Raymond Paul Giroux, Dist.M. ASCE

Chairman and Principal Lecturer for the Brooklyn Bridge 125th Anniversary

Raymond Paul Giroux, Dist.M. ASCE received his BS in Construction Engineering from Iowa State University in 1979. Since then, Paul has been with Kiewit Corporation for the past four decades and has played a key role in the construction of several heavy civil engineering mega projects throughout the United States.

He is a member of the Iowa State University Civil Engineering Advisory Board, the Transportation Research Board, and has been active in various national ASCE committees.

Paul has had leadership and key speaking roles for the anniversaries of several civil engineering icons including the Brooklyn Bridge 125th, the Hoover Dam 75th, the Golden Gate Bridge 75th, the Panama Canal 100th, the Grand Coulee Dam 75th, and the Transcontinental Railroad 150th anniversary.

Paul is the author of several bridge design and civil engineering history papers. He has presented over 100 engineering seminars at conferences and public venues throughout the United States and internationally, as well as over 250 lectures at over 70 engineering schools.

He has been recognized with several awards including ASCE's Civil Engineering History and Heritage Award and the G. Brooks Earnest Technical Lecture Award. In 2016 Paul received the Norm Augustine Award from the American Association of Engineering Societies. He was elected as a Distinguished Member of ASCE in 2016. In 2017 Paul received ASCE's Roebling Award for Construction Engineering, and in 2018 he was inducted into the Iowa State University Construction Engineering Hall of Fame.

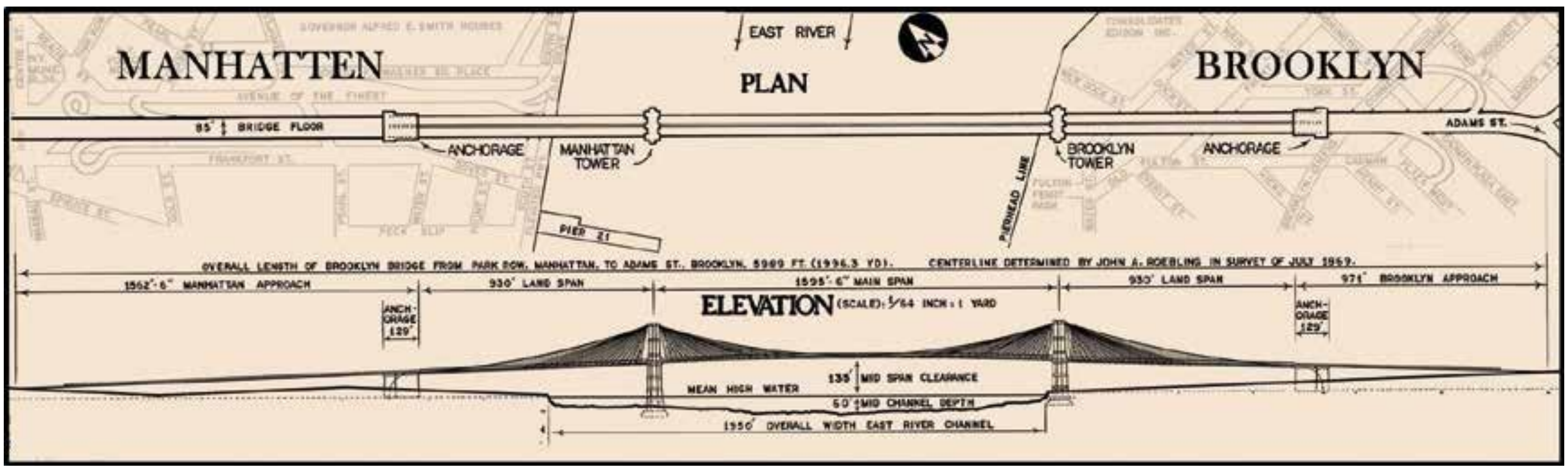
5. The Brooklyn Bridge USA - the world's longest bridge span in 1883

