John A. Roebling

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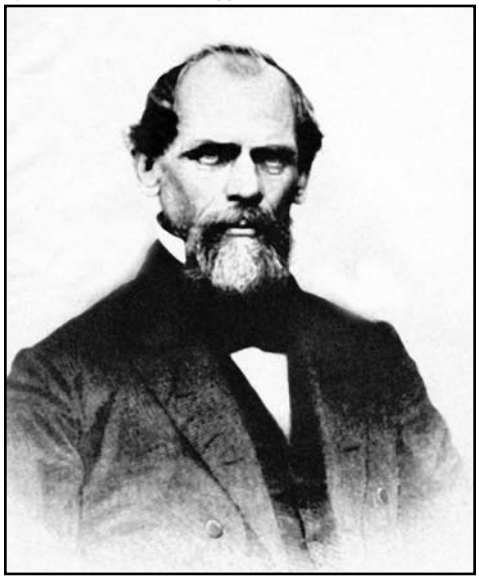
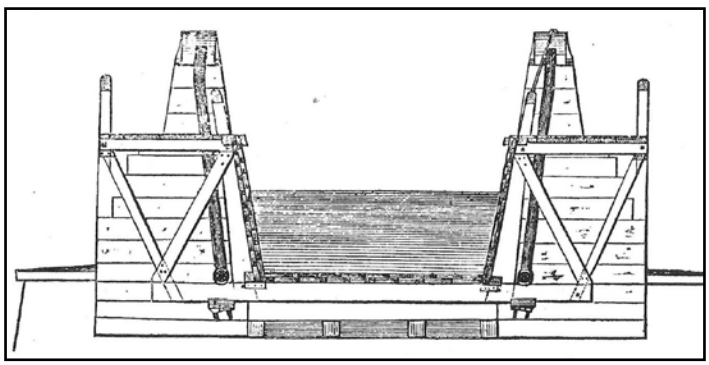


John A. Roebling

Roebling is perhaps the most well known American civil engineer of the 19th century due to D. B. Steinman's book *The Builders of the Bridge* and David McCullough's *The Great Bridge*. In addition, Ken Burns' series on the building of the bridge expanded his reputation significantly. This brief biographical sketch cannot do justice to a remarkable career, but it may create an interest in the reader to study the existing books on Roebling. This article of necessity omits the large number of patents he received, his vast contributions to the journals of his day, his wire factory accomplishments and the dozens of unsuccessful proposals he made for bridges around the country. After a brief summary of his early life and engineering accomplishments, this article covers his major suspension bridges built between 1845 and 1869.

He was born in Mulhausen, Germany on June 12, 1806 the youngest of five children. His father ran the local tobacco shop, and his mother aspired for great things from her children, especially John (Johann). After studying at the Pedagogium in nearby Erfurt, he was enrolled in the prestigious Berlin Bauakademi in Berlin where he studied engineering under Johann Eytelwein and philosophy under Georg Hegel. Then he embarked on the mandatory three-year on-the-job training. After graduating in 1827, he went to work for the government but found it to be extremely bureaucratic. He apparently never took the final exam to become a Baumeister (Building Master). In 1830, after three years of what he called "an army of councilors, ministers, and other officials discussing the matter for ten years, making long journeys, and writing long reports, while money spent in all these preliminaries comes to more than the actual accomplishment of the enterprise," he decided to go to America. He remembered the words of Hegel, who called America "a land of hope for all who wearied of the historic armory of Europe." He and his brother Carl immigrated to America and found an agricultural utopia for Germans who sought to escape the repressive conditions rampant in most of Europe at the time.

