FIRST FIBRE-REINFORCED POLYMER BRIDGE DECK

The first fibre-reinforced polymer (FRP) bridge deck to be installed on the Australian road network is functioning well at Coutts Crossing in NSW.

The bridge at Coutts Crossing spans the Orara River, in northern New South Wales. The FRP bridge deck was installed in 2003 to replace a timber span constructed in the 1930s. The Coutts Crossing bridge is 90 metres long and 7 metres wide. The FRP deck replaced 12 metres of the bridge length.

It was commissioned by the Roads and Traffic Authority of New South Wales (RTA), and was constructed and installed by Wagners Composite Fibre Technologies Pty Ltd (WCFT). The FRP bridge deck was designed by Connell Wagner, drawing on an earlier WCFT-University of Southern Queensland (USQ), Fibre Composites Design and Development (FCDD) prototype design.

Coutts Crossing is Australia's first FRP bridge deck on a road network, and is one of the first such bridge decks in the world. Although many fibre composite pedestrian bridges have been built as technology demonstrators overseas, the development of the FRP fibre composite bridge at Coutts Crossing pushed the boundaries of conventional bridge construction methods and materials as well as current fibre composite technology worldwide.

The main achievement of the technology at Coutts Crossing was that bridge members were far bulkier and more robust than those found in existing FRP bridges worldwide, making them suitable for Australian conditions and carrying vehicular traffic. This achievement relies on the modular construction method pioneered in

Wagner Composite Fibre Technologies and FCDD's prototype bridge beam.

The Coutts Crossing bridge is the result of close collaboration between RTA and WCFT, which saw the parties share costs. RTA paid for the cost of a conventional bridge and WCFT making up the extra 50 per cent difference to pay for the FRP bridge. The new bridge deck design offered substantial benefits over traditional bridge deck design, including the following estimates:

- installation in only five days, instead of eight to ten weeks;
- 90% saving on traffic control costs; and
- 75% saving on bridge transportation costs.

Costs to fall

The Coutts Crossing FRP bridge is a hand-made prototype and was relatively costly to build. Research by the manufacturer, however, suggests that the installed cost of its FRP bridges will match that of conventional bridges when it commences full-scale manufacture in 2004 and begins to reap economies of scale.

The innovation within the bridge lay in the modular construction of the FRP bridge deck and the hybrid engineering of the material usage. There are three basic shapes that make up a FRP beam - a hollowed-out glass square shape, a long carbon strip, and a rectangular concrete shape.

These shapes are adhered with special adhesives to make a beam. The hollowed-out glass squares are adhered together to create a box section. The carbon strip is glued along the bottom of the box section and the concrete is then adhered on top of the glass box to complete the beam section. These beams are then glued together to make a deck section.

A number of decks go to make up a complete bridge deck. Because the system is modular, if bridge length increases, more modules are used; if bridge length decreases, fewer modules are used.

These components, and their mechanical interaction, constitute the particular composite mix (the FRP) employed at Coutts Crossing (and in the prototype bridge). This composite design has never before been used, and was developed specifically for bridges, to mimic a conventional concrete bridge deck which is accepted best practice.

The benefits

In general terms, composite fibre structures have a number of features that make them attractive for use in bridge structures including high strength-to-weight and stiffness-to-weight ratios, corrosion and fatigue resistance, and tailorability.

Replacement of concrete and timber decks by lighter fibre composite decks allows for an increase in traffic load, without an overall increase in load on the supporting structure. Fibre composite decks also have potential for use in areas where longer spans are necessary or where lower weight would translate into increased seismic resistance.

Additionally, fibre composites have significant benefits when used in so-called 'aggressive' environments, such as on the coast or in environments with snowfalls and de-icing salts, because the product is completely inert, i.e. non-corrosive and non-conductive.

FRP bridges are expected to have much lower ongoing maintenance costs when used in such environments. While this is unproven at this stage, parties involved in the project believe this has enormous potential. The composite bridges a similar, if not longer, lifespan to alternative bridge designs. Current research is looking at ways to optimise the design to bring costs down even further.

