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.

Kingsway to the Casino

Consulting Engineer, Connell Wagner, didn't gamble when choosing composite steel construction for access ramps to Melbourne's Crown Casino carpark facilities.

To make entry to Melbourne's Crown Casino carpark considerably easier for patrons, two new bridge ramps were constructed from the old Kingsway Viaduct. The ramps lead to the carpark under the casino. The project, with an overall cost of some $7 million was designed and constructed successfully within a very tight time frame of 12 months, so ensuring completion prior to the opening of the casino.

Composite steel girders were used for the superstructure of the bridges, which were successfully constructed on time and on budget. The new bridges match the form of construction of the existing Viaduct and improve its overall appearance through the superior detailing of the girders. The use of steel enabled savings in foundation costs and allowed fast, economical construction of this complex structure in a congested site.

The Project

The Crown Entertainment Complex was opened in 1997 on the Southbank of Melbourne's Yarra River. Connell Wagner carried out the structural design of this development which covers an entire city block. The new Casino structure encloses the Kingsway Viaduct over a length of some 125 metres.

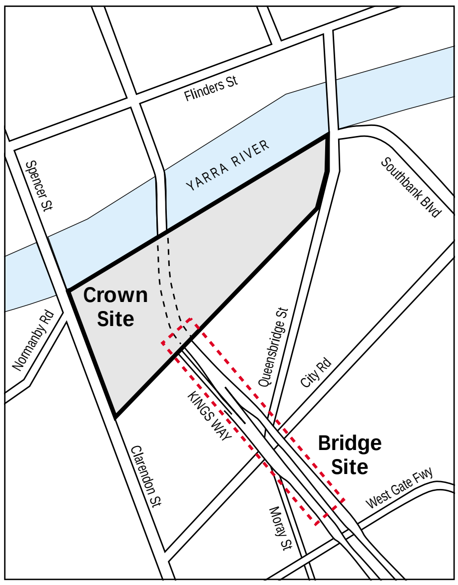
The Entertainment Complex's carpark facilities comprise a two level basement for 3000 cars and a separate 3500 carpark on a site immediately south of the main building footprint. Access to the basement carpark was provided by construction of a tunnel from the east, by replacement of some spans of the low level Kings Bridge across the Yarra for access from the north and by construction of southern ramps to and from Kingsway Viaduct to the south. These ramps provide access to the existing street system as well as to the Entertainment Complex carparking facilities. The south bound ramp is 9 metres wide between barriers and 245 metres long. The north bound ramp has a similar width and is 235 metres long.

Girder segments being bolted together before lifting directly above.

Existing Kingsway Viaduct

The existing Viaduct is a composite steel and concrete deck structure, constructed in the early 1960's. In the section affected by the new ramp construction, the Viaduct comprises twin bridges each with two carriageways and four main girders. The existing bridges make extensive use of cantilevering back spans with drop-in spans supported on half joints. The typical arrangement consists of back spans of 9 metres with cantilevers at each end 2.5 metres long and drop-in girder lengths of 26 metres. The largest span across City Road and Queensbridge Street is 74.5 metres comprising 12.5 metre cantilevers at each end and a drop-in span of 49.5 metres.

Bridge location map.



The major challenge facing the designers, Connell Wagner, and the contractor, McConnell Dowell, was how to integrate the new structures into the existing Kingsway bridge with least disturbance to the existing structure and little disruption to the considerable traffic. In addition, the articulation between the existing bridge and the ramps had to allow for any differential settlement of the pier foundations. At the bridge ends, the high constant settlement of the road approaches required a special treatment to ensure a smooth transition onto the bridge over the long term.

The Solution

A composite steel and concrete superstructure system was the chosen solution. The ramps and widening have spans varying between 19 metres and 74.5 metres. The bridge articulation is matched to the existing Viaduct with the largest 74.5 metre span across City Road and Queensbridge Street comprising 12.5 metre cantilevers at each end and a drop-in span of 49.5 metres.

Steel Girders

The steel girders vary in size along the bridge. They consist of OneSteel Welded Beams Grade 300PLUS L15 ranging in size between 800WB122 and 1200WB392 and custom-made three-plate girders. Steel Grade 350 L15 was used for most of the girders with some using Grade 250 L15. Girder depths vary between 730 and 2570 mm.

Webs were sized without plate stiffeners, with web thickness ranges of between 16 and 25 mm. The 'clean webs' were considered more economical than stiffened webs and also much more attractive in comparison to the original bridge with its intermediate web stiffeners.

A typical bridge cross-section consists of twin girders. Bracing typically consists of K frames connected with M24 8.8/TF bolts. Horizontal bracing is used between the bottom flanges of the twin girders.

The girders were manufactured by Transfield in Sydney, transported in segments and bolted together on site prior to lifting. Typically, pairs of girders were fully pre-assembled with horizontal and vertical bracing in place. The location and design of the bolted splices were coordinated with the contractor during design development. The girder pairs were pre-assembled in the workshop to check for fit. This paid dividends as most components fitted easily, on site.

