Captain C. Shaler Smith, CSA

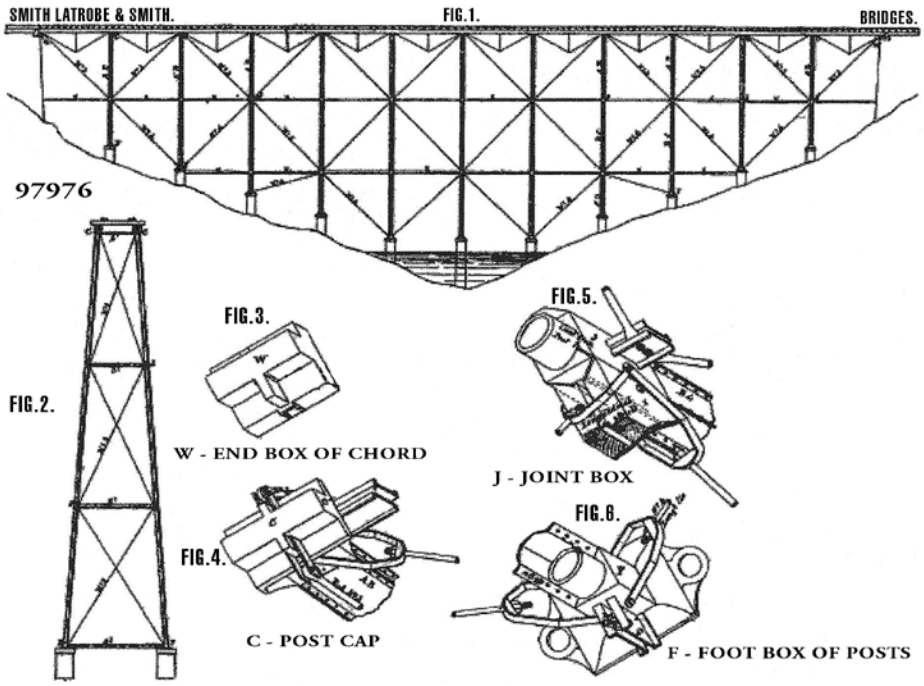
C. Shaler Smith

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

C. Shaler Smith, one of the premier bridge builders of the post-Civil War period, was born in Pittsburgh, Pennsylvania on January 16, 1836. After attending a private school in Pittsburgh, he went east and became a rodman on the Mine Hill and Schuylkill Haven Railroad near Philadelphia. In 1858, he was in charge of the Tennessee division of the Louisville and Nashville Railroad under George Macleod and Albert Fink. He moved up to Chief Engineer of Bridges and Buildings on the Wilmington, Charlotte and Rutherford Railroad in North Carolina in 1859.

At the start of the Civil War, Smith chose the Confederate cause and was commissioned as Captain of Engineers. His main job early in the war, as Chief Engineer of Government Works in the Augusta District, was to build the Confederate Powder Works at Augusta, Georgia. During the war, it claimed to be "the best powder mill in the World."

In 1865, Smith published his first paper, *A Comparative Analysis of the Fink, Murphy, Bollman and Triangular Trusses*. Referring to himself, he wrote, "He has no property in any of the patents involved in the different systems, and no other interest in the adoption of one rather than another, except in so far as his demonstration of its superior economy may cause a structure to be erected, which on a more expensive plan would not be built at all. If his effort should, upon this ground, result in increasing the replacement of temporary and unsafe by permanent and reliable constructions of moderate cost, his field of labor in this branch of his profession will be enlarged, not of course exclusively but in fair competition with others whose interests as well as his own, he will thus have been instrumental in promoting." He concluded: "Taking, therefore, all the points above reviewed into consideration, the conclusions would seem to be these, viz. that for all spans where the weight of the train is great in proportion to the weight of the truss, the Suspension trusses *[Fink and Bollman]*…are the best, and of these two the Fink is almost invariably preferable. This truss also ranks first for an undergrade *[deck]* bridge of any length of span, while for all overgrade *[through]* bridges of more than 100 feet span the Triangular is the best truss."



Viaduct Patent.

