InfraBuild

Hindmarsh Island Bridge Adelaide

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

Hindmarsh Island Bridge

A showpiece for composite bridge design.

THE BRIDGE, SOME 70 KILOMETRES SOUTH-EAST OF ADELAIDE, CROSSES THE MURRAY RIVER AND LINKS HINDMARSH ISLAND TO GOOLWA.

FOR MORE THAN 140 YEARS A CABLE FERRY SERVICE OPERATED ACROSS THE MURRAY, HOWEVER THE HIGH COST OF MAINTAINING THE SERVICE AND THE POTENTIAL OF THE ISLAND AS A TOURIST DESTINATION, LED TO A BRIDGE BEING PROPOSED IN 1987.

CONCEPT

Hindmarsh Island Bridge is an incrementally launched composite structure of fabricated steel girders, OneSteel Structurals, and concrete deck, with 10 spans totalling 319 metres in length. The spans vary from 28 metres to 33 metres. The bridge is curved in plan and partially curved in elevation, with a curved centre section linking approach grades of eight per cent. Navigation clearance at the two central spans is 24 metres wide and 14 metres high.

The horizontal curve had to provide clearance for uninterrupted operation of the cable ferry during construction of the bridge. The vertical alignment was dictated by shipping clearance requirements and the need to keep embankments as low as possible to minimise costs.

The bridge cross-section comprises a 7.6 metre carriageway with a 2.05 metre footway, plus steel crash barriers and pedestrian railings. Total width is 10.8 metres. The superstructure comprises four steel I-Girders topped by a 200 mm thick reinforced concrete slab and 50 mm of asphalt. Suspended below the deck is a 300 mm diameter water main.

The Goolwa abutment spread footing is founded on reinforced soil retaining walls whilst the Hindmarsh abutment is founded on piles. All piers are supported on piled footings. The river piers are founded on sealed tubes of Grade 250 steel, driven to refusal and then filled with concrete. The sole land pier, on the Goolwa side, is founded on driven bulb-base cast-in-situ concrete piles.

PIER REDUNDANCY

With the bridge positioned at the mouth of the Murray, the design had to be both convenient and safe for navigation.

With a variety of vessels travelling The Murray, including the 360 tonne Murray River Queen, the bridge had to be able to withstand the full impact of a collision. Transport SA specified that, in the event that a bridge pier was subjected to the full impact of a vessel, the superstructure must not collapse, indicating pier redundancy as an acceptable approach.

This concept is such that if any pier collapses, through impact by vessel or otherwise, the bridge superstructure would span the additional distance without fracturing, allowing opportunity to repair the affected pier.

According to Jeffrey Foggin, lead designer from Maunsell McIntyre, **this not only provided significant savings in piling but was also the best and safest design**. "This bridge is virtually indestructible and very safe for both motorists and river shipping. That could only be achieved economically by using steel for the deck structure, because of its light weight and ductility."

SUPERSTRUCTURE

Girders used in the superstructure are typically a constant 1200 mm deep with a 16 mm web, 450 x 20 mm top flange and 500 x 50 mm bottom flange. Grade 250 steel was used for the top flange and web, with Grade 350 for the bottom flange.

Project Team

CLIENT:
Transport – South Australia

PROJECT MANAGER:
Connell Wagner

MAIN CONTRACTOR:
Built Environs

DESIGNER:
Maunsell McIntyre

FABRICATOR:
Ahrens Engineering

The size of the bottom flange was governed by the requirements of the "pier collapse condition" when the maximum span becomes 66 metres. In this condition the bridge has limited live loading capacity.

Girders were braced in pairs, with the bracing design governed by the need to allow the passage of mobile deck formwork wheels. Bracing consisted of over 60 tonnes for OneSteel Structural sections 360 UB 45 with 530 UB 82 at abutments and a fabricated 500mm deep I-girder at the piers to allow for future jacking to replace bearings. Diagonal plan bracing comprising OneSteel angles was used to prevent longitudinal sway during launching.

