BROOKLYN BRIDGE

The Brooklyn Bridge is a hybrid cable-stayed/suspension bridge in New York City, spanning the East River between the boroughs of Manhattan and Brooklyn. Opened on May 24, 1883, the Brooklyn Bridge was the first fixed crossing of the East River. It was also the longest suspension bridge in the world at the time of its opening, with a main span of 1,595.5 feet (486.3 m) and a deck 127 ft (38.7 m) above mean high water. The span was originally called the New York and Brooklyn Bridge or the East River Bridge but was officially renamed the Brooklyn Bridge in 1915. Proposals for a bridge connecting Manhattan and Brooklyn were first made in the early 19th century, which eventually led to the construction of the current span, designed by John A. Roebling. The project's chief engineer, his son Washington Roebling, contributed further design work, assisted by the latter's wife, Emily Warren Roebling. Construction started in 1870, with the Tammany Hall-controlled New York Bridge Company overseeing construction, although numerous controversies and the novelty of the design prolonged the project over thirteen years. Since opening, the Brooklyn Bridge has undergone several reconfigurations, having carried horse-drawn vehicles and elevated railway lines until 1950. 1,595.5 feet (486.3 m) and a deck 127 ft (38.7 m) above mean high water.

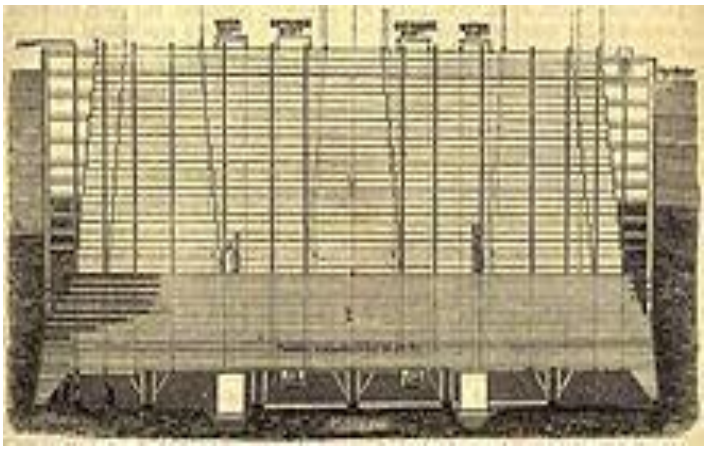
HISTORY

Proposals for a bridge between the then-separate cities of Brooklyn and New York had been suggested as early as 1800. At the time, the only travel between the two cities was by a number of ferry lines. Engineers presented various designs, such as chain or link

bridges, though these were never built because of the difficulties of constructing a high enough fixed-span bridge across the extremely busy East River.
There were also proposals for tunnels under the East River, but these were considered prohibitively expensive. The current Brooklyn Bridge was conceived by German immigrant John Augustus Roebling in 1852. He had previously designed and constructed shorter suspension bridges, such as Roebling's Delaware Aqueduct in Lackawaxen, Pennsylvania, and the John A. Roebling Suspension Bridge between Cincinnati, Ohio, and Covington, Kentucky.In February 1867, the New York State Senate passed a bill that allowed the construction of a suspension bridge from Brooklyn to Manhattan.
Two months later, the New York and Brooklyn Bridge Company was incorporated with a board of directors (later converted to a board of trustees). There were twenty trustees in total: eight each appointed by the mayors of New York and Brooklyn, as well as the mayors of each city and the auditor and comptroller of Brooklyn. The company was tasked with constructing what was then known as the New York and Brooklyn Bridge.

CONSTRUCTION

Construction of the Brooklyn Bridge began on January 2, 1870. The first work entailed the construction of two caissons, upon which the suspension towers would be built. The Brooklyn side's caisson was built at the Webb & Bell shipyard in Greenpoint, Brooklyn, and was launched into the river on March 19, 1870. Compressed air was pumped into the caisson, and workers entered the space to dig the sediment until it sank to the bedrock. As one sixteen-year-old from Ireland, Frank Harris, described the fearful experience



The six of us were working naked to the waist in the small iron chamber with the temperature of about 80 degrees Fahrenheit: In five minutes the sweat was pouring from us, and all the while we were standing in icy water that was only kept from rising by the terrific pressure. No wonder the headaches were blinding.
Once the caisson had reached the desired depth, it was to be filled in with vertical brick piers and concrete. However, due to the unexpectedly high concentration of large boulders atop the riverbed, the Brooklyn caisson took several months to sink to the desired depth. Furthermore, in December 1870, its timber roof caught fire, delaying

construction further. The "Great Blowout", as the fire was called, delayed construction for several months, since the holes in the caisson had to be repaired. On March 6, 1871, the repairs were finished, and the caisson had reached its final depth of 44.5 feet (13.6 m); it was filled with concrete five days later. Overall, about 264 individuals were estimated to have worked in the caisson every day, but because of high worker turnover, the final total was thought to be about 2,500 men in total. In spite of this, only a few workers were paralyzed. At its final depth, the caisson's air pressure was 21 pounds per square inch (140 kPa).

The Manhattan side's caisson was the next structure to be built. To ensure that it would not catch fire like its counterpart had, the Manhattan caisson was lined with fireproof plate iron. It was launched from Webb & Bell's shipyard on May 11, 1871, and maneuvered into place that September. Due to the extreme underwater air pressure inside the much deeper Manhattan caisson, many workers became sick with "the bends"—decompression sickness—during this work, despite the incorporation of airlocks (which were believed to help with decompression sickness at the time). This condition was unknown at the time and was first called "caisson disease" by the project physician, Andrew Smith. Between January 25 and May 31, 1872, Smith treated 110 cases of decompression sickness, while three workers died from the disease. When iron probes underneath the Manhattan caisson found the bedrock to be even deeper than expected, Washington Roebling halted construction due to the increased risk of decompression sickness. After the Manhattan caisson reached a depth of 78.5 feet (23.9 m) with an air pressure of 35 pounds per square inch (240 kPa), Washington deemed the sandy subsoil overlying the bedrock 30 feet (9.1 m) beneath to be sufficiently firm, and subsequently infilled the caisson with concrete in July 1872.

Washington Roebling himself suffered a paralyzing injury as a result of caisson disease shortly after ground was broken for the Brooklyn tower foundation. His debilitating condition left him unable to supervise the construction in person, so he designed the caissons and other equipment from his apartment, directing "the completion of the bridge through a telescope from his bedroom. His wife Emily Warren Roebling not only provided written communications between her husband and the engineers on site, but also understood mathematics, calculations of catenary curves, strengths of materials, bridge specifications, and the intricacies of cable construction. She spent the next 11 years helping supervise the bridge's construction, taking over much of the chief engineer's duties, including day-to-day supervision and project management.

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.