Counterweight Repair of Historic St. Charles Air Line Bridge

Chicago, IL

Submitted by Vector Construction

Fig. 1: St. Charles Air Line Bridge, 1919

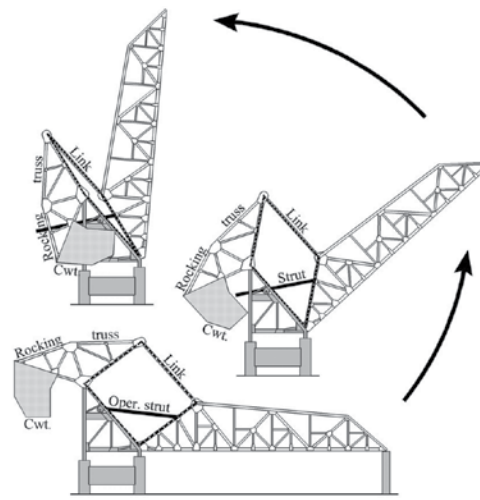

Fig. 2: Operation of the Strauss Heel trunnion bascule bridge

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 (Fig. 1).

The Consulting Bridge Engineer was Joseph B. Strauss of the Strauss Bascule Bridge Company of Chicago, IL. Strauss was later known as the Chief Engineer of the Golden Gate Bridge in San Francisco, CA. The fabricator was the American Bridge Company of New York, NY, and the erector was Ferro Construction of Chicago, IL.

Strauss was well-known at the time for innovation in trunnion bascule bridges, sometimes referred to as Chicago Bascules. The St. Charles Air Line Bridge used a patented heel trunnion Warren through truss design with two hinges and a counterweight that moves independently from the vertical rotation of the span (Fig. 2).

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 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 to 1919. Once completed, the line was operated by the Illinois Central Railroad. Today, the structure is maintained by the Canadian National Railway Company (CN) and carries freight and passenger traffic by Amtrak.

Fig. 3: The south branch of the Chicago River was straightened and the bridge relocated in 1930

When it was originally constructed, the St. Charles Air Line Bridge held the record as the longest bascule bridge at 260 ft (79 m) in length. The bridge was also 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.

The south branch was straightened between 1927 and 1929 (Fig. 3). In 1930, the bridge was moved one-quarter of a mile (0.4 km) to the west and shortened to approximately 220 ft (67 m) 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.

CONCRETE COUNTERWEIGHTS

When the bridge was relocated in 1930, new concrete counterweights were installed to accommodate the shortened span (Fig. 4). The two "winged" counterweights provide for balancing and smooth operation of the bridge and consist of concrete slabs weighing 885 tons (803 tonnes) each, at an estimated concrete unit weight of 148 lb/ft^3 (2371 kg/m^3). The concrete counterweights, cast integral with the rocking truss, were viewed as an innovative feature because they were more economical than a single-block iron counterweight.

Each counterweight has similar dimensions at 56.5 ft (17 m) high, widths varying from 10 to 40 ft (3 to 12 m), and 6 ft (1.8 m) thick. Together, they account for approximately 9000 ft^2 (836 m^2) of surface area and 1770 tons (1606 tonnes) 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, and 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.

REPAIR HISTORY AND CONCRETE DETERIORATION

The counterweights have seen a series of previous concrete repair projects in 1949 (Fig. 5) and 1987 when the repairs were typically directed

