

HISTORIC STRUCTURES

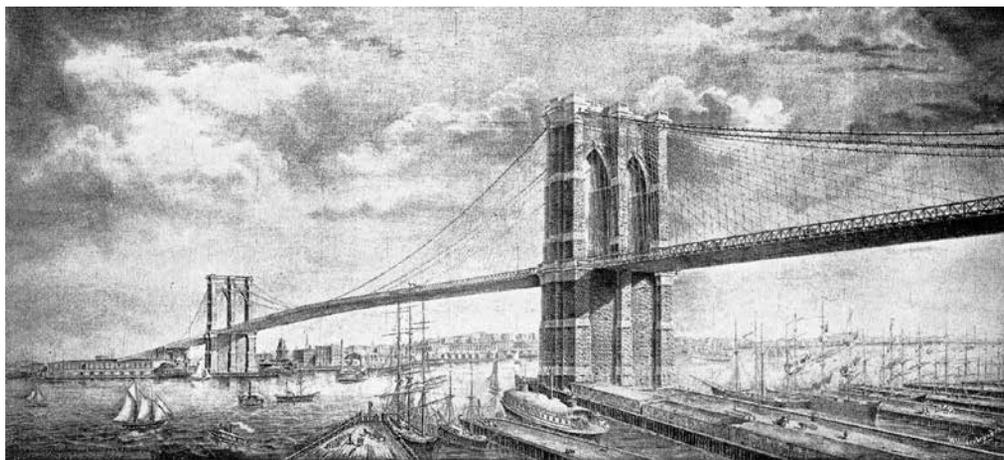
significant structures of the past

Brooklyn Bridge

Part 1

By Frank Griggs, Jr., Dist. M.ASCE,
D.Eng., P.E., P.L.S.

Dr. Griggs specializes in the restoration of historic bridges, having restored many 19th Century cast and wrought iron bridges. He was formerly Director of Historic Bridge Programs for Clough, Harbour & Associates LLP in Albany, NY, and is now an Independent Consulting Engineer. Dr. Griggs can be reached at fgriggsjr@verizon.net.



John A. Roebling's vision of the Brooklyn Bridge 1867.

The Brooklyn Bridge, across the East River in New York City, is perhaps the most recognized bridge in the United States. As a result of David McCullough's book *The Great Bridge* and Ken Burns' *American Stories – Brooklyn Bridge* series, many engineers know some of the backstories of the bridge. Don Sayenga's book, *Washington Roebling's*

Father, also clarified which Roebling, John or Washington, built the Bridge. Part 1 starts with the earliest plans for a bridge and runs up to John Roebling's death in 1869 before the onset of construction.

In the 19th century, Manhattan and Brooklyn were the first and third largest cities in the United States, separated only by the East River, which varied in width along its length. Some of the earliest proposed bridge locations were across Blackwell's Island, well above the centers of population where the island separated the river into two channels. Proposals were made as early as 1804 to cross the river at that point. Graves, in 1837, and John A. Roebling, in 1856, made following proposals. Farther to the south, closer to the centers of population, Thomas Pope proposed his Flying Pendant wooden bridge in 1809, followed by a suspension bridge by Julius Adams in 1864 and another suspension bridge by John A. Roebling in 1867. Roebling had been looking at a bridge at the Fulton Ferry for many years, starting in 1852 when, as the story goes, he and his son Washington were stuck on a ferry in an ice jam. He wrote a letter to Abram Hewitt, a New York City leader, about his plan for a bridge. Hewitt forwarded the letter to the *Journal of Commerce* for publication. His plan was for a 1,600-foot span with a vertical clearance of 130 feet with ornate towers.

In March 1860, he had completed his Niagara Railroad Bridge and started his 1,057-foot span Covington and Cincinnati Bridge (STRUCTURE, May 2016) across the Ohio

River. It was then that the *Architects and Mechanics Journal* wrote an article questioning if a long suspension bridge was even possible in Brooklyn. Roebling responded with a lengthy letter supporting his proposal, entitled *Bridging the East River*. He wrote, "A few years ago I was requested by some prominent citizens of New York and Brooklyn, to investigate this project and to state my views in a general way. Those views were published in the *Journal of Commerce*. They have been undergoing, since, a further review and scrutiny." He made three main points. The first being that only a suspension bridge or a tunnel would keep the harbor free for ship traffic. The second that trains of cars propelled by wire-operated ropes and stationary engines were necessary to move a half million people daily across the bridge. Moreover, finally, "the merits of the enterprise as a good first rate investment must be undoubted, else no private capital can be enlisted. As to the corporations of Brooklyn and New York undertaking the job, no such hope need be entertained in our time. Nor is it desirable to add to the complication and corruption of the governmental machinery of these cities. There would be no objections to a subscription by either corporation, but the enterprise to be successful must be conducted by individuals."