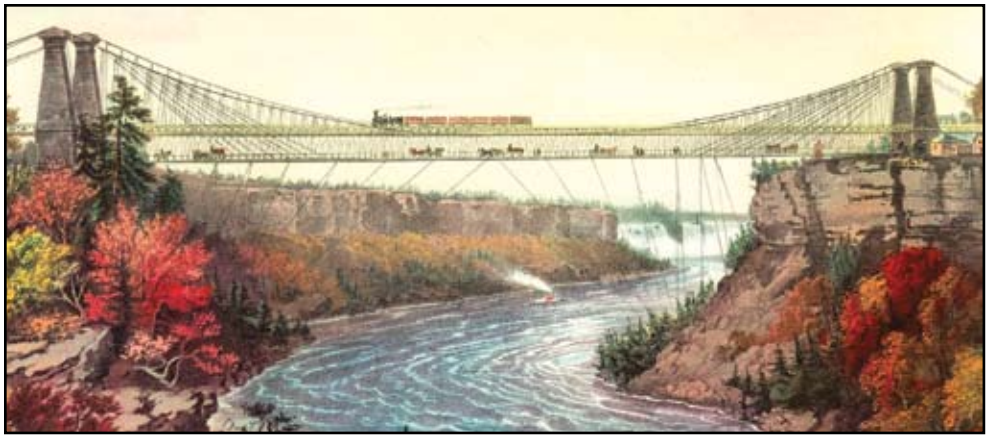
He arrived in Philadelphia August 6, 1831 where he would see the bridges over the Schuylkill River by Timothy Palmer and Lewis Wernwag. Shortly after he and his brother went to Pittsburgh via the early Pennsylvania canals to Huntington. and then over the Allegheny Mountains by wagon trails to his destination. After a brief search for land on which to start his community, he purchased a parcel 25 miles north of Pittsburgh in Butler County. For the next six years he sought to build up this community, called Saxonburg, by encouraging more emigrants and clearing more land. In 1836, he married another German emigrant, Johanna Herting, and they had eight children over the next decade. While successful in his effort to build a community, he found that farming was not fulfilling. The next year was pivotal in his life as his brother died, he became a United States citizen, his first son Washington was born on May 26th, and he left farming and returned to his engineering career as a surveyor on the Sandy and Beaver Canal. This brief assignment was interrupted by the financial panic of 1837. He soon obtained employment on a feeder canal to the Pennsylvania Canal, followed by location surveys for the Allegheny and Portage Canal between Johnston and Hollidays which was completed in mid 1839. His next project was locating a line for the Harrisburg and Pittsburgh Railroad across the Allegheny Mountains, which took him through late 1841.



Allegheny Aqueduct 1845

Brooklyn Bridge (Courtesy of HAER)

While becoming progressively more responsible for canal and railroad projects, he never seemed to have forgotten his interest in suspension bridges dating from his last year at the Berlin Bauakademi, when he visited an iron chain suspension bridge in Bamberg, Germany in 1830. In late January 1840, he wrote to Charles Ellet (*see STRUCTURE® magazine, October 2006*) who proposed a wire suspension bridge over the Schuylkill River in 1839 and who was seeking the contract to build a bridge on the abutments of Wernwag's Colossus Bridge that burned in 1838. Ellet was supportive, but he did not have a contract at the time. Later Roebling was approached by another contractor to assist him in building the bridge, as he apparently thought he had the contract. Unfortunately for the contractor, and Roebling, the contract was later awarded to Ellet who built the bridge in 1842. To pro-



Niagara Falls Bridge, Currier and Ives

mote his interests he wrote an article on suspension bridges in April 1841 in the *American Railroad Journal* following Ellet's article in the same journal in 1839. While unsuccessful in gaining his first opportunity to assist in the building of a wire cable suspension bridge, he turned his interest to the design and fabrication of twisted wire cables to be used on the inclined planes of the Portage Canal. Prior to his invention, the canal boats were hauled up inclined planes by 7- to 9-inch circumference hemp ropes, which had a very short life. He proposed that he build a twisted wire rope for use by the Canal Company. His request was approved, but he was to supply the wire rope at his own risk. He built his rope on his farm at Saxonburg with the assistance of the residents of the community, and used a ropewalk similar to the method used in hemp rope fabrication. He placed the wire rope into position as a trial, but unfortunately it broke under the load. It was later determined that someone cut the wire at a splice, and the company authorized Roebling to furnish the plane with new rope. After this he received the contract to replace all hemp ropes with his twisted wire cable. This was the beginning of this type of cable that continues to be used in the present day.

