Reconstructing the Old Bridge at Rochester 1911-1914

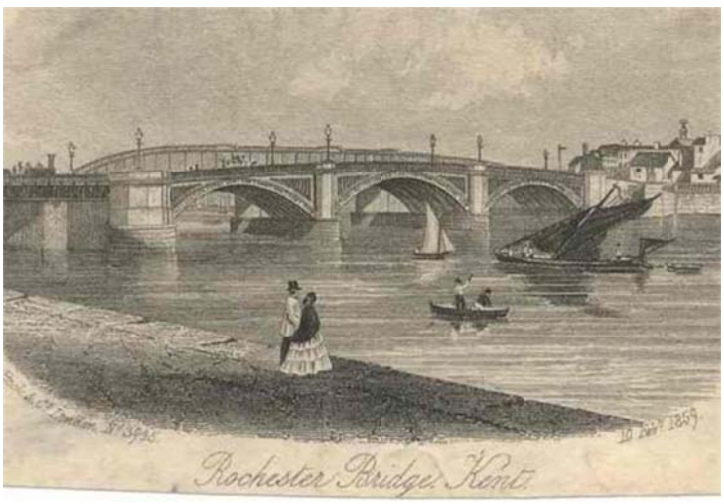
On Thursday 24th April, a lecture was given by the Bridge Clerk (Chief Executive) as part of the series of events to celebrate the centenary of the Reconstruction of Rochester Bridge. The lecture focused on the engineering aspects of the reconstruction and was aimed at a general audience.

Mrs Threader began by explaining the history of Rochester Bridge in brief. The first bridge at Rochester was built by the Romans soon after the invasion in AD43. Although much repaired, this bridge lasted for over 13 centuries until, in 1381, the River Medway froze. When the thaw came, the ice and flood water swept away the bridge.

Luckily for Rochester, two benefactors arrived on the scene – Sir Robert Knolles and Sir John de Cobham. They built a new stone bridge which was complete by 1391.

Knolles and Cobham also persuaded their friends and acquaintances to donate land and money for the perpetual maintenance of the bridge. They convinced King Richard II to grant letters patent which gave the right to appoint two Wardens to look after the land and property of the bridge, and with that act, the Rochester Bridge Trust was founded in 1399. Today, the Trust has two Wardens and ten Assistants who continue to provide crossings of the River Medway free of charge to the public.

The medieval bridge lasted into the 19th century until the increased road and river traffic arising from the industrial revolution meant that major modifications were needed. In 1824, Thomas Telford undertook the "Great Arch" project, which widened the roadway and produced a safer central channel for shipping. Telford's improvements gave only temporary relief, however, and by 1856, the Wardens had constructed a new cast iron bridge on the line of the old Roman Bridge and commissioned the Royal Engineers to demolish the medieval bridge using gunpowder.



The 1856 cast iron bridge had three elegant arches and a swing bridge section, stone piers and abutments. It was designed by Sir William Cubitt, most famous for his work as the engineer for the Crystal Palace and for designing the prison treadwheel. The bridge had three main arches of cast iron, of 140, 170, and 140 feet in length. The swing bridge was 50 feet long, giving a total length between abutments of 500 feet. The highest part of the centre arch was 18 feet above high water on an average Spring Tide and the clear width of the bridge between the parapet rails was 40 feet.

Using a wooden model, Mrs Threader demonstrated the basic engineering principles of an arch bridge. She showed the audience that all the main force in an arch is compression. She explained that an arch has to be complete in order to stand up and be stable. If any block is missing then an arch will collapse. She showed that it is essential that the abutments of an arch bridge are strong and substantial enough to exert as much counter-thrust as possible.

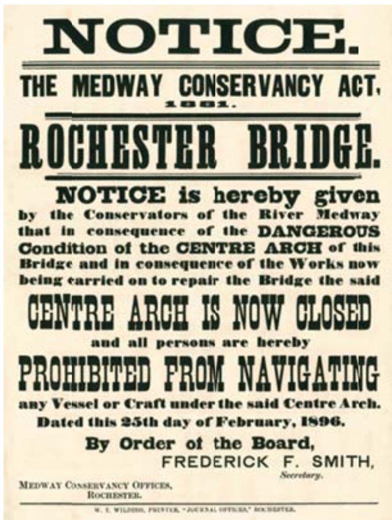
Returning to the bridge at Rochester, for 40 years after the completion of Cubitt's structure, the main business for the Wardens related to routine maintenance, minor repairs, and requests for utility companies to carry their services across the Medway.

