Eminent Structural Engineer: David B. Steinman (1886–1960)

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Against the city's gleaming spires,
Above the ships that ply the stream,
A bridge of haunting beauty stands –
Fulfillment of an artist's dream.

– D. B. Steinman,

"Brooklyn Bridge – Nightfall"

The Bridge Builder

David Barnard Steinman (*Fig. 1*) was born in 1886 in New York City, the son of immigrants. His first home was in the shadows of the then just-built Brooklyn Bridge, and growing up he witnessed the construction of two other major suspension bridges, the Williamsburg and the Manhattan Bridges. This experience was to mark him for life.

Gifted with mathematical prowess, he started taking college classes at City College of New York even before completing high school, obtaining his Bachelor-of-Science degree *summa cum laude* in 1906. As a student he managed to gain access to the worksite and observe the cable spinning operations on the Williamsburg Bridge. He went on to study Civil Engineering at Columbia University, where he graduated with the thesis "The Design of the Henry Hudson Memorial Bridge as a Steel Arch", and where he later completed his doctorate with the thesis "Suspension Bridges and Cantilevers: Their Economic Proportions and Limiting Spans". After a few years in academia, he returned to New York to work on bridges such as the Hell Gate and the Sciotoville Bridges under noted bridge engineer Gustav Lindenthal.

In 1920, Dr Steinman met Holton D. Robinson, who had been responsible for the construction of the Williamsburg Bridge cables and who was in charge of design and construction for the Manhattan Bridge. Their first collaboration was an international design competition for a bridge in Florianapolis, Brazil, which they won with an unusual and innovative design (*Fig. 2*). When completed in 1926, the 340 m main span was the longest suspension bridge in South America, and the longest eyebar suspension bridge in the world.

Steinman's strength in the theoretical aspects of bridge engineering and Robinson's practical experience in construction complemented each other, and the office of Robinson and Steinman began obtaining commissions for significant structures, such as the Carquinez Bridge in 1927 (the second largest cantilever truss in the US),

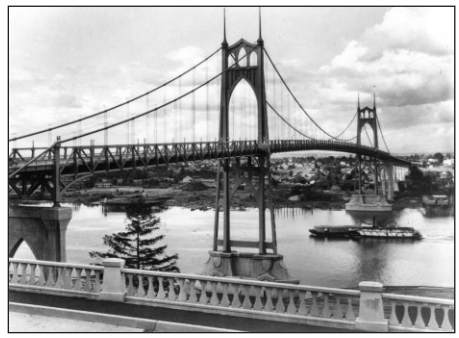

Fig. 3: St. Johns Bridge

the Mount Hope and Grand Mere suspension bridges in 1929, the St. Johns (*Fig. 3*) and Waldo-Hancock suspension bridges in 1931, and the Deer Isle and the Thousand Island suspension bridges in 1938–1939.

Over 25 years after presenting his thesis at Columbia University, Steinman had the satisfaction of preparing final design plans for the Henry Hudson Bridge, with only minor changes with respect to the design shown in his thesis. This 256 m span became the longest fixed arch, and the longest plate girder arch span in the world.

The collapse of the Tacoma Bridge in 1940 led him to conduct a series of studies and mathematical modeling (at which he excelled) to analyze the relationship between the weight and depth

Fig. 1: David B. Steinman

Fig. 2: Florianapolis Bridge (Photocredit: John Schmid)

Fig. 4: Mackinac Straits Bridge

of girders, stay bracing and rigidity in relation to the aerodynamic stability of suspension bridges. He concluded that it would be "*more scientific to eliminate the cause than to build up the structure to resist the effects*" of wind on the structure, and this led him to suggest the use of "*open spaces in the floor*" (such as by using open steel grid deck) or the addition of wind-deflecting elements. In spite of Steinman's prominence in those days, he was not a member of the board of engineers appointed to investigate the collapse, but his publications on the subject during those years were extensively referenced in a 1952 report by the Federal Advisory Board on the Investigation of Suspension Bridges.

