Charles Macdonald as ASCE President.

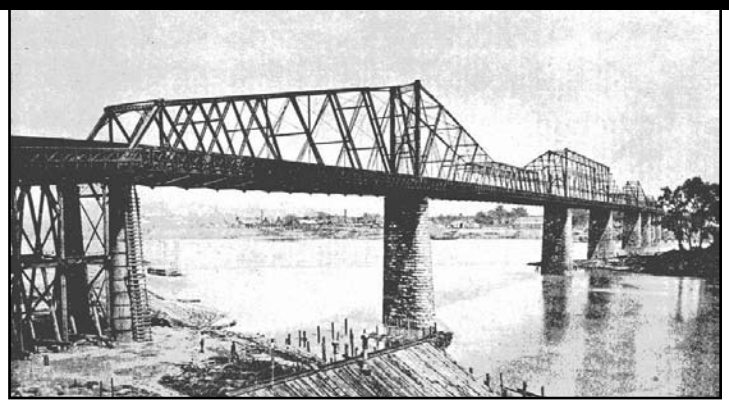
Charles Macdonald

By Frank Griggs, Jr., Ph.D., P.E., P.L.S.

During the period from 1867 to 1912, Charles Macdonald was one of the leading bridge engineers in the world. His bridges crossed major rivers in both the United States and Australia.

Macdonald was born in Qananoque, Ontario on January 26, 1837. At the age of 15, he worked for Samuel Keefer, one of Canada's premier engineers, on the Grand Trunk Railroad in Ontario. He then attended Rensselaer Polytechnic Institute in Troy, New York between 1854 and 1857.

Upon graduation, he returned to the Grand Trunk. He was then appointed assistant engineer on the Philadelphia and Reading Railroad. In late June of 1863, Robert E. Lee and his Confederate troops were invading Pennsylvania and reached the Susquehanna River at several points. Charles joined the 26th Pennsylvania Emergency Infantry and was given the rank of corporal. He was sent on a special assignment with two other men. When they arrived at the gate on the York Turnpike, they met confederate cavalry and after a brief fight were captured. After the battle at Gettysburg, Macdonald was paroled and returned to work on the Philadelphia and Reading Railroad. J. Dutton Steele was Chief Engineer of the line and, starting in 1863, built short span iron bridges on what he called the isometrical plan. He received a patent on the design, and set up a company in Pottstown to promote and sell rights to build the bridge. He needed a promotional piece and asked Macdonald to prepare a pamphlet describing his Isometric truss. Macdonald prepared a 28-page report entitled, *A Discussion of the General Principles Involved in the Construction and Action of the Isometric Truss*. His conclusion was that the Isometrical Truss required less iron in the web system than any other trusses considered. Macdonald's first bridge was the Perkiomen Bridge, of wood and iron on the Isometrical principle, over the Schuylkill River at Phoenixville.



Kentucky and Indiana Bridge.

In 1868, for a short period, Charles went into a partnership under the name Macdonald & Burton, building replacement bridges for the Delaware & Lackawanna Railroad between Hoboken and Dover, New Jersey on what was called the Boonton Branch. After working as superintendent of bridge construction for the Delaware, Lackawanna and Western Railroad, he set up a company of his own in New York City. In 1871 and 1872, he built three bridges on the western end of the line.

In late 1871, Macdonald built his first major swing bridge carrying Point Street over the Providence River in Providence, Rhode Island. The swing span was 250 feet and opened on October 22, 1872. *Engineering, London* gave a full description of the bridge in their February 14 and 24, 1873 issues.

In 1875, Charles went into business with Edward Hemberle as the Delaware Bridge Company. It was the design arm of Cooper, Hewitt and Company of Trenton, N. J. After several years in business, he published an *Illustrated Album* of his bridges and other iron works that is undated, but was probably from the early 1880s. In it, Macdonald gave descriptions and plates of many works completed by the firm.

