Counterweight Repair of Historic St. Charles Air Line Bridge

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Owner
CN

Prime Contractor
Vector Construction Inc.

Repair Contractor (Sub)
Sitar Construction

Shotcrete Contractor (Sub)
R.H. Ward And Associates

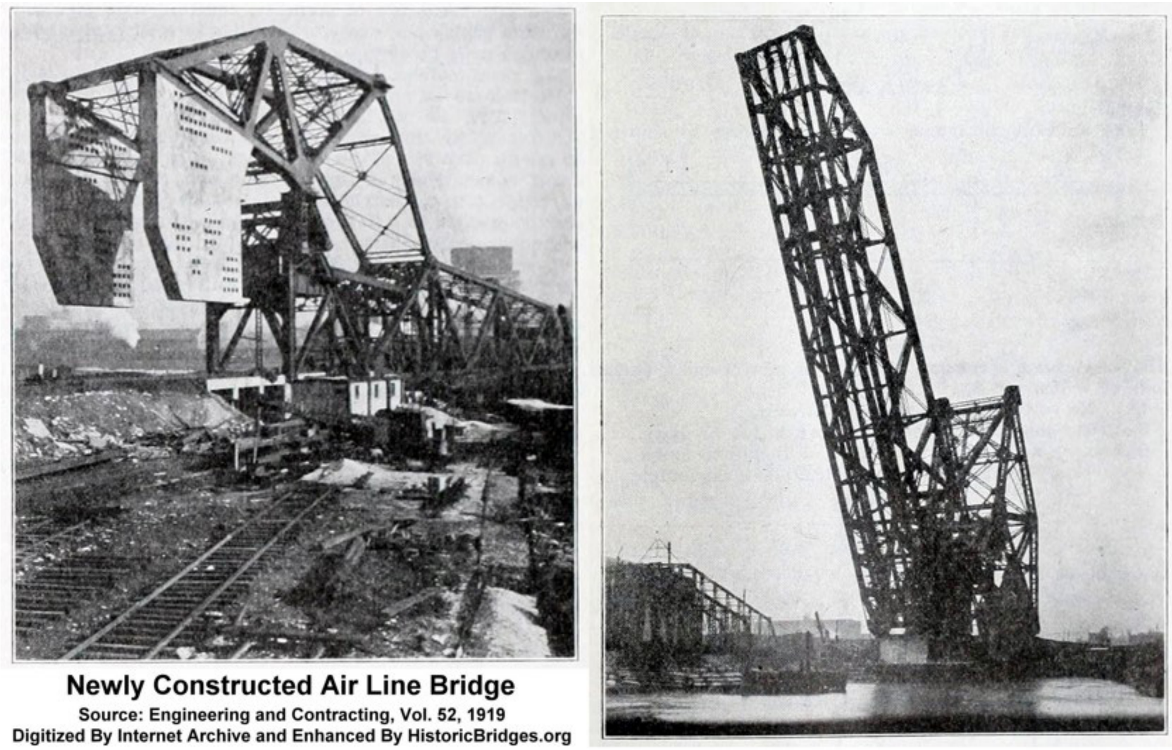

Figure 1 - Photo of St. Charles Air Line Bridge, 1919

History of the St. Charles Air Line Bridge

The St. Charles Air Line Bridge, also known as the 18th Street Railroad Bridge, is a historic single leaf bascule bridge that crosses the South Branch of the Chicago River south of Roosevelt Boulevard.

The consulting bridge engineer was Joseph B. Strauss of the Strauss Bascule Bridge Company of Chicago. Strauss was later known at the chief engineer of the Golden Gate Bridge in San Francisco. The fabricator was the American Bridge Company of New York and the erector was Ferro Construction of Chicago.

Mr. Strauss was well-known at the time for innovation in trunion bascule bridges, sometimes referred to as Chicago Bascules. The St. Charles Air Line Bridge utilized a patented heel trunion Warren through truss design with two hinges and a counterweight that moves independently from the vertical rotation of the span.

