PROJECT

Coplay-Northampton Bridge: Innovative Rehabilitation of a Historic Pennsylvania Structure

by Thomas J. McNavage Jr., AECOM

This project involves the rehabilitation of the existing seven-span viaduct structure carrying State Route 7404 (Chestnut Street) over the Lehigh River, Norfolk Southern Railroad, Bridge Street, and the Ironton Rail Trail in the boroughs of Coplay, Lehigh County, and Northampton, Northampton County, Pa. Almost nine decades after its construction in 1930, the historic structure required rehabilitation due to significant deterioration, inadequate load-carrying capacity, and public safety concerns.

At the time of its closure, the existing bridge carried approximately 11,000 vehicles per day. It also had two sidewalks for pedestrian traffic, but one sidewalk was already closed due to significant deterioration of the concrete railing. Rampant spalling of the concrete encasement of the steel girder–floorbeam spans necessitated the installation of a canopy to protect users of the Ironton Rail Trail, which crosses under the structure. Deteriorated components of the concrete arch spans led to a reduced load-carrying capacity that required load posting of the existing bridge. Additionally, a collapsed drainage culvert on the east side prompted sinkhole concerns, which would need to be addressed in the design of the rehabilitated structure. The rehabilitated structure was designed to take advantage of the newest available technology to produce a nearly maintenance-free structure type.

Aerial photo of the original Coplay-Northampton Bridge (constructed circa 1930). The existing bridge was eligible for listing in the National Register of Historic Places because it included three structure types typical of the era. Photo: Ann Bartholomew, Delaware and Lehigh Canals. Easton, Pa.: Center for Canal History and Technology.

Site-Related Challenges

The rehabilitation project faced substantial challenges related to site constraints and the historic significance of the original structure. The approaches of the 1116-ft-long existing bridge were located adjacent to relatively

profile

COPLAY-NORTHAMPTON BRIDGE / BOROUGHS OF COPLAY AND NORTHAMPTON, PENNSYLVANIA

BRIDGE DESIGN ENGINEER: AECOM, Conshohocken, Pa.

GEOTECHNICAL ENGINEER: Dawood Engineering, Inc., Harrisburg, Pa.

PRIME CONTRACTOR: Trumbull Corporation, Pittsburgh, Pa.

PRECASTER: Northeast Prestressed Products, Cressona, Pa.—a PCI-certified producer

POST-TENSIONING CONTRACTOR: DYWIDAG-Systems International, Bolingbrook, Ill.

closely spaced buildings. Retained fill approaches of 206 ft and 94 ft on the west and east ends, respectively, connected the existing bridge to the intersections of Chestnut Street and Front Street in Coplay and 9th Street and Main Street in Northampton. The existing structure was eligible for listing in the National Register of Historic Places because it was composed of three distinct structure types in use at the time of construction: a 350-ft-long three-span steel girder–floorbeam system on the western approach, three concrete arch spans in the 548-ft-long main unit over the river, and a single-span 218-ft-long steel truss on the eastern approach.

Combining the Old with the New

The project involved an elaborate superstructure replacement and is considered to be a structure rehabilitation because it retained significant portions of the existing substructure units. The existing steel girder-floorbeam spans were replaced with prestressed concrete PA bulb-tees made continuous for live load. The existing single-span steel truss was replaced with two spans of prestressed concrete PA bulb-tees also made continuous for live load over the new reinforced concrete pier founded on micropiles. The arch spans were replaced with fully continuous spliced prestressed concrete PA bulb-tee units—the first use of this structure type in Pennsylvania. This technology was chosen for use at this location because of the desire to retain the existing pier footings for the river spans and the recent approval of spliced prestressed concrete girder standards by the Pennsylvania Department of Transportation (PennDOT).

The design team believed it would be advantageous to reuse the existing, massive (21 by 64 ft in plan, and nearly 30 ft deep) concrete footings of the river piers if they were structurally sound. Concrete testing of the pier footings was performed, and the concrete was found to be in excellent condition, with a compressive strength of 10 ksi and minimal chloride contamination. Retaining the existing pier footings saved considerable time and expense.

