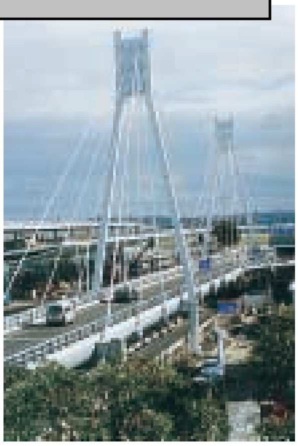
This case study was written at the time when OneSteel was part of BHP. In that context, in some instances within this case study, reference may be made to BHP.



Airport bridge streamlines traffic flow

Users of Sydney's domestic airport will no longer be subjected to frustrating traffic congestion and endless queues at the taxi rank thanks to the recently completed upper level access bridge which practically doubles road traffic capacity and separates arrivals from departures.

above: Night and day, the new road bridge serves to ease traffic congestion at Sydney airport.

The bridge is part of a significant upgrading program to improve the airport's infrastructure, including new underground railway stations at the domestic and international terminals for the airport-city rail link, a new hotel complex for the international airport and improvements to terminal buildings.

Designed by Cardno MBK (formerly McMillan Britton & Kell) and constructed by Transfield Constructions for the Sydney Airport Corporation Limited, the bridge will serve the new upstairs departures levels at the Ansett and Qantas terminals, increasing traffic capacity to cope with expected demand to 2020.

The $44 million bridge was completed early in 1999, on budget and within the program time of 80 weeks.

Design Concept

Although the basic function of the bridge was straightforward - to provide upper level vehicular access to departure lounges and parking stations - the airport will also be the gateway to the Sydney Olympics and therefore the bridge had to be aesthetically impressive.

The concept and detailed design for the bridge was carried out by Cardno MBK. Architectural consultants HBO+EMTB provided input on material finishes, colours and architectural details.

The cable-stayed spans produced a principal feature of interest. Aesthetic considerations in the design included uniformity of detailing throughout, minimising the deck width so as to maximise natural light to the ground level under the bridge, enclosing the superstructure steelwork and integrating the bridge girders at the same level as the pier cross-heads. The composite aluminium cladding around the steelwork under the deck, the column-free space created by the long spans, the coordinated colours and the lighting at both upper and lower levels contribute to the visual impact of the structure.

The bridge follows the existing ground level and comprises two traffic lanes in a 7.1m carriageway with a total length of 985m. Approach spans, varying between 21 and 32m, link two cable stayed sections comprising spans of 45, 105 and 45m. The approach spans consist of multiple (typically four) composite steel I-girders topped by a 250mm thick reinforced concrete deck slab. The slab is topped by a waterproof membrane and asphaltic concrete. The cable stayed sections consist of two edge I-girders supported by cables and cross-girders at 5m spacing.

The design was carried out in accordance with the 1996 Australian Bridge Design Code and focussed on maximising the use of off-site fabrication and precasting to speed construction in a severely constrained work site and limited access hours.

Significant Site Constraints

Construction of the bridge was a major strategic exercise. The prime objective was to maintain the efficient and safe operation of the busy airport at all times, as there was no option to close the facility or divert traffic elsewhere. This required synchronising construction work with the road traffic directly under the bridge and all other service providers at the airport to avoid delays. Most of the construction work was done during the airport curfew hours between 11pm and 6am.