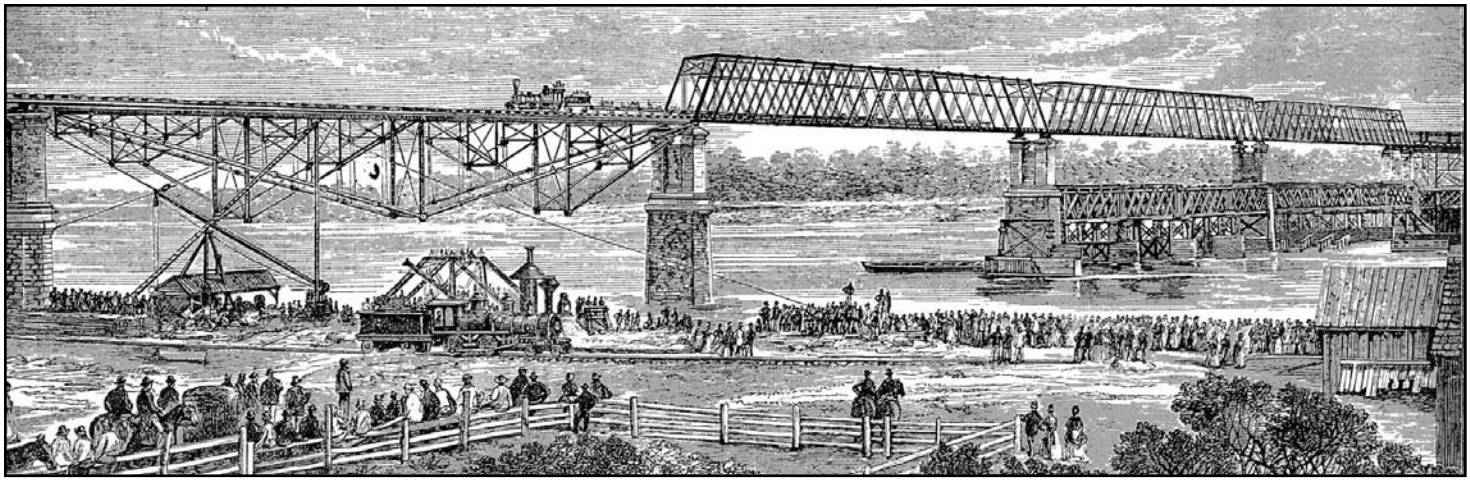
Benjamin H. Latrobe, formerly Chief Engineer of the Baltimore and Ohio Railroad, reviewed his pamphlet. Latrobe wrote, "The memoir by Mr. C. Shaler Smith, upon the comparative merit of different forms of bridge trusses, has been submitted to me by that gentleman for my professional opinion, and after an attentive examination of his paper I am prepared to say that I consider the principles upon which he has conducted his investigations to be scientifically accurate, and his conclusions correct."

Smith stayed in the South for several years after the war, and began building bridges on the Charlotte and South Carolina Railroad that crossed the Catawba and Congaree Rivers using iron Fink Trusses. In 1866, he joined with Charles Hazelhurst Latrobe, former chief engineer of the Pensacola and Georgia Railroad, to form Smith, Latrobe & Company based in Baltimore and Charlotte, North Carolina with Benjamin Latrobe acting as a consulting Engineer to the firm. In 1867, they built a 470-foot iron trestle (viaduct) called the Bullock Pen Viaduct for the Cincinnati & Louisville Short-Line. The firm built many other viaducts, including the Running Water Viaduct on the Nashville and Chattanooga Railroad, Lynn Brook Viaduct on the New York and Oswego Railroad, and a 1,500-foot viaduct on the same line, Clarke's River Viaduct on the Elizabethtown and Paducah Railroad, and the Arequipa Viaduct on the Arequipa and Puno Railroad in Peru.

C. S. Smith, C. H. Latrobe and Frederick Smith received patent # 97975 on December 14, 1869 for an Improvement in Construction of Bridges.

The only surviving bridge by Smith Latrobe is the 1868 Zoarville Bridge with a 108-foot span that has recently been restored.

In 1869, the firm changed its name to the Baltimore Bridge Company with offices in Baltimore and Phoenixville, Pennsylvania. The firm continued to design many major



St. Charles Bridge, Missouri River.

bridges in the United States, including the Mississippi and Ohio Railroad "High Bridge" over the Appomattox River Valley with 21 spans of 125 feet each, the Rock Island Bridge across the Mississippi River in 1872, the St. Charles Bridge over the Missouri River in 1871, and a portion of the Susquehanna River Bridge for the Philadelphia, Wilmington and Baltimore Railroad at Havre de Grace. They also designed the famous Verrugas Viaduct erected in Peru in 1871-72 by Leffert L. Buck.