Surface coating consists of Inorganic Zinc primer over a 2.5 Class blast, with a Micaceous Iron Oxide tie coat and Polyurethane top coat to match the red colour of the existing bridge.

The girders were erected in braced pairs by two cranes working in tandem. The 49.5 metre (47.8 metre on the north bound ramp) long drop-in spans across the busy City Road and Queensbridge Street were erected at night to avoid any hindrance to traffic.

Bearings

Pot bearings were adopted throughout in order to limit size requirements. This was necessary to accommodate the bearings within the stepped joints in the girders. At the suggestion of the bearing supplier, the number of bearing restraint bolts was limited by using Grade 10.9 bolts.

Longitudinal Deck Joint

The design of the longitudinal joint between the existing structure and connecting ramps was considered carefully. The ramps transition onto the existing structure over the main 70 metre span where the existing and connection structures are most flexible. The main concerns in designing the connections were to provide a safe transition for merging traffic and ensure no adverse effects to the existing structure. The joint is 75 metres long for the south bound ramp and 60 metres long for the north bound ramp.

The adopted joint consists of a simple open longitudinal joint. The proprietary joint was anchored using fibre reinforced concrete in order to maximise its durability and toughness. This joint will allow independent movement of the bridges ensuring no adverse effect to the existing structure.

Left: Stepped joint with pot bearing for drop-in span.

Above, centre: Underside of bridge showing bracing and Transfloor decking.

Above: Cranes in position to lift 45.5 metre girders.

Top: Steel girders in place.

Above: Transfloor decking with precast kerb units.

Deck Construction

The deck slab was cast on site over Transfloor permanent decking. The overall deck thickness is 235 mm, including the 75 mm Transfloor decking thickness.

John de Araugo, lead designer for Connell Wagner, said: “The construction time of the connection ramps was significantly shortened by the adoption of precast Transfloor decking with precast kerb units.”

John added: “The deck cantilevers required for this project were relatively large at 0.9 metres to face-of-kerb and to ensure satisfactory behaviour it was necessary to cast the deck overlay concrete in two stages. The section above the girders was cast first to ensure it was properly filled and to provide compressive capacity to bottom chord members of the Transfloor trusses when acting as cantilevers to support the wet weight of cantilever deck concrete. The capacity and deflection characteristics of the Transfloor decking prototypes were confirmed by testing at the manufacturer’s yard before construction. Additional longitudinal reinforcement was added across the deck panel’s joints to resist local wheel effects.”

Shear Studs

The shear stud design was in accordance with the 1996 Australian Bridge Design Code. The shear studs were flash welded on site on the steel flanges, after erection of the Transfloor decking. This proved to be very fast and effective in avoiding potential fitment problems with the decking reinforcement.

Transition structure

Foundation conditions at this site are typically very poor with weak Coode Island silts and other soft alluvial deposits overlying gravels on top of Silurian mudstone at depths of around 30 metres. The Coode Island silt deposits are approximately 15 metres thick and are overlain typically by 1 to 1.5 metres of recent reclamation fill. The compressibility of the Coode Island silt generates surface settlements in the order of 5 to 10 mm / year. This results in ongoing remedial works at the transitions from the surface roads to the existing structure.

In order to minimise the effect of continuing settlement on the serviceability of the bridge, lightweight composite steel transition structures were adopted to connect from the piled (i.e. non-settling) abutments to the adjacent ground level pavements, settling at 5–10 mm per year.

The girders span across the road and are supported by concrete side walls on spread footings. The side walls are connected at each end by transverse girders. At the abutment end the transverse girder is supported by pot bearings while at the other end the transverse girder acts as a spread footing integral with the base of the side walls. This configuration, with side walls approximately 14 metres long, allows deflection of the approach pavement relative to the piled abutment and provides a smooth transition in pavement levels. In addition to the lightweight transition structure, a conventional run-on slab was adopted.

Conclusion

The use of structural steel combined with precast decking enabled fast, safe and economical construction of the ramp superstructures in a congested site. Steel’s flexibility is exemplified by the way the different spans are transitioned smoothly by gradual depth changes to achieve an aesthetically acceptable bridge profile. Detailing of the girders with unstiffened ‘clean webs’ has improved the overall aesthetics of the Kingsway Viaduct. A lightweight composite steel transition structure will reduce settlements at the approaches to minimise future maintenance costs.

The successful completion of the project within a very tight time frame further illustrates the benefits of using structural steel in today’s environment. Its light weight and ease of interstate transport ensured competitive prices and minimised risk of delays. Additionally, site splicing using bolts allowed assembly and erection of the large girders within a short time, avoiding disruption to traffic.

Client:	Crown / Hudson Conway
Designer:	Connell Wagner
Head Contractor:	McConnell Dowell
Steelwork Fabricator:	Transfield
Bearing Supplier:	Hercules