By 1864, while still working on the Covington & Cincinnati Bridge, he wrote an article for *Engineering Magazine* in London. It was under the heading *Proposed American Suspension Bridge*:

I propose to start in the vicinity of the Park of the city of New York, at an elevation of about 80 feet above tide, thence ascending about 125 feet, to the centre of the East River (having a clear elevation of 180 feet), thence descending towards the heights of Brooklyn, and landing within sight of the City Hall... The superstructure of this magnificent bridge would thus form an arch about two miles long, clearing the water of the east River in one sweep of 1,600 feet to 1,800 feet span, and extending over the houses of both cities... My plan provides two floors similar to the Niagara

Bridge, the upper floor for railway conveyance, the lower one for promiscuous travel on foot, horseback or carriage. The entrance of the upper or railway floor will be next to the City Halls of New York and Brooklyn and may be kept independent of the entrance to the lower floors, which may be located nearer to the river. There will be sidewalks on both floors, and these will become favorite resorts for those who want take exercise in the open air. The great majority of passengers will of course, use the cars on the upper floor. My experience and long familiarity with the working of inclines enables me to devise such plans as will render this portion of the structure and its operation, perfectly successful. The materials of construction will be principally granite and iron, the latter placed so that it can be readily preserved by painting. The rigidity of the superstructure will be as great as that of a tubular bridge. Iron trusses of great depth, connecting both floors, together with effective over-floor stays, and the great weight of the structure itself and inherent rigidity of the cables will provide ample stiffness.

He kept working on different deck layouts, starting with the Niagara double deck plan as well as a single level deck with two tracks down the middle flanked by roadways. In late 1866, William Kingsley, a well-known Brooklyn contractor, was convinced that a bridge was possible and decided to visit the home of Henry Murphy, a New York State Senator, about supporting legislation to authorize the creation of a corporation to build and operate a toll bridge across the river. On January 25, 1867, Murphy, good to his word, submitted the proposal to the legislature. The act was approved on April 16, 1867, as Chapter 399 of the 19th Session. It was entitled "An Act to incorporate the New York Bridge Company, for the purpose of constructing and maintaining a bridge over the East River, between the cities of New York and Brooklyn." The capital stock was fixed at \$5,000,000 in shares of \$100 each. The bridge was to be completed on or before June 1870 and was to provide a clearance of 130 feet over the East River so as not to obstruct river traffic.

One month after the Company was formed, *The Brooklyn Daily Eagle*, May 24, 1883 wrote,

"The managers came to the point where it was necessary to appoint a chief engineer to complete the plans and build the bridge. Among those earliest suggested for the position was Julius W. Adams, who was regarded as a brilliant and talented member

of the profession. He was strongly pressed for the place by incorporators and outsiders. Objection was made, however, that he had never built a large structure of this kind, and it was deemed advisable to secure, if possible, the services of someone experienced in the construction of great suspension bridges, particularly as the public were beginning to doubt the possibility of building the bridge in consequence of the natural and mechanical difficulties to be overcome. It was known to some of the incorporators that John A. Roebling, then residing in Trenton, N. J. has had large experience in works of the character of the proposed to be built."

Kingsley approached Roebling in Trenton, and Roebling agreed to take on the role of Chief Engineer provided he was also appointed to supervise the construction of the bridge and not just prepare the plans. He was awarded a contract dated May 23, 1867, for \$8,000 per year and told to begin work immediately, with the understanding that Kingsley would pick up the initial costs while financing of the bridge was initiated.

On or about the time he was approached by Kingsley, he modified his deck design once again to provide for a central walkway by separating the two center cables, with the walkway or promenade just above the adjacent railway and carriageway.