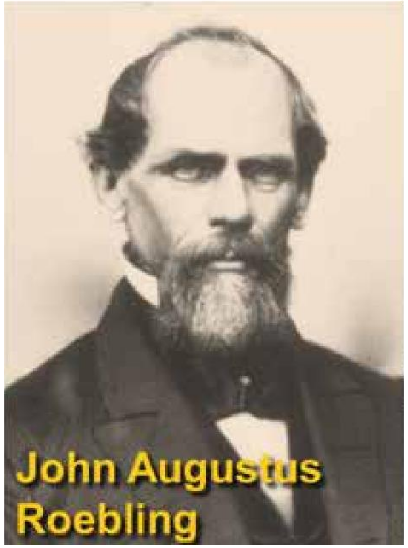
Raymond Paul Giroux

Following in the footsteps of the Union Chain Bridge - 1820, Menai Straight Bridge – 1826, many of the early nineteenth century bridge builders were relying on iron bars and wire to manufacture the bridge materials. As bridge designers increased load capacities and span distances, iron began to show its shortcomings due to its limited elastic behaviour and ductility. With the advent of the Bessemer Process for making steel in 1856 steel became economical, allowing bridge designers and builders to explore the use of steel. Self-taught engineer James Eads had the courage to specify steel for critical arch components for his record-setting Eads Bridge in St. Louis (1867-1874). While steel quality was not consistent at the start of the Eads Bridge construction, through his persistence and the help of steel chemists from the United States and Europe, steel quality did improve through the efforts of Eads and others.

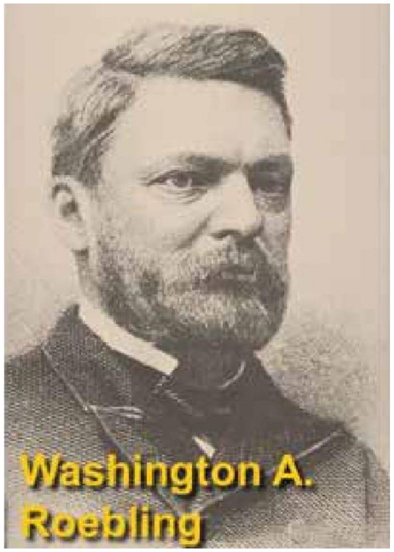
Indeed, the late 1860's were a transformational time in bridge design and construction. When John Augustus Roebling was named Chief Engineer of the Brooklyn Bridge in 1867 he envisioned the superstructure of the bridge to be made from iron. Yet, with improvements in steel prices and quality more and more engineers would specify steel into their bridges.

The Brooklyn Bridge (1869-1883) was the first use of steel suspension wire for a major bridge. Brooklyn Bridge is a pivotal project in civil engineering.





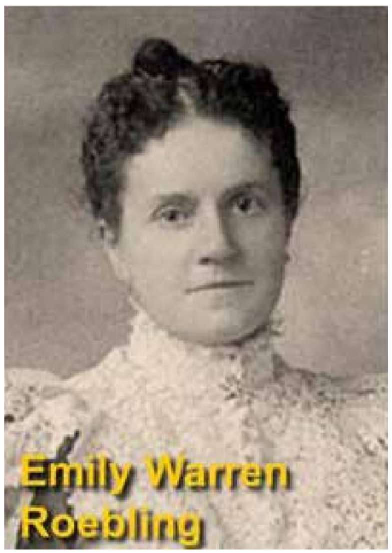
John Augustus Roebling



Washington A. Roebling

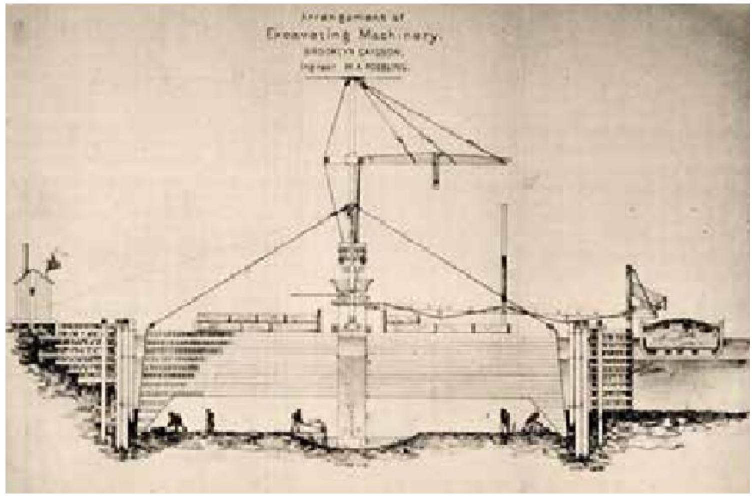
THE VISION:

Early in the 19th century, as the cities of Brooklyn and New York grew, civic leaders envisioned bridging the East River. While civic leaders dreamt of a great bridge, engineers lacked the materials and knowledge to span such a great distance. In 1866, Brooklyn politicians William Kingsley and Henry Murphy garnered enough political support for the bridge and appointed 60 year old bridge builder, John Roebling, Chief Engineer.



Emily Warren Roebling

Tragically, John Roebling died in the summer of 1869 as a result of injuries suffered while surveying for the new bridge. Roebling's son, Washington A. Roebling then took over as Chief Engineer at the age of 32.