Under the heading of repairs, it was the swing bridge that proved most troublesome. Although well designed and balanced, and having an ingeniously simply manual operating system through shafts and gears, the swing bridge did have some weak points. For instance, the surface of the bridge was initially wooden planking. This had to be substantially repaired in 1864, again in 1874, and again in 1881. Eventually the rotten wooden footways were replaced completely with corrugated wrought iron plates covered with concrete and asphalt.

As new amenities became available, it was inevitable that pressure would increase to carry services across the bridge. Applications were made for water pipes in 1860, a gas main in 1871 and electricity in 1888. Ingenious methods had to be designed so that the services could be disconnected to allow the opening of the swing bridge.

Despite the cost and difficulties of providing the swing bridge, the bargemen of the Medway seemed to be content to lower their masts and pass under the bridge through one of the main spans as they always had and the bridge was never opened. A permanent solution to the swing bridge problem resulted from the actions of the South Eastern Railway Company. In 1881, the company introduced a bill in Parliament for powers to construct a railway from Strood to Chatham with a bridge downstream to the two existing bridges. The Wardens petitioned against the bill asking for clauses to be inserted to require a swing bridge to be constructed in the new railway bridge and this was duly written into the Act. Contrary to the provisions of their Act, the South Eastern Railway Company proceeded to build the new railway bridge without an opening. The Wardens were pleased to be relieved of the expense of maintaining their unused swing bridge and soon fixed it closed permanently, resurfaced it to make it uniform with the rest of the bridge and removed the mechanism. All that remains is the old machine room in the Island Pier which is still visible on the upstream side of the Old Bridge.

Maintenance problems far more serious than routine repairs or requests from service companies confronted the Wardens at the end of the century. On 20th February 1896, the lighter "Diamond" which was being towed upriver on high tide, struck girders of the central arch carrying away 25 tons of cast iron.


NOTICE.

THE MEDWAY CONSERVANCY ACT. 1881.

ROCHESTER BRIDGE.

NOTICE is hereby given by the Conservators of the River Medway that in consequence of the DANGEROUS Condition of the CENTRE ARCH of this Bridge and in consequence of the Works now being carried on to repair the Bridge the said

CENTRE ARCH IS NOW CLOSED

and all persons are hereby

PROHIBITED FROM NAVIGATING

any Vessel or Craft under the said Centre Arch.

Dated this 25th day of February, 1896.

By Order of the Board,
FREDERICK F. SMITH,
Secretary.

Medway Conservancy Offices,
Rochester.

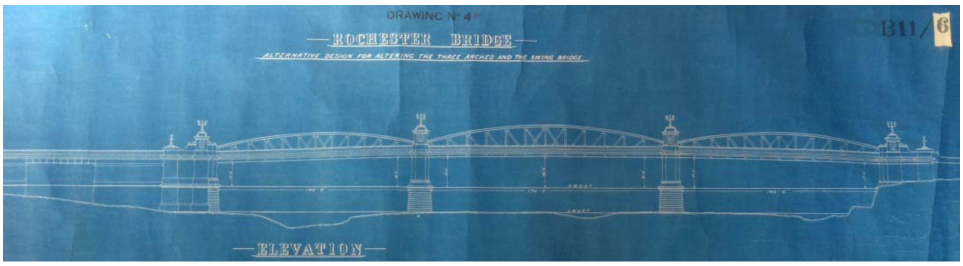
The collision affected the stability of the bridge. Navigation through the space was prohibited, traction engines were banned, and carriages restricted to walking pace.

Temporary girders and protective measures had just been put in place, when the bridge was struck again, this time by the lighters “Ruby” and “Turquoise”. The tugs towed six lighters two abreast, and navigation upstream against the tide was particularly difficult. In July 1907, the lighter “Spurn” belonging to Associated Portland Cement collided with Rochester Bridge again, damaging one of the girders.

The Wardens concluded that the headway under the whole of the main span needed to be at least 21 feet above the high spring tide. Three alternative plans were commissioned from Sir John Wolfe Barry and Partners who had designed Tower Bridge. These plans increased headway marginally to 23 feet in the middle of the central arch by changing to shallower wrought iron ribs but kept the arch form so there would still only be 6ft of clearance next to the piers. The cost would have been £35,000, and the Wardens concluded that the benefits were insufficient.

