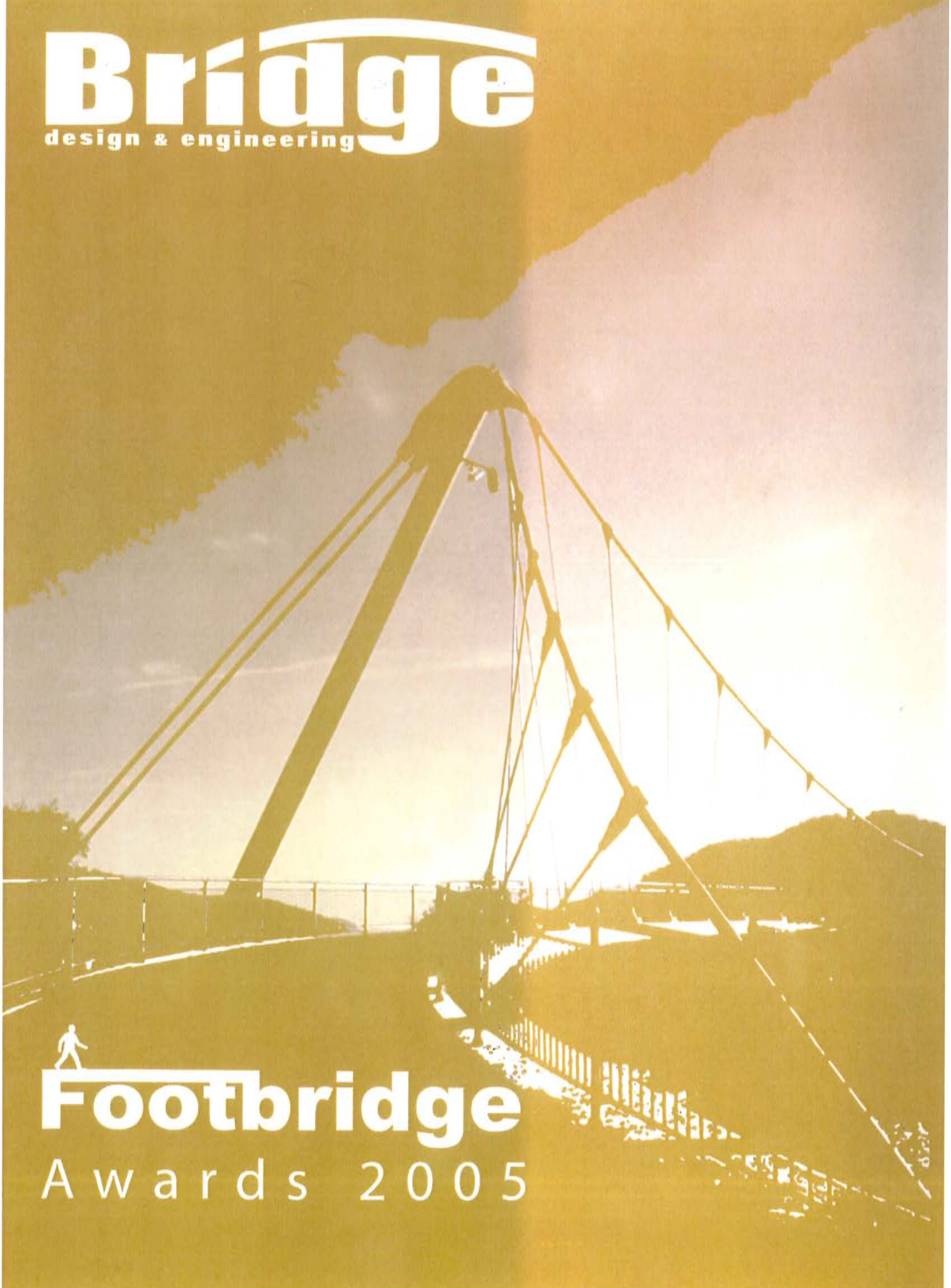
Bridge
design & engineering

Footbridge Awards 2005



'Bridge of Aspiration'

London, UK
Opened: March 2003

The Bridge of Aspiration provides an elegant and graceful glazed link, twisting high above Covent Garden's Floral Street to link the practice and performance areas of the Royal Ballet School. Dancers now have a direct passage between the School's new building on Floral Street and the Grade I listed Royal Opera House opposite.

