Award

ROLLING BRIDGE

Paddington Basin

Architect Thomas Heatherwick Studio **Structural Engineers** SKM anthony hunts and Packman Lucas
Steelwork Contractor Littlehampton Welding Ltd **Main Contractor** Littlehampton Welding Ltd **Client** Chelsfield PLC

Imagine a steel pedestrian bridge rising up over a canal inlet and curling into a ball on one side to allow passing water traffic through. That was the vision that Thomas Heatherwick had when he designed the Rolling Bridge for the new commercial development at Paddington Basin in London.

The 12.9 metre pedestrian bridge spans an 8.5 metre canal inlet at the new commercial development in London's Paddington Basin. The bridge maintains the continuity of the canal towpath to foot traffic and tackles the issue of access to the inlet in a unique and novel fashion.

With the end bay securely fixed to one side of the dock, the remaining seven bays, powered by hydraulic rams, push the handrails upwards lifting the bridge and then rolling it back to form an enclosed ball. The result is a delicate balance of art, machine and structure.

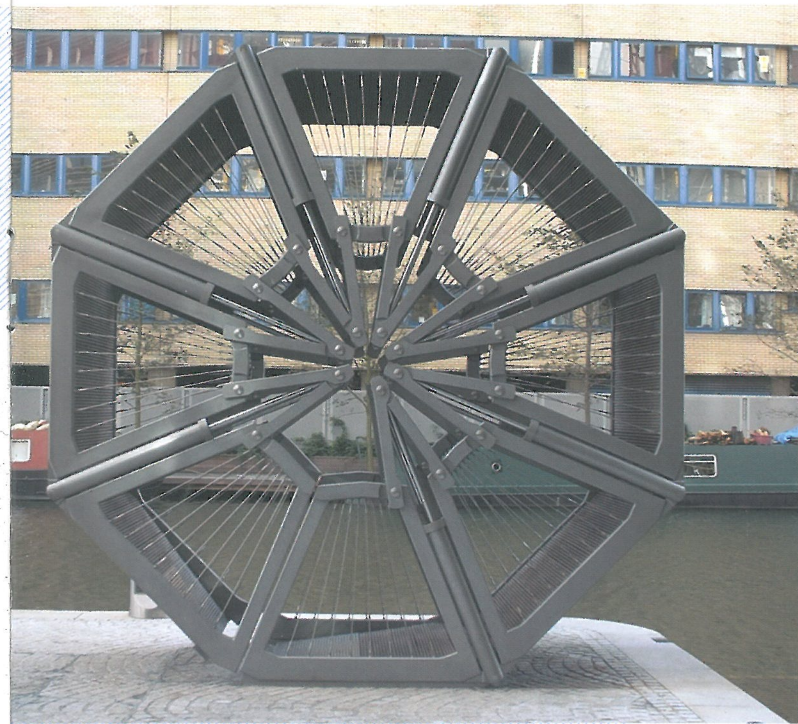
Designed to open in 180 seconds, the innovative concept was realised by the close cooperation and skills of the design team. The unusual nature of the bridge led to a number of interesting and esoteric engineering challenges as the design has to contend with the ever-changing geometry and load conditions associated with movement.

The project required precision bearings and pins with challenging fabrication tolerances. Fabricated with grade S355 hollow section steel tubes, the structural frame has a hardwood timber deck to both faces of the base. The void within the deck is used to route the hydraulic feed and return hoses to power the rams.

The unusual nature of the bridge led to a number of interesting and esoteric engineering challenges. As well as the usual bending, shear, deflection and dynamics checks common to all structures, the bridge design has also to contend with the ever-changing geometry and load conditions associated with the movement.

In its unrolled 'bridge' configuration the handrails act as the top boom of a simple truss. The handrails are pulled below the horizontal to lock the bridge in position, this guarantees that a small component of the compression load is directed downwards ensuring the stability of the bridge under load. The Handrail (compression boom) is afforded lateral restraint by the U frame nature of each segment. As the bridge opens the handrail pushes through the horizontal, this initial movement momentarily extends the top boom causing the bridge to arch. To relieve the large forces that would otherwise be generated by this movement, the 'fixed' segment of the bridge is mounted on a rocker allowing the necessary rotation.

At this point the lift begins and the structure changes from a simply supported truss to a cantilevered truss with the obvious load reversal between top and bottom booms. During the lift the hydraulic rams become an integral structural component with a number of the segments once again experiencing complete load reversal as the bridge rolls over centre. In the closed condition, stops mounted at the top of each hydraulic cylinder carry the static load of the bridge. The hydraulic team achieved the delicate control of the bridge through pure hydraulics. A hydraulic pump drives a master cylinder; which is mechanically linked to 14 slave cylinders. In turn, the slave cylinders drive the bridge cylinders. Ensuring all the cylinders are driven at a constant rate is key to the operation of the bridge.



Judges' Comment

This machine-like structure is a wonderful joyful addition to the development around Paddington Basin. Its purpose is to provide a footpath across the entrance of a small dock while still allowing boat passage when rolled up.

When in position the elements are configured so as to form a structure without the need for the power hydraulics. When rolled the machine has all the appearance of a Leonardo sketch.

The workmanship and detailing of the construction is more reminiscent of the frame of a grand piano than a piece of structural engineering. It is a delight.

The operation of the bridge is by a remote pendant control, similar to those commonly used on British Waterways installations. The operation is continuous so long as the switch is held in the closed position. Simply releasing the control can facilitate an emergency stop, this presented another engineering challenge, to design for the additional dynamic effects in dissipating the momentum of the moving structure.

The fabrication proved equally challenging. To achieve the geometry in the bridge configuration, and more especially in its closed form, required fabrication tolerances normally found only in the domain of mechanical engineering. When closed, the handrail components converge in the centre of the bridge with a little less than 10mm clearance between them.

PTFE impregnated dry bearings were employed for their dimensional stability, longevity and maintenance free operation. The bearings and (Duplex) stainless steel pins are fitted to a tolerance +0 −0.016mm, with a tolerance between pin centres of just +/-0.15mm.

Each bridge segment is fabricated in three sections, two welded side frames and the deck. It was originally intended that the segments would be fully welded frames, but to practically achieve the required machining tolerances a bolted connection was introduced between the side frame and deck.

Extensively modelled in CAD and exported to Robot analysis software, bridge models were used for the static analysis as well as confirmation of the geometry. In addition, using animation tools, a virtual working model was generated to confirm the motion and allow component measurements in any configuration.