The Trust’s retained bridge engineer, John Robson, came up with a range of alternative designs. Mrs Threader used a special model of Rochester Bridge, which had been designed by one of the Trust’s current bridge engineers, William Day FICE and built for this purpose, to explain the principles of the different options. First, Robson suggested raising the height of the piers and constructing a new, higher arch just for the central span. Although he proposed filling the hollow piers with steel reinforced concrete, Mrs Threader explained that it would have been very difficult to achieve sufficient counter-thrust to give the bridge the necessary stability. A three-arched alternative was also doubtful in structural engineering terms, as it would have become unstable under asymmetric loading.

By June 1908, Robson had refined his design and produced a plan to change the bridge from an arch form to a truss bridge. He described his trusses as “hog-backed” trusses although the usual engineering terminology is “bowstring trusses”.



Cast iron arches formed an arc over the deck of a bridge and were held together by wrought iron tension members stretched across the bottom of the arch like the string of an archer’s bow. Bowstring truss bridges are sometimes known as Whipple Bridges, named for Squire Whipple, a New York engineer who perfected and patented the design in 1840.

Using the model, Mrs Threader demonstrated how adding the tension member turns an arch form into a bowstring truss which would give the extra stability required and provides much greater clearance below the deck of a bridge.

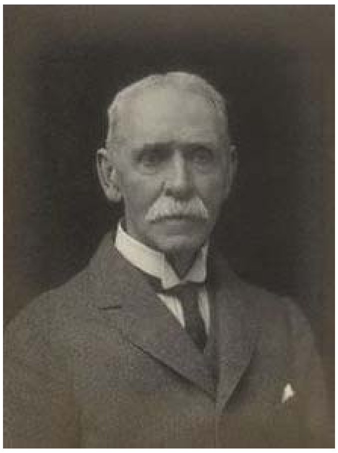
Although popular in the US from the 1850s onwards, the bowstring truss was less commonly used in the UK. Mrs Threader showed a photograph of a very early UK example, St. Olave's Bridge on the A143 between Great Yarmouth and Beccles, which was built in 1847. This is a cast-iron example with a single, clear span of 80 ft.

[Photo: Ian Carstairs, www.visitwaveneyvalley.co.uk]

John Robson proposed a bowstring truss on the outside of each 25 foot wide carriageway, with an additional 7 foot wide cantilevered footway on each side. Under each footway, a hollow conduit would be formed to carry pipes and cables. The swing bridge was to be removed and replaced with a fixed steel span. The proposal allowed for one half of the bridge to be constructed at a time over the existing arches so that no temporary staging would need to be erected in the river and it would be possible to keep the crossing open to traffic throughout the work. Robson estimated the cost of reconstruction as £48,600.

The Wardens accepted Robson's proposals but seemed nervous of trusting him with the job of rebuilding the bridge. They appointed the consulting engineers, Baker & Hurtzig, who had been responsible for the Forth Rail Bridge, to act as chief engineer jointly with Robson.

The lowest tenderer was John Cochrane and Sons who proposed to use the steel fabricator and shipbuilder, Joseph Westwood and Company, as the main subcontractor. There was some dispute with Baker & Hurtzig over the contractor's stress calculations. The Charity Commission became involved and appointed the vice president of the Institution of Civil Engineers, Robert Elliott-Cooper, to arbitrate. He supported Cochrane's figures and the project was able to proceed. A contract was finally signed on 14th February 1911 for a tender price of £71,000.