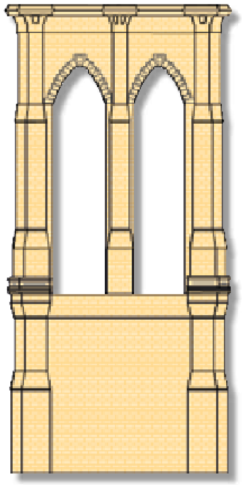
CAISSONS:

The new bridge would require the largest bridge foundations in the world to be built in the East River. Roebling elected to use pneumatic caissons (boxes) which required workers to excavate soil in a pressurized air chamber at the base of the caisson. As the material was excavated, the caissons would advance deeper and deeper.

At the same time, layer upon layer of masonry were added to the top. Ultimately, the Brooklyn caisson was 44.5 ft deep and the New York caisson was 78.5 ft deep in order to reach suitable bearing.

Work in the caissons was dangerous, ultimately taking the lives of ten workers by the completion of the caissons in the summer of 1872. Washington Roebling led several heroic efforts in the caissons, and his extended time working in the compressed air left him incapacitated by "caisson disease". So, with some ten years left on construction, Emily Warren Roebling, Washington Roebling's wife became the eyes, ears, and voice of Washington in the field as her husband's surrogate Chief Engineer.

TOWERS:



Like the caissons, there was no precedent for the design or construction of the massive bridge towers. Roebling determined the towers would need to have a height of 276 feet, and they would be 140 feet wide at the base. Unlike today, in 1883 the massive granite towers would dwarf everything else in view. The Brooklyn Tower was completed June 1875, and the New York Tower was completed July 1876.

ANCHORAGES:

In order to anchor the massive superstructure of the bridge Roebling's plan called for the construction of two massive anchorages, one in Brooklyn and one in New York. The anchorages served to function as the bridge cable's end anchors. The 60,000 ton anchorages measure 119 feet by 129 feet at the base. Embedded near the base within each anchorage are four massive "Anchor Plates". These anchor plates coupled with 9 pairs of wrought iron "Eye Bars" that secured a chain of eye bars that eventually split into 38 eye bars at the top of the anchorage to secure the bridge's cables.

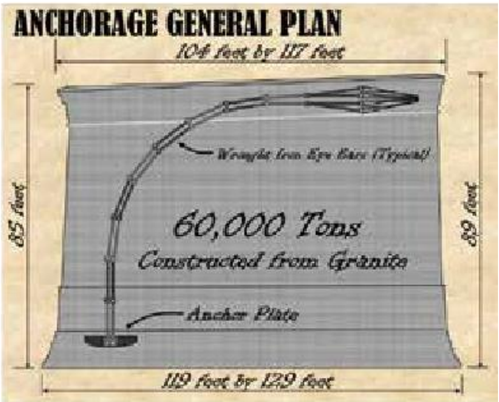
CABLES:

After both towers had reached full height and anchorages were complete, work now shifted to the installation of the bridge's four main cables. "Cable Spinning" as it was referred to would require placing 14,400 miles of 1/8 inch diameter steel wire. With each pass of the cable spinning wheel a pair of 3,600 foot long wires were installed between the Brooklyn and New York anchorages. Each of the bridge's four main cables is comprised of 19 strands, with each strand being comprised of 278 wires. Cable installation began the summer of 1876 and was completed by the fall of 1878.

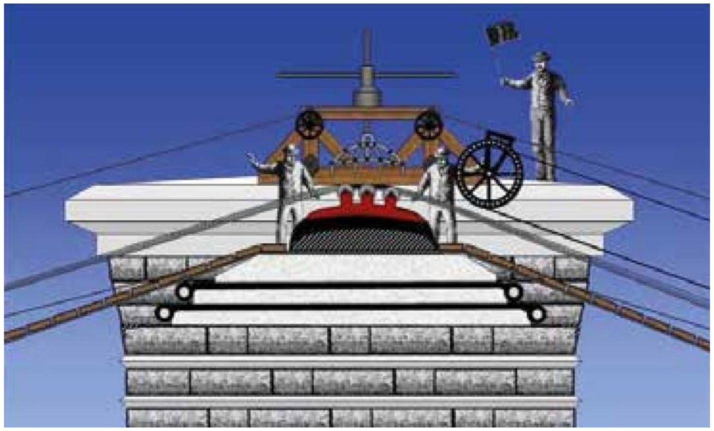
To gain access to the work, a footbridge had to be installed from the Brooklyn to the New York Anchorage. This was completed by February 1877.

Roebling specified the cable wire to be "Number 8, Birmingham Gauge". Approximately 1/8" in diameter, this steel wire was to have a minimum breaking strength of 3,400 pounds and was to be galvanized.

