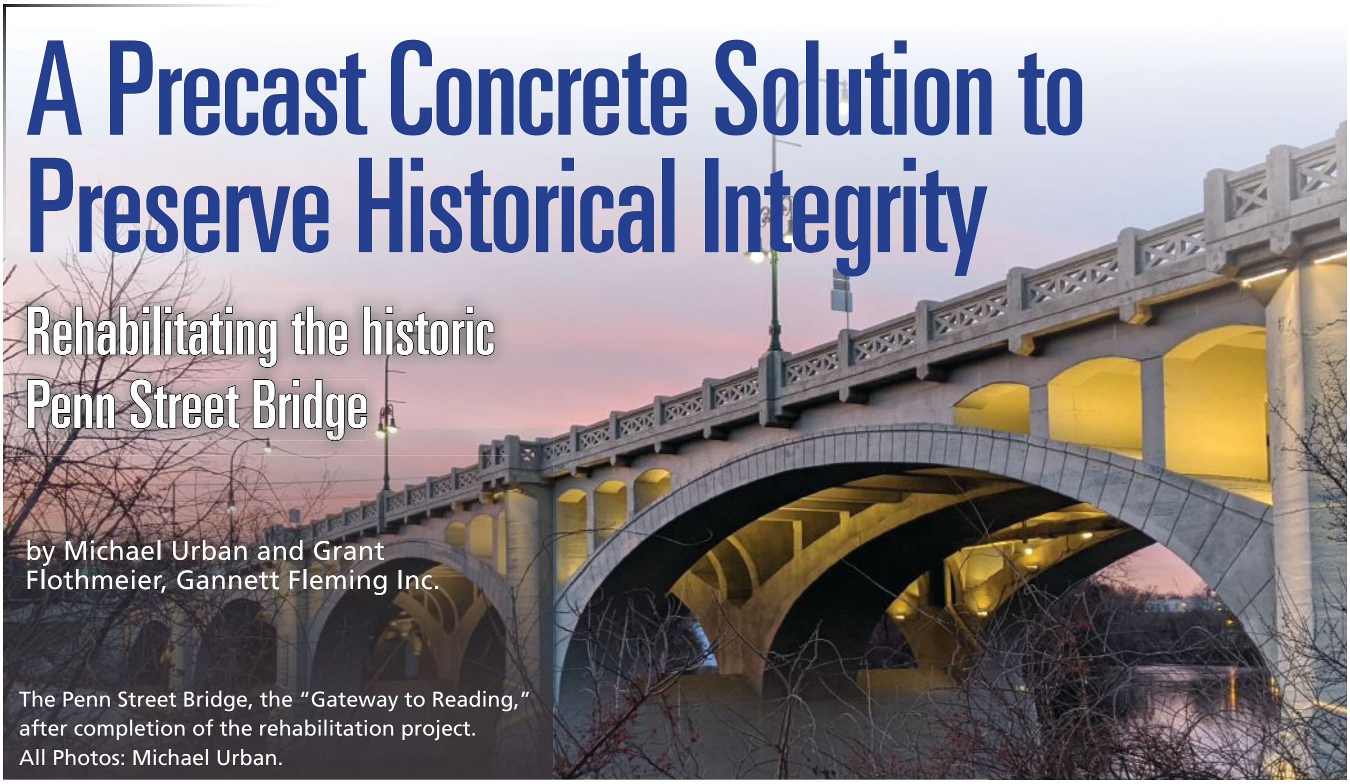
PROJECT

A Precast Concrete Solution to Preserve Historical Integrity

Rehabilitating the historic Penn Street Bridge

by Michael Urban and Grant Flothmeier, Gannett Fleming Inc.



The Penn Street Bridge, the "Gateway to Reading," after completion of the rehabilitation project. All Photos: Michael Urban.

Located on the Schuylkill River, the city of Reading, Pa., with a population of more than 88,000, is bustling with industry, art, and culture. The city's residents are very proud of its deep history and love its five large, open-spandrel concrete arch bridges that cross the river. The jewel of these bridges is the century-old Penn Street Bridge, considered the "Gateway to Reading."

The 1337-ft-long concrete viaduct, built in 1913, spans the Schuylkill River, Norfolk Southern railroad, Reading Area Community College, Front Street, a local trail, and a utility access road. The bridge is adjacent to a limited-access freeway, State Route 422, which is locally known as the West Shore Bypass. The bridge serves as the transition from the West Shore Bypass to the city via five open-spandrel arch spans, nine closed-spandrel arch spans, a concrete pile-supported slab structure, and a two-span concrete T-beam ramp attached to the main bridge.