The St. Charles Air Line Bridge is a complex arrangement of rivet-connected trusses that incorporated a massive but economical concrete counterweight design in lieu of more commonly used iron counterweights. This is reportedly the first bridge where Strauss designed air buffered pistons for use on the struts. The bridge lowers

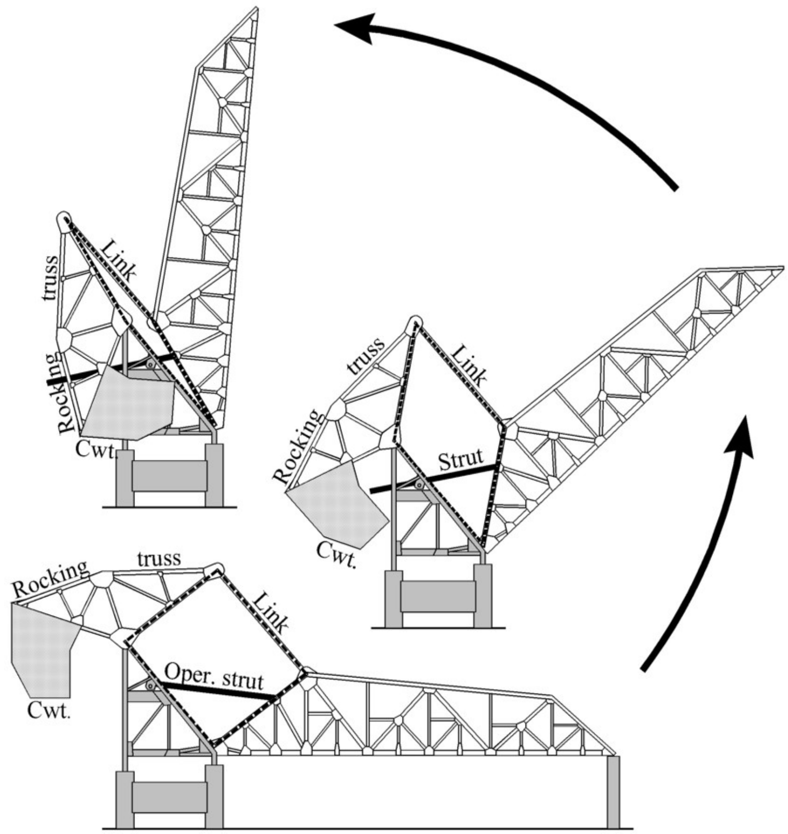

Figure 2 - Operation of the Strauss Heel Trunion Bascule Bridge

and raises to allow for boat traffic to pass on the river, taking less than 2 minutes to open or close.

An agreement between several railroad companies (Chicago, Burlington & Quincy, Chicago & Northwestern, Michigan Central, and Illinois Central Railroad) to finance and maintain the structure allowed the St. Charles Air Line Bridge to be built from 1917-1919. Once completed, the line was operated by the Illinois Central Railroad. Today the structure is maintained by CN and carries freight and passenger traffic by Amtrak.

When it was originally constructed, the St. Charles Air Line Bridge held the record as the longest bascule bridge at 260 ft. in length. However, the bridge was constructed with the foresight that it would be moved and shortened after the eastward bend in the Chicago River was straightened to make room for the construction of a railroad terminal.

