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.

Revitalized Harbourside

Harbourside, the retail and dining complex at Sydney's Darling Harbour, was opened during the Bicentenary celebrations in 1988. Visited by over 14 million people annually, the complex recently underwent major refurbishment and extension.

Despite being Australia's third most visited destination, it was felt that there was a need to reposition Harbourside as a fine dining and speciality retail venue for the newly revitalized suburbs of Pyrmont and Ultimo, as well as for the Sydney CBD. In short, there was a desire to increase trading volume and gross lettable area, with a focus on the more discerning retail market. This increase in lettable area would assist in offsetting some of the refurbishment cost.

The Challenge

The considerable challenge for the design team was to add lettable area without changing the external envelope of the building. Important sight lines between the Cockle Bay area, CBD and the numerous apartments and hotels behind Harbourside had to be maintained. In addition, maintaining an ongoing operating environment for the existing retailers during construction was also crucial to the success of the redevelopment.

Steel Provides the Solution

Harbourside originally consisted of two levels of retail outlets and food-courts, with a total floor area of 13,400 m^2. Given the considerable building constraints, it was decided that the only feasible way to increase the floor area to the required 20,000 m^2 was to add a third retail level. This was made possible by relocating existing plant rooms housed in recessed atria along the centre-line of the roof, meaning neither sight lines nor the original building envelope would be altered.

Construction was undertaken in four stages to allow the centre to continue to trade for the duration of the project. Existing tenants were progressively relocated as the new trading areas were completed.

To ensure that the external building envelope was not altered, new structural framing had to be integrated into the existing structure. Built on a 9.6 x 9.6 metre grid, the new floor level had to sit on top of existing columns, to match this grid. Wherever possible existing columns were to be used without strengthening, especially on the ground floor where retail trading was ongoing. Additionally, no back-propping was permitted on the ground floor.

To ensure minimal interruption to trading, the existing foundations also needed to be able to take the increased load, as no foundation strengthening was permitted.

After looking at many framing options, the design team concluded that a composite structural steel solution was the only viable way to ensure that a new level could be constructed that would match the current grid and eliminate the need for column strengthening. In addition, by using structural steel the new level could be built within the existing envelope, without back-propping and be light enough to be supported on the existing foundations.

The interior of Harbourside, Darling Harbour.

Speedy Composite Design Lowers Cost and Mass

The new level is designed for a live load of 5.0 kPa and a superimposed dead load of 2.5 kPa, taking into account floor toppings, partitions and services loads.

Building of Stage I, at the northern end of the structure, commenced in July 1996. The structural floor system was designed by consulting engineers Taylor Thomson Whitting (TTW) using the Composite Code AS2327.1-1980 (working stress version). Designing around the 9.6 metre grid, the primary beams are 700WB130 300PLUS Welded Beams with pairs of shear studs at 200 mm centres. The secondary beams are spaced at 2900 mm centres, and are 460UB67 300PLUS, also with pairs of shear studs at 200 mm centres.

Design of the subsequent stages, commenced in January 1997. TTW took advantage of the updated version of the Composite Structures Code AS2327.1-1996 to design the later stages to the new limit state format. Preliminary designs were done according to the code, and checked using COMPBEAM™ software. Once TTW had verified the accuracy of COMPBEAM, it was then used for the final design of the floor beams. Primary beams designed to the new code are 700WB115 300PLUS with only a single row of studs at 200 mm centres and the secondary beams are now 410UB54 300PLUS, again only with a single row of shear studs at 200 mm centres. **The mass reductions achieved by using the new code represent a saving of 11.5% for the primary beams and 19.5% for the secondary beams.** The reduction in height of the secondary beams was critical, due to the large mechanical ducting. Additionally, only 50% of the original number of shear studs were required, enhancing economy as well as providing faster construction through reduced on-site stud welding.