One of the many projects that had been postponed in the wake of the Tacoma Narrows Bridge collapse and World War II was the crossing of the Mackinac Straits in Michigan's Upper Peninsula – a project identified as far back as 1888 by railroad magnate Cornelius Vanderbilt. By 1950, tourism in the area had rendered the ferry service inadequate and a serious move was made to build a bridge in the hope of spurring year-round economic development. Having established his reputation as a suspension bridge designer and expert in the area of aerodynamic stability, Steinman managed to become selected to design this major bridge (*Fig. 4*).

Although the 1158 m main span was shorter than Golden Gate's 1280 m, the Mackinac Bridge attained the title of the world's longest suspension bridge from anchorage to anchorage when it opened in 1957. The design incorporated some of the features identified during the study of the Tacoma Narrows Bridge collapse: deep trusses, a partially open grid deck, and a center tie, resulting in an inherently stable superstructure.

Steinman's Inspiration

For Steinman, the Mackinac Bridge represented the realization of the "American Dream", the dream of opportunity for everyone according to ability or achievement, and inspired him to write:[1]

As far back as in 1893, when I was a newsboy selling papers near the Brooklyn Bridge, I told the other newsboys that someday I was going to build bridges like the famous structure that towered majestically above us. They laughed at me. Now I can point to 400 bridges I have built around the world, and to my masterwork – the Mackinac Bridge – the greatest of all.

And, in fact, the Brooklyn Bridge was a major inspiration muse for Steinman. Early on, the famous gothic arches of its towers found their way into his signature bridges, albeit executed in steel rather than in masonry. Steinman's admiration for its builders, the Roebling family, is apparent in his writings.[2,3]

When after 60 years of service, and a three-fold increase in the traffic loadings with respect to the original design load, it was time to remodel the Brooklyn Bridge, the City of New York engaged the consulting engineering services of D. B. Steinman. In his own words, "*Much reconstruction work was necessary, but every effort was made to retain the original appearance of the bridge.*"

He was successful in this, and in 1953 the American Institute of Steel Construction awarded this reconstruction a special citation for its artistic achievement, in which he took much pride.[7]

Steinman's Legacy

Although Steinman had the opportunity to work on many types of bridges, his technological legacy is almost always associated with suspension bridges.

One design innovation developed by Steinman is the use of a center tie to rigidly connect the superstructure to the main cables, as a way of stiffening and stabilizing the superstructure. North America's first flexible plate girder suspension bridges, the two very slender Thousand Island suspension bridges, were designed by Steinman.[4] Motivated by steel economies rendered necessary during the Depression years, and supported by the advancements in theoretical analysis, the plate girders on these bridges were extremely shallow and flexible, to the point where large deflections were visible under moderate winds even before the bridges were opened to traffic. Steinman immediately devised a "center tie" rigidly connecting the girders to the cables at midspan, which was successful in considerably reducing the oscillations. This solution was later implemented in most of his other suspension bridges, including Deer Isle and Mackinac Bridges, and the Tagus River Bridge in Portugal, for which he developed the preliminary design prior to his death.

Another innovation was the use of stiffening cables connecting the superstructure near the tower to various points along the main cables, which he used on the Thousand Island and the Deer Isle suspension bridges, since both have a sleek plate girder design (*Fig. 5*). Steinman argued, most notably with eminent contemporary engineer Othmar Ammann, that his system was more effective in providing aerodynamic stability than the more conventional layout (with stays from the top of the tower) that had been used on the Brooklyn Bridge, and which Ammann had applied on the Bronx-Whitestone Bridge. Ironically, more than 50 years after their construction and the arguments between their

