TOWER BRIDGE

Tower Bridge is a Grade I listed combined bascule and suspension bridge in London, built between 1886 and 1894, designed by Horace Jones and engineered by John Wolfe Barry. The bridge crosses the River Thames close to the Tower of London and is one of five London bridges owned and maintained by the Bridge House Estates, a charitable trust founded in 1282. The bridge was constructed to give better access to the East End of London, which had expanded its commercial potential in the 19th century. The bridge was opened by Edward, Prince of Wales and Alexandra, Princess of Wales in 1894. The bridge is 800 feet (240 m) in length and consists of two 213-foot (65 m) bridge towers connected at the upper level by two horizontal walkways, and a central pair of bascules that can open to allow shipping. Originally hydraulically powered, the operating mechanism was converted to an electro-hydraulic system in 1972. The bridge is part of the A100 London Inner Ring Road and thus the boundary of the London congestion charge zone, and remains an important traffic route with 40,000 crossings every day. The bridge deck is freely accessible to both vehicles and pedestrians, whereas the bridge's twin towers, high-level walkways and Victorian engine rooms form part of the Tower Bridge Exhibition.

HISTORY

In the late 19th century, commercial development in the East End of London increased, leading to demand for a new river crossing downstream of London Bridge. A traditional fixed bridge at street level could not be built because it would cut off access by sailing ships to the port facilities in the Pool of London between London Bridge and the Tower of London.

A Special Bridge or Subway Committee chaired by Sir Albert Joseph Altman was formed in 1877 to find a solution. More than fifty designs were submitted, including one from civil engineer Sir Joseph Bazalgette, which was rejected because of a lack of sufficient headroom. A design was not approved until 1884, when it was decided to build a bascule bridge. Sir John Wolfe Barry was appointed engineer and Sir Horace Jones the architect (who was also one of the judges).

An Act of Parliament authorising construction was passed in 1885. It specified that the opening span would provide a clear width of 200 feet (61 m) and headroom of 135 feet (41 m). The design had to be in a Gothic style.[5] Construction was funded by the Bridge House Estates, a charity established in 1282 for maintenance of London Bridge that subsequently expanded to cover Tower Bridge, Blackfriars Bridge, Southwark Bridge and the Millennium Bridge.

CONSTRUCTION

Construction started in 1886, with the foundation stone laid by the Prince of Wales on 21 June, and took eight years. Major contractors included Sir John Jackson

(foundations), Armstrong, Mitchell and Company (hydraulics), William Webster, and Sir William Arrol & Co. 432 people worked on the site; E W Crutwell was the resident engineer for the construction. Two piers, containing over 70,000 long tons (78,400 short tons; 71,123 t) of concrete, were sunk into the riverbed to support the construction. More than 11,000 long tons (12,320 short tons; 11,177 t) of steel were used in the framework for the towers and walkways, which were then clad in Cornish granite and Portland stone to protect the underlying steelwork. Jones died in 1887, and George D. Stevenson took over the project. Stevenson replaced Jones's original brick façade with the more ornate Victorian Gothic style, which made the bridge a distinctive landmark, and was intended to harmonise the bridge with the nearby Tower of London. The total cost of construction was £1,184,000 (equivalent to £138 million in 2020).

Tower Bridge was officially opened on 30 June 1894 by the Prince and Princess of Wales. The opening ceremony was attended by the Lord Chamberlain, the Lord Carrington and the Home Secretary, H. H. Asquith. An Act of Parliament stipulated that a tug boat should be on station to assist vessels in danger when crossing the bridge, a requirement that remained in place until the 1960s. The bridge connected Iron Gate, on the north bank of the river, with Horselydown Lane, on the south – now known as Tower Bridge Approach and Tower Bridge Road, respectively.[13] Until the bridge was opened, the Tower Subway – 0.25 mi (400 m) to the west – was the shortest way to cross the river from Tower Hill to Tooley Street in Southwark. Opened in 1870, Tower Subway was among the world's earliest underground ("tube") railways, but it closed after just three months and was reopened as a tolled pedestrian foot tunnel. Once Tower Bridge was open, the majority of foot traffic transferred to using the bridge, as there was no toll to cross. Having lost most of its income, the tunnel was closed in 1898.

