# Bridge bolstered for 100 years' extra life

## West Gate Bridge, Melbourne

**An efficient design approach to bridge strengthening using standard grades of steel has accommodated an extra traffic lane in both directions on Melbourne's iconic West Gate Bridge at significantly lower cost of alternative methods of increasing vehicular capacity.**

The West Gate Bridge is a steel box girder cable-stayed bridge in Melbourne spanning the Yarra River and at 2.56km is twice as long as the Sydney Harbour Bridge.

Completed this month, the project was jointly funded by the Victorian and Australian Governments, and was delivered by an Alliance involving VicRoads, John Holland, Sinclair Knight Merz and Flint & Neill.

The project is considered without precedent in terms of delivery timeframes and scale as other bridges upgraded overseas only carry a fraction of the current 160,000 vehicles which cross the West Gate every day.

Project Manager of the West Gate Bridge Strengthening Alliance (WBSA), **Kevin Devlin** said that several options were considered early in the planning stages but the most economical option was to convert the existing emergency lanes to create the extra lanes.

"Proposals that involved substantial changes to the bridge such as widening or converting it to a suspension bridge were an order of magnitude more costly," Mr Devlin said.

He said experience gained on other bridges designed and constructed about the same time as West Gate overseas was brought to bear, particularly from the UK.

"There are a number of features that put this project high on the list for international Best Practice," he said.

"Rather than contriving a 'deemed to comply' loading for the design, it is based on the loading that the bridge is actually carrying and expected to carry in the foreseeable future.

"This loading is substantially less than the standard ones specified by current bridge design codes which would have been inappropriate."

Design Manager, **John Noonan** who worked on the fabrication and subassembly of the original bridge in the early 1970s is confident that both the original designers and those working on the re-design would never have expected the loads the project has had to accommodate with the strengthening.

"There was virtually no provision in the original design or construction for additional strengthening to accommodate higher loads," he said.

He emphasised that the design had to consider both global and local live loadings.

"The existing breakdown lane was only designed to be occupied locally. The global loading was taken as eight lanes of H20-S16 loading, while local loading on the deck was assessed using a HS20-44 standard truck," Mr Noonan said.

"On the other hand, the design loading for the strengthening is based on a probabilistic analysis of actual loadings due to current traffic and for local loadings similarly to be T44/L44.

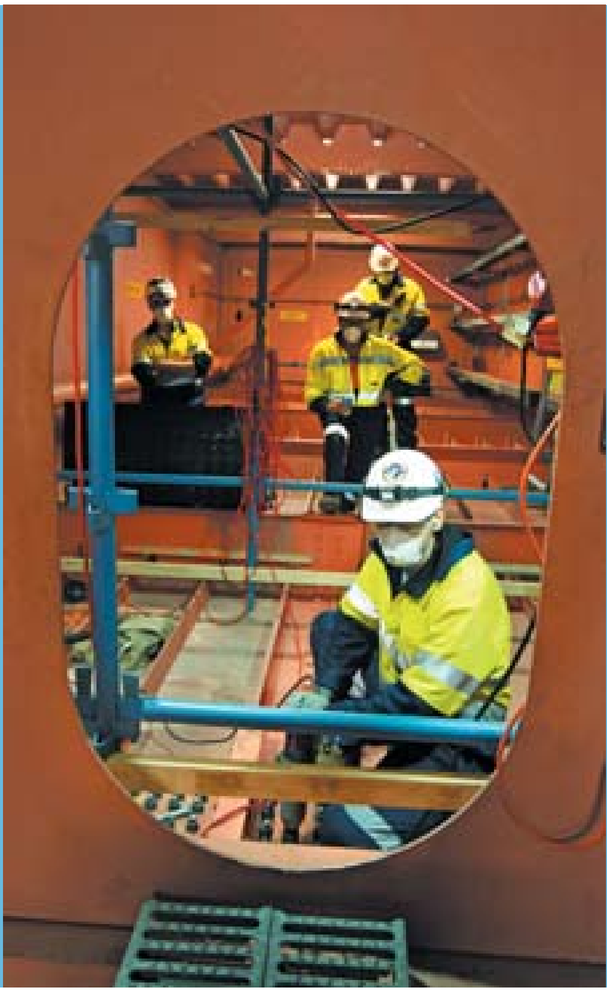
"The HS20-44 truck weighed 32 tonnes whilst a T44 truck weighs 43 tonnes. Quad-Quad Axle B Double High Productivity vehicles were also considered."

He said the bridge was originally designed to hold a concrete deck over the full deck area. "Consequently, although the strengthening is virtually all achieved with additional steel members, the total loads are still within the capacity of the main load carrying members."