Overall, 6.8 million pounds of wire would be required;



Left -
The arrangement of the anchorages. Wrought iron eye bars connect the cast iron anchor plates to the steel wire suspension cables.



Right -
The arrangement of the spinning mechanism at the top of the towers"

however the specifications were deemed by some to be vague, and were silent on the type of steel, either “Crucible Steel” or “Bessemer Steel”.

There was also controversy about the bidders for the wire. Ultimately, J. Lloyd Haigh Company of Brooklyn was awarded the contract for the steel wire, promising to use “Crucible Steel” in its manufacture.

By early 1877 the foot bridges were installed to allow access to install the bridge cables. The wire spinning wheel is shown on the left. In the lower right, wrought iron eye bars are being stored for placement in the cable splay chamber.

DECK:

In order to create the “great avenue” across the East River, John Roebling envisioned an iron superstructure. By 1879 when the superstructure started, the master builder Washington Roebling elected to use steel, he wrote; “There are so many points to be considered. I want to reduce the aggregate weight so as to keep down the pressure on the masonry. I want to simplify the superstructure so as to make work in the shop easy and erection easy and safe and I also want to keep down the wind surface as much as possible.”

His deck design was comprised of deep stiffening steel trusses that protected the deck from both high winds and vibrations, well before any wind testing was developed. When completed on May 24, 1883, the 1,595 ft main span was the longest in the world at the time and is still among the top 50 longest today.

Even as work neared completion on the Brooklyn Bridge, Roebling had to overcome the public’s doubts about the safety of the bridge. Sensational bridge collapses like the Ashtabula, Ohio Railroad Trestle disaster in December 1876 which killed 92 people, and the Firth of Tay Bridge collapse in Scotland, December 1879 which claimed the lives of 75 people only stirred the public’s doubts.

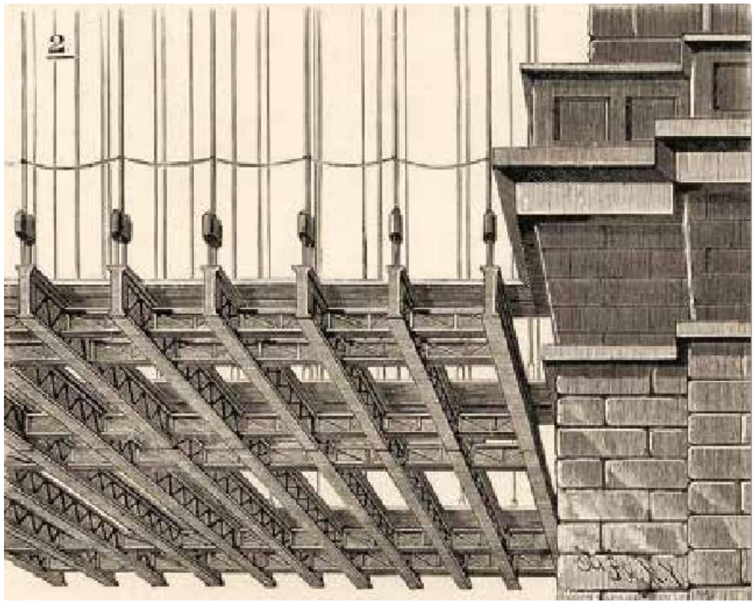
Yet, after thirteen years of construction, and millions of manhours, the great bridge was finished on May 24th, 1883.

Despite being in constant pain, yet with the support of Emily Roebling, Washington Roebling directed the building of the greatest bridge of the day from his Brooklyn Heights apartment for 10 years. By looking through field glasses and receiving daily communications from Emily, he completed the job his father had started.

Arguably, the caisson work would be the most challenging on the bridge; however, Roebling and his team had to overcome countless other challenges during the tower construction: the stringing of the cables, the anchorages, the steel deck truss work, and the approaches. Only through Washington Roebling's attention to detail and detailed planning did the work succeed.

The master builders, John and Washington paid a high price building the bridge; one with his life, the other left incapacitated. Not only did they have to overcome unprecedented engineering challenges, they also had to overcome the doubts of their profession, political distractions, financial difficulties, and often a hostile press.

Nearly 140 years after its opening, the Brooklyn Bridge still carries some 100,000 vehicles per day. Many of the manufacturing and construction techniques developed by the Roeblings were instrumental to the advancement of long-span suspension bridges during the late 19th century and through the 20th century.



The steel transverse lower deck trusses. Upper truss members were added later.

Washington Roebling elected to use steel for the superstructure. This photo shows the deck truss advancing from the Brooklyn Tower. When completed on May 24, 1883, the 1,595 ft main span was the longest in the world.