Testing indicated that the existing piers could be incorporated into the rehabilitated structure. Dowels were installed to tie the new pier to the existing footings. Retaining the existing pier footings saved considerable time and expense. Photo: AECOM.

The river spans were 181, 181, and 186 ft long, from west to east. Initially, these span lengths were considered too long for the use of prestressed concrete beams, so a steel superstructure was proposed. However, standards for spliced precast, prestressed concrete beams had been recently approved by PennDOT, prompting the design team to evaluate that structure type as an alternate. Ultimately, the team concluded that precast concrete would be economically competitive.

Shipping considerations such as truck-turning radius and vertical clearance limited the girder segments to 125 ft 0 in. in length and a maximum depth of 115 in. Seven beam segments were originally proposed for each fully continuous beam, with a total of five beams ranging in depth from 79 in. to 115 in. over the piers. During construction, the number of segments was reduced to five after alternate shipping routes were identified. Beam segments were delivered to the project

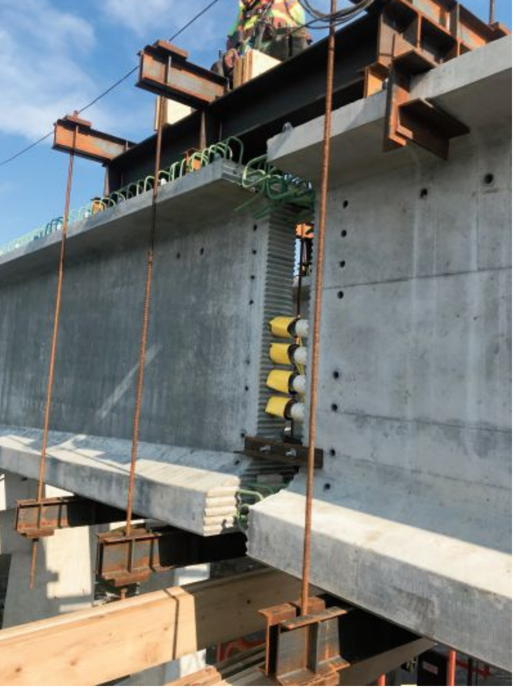
Pier segment delivery and erection. Beam segments were delivered to the project using trailers with steerable dollies and erected from a temporary causeway constructed in the Lehigh River. Photo: AECOM.

LEHIGH COUNTY, OWNER

BRIDGE DESCRIPTION: Eight-span, 1116-ft-long bridge with widths between 44 ft 8¼ in. and 50 ft 8¼ in. The bridge is composed of a three-span, 350-ft-long approach unit with prestressed concrete bulb-tee beams made continuous for live load; a three-span, 548-ft-long, fully continuous post-tensioned, spliced prestressed concrete bulb-tee beam main unit; and a two-span, 218-ft-long approach unit with prestressed concrete bulb-tee girders made continuous for live load. Multicolumn bent piers were constructed on reused foundations.

STRUCTURAL COMPONENTS: For the main unit: spliced prestressed concrete modified (increased web thickness) PA bulb-tee beams post-tensioned for full continuity. The unit was constructed with five girder lines with five segments each, including haunched pier sections; four post-tensioning tendons for each girder line, with one tendon per girder using electrically isolated tendon (EIT) components. For the approach spans on both ends of the bridge: conventional prestressed concrete PA bulb-tee beams made continuous for live load; piers doweled into existing footings with two existing pier foundations stabilized using limited-mobility grouting; one additional reinforced concrete pier constructed and founded on micropiles. All spans have an 8-in.-thick reinforced concrete deck slab.

BRIDGE CONSTRUCTION COST: $25.8 million (total project).