There was extensive use of 3D finite element models.

"These models allowed us to better understand the behaviour of some very complex areas within the bridge and minimise the amount of strengthening to be added," he said.

There was very little strengthening required on the outside of the bridge. He also pointed out that carrying out the work on a busy existing structure posed numerous



challenges that the steel-intensive approach helped navigate through.

The logistics and structural integrity constraints involved minimising disruption to motorists on the bridge, safety issues of working above Australia's busiest shipping channel and high voltage power lines, and at heights and in confined spaces.

"A significant feature of the work was that new challenges were being encountered almost every day, requiring a quick response from the fabricators to meet the needs. As the work progressed, there was a greater focus on fabricators that were able to respond to these needs," Mr Noonan said.

"The Alliance developed a range of innovations to meet these challenges and deliver five lanes by late June 2011, starting with a suite of standard details being developed.

"The design of the strengthening for each section then involved selecting the most appropriate detail, with every effort made to keep the weight of components down, given the difficulty of transporting material onsite.

"Bolted connections were used in preference to welded connections. In one section of the bottom flange where existing steelwork made installation of strengthening steelwork difficult, post-tensioning tendons were installed inside the box girder.

"Techniques were developed to strengthen existing under-strength bolted connections without materially reducing the splice capacity during the process."

Mr Devlin said that the initial construction involved substantial enabling works to improve access to the inside of the bridge.

"It included cutting a number of access holes in the soffit of the bridge as the only access was through manholes in the bridge median prior to the project," he said.

"In addition, access holes through the webs and diaphragms were enlarged and walkways were installed inside the bridge, which each required individual strengthening in the vicinity to enable holes to be cut or enlarged.

"Strengthening members were designed to minimise weight and size allowing them all to be installed by hand or with the use of chain blocks.

"Close tolerance bolts were used in a number of locations where large plates were being fixed to existing plates such as on the face of the towers and on the internal diaphragms."

A significant feature of the completed bridge is the Public Safety Barrier system along each side, development of which involved investigation of current practice in Australia and overseas and wind tunnel testing to examine the effect of the barrier on the bridge dynamics.

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"Extensive use was also made of steel platforms to provide access to the outside of the bridge for the installation of 526 outrigger cantilever props. Square hollow sections were used for the props to keep the weight down and facilitate handling," he said.

The project consumed 400,000 bolts and 1600 tonnes of steel fabricated into 80,000 pieces.

**Project Team**

**Main Construction Contractor:** John Holland

**Design Engineering (Steel):** Flint & Neill, Sinclair Knight Merz

**Finite Element Analysis:** University of Melbourne

**Steel Fabrication and Detailing:** Kiewa Valley Engineering, JP Pipe and Steel Engineering, Geelong Fabrications, Kara Industrial Engineers, Alfasi Steel Constructions, Stilcon Steel Manufacturing, Best Fab, Tec Metal Engineering

**Blasting and Painting Preparation:** McElligotts Partners

**ASI Steel Manufacturers:** BlueScope Steel Industrial Markets, OneSteel Australian Tube Mills, OneSteel Market Mills, Orrcon Steel

**ASI Steel Distributors:** BlueScope Distribution, OneSteel Steel and Tube, Orrcon Steel, Surdex Steel

## Local commitment lifts confidence

The decision made during the early development phase in late 2008 to stipulate 100 percent Australian milled steel for all structural elements of the West Gate Bridge Strengthening was based on previous experience and project-specific tests.

The Alliance's Project Manager, **Kevin Devlin** said structural steel supply assurance was critical on the high profile development.

"As the bridge is subject to transient stress cycles, quality of the steelwork was very important," he said.

He said that an early assessment was conducted of supply options for local and imported steels available through major suppliers and fabricators.

"While the overseas steel was found to be just marginally cheaper, the project people were not at all satisfied with quality levels," he said.

"The traceability provisions for Australian steel are excellent, providing 100 percent identification right back to exact batches from mills. The imported steel didn't provide the same level of assurance.

"The only imported steel used on project was product of Japan used for some non-critical components like mesh."

It was also required by the Project's designers that all steel met the relevant Australian standards.

Mr Devlin added that the Project's key welding tester had previously encountered problems with the imported steel on the massive EastLink project ranging from laminating to uncertain verification certificates.

There was also a commercial element to it which was the Victorian Industry Participation Policy (VIPP). This requires potential suppliers/subcontractors "to demonstrate they have considered the local industry development implications of their tender according to the VIPP" to maximise opportunities for Australian and New Zealand suppliers to compete on a best value for money basis.