GATESHEAD MILLENNIUM BRIDGE

SYNOPSIS – STEEL BRIDGE SEMINAR

INTRODUCTION

The Gateshead Millennium Bridge is a unique tilting opening bridge for pedestrians and cyclists spanning some 100m across the River Tyne in the north east of England.

It was the result of an architect/engineer collaboration in a design competition and procured through a partnering process.

The paper describes the design from concept through development and analysis and explains the design criteria adopted for static and dynamic conditions.

Aspects of the steelwork fabrication and bridge construction are described and discussed.

CONTEXT

The River Tyne has six major bridges in the central city area, many have historic roots.

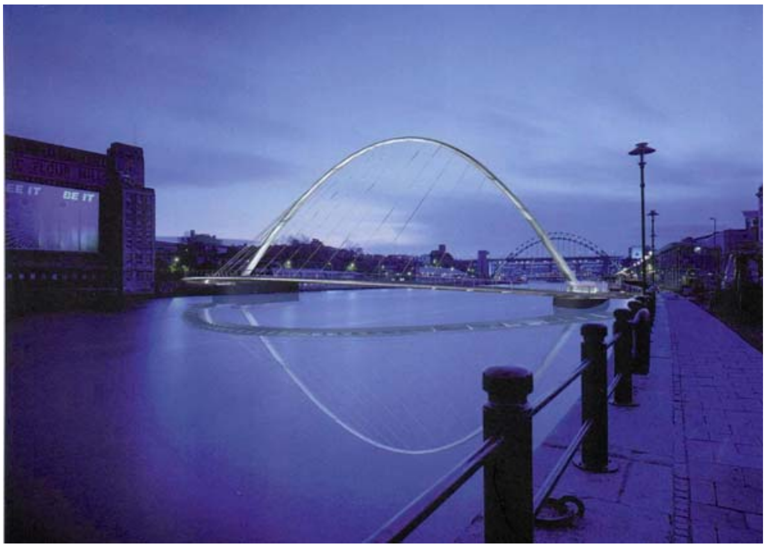
The Tyne Bridge itself, opened in 1928, was designed in parallel with the Sydney Harbour Bridge. Armstrong's Swing Bridge, the only low level bridge, was opened in 1876, and was the largest swing bridge constructed at that time. The high level bridge, 1849, is a double-deck rail and road bridge designed by Robert Stephenson. Each of these structures was at the forefront of innovation in their day.

In the mid 1990's Gateshead Metropolitan Borough Council conceived plans to redevelop the riverside and adjacent derelict areas linking this to the already regenerated quayside on the Newcastle side of the river. With the opportunities offered by funding from the Millennium Commission, Gateshead Council initiated a design competition for a new crossing and invited six prequalified teams to submit design proposals.

CONCEPT DESIGN

The brief required a landmark structure which provided 25m clearance in the open position across the navigation channel, yet link the quaysides at only 4-5m above river level, and without any construction on the quays themselves.

The solution proposed by Gifford & Partners (Consulting Engineers), working with Wilkinson Eyre Architects, was a simple but innovative and adventurous solution in the form of a tilting bridge formed by a pair of steel arches, pivoting from a common springing point within concrete pilecaps. It can be compared in the way it operates with the raising of a visor on a motorcycle helmet, or the opening of an eyelid. The whole 800 tonne bridge rotates and opens to allow passage of ships underneath. In this respect, it is unique and simple. The operating system has hydraulic jacks which push on a steel paddle from underneath a pivot point and rotate the bridge as a whole. In the open position the connecting suspension cables are horizontal and hold the pair of arches together.



PROCUREMENT

The unique and complex nature of the project led to a desire to appoint a 'preferred contractor' at an early stage, to enable their input into the development of the design. It was decided to adopt an NEC target cost contract and following a two stage process Harbour and General Works Limited/Volker Stevin were appointed. Design development then brought into play preferred sub-contractors for steelwork and M&E, Watson Steel and Kvaerner Markham respectively following similar qualification processes in conjunction with the main contractor.

Over a period of about 12 months the design was developed and target cost established.

STRUCTURAL DESIGN

The parabolic steel arch section comprises a kite-shaped section tapering in both plan and elevation. It is fabricated primarily from steel plate up to 35mm thick, stiffened both longitudinally and transversely. The arch houses stay anchorages orientated into the plane of the stay cables.

External to the arch, the connection of the spiral strand stay cables is by traditional open fork ended sockets. Attachment lugs on the arch are seated in the hemispherical recesses and connect through onto diaphragm plates and stiffeners within the arch. The 18 stay cables are formed from galvanised wire and have an adjustable anchorage at the connection to the deck where they pass through a cylindrical hole within which the anchorage plate is bedded.