Deterioration of the historic structure was noted in the bridge inspections and led to the evaluation of rehabilitation options. At the onset of the project, it was understood that the estimated $42.5 million bridge rehabilitation would require many carefully coordinated details to respect the historical integrity of the structure while extending its useful life. Priorities included incorporating as many of the original details of the bridge into the rehabilitation as possible while upgrading to current safety standards. Originally, the bridge carried both trolley tracks and a vehicular lane in each direction along with wide sidewalks. This configuration provided enough width to update the roadway cross section to today's standards without widening the structure. Character features such as detailing on the arch ribs, jack arches, and floor beam dimensions were relatively easy to replicate. However, today's standards for crashworthy barriers require a greater resistance to impacts, leaving the detailing of the existing barriers obsolete and not suitable for current requirements. By providing a new crashworthy barrier at the sidewalk curb, the original reticulated balustrade barrier could be recreated as part of the rehabilitation.

Preserving and Restoring Historic Details

The bridge is eligible for the National Register of Historic Places, so the rehabilitation had to balance preserving the bridge's character with bringing it up to current standards, as well as not precluding future work planned around the bridge. Due to the historic nature of the bridge, a goal of the project was to salvage as much of the original structure as possible. However, preliminary evaluation and

profile

PENN STREET BRIDGE OVER THE SCHUYLKILL RIVER / READING, PENNSYLVANIA

BRIDGE DESIGN ENGINEER: Gannett Fleming Inc., Audubon, Pa.

OTHER CONSULTANTS: Susquehanna Civil Inc., York, Pa.; Specialty Engineering Inc., Bristol, Pa.; CHRS Inc., Lansdale, Pa.; Liberty Environmental, Reading, Pa.; SoftDig, West Chester, Pa.; TRC Companies Inc., Export, Pa.

PRIME CONTRACTOR: J.D. Eckman Inc., Atglen, Pa.

Reusable formwork for a precast concrete railing panel. Slots in end and top forms are for extended J-bars. The panels were cast on site under a span that could be closed to the public. Tarps were hung to control the environment.

Two panel forms with epoxy-coated reinforcement installed, including J-bars extending from the top and sides of the panels to tie into the cast-in-place posts and rails. Inserts embedded in sides of the panel feet (see arrows) are for installing longitudinal reinforcement to tie panels to the sidewalk reinforcement.

Precast concrete panels ready for erection. J-bars extending from top and sides of panels tie into cast-in-place posts and rails. Pieces of the reusable two-part blockout forms are sitting on the panels.

hands-on inspection of the bridge found that some of the original elements, including the existing deck, sidewalks, floor beams, and reticulated balustrades, were deteriorated beyond repair and required replacement. The original arch ribs, closed-spandrel arches, and piers were in good condition considering their age and could be rehabilitated with only concrete repairs. The rehabilitation included a two-part, breathable, polymer-modified, cementitious base coat applied to the entire structure below the new deck, which provided texture to the new smooth concrete while filling in the deeper profiles of the weathered existing concrete. A breathable acrylic topcoat provided long-lasting protection and achieved a uniform color finish while adding corrosion protection.

Early on, the character-defining and aesthetic features of the bridge were identified: namely, its reticulated balustrades and outlooks. Originally, at each pier of the open-spandrel spans, an outlook extended from the sidewalk, allowing pedestrians to step away and enjoy the river scenery. However, in the 1950s, a major rehabilitation of the bridge included closing off these outlooks due to deterioration of the

"Panel feet" were incorporated into the design of the precast concrete panels so that the feet could be placed directly on the sidewalk and the panels required only temporary lateral support before casting the posts, curb, and top rail.

Typical precast concrete panel with cast-in-place posts, curb, and top rail. A conduit and a junction box for bridge lighting are visible.

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION, ENGINEERING DISTRICT 5-0, OWNER

BRIDGE DESCRIPTION: 1337-ft-long, 14-span reinforced concrete open- and closed-spandrel arch bridge

STRUCTURAL COMPONENTS: New cast-in-place reinforced concrete deck, sidewalks, and floor beams; precast concrete barrier panels with cast-in-place posts, curbs, and rails to replace existing reticulated balustrades; rehabilitated original arch ribs, closed-spandrel arches, and piers

CONSTRUCTION COST: $43.2 million

AWARD: 2020 American Society of Highway Engineers East Penn Project of the Year piers. Likewise, renovations in the 1970s replaced the original obelisks, which initially supported gas lamps, with light poles and electric lighting.