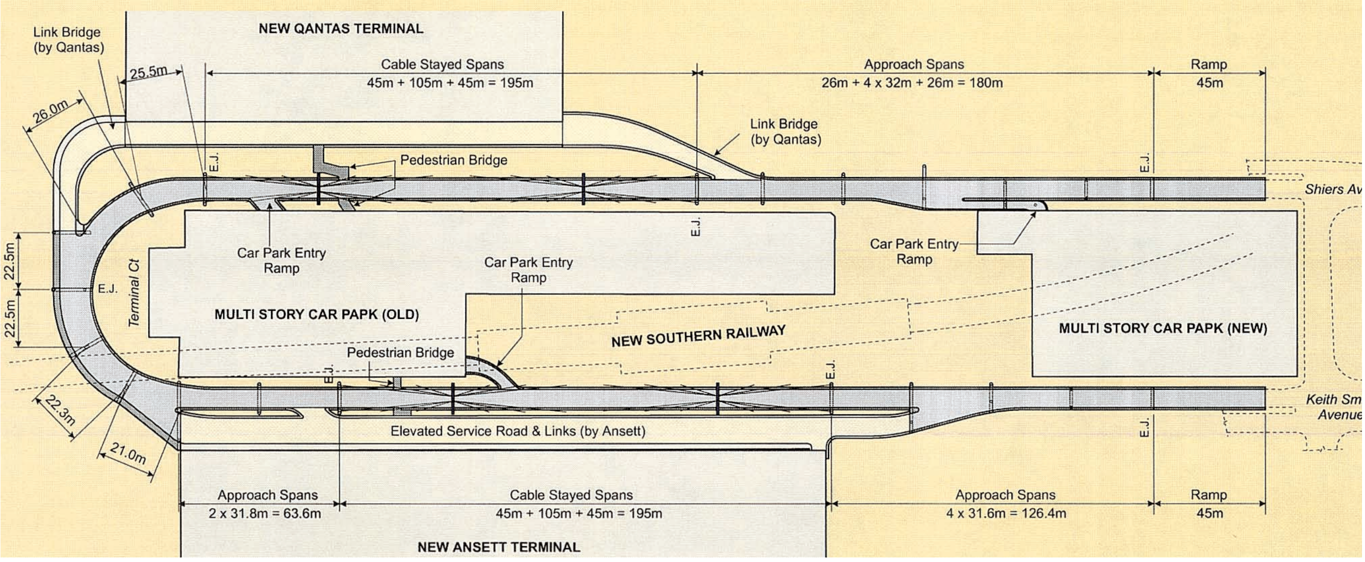
Cardno MBK's principal design engineer, Richard Woods said: "To devise, design and construct the elevated roadway in such a constricted site, with other major construction works in the precinct and with minimum hindrance to the public and all operators at the airport presented a major challenge".

"The bridge had to fit within the limited space available between the terminals and the multi-storey car parks. The complex ground level traffic system, access requirements to the terminals and uncertainties in the new Ansett terminal design added to the challenge." he said.

Substructure Challenge

The design and construction of the substructure was one of the major challenges. The positioning of the columns and foundations had to avoid a vast array of underground services including the New Southern Railway Tunnel, while providing a viable ground level road system and reasonably uniform spans. An additional complication was that the location of some services were not recorded, going back to the earliest days of the airport some 70 years ago.

"This work was at times more like an archaeological dig," said Transfield's John



Plan of the elevated roadway.

Ilott, reflecting on the painstaking nature of the operation.

Large diameter (1200 and 1500mm) reinforced concrete bored piles were used extensively with construction done under bentonite to support the water-charged sandy soil.

Cable-stayed Superstructure

Each cable-stayed section has a 105m main span with two 45m flanking spans. Two edge girders, 1200mm deep, with cross-girders spanning between them at 5m average centres are used for the superstructure. The reinforced concrete deck is 300mm thick. Cables are made from 15.7mm diameter galvanised steel strand and are connected to the edge girders at 15m centres. At the cable connection points, special compound cross-girders extend beyond the edge of the deck to keep deck width to a minimum and maximise daylight penetration under the structure. Backstay cables are anchored through reinforced concrete cross-heads at each end of the cable-stayed bridge. Special pot bearings at both ends are designed to resist uplift forces due to live loads.