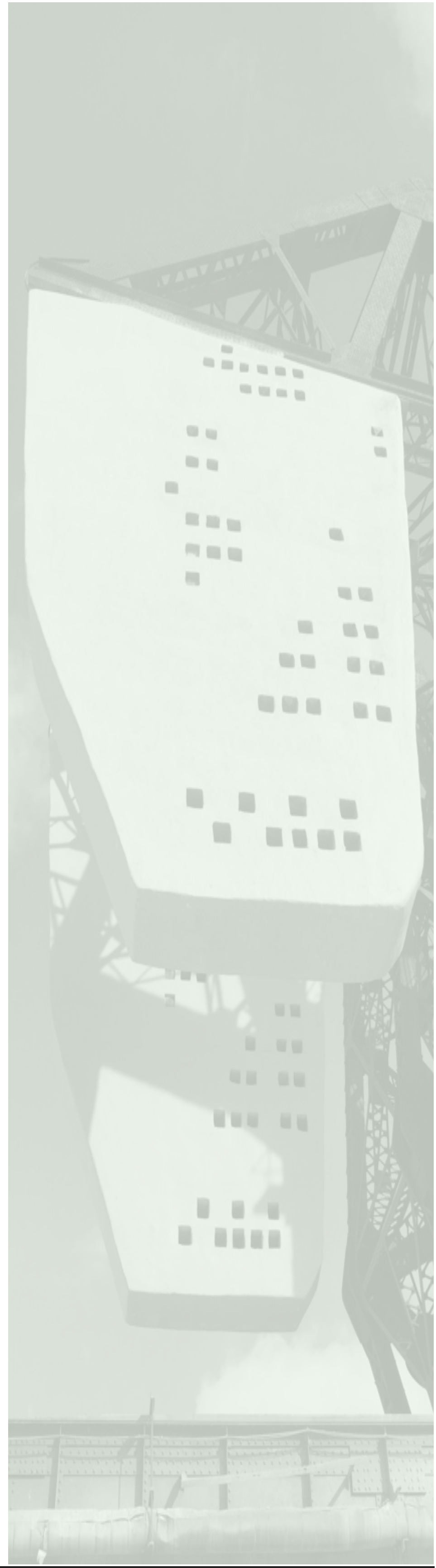

Figure 3 - The South Branch of the Chicago River was Straightened and the Bridge Relocated in 1930

The south branch was straightened between 1927 and 1929. In 1930, the bridge was moved ¼ of a mile to the west and shortened to approximately 220 ft in length to span the narrower relocated riverbed. At that time, the bridge also received newly constructed concrete counterweights to rebalance the bridge.

In December of 2007, the structure was deemed to be a Designated Chicago Landmark to commemorate its innovative design and connection to Chicago's industrial roots.

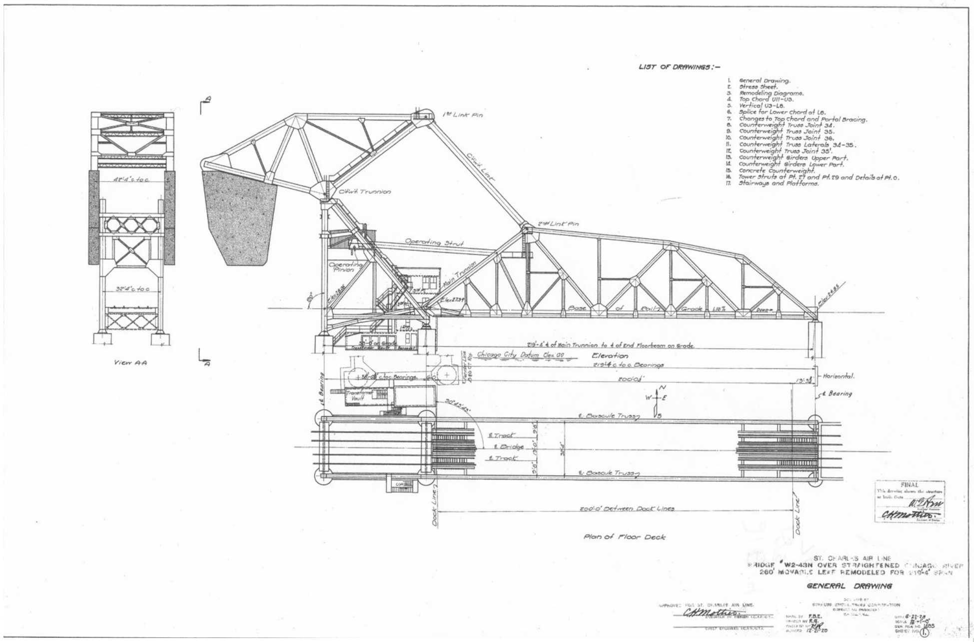

Figure 4 - Revised Plans for the Shortened Bridge

Concrete Counterweights

When the bridge was relocated in 1930, new concrete counterweights were installed to accommodate the shortened 219' 4" span. The two 'winged' counterweights provide for balancing and smooth operation of the bridge and consist of concrete slabs weighing 885 tons each at an estimated concrete unit weight of 148 lb./ft3. The concrete counterweights, cast integral with the rocking truss, were viewed as an innovative feature as they were more economical than a single block iron counterweight.

