

Highlights

- **First suspension Bridge with steel towers**
- **Glass encased structure obviates need for painting**
- **FRP pile repairs with ambient salt water as catalyst**

Items

- **Rebuilding a new bridge around existing bridge & traffic**
- **Architectural enhancements effecting life cycle economy**
- **Interagency synergy**

SPANS



The Quarterly Newsletter of Inspired Bridge Technologies

January 2004, 1, Volume 2

REFLECTIONS ON MANHATTAN'S GLASS BRIDGE



FIGURE 1: Aerial view of the Williamsburg Bridge.

New York City's second East River Span, the Williamsburg Bridge, is one hundred years old this December, 2003. The 1,600' main span, joining the borough of Manhattan and Williamsburg, is suspended between steel towers 332'-8½" tall, the first steel towers for any suspension bridge. Leffert Lefferts Buck, the bridge's design engineer, showed an early disposition for mechanics while working in a foundry in upstate New York for four years before joining the Union Army early in the American Civil War. Returning home four years later and not yet 20 years old, he was a

decorated veteran with the rank of captain when he enrolled in the School of Engineering at Rensselaer Polytechnic Institute, near Albany, New York. Upon graduating in 1868, he was invited to join the staff of John Roebling who was then designing the Brooklyn Bridge. With the completion, in 1883, of the Brooklyn Bridge, he left and actively pursued a career building railroad bridges in the mountains of South America and the Pacific North West of the United States.

The East River Bridge Commission was established on May 27, 1895 and was directed to build a

bridge to augment the overwhelmed capacity of the Brooklyn Bridge. L.L. Buck was their choice for Engineer and O.F. Nichols was to be his assistant. The design started in August and the criteria was established: provide for two rail lines, four trolley lines, two carriage ways, two bicycle ways and a pedestrian way. No radical change from the Brooklyn Bridge would be allowed without technical justification, but the older structure was not to be copied.

Mr. Buck met the challenge of providing a fifty percent increase in traffic by resorting to a new material, steel. He found that the conventional masonry solution became impractical for a roadway with the new width. He, therefore, chose to build his towers in steel, a precedent setting decision.

The four, one thousand ton, 18-5/8" diameter bundles of 3/16" diameter wires were the most expensive, single item for the bridge and, in an effort to reduce costs, Mr. Buck chose to suspend the main span only. He built the two side spans with trusses supported on steel piers allowing him to shorten the distance between anchorages and, consequently, reduce the lengths (and costs) of the main cables. Ominously, with these cost

cutting measures, Mr. Buck was compelled to use fish oil and graphite instead of galvanization to provide corrosion protection.

Construction was well advanced in 1898 when America's largest and 3rd largest cities (New York and Brooklyn) merged, effecting a final cost for the bridge of \$11 million (up from \$7 million) and a one year delay. Mr. Buck, the original Chief Engineer of the Williamsburg Bridge, was made a Consulting Engineer under Gustav Lindenthal who was appointed Bridge Commissioner by Mayor Seth Low during the change in administration of 1902. He was present for the ceremonies on December 19, 1903 when Mayor Low presided over the official dedication of the bridge.

In 1978, the New York State Department of Transportation initiated a comprehensive survey for the entire bridge leading to a 10 year, \$197.5 million rehabilitation program. In 1984, the City received its first unsolicited proposal to rebuild the main span and two side spans without interrupting rail, roadway, walkway or waterborne traffic. The city decided to hold a competition which received 25 proposals, 24 to build an all new bridge and one (the 1984 unsolicited proposal) for a new bridge on existing foundations. The results of this competition demonstrated that for an estimated \$800 million an all new bridge could be built with little disruption to travel and the community.

The original, unsolicited proposal was not one of the finalists, but is an extremely innovative concept which could prove useful in the future, on other bridge expansions. This concept entailed framing the existing towers with a box-truss doorway having the sill bearing directly on the existing piers while encapsulating the present tower bases and projecting outboard of the overhead bridge footprint. The jambs of this giant doorway reach skyward to a point 40' above the existing, 333' towers. Then, this tuning-fork