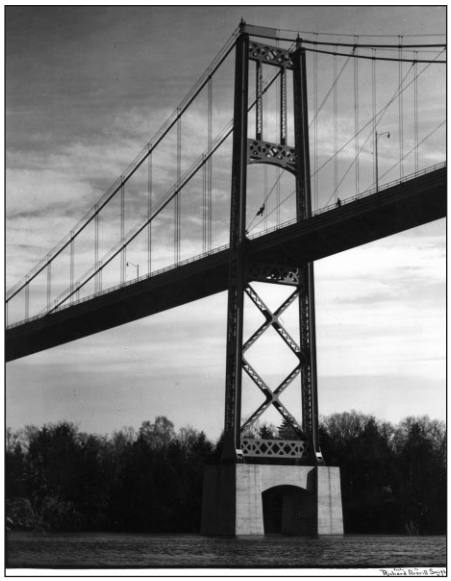

Fig. 5: The Thousand Islands Bridge showing stiffening stays

respective designers, both the Deer Isle and the Bronx-Whitestone Bridges were retrofitted with fairings, which have even more effectively reduced the oscillations that are intrinsic to these slender girder spans.

Beyond Bridge Design

Steinman was a very outspoken individual, and he felt strongly about the need for licensure and professional registration of engineers. He founded and was the first President of the National Society of Professional Engineers in 1934, through which he urged that the professional title "Engineer" be used in front of individuals' names, but encountered great resistance; and to this day this title, commonly used all over the world, is not used in North America.[8] Steinman also spoke often about engineering education. More than 70 years later, his words still ring true:

The four-year course may have been adequate two generations ago, but the increasing content of essential engineering knowledge and the growing recognition of the desirability of a background of liberal arts and cultural studies for a professional man have altered the picture.

Sadly, the 4-year civil engineering curriculum is still in place, but many students (and engineering companies) are realizing the importance of post-graduate studies.

A prolific author, Steinman wrote numerous technical and scientific papers, as well as fairly popular books on bridge construction for laymen[1,2] and even for children.[5] His love of bridges spilled over into his enthusiasm for poetry, although it is widely considered that he did not excel in this particular genre.

Steinman's Dream

Steinman's ambition was to build the world's longest suspension bridge, and, in 1950, when the Italian Steel Institute retained him to prepare a design for a bridge across the straits of Messina, he proposed a suspension bridge with a 1524-m main span, thus exceeding the longest one at the time, the Golden Gate Bridge in San Francisco, by 244 m. For this bridge, which was to carry both vehicular and railroad traffic, he proposed the use of trusses similar to the ones on the Florianapolis Bridge, as well as auxiliary cable stays radiating from a point on the towers just above the roadway which "*increase the degree of rigidity demanded for resistance to aerostatic and aerodynamic forces…and to earthquake vibrations. ….it would be one of the safest and most rigid suspension bridges ever built*". Interestingly, even as he developed this design, in 1954[6] and again in 1957[2] he wrote, "*Now bridge engineers confidently agree that suspension spans as long as 10000 feet [3048 meters] are practically feasible.* ***And such spans will be built***". In spite of the boldness of this assertion, 50 years later such spans are yet to be built.

The Steinman design for the Messina Straits Bridge has been replaced with a design for an even longer span that incorporates later developments in suspension bridge technology, but some of his legacy remains in the current design for a 3300 m span: e.g. in the use of a partially open grid deck to improve aerodynamic performance.

Afterword

David B. Steinman died on 21 August 1960. The firm he started in 1921 continued to keep his name, most recently as Steinman Boynton Gronquist and Birdsall, until 1988, when it was bought by the Parsons Corporation.

Today, Steinman's legacy is alive in the New York office of Parsons, in the firm's Bridge Division, where a new generation of engineers ensures that his bridges and many others are maintained and rehabilitated and continue to perform as originally designed, and where new suspension bridges are designed with innovative features, in the tradition of the firm's founder.

When I first arrived in New York 20 years ago with a fresh degree in Structural Engineering and a passion for bridges, the fact that Steinman had prepared a design for the often-dreamed-of bridge across the Messina Straits in my family's country of origin drew me to the firm that he had founded. Although this bridge may remain a dream for me and many bridge engineers for some time to come, many of the bridges designed and built by David B. Steinman continue to inspire us to seek the way to combine innovation, strength, durability, and beauty in our everyday engineering work.

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