Each counterweight has similar dimensions at 56' 6" high, width varying from 10'-40', and 6' thick. Together, they account for approximately 9,000 ft2 of surface area and 1,770 tons of concrete

The concrete counterweight contains a series of square apertures, rectangular through-pockets in which adjustment blocks are added to obtain the exact weight required to balance the bridge. The original contractor was responsible for providing sufficient blocks to initially balance the bridge plus 100 extra for future use. Additional adjustment blocks can be added over time if required due to changes in bridge weight from modifications, painting or maintenance.

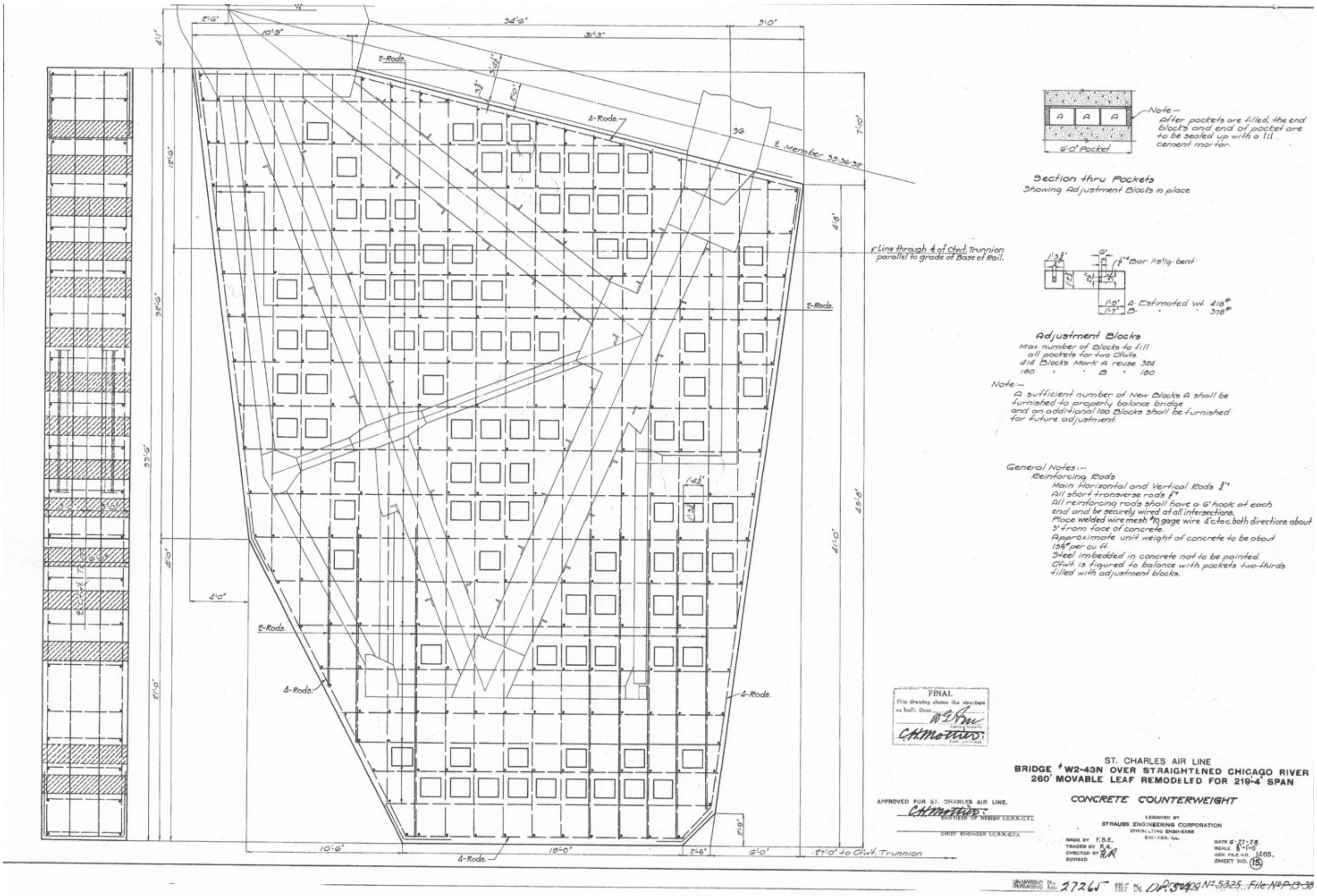

Figure 5 - Revised Counterweight Design for the Shortened Bridge, 1930