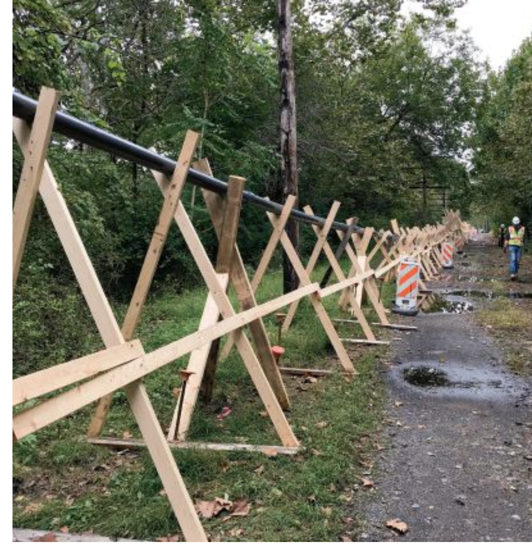


Girder splice with strongback support. The 1-ft-wide gap between girder segments for post-tensioning duct splicing was later filled with 9000-psi cast-in-place concrete, which was placed simultaneously with the diaphragms. Photo: AECOM.

using trailers with steerable dollies and, in some instances, drivers had to back the trailers nearly one mile to deliver the segments to the site. The beam segments were erected from a temporary causeway constructed in the Lehigh River, which washed out repeatedly in heavy rains. The contractor ultimately decided to construct a concrete footing on the causeway to provide a temporary support that was less likely to be compromised as hurricane season approached.

Once in place and temporarily supported, the beams were made continuous by the placement of a 1-ft-wide, 9000-psi, cast-in-place concrete closure at each splice. Upon completion of the concrete closures, four post-tensioning tendons, each tensioned to 660 kips and consisting of fifteen 0.6-in.-diameter seven-wire strands, were used to tie the segments together. With the beams fully continuous, the temporary supports were then removed and the 8-in.-thick deck was constructed in the conventional manner.

During construction, the Federal Highway Administration (FHWA) elected to make the Coplay-Northampton Bridge a demonstration project with respect to the use of electrically isolated tendon (EIT) systems. PennDOT and both Lehigh and Northampton counties agreed to allow the use of EIT technology on the bridge. EIT technology uses special anchorage hardware for the post-tensioning tendons and links the reinforcement to form an electrically continuous loop through the entire beam. After the tendons were tensioned and grouted, electrical resistance was measured at the beam end using a multimeter. If the resistance measured was above a calculated level, the tendon was considered fully encapsulated in grout and thus fully protected from corrosion. One tendon per beam used the EIT technology, and the short-term tests indicated that they were fully encapsulated. Lehigh University will be performing long-term EIT monitoring of the spliced girders (see the related Concrete Bridge Technology article in the Spring 2019 issue of *ASPIRE*® for more details).



The contractor was required to provide a mock-up of a single 540-ft-long tendon duct to demonstrate the ability to completely encapsulate the strands in the tendon with grout from end to end. Clear plastic duct was used at critical points along the profile for inspection purposes. Photo: AECOM.

Aesthetics, Accessibility, and Traffic Flow

In cross section, the rehabilitated bridge accommodates two lanes of traffic and varies in width from 44 ft 8¼ in. to 50 ft 8¼ in. to accommodate a turn lane at the east end. The bridge also has an 8-ft-wide sidewalk with a vertical wall barrier (1 ft 0 in. wide, 3 ft 6 in. high) on the south side and a safety-shape concrete barrier (1 ft 8¼ in. wide, 3 ft 6 in. high) on the north side. The structure is supported on full-height cantilevered reinforced concrete abutments, which use the existing abutment footings for support, and seven reinforced concrete multicolumn bent piers. Approximately 110 lineal ft of protective fence are mounted on top of the south bridge barrier in the span over the Norfolk Southern Railroad.

AESTHETICS **COMMENTARY**

by Frederick Gottemoeller

Replacing a 90-year-old historic landmark is always a challenge, particularly when the old bridge includes three different structural systems, and none of the three lends itself to emulation by modern structural systems. If the goal is to reflect some aspect of the old bridge in the design of the new bridge, then the challenge becomes, "Which of the old systems do we respond to?"

