

BRIDGE CONSTRUCTION

BY CHRISTOPHER J. MENNA, P.E.
CONTRIBUTING AUTHOR

Sound Investment

One-of-a-kind bridge's reconstruction includes numerous challenges

The 42nd Street Bridge over Amtrak and Norfolk Southern is a three-span, through-deck, concrete-filled steel arch bridge. Built just after the turn of the century, this one-of-a-kind bridge spanned over a very busy Pennsylvania Railroad rail bed and led into an affluent section of West Philadelphia—the home of the 1876 Centennial Exposition.

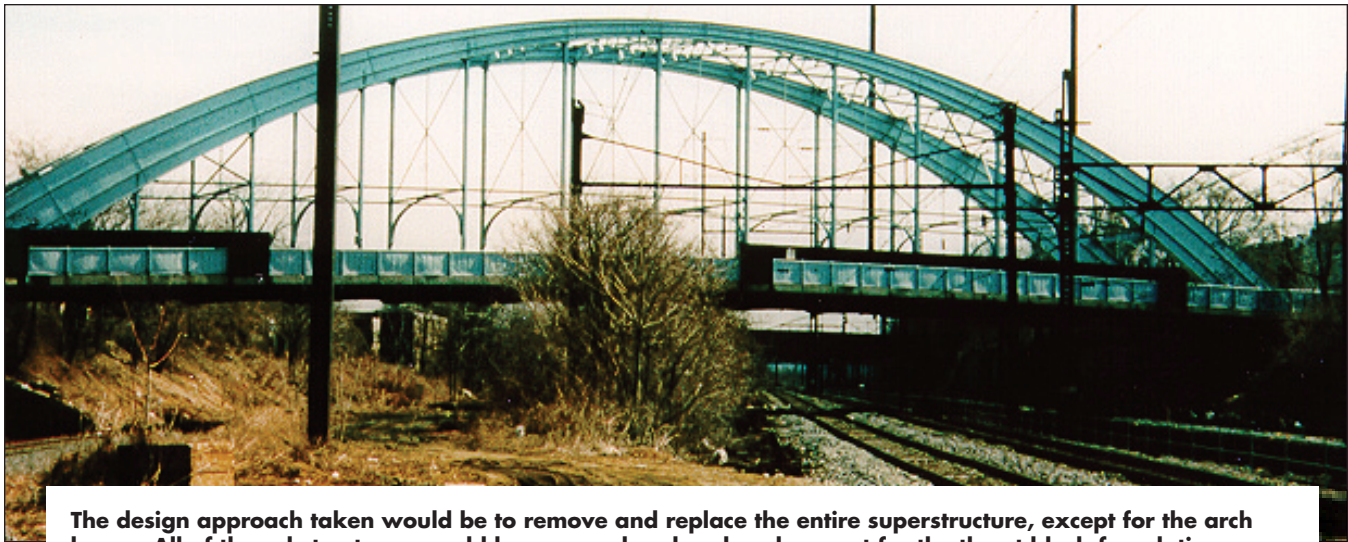
In addition to classical and graceful architectural features, the bridge demonstrated innovative dampening design within the arch boxes that required concrete placement into the same structural elements via access ports. The main span is supported by two variable-depth steel-box sections terminating into massive con-

crete thrust blocks at the ends. The arch boxes are braced by transverse trusses and by diagonal bracing within each bay. The deck in turn is supported by I-beam hangers and transverse, tapered floorbeams. Between the floorbeams are longitudinal stringers. Additional stiffness is provided by transverse X bracing be-

tween the hangers, transverse decorative canopy bracing, longitudinal struts between the hangers and by portal bracing at each entrance to the bridge.

Challenges abound

During 1993 and 1995, the city of Philadelphia Bridge Section per-



The design approach taken would be to remove and replace the entire superstructure, except for the arch boxes. All of the substructures would be removed and replaced, except for the thrust block foundations.

formed in-depth inspections to develop rehabilitation and reconstruction strategies.

The major findings were as follows:

- Moderate to severe underside concrete encasement spalling of the floorbeams and stringers;
- Moderate to severe underside concrete spalling of the deck jack arches;
- Recurring vehicular collision damage to the vertical deck hangers;
- Recurring vehicular collision damage to the decorative canopies;
- Moderate spalling of the drivable concrete deck surfaces;
- Seized and malfunctioning expansion dams and bearings;
- Inadequate bridge lighting;
- Moderately to severely corroded aerial steel, except for arch boxes; and
- Failure of the paint system applied to the aerial steel, except for the arch boxes.

The design approach taken would be to remove and replace the entire superstructure, except for the arch boxes. Likewise, all of the substructures would be removed and replaced as well, except for the thrust block foundations. All of the work was

envisioned to take place within a fenced-off area for the closed bridge. Work would be done in shifts, where required, and would be coordinated with Amtrak, SEPTA and PECO Energy. Fortunately, there were no utilities on the bridge.

In keeping with the uniqueness and historic character of this bridge, the design team faced numerous challenges. Since the majority of the steel-deck members would be replaced in kind, one of the immediate concerns was whether we could weld to the original steel. In-house material sampling by the city's lab determined that the existing steel contained many impurities, most notably silicon. It was determined that welding new steel to the old would not be feasible and should be avoided wherever possible. Field drilling and bolting would be used in lieu of welding.