The sensitive historic context and an awkward alignment were among the difficult challenges faced by the designers. Architecture, sculpture and engineering have been brought together in a solution that suits both the function and context while providing a dramatic landmark high above Covent Garden.

The design needed to be rhythmic or balletic while solving a complex set of design restraints; the bridge's appropriate 'pirouette' form is in fact a pragmatic response to the site. In particular, the link had to follow a skewed alignment with differing landing levels at each end, which presented a considerable design challenge.

Use of an orthogonal form was rejected as it would have resulted in awkward geometry at the intersection with the buildings. In contrast, the chosen twisting form successfully addresses the issues of context and geometry. It is used to great advantage and at first glance visually disguises the alignment. On closer inspection, the bridge gives the impression of defining the route, rather than responding to the constraints.

The twisted form is achieved through a concertina of 23 square portals, which are linked by glazing and are supported from an aluminium spine beam. Each portal is rotated by approximately 4 degrees relative to its neighbour. This results in the entire envelope performing a quarter turn along its length, twisting around the deck threaded through its centre.

A combination of latest technology and exceptional craftsmanship was needed to achieve the structure's complex form and high tolerances. The integrated design, manufacturing and assembly processes involved both extensive computer analysis and skilled hand crafting.

Fabrication of the structural aluminium box beam, glass strips and composite aluminium and timber frames was carried out in Austria. All parts were shipped to an assembly area in West London. There, the frames were fixed to the beam and then glazed. The frames were fixed in position once the glass panes had been installed and sealed.

Proof of the exemplary workmanship came when the assembled bridge was brought to the busy central London site and installed with minimal disruption in less than two hours. ■

COMMISSIONING AUTHORITY:
The Royal Ballet School

PRINCIPAL DESIGNER:
Wilkinson Eyre Architects

STRUCTURAL ENGINEER:
Flint & Neill Partnership

PRINCIPAL CONTRACTOR:
Gig Fassadenbau

JUDGES' COMMENTS:

"Combining imagination, elegance, audacity this unreal footbridge is an exemplary construction, the equilibrium between form and function and judicious application of the right materials."

"The idea of a twist is brilliant considering that the bridge provides a link for dancers."

Esla Canal Footbridge

Valencia de Don Juan, Leon, Spain
Opened: November 2004

Two footbridges were needed to give access across a canal from the newly-built Esla River Park to the historic city of Valencia de Don Juan. The design had to be to high aesthetic standards given the area's great natural beauty, particularly as work was being carried out to attract more visitors to the medieval town.

The challenge for the designers was find a harmonious way of integrating the footbridges into the landscape while avoid any tendency "to make them 'disappear' or to be 'shy'".

The result is an efficient, no-frills economic design that nevertheless meets the aesthetic and environmental criteria of the site. It is based on a modern structural concept, with glued laminated timber arches forming the underlying framework.

The design adhered to the philosophy of form following function. The structural form developed from a multitude of site constraints and particularly economic requirements - only a limited budget was available.

The footbridges are 2.8m wide. The 15m span length is achieved through two twin arches made of glued laminated timber with underlying tension members. The twin arches, separated by 1.8m, are connected by transverse beams at 2.5m centres. The arches' 94m radius was mandated by the allowable slope for pedestrian bridges while the canal clearance dictated the position of the horizontal tension members, which are made up of high performance cables.

The arches and the cables are connected by vertical posts made from structural steel aligned with the transverse beams.

The slenderness of the system subjects the timber arches to substantial bending moments which are partially offset by the eccentric connection between the tension members and arches at their supports. The cables were slightly prestressed to improve system performance. ■

COMMISSIONING AUTHORITY:
Aguas del Duero

DESIGNER/ARCHITECT:
Cesma Ingenieros

PRINCIPAL CONTRACTOR:
Vias y Construcciones

JUDGES' COMMENTS:

"The use of materials – particularly wood – and the way in which they were used, led to a bridge in harmony with its surroundings, as well as being very easy on the eye."