During the Second World War, Tower Bridge was seen as a major transport link to the Port of London, and consequently was a target for enemy action. In 1940, the high-level span took a direct hit, severing the hydraulic mechanism and taking the bridge out of action. In April 1941, a parachute mine exploded close to the bridge, causing serious damage to the bascule, towers and engine room. In 1942, a third engine was installed in case the existing ones were damaged by enemy action. It was a 150 hp horizontal crosscompound engine, built by Vickers Armstrong Ltd. at their Elswick works in

Newcastle upon Tyne. It was fitted with a flywheel having a 9-foot (2.7 m) diameter and weighing 9 tons, and was governed to a speed of 30 rpm. The engine became redundant when the rest of the system was modernised in 1974, and was donated to the Forncett Industrial Steam Museum by the City of London Corporation.
The southern section of the bridge, in the London Borough of Southwark, was Grade I listed on 6 December 1949.[25] The remainder of the bridge, in the London Borough of Tower Hamlets, was listed on 27 September 1973.[26] In 1974, the original operating mechanism was largely replaced by a new electro-hydraulic drive system, designed by BHA Cromwell House, with the original final pinions driven by modern hydraulic motors.

DESIGN

Strauss was the chief engineer in charge of the overall design and construction of the bridge project. However, because he had little understanding or experience with cablesuspension designs, responsibility for much of the engineering and architecture fell on other experts. Strauss's initial design proposal (two double cantilever spans linked by a central suspension segment) was unacceptable from a visual standpoint. The final graceful suspension design was conceived and championed by Leon Moisseiff, the engineer of the Manhattan Bridge in New York City.
Irving Morrow, a relatively unknown residential architect, designed the overall shape of the bridge towers, the lighting scheme, and Art Deco elements, such as the tower decorations, streetlights, railing, and walkways. The famous International Orange color was Morrow's personal selection, winning out over other possibilities, including the US Navy's suggestion that it be painted with black and yellow stripes to ensure visibility by passing ships.
Senior engineer Charles Alton Ellis, collaborating remotely with Moisseiff, was the principal engineer of the project. Moisseiff produced the basic structural design, introducing his "deflection theory" by which a thin, flexible roadway would flex in the wind, greatly reducing stress by transmitting forces via suspension cables to the bridge towers. Although the Golden Gate Bridge design has proved sound, a later Moisseiff design, the original Tacoma Narrows Bridge, collapsed in a strong windstorm soon after it was completed, because of an unexpected aeroelastic flutter. Ellis was also tasked with designing a "bridge within a bridge" in the southern abutment, to avoid the need to demolish Fort Point, a pre–Civil War masonry fortification viewed, even then, as worthy of historic preservation. He penned a graceful steel arch spanning the fort and carrying the roadway to the bridge's southern anchorage.
Ellis was a Greek scholar and mathematician who at one time was a University of Illinois professor of engineering despite having no engineering degree. He eventually earned a

degree in civil engineering from the University of Illinois prior to designing the Golden Gate Bridge and spent the last twelve years of his career as a professor at Purdue University. He became an expert in structural design, writing the standard textbook of the time. Ellis did much of the technical and theoretical work that built the bridge, but he received none of the credit in his lifetime. In November 1931, Strauss fired Ellis and replaced him with a former subordinate, Clifford Paine, ostensibly for wasting too much money sending telegrams back and forth to Moisseiff. Ellis, obsessed with the project and unable to find work elsewhere during the Depression, continued working 70 hours per week on an unpaid basis, eventually turning in ten volumes of hand calculations. With an eye toward self-promotion and posterity, Strauss downplayed the contributions of his collaborators who, despite receiving little recognition or compensation,[23] are largely responsible for the final form of the bridge. He succeeded in having himself credited as the person most responsible for the design and vision of the bridge. Only much later were the contributions of the others on the design team properly appreciated. In May 2007, the Golden Gate Bridge District issued a formal report on 70 years of stewardship of the famous bridge and decided to give Ellis major credit for the design of the bridge.