Based on input from stakeholders, it was determined that these original features would need to be incorporated into the design of the rehabilitation. Although current standards for street and pedestrian lighting required a luminaire height that prevented the use of obelisks in the original locations, adding two obelisks to the eastern end of the bridge met design requirements while preserving the obelisk's original character and enhancing the entrance to the city. In addition, with the rehabilitation and strengthening of the piers, the outlooks could be incorporated into the design.

Precast Concrete Barrier Panels

One of the major character-defining features of the Penn Street Bridge is the reticulated balustrade barrier. Each panel of the barrier consists of three X-shaped balustrades typically separated by a 1-ft 6-in.-wide post as well as a 4-ft-wide post at the midspan of the arches and at the piers. Some of these 4-ft-wide posts also support the new light poles. On the exterior face, post details extend below the soffit of the deck, breaking up the horizontal line at the bottom of the soffit. Conduits and junction boxes for the above- and below-bridge lighting were required to pass through the barrier curb along the length of the bridge.

In addition to the detailed requirements for the barriers, construction duration was also a key component of the rehabilitation. Penn Street serves as the entrance to downtown Reading, and construction staging already required reducing the four-lane bridge to three lanes during construction. It was critical that a tight schedule be maintained to avoid delaying any of the six construction stages.

The ornate detailing of the barriers required a construction technique that would satisfy the time constraints and provide a quality product worthwhile of the historical rehabilitation. Due to the X-shape within the panels, using typical cast-in-place construction could potentially lead to poorly consolidated concrete, resulting in unnecessary patching or the need for horizontal construction joints.

To eliminate these potential construction issues, the new barriers were designed using a combination precast concrete and cast-in-place system, with precast concrete panels for the X-shaped balustrades designed specifically to minimize construction time and provide a quality finish to the barrier. The panels varied in length from 10 ft 1 in. to 9 ft 3 in. along the length of the bridge, with smaller panels used around the outlooks. Each panel was approximately 3 ft high and 6 in. thick. The posts, curbs, and rails of the barrier were cast in place around the precast concrete balustrade panels to give the barrier its final appearance. This system enabled a high quality of construction, while providing for the conduits and junction boxes and creating a strong connection between the deck and barrier.

Because a crashworthy barrier is provided at the sidewalk curb, the reticulated balustrade barriers did not have to be designed to resist crash loads and were therefore designed to resist pedestrian and wind loads. No modifications to the original geometry of the reticulated balustrade barriers were required to resist these design loads. With a minimum height of 45 in., the original reticulated balustrade barriers also met current height requirements for pedestrian railings. To allow for any movement, vertical expansion/deflection joints were provided in the barrier, where they were placed inconspicuously adjacent to the posts.

Construction

The need to anchor the precast concrete panels to the deck while also limiting the required support when casting the posts, curbs, and rails led to the addition of "panel feet." The feet were placed directly on the sidewalk such that the panels required only temporary lateral support before the posts, curb, and top rail were cast. Inserts were embedded in the sides of the feet to receive longitudinal reinforcement that tied to hooked reinforcing bars projecting from the sidewalk between the panel feet. The height of the foot was based on the dimensions of the junction box that had to be positioned between the panel feet at certain locations. Epoxy-coated reinforcing J-bars extended from the top and sides of the panels to tie into the cast-in-place posts and rails. The J-bar provided adequate development for the reinforcement to secure the panels in place.

During construction, the contractor opted to cast the panels on site, using the space below one of the closed-spandrel spans that could be closed to the public. Tarps were hung to provide the contractor with a controlled environment and enough space to cast several panels at a time. Once casting was completed, the same area was used to store the panels until they were ready for installation.

As required by the tight schedule, the efficiency of having the panels on site and ready to erect omitted the time-consuming steps of forming, placing, and curing the concrete for the intricate geometry of the panels in place. In addition, defective castings would not slow the construction process.

An Impressive Gateway

The rehabilitation of the Penn Street Bridge was completed in 36 months, which was four weeks ahead of schedule, and within 2% of the original bid, a credit to all those who worked together on every detail. From beginning to end, the project team focused on the details so that the "Gateway to Reading" could be restored to its former glory and reestablish itself as the jewel of Reading's Schuylkill River bridges.

Michael Urban is a senior engineer and Grant Flothmeier is a project engineer, both with Gannett Fleming Inc. in Valley Forge, Pa.

Outlooks at the river piers, which were closed off during rehabilitation in the 1950s, were reconstructed as a part of this project.