Well rounded way wedded with busy waterside

Jim Stynes cyclist and footbridge, Melbourne

Careful engineering and fabrication has enabled the integration of an ambitious, circular pathway for cyclists and pedestrians alike along the northern shoreline of the Yarra River connecting the Docklands precinct to the Melbourne CBD.

Named after prominent AFL player, the late **Jim Stynes**, the bridge is part of a $25 million Northbank redevelopment with the innovative 'hovering' steel arc bridge the first of its kind in Australia.

The 125-metre long, lightweight structure weaves under the Charles Grimes road bridge and over the water edge with the bridge's arc allowing the structure to act in tension as a horizontal suspension bridge.

The project's engineers, Aurecon Australia devised a structural solution based on a unique, horizontal, self-tensioned catenary that is integrated with the truss and designed to resist the rotating force induced by the cantilevered deck and the curved truss.

Steel was chosen for the main supporting structure of the bridge due to its high tensile capacity. The footbridge incorporates 428 tonnes of steel ranging from 350 grade plate up to 8620 solid bar (up to 180mm diameter) as well as hollow sections. All the main support beams are of Australian steel and all steelwork supplied was required to comply with Australian Standards.

Aurecon Australia Technical Director, **Peter Murenu** said that for the horizontal catenary to be stable, the bridge needed to be perfectly circular in plan whilst anchoring it securely at irregularly located points to the existing roadway infrastructure, making the most of what is already there.

"There were a number of physical constraints that needed to be respected such as head clearance below the existing road bridge with the low point needing to be above a one in 10 year flood event and truss node points to line up between the existing super-T bridge beams supporting the roadway," he said.

"In order to achieve all of these geometrical requirements, Aurecon and Cox Architects worked closely together utilising parametric modelling so that variables could be altered and the 3D model updated instantly.

"Iterations were therefore very quick and a process that would have taken weeks, the geometry of the structure was completed in a few hours.

"The result is a beautifully formed piece of infrastructure that is true to itself. Every element of the bridge is doing something, down to the last detail. The integration of structure, architecture, specialist lighting and landscaping came together seamlessly to form a robust and lasting legacy for the people of Victoria.

"The success of the project is attributed to the exceptional team that developed a close bond during the course of the project. From the client right through to the workers onsite, everyone worked together to overcome the many and varied challenges this technically complex project offered."

He said that the structure came to site as prefabricated modules, sizes determined by allowable transport dimensions. The modules were all prefabricated and joined together with tailor-made coupler connections.

"The positions of the couplers were matched with lower stress points in the structure to keep coupler sizes to a minimum so that they are nestled within the diameter of the top chord member," Mr Murenu said.

"All solid bar sections were predominantly subjected to tension forces to keep the section sizes to a minimum while allowing the forces to resolve cleanly, hence the desire to use solid bars over hollow sections."

To reduce the weight of the structure, high strength steel was used for the solid bars.

