2020 National Award, Special Purpose
Frances Appleton Pedestrian Bridge
Boston
photo: Juan Navarro
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**NSBA**

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2020 Merit Award, Major Span
Portageville Bridge Replacement
Portageville, N.Y.
photo: John Kucko
The art of designing and building beautiful, efficient, economical, and sustainable steel bridges has been practiced for more than a century. AISC announced the first Prize Bridge award in 1928 as a way to showcase the beauty of steel bridges.
The National Steel Bridge Alliance, a division of the American Institute of Steel Construction, is proud to present 2020 Prize Bridge Awards to 19 outstanding structures across the country.

The winners span everything from a rugged section of Lake Tahoe’s shoreline to a tight Idaho Canyon to a wide stretch of railroad tracks along Chicago’s lakefront to a high-profile expressway in Philadelphia’s Center City to the Hudson River’s massive Tappan Zee. All have made an enormous impact on the lives of the people they serve—some in particularly dramatic ways. For example, the Pfeiffer Canyon Bridge reconnected a California community after a landslide damaged a concrete bridge beyond repair (so much so that groceries and fuel had to be brought in by helicopter).

“These projects are tributes to the creativity of the designers and the skills of the fabricators and builders who collaborated to make them reality,” said AISC’s president, Charles J. Carter, SE, PE, PhD. “Steel shines and soars on their talents, and we celebrate the accomplishments these projects represent.”

NSBA, AISC, and the entire structural steel industry look forward to watching this year’s winners continue to bring people together for decades to come.
Steel bridges have a proud history. They connect communities, in some cases for more than a century. Steel bridges endure, as does our commitment to showcasing the best of bridge engineering and architecture.

History

In the early years, the judging groups included engineers, architects, and museum curators, reflecting the desire to choose winners purely based upon aesthetics. Over the decades the competition has evolved and now places more weight on innovation, economics, and problem-solving skills. Aesthetics still play a role, but today’s judges are selected from the broader AEC community.

In that first competition, there was a single category with one prize. First place was awarded to the Sixth Street Bridge in Pittsburgh, Pa., which embodied innovation in the steel bridge industry at the time. The bridge was one of the first self-anchoring suspension bridges; it used solid steel eye-bars for both the main suspension cables and the vertical support for the bridge deck. Now more than 90 years old, the Sixth Street Bridge—renamed the Roberto Clemente Bridge in 1998 after the legendary Pittsburgh Pirates outfielder—has come to define a city and its history.

Many competition bridges have outlasted the companies for which they were built. For example, a railroad viaduct constructed for the Wabash Railroad, winner of the 1941 Class C category, still carries rail traffic in Wayne County, Mich. The Wabash railroad merged with the Norfolk and Western Railway in 1964, which then became the Norfolk Southern Railroad in 1982. The Wabash railroad signage might not exist but the bridge still performs its duties just as well as it did when originally constructed more than 70 years ago.

NSBA continues to recognize outstanding bridges biennially. Keeping with tradition, bridges are eligible for the competition based on the date they first opened to traffic.

Competition Details

Categories

The panel of industry professionals judge the entries in eight categories.

- **Major span** – One or more spans greater than or equal to 400 feet
- **Long span** – Longest span equal to or greater than 250 feet but less than 400 feet
- **Medium span** – Longest span equal to or greater than 140 feet but less than 250 feet
- **Short span** – No single span greater than 140 feet
- **Movable span**
- **Rehabilitation** – Restoration or repair on a structure that preserves the main load-carrying members
- **Reconstructed** – Restoration or repair that results in a new structure on an existing alignment
- **Special purpose** – Does not fit any of the above categories. Examples include bridges for pedestrians, pipelines, and airplanes.

At their discretion, the judges may also offer a special commendation to outstanding projects that truly exemplify the remarkable, unique attributes of structural steel.

Eligibility

To compete in the 2020 Prize Bridge Awards, bridges must have been:

- Built of structural steel
- Located in the U.S., defined as the 50 states, the District of Columbia, and all U.S. territories
- Completed and opened to traffic between January 1, 2017, and December 31, 2019

Judging Criteria

The judges considered the following criteria while evaluating submissions.