The girder web thickness and both flanges were selected to be constant for the full length of the bridge. The only exception was at the outer beams over the piers where the web thickness was increased to 20 mm, Grade 350 steel, to enable a clean line along the outside of the girders without the need for an external stiffener over the bearing.

INCREMENTAL LAUNCH

Incremental launching was chosen to speed up construction and to overcome some serious challenges caused by the geometry of the design. In addition to the horizontal curve of the bridge, construction had to accommodate the combination of straight vertical grades with a central curved section. Because the section being launched included a curved central section, the growing deck did not lie flat along the top of the piers. The design therefore needed to allow for lift-off of the following sections at some piers during launching.

It was decided to launch the steelwork first, with no decking in place. According to Jeffrey Foggin the light weight of the steelwork minimised stresses and overcame the risk of damage.

Launching took place from the two abutments consecutively, with the two halves joining in the middle of the bridge. This enabled construction of the concrete deck to proceed in parallel with the launching of the steelwork for the second half, leading to significant time and cost savings. The steelwork was launched twice weekly in lengths of around 18.5 metres.

David O'Sullivan, managing director of Built Environs, said the choice of materials and method worked very well. "We kept it simple by launching the steelwork first, which was more flexible and manageable than launching with the deck in place."

STEELWORK FABRICATION

Ahrens Engineering won the contract to supply, fabricate and assemble the steel I-girders, which were welded in lengths varying from 18.5 to 19.5 metres to allow for easy and economical transportation. To reduce fabrication splicing costs, provided plates were rolled to the required length.

Girders were fabricated with both camber and curvature using sub-arc process. A high level of control through strict tolerances ensured that the final profile was achieved. All the welds were 100 per cent magnetic particle and ultrasonically tested. The girder segments were braced in pairs before being transported to the site. Before launching, the segments were positioned and welded to the previous segments with complete penetration butt welds.

SURFACE PROTECTION

Transport - South Australia specified a three-coat system comprising 75 to 125 microns of Type 3 water-borne inorganic zinc primer, a 250-micron mid-coat of micaceous iron oxide (MIO) and a re-coatable polyurethane topcoat of a thickness to ensure full hiding of the mid-coat.

A South Australian artist decorated the outer surfaces of the edge girders with a design depicting South Coast marine flora and fauna.

BEARINGS

Fixed pot bearings were used for the three central piers, with sliding pot bearings used for the remaining six piers and the abutments. Launching was done over the permanent pot bearings using teflon sliding pads.

DECK CONSTRUCTION

Construction of the concrete deck slab was another major innovation on this project, as the slab was cast using a mobile formwork unique in Australia. Conceived by Built Environs project manager John Allen and designed by Carlo Muneretto, from Applied Innovations, the system comprised a frame on wheels rolling on the bottom flange of the outer girders to form the outside cantilevers. Between the girders, the formwork was mounted on wheels that rolled on top of the girder bracing.

With the structural steelwork in place, the deck was cast in sections of 33 metres, and the forms were stripped after four days of water curing at ambient temperature. The internal forms were lowered and moved forward to the next section by rolling onto the bracing. Similarly, the cantilever forms attached to the frame were also lowered and moved to the next section to be cast.

SUBSTRUCTURE

Each of the nine piers comprised a single reinforced concrete column with a cross-head on a concrete pile cap supported by steel piles of 610mm outside diameter, driven to refusal into the river bed. One land pier was founded on bulb-base cast-in-situ concrete driven piles. The steel piles were driven with closed ends with a diesel-powered internal hammer. This avoided any material excavation to comply with environmental requirements. The pile cap was constructed using precast concrete formwork, and was placed after completion of the piles and after surveying their actual location

CONCLUSION

The construction of the bridge opens the way to increased tourism and development in Hindmarsh Island and Goolwa.

Several innovative techniques involving steel were used in the design and construction of the bridge, including the use of pier redundancy, which provides a bridge that is safe for vehicles and shipping and virtually indestructible.