Later in May, as he was beginning to put together his report, he maintained the pedestrian way in the middle of the bridge but raised it, evidently to give the pedestrians a better view of the river. His six (6) lines of equal depth trussing were apparently fixed in his thinking at this time, but he widened his outer carriageways.

He knew the success of his project was having a firm foundation for his masonry towers and anchorages. He sent Washington to Europe on a belated honeymoon and also to study what the Europeans were using for bridge foundations, especially pneumatic caissons and their use of steel in their bridges. Washington graduated from Rensselaer Polytechnic Institute in Troy, New York in 1857. He then worked on Roebling's Allegheny River Bridge in Pittsburg, after which he enlisted in the Union Army in which he served for over three years, resigning with the rank of Lieutenant Colonel. He had married Emily Warren, the sister of General G. K. Warren, his commanding officer, and worked on finishing the Covington & Cincinnati Bridge that opened on January 1, 1867, staying on for another few months finishing up the project.

While Washington was away, John worked on the preliminary plans for the bridge with Wilhelm Hildenbrand and Griefenberg, both

Important news for Bentley® Users

- Prevent Quarterly and Monthly Overages
- Control all Bentley® usage, even licenses you do not own
- Give users visibility of who is using licenses now
- Warn and Terminate Idle usage

CONTACT US NOW:

(866) 372 8991 (USA & Canada)
 (512) 372 8991 (Worldwide)
www.softwaremetering.com



Additionally, SofTrack provides software license control for all your applications including full workstation auditing of files accessed and websites visited. Many customers also benefit from SofTrack's workstation specific logon activity reporting.

© 2016 Integrity Software, Inc. Bentley is a registered trademark of Bentley Systems, Incorporated



SofTrack controls Bentley® usage by Product ID code and counts (pipe, inlet, pond, and all others) and can actively block unwanted product usage

SofTrack also supports Autodesk® Cascading Licensing

and

SofTrack directly reports and controls ESRI® ArcGIS license usage

ADVERTISEMENT For Advertiser Information, visit www.STRUCTUREmag.org

German immigrants. By September 1, 1867, he had completed his preliminary plans and written a 48-page report. On September 7, he gave an oral report to the Board. The Report, like all of Roebling's writings, was well written and thorough. He ended with,

As a great work of art, and as a successful specimen of advanced Bridge engineering, this structure will forever testify to the energy, enterprise and wealth of that community, which shall secure its erection.

He still hadn't decided on a foundation as Washington had not returned from Europe with his suggestions. On September 10, the *Brooklyn Eagle* published an extensive summary of the report in which Roebling gave an estimated cost of \$6,675,357. It said:

We devote a very considerable portion of our space today to the report of Mr. Roebling, the engineer of the proposed bridge across the East River designed to secure to these two great centres of population ample and uninterrupted communication. The report will attract great interest, for it may be accepted as the first practical step towards the realization of one of the most remarkable enterprises of our time, and inaugurating a new era in the history of Brooklyn.... Mr. Roebling discusses in his report seven questions. The people of Brooklyn and New York are mainly interested in three of them

Is a Bridge necessary?

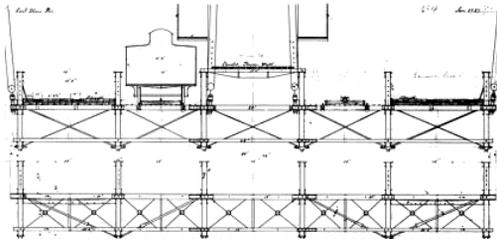
Can it be built?

Will it pay?

They agreed with Roebling that the answer to all three questions was yes, quoting from his report and adding thoughts of their own. They concluded:

But the project will pay? As an investment, it will receive encouragement from capitalist everywhere. Brooklyn herself can afford to build. Nothing is more certain than that she cannot afford not to. We refer our readers to Mr. Roebling's report with great pleasure.