Concrete Deterioration & Repair History

The concrete counterweights are subject to surface scaling and freeze-thaw damage. Deteriorating and falling concrete is a safety hazard to people and property below and can cause the bridge to be out-of-balance, thus not raising or lowering in a smooth fashion.

The counterweights have seen a series of previous concrete repair projects in 1949 and 1987 when the repairs were typically directed toward fixing cracked and crumbling concrete on the edges of the counterweights.

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Figure 6 - Condition of the Winged Concrete Counterweight

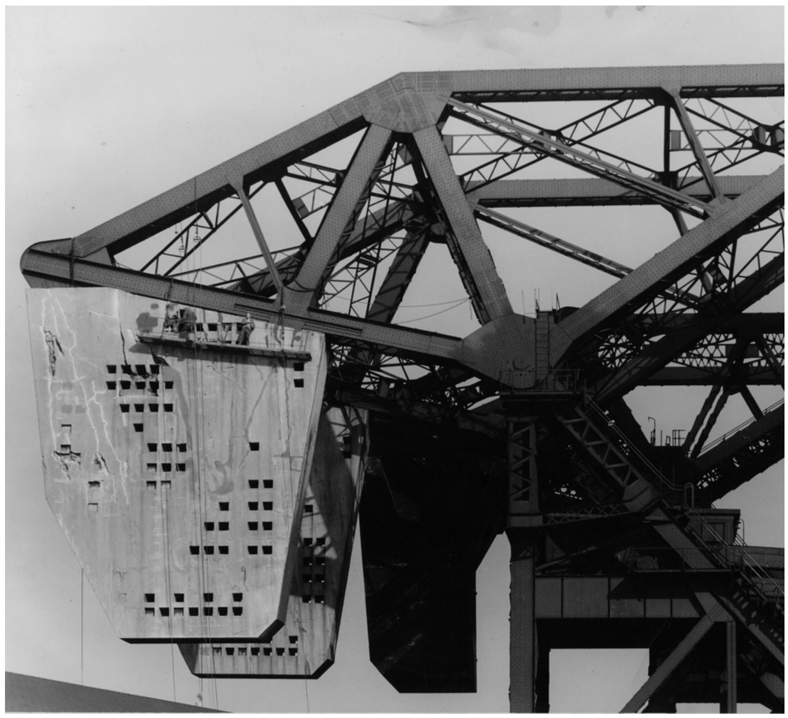
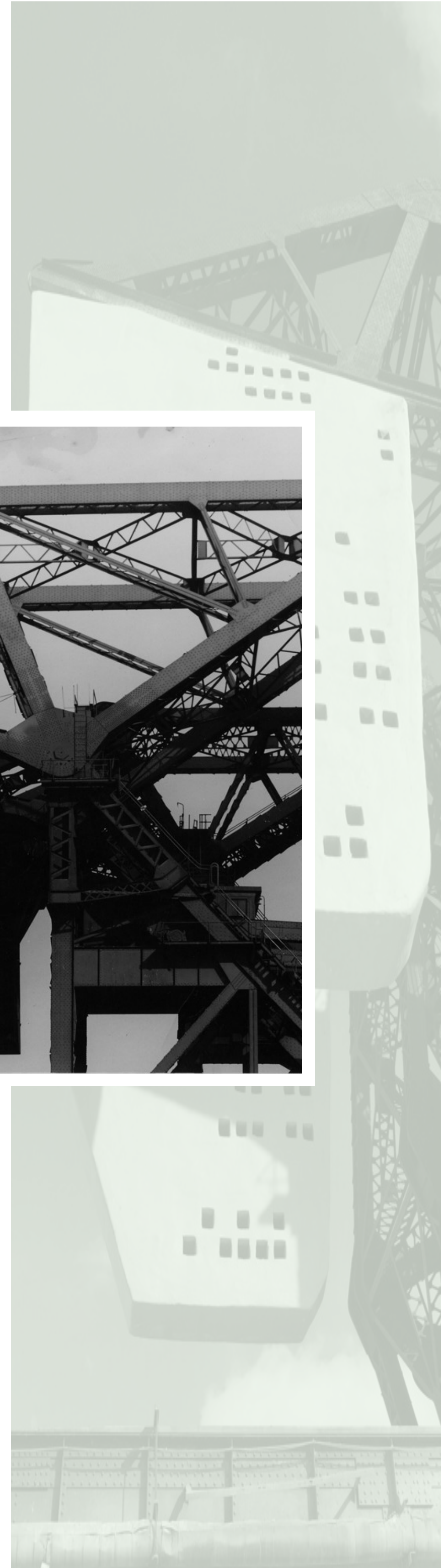