The Rock Island design was used for what was called the Arsenal Bridge, and included fixed spans of 220 feet and 260 feet and a swing span of 368 feet, with five shorter spans of Fink Trusses making the total length of the bridge 1,840 feet. It was double-decked, with the railroad on the upper level and wagons on the lower level. Smith moved to St. Charles, Missouri in 1868 to oversee construction of the St. Charles Bridge over the Missouri River just upstream from St. Louis. His bridge was a high level bridge with a clearance of 90 feet above low water. It consisted of three 322-foot spans of double triangular Warren trusses, four 304-foot spans of Fink deck trusses (the longest Fink trusses ever constructed), two spans of 64 feet, one of 48 feet and 4,518 feet of iron viaduct work for a total length of 6,676 feet. When built, it was the longest iron bridge in the United States. In 1871, after finishing the St. Charles Bridge, Smith moved to St. Louis, where he spent the rest of his life.

In the spring of 1873, James Eads issued specifications for the long eastern approach to his St. Louis Bridge. He sent them out to several bridge firms, including the Baltimore Bridge Company. Smith's firm won the contract to build the entire eastern approach for the bid price of $377,900. They finished the approach in June 1874, one month before the opening of the bridge. Smith had also worked closely with Eads and Henry Flad on designing the main arches.

In July 1873, Smith, C. H. Latrobe and Charles Bender, an associate of the Baltimore Bridge Company, patented (#141,310) *Improvements in Iron Bridges*. Smith's first effort using this patent was the continuous/cantilever truss bridge over the Kentucky River. He used cantilever methods to build the bridge as a continuous truss on two abutments and two central piers, and then converted it into a cantilever bridge.

Smith's next cantilever was for the Chicago, Milwaukee & St. Paul Railway in 1879 over the Mississippi River between Wisconsin and St. Paul, Minnesota. The bridge was sometimes called the Minnehaha Bridge or sometimes the Short Line Bridge. The site was similar to his Kentucky River site, as the river flowed through a chasm with rock on both sides. In this case, however, the river was only 150 feet below and the main bridge only needed to span 868 feet. It was a much smaller bridge and, like the Kentucky Bridge, would be for a single track.

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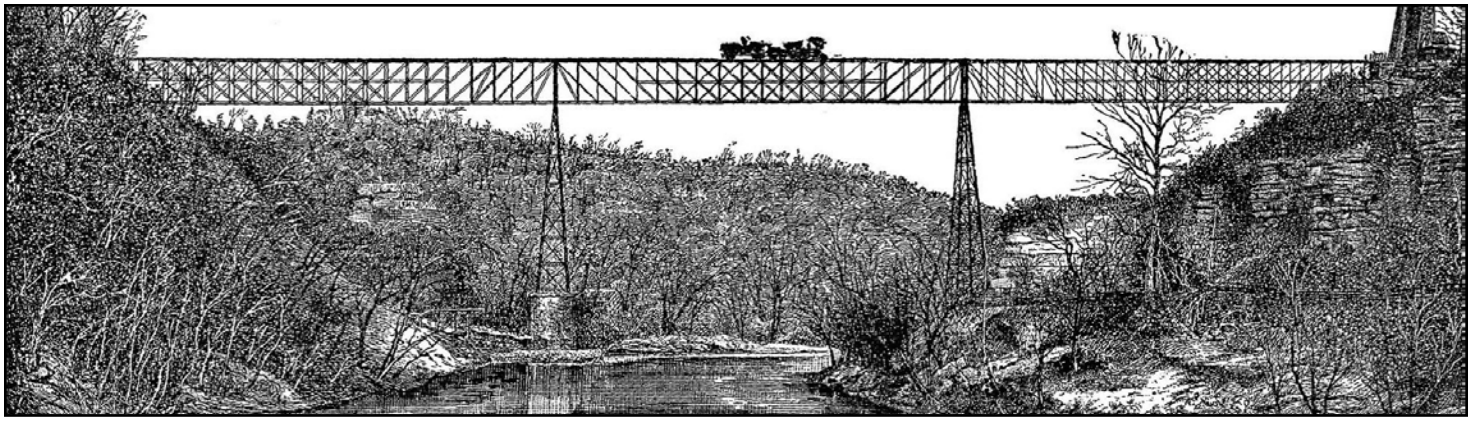
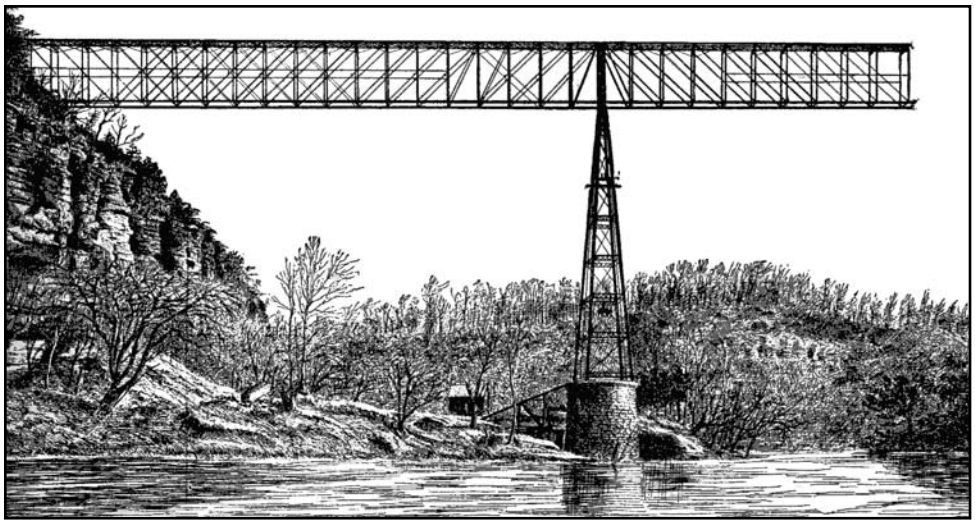