Thankfully, the widening acceptance of spliced precast concrete girder technology provided an answer for this structure. It allowed the precast concrete girders for the three longest spans over the river to be haunched at the piers. Those girders thus recall the haunched steel girder spans of the original bridge. This decision also adds visual interest to the bridge. The haunched girders make evident where the forces in the bridge are the greatest and give observers an idea of how the bridge is working.

The original haunched steel girder spans also provided the inspiration for the bridge's new piers, which emulate the features of the old piers. That provides observers another recollection of the old bridge. Finally, replicating the towpath apron along the former canal gives future users of the Delaware and Lehigh Trail another feature that they can relate to the old bridge. It is easy to understand why local officials are so pleased with the results of this project.

The existing concrete towpath apron attached to the face of the pier adjacent to the former Lehigh Canal was retained and rehabilitated to its original condition. A trail will be constructed under the bridge. Photo: AECOM.

Decorative lighting poles are mounted on the barriers at blister locations, generally at the substructure units and along the retaining walls at each corner. The light poles and luminaires were selected to match those of the nearby Pine Street Bridge.

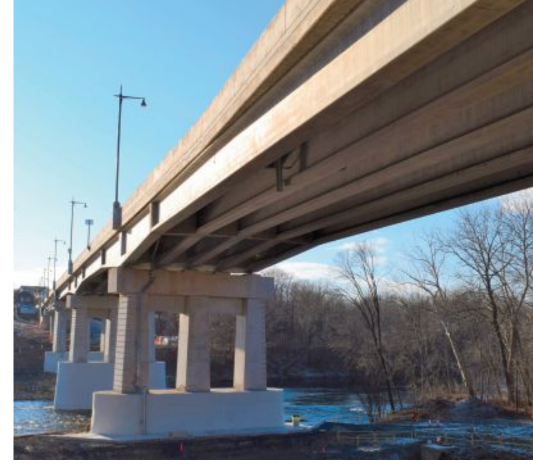
In addition to decorative lighting, other architectural elements were included in the design of the bridge to mitigate the effects of the rehabilitation and reflect the historic significance of the existing structure and its location. The piers were designed as multicolumn bents, keeping the same style as the existing approach span piers. All piers incorporated a horizontal, incised pattern to replicate the one used on the existing bridge. The existing concrete towpath apron attached to the face of the pier immediately adjacent to the former Lehigh Canal—which is intended to be part of the future Delaware and Lehigh Heritage Trail network—was retained and rehabilitated to its original condition. An interpretive panel describing the Lehigh Canal, which has been filled in at this site, and its historic significance to the region was also installed at this location.

Extending the Service Life

The rehabilitated structure is designed to achieve PennDOT's goal of 100-year service life for bridges. Use of deck joints was minimized to the fullest extent possible, and the selection of prestressed concrete spliced girders will reduce maintenance needs and extend service life compared to a steel structure. Epoxy-coated and stainless steel reinforcing bars were used in areas with a high potential for corrosion. Additionally, the remaining portions of the existing substructure units received a coating of epoxy resin as a permanent sealant.

Conclusion

The rehabilitated bridge—which is dedicated to Brigadier General Anna Mae Hays (1920–2018), a former resident of the Coplay-Northampton area, and the first woman in the U.S. Armed Forces to be promoted to a General Officer Rank—was opened to traffic on December 19, 2019. Construction is scheduled to be completed on June 30, 2020. Lehigh County officials have indicated that they are extremely pleased with the final structure and the cooperation exhibited by all involved parties to renew a vital transportation link in the region.



View of the completed bridge looking west. The horizontal, incised pattern on exterior pier columns mimics the details of the original bridge. Remaining portions of the existing piers are coated with epoxy resin. Photo: AECOM.

Thomas J. McNavage Jr. is a project engineer with AECOM in Conshohocken, Pa., and the engineer of record for the Coplay-Northampton Bridge.

Typical section of main unit that used modified (thickened web) PA bulb-tee beams spliced and post-tensioned for full continuity—the first use of this structure type in Pennsylvania and the first use of electrically isolated tendons in the United States. Typical sections of the approach spans are similar, but the bulb-tee beams were not spliced. Figure: AECOM.