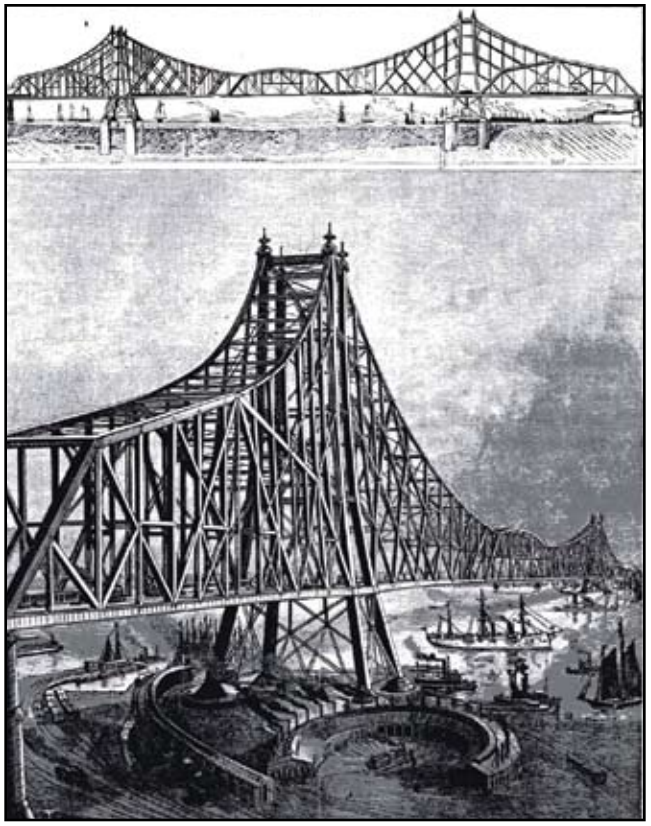
One of the major bridges he prepared designs for in this period was the proposed Blackwell's Island Bridge at 76th Street over the East River in New York City. A design competition was set up with bridge companies asked to submit proposals for a bridge to cross over two branches of the East River and Blackwell's Island. Macdonald's design won the competition. He immediately had a beautiful engraving made of his winning design and included it as a focal point in his first catalog. Due to a lack of funding, a bridge was not built across Blackwell's Island until 1909.

In 1881, C. Shaler Smith was retained by the Kentucky and Indiana Bridge Company to design a bridge across the Ohio River at Louisville. However, in 1883 Macdonald took over. He and Hemberle modified Smith's plans and proposed one for a similar cantilever. Their steel span lengths were the same as Smith's, but their truss patterns were very different. All foundations were in place by July 6, 1885, and the bridge was tested and opened on July 15, 1886.

On March 4, 1884, while the Kentucky and Indiana Bridge was under construction, Macdonald, along with T. C. Clarke, George Field, Edmund Hayes, Charles Kellogg and Charles S. Maurice, formed the Union Bridge Company with offices in New York and shops (Works) in Athens, Pennsylvania and Buffalo, New York. The former Kellogg and Maurice

Macdonald Advertisement.

Union Bridge Company advertisement.



New York and New Jersey Cantilever Span 1894.

Company, formed in 1872, had its fabrication shop in Athens, Pennsylvania. The Works in Buffalo, New York were formerly the shops of the Central Bridge Company that was formed in 1881. Macdonald, Clarke and Hayes were the engineers and Field, Kellogg and Maurice the fabricators. In their advertisement, they displayed C. C. Schneider's Niagara Cantilever built by Central Bridge in 1883. Macdonald was the acknowledged leader of the team and had the most money invested in the company.

The Poughkeepsie Bridge across the Hudson River was under consideration for many years. Construction actually began in 1873 on a design by the American Bridge Company, but caisson problems caused them to go into bankruptcy and work stopped in 1874. The new company took over the construction in 1886 and "proceeded immediately to work, and made a sub-contract with the Union Bridge Company." Based upon experience with the Kentucky and Indiana Bridge as well as the Niagara Bridge, they decided a cantilever design would best meet site conditions and restraints. The falsework was very complex, as the bridge deck would be 212 feet above sea level. Wooden piles over 130 feet long were driven to support the falsework, which reached another 120 feet in the air to support the traveler used to erect the steel. From tip of pile to top of traveler was over 340 feet. The speed of steel erection was extremely rapid, as was placing of foundations for the piers in the deep water of the Hudson River. They started work on October 8, 1886 and the approach viaduct, which was a major structure in its own right, was completed December 29, 1889. On January 1, 1890, the day the charter ran out, regular service began. Its 525-foot anchor trusses were the longest simple spans in the world at the time of construction. The 548-foot cantilever spans were the longest in the world as well. The bridge is currently being restored as a pedestrian bridge, and is scheduled to open in 2009.