Figure 7 - Concrete Repair Process circa 1949



However, the deterioration continued to advance over time leading CN to implement a new plan to repair and protect the entire counterweight surface. This time, a majority of the counterweight surface would be repaired then the entire surface strengthened and protected with a surface-applied FRP system.

This plan was executed via separate contracts in 2011 and 2014. The 2011 project scope was to repair the outer counterweight surfaces and the 2014 project included the inner counterweight faces and the FRP system addition.

Project Challenges

To manage the project risk, the railway selected a concrete repair team with significant experience in concrete repair, shotcrete and application of structural strengthening systems and also had previously completed successful concrete repair projects for Canadian National Railway.

The St. Charles Air Line Bridge repair project presented unique challenges to the concrete repair team.

- The bridge had to remain operational with the ability to accommodate unscheduled rail traffic, many times with only 1 to 2 hours notification

- The contractor had to maintain the counterweight balance to allow raising and lowering the bridge

- The repair team was working on or near active tracks, an active roadway and in an active rail yard so planning and safety were of utmost concern.

- Repair heights up to 110’

- Liquidated damages of $1,000 per 15 minutes of train delays

The repairs were completed using a regular nightly schedule to work during a 10-hour window when there was less train traffic including no Amtrak trains and no river traffic. In order to maintain the bridge balance, a maximum of 3 cubic yards of concrete could be removed at one time.

Nightly Schedule for Concrete Repairs

22:00 Last Amtrak train

22:30 Road closed and equipment set up

23:00 Concrete demo, maximum 80 ft2

02:00 Sandblast repair cavity

03:00 Place supplemental steel (2”x2” galvanized WWF)