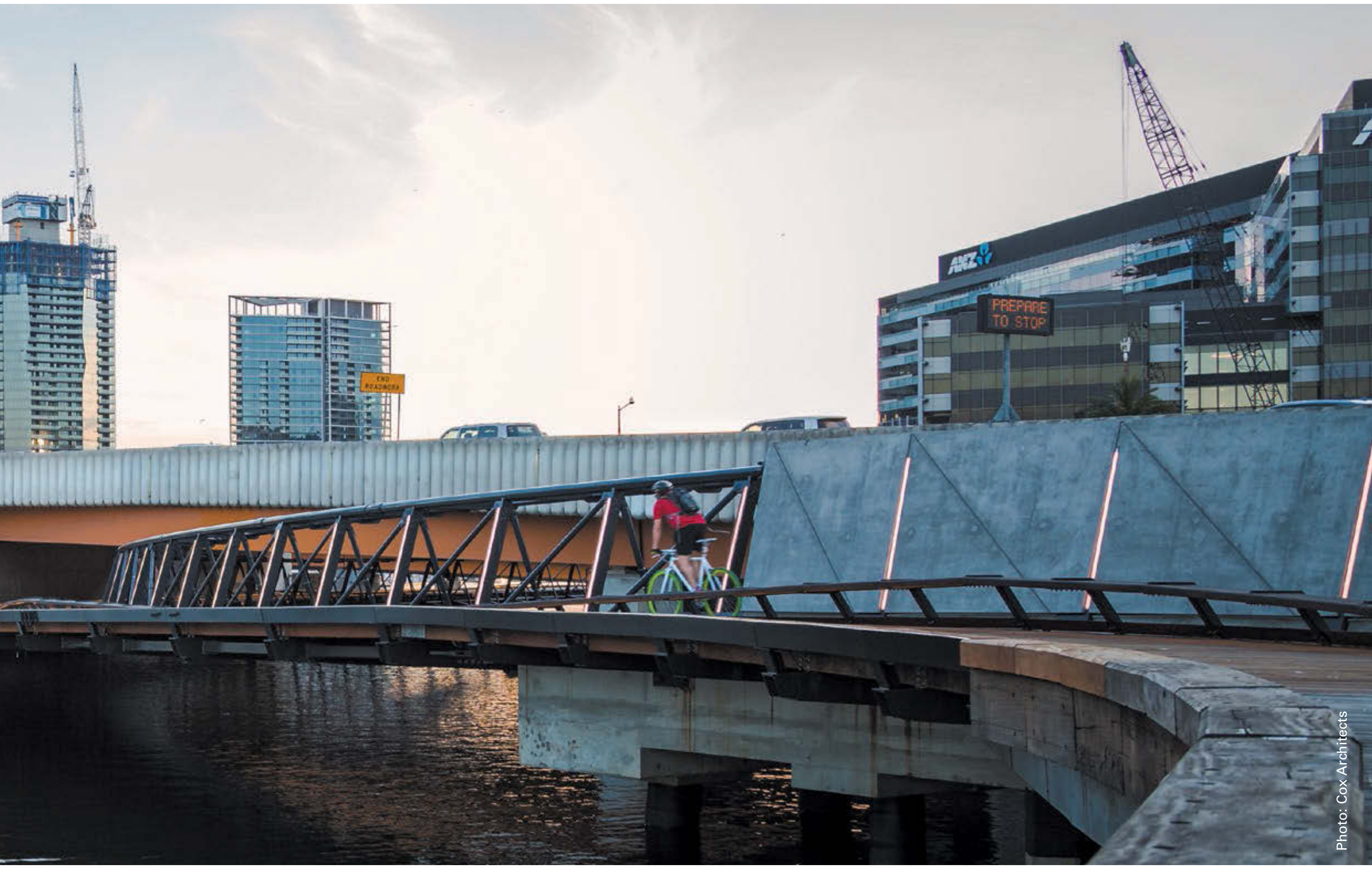


Photo: Cox Architects

He said the structure is designed to be submerged during major flood events and to withstand log impact from debris floating down the river. The steelwork is coated with a high performance paint system.

Fabrication ability tested

To achieve the correct geometry of the structure after installation, the bridge was fabricated in a pre-cambered geometry to counteract self-weight deflections of up to 150mm. The resulting geometry therefore took the shape of a wave to respect the high and low deflections expected. The steel used and its particular waveform design brought with it a lot of challenges in fabrication and assembly that needed to be overcome.

Focus Engineering & Construction Managing Director, **James Webb** said that its QA system was used to record, obtain and test the steelwork as per design specifications to ensure the project conformed to Australian Standards.

"All steel supplied and used in fabrication had a heat certificate to Australian Standards and all welders and welding processes were tested and certified prior to fabrication for the required joints," he said.

"Non-destructive testing was performed both during and after fabrication including ultrasonic and MP testing to ensure conformity."

He said that the particular challenges faced during this project were addressed both prior to starting the project and during the fabrication and assembly.

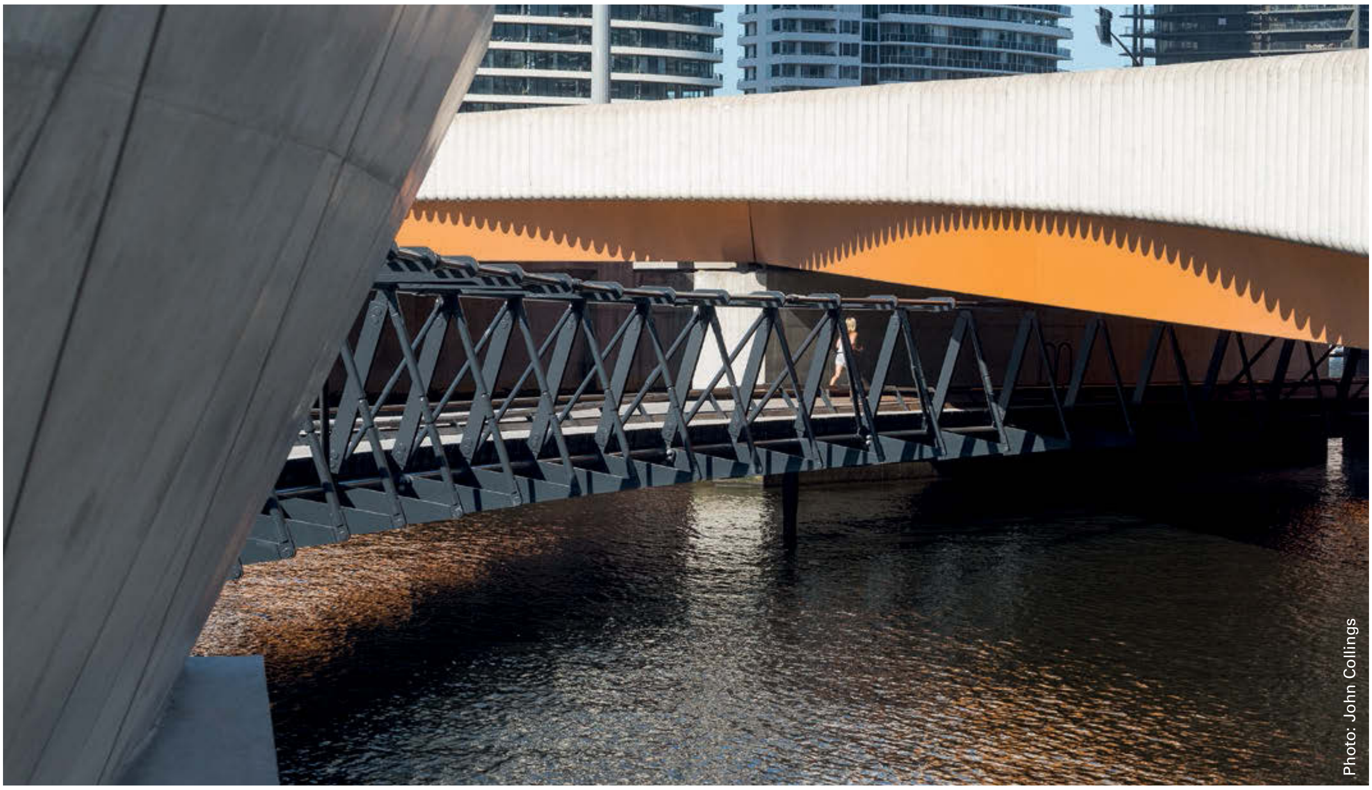
The bridge was fabricated in 14 sections with each split into two sections so the maximum width of each was 6.2 metres wide. Each section was unique within the waveform design in degree of curve in the fabricated steel.

