This case study was written at the time when OneSteel was part of BHP. In that context, in some instances within this case study, reference may be made to BHP.

Mercantile Mutual Extension

Many buildings have been extended horizontally while the existing structure remains occupied. A few buildings have been strengthened and extended vertically, but the existing building is usually vacated during construction. However, in this case, extensive construction works were undertaken to build an 8 storey vertical extension while the existing building below continued to provide a safe working environment for one thousand employees!

The brief was set by the institutional owner of the Mercantile Mutual Centre at 347 Kent Street, Sydney to the Project Manager, Construction Project Management (CPM) in November 1994. Simply put, it involved extending the existing 18 level commercial office block to achieve the maximum allowable office space under current building regulations while maintaining normal business activity in the existing building.

Business as usual at Mercantile Mutual, while the new extension soars above.

A challenging brief, but achievable using innovative engineering and BHP Structural Steel.

When looking at how to extend the building, two different architectural envelopes were considered. The first option was to build the extension alongside the existing building, joining along a common facade. When analysed further, it was found that this option offered a lower capital construction cost, a simpler design and construction solution and less disruption to the existing building. The second architectural option however was a vertical extension, where the new building would be built on top of the existing structure. This option was investigated at concept stage by the structural engineers for the project, Sinclair Knight Merz and it was assessed to be structurally feasible. This alternative offered several very attractive outcomes. Due to the increased height of the building and the better views over Darling Harbour, the option to vertically extend resulted in more valuable floor space. Also, the taller building offered a more desirable completed building appearance, as well as a higher level of exposure for corporate signage.

The role of structural steel as a framing system also factored into this choice. By framing the extension in steel, the mass of the new structure was minimised, resulting in a reduced amount of column strengthening in the existing structure. By having steel members fabricated off-site, the level of on-site activity was minimised, reducing the number of workers on site. This reduced site activity limited the disruption to tenants and to the surrounding streets. The reduced reliance on concrete also minimised concrete pumping noise at street level. The faster construction programme provided by steel in this case, multiplied the benefit of the reduced noise and disruption that is a feature of steel construction.

Existing Structure

To service the additional floors of the building, a new core was added. By having this lift core external to the original facade, the existing lifts could remain fully functional during construction. An external lift core also increased the useable floor area on each new floor, as the usual centre lift well intrusion was absent.

The degree of strengthening required to the existing structure was the subject of a detailed analysis. The structural engineer for the project, Sinclair Knight Merz, carried out a study of the increased loads and load paths imposed by the extension and as well as analysing the existing and required capacities of the structural members in the original building. With the existing foundations bedded on 10,000 kPa

Steelwork on Level 16, showing web penetrations.

Sydney Sandstone, few of the existing foundations required strengthening. Also with the lighter mass of the structural steel extension, only 50% of the existing columns required strengthening. All strengthening work in existing tenant areas was carried out at night, with extensive dust and debris protection used to keep dust levels to a minimum.

New Structure

Design of the lateral resisting systems was checked for both wind and earthquake conditions, with the ultimate wind case governing. Analyses of the existing core of the original building were carried out which determined that it was able to take the additional loads imposed without any strengthening work. The westerly wind provided the highest wind load and the new lift core on the western face was utilised to augment the moment resisting capacity of the core in that direction. However, Sinclair Knight Merz' structural project manager Mr John Hellawell explained that "…the presence of the new lift core altered the building's performance when subjected to earthquake loads. Because of the external core, the centre of stiffness of the building moved away from the centre of mass. To counter this, partial moment connections were introduced to several of the primary floor beams on each floor to drag the centre of stiffness back towards the centre of mass of the building. By cunningly choosing which connections to alter, we were able to locate the centre of stiffness to within 10% of the width of the building of the centre of mass".

The partial moment connection developed involved the addition of cleat plates and friction grip bolts to both the top and bottom flanges of the beams, transferring some of the beam moments into the columns. By controlling the amount of moment that could be transferred into the columns, partial moment connection was achieved, satisfying the sway stiffness criteria but preventing a full live load moment transfer which would have overstressed the columns in bending.

To match the look of the existing structure, a floor-to-floor depth of 3.74m needed to be achieved, which required the mechanical ductwork to be located in penetrations through the composite steel floor beams. Also, due to the tight construction program the steel floor beams in the extension had to be fabricated with penetrations prior to letting the mechanical services subcontract. Sinclair Knight Merz' Mr John Hellawell said; "This entailed painstaking co-ordination between the mechanical and structural engineering consultants very early during the design of the building. By doing this however, it was possible to issue structural and mechanical drawings with exact sizes and locations for the penetrations prior to the commencement of shop drawings".

This effort saved valuable time on the project. The overall floor-to-floor depth of 3.74m was achieved with the steel solution while still meeting a required floor-to-ceiling requirement of 2.65m.

The new core to the building extension was a braced steel frame. Diagonal cross bracing and K-bracing was used as dictated by doorway and other openings.

In terms of the floor system design, beams were designed in accordance with AS2327.1 Simply Supported Composite Beam code. Additional top reinforcement was placed in the Bondek II slabs and Vermiculite fire spray was applied to the structural steel to achieve the required 120 minute FRL. Generally 1.00mm Bondek II was used with an overall slab thickness of 125mm. Typically secondary beams were 530UB's spanning 9.5m and primary beams were 660mm deep fabricated beams spanning approximately 10m.

As mentioned, full occupancy was maintained during the construction of the extension. This necessitated keeping the plant room at Level 14 (top of exiting building) intact and operational while the new building was being constructed above. To maintain services, the extension had to be completed and the new plant room on Level 21 commissioned before the existing plant room could be demolished. To achieve this it was necessary to delay the erection of the floor beams on Level 15 (the first floor of the extension) until after the remainder of the building frame was completed and the original plant room was demolished. This created additional challenges for the structural designers.

Columns extending from Level 14 to Level 16 were designed to handle the increased effective length as a result of having no floor at Level 15 during construction. The curtain wall was also attached prior to the construction of the Level 15 slab which normally acts as a diaphragm in resisting wind loads. Temporary braces were attached to the columns at Level 15 and braced back to the floor slab on Level 14 to resist these wind loads until the slab was poured.

Overall site co-ordination of materials was considerably easier with the structural steel system. Fabricated beams were lifted from the semi-trailer at street level directly into their final position with no multiple handling of members. Choosing the structural steel solution meant that barely one quarter of the number of people on site were required, when compared with alternative systems.

For erection purposes, a single tower crane was used. As it was not possible to attach the crane to the exterior of the building it was constructed on top of the existing building at Level 14, and penetrated up through the Bondek II floor slabs at each level. These penetrations were then infilled after the crane was removed.

The design of the extension required that the facade match the existing glass, granite and

Diagonal bracing indicated core location.

Erection of perimeter beams.

aluminium curtain wall. This was achieved by carefully selecting the granite, sourced from South Africa, and matching the glass which was imported from the United States.

Key objectives met

Key challenges of the project team were to maintain the safety and comfort levels of the occupants during the construction phase, as well as minimising any impact of the construction work.

Practical completion of the 347 Kent Street project was achieved in August 1997 allowing the office fitout stage to proceed on programme. This was 29 months after the initial scope of the project was conceived in March 1995.

The budget for the original scope of works was achieved and the original quality standards were maintained or improved.

Project participants

Client:	Mercantile Mutual
Project Manager:	Construction Project Management
Structural Engineer:	Sinclair Knight Merz
Architect:	Kann Finch Architects
Builder (extensions):	Baulderstone Hornibrook
Builder (strengthening):	Grindley Constructions
Fabricator:	Adua Engineering