Steel conquers

The longest in Indonesia, at over 1km in length, the Barito river bridge is an excellent example of Australian ingenuity and industry capability. Completed in April this year, the steel suspension bridge over the wide Barito river forms a link between Banjarmasin and central Kalimantan. Replacing a car ferry, the bridge carries the Trans Kalimantan highway, a major road artery 2,800 km long which connects all areas of Kalimantan.

The bridge provides an excellent study in steel construction. The drive to minimise costs made steel a winner for this project. Steel has been used to maximum advantage and techniques have been employed to facilitate speed and safety in construction. All this has been achieved in remote and difficult terrain and with a labour force relatively inexperienced in sophisticated construction. A large quantity of steel was needed to complete the bridge - the total weight of fabricated steelwork for the project was 2,500 tonnes with the majority of steel (1,850 tonnes) being supplied by OneSteel

Transfield Construction was awarded the contract for the design and detailing of the bridge, supply of all superstructure steelwork and provision of site advisers to oversee construction. Mc Millan, Britton and Kell (MBK), in association with Engineering Superstructures (Sydney), were involved in all phases of the design. Austress Freyssinet carried out the cable erection, lifting of truss segments and hanger adjustment. The main contractor for site construction was the State owned PT Adhi Karya.

Design features

The main criteria for the bridge project set by the client, the Direktorat Jenderal Bina Marga (Public Works Department) were, for an economical, yet aesthetically pleasing design, which still allowed adequate clearance for shipping traffic.

The chosen solution comprises two suspension bridges end to end and each 420 m in length, with approach spans totalling 181 m on the Banjarmasin side and 60 m on the Kalteng side. Each suspension bridge comprises a central 240 m span and flanking spans of around 90 m each (Fig.1).

The challenge facing MBK, design consultant, was to design a sophisticated structure which could be built safely and economically by the local contractors who had little experience with large bridges of this type.

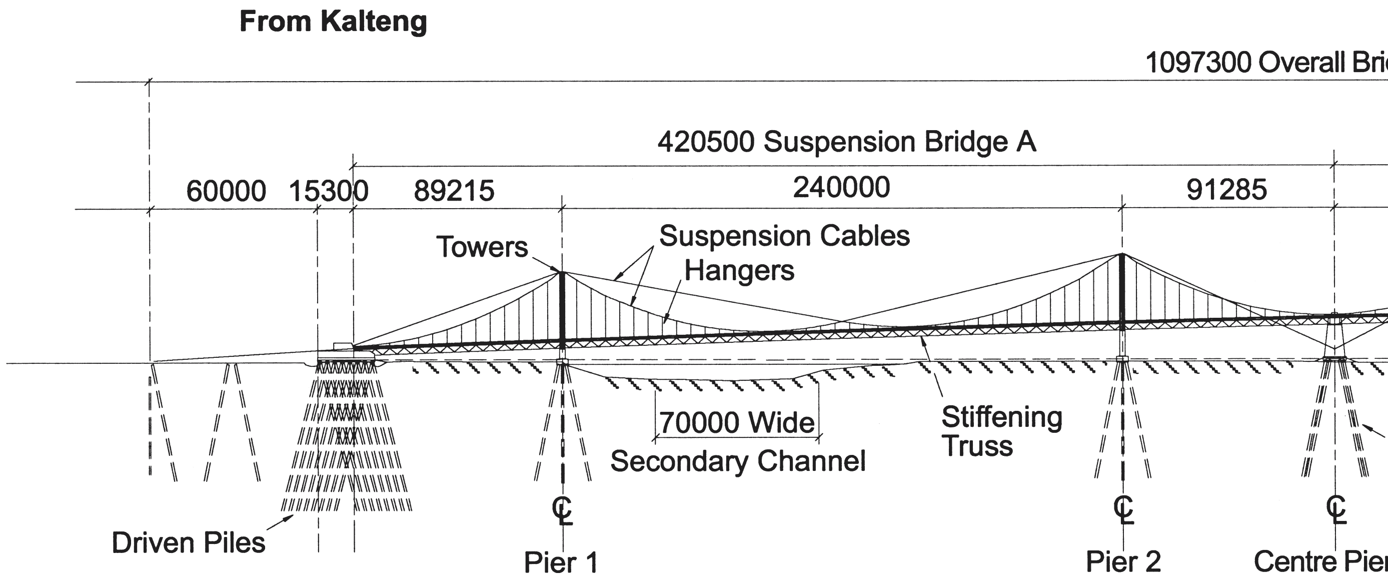
Superstructure

The bridge (Fig. 2) comprises two 3.5 m traffic lanes and 1.5 m footways on each side. The width between cables is approximately 12 m.