"The sections were very difficult to assemble and disassemble because four sets of threads needed to line up with three bars at the back and the bar at the front had to be simultaneously screwed together, so precision was essential," Mr Webb said.

"The biggest challenge was bending to shape the 180mm diameter 8620 bar but this was solved by building our own bending machine specifically to shape the high strength bar and all others could then be bent using this machine in our own workshop."

He added that transport and delivery of the project also had its challenges with limited area and road access for delivery into the inner city. Police escorts coordinated the delivery into the city in the late night hours to ensure the easiest possible delivery with the least disruption to normal traffic. In addition, part of the structure was fabricated in one of the nearby Docklands sheds where Fitzgerald Constructions set up a temporary fabrication shop to complement the work being done by Focus Engineering.

"In order to achieve all of these geometrical requirements, Aurecon and Cox Architects worked closely together utilising parametric modelling so that variables could be altered and the 3D model updated instantly."



Proven design guidance

Aurecon was able to draw upon its experience in developing sturdy lightweight bridges in their design approach to preserve structural integrity.

Based on Aurecon's experience on the Falcon Street pedestrian bridge in Sydney, they used the same methodology for procuring and implementing the tuned mass dampers (TMDs) that were installed to limit vibrations in the structure.

"As both projects are lightweight structures, they are susceptible to vibrations due to people walking. As a result, they both benefit from the use of tuned mass dampers to counteract any vibrations," Mr Murenu said.

"Vibrations in the vertical direction were the critical case as there was adequate stiffness in the horizontal direction to limit vibrations. We were able to educate the client in footbridge vibrations so that the vibration loading criteria and acceptability limits were agreed as a design team."

He said that cases considered encompassed pedestrians walking as individuals and collectively and for a single jogger.

"We researched local and international standards and guidelines so that we could bring international best practice to this project," he said.

"It was considered from the outset that tuned mass dampers would be required to limit the vibration of the structure. A Strand7 model of the structure was constructed with pedestrian loads applied as a time-history oscillating force.

"The TMDs were also modelled as a mass with a damped spring. Around nine mode shapes were considered to be within the excitation frequencies of pedestrian loading. A time-history analysis in Strand7 generated accelerations and displacements that were compared against acceptance limits.

"In the Strand7 model, we were able to easily adjust the mass, spring stiffness, damping ratio and location of the TMDs to find the most effective combination. Ultimately, seven TMDs were installed in the structure at locations to counteract the various mode shapes."

The bridge was officially opened in July 2014.

Project Team

Client: State Government of Victoria in partnership with the City of Melbourne

Design Concept: Cox Architects, Oculus

Structural Engineering: Aurecon Australia

Builder: Fitzgerald Constructions Australia

Non-destructive Testing: ALS Industrial, Gippsland NDT Services

Steel Detailing: Quantech Design, CADRAW Professional Drafting Services

Steel Fabricators: Focus Engineering & Construction, Fitzgerald Constructions Australia

Transport to Site: Atkins Transport

Coatings Suppler: International Paint

High Tensile Steels: Interlloy

ASI Steel Distributors: BlueScope, OneSteel

ASI Steel Manufacturers: BlueScope, OneSteel