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## ELIZABETH QUAY PEDESTRIAN BRIDGE, PERTH – THE JEWEL OF THE QUAY

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### Summary

The Elizabeth Quays twin arch pedestrian bridge artfully meanders across the entrance to the newly created inlet in the Perth CBD, Australia. The distinctive bridge completes a waterfront redevelopment that has transformed the foreshore into a busy promenade. Visitors to the precinct can now walk, run or cycle across the bridge enjoying spectacular views of the river and city in all directions.

The design brief was for a bridge that is simple, iconic, and transparent; cognisant of the potential views. It had to allow access by ferries into the inlet and provide equitable access on the 5m wide and 110m long deck. Arup architects and engineers worked collaboratively to optimize the design, challenge constraints and innovate for the elegant curvaceous deck form and counterpoised inclined steel arches. The deck is in an S shape in plan comprising a steel box supported on one side by cables suspended from the 22m high arches. Concrete piers frame the navigation channel and continue the force lines from the arches down to the water surface.

The bridge was successfully completed in early 2016, exceeding the client's expectations.

**Keywords:** CBD location; aesthetics; planning; steel arches; navigable waterway

### 1. Introduction

Elizabeth Quay development opened in Perth in January 2016. It is graced by a distinctive, dual-arched bridge for pedestrians and cyclists. An artfully meandering structure, designed to delight those who use it, the bridge spans a newly-created inlet of the Swan River, its curvaceous form visually linking city and water. Visitors to the precinct can now walk, run and cycle across the bridge, enjoying spectacular views in all directions.

### 2. Client Aspirations

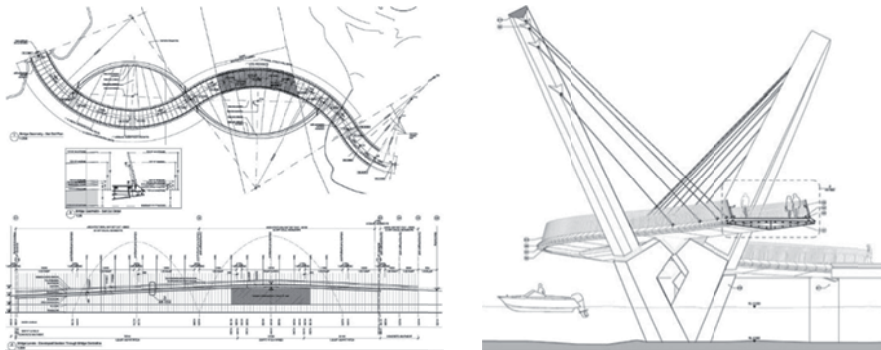
Elizabeth Quay is an essential element of the Western Australian Government's plans to revitalise central Perth by reconnecting the Swan River to the city. Elizabeth Quay creates for the first time a north-south axis for the CBD and adds a vibrant new destination for business, shopping and leisure.

Bridge design was to be simple, iconic, and transparent; cognisant of the potential exciting views. The bridge deck being high enough for ferries to pass safely below to access the new ferry terminal and a deck width sufficient for shared use. It must meet whole of life cost expectations, a 100 year design life and comply with safety in design.

Arup was engaged by the Metropolitan Redevelopment Authority and novated to the managing contractor. Bridge construction was delivered under a construct only contract tendered and managed by the managing contractor. Arup provided architectural and engineering services to the bridge project.

### 3. Accessibility For all

Critical to the bridge geometry was the required clearance for the navigational channel; for each 100mm increase in clearance, the bridge length would increase by up to 7m. Arup successfully negotiated for the relocation of the ferry airdials and challenged the design brief requirements regarding the probability of concurrent storm surge, flooding, waves and sea level rise. These changes delivered a significant cost saving, enabled a shorter bridge length and created opportunity for a simple yet interesting bridge geometry. The smooth curves of the final geometry would not have been possible otherwise. The lowered bridge deck results in better user experience from the proximity of the water, interesting view angles, less height climb, shorter path length and safer cyclist speed.



The 'S' form of the 5m wide steel box bridge deck incorporates the 110m length required to clear the navigation channel at acceptable gradients whilst providing dynamic and changing viewpoints for pedestrians and cyclists using the bridge. Feature lighting creates a relaxing and sophisticated ambience on the Quay when night falls.

### 4. Design

Parametric modelling was used to optimise the geometry of the pathway. Two 22m high leaning arches with 45m spans, sweeping down towards the water to rest on the central concrete pier. The support cables are all on one side of the deck providing unhindered views from the bridge in different directions on each span. The steel box deck responds to deck torsion from the eccentric support cables. The deck shape is deepest at the centre line and only 250mm deep at deck edges. This elegant appearance exceeded the client's aesthetic expectations. The detailing of the deck was carefully selected to facilitate the fabrication using a "coffin" sequence.

The jarrah wood bridge decking is mounted within framed panels to simplify fixing to the deck and maintenance. The stainless steel mesh balustrading provides the desired level of transparency for unrestricted views. The digital design workflow was a highly collaborative process between Arup's Architects and Engineers and proved to be pivotal in the successful delivery of the project, increasing efficiency and reducing risk.

### 5. Construction

The decision by the managing contractor to retain an earth bund at the bridge had a significant impact on the construction. There are no near horizontal surface to the piers meaning all surfaces had to be formed during construction and self-compacting concrete used. The arches were fabricated offsite in three lengths, and the deck in twelve lengths. Standing each of the two arches was done in a single operation lasting about two hours. The deck segments were placed onto a temporary support system and then welded together. The cables from the arches were attached to the deck, abutment bearings installed and the deck weight transferred to the cables.

### 6. Project Outcomes and Conclusion

Elizabeth Quay pedestrian bridge was opened in January 2016 on time and within budget. The client was delighted with the bridge and commented: 'Arup's design excellence has resulted in a 110m bridge that responds exceptionally to the MRA's core brief of an iconic structure that is timeless and refined in its simplicity'.