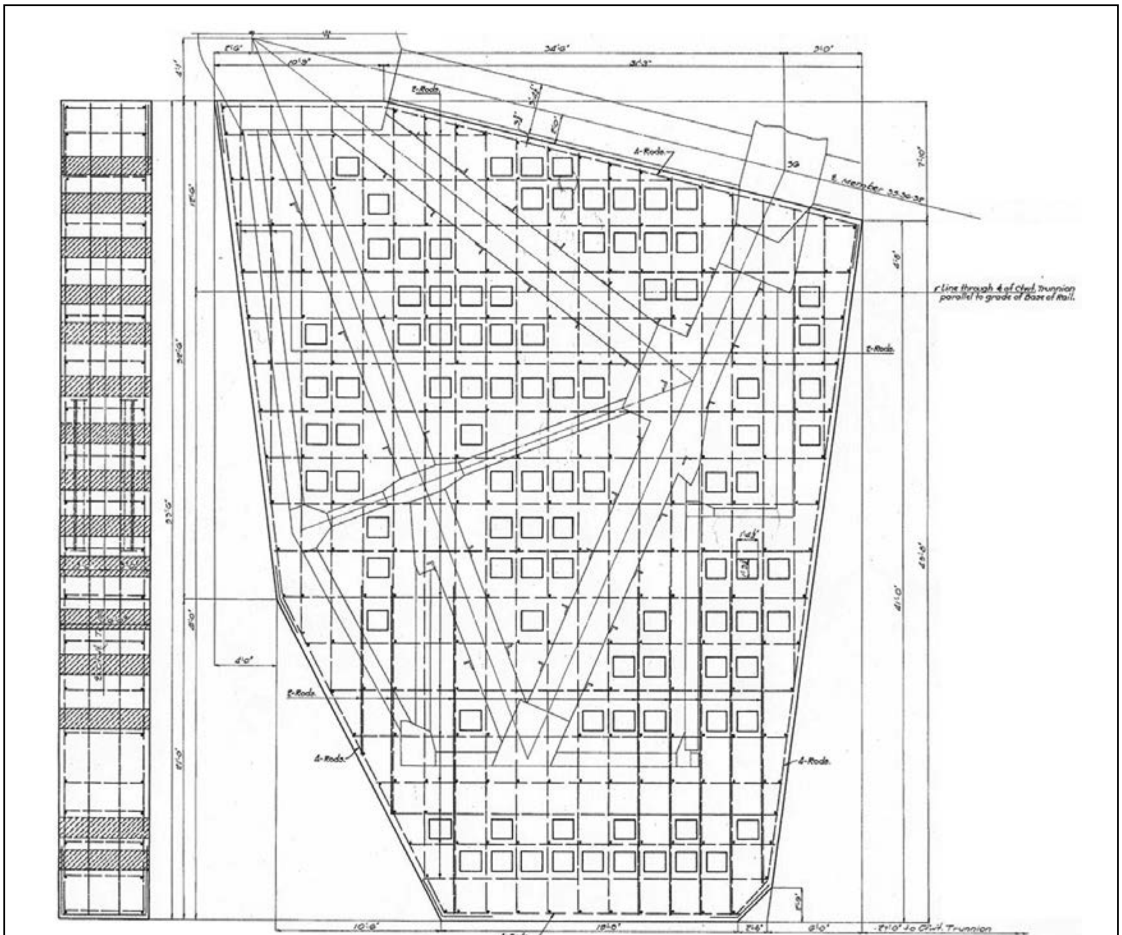

Fig. 4: Revised counterweight design for the shortened bridge, 1930

toward fixing cracked and crumbling concrete on the edges of the counterweights.

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, and the entire surface strengthened and protected with a surface-applied fiber-reinforced polymer (FRP) system.

The concrete counterweights exhibited surface scaling and freezing-and-thawing damage (Fig. 6 and 7). Deteriorating and falling concrete was a safety hazard to people and property below and could cause the bridge to be out of balance, thus not raising or lowering in a smooth fashion.

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

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 had previously completed successful concrete repair projects for CN.