Something had to be done to protect the deck hangers from repeated hits. In fact, two hangers were so bad that they had to be totally replaced and spliced just below the underside of the arch boxes. Since a standard curb would not be sufficient, a decision was made to employ a Maine DOT tubular steel barrier system curbside to protect the hangers. The barrier system selected incorporated

9-in.-tall curbs in the system.

Similar to the hangers, the decorative, transverse steel canopies were being hit on a regular basis. To solve this problem, a 14-ft-high clearance envelope was selected. The envelope would cross the entire cartway and would include the radial corners of the canopies. Raising the end canopies involved a check on the bracing length of the arch members and was found to be acceptable. This enabled us to retain the handsome look of the braces while providing adequate clearance.

At the time of original construction, back-to-back double angles and built-up members were in extensive use. Maintenance of these members is very difficult, time-consuming and costly—specifically where blasting and painting are involved. The design team decided to use modern, equivalent WT sections and angles wherever possible. The new steel would be easier to maintain, would not trap water and would drain more easily.

Another challenge would be to redesign the stub hanger to arch box connection at the point where the deck meets the arch boxes. Clearance at this location was very tight. We needed strong, short steel members that could fit into a small area.

We also were looking for a member that had good section properties and one that could bolt well to the existing arch boxes. In addition, we would have to build out from the arch box web to clear the arch box stiffeners. The solution was a member type not typically used by our office: square tubular steel. The square tubing satisfied all of the requirements.

It was noted that the condition of the arch box paint coatings was very good. We also wanted to avoid costly full-containment blasting over a very active railbed. The design team liaised with PennDOT's chief chemist and decided to use the overcoating method for the arch boxes. An organic zinc system was used for the overcoating of the arch sections and remaining existing steel, while an inorganic zinc system was employed for all new steel. The results were an economical and high-performance paint system.



The rehabilitation of the 42nd Street Bridge was a sound investment. First and foremost, it restored a historic landmark.

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Lights were evenly spaced across the main span and were mounted higher and directly to the hangers.

With such a large span, lighting was an issue at night. The existing bridge had only two lights toward the center of the structure. The existing lights were low and were not hidden well within the aerial bracing. Four new lights would be evenly spaced across the main span. These lights would be mounted much higher and directly to the hangers. Also, the conduit runs from the lights would be hidden at the columns and behind the aerial struts to promote aesthetic appeal.

Of course, many other historic requirements had to be met. Once we sampled the original paint color in the city's lab, we were able to find a suitable modern-day color. All of the bracing would have to be replaced in kind as much as possible. Redesigning the decorative bracing was not easy, as they included lots of complex layout geometry and multiple member types. Lastly, where rivets were slated for removal,

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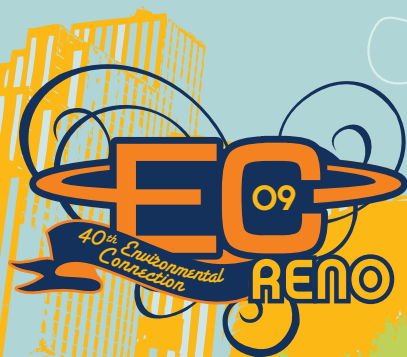
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they had to be replaced with a historic-looking bolt. The bolts chosen included rounded rivets at both ends. The actual bolt head featured a twist-off mechanism—set to go off when a certain torque was achieved by the ironworker.

A learning experience

The project would be loaded with interesting construction challenges as well. Regarding stability of the arch boxes, the contractor was not allowed to remove and replace more than one transverse bay at a time. Each bay also featured diagonal bracing on each side, following the profile of the arch boxes. The contractor had to carefully schedule his work to meet this requirement.

Stability had to be maintained at all times to resist wind forces and to keep the arch boxes in alignment. The price per pound to furnish and install the aerial steel was very high

for this project—in the order of \$25 to \$30 per pound. This was due to two main reasons.

The first was that all existing steel had to be re-measured and confirmed by the general contractor at the beginning of the job. The second was due to the necessity to have an onsite miscellaneous fabrication shop during construction. The shop allowed for ease and quickness in replacing gusset and other types of connection plates.

As mentioned previously, extensive field drilling and reaming would be required on this project. Drills with magnetic setups would be used. Also, many of the holes were exceptionally long—especially through the arch boxes. The arch boxes were made up of two thick webs, as well as a thick composite concrete core. The extensive drilling operations surely added cost to the steel work.

Fabrication and inspection of the

historic-looking railings and protective barrier proved to be a challenge as well as a learning experience for all. Intricate aluminum work cannot be inspected the same way as steel. Inspection methods had to follow those of other commercial consumer products. And these items had to be installed piece by piece along the bridge to ensure that all vertical elements were plumb and all horizontal items followed grade. Erection crews had to work on each side of the bridge and work from one end to the other.

The rehabilitation of the 42nd Street Bridge was a sound investment in this West Philadelphia neighborhood for many reasons. The project restored a historic landmark, generated short-term and long-term economic development and provided hope for the citizens in this resurging locale. The most direct route through the neighborhood was restored as



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bridge will continue to serve and delight the public for many years to come. 

Menna is with the city of Philadelphia, Streets Department, Bridge Section.



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