Full sections of deck steelwork, up to 23m long and complete with cross-girder bracing and Bondek formwork, were assembled in Transfield's compound at the Airport. From there they were trucked to the bridge site, lifted into position by crane and suspended from temporary steel portal frames, which supported all the steelwork and the cast concrete deck, prior to cable installation. Bondek, installed with ribs down, was used as lost formwork to provide a safe working platform. The gaps between ribs were sealed with a purpose-made plastic expanding sealer to ensure a water tight form for concreting.

Spiral ribbing on stay cable tubes was used to avoid wind-rain induced cable vibration. Forty-eight cables were used in total, each comprising between 15 and 23/15.7mm diameter strands.

Towers

Two main towers support the cable stayed superstructure and provide access for the installation of the cables. The towers are 37.5m high, in line with height limitations at the airport, and consist of steel box sections, 0.8m wide, with depth varying between 1.2m at the base and 1.0m at the top, with tension rod ties at the knee joints. Plate is Grade 350L15 and thickness generally 28mm with 40mm plate flanges in the lower vertical sections.

The towers were prefabricated in four pieces, delivered to the site and then welded together before erection by a 200 tonne Manitowoc crane in one single operation. This was a finely tuned procedure which required detailed planning for both moving and lifting by crane and traffic management to minimise disruption.

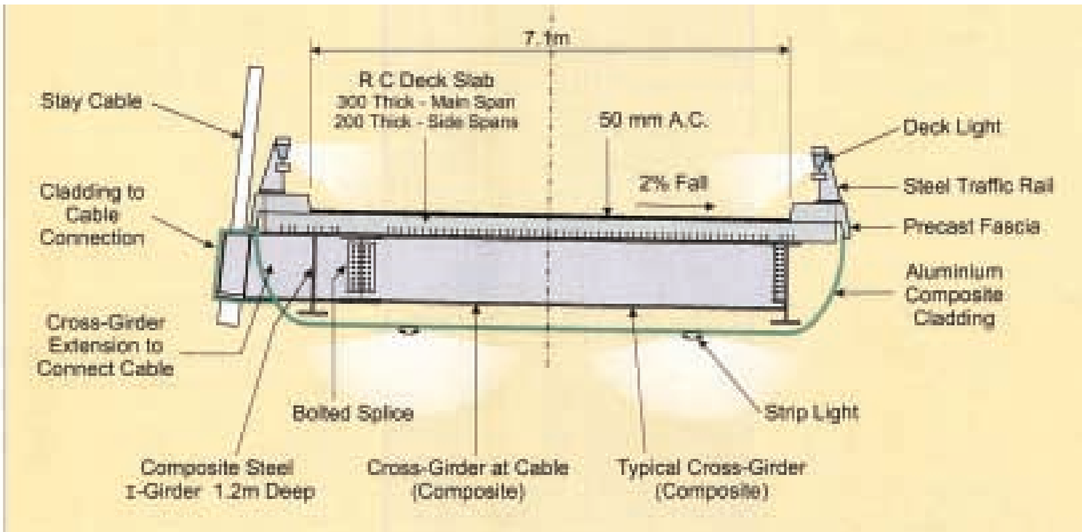
The bottom section of the tower legs are filled with concrete to stiffen the base-plate area and safeguard against vehicle impact.

