of the building have conventional column and beam steel frames, utilising concrete-filled Circular Hollow Sections (CHSs) and a collar arrangement for the beam to column connections. Lateral load resistance in the short direction is provided by in situ concrete shearwalls and concentrically braced steel frames. In the long direction, the lateral resistance provided by the external raking steel frame is supplemented by more in situ shearwalls. A pre-cast double-tee flooring system creates a 15m wide column-free floor plate. This allows a high degree of future flexibility in the configuration of teaching and circulation spaces.”

Figure 5. *The interior sides of the building have conventional column and beam steel frames, utilising concrete-filled Circular Hollow Sections (CHSs) and a collar arrangement for the beam to column connections. The CHSs were fabricated by Jensen Steel Fabricators of Tauranga*

The capping of the rail trench was completed before the station opening. An even greater challenge was the atrium roof structure, as Jeremy Austin explains: “The roof structure spans some 26m across the trench and is seismically isolated at one end. It is also required to support the large, overhanging lift lobbies to the north and south of the atrium, as well as the main north/south access bridge. There were two, key geometrical constraints affecting the final design for the atrium roof structure: the first was that the atrium ceiling had to be a feature; the second was the glazed perimeter clerestory. A third constraint (not geometrical) was the cost. We went through several iterations, but I think we eventually arrived at a solution that achieves the architectural intent of the space in a cost-efficient manner.”

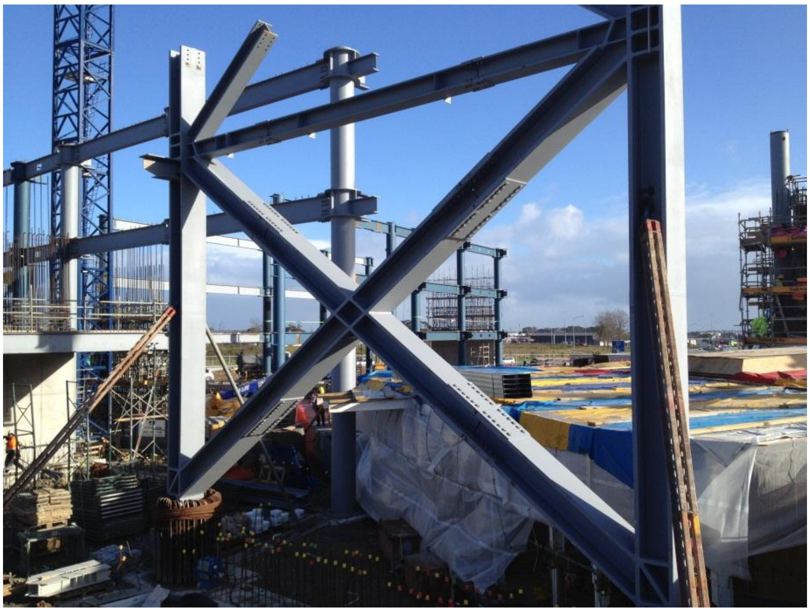

Figure 6. *A crucial Eccentrically Braced Frame, this was fabricated for MJH Engineering by D&H Steel from 60mm flange plates with a 50mm web using full penetration welds.*

Fabrication Teamwork

MJH Engineering was appointed the lead steel constructor on the understanding that certain components of the fabrication would have to be sub-contracted. The team, all SCNZ members, contributed as follows:

D&H Steel Construction: 18 “Y” nodes, 15 “X” nodes, 16 inverted “V” nodes; 4 elbows, 1 corner, floor beams and heavy gauge CBFs

Eastbridge: 72 box sections each 400mm square, 24 with 40mm flanges and 48 with 36mm flanges (all full penetration flange top web welds)

Jensen Steel Fabricators: 22 lower and 22 upper CHSs with collar plate connections fitted

MJH Engineering provided the rest of the fabricated steel and completed the onsite erection.

Official opening first quarter of 2013.

Construction Considerations

Inevitably, there were complexities associated with the construction of such a building; the methodology was adapted to accommodate the key engineering elements, which in turn determined the sequencing.

The Raking Frames

In the final analysis, the horizontal force is transferred into the floor diaphragm and redistributed to the raking frame. But there was an added complication: because the beam that supports the flooring system is located inside the line of the raking frame, resulting in an out-of-plane torque, as erection took place, a series of diagonal props back to the interior side of the building was needed to maintain the stability of the steelwork as it underwent deflections.

Figure 7. *The beam to support the flooring system is located inside the line of the raking frame, resulting in an out-of-plane torque.*

Figure 8: *As erection takes place, a series of diagonal props back to the interior side of the building is needed to maintain the stability of the steelwork while it undergoes deflections.*

The Western Atrium Bridges

At the western end of the atrium, the north and south elements of the building are connected by six 25m-long bridges. These could not be supported from below because of the presence of the rail trench structure. The bridges, therefore, are to be suspended from large atrium roof trusses. Only once the roof structure is in place and the hangers installed will the concrete topping for the bridges be poured.

Figure 9. *The first two of six 25m-long bridges connect the north and south elements of the building at the western end of the atrium.*

Cantilevered Lift Lobbies

The cantilevered lift lobbies on both the north and south side of the atrium are 6m wide and overhang the train station below. They too are suspended from the atrium roof trusses. However, the loads associated with this hanging structure were significantly higher than the loads of the six bridges. Moreover, it was not possible to defer construction of this portion of the building until the atrium roof structure had been completed. So a temporary structure was installed at the base of the frame to enable a conventional bottom-up construction sequence. This temporary structure was then jacked, allowing the primary structure to be connected to the roof truss once this was in place. With the release of the jacks, the temporary structure was removed.

Figure 10. *The bridges (to the left) will be suspended from large atrium roof trusses, as will the cantilevered lift lobbies (centre).*

Mike Turner, Mainzeal's Project Manager, says keeping the construction programme on track was his biggest challenge. "It's 2,000 tonnes of steel and, although the footprint isn't big, the project has been very complex and intense. I'm pleased that the whole process has gone very well. I've been very impressed by MJH Engineering as the main structural steel contractor; their detailing has been excellent, and they have also managed the Just-In-Time deliveries of steel very smoothly. By subcontracting components of the fabrication to other Steel Construction New Zealand (SCNZ) fabricators, MJH provided a good solution to the project's steel procurement and was still able to make its own contribution from Wellington."

Malcolm Hammond, MJH's Managing Director, said the co-operation of fellow members of Steel Construction New Zealand played a key role in the successful outcome. "We knew that D&H Steel in Auckland, Jensen Steel in Tauranga and Eastbridge in Napier could be relied upon because we all share the same high standards and experience when determining buildability solutions."