The Hawkesbury Bridge in Australia was a major accomplishment for Macdonald and Clarke, as they won an international competition beating out many international bridge building firms. A request for proposals went out in 1884 and 15 bridge firms responded, with Union Bridge submitting a design for seven spans of 416 feet using Whipple Double Intersection trusses with five piers being sunk to a depth of 150 to 160 feet. The Board of Examiners was unanimous in recommending Union Bridge for the project even though the bid was not the lowest. They were awarded the project in January 1886 and Macdonald went to Australia to supervise portions of the work. The bridge as built was on time and within budget.

Poughkeepsie Bridge.

Clarke and Kellogg left the company in 1887 but Union Bridge, under Macdonald, continued to build major bridges in the United States. In response to requests for proposals, they built Theodore Cooper's Sixth Street Bridge across the Allegheny River in Pittsburgh and to the designs of George Morison the Merchants Bridge, the Memphis Cantilever and the Winona Bridge all over the Mississippi, the Leavenworth Bridge over the Missouri River and the Cairo Bridge over the Ohio River. They built the Sibley Bridge across the Missouri and the Fort Madison Bridge across the Mississippi for Octave Chanute.

In 1894-95, Macdonald prepared plans for a bridge across the Hudson River where T. C. Clarke was Chief Engineer for the New York and New Jersey Bridge Company. Clarke requested proposals for a 2,300-foot span, 2,000 feet clear, cantilever bridge with the New Jersey pier 900 feet into the river. The War Department rejected the plan and required the bridge be built with no piers between the pier head lines. Clarke and Theodore Cooper updated the specifications, calling for a 3,000-foot clear suspension span. Macdonald submitted a new plan that was approved by the war department, but due to funding problems the bridge was never built.

On March 4, 1901, J. P. Morgan and his new American Bridge Company bought 24 bridge fabricating and design firms, including Union Bridge Company. Macdonald was

named to the Board of Directors as were most of the leaders of the other companies, and he was appointed Vice President. After a year, he retired from the active practice of bridge building.

The Quebec cantilever collapsed while under construction in 1907, killing 75 men. Macdonald was called out of retirement to serve on a Board that was determining what kind of bridge would replace the Phoenix Bridge Design. He agreed to serve only as long as necessary to evaluate the tenders. After a disagreement over the design, the chairman of the Board resigned and Macdonald took over as acting Chairman. With the design selection and the signing of the contract, Macdonald resigned and was replaced by Lt. Col. Charles N. Monsarrat. The bridge finally opened in 1917 after another major failure during construction, when the suspended span fell into the river during placement and killed another 13 men. This was the last project Macdonald worked on as a practicing engineer.

He was a lifelong supporter of Rensselaer Polytechnic Institute, serving on the Board of Trustees for many years. He was active in ASCE serving as Director, Vice President, and President in 1908.

In his ASCE presidential address on *Engineering Ideals*, he wrote that the engineer:

"must combine strength and durability with attractive outline and artistic excellence. It is not sufficient that a bridge, for example, shall be strong enough to carry its load… It is true that what is called Art has not been considered a fixed science…Nevertheless, I believe it will be found to be the fact that the structure which has been designed upon the most scientifically accurate proportions, that is to say which accomplishes the object for which it was intended in accordance with Nature's great law, will present the most pleasing outline, and that eventually the conception of the Engineer and the Architect will merge in that of the true Artist and Engineer of whom the immortal Michael Angelo was the great prototype."

Macdonald died in his hometown July 8, 1928 at the age of 91. A newspaper article noted, "The late Dr. Macdonald was entitled to the recognition as one of the greatest bridge builders of the North American continent and enjoyed a reputation in this connection second to none."▪

New York and New Jersey Suspension Bridge with Terminal on right.

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