A key feature of the design is the dual, asymmetric cable arrangement which provides a 70% increase in bridge stiffness when compared to a conventional, single cable arrangement, as illustrated in Fig. 1. This arrangement, used by MBK on two previous jobs and championed by Prof. Max Irvine of Engineering Superstructures, resulted in a 40% savings in steel in the towers and deck truss.

The galvanised stiffening truss is suspended

Figure 1.



the Barito River

from the main cables and supports the roadway and footways. Construction of this space frame was simplified by use of standardised, bolted truss connections.

The deck is also simple in construction, being a composite concrete deck cast in place on permanent steel formwork. The composite action between the deck and the truss results in significant increases in strength and stiffness. The stiffening truss is supported on pot bearings.

Substructures

The concrete abutments and pile caps are supported by 600 and 1015 mm diameter steel tube piles filled with concrete and reinforced in the upper section to permit a moment connection to the pile cap.

Towers

Made of steel, the towers are supported on reinforced concrete pedestals built off the pile caps. Each tower consists of two main box-section columns interconnected with tubular cross bracing and catwalk beams which join the columns at the top. Economical in design, the box section of each column is formed by four steel tubes 600 mm in diameter and filled with reinforced concrete which acts compositely with the tubes. The tubes are interconnected by 10 mm thick plates.

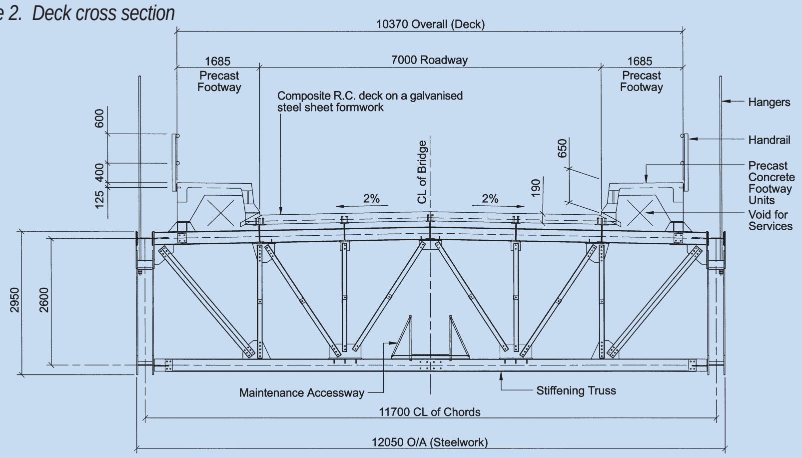
Suspension cables

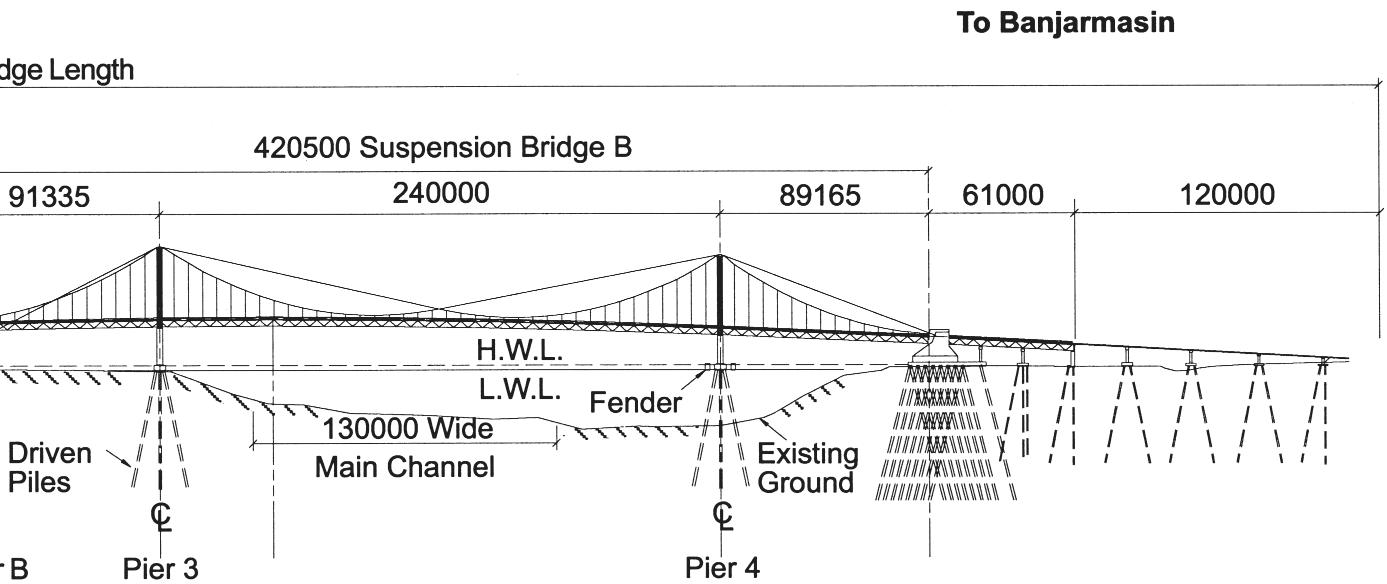
Each of the two suspension bridges has four suspension cables, each cable comprising 7 individual 64 mm diameter strands, bundled together to form a 200 mm diameter cable. At Centre Pier B, the draped cables from both bridges connect to a fabricated connection assembly which is stressed to the substructure. At the tops of the towers, the cables are supported by, and clamped to saddles bolted to the tops of the towers. The stiffening truss is suspended from the cables by cast steel cable clamps and hangers at each node point. Hanger rods consist of one or more lengths of 38 mm diameter high tensile bars joined together with threaded couplers.