04:00 Wet Mix Shotcrete Placement

07:00 Clean-up

08:00 Bridge open for first scheduled train

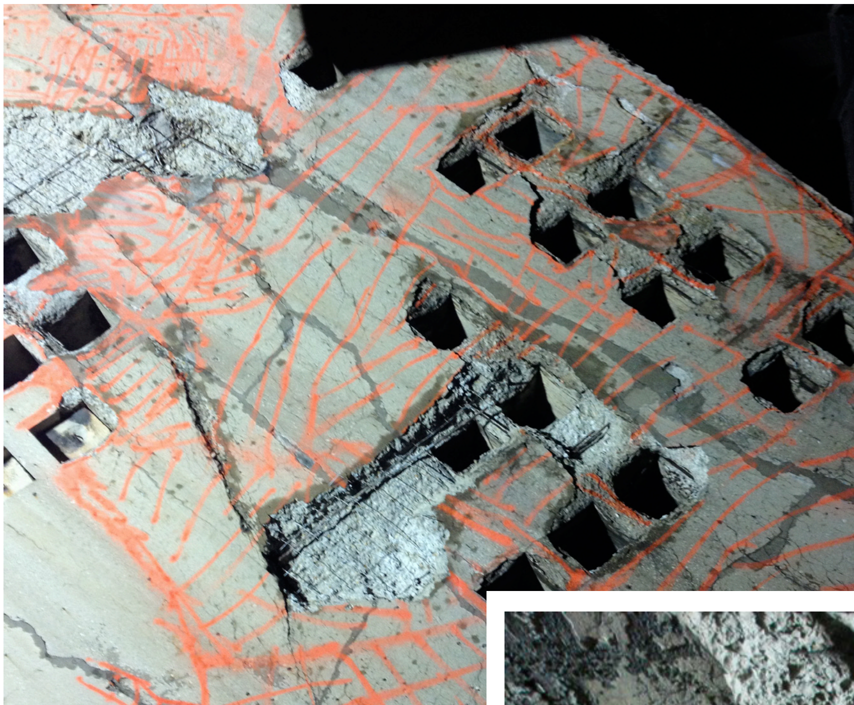


Figure 8 - The 21st Century Repair Plan Required Approx. 9,000 ft² of Surface Repairs

Figure 9 - Concrete Removal was Limited to 3 yd³ to Maintain Balance During Repairs

Figure 10 - The Depth of Concrete Repair was 10-12"

Figure 11 - The Bridge was Raised at Night to Allow Counterweight Access by Boon Lift

Based on previous experience, the repair depths were expected to be 10-12". Each evening the bridge would be raised to lower the counterweight working height allowing access to the bridge by a boom lift with a platform height of 80'. Vehicular traffic was detoured to create safe working conditions.

Figure 12 - Installation of 2"x2" Galvanized Welded-Wire Fabric

Wet mix shotcrete was selected as the repair method using custom-designed equipment that allows for vertical pumping and placement at heights up to 100'. The pressure pump contains internal agitators to keep the wet mix shotcrete fluid and allows for instant on/off control by the nozzleman.

Figure 13 - Wet Mix Shotcrete was Selected for the Repairs

A prepackaged wet shotcrete mix was selected for the repairs as it offered the convenience of reduced material handling as well as excellent product quality. The selected shotcrete was a superplasticized 5,000 psi mix, 20% added 3/8" pea gravel, with accelerator added at the nozzle. After the shotcrete was replaced, it was cut back and finished level with the existing counterweight surface.