Approach Spans

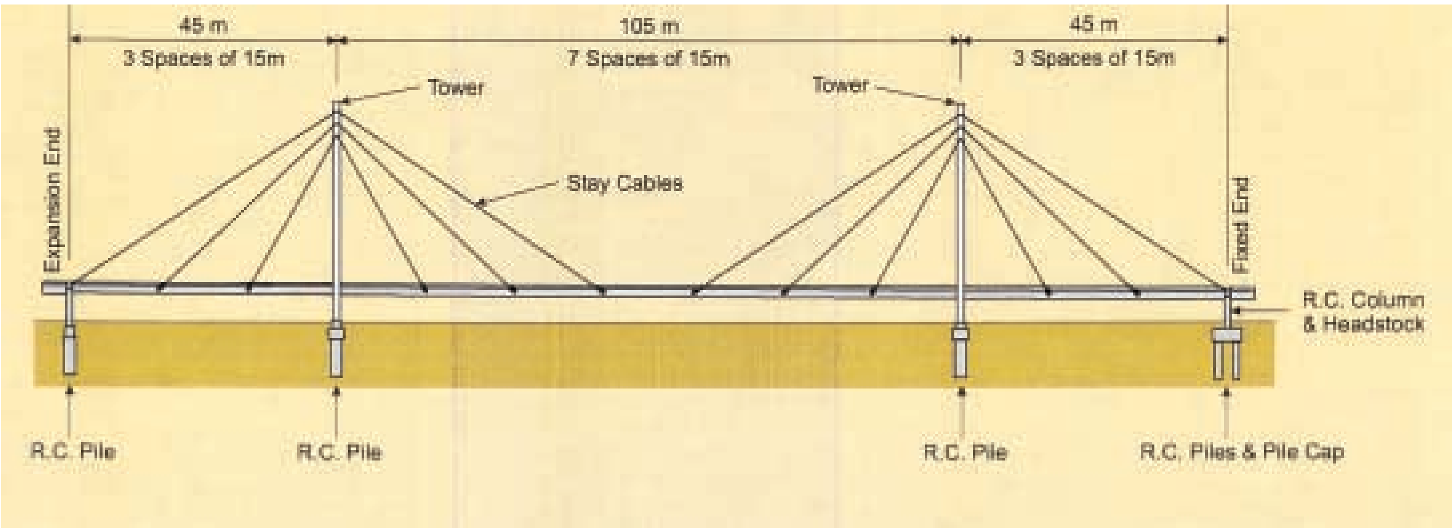
The approach spans comprise composite steel I-girders and concrete deck with spans of approximately 21 to 32m. The girders are supported by precast concrete cross-heads which rest on pot bearings directly above the supporting reinforced concrete columns.

The pier cross-heads and the girder soffits are at the same level and of similar depth to minimise the overall superstructure depth. This required the development of an innovative girder connection detail to provide fast erection of the girders and concrete deck continuity. The design adopted consists of girders with end plates clamped to the cross-head with stress-bars. The mortar

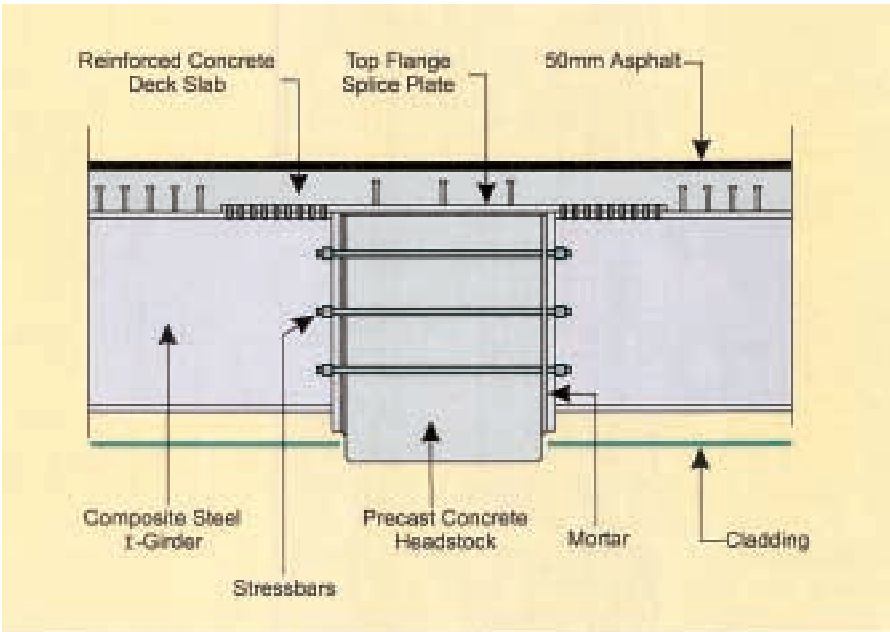
External cable connections kept deck width to a minimum.