- What are the unique attributes of the bridge?
- Did the fabrication or construction of the bridge require an innovative approach?
- How did this project advance the state of the art in the steel industry?
- What made this bridge type economical for this situation?
- Did the team face any particularly unusual or interesting engineering challenges?
**2020 Jury**

**Dennis Golabek**
Senior Technical Principal  
WSP

Dennis Golabek, PE, is currently assigned to work with the FDOT Structures Design Office in Tallahassee, Fla. He has been in the bridge profession for over 30 years and has worked for consulting firms and the FDOT. His experience includes the analysis, design, and review of steel and concrete bridges with an emphasis on the analysis and design of horizontally curved steel girder bridges. He is a member of TRB AKB20 Steel Bridges committee and AASHTO/NSBA Steel Bridge Collaboration and a former member of AASHTO CBS Technical Committees T-5, T-12, T-14, and T-17. He has also been involved in numerous research projects involving specialized skills in finite element analysis and innovative material usage. He received his BSCE and ME in structural engineering from the University of South Florida. He occasionally teaches graduate classes at the FAMU-FSU College of Engineering in Tallahassee, Fla.

**Richard Marchione**
Deputy Chief Engineer Structures (retired)  
NYS Department of Transportation

Richard Marchione retired from NYSDOT in 2019, capping off more than 37 years of bridge engineering experience with the Department. He was the executive-level manager of the Department’s Office of Structures, with responsibility for the safety of bridges in New York state through the implementation of a rigorous inspection and evaluation program as well as the development and delivery of a structures capital program on a statewide level. As NYSDOT’s top bridge engineer, he served as the primary member for the American Association of State Highway Transportation Officials (AASHTO) Committee on Bridges and Structures and served on the Structural Steel Design, Bridge Management, Evaluation, and Rehabilitation and Bridge Preservation Technical Committees. He was also a member of the TRB Subcommittee on Accelerated Bridge Construction and the Steering Committee Chair for the NY Statewide Conference on Local Bridges. He has served on the Board of the Association of Bridge Construction and Design (ABCD) Eastern NY, and continues to serve as the chair of the External Advisory Board for the Institute of Bridge Engineering at the University at Buffalo.
Shane W.R. Kuhlman, PE
State Bridge Engineer
New Mexico DOT
Shane Kuhlman is a graduate of New Mexico State University with a Bachelor’s and Master’s Degree in Civil/Structural Engineering. He is a licensed Professional Engineer in the state of New Mexico. He has worked as a structural engineer in both the private and public sectors as a building and bridge engineer. As the State Bridge Engineer in N.M., he is currently responsible for designing and managing New Mexico’s bridge inventory.

Rob Richardson, PE, PEng,
ENV SP
Vice President
West Region Bridge Leader
HDR
Rob Richardson is a Registered Professional Engineer in multiple states and Canadian provinces. After earning a BS in Civil Engineering from the University of California, Davis in 1992, he spent nearly 28 years on project delivery as both a Caltrans and consulting engineer. He has successfully designed a diverse array of transportation/bridge projects with varying degrees of complexity and size for multiple agencies, focused on practical solutions that maximize project value. He is also an ISI Envision Sustainability Professional and HDR’s Bridge and Structures Sustainability Leader, responsible for development of bridge sustainability best practices and internal education. Outside of bridge engineering, he has been an avid scuba diver for over 25 years and is a strong advocate for shark awareness and protection.

Francesco Russo, PhD
Vice President and Technical Director,
Bridge Engineering
Michael Baker International
Francesco M. Russo, PhD, is Vice President and Technical Director, Bridge Engineering for Michael Baker International. With more than 25 years of experience in bridge engineering, he is responsible for complex project support nationwide, including serving as the NDT and engineering services manager for various in-service steel bridge assessments. He received a Special Achievement Award from AISC in 2019 for his contributions to the advancement of knowledge in inspection and emergency rehabilitation of complex steel structures.
THE VINE STREET EXPRESSWAY is well-known to Philadelphia commuters.