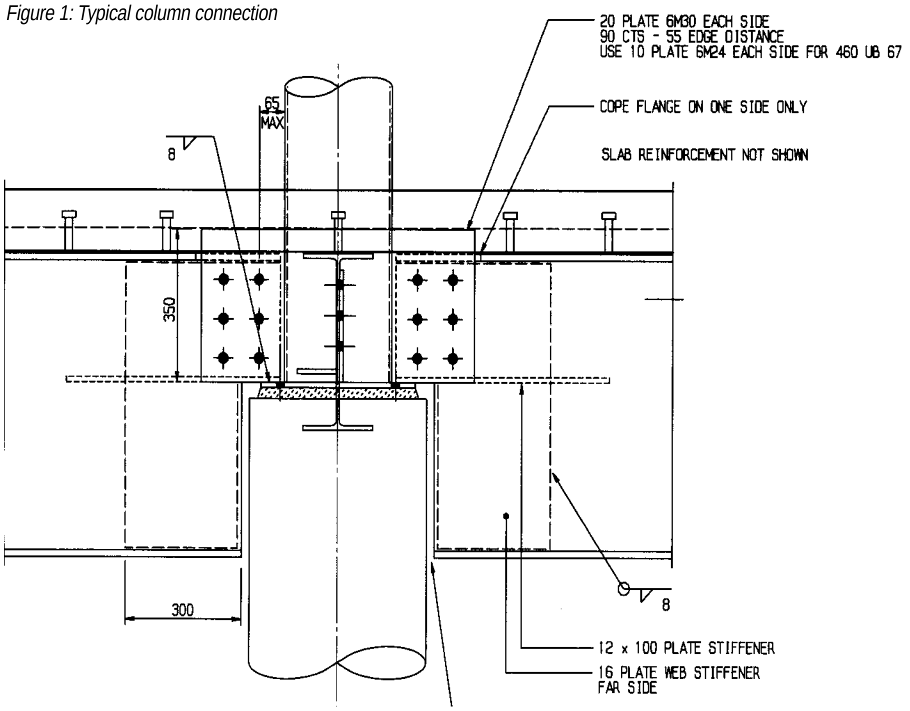
"COMPBEAM allowed us to speed up the design process," said Barry Young, Technical Director of TTW. He added, "Once we had verified by hand calculations that COMPBEAM was giving us accurate answers, we used it exclusively for final design. The program was especially helpful in determining the reduced number of shear studs for the composite beams." To achieve the prescribed 3 hour fire rating required by the BCA, a 140 mm thick slab was supported on 1.00 mm Bondek II™ profiled sheet decking. BHP Deckmesh reinforcement was also used on the perimeter primary beams.

To maximise headroom in the new level, connections between the primary beams and exiting columns were specially fabricated, which had the effect of lowering the level of the new floor by 400 mm. This required most of the primary beams to be notched and stiffened locally at each end. (Refer Figure 1)

Connection positions for the secondary to primary beam joints were detailed to avoid interaction between the primary beam and column connections. This simplified both these connections and allowed for easier on-site construction.

A study of the original foundations, most of which were Frankipiles, revealed that their capacity could be increased by up to 30% by accepting larger settlements. This increase, combined with the relative light weight of the new structural steel frame, ensured that no strengthening was required on any of the foundations. The existing columns were also checked to ensure that they could support the new level and again the selection of structural steel ensured that the majority of columns did not require to be strengthened.

Figure 1: Typical column connection



Original top floor showing narrow walkways and original plantroom above shop premises.

The new floor in the Crystal Galleria, connecting retail areas from north and south.

Only in a very few instances did some existing steel CHS columns require strengthening at their base, where they supported the new primary beams for Level Two. The required increase in capacity was achieved by site-welding steel plates onto the exterior, or in some instances through the CHS sections.

Steel Aids Constricted Construction Conditions

Construction was undertaken on two major fronts; the new roof and the construction of

Level Two. Firstly a new roof was constructed over the majority of the foot-print. This new roof was built over the existing roof and matched the existing lines. Spanning up to the centre ridge line, this roof covered an existing 18 metre wide, recessed plant area that ran along the spine of the majority of the building. This increase in roof height (without encroaching on existing roof sight lines) provided the majority of the required headroom for the new trading area. Short column stubs were first erected through the existing roof to support the new roof rafters, purlins and roof sheeting. Longer columns were required where the new roof was erected over the recessed plant area. All new columns were erected on top of existing columns.

While the roof construction was proceeding, Level Two was also being constructed. New columns were erected above the existing columns, with the primary and secondary beams manually 'skated' into position using small trolleys. Due to the very tight construction envelope, no major cranage was used on the site. Steel members were erected in a variety of ways, including the use of fork-lifts and block-and-tackles. Once the primary and secondary beams were erected, the 1.00 mm Bondek II decking was laid out, then automatically welded shear studs were affixed. Reinforcement was laid before pouring the slab.

Once both the new roof and new level were completed and the area could be guaranteed waterproof, the old roof as well as the existing plant rooms were removed. The new plant rooms and services were progressively installed, followed by the fit-out of the individual tenancies.

Conclusion

Opened on 5 June 1999, the revitalized Harbourside has benefited from the advantages of structural steel, coming in on budget. Composite structural steel allowed the design team to generate a solution that could be supported on the existing structure without any strengthening of the existing foundation or the majority of the columns. Structural steel also provided increased flexibility for the builder, given the required construction scheduling and movement of materials around a constricted site, as well as allowing the centre to trade during construction.

Client:	Harbourside Retail Centre
Architect:	The Rice Daubney Group
Engineer:	Taylor Thomson Whitting
Builder:	Abigroup
Fabricator:	Profab Industries
Shop Detailer:	Southline Drafting