Smithfield Street Bridge Monongahela River Pittsburgh 1846

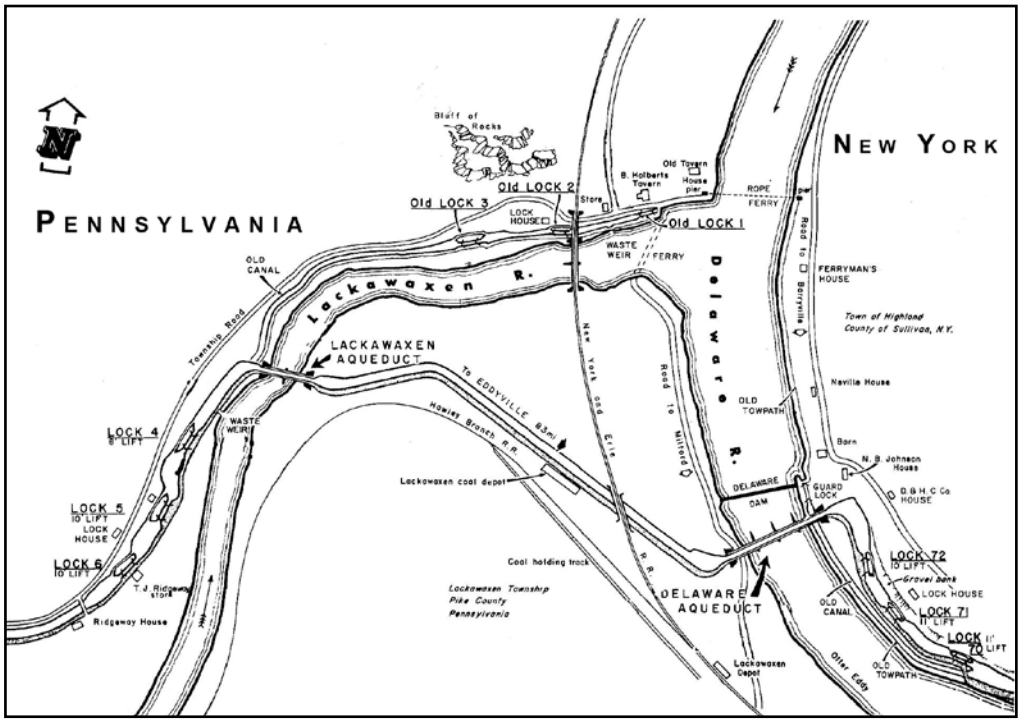
In mid May of 1844, he received his next opportunity to build a wire cable suspension bridge when the old 1836 wooden aqueduct built over the Allegheny River was determined to be unsafe. He entered a competition, along with 43 other men, to win a $100 premium to replace the bridge. In August, he was notified that his design for a bridge in which the trunk carrying the water was supported by wire cables was awarded the premium. He was issued a contract to build the bridge. Using some of the existing piers for his towers he built a seven span bridge with each span being 162 feet and a trough with a width of 16.5 feet at the top, 14 feet at the bottom and a depth of 8.5 feet. Towpaths on each side were built for mules that pulled the canal boats. This bridge opened May 22, 1845. He immediately wrote an article for the *American Railroad Journal* describing his bridge.

Just prior to the opening of his aqueduct, a massive fire spread over the city and burned the Wernwag bridge on Smithfield Street over the Monongahela River (built in 1818). Roebling was given the contract to rebuild the bridge as a suspension bridge on the same piers. After rebuilding and raising the piers, he built a bridge with 8 main spans of 188 feet with two anchor spans, for a total length of 1,500 feet. Due to the small size of his piers, he adopted cast iron columns and fabricated the cables on shore. He then lifted them into place, connecting them with pins to pendulums he placed at the top of his towers to ensure equal pull at the top of each tower. This bridge was opened in February 1845, only eight months after the fire. The bridge description was also carried in the *American Railroad Journal* in April 1846.