Figure 14 - 2014 Repairs in Progress

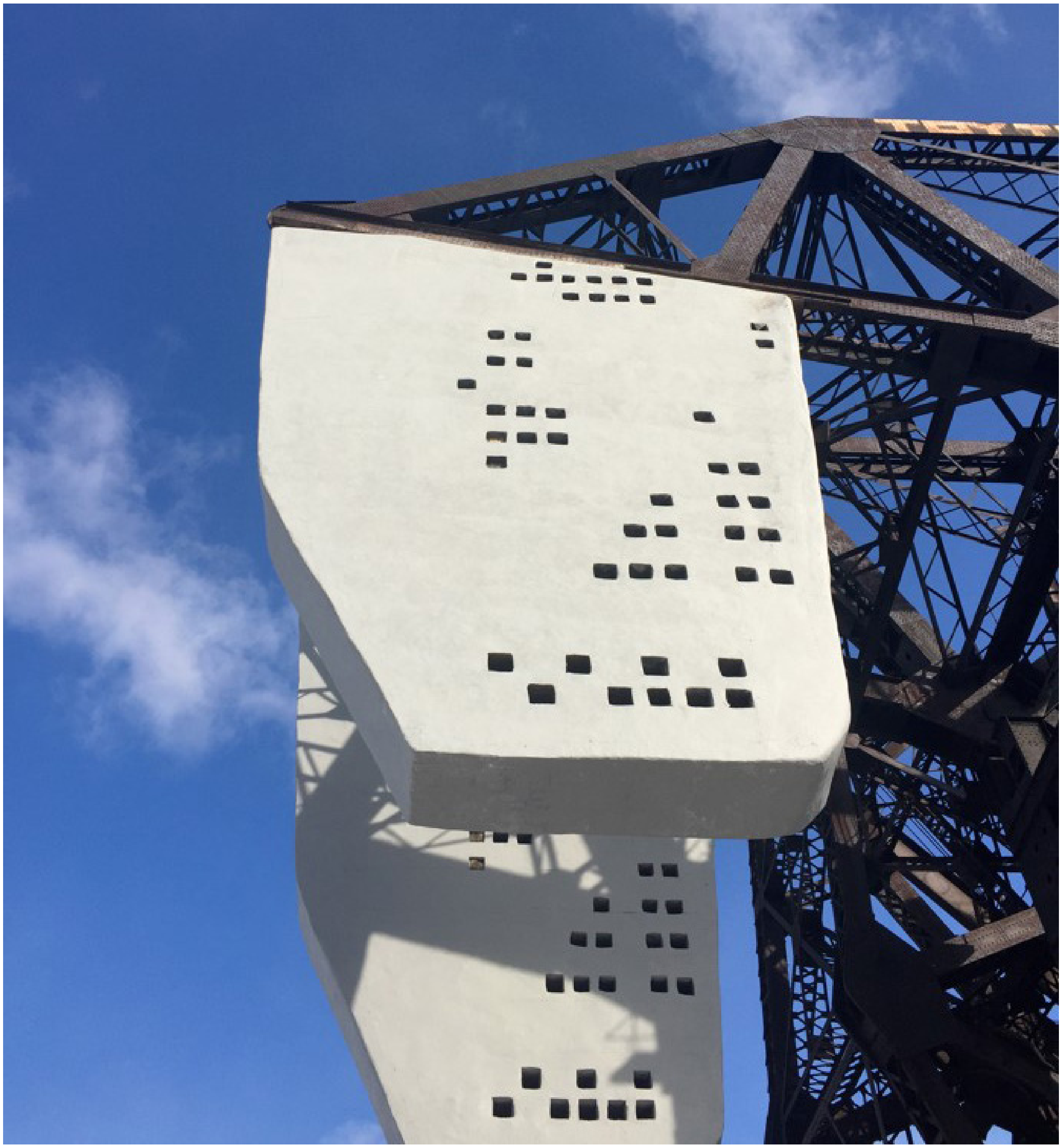


Figure 15 - The Completed Repair With Surface Applied FRP and a Light Gray Acrylic Topcoat

Strengthening and Protection

To extend the life of the repairs, CN specified that a surface-applied FRP system be installed. The installed system was a bi-directional g lass fiber system with a protective water-based acrylic top coat. Approximately 9,000 ft2 of FRP was used to encase and protect the counterweights.

The application of the FRP system faced the same challenges as the shotcrete repairs with a restricted nighttime work schedule, the potential for unscheduled rail traffic, and maintaining the operational capabilities of the bridge.

Summary

Over a 5 month project duration, the inner counterweight surfaces were repaired with 6,000 cubic feet of wet mix shotcrete and 100% of the counterweights' surface area was protected with glass fiber FRP. The project was successfully executed with no injuries, accidents, delays or damage to the owner's property while maintaining an operational and balanced bridge.

The historic St. Charles Air Line Bridge was repaired and protected with 21st Century materials and methods. The refurbished single leaf bascule rail bridge will continue to stand as a symbol of Chicago's industrial heritage while providing an interesting contrast to Chicago's modern skyline.