The nearly two-mile stretch of Interstate 676 in the City of Brotherly Love’s downtown (aka Center City) is critical to the area’s transportation network. But in recent years, six bridges carrying local roads over the expressway were aging and suffering from significant deterioration. The Pennsylvania Department of Transportation (PennDOT) decided to replace these two-span prestressed concrete non-composite adjacent box-beam bridges with single-span welded-plate-girder steel bridges. The project considered vertical clearance issues, reuse of existing bridge abutments, relocation of several utilities supported by the bridges, and high aesthetic standards, including extensive landscaped areas and streetscape finishes atop the new structures.

Each bridge had its own challenges and unique aspects. For example, the deck for the new Family Court pedestrian bridge, located between the 18th and 19th Street bridges, is now a park for the community. This new configuration required that the bridge carry a heavier load to support trees, additional sidewalks and seating areas, and a lawn—a task for thicker flanges. But it still had to be able to flex on the bearing pads on the existing abutment and expand and contract smoothly with temperature changes. Steel was pivotal for supporting the new loads that came with these features while maintaining the clearance needed below the bridge, providing the necessary strength in a shallow profile.

The 19th Street Bridge and the four bays of utilities it supports presented a different challenge. The team prepared a steel design and construction schedule that would allow the utilities to remain in service throughout construction. The utilities were moved to temporary supports while the bridge was removed around them, then the newly fabricated beams were set in place and the utilities were relocated to the new beams while the remainder of the new bridge was built. This reduced the need for outages to move critical utilities and kept them in working order throughout the construction.

Challenging geometry drove the design of the new bridge that would combine the existing 20th Street, Ben Franklin Parkway, and Free Library Bridges into one structure: the 20th/BFP/FL Bridge. Given the sharply skewed geometry (35°) of the Parkway across the bridge, the team investigated whether the design for vehicular live loads could produce larger girder moments and shears running along the sharp skew as opposed to the typical live load configuration of vehicles traveling parallel to the girders. The team developed a 3D finite element model, which confirmed that the skewed
live loading condition did not produce effects greater than the standard design vehicular loads running parallel to the girders. The resulting design yielded girders with 24-in.-deep webs and maximum 24-in.-wide bottom flanges.

The 22nd Street Bridge posed particular challenges. The clearance below the bridge was too low. There was a pump station behind one of the existing abutments that could not be removed, and the bridge would have numerous existing and proposed utilities. Implementing shallow steel beams eliminated the center pier, raising the profile to the minimum 14 ft, 6 in. without exceeding the capacity of the existing abutments.

The existing concrete 18th Street Bridge carried a heavy 22-in. steam pipe below the deck. The design team worked with the local utility to employ a lighter pipe using less insulation so that the new steel span would be able to not only carry it but also fit it between the bridge beams.

Finally, the 21st Street Bridge had the longest span of all the bridge replacements due to the presence of on/off ramps below the structure, meaning that the abutments had opposing skews of up to 10° from the girder span. As such, each steel girder on this span was unique, resulting in more extensive detailing.

Steel Fabricator and Detailer
High Steel Structures LLC, Lancaster, Pa.

Structural Engineer
Pennoni, Philadelphia

General Contractor
Buckley and Company, Inc., Philadelphia

Owner
Pennsylvania Department of Transportation, Harrisburg, Pa.

Bridge Stats

Opened to traffic: November 1, 2018

Span lengths:
- 18th Street: 95 ft, 2 in.
- Family Court: 95 ft, 5 in.
- 19th Street: 95 ft, 2 in.
- 20th Street/Benjamin Franklin Parkway/Free Library: 95 ft, 8 in.
- 21st Street: 119 ft, 5 1/2 to 133 ft, 10 in.
- 22nd Street: 106 ft, 5 in.