Kentucky High Bridge.



Kentucky High Bridge half done showing iron towers.

Smith's last major bridge project was in Canada for the Canadian Pacific Railroad which was looking to extend its line to the east and across the St. Lawrence River near Montreal. After several unacceptable designs, the Chief Engineer, in the summer of 1884, called in Smith as consulting engineer. Upon reviewing the site, Smith was worried about building piers in the St. Lawrence and proposed that "there should be introduced two spans of 258 ft. and two spans of 408 ft. over the channel, thus getting rid of one deep water pier, and probably one years time in the construction of the bridge." The two 408-foot spans would be erected on the cantilever principle with 258-foot anchor spans.

Smith had considered various schemes for building the channel spans. The top plan was for a bridge with two piers in the main channel and pins inserted at points of contraflexure, making it a cantilever with all reactions determinate. The middle plan was for a single pier in the main channel and pins again inserted in the lower chords and a top chord peaking over the center span making it also a cantilever with all forces determinate. The last alternative was the selected one, with trusses being continuous. The erection process consisted of building the 270-foot anchor spans first, on falsework. The channel spans were then cantilevered out 10 panels from each anchor span using conventional techniques. The new twist in the erection was to build cantilevers out each way from the central pier. This was known in Smith's office as the 'Flying Cantilever,' and was first proposed for the Storm King Bridge over the Hudson river in New York. A short temporary falsework was built off the central pier to support the first panel point in each direction. After the construction of these two panels, the spans were built out equally with a traveler moving in each direction and great care taken to keep the spans in balance. In addition, cables were strung from the completed cantilevered spans to help maintain the central portion in a stable position throughout the construction of the eight closing panels.