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

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

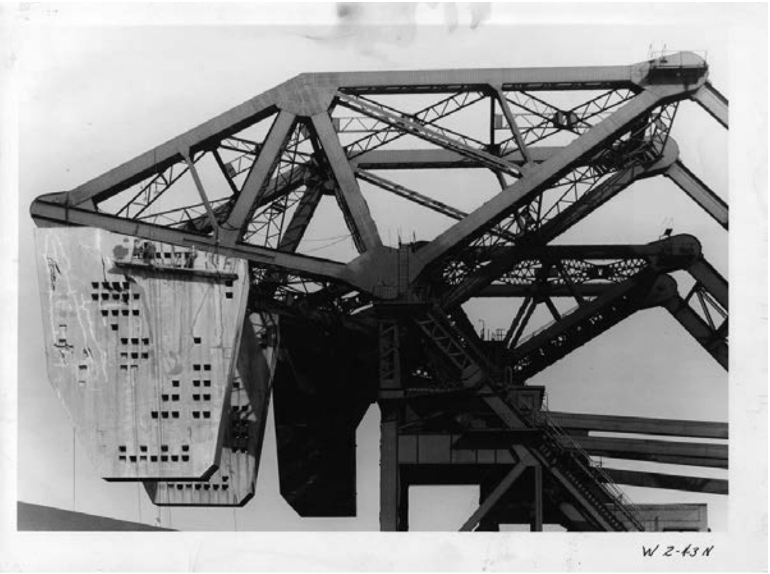

Fig. 5: Concrete repair process, circa 1949

- The contractor had to maintain the counterweight balance to allow for raising and lowering the bridge;
- Planning and safety were of utmost concern, as the repair team was working on or near active tracks, an active roadway, and in an active rail yard;
- Repair heights were up to 110 ft (33.5 m); and
- Liquidated damages of $1000 per 15 minutes were in effect for train delays.

The repairs were completed using a regular nightly work schedule, during a 10-hour window when there was less train traffic, including no Amtrak trains, and no river traffic (refer to Table 1). To maintain the bridge balance, a maximum of 3 yd^3 (2.3 m^3) of concrete could be removed at one time (Fig. 8).

Fig. 6: Condition of the winged concrete counterweight

Fig. 7: The plan required approximately 9000 ft^2 (836 m^2) of surface repairs

TABLE 1: NIGHTLY SCHEDULE FOR CONCRETE REPAIR WORK

22:00 p.m.	Last Amtrak train
22:30 p.m.	Road closed and equipment set up
23:00 p.m.	Concrete demolition, maximum 80 ft^2 (7.4 m^2)
02:00 a.m.	Sandblast repair cavity
03:00 a.m.	Place supplemental steel (2 x 2 in. [50 x 50 mm] galvanized welded-wire fabric [WWF])
04:00 a.m.	Wet-mix shotcrete placement
07:00 a.m.	Clean-up
08:00 a.m.	Bridge open for first scheduled train

Fig. 8: Concrete removal was limited to 3 yd^3 (2.3 m^3) to maintain balance during repairs

Fig. 9: The bridge was raised at night to allow counterweight access by boom lift

Based on previous experience, the repair depths were expected to be 10 to 12 in. (250 to 305 mm). Each evening, the bridge would be raised to lower the counterweight working height, allowing access to the bridge by a boom lift (Fig. 9) with a platform height of 80 ft (24 m). Vehicular traffic was detoured to create safe working conditions.

Wet-mix shotcrete was selected as the repair method (Fig. 10) using custom-designed equipment that allowed for vertical pumping and placement at heights up to 100 ft (30 m). The pressure pump contained internal agitators to keep the wet-mix shotcrete fluid and allow for instant on/off control by the nozzleman.

A prepackaged wet shotcrete mixture was selected for the repair material, as it offered the convenience of reduced material handling as well as excellent product quality. The selected shotcrete material was a superplasticized 5000 psi (34.5 MPa) mixture, 20% addition of 3/8 in. (9.5 mm) pea gravel, and accelerator added at the nozzle. After the shotcrete was placed, it was cut back and finished level with the existing counterweight surface (Fig. 11).

STRENGTHENING AND PROTECTION

To extend the life of the repairs, CN specified that a surface-applied FRP system be installed on the counterweights. The installed system was a bidirectional glass-fiber system with a protective water-based acrylic topcoat (Fig. 12). Approximately 9000 ft^2 (836 m^2) 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

Fig. 10: Wet-mix shotcrete was selected for the repair material

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 6000 ft^3 (170 m^3) of wet-mix shotcrete and 100% of the counterweights' surface area was protected with glass 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 twenty-first-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.