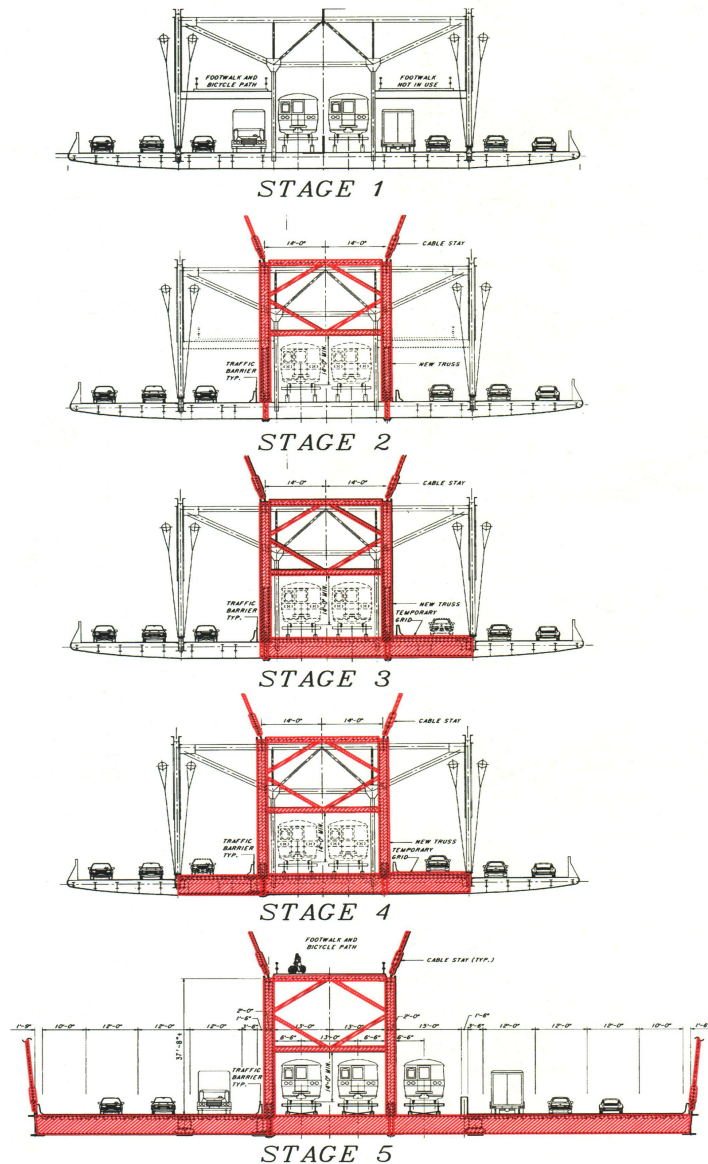


FIGURE 2: A mid-span section with sequential evolution of the new structure.

configuration was closed by spanning between these two outreaching fingers.

Referring to Figure 2, Stage 2, we see the new spine truss that is installed encapsulating the existing, horizontal truss while being supported by two planes of cable stays focusing upon the top of this new truss. Stages 3 and 4 depict the new floor beams being cantilevered, sequentially off the new, stayed truss in order to receive the new, phased roadway. With stage 5, the cantilevered floor beams extend to points which connect to the 3rd and 4th planes of stays. Similar to stage 3 and 4, roadway traffic is phased as the new

flooring systems are installed during off peak traffic periods. The balanced stayed system ends when the back spans are completed at 600'. At this point, the 1,600' new main span has a consequent 400' gap at mid-span. Continuing with the 200' from each tower to close this new main span, the stays over the completed, back span are bundled and delivered to the existing anchors as one. This new, more expansive configuration (Fig. 2, Stage 5), would add 20% more deck area than the existing bridge and removes all the piers supporting the existing back spans. Moreover, the restrictive vertical and


horizontal clearances (Fig. 2, Stage 1) on the existing bridge are eliminated and emergency shoulders would be provided avoiding current, traffic stoppage due to vehicle break downs on the main bridge. Coincidentally, a third rail line is included to accommodate the existing rail line that dead ends on the Manhattan side.

The demolition of the existing structure would be accomplished by employing labor intensive methods and lowering scrap to water-borne barges. Removing the main suspension cables presented a major challenge. They would support a set of slings on rollers that would receive 60' sequentially cut segments, 4" in girth, which, when bundled were to be lowered first by riding along the cable in the slings to a low point for transfer to the deck then the barges waiting below.

The Architect suggested encasing the steel structure in a self-cleaning, glass envelope (Figure 3) that would protect the steel

from the highly corrosive environment. During the entire life of the new bridge, it would not be necessary to paint these elements. Crowning the towers would be a restaurant on the east tower and a museum on the west tower. When the competition concluded, the New York media erupted with interest providing articles, photos, and even good-natured cartoons about the bridge.

When the Williamsburg Bridge first opened in 1903, it was heavily criticized as lacking grace, but Mr. Buck had no references by which to gauge the proportions for this new building material, steel. However, during his early South American experience, he may have come upon a French engineer, who was there at the same time as Mr.

Buck. This Frenchman was Alexander Gustav Eiffel, whose magnificent iron tower opened at the Paris Exposition of 1889. The little fence around Buck's tower heads is reminiscent of Eiffel's treatment for his masterful, cast iron tower. 