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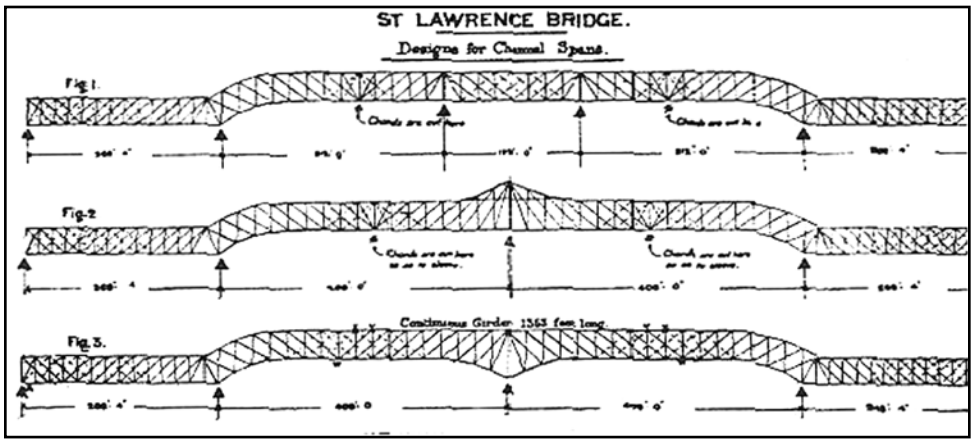
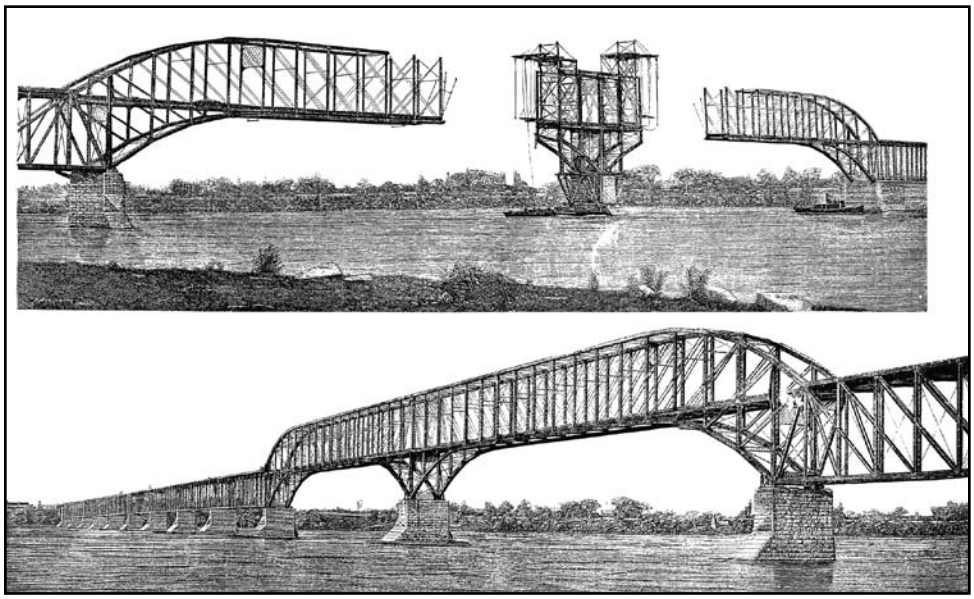


Smith's proposed designs.



Lachine Rapids Bridge under construction and completed.

The bridge was completed successfully and opened to traffic in July 1886. Smith was virtually on his deathbed during the bridge construction and died shortly afterwards. With these three cantilever/continuous bridges, he was the most prominent engineer to adopt continuous truss design in the United States.

Smith was an active contributor to the *Transactions ASCE*, writing papers in addition to being a regular discusser of papers by his colleagues. He died in St. Louis on December 19, 1886 at the age of 50. A local paper headline announced his death "C. Shaler Smith Dead. One of the Greatest Bridge Engineers In the Country Passes Away." He was described by one source as:

> "reticent and reserved among strangers, but with his friends a most genial companion; flashing with wit and full of varied and exact information on a great number of subjects; devoted to field sports, in which he was almost as accomplished an expert as in bridge building; always courteous and considerate with his employees, by whom he was beloved, and of the strictest integrity in all his dealings, he had altogether a most attractive personality. In his professional work he displayed marked originality and boldness."

J. A. L. Waddell in his book *Addresses to Engineering Students*, noted Smith "was one of the finest men and greatest engineers that America has ever produced."▪

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****.*

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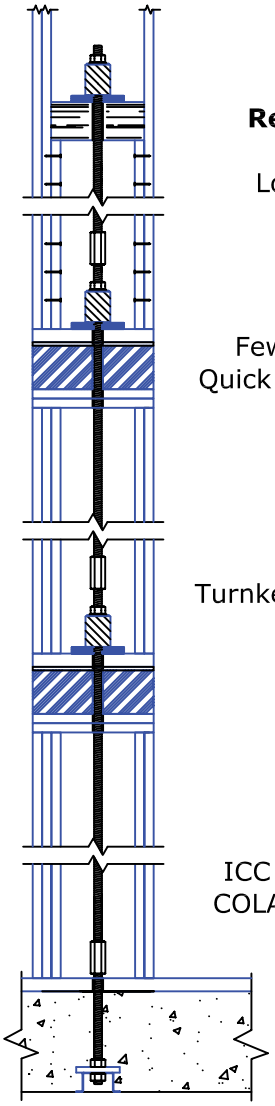

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