For the first time he used diagonal stays of iron bars, which became characteristic of Roebling bridges. With these two bridges, his reputation spread and placed him on a par with Charles Ellet in the minds of many. It was replaced in 1883 with a bridge designed by Gustav Lindenthal.

In 1847, he proposed much longer span bridges at Niagara Falls, St. Louis, Cincinnati, and Wheeling in competition with Charles Ellet and others. However, Ellet received contracts to build the Niagara Falls and Wheeling Bridges, with no action being taken for the other two. Ellet opened his Wheeling Bridge with its 1,010-foot span in 1849 and his 800-foot Niagara Bridge in 1848.

In 1848, Roebling was approached by the D & H Canal to submit a plan for an aqueduct, similar to his Pittsburgh structure, over the Delaware River at Lackawaxen and another over the Lackawaxen River just upstream from its intersection with the Delaware. In competition with a trussed wooden structure, his plan was selected. The original method used to cross the Delaware had not worked and the company was looking at rerouting the canal, resulting in the need for two river crossings. The first bridge, completed in late 1848, was a four span bridge with three river piers. In early 1849, he completed the second bridge and the canal opened in April 1849 with both

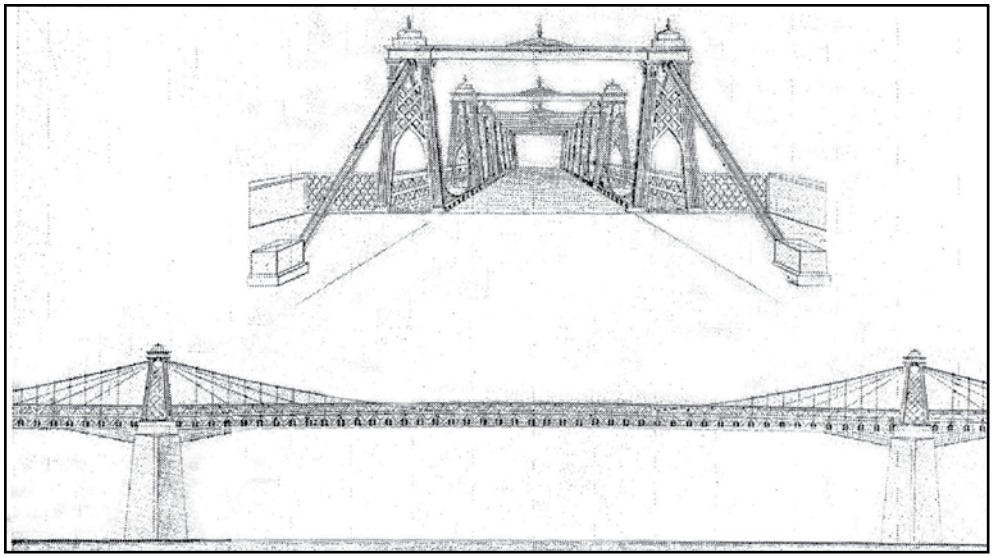


D & H Aqueduct Sites. Courtesy of Manville B. Wakefield.

aqueducts in service. Based upon the success of these two bridges, he was awarded contracts to build a bridge at High Falls over the Rondout Creek and one over the Neversink River at Cuddebackville that he finished in 1850. They were both single span bridges, with the High Falls Aqueduct a 135 foot span and the Neversink Aqueduct a 170 foot span.

All four of his aqueducts were in use until late 1898 when the canal closed. The Delaware River structure was the only one suited for adaptive reuse, and it was sold and converted into a roadway toll bridge with the roadway on the bottom of the trough. It was later purchased by the National Park Service and restored in 1995. It is the oldest extant suspension bridge in the country.