Total lengths:
- 18th Street: 97 ft, 10 in.
- Family Court: 98 ft
- 19th Street: 97 ft, 10 in.
- 20th Street/Benjamin Franklin Parkway/Free Library: 98 ft, 6 in.
- 21st Street: 120 ft, 3 1/2 in. to 135 ft, 6 7/8 in.
- 22nd Street: 108 ft, 11 in.

Average widths:
- 18th Street: 69 ft, 10 1/2 in.
- Family Court: 120 ft
- 19th Street: 64 ft, 11 in.
- 20th Street/Benjamin Franklin Parkway/Free Library: 643 ft
- 21st Street: 67 ft
- 22nd Street: 83 ft, 6 in.

Total structural steel: 2,846 tons

Cost: $65.4 million for entire project

Coating/protection: Three-coat system consisting of an inorganic zinc primer, urethane intermediate coat, and aliphatic urethane finish coat.
ANCHOR BAY DRIVE is a scenic road along Lake St. Clair in Clay, Mich., that carries fishing boats and yachts to the marina at the end of the road. Three bridges along the route provide access to the hundreds of homes that take advantage of the spectacular views of the lake and lagoon.

County engineers recently determined that these crossings—prestressed concrete box-beam superstructures with only a 30-year service life—had become either structurally deficient or functionally obsolete. New galvanized steel press-brake-formed tub girder (PBFTG) bridges with a life expectancy two-and-a-half times as long replaced the existing structures. Combined with reinforced precast concrete deck panels, this steel solution provides a cost-effective replacement option at an accelerated construction schedule with a service life expectancy exceeding 75 years.

The St. Clair County Road Commission was able to bundle these three bridges into a collective, successful superstructure replacement project. However, the bridges provide the only point of access to the far reaches of Anchor Bay Drive, rendering a complete tear-down and rebuild impossible. In addition, space around the bridges is extremely tight, with houses packed in close to the roadway and very little dry land to maneuver on.

Luckily, the chosen PBFTG option, TEG Engineering’s Con-Struct Bridge System, addressed these issues. The original bridge abutments were in good shape and would not require replacement, and the Con-Struct system can be installed on top of existing substructures. In addition, the system can be delivered two ways: with the precast concrete deck pre-attached to the tub girders, or with it separated. For this project, the team did not want the girders and deck to be attached, due to the space limitations at the installation site.

The county demolished and installed the bridge one side at a time to ensure that traffic flow could continue unhindered. The installation was much quicker than other available options due to the system’s modular design. Both the galvanized steel tub girders and the decking took about half a day to set in place. The county’s own crew and equipment easily managed installation without additional equipment rentals or labor, saving the county even more time and money.

**Fabricator and Detailer**
Valmont Industries, Valley, Neb.

**Structural Engineer**

**Owner and General Contractor**
St. Clair County Road Commission, St. Clair, Mich.
Bridge Stats

**Opened to traffic:** July 2, 2019

**Span/total length:** 57 ft

**Average width:** 30 ft

**Total structural steel:** 58 tons

**Cost:** $220,000 per bridge superstructure

**Coating/protection:** Galvanizing
GRAND AVENUE IN GLENWOOD SPRINGS, COLO., has a grand new thoroughfare.

An aging and functionally obsolete bridge, a nine-span, 676-ft-long steel plate girder bridge constructed in 1953, carried SH82 over Interstate 70, the Colorado River, and Union Pacific Railroad (UPRR) lines before descending into the historic downtown business district of Glenwood Springs. It was one of only two crossings serving Glenwood Springs as well as other communities along the Roaring Fork River valley, including Aspen to the south.

The existing bridge had four roughly 9-ft-wide lanes that had effectively become a bottleneck. The bridge’s structural capacity didn’t meet current codes and it had limited shelf life remaining; simply widening it wouldn’t work. Opposition groups had successfully shut down a previous Colorado Department of Transportation (CDOT) replacement project. This time, CDOT made a concerted effort to improve the process by involving the designer, contractor, and public early in the design.