Fig. 11: 2014 repairs in progress

St. Charles Air Line Bridge

OWNER
CN
Homewood, IL

REPAIR CONTRACTOR (PRIME)
Vector Construction, Inc.
Decatur, IL

REPAIR CONTRACTOR (SUB)
Sitar Construction
St. Charles, IL

SHOTCRETE CONTRACTOR (SUB)
R.H. Ward and Associates
South Chicago Heights, IL

MATERIAL SUPPLIERS/MANUFACTURERS
Sika Corporation
Lyndhurst, NJ

JE Tomes & Associates
Blue Island, IL

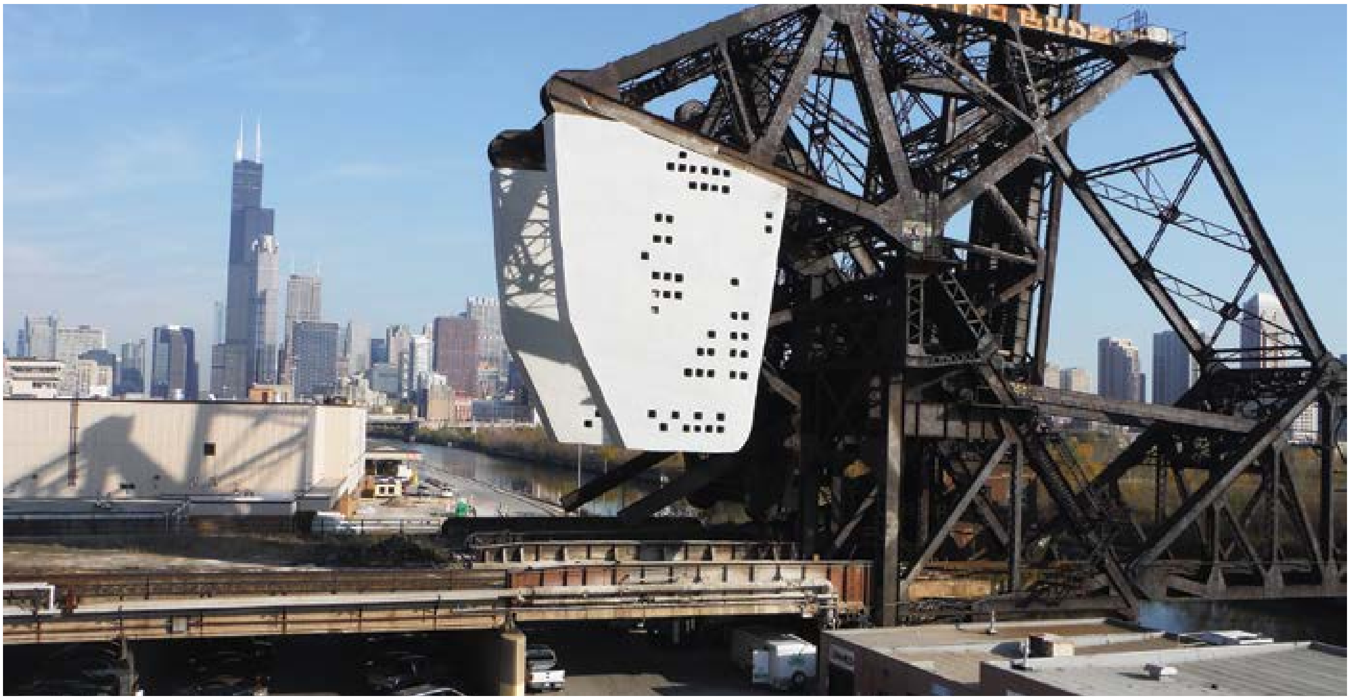

Fig. 12: The repaired counterweights with surface-applied FRP and a light gray acrylic topcoat