Sir Robert Elliott-Cooper, KCB

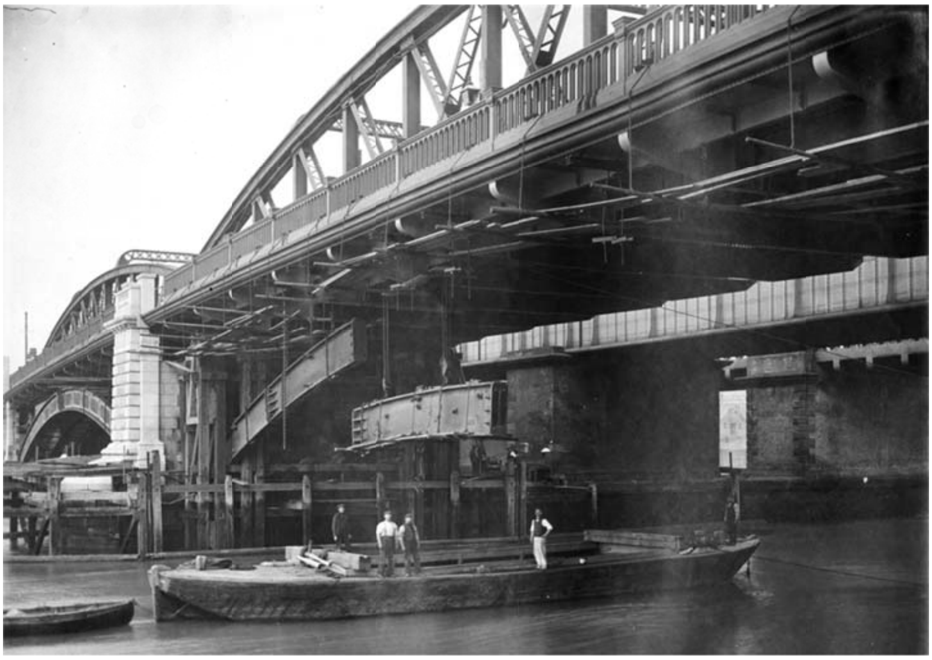
Having explained the background to the project, Mrs Threader explained the construction process. Traffic was diverted to the upstream side of the bridge. In order to keep the bridge open throughout the reconstruction a temporary timber cantilever was built on the upstream side to carry the footway. A speed limit of 2mph was put in place. On the downstream side, Cubitt's bridge was stripped down to the deck plates to allow the erection of the bowstring trusses. Simple wooden lifting cranes were used which were generally not power-assisted and relied on block and tackle, a technique which would have been used by the Romans. The steel sections of the bowstring trusses were delivered on lighters from Joseph Westwood's yard at Millwall and then riveted together on the site.

Mrs Threader showed a photograph of the engineers and contractors' staff inspecting progress on the downstream section. The photograph shows the steel buckle-plates which form the deck. Mrs Threader explained that the photographs still proving a vital resource for the Trust's engineers as they are able to gain a detailed understanding of the original structure without excavation.

Traffic was diverted back onto the downstream side of the carriageway by the end of November 1912. The swing bridge across the Old Ship's Passage was completely reconstructed as a fixed crossing.

The audience was shown a photograph which illustrated the construction sequence for the bowstring trusses. The lower tension girder is in place; the vertical and diagonal members have been installed; finally the top compression members will be riveted in place.

The upstream girders were complete by the end of June 1913. With the structural work complete, it was possible to remove the old arches between July and October 1913. Mrs Threader explained the very simple process by which Cubitt's old bridge was removed. By using chains and simple pulleys, each section of the cast iron girder was lowered into a barge waiting below. Clearly the workers would have waited for a very calm day on the river to carry out this work, but, nonetheless, the apparent nonchalance of the men and apparent disregard for their own safety was remarkable. In particular, the stability of the lighter once the girder was loaded on would be questionable.



The finished bridge was painted a light grey with a copper coloured coating being given to lamp columns. There was a hold up in the completion of the decorative stonework as the granite supplier, United Stone, had gone into liquidation but the bridge was finally completed at the end of April 1914 and formally opened to traffic by Lady Darnley on 14th May 1914 (for details of the opening ceremony, see the account "I declare this bridge open!").

Mrs Threader summarised how the bridge has changed since its completion in 1914.

- The gas lighting was changed to electricity in the 1950s;
- The cross girders were changed from lattice trusses to closed beams.
- The bridge has been painted many times, the last occasion being in 2006 when nearly all of the super-structure above the deck was taken back to bare metal.
- The Island Pier was reinforced with concrete in the 1950s to improve stability.

Today, the Old Bridge is in remarkably good condition considering that the piers and abutments are 158 years old and the rest is celebrating its 100th birthday. This is the case because the bridge has been carefully and properly maintained by the Trust and any problems are dealt with when they arise. Mrs Threader explained that it would be necessary to carry out some works later in 2014. The Trust would be working closely with the contractor to minimise disruption to the public. The works would include:

- Strengthening the footways on the Old Ships' Passage to rectify a design problem but also to repair water and pigeon damage;
- Waterproofing of the deck, replacement of failed expansion joints and resurfacing;
- Repairs to the masonry and some corroded steelwork beneath the deck;
- Replacement of the electrical systems which have reached the end of their life;
- Restoration and renovation of all the street lighting. Original light fittings will be upgraded with modern luminaires to give a much better standard of lighting;
- Installation of permanent coloured enhancement lighting to replace unreliable and expensive Christmas lights.