The deck is also parabolic in elevation and, being curved in plan, presents a most complex geometrically warped shape.

The main element is of steel box construction, tapering in plan from the quayside towards the centre of the river. The box section accommodates the stay cable anchorages in elliptical recesses accessed from the soffit, and sized to enable any stressing of the cables to take place from this location. The upper surface of the box will be coated with a non-slip epoxy coating.

From the steel box are cantilevered transverse steel beams at about 3 metre spacing which radiate outwards around the curve and support a lightweight aluminium deck to carry the cycleway. The cycleway is of constant width over the length of the bridge and is about 300mm lower than the adjacent footway, thus enabling the different required parapet heights to be accommodated uniformly across the section.

The two elements, cycleway and footway, are connected at intervals by a series of steps, and separated between by an integral seating arrangement so that bridge users can pause to enjoy the spectacle of the views of the riverside.

MECHANICAL AND ELECTRICAL

As part of the package for mechanical and electrical services it was decided to subcontract both detailed design and manufacture of the equipment required to move the bridge as well as the bearing assemblies onto which the bridge was to sit.

The bridge requires systems to open it which could push and pull, because the centre of mass passes over the pivot point during opening. Ram loads could change from 10,000 kN push to 4,500.kN pull during this sequence, in fully operational wind conditions. Various emergency procedures and requirements were stipulated to allow for system failures or adverse conditions.

Synchronisation of the ram systems on each side of the river was vital to ensure the structure was not adversely twisted and control devices keep the two sets within 25mm of each other.

All the necessary plant and equipment including pumps, control panels and emergency generators are housed within the end supports of the structure. Main power is supplied from a substation on the south bank and passes through the deck to supply the systems on the north side.

ERECTION

Initial plans were that the erection sequence would be as follows:

- Transport steelwork segments to local work area for joining.

- Weld Arch into one piece and attach bearing trunnion housings and install with floating cranes and temporary guying.

- Join deck segments with three parts and install side “thirds” followed by central part temporarily supported on piles.

- Make site connections, install stays.

- Install and commission Mechanical and Electrical services.

Design development and enquiries over crane availability led to a revised proposal (which had been considered at concept stage) to assemble the bridge on the quayside and lift it into position as one piece. This plan would remove a great deal of the risk of working over water and shorten the programme for installation by largely completing steelwork fabrication prior to erection.

The various sections of steelwork were delivered by road to the AMEC works at Hadrian Yard on the banks of the River Tyne and the arch segments painted and welded in flat position on a carefully set out support system. On completion the arch was lifted up into elevational position and the deck segments were moved under it to be joined. The stay cables hung surreally from the arch, looking for something to support.

The cycleway cantilever beams were welded on and nosing added. At this stage the sheer scale and elegance of the structure began to be realised and preparations were in hand for meeting the proposed lifting date of 6 November 2000.

The Asian Hercules floating crane, with a capacity; of 3,200 tonnes is the largest in-shore floating crane in the world and was prepared in readiness for the 9km journey up river. However, weather conditions were such that the planned lift date was unsuitable.

The weather finally relented and the bridge was successfully lifted, transported and positioned on the 20 November 2000 in spectacular style.

FINISHES

Apart from the general form of the bridge which impacts on the user in a visual way the finishes of the bridge are the part which the user comes into direct contact with most. These comprise firstly the deck. For the cycle path this is made up from a series of aluminium extrusions with integral linking. This surface offers good grip for cycles but moreover is of light construction which is important for the outermost cantilevered part of the deck. With the lightness the deck also provides a degree of transparency which will be perceived best when the bridge is tilted open and the underside of the deck is fully exposed. The main pedestrian deck surfacing consists of epoxy bound aggregate system.

Between the two decks which are at differing levels are located a series of benches and metal ‘hedges’. The benches offer the opportunity to pause and reflect on the bridge, admiring views back up to the Tyne Bridge, while the hedges, which consist of formed perforated stainless steel sheet on an internal frame, offer a degree of protection from the wind. The parapets are metal and are all purpose designed. At the ends of the bridge a series of gates are incorporated to control access to permit opening. The two concrete supports to the bridge, built into the river, provide all glass enclosures, one of these to be used as a control room and the other is expected to be fitted out in the future to house events or possibly exhibitions.

COMPLETION

The unique design of the Gateshead Millennium Bridge has been a fascinating and exciting challenge.

The bridge was opened to the public on 17 September 2001 with reported queues of 30,000 people waiting to cross and proudly promoted as the focal point of the region’s regeneration.