In 1851, three years after Ellet was removed as engineer of the Niagara Bridge, Roebling was retained to complete the project. At that time he determined that, unlike Ellet's single deck structure, he would build an 820-foot long double deck structure, with the railroad on the upper level and the carriageway and pedestrian way on the lower level. Earlier in 1847, he submitted proposals for both a single level and a double deck structure. He submitted his report to the Bridge Companies (one Canadian and one American) on July 28, 1852. Financing was slow and he did not begin construction on the anchorages until late 1852 and the towers in late 1853. Robert Stephenson wrote in a letter to Roebling, "If your bridge succeeds, then mine have been magnificent blunders." Stephenson, the builder of the Menai Straits and Conway tubular bridges, was in Canada building his tubular bridge over the St. Lawrence River. The Niagara Bridge was opened on March 16, 1855 with Roebling writing that "One single observation of the passage of a train over the Niagara Bridge will convince the most skeptical, that the practicability of Suspended Railway Bridges, so much doubted heretofore, has been successfully demonstrated…Bridges of a half a mile span, for common or Railway travel, may be built, using iron for the cables with entire safety but by substituting the best quality of steel wire, we may nearly double the span, and afford the same degree of security."



Smithfield Street Bridge profile and section

The bridge was upgraded several times by Leffert L. Buck before being replaced August 27, 1897. Buck built an open spandrel arch

Allegheny River Bridge 1860 to 1891

double deck, twin track bridge under the Roebling Bridge without interrupting traffic. Even with Roebling's statement that railroad suspension bridge spans over a mile long were feasible, no one else built a suspension bridge to carry railroad traffic, as the cantilever bridge became the preferred long span railway structure.

At the same time Roebling was working on Niagara, he was awarded a contract in 1853 to build a 1,224-foot long single track suspension bridge to carry the Lexington and Danville Railroad over the Kentucky River. Between 1853 and 1868, he built the masonry towers and anchorages and had wire delivered to start spinning the cables, when the company went bankrupt stopping construction. Between 1855 and 1868 he kept in touch with individuals who proposed completing the railroad and bridge, but no further work was done until C. Shaler Smith built a cantilever bridge over the gorge in 1877.

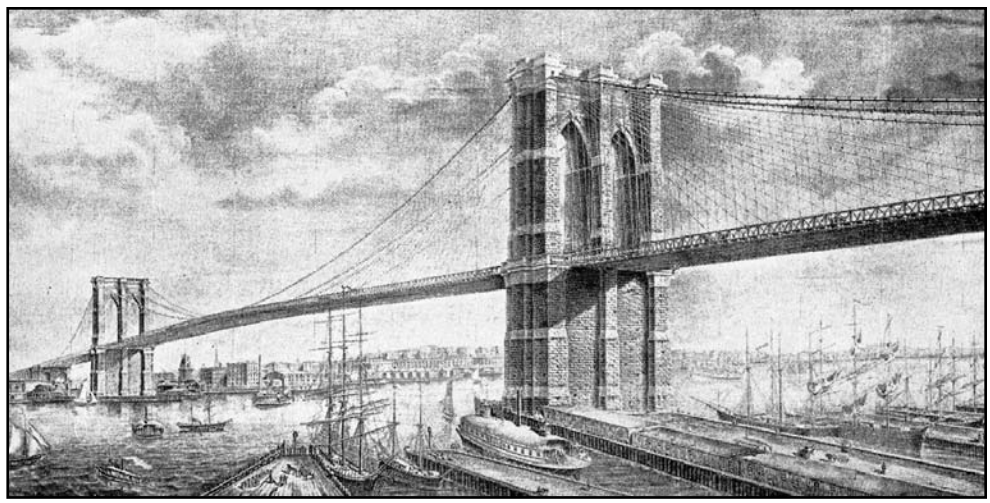
Cincinnati Covington Suspension Bridge 1868 to Present

On August 18, 1856, Roebling signed a contract to build a bridge across the Ohio River connecting Cincinnati and Covington, KY. Earlier, in 1847, he submitted as plan for a bridge with a pier in the middle of the river flanked by two 800-foot spans to shorter towers with 200-foot spans from the short towers to the anchorages. His proposal was challenged by shipping interests as restricting river traffic. The bridge company was not successful in getting its charter amended until 1856, after which Roebling wrote a new report for a single span bridge 1,057 feet in span, or 47 feet longer than Ellet's Wheeling Bridge that opened in 1849 and collapsed in 1854. The 1849 charter stated there be no piers in the river, a minimum span of 1,400 feet and a deck height of 112 feet, but the 1856 charter cut the minimum span length to 1,000 feet and the clearance to 100 feet. After getting his tower foundations in and starting the masonry, the company ran into financial problems during the panic of 1857 and work stopped. With the advent of the Civil War, the project was virtually shut down until work resumed slowly in 1863. The towers and anchorages were finished in 1864. Near the end of the War his son Washington, who graduated from Rensselaer Polytechnic Institute in Troy, NY in 1857, was discharged from the Army and took over the job of spinning the cables and hanging the deck. The bridge was finished in late 1866 and formally opened on January 1, 1867.