Deck

The deck slab is cast on custom made corrugated steel decking panels which act as permanent formwork. Slotted holes were pre-punched in the decking to accommodate the studs. The 190 mm thick slab acts compositely with the steel stringers with both elements acting as part of the truss "top chord". Precast units each side form footways 650 mm above the roadway level.

Figure 2. Deck cross section





Construction

Tower erection

The columns were supplied in 16 m long sections. The first stage of erection involved the complete preassembly of each tower on the ground and the welding together of the two sections of each column. Weighing 30 tonnes each, the columns were erected using a 200 tonne crane, with the bracing and catwalk beams then erected separately, assisted by a second crane with a man box for access. This method of assembly avoided the need for scaffolding and ensured accurate pre-assembly on the ground prior to welding.

Erection of cables

Strands were erected individually using specialized equipment. Each strand was hauled out from a cable reel behind the outer anchorages, through the outer anchorage tubes, over sheaves at the two towers and through the anchorage fittings at Centre Pier B. The strands were pulled by a 10 tonne outhaul winch at Centre Pier B.

Cable clamps and hanger rods were installed with cranes, using specially designed C-Hook man boxes. An average of one clamp was erected every half hour as erection proceeded on a two shift, round the clock operation.

Lifting of the stiffening truss

The stiffening truss components were sub-assembled in the workshop in 12 m lengths. The sub-assemblies were then joined together into erection segments 50 - 60 m long below their final position or on barges ready for floating into position and lifting. All segments were surveyed for precamber and straightness before bolt tensioning. Bolts were tensioned with impact guns using load indicating washers for tension control. Corrugated steel sheeting covering the entire width of the bridge was also installed during assembly.

After erection of cables and clamps, each stiffening truss segment was lifted into position at four points by four hydraulic climbing jacks acting on strands. Segments weighed between 100 and 138 tonnes.

After lifting all truss segments the hanger bars were installed and adjusted to pre-determined lengths to bring the segments into alignment. The truss segments were then interconnected. The truss was cambered upwards by controlled adjustment of hangers before the deck was cast and the precast footway units installed. A final set of hanger adjustments brought the deck to the final level.

Richard Woods, an associate director at MBK and leader of the design team said: "The extensive use of steel on this bridge allowed rapid, safe construction in difficult conditions. The most complex and technically demanding work was done off-site enabling simple, safe assembly on site to suit the skills of the workforce. With the poor founding conditions, including soft silts and peat layers in the upper 20 metres, the lighter structure led to significant savings in the foundations."

This bridge is an excellent example of clever and practical Australian engineering. The close co-operation among the project participants from the outset ensured the successful realisation of this landmark structure in difficult conditions.

Project participants

Client:	Direktorat Jenderal Bina Marga (Public Works Department - Indonesia)
Designer:	Mc Millan, Britton & Kell and Superstructures Engineering
Site works contractor:	PT Adhi Karya
Main sub-contractor:	Transfield Construction
Fabricator:	Transfield Fabrication - Seven Hills