The project included changing the SH82 alignment over the bridge from straight to curved with a 625-ft radius. The new alignment and proposed intersections at the north end improved traffic flow at the SH82/I-70 interchange but made the new bridge geometrically challenging. The horizontal curvature resulted in the bridge crossing I-70, the river, and the railroad at varying degrees of skew. The north end of the bridge was tangent and required a flaring deck width to accommodate the changing lane requirements near the SH82/I-70 interchange. The profile also required a sharp vertical curve to get up and over the UPRR and then immediately begin the descent into downtown.

The new bridge had two distinct regions with significant variation in the required structure depths. A deeper structure of approximately 7 ft was required for the longer spans over the highway, river, and railroad, but a shallower structure of approximately 3 ft was required for the shorter downtown spans to allow adequate headroom for a planned pedestrian plaza under the bridge.

A five-span trapezoidal steel tub girder bridge using 6-ft deep girders was selected for the deeper, steel portion of the bridge (Unit 1), which included the main spans over the Glenwood Hot Springs Pool parking lot, a frontage road, I-70, the Colorado River, and UPRR. A tub shape with sloped sides provides a clean look, while also paying homage to the many steel and concrete tub/box girder...
structures supporting I-70 in nearby Glenwood Canyon. Tub girders also provide excellent torsional properties to efficiently handle the sharp curvature of the bridge. The tub girder section was optimized by using a narrower bottom flange (5 ft, 7 in. web to web) than had typically been used in Colorado. This, combined with recent enhancements in AASHTO LRFD Bridge Design Specifications regarding local flange buckling, helped achieve practical bottom flange thicknesses of 2 in. or less without longitudinal bottom flange stiffeners. The increased web-to-web spacing between adjacent tub girders did affect the deck design, but this proved to be relatively inconsequential when compared with an even web spacing.

The originally planned four tub girder lines eventually dropped to three, resulting in fewer members to fabricate and erect and a maximum web-to-web spacing of 18.6 ft at the flared north end of the bridge. In addition, a refined deck analysis led to a reasonable deck thickness and reinforcement in this region. The contractor attached a temporary floor beam/stringer system from the tub girders to form the widest deck spans in the flared region. This proved more cost-effective than adding another girder line, which would have otherwise been required to accommodate standard deck forming systems in the flared region.

The reduction in girder lines also resulted in increased top flange lateral bracing demands, especially in the flared region. After a study comparing Warren and Pratt truss layouts, the team concluded the Pratt truss was most optimal for this bridge. The Warren truss design would have resulted in larger diagonal member forces in compression, which would have required larger diagonal members and the use of gusset plates at the flange connections. By comparison, the Pratt truss allowed strategic changes in diagonal member orientation to balance the member forces in either compression or tension while mitigating the magnitude of the diagonal member connection forces. The result was reasonable diagonal member sizes and direct connections to the top flange, and no gusset plates were needed.

Steel Team
- **Fabricator**
  - W&W | AFCO Steel, San Angelo, Texas
- **Detailer**
  - ABS Structural, Melbourne, Fla.
- **Erector**
  - Pioneer Steel, Inc., New Castle, Colo.
- **Structural Engineer**
  - RS&H, Inc., Greenwood Village, Colo.
- **General Contractor**
  - Granite/RLW Joint Venture, Glenwood Springs, Colo.
- **Owner**
  - Colorado Department of Transportation – Region 3, Grand Junction, Colo.
THE TWO-LANE WILLIAMS CREEK (SHOUP) BRIDGE proves that two is sometimes better than one as it replaced an existing single-lane river crossing in Salmon, Idaho, with an attractive two-lane bridge.

The original span was a flat compression-loaded bridge that sat on two concrete piers with sheet metal guard rails. Its replacement demonstrates architectural finesse with arched beams for the main frame with tension-loaded cross cables. The design team performed a fair amount of graphical design work to render the different bridge alternatives it was considering in order to facilitate engaged open houses and public meetings. The team solicited local residents and business owners for their feedback on the various bridge types and looks. Modeling the different stages of steel erection, deck placement, deck curing, temporary support removal, and cable tensioning was a very involved and detail-oriented process, which allowed the team to accurately capture the cable tension and elastic lengthening and account for all of that elastic deformation in the design of the steel members. When everything was completed and all of the loads were on the bridge, the arch had a nice, rounded shape and the roadway profile was at the proper elevation.