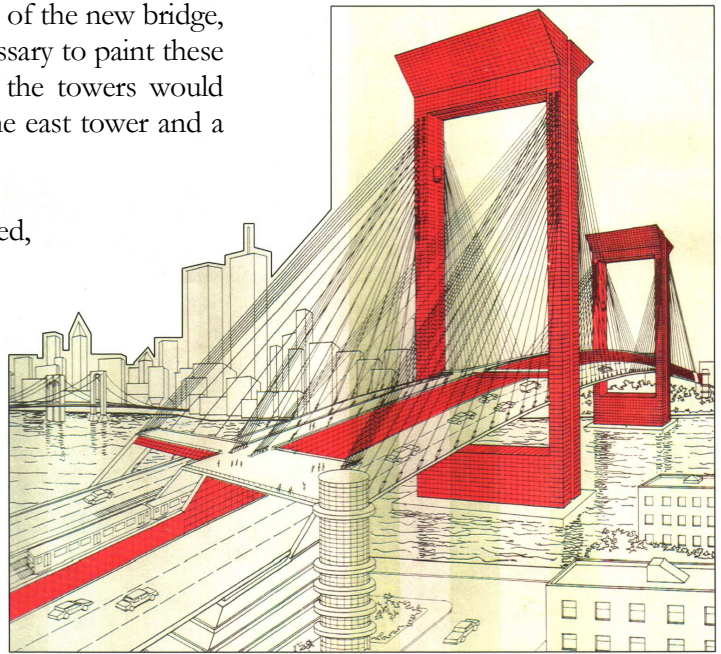


FIGURE 3: Williamsburg Bridge replacement, on existing foundations, sheathed in glass, a proposal

USF, Hillsborough County, Research Partners



FIGURE 4: Existing piles' surface cleaned



FIGURE 5: Piles wrapped above and below water



FIGURE 6: Painted, UV protected piles

In July of this year, the University of South Florida (USF) and Hillsborough County joined forces in a research study on the Friendship Trails Bridge (Old Gandy Bridge). The purpose of the study, lead by Dr. Rajan Sen and Dr. Gray Mullins, (of the Civil Engineering Department), is to determine the feasibility of using

fiber reinforced polymer (FRP) for repairing reinforced concrete piles in saltwater without cofferdams. The photos above show the FRP wrap process in 3 stages. Figure 4 shows the piles after being cleaned and prepared for the FRP wrap application. Figure 5 indicates the piles after being wrapped.

Figure 6: Voila, the finished product. Here, the piles have been painted with a protective UV coating, showing the piles' like-new appearance. To date, a total of 4 piles have been successfully wrapped and another two are planned. A detailed article featuring USF's research study and its results will be coming in a future edition of SPANS.

Guest Commentary

By Scott B. Cottrell, P.E., Colonel, U.S. Army (Ret)

Bridging and the Military – Then and Now

Bridges (or lack thereof) have often played a significant role in military history. As far back as 49 BC, Julius Caesar made his most famous decision by “Crossing the Rubicon” River Bridge to take on Pompey and the Roman Senate to become the first dictator of Rome. During the American Civil War, both sides used wooden pontoon bridges to cross men, horses, artillery pieces, caissons, and supply trains over the rivers to engage their opponent (or in some cases remove themselves from the fray). Robert E. Lee and the Confederate Army escaped to fight another day after the Battle of Gettysburg in July 1863, using makeshift pontoon bridges built with lumber from nearby warehouses. Of course, we all remember a “Bridge Too Far” at Arnhem, and crossing the Rhine River at Remagen, Germany in March 1945.

In World War II, American forces took advantage of the British-designed Bailey Bridge, to install literally hundreds of these panel bridges across the European Theater of War. Some are still in use today. The M2 Bailey Bridge is currently employed by American forces as a general engineering and temporary line of communications bridge, replacing the more mobile assault bridging that accompanies the mechanized and armored forces. The Bailey Bridge is one of the more versatile bridges available, configurable by length and strength.

In 1973, the Egyptian military gained operational surprise over the Israeli Defense Forces by crossing the Suez Canal with a new kind of float bridging, and driving deep into the Sinai Desert. Since then, the US Army has reverse engineered this Soviet-design bridge and fielded the Ribbon Bridge (RB), capable of crossing the 70 Ton M1 Abrams tank under certain conditions. The Improved Ribbon Bridge (IRB) has a military load classification (MLC) of 80. The IRB and RB are carried in folded fashion to the river on bridge trucks. The trucks then back down to the river bank, raise their beds, the sections of bridge slide into the water, and 22 foot sections pop open. US Army forces crossed the Sava River from Croatia into Bosnia with Ribbon Bridge at flood stage in 1995. This bridge was 620 meters long – one of the longest assault float bridge in the annals of military history.

Developed in the 1970’s, the Median Girder Bridge (MGB) can be built more rapidly than the Bailey Bridge. One bridge set can produce 102 feet of Class 60 bridge, and can even carry the 70 Ton M1 Abrams with some limitations. The MGB is “hand-erectable” (but really heavy, speaking as one who has helped to carry the panels) and extremely flexible. With a link reinforcement kit and two MGB sets, a gap of 160 feet can be crossed by MLC 60 loads.

Twenty one centuries ago, bridges were a vital adjunct to war for the Roman Legions. Today, as we see, war still entails the ability to take out the enemy’s most vital infrastructure, bridges, and of equal importance, the flexibility to replace bridges quickly, which gives the commander the advantage of surprise.

Coming Issues:

- Tampa Hillsborough Expressway Authority, Elevated, Reversible Segmental Roadway
- Hillsborough County’s Sunshine Skyway Bridge
- Baytown – La Port bridge over the Houston Ship Channel

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PASS-IT-ON, Please!



A Special Thanks to our Guest Commentator:

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A Special Thanks to:

An Di Nguyen, formerly with SPANS, now with the Roadway Section for initiating efforts in SPANS, and to Dr. Rajan Sen for providing FRP wrap photos.