"The bridge is elegant for its lightness."

Footbridge over the Gahlensche Strasse

Bochum, Germany
Opened: April 2003

This new suspension bridge over Bochum's Gahlensche Strasse is supported at only the inner edge of the deck, making innovative use of the structure's properties.

The bridge provides access for pedestrians and cyclists across an area that has been dominated by heavy industry for decades. The site was challenging, with the bridge needing to cross a road and two railway bridges.

The S-shaped deck has created a bridge that uses the structural behaviour of a suspension bridge in an unusual and innovative way, through a circular ring girder. A curved beam needs only to be supported at one edge, whereas a straight girder needs either two lines of support or a clamped support, explains engineer Schlaich Bergermann & Partner. If the circular girder rests on the inner edge, a line load causes ring tension in the upper side and ring compression in the lower side of the deck. The curvature of the deck leads to these forces causing deflection forces towards the centre at the top of the deck and outwards at the bottom. The pair of forces maintains the balance with the cantilever moment.

The result is that the structure needs only one plane of hanger cables. The two 30m-high inclined masts have been positioned such that each carries half of the bridge's weight. They were arranged so that the bridge is self-stablised, with no additional back stay cables needed.

A number of elements make up the deck. The upper plate takes the tension force of the upper side of the section, while the compression element takes the compression forces of the lower side. Ribs are arranged radially to take the deviation forces. The hangers are connected to the deck at each rib, changing their inclination continuously along the length of the structure, giving users a three-dimensional experience of the structure.

Diagonals between the ribs provide additional stiffness to cope with non-uniformly distributed loads. As the deck is not a full ring, it needs additional restraints at the ends. These take the form of abutments, each founded on three concrete piles with an average length of about 30m ■

COMMISSIONING AUTHORITY:
Kommunalverband Ruhrgebeit

PRINCIPAL DESIGNER:
Schlaich Bergermann & Partner

PRINCIPAL CONTRACTOR:
Maschinen-und Stahlbau Dresden

JUDGES' COMMENTS:

"The structure meanders over the obstacles and seems to nonchalantly defy the natural laws of equilibrium."

"This S-shaped bridge not only looks great, it takes advantage of the structural form, supporting the bridge only along one side."

Esla River Footbridge

Valencia de Don Juan, León, Spain
Opened: November 2004

Design of the new footbridge over the Esla River was influenced by poor geotechnical conditions at the site. A 110m-span footbridge was needed but the location – an area of great natural beauty – meant that the bridge had to meet high aesthetic standards, and there were also economic constraints.

The solution is an elegant bowstring arch that fits all the criteria, and was the most efficient structural system; the horizontal thrust is resisted by the tension member of the bridge deck. This suited the geotechnical conditions, as only vertical loads needed to be transferred to the ground.

Structural steel was chosen as an economic solution for fabrication of the arches and hollow members turned out to be the best solution. Box sections for the arches achieve the necessary in-plane and out-of-plane stability. Box sections were also chosen for the ties, both for aesthetic and durability reasons – open cross-sections would have been prone to accumulate moisture and mud. The hangers are circular hollow sections, which were much cheaper than cables or rods.

Great attention to detailing was vital for achieving durability, correct load transfer, sufficient fracture toughness and fatigue resistance. This made fabrication easier and influenced the final appearance.

The bowstring is made of two inclined arches with a rise to span ratio of 1:12. They are braced with transverse members at 12m centres to improve the buckling resistance. The inclination of the arches dictated rhomboid-shaped cross-sections for the arches and the ties. Transverse beams at 3m centres support the deck. The bridge is connected to rigid transverse beams at the abutments, contributing to the resistance of horizontal thrust ■

COMMISSIONING AUTHORITY:
Aguas de Duero

PRINCIPAL DESIGNER:
Cesma Ingenieros

PRINCIPAL CONTRACTOR:
Vias y Construcciones

JUDGES' COMMENTS:

"An entirely appropriate design that offers cost savings and ease of construction."

"Very sleek but classical design."