In 1898, the bridge was upgraded and strengthened by the placement of two additional cables and steel trussing by Wilhelm Hildenbrand, a Roebling protégé. The Commonwealth of Kentucky purchased it in 1953, and continued to collect tolls until 1963 when it was made a free bridge. On June 27, 1993 it was officially renamed the John A. Roebling Suspension bridge.

During the pause in construction of the Cincinnati Bridge, Roebling was awarded a contract to replace another Wernwag six span wooden bridge in Pittsburgh across the Allegheny River at Sixth Street (formerly St. Clair Street). For the first time in his career, money was readily available and in 1859 he wrote, when the towers were completed, "The bridge will be beautiful." It was a four span bridge with main span lengths of 344 feet and shore spans of 177 and 171 feet. For the first time Roebling used wrought iron side trusses (railings) to stiffen his deck, and towers consisting of four cast iron posts tied together with lattice wrought iron strapping. He used four cables, two on each side and placed ornamental spires, etc. on top of each tower. His son Washington worked with him on this project. When John was back at Cincinnati, Washington was left in charge of the bridge. When completed in 1860, *Engineering News* wrote that it was "considered the finest in the world…and…a structure of importance in the history of bridges." It lasted until 1891 when it was replaced with a bridge by Theodore Cooper.

In 1867, Roebling was selected as Chief Engineer for the proposed Brooklyn Bridge across the East River connecting Manhattan and Brooklyn. He began working on a design for the bridge starting in the mid 1850s, with Abram Hewitt his associate from Trenton, NJ.



Proposed Brooklyn Bridge 1870

Niagara lower deck and side trusses

He wrote letters promoting the construction of the bridge in 1857, 1860 and 1864, but the time was not right until the winter of 1867 when a severe ice jam closed the ferries across the river. A charter was approved for the bridge in April 1867 and Roebling was assigned a contract to not only design the bridge, but also supervise its construction for $8,000 per year. He presented his report to the Bridge Company in September for a bridge with a span of 1,600 feet, with the railway and carriageway on the same level and a central elevated promenade. Washington went to Europe to study advances made in the use of pneumatic caisson while the report was being compiled. Funds to build the bridge were slow in coming, so work did not start until mid 1869.

During the survey for the bridge's location, Roebling's foot caught between some timbers on the ferry dock and was crushed. After several weeks, he contracted lockjaw and died on July 22 before any work had been done on the bridge. *The Scientific American* wrote: "Altogether few men have lived whose history can record a series of more brilliant successes than that of Mr. Roebling. He leaves behind him monuments of his greatness, and his name will pass into history among the brightest of those who have achieved immortality, by benefiting the human race. That he has been cut off thus on the threshold of his greatest undertaking, adds to our sincere regret; but that he could not live to see its completion will not detract from the well won renown of its gifted and accomplished designer."

Roebling's vision of his bridge was contained in his report when he wrote: "The contemplated work, when constructed in accordance with my design, will not only be the greatest Bridge in existence, but it will be the great engineering work of this continent, and of the age. Its most conspicuous feature, the great towers, will serve as landmarks to the adjoining cities, and they will be entitled to be ranked as national monuments. 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."

Between 1869 and 1883, his son Washington, who made many changes in the design and choices of materials, built the bridge. It was the capstone to a remarkable career. After 123 years, it continues to serve the citizens of New York. As Roebling predicted, it is "the great engineering work of this continent, and of the age."▪

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 by email at ***fgriggs@nycap.rr.com***

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