The team essentially had to start its analysis with the final product and work its way backwards to determine what shape the arch ribs and tie girders needed to be before they were erected and loaded. “The member lengths and shape of the arch in the final configuration are not the same as the lengths and shapes that get fabricated,” noted one project engineer. “For me, that was the most complex part: the level of detail involved in the finite element model we built to determine all of the different loads and deflections anticipated for various support conditions throughout the entire fabrication to erection process.”

During the construction phase, increased spring runoff flooded the Salmon River, and general contractor RSCI implemented progressively adaptive construction methods by shifting schedules for in-water work to meet the changing and unexpected water levels.
and fish spawning seasons. The allowable in-water work windows were tight. RSCI came up with alternate ways and times to set coffer dams, diversion barriers, and other elements to mitigate delays related to the historically high water flows and ice dams.

The team employed an Acrow temporary bridge structure for traffic during demolition and construction of the new bridge. The old bridge superstructure was demolished and the new single-span bridge was built using the existing bridge piers as temporary support structures; the piers were later demolished after traffic patterns were redirected onto the newly constructed bridge. This option was provided as a no-cost change order that eliminated the need to completely shut down traffic over the bridge for a period of 48 hours, providing continued use of the bridge during the contracted bridge slide. This method also minimized environmental impact to the river by eliminating the need to install and remove temporary piers required to support construction of the new bridge.

In a similar fashion, RSCI implemented an alternate approach for structural steel erection that provided environmental and schedule benefits to the project. This involved designing, installing, and working from a platform that was built directly onto the permanent bridge girders and diaphragms. The work platform was constructed in modular units in the construction lay-down yard and erected along with the girders, allowing immediate use of the structurally supported working area as soon as the substructure steel was installed. This working structure allowed for the use of aerial lifts, materials staging, and manpower to access parts of the bridge that would have otherwise required an additional work platform to be constructed adjacent to the bridge using a pile system. This system proved less disruptive to the highly protected Salmon River.

**Steel Fabricator**
Thompson Metal Fab, Inc. Vancouver, Wash.

**Structural Engineer**
WSP|Parsons Brinckerhoff, Portland, Ore.

**General Contractor**
RSCI Group, Boise, Idaho

**Owners**
U.S. Department of Transportation Federal Highway Administration, Vancouver, Wash.
Lemhi County, Salmon, Idaho

### Bridge Stats
- **Opened to traffic:** November 17, 2017
- **Span/total length:** 224 ft
- **Average width:** 32 ft
- **Total structural steel:** 173 tons
- **Cost:** $6.5 million
- **Coating/protection:** Weathering steel
THE MANNING CREVICE BRIDGE carries Salmon River Road across the Salmon River in a picturesque, V-shaped canyon 14 miles upstream from Riggins, Idaho.

A main artery for recreational users of the river and forest lands, Salmon River Road provides access to homes, resorts, and commercial rafting ventures. The existing bridge, built in 1938, had reached the end of its service life and required replacement. The location is remarkable not only due to its beauty but also its limited access and very limited space available to stage construction equipment and materials. Choosing steel for temporary and permanent works was key to developing a feasible erection scheme on this difficult site.

After evaluating six different structure configurations, the team chose a single-tower, asymmetric suspension bridge. Competent bedrock at the site provided ample capacity for anchoring large horizontal forces, which favors arch and suspension bridge types over cable-stayed options. The team also concluded that a suspension option would be more constructable than an arch option, due to the light weight and flexibility of steel cables as well as limited access for construction equipment at the site. The bridge span length is 300 ft, and with a cable sag of 18.5 ft at mid-span, the resulting sag ratio (span/sag) of 16.2 is much flatter than the classical suspension bridge sag ratio of 10.