Looking at the Coutts Crossing project in particular, several forms of superstructure replacement could have been used, including:

1. Doolan timber concrete composite decking;
2. M-Lock decking;
3. NSW conventional PSC planks with *in situ* concrete overlay;
4. Queensland conventional PSC planks without *in situ* concrete overlay; and
5. Other, less used proprietary decking systems.

Options (1), (2), and most of (5) could have been installed over much the same timeframe as an FRP deck; quicker than options (3) and (4). Hence, FRP savings in traffic management costs would have been marginal when compared with options (1), (2) and (5). However, the major advantage of the FRP structure over all the listed alternative superstructures was its light weight and the associated reduction in transportation and foundation costs this could deliver.

For the conditions associated with the Coutts Crossing project, (3) was considered the next best alternative to the FRP bridge and is the comparator used to derive benefit estimates. Time required to install (3) was estimated to be

8 to 10 weeks, while the FRP bridge was installed in 5 days, translating to substantial traffic management savings of approximately 90%. The lighter deck weight of the FRP bridge (55 tonnes compared to 114 tonnes) also saved 75% in transportation costs.

Normally, there would also have been an associated reduction of 27% in foundation costs; however, as the Coutts Crossing bridge was a demonstration project, the loading for a relatively heavy conventional prestressed concrete plank deck was used in design to reduce risks. It is expected that this measure will prove unnecessary in the future. Indeed, the design at Coutts Crossing was conservative, since it was the first project of its kind, and it can be expected that weight and related cost savings will be greater on future projects.

The implementation process

The installation of the bridge deck at Coutts Crossing represented the culmination of more than five years of extensive collaborative research and development by a number of enthusiastic individuals and organisations, including state and federal government departments, private sector firms and the university sector. The Coutts Crossing project would not have been possible without this background research and development.

USQ's FCDD Group started research into fibre composite bridges in 1996. Shortly afterwards, Connell Wagner consulting engineers joined the research effort, with the Department of Main Roads (DMR) becoming involved in 1998 and contributing important practical design information.

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PREVENTING EROSION OF EMBANKMENTS

Recently, the Tri-lock Erosion Control system has been used by the Queensland Department of Main Roads on the Eumundi Interchange and the Caboolture Bypass and will be installed on the Mt Lindsay Highway Upgrade project.

The Tri-lock system is used for embankment protection on bridge abutments. It is a total membrane, not a set of separate mats functioning independently. Every unit in the Tri-lock system is firmly locked into two adjacent units, allowing the system to act as one.

The concrete components are precast units having a compressive strength of not less than 25MPA and have an exposure category durability rating for salt-attack resistance. The oven-dry weight is no less than 2150kg per m^3 as per AS4456.8 2003.

The pre-cast concrete blocks made up of two components: a 'lock block' and a 'key block'. The male and female parts of these blocks link together in an infinitely repeating pattern providing multi-dimensional stability and integrity over large areas. This feature, as well as enhancing the hydraulic characteristics, prevents major revetment failure.

These blocks are normally laid by hand in dry conditions over a specially engineered filter-fabric substrate material. Infill aggregates can be used to enhance the aesthetics and to further protect the filter fabric and substrate material. Installation is typically a relatively quick process with no down-time lost to any requirement for curing.

Tri-lock is a patented system of erosion control not limited to bridge abutments and can be used in a diverse range of erosion control applications including banks of inland and coastal waterways, drainage canals, river embankments, culverts, boat ramps, temporary access roads and other problem areas.

A bevel at the interlock of Tri-lock blocks enables the system to conform to undulating land contours and grades. There is adequate open area to relieve any hydrostatic pressure across the revetment. Voids are evenly and closely spaced.

The voids in the system may be filled with top soil and seeded with grass or other vegetation. The absence of projections or abrupt unevenness permits easy maintenance with conventional grass cutting equipment while the evenness of the revetments provides a safe surface for both vehicle and pedestrian traffic, allowing easy access to the water's edge.

For more information, contact Hanson Building Materials on 1300 365 565 or visit www.hanson.biz.com