Typical section - cable stayed bridge.



Elevation of cable stayed bridge.



Typical detail - Girder connection at headstock.

gap between the beam end plates and cross-head allows for some dimensional tolerance. The girder and deck continuity allows good riding quality by eliminating a number joints and also reduces cost and future maintenance.

The girders were delivered to the site in complete span lengths and installed by crane in pairs. Temporary steel brackets fixed to the cross-head provided temporary support to the girders prior to attachment to the precast cross-heads with the stress bars. The deck was formed in a similar way to the cable-stayed section.

Richard Woods said construction at the curved end of the bridge was more complicated.

"The curved alignment, varying width of the roadway and uneven spans made the development of a suitable girder arrangement challenging, but we managed to keep it simple by using straight internal girders and curved edge girders," he said.

Steel Girders

All the I-girders were fabricated by Lifese Engineering using mainly Grade 350L15 plate. By working closely with OneSteel, the fabricator was able to reduce wastage by ordering a large quantity of its steel requirement directly from the mill.

Mig welders with semi automatic weld machines were used throughout. The edge girders for the cable-stayed sections were 1200mm deep and typically comprised a 20mm web with 350x20mm top flange and 400x20mm bottom flange. Flange thicknesses up to 45mm were used at high stress locations.

The girders for the approach spans were 1200mm deep with webs of 12 and 16mm. Top flanges range from 300x16 mm to 400x45mm. Bottom flanges were 400mm wide and ranged from 16 to 50mm thick.

The complex geometry did not allow extensive mass production of the girders, however John Elomar of Lifese Engineering said the use of CAD drafting facilitated automated precise cutting and fitting of the plates.

"Transfield Power Technologies were responsible for the shop drawings and they were able to make my job of fabricating a relatively easy task considering the complex work," he said.

"Our riggers pre-assembled the heavy steelwork in our factory to doubly ensure that the task of mating the complex sections never faltered during the on site erection. In the end, fit of the steelwork was excellent."

Surface Treatment

All the I-girders were painted with a single-coat of 125 microns solvent based inorganic zinc silicate (IZS). This coating should provide very long term protection to the steelwork, especially since its enclosure will ensure a very favourable environment.

"The coating was economical and easy to apply," John Elomar said.

"We applied it in two separate but consecutive coats to avoid 'bleeding' because of the high thickness specified. This was relatively easy and trouble-free. The coating became quite tough quickly and we experienced very little damage during transport. I would like to use this paint on all future bridge-works," he said.

The towers were painted using 125 microns of IZS topped with two coats of polyurethane paint, each of 125 microns. This was required to achieve the brilliant white colour and should provide very long term protection.

Safety

The safety record on this project was outstanding, despite the size of the undertaking and obvious risks.

"A total of 119,735 employee hours were spent on fabrication, free of any injuries," John Elomar said.

A World Class Landmark

This project was certainly most challenging in both design and construction. Its successful completion on time and within budget is an outstanding achievement. The number and calibre of innovations and the attention to detail is a reflection of the level of commitment shown by the organisations involved to achieve excellence in their endeavour. The safety record achieved during construction and the attention paid to environmental issues is very reassuring and bodes well for future projects.

The extensive use of steel allowed fast, safe construction under very difficult conditions and the resulting architecture is impressive and complements the other nearby buildings very well.

The bridge is a remarkable, eye catching structure and is certain to have fulfilled the vision of the client for a striking world class landmark.

Project Participants

Client:	Sydney Airports Corporation Limited
Consulting Engineers:	Cardno MBK (NSW) Pty Ltd
Architects:	HBO+EMTB
Main Contractor:	Transfield Construction
Fabricator:	Lifese Engineering
Shop drawings:	Transfield Power Technologies

Construction of the elevated roadway was acheived with minimal disruption to traffic below.