The Committee on Plans and Surveys approved the Report, with the understanding that some things were still not fixed but that they could be addressed during the next phase of design. Later in October, the full Board met and accepted the recommendation of the committee for the "immediate commencement of the work." This would be the last meeting for over a year as the Board was to have great difficulty in interesting many people in the value of its stock. Funding was a problem. Much of 1868 was taken up in getting the Cities of New York and Brooklyn to take stock in a private bridge building company. The infamous Boss Tweed and his colleagues in Tammany Hall of New York City had their



1867 plan with elevated walkway and two cross beam designs.

hands out. Brooklyn approved the purchasing of 30,000 shares on December 22, 1868, and New York City purchased 15,000 shares two days later. Private individuals, including Tweed's 560 shares for which he paid nothing, held the remaining 5,000 shares.

In early January 1869, Roebling, sensing that momentum was growing for the bridge, suggested to the Board that they appoint a Board of Consulting Engineers to review his plans. The Board approved of this, believing that confirmation and approval by some of the leading engineers of the country would bolster public confidence in the bridge. The Board consisted of seven (7) prominent engineers: Horatio Allen, Chairman, Benjamin H. Latrobe, William J. McAlpine, John Serrell, James Kirkwood, J. Dutton Steel and Julius Adams. The fledgling American Society of Civil Engineers had been reconstituted in 1868 after a period of inactivity of 10 years, and four of its early presidents were Kirkwood, McAlpine, Allen, and Adams.

The committee started meeting in March 1869, with both John and Washington in attendance, reviewing the plans and listening to John's description of his report and design. To give a better understanding of the plans, especially as this bridge would have almost a 40% increase in span length and be a much more heavily loaded bridge with an 85-foot wide deck, Roebling suggested they make a grand tour of his bridges in Pittsburg, Niagara, and Cincinnati. In Pittsburg, on April 15, he showed them his Smithfield Street Bridge over the Monongahela River built in 1845-46 and his Allegheny Bridge constructed in 1860. They then moved to Cincinnati on April 17 to view his 1,057-foot long bridge with a deck width of 35 feet, then the longest suspension bridge in the world. This was followed, several days later, by a trip to Niagara to view his 820-foot span double deck railroad/carriage/pedestrian bridge (STRUCTURE, June 2016) over the Niagara Gorge. This bridge was finished in 1855 and, after 12 years of service, was performing at a high level.

The Board of Engineers submitted their report in June 1869, fully supporting Roebling's plans writing,

That it is beyond doubt entirely practicable to erect a steel wire suspension bridge

of 1,600 feet span, 135 feet elevation, across the East River, in accordance with the plans proposed by Mr. Roebling, and that such structure will have all the strength, stability, safety and durability that should attend the permanent connection by a bridge of the cities of New York and Brooklyn. With this expression of our professional judgment we could, and perhaps should, close this report.

It was not until June 21, 1869, that General A. A. Humphries of the Corps of Engineers informed Murphy and the Bridge Company of the findings of his Board of Engineers. He had four conditions, the first of which had the most impact on the design of the bridge. It was "... the centre of the main span shall, under no conditions of temperature or load, be less than one hundred and thirty-five feet in the clear above mean high water of spring tides, as established by the United State Coast Survey." The other conditions dealt with the sizes of structural members, stating that no member shall be reduced below the sizes given, no part of the foundations of the piers shall project beyond the existing pier lines, and "no guy or stays shall ever be attached to the main span of the bridge which shall hang below the bottom chords thereof." Humphries wanted the higher clearance as the busy Brooklyn Navy Yard was just north of the bridge site. This clearance was greater than Roebling thought necessary, but the Company was forced to submit to it.

Things were looking up for Roebling and the Company and, in June, Washington was at the bridge performing the survey that would be used during construction of the bridge. Using triangulation methods, they measured a base line and the required angles to arrive at the final centerline of the bridge from City Hall, New York to City Hall, Brooklyn. When these spikes were set, and the lines marked on buildings, it was the first actual work on the ground since the borings were taken in 1867.

Later that month, John came up from Trenton to either help in the survey, or to check the work Washington and his crew had done. On Monday, June 28, John was standing on some guide piling, called the rack, leading to the Fulton Ferry slot when a ferry hit against the piling and a string piece moved causing his foot to be crushed between the timbers or piling. The doctors recommended amputating his crushed toes. Roebling consented but insisted that it be done without anesthesia. After that, Roebling followed his own advice and used a water drip therapy. This was unsuccessful. After two weeks tetanus set in followed by lockjaw, and he died on July 22nd. The Chief Engineer was dead. What would happen to the Bridge? ■