The site features a narrow shelf road with steep drop-offs in hard rock terrain. Standard construction techniques for such steep sites typically involve temporary benching, but the hard rock and pristine canyon location made benching both cost-prohibitive and inappropriate. A temporary crane platform on the north side of the river allowed for erection of the tower and cable anchorages. Additional temporary platforms facilitated construction at the north anchorage and behind the tower base. The existing south-side roadway bench was wide enough to accommodate a crane while allowing vehicles to pass. All construction materials were staged and delivered from Riggins to the north end of the bridge.

Project requirements for the bridge replacement included:

- A bridge deck clear width of 16 ft for a single lane
- A minimum vertical clearance of 18 ft
- A minimum load capacity of AASHTO HL-93 and a 45-ton logging vehicle
- Roadway curvature at the bridge ends must allow a logging truck to approach the bridge
- Reduce the visual contrast of the bridge within the context of the river canyon

The site added additional complexity. Construction work could not impede the flow of traffic—both for vehicles on the bridge and rafters below it. Construction equipment is not allowed in the river, nor is any permanent construction in the 100-year flood plain.

Structural steel was integral to the success of the project, especially with regard to treading lightly on the site. The robustness of the erection equipment and temporary crane platform at the north abutment were directly proportional to the piece weights erected at mid-span over the river. The light weight of the structural steel sections, combined with the ease of connecting them using high-strength bolted splices, allowed for an erection scheme using only two fixed crane positions with reaches up to 160 ft.
Representatives from the National Park Service were instrumental in identifying key aesthetic concerns. The bridge deck overlay was designed as an ultra-thin bonded wearing course, with aggregate color that blends with the canyon setting. The bridge deck of cast-in-place concrete uses integrally colored, internally cured concrete to enhance long-term durability and reduce visual contrast by providing a color that mimics the dark appearance of the weathered granite rock outcrops adjacent to the bridge. A surface stain on the abutments and wind walls accomplishes the same objective.

The completed structure should last more than 100 years, thanks to its protection scheme. Class C galvanizing was specified for the steel cables, and Grade 50 weathering steel was used for the towers and superstructure, both for corrosion resistance and the aesthetic considerations mentioned above.

The community, both in terms of local residents and river user groups, has received the project very positively. The bridge officially opened June 5, 2018 with a ribbon-cutting ceremony, and many attendees at the ceremony commented on how well the weathering steel finish complements the natural beauty of the canyon. The new single-tower bridge adds a touch of uniqueness to the canyon, with a force layout that reflects the constraints of the site.

For more on the Manning Crevice Bridge, see “Narrow Margin” in the October 2018 issue of Modern Steel Construction, available at www.modernsteel.com.

Steel Team
Fabricator
Rule Steel , Caldwell, Idaho
Detailer
ABS Structural , Melbourne, Fla.
Erector
Donahue McNamara Steel , Hailey, Idaho
Engineers
Atkins, Denver (structural design and project management)
Horrocks Engineers, Meridian, Idaho
(CM/GC advisor and roadway design)
Shannon and Wilson, Denver
(geotechnical design)
General Contractors
RSCI Group, Boise, Idaho
(also construction manager)
Inland Foundation Specialties, Boise, Idaho
(ground anchors and micropiles)
Owners
U.S. Department of Transportation Federal Highway Administration, Vancouver, Wash.
Idaho Transportation Department, Boise, Idaho
Idaho County, Grangeville, Idaho

Bridge Stats
Opened to traffic: January 22, 2018
Span/total length: 300 ft
Average width: 20.1 ft
Total structural steel: 188 tons
Cost: $7,912,900
Coating/protection: Weathering steel
RECORD RAINFALL IN THE WINTER of 2016/2017 effectively made an island out of a portion of Big Sur in Monterey County, Calif. A landslide undermined a support for the Pfeiffer Canyon Bridge on scenic coastal State Route 1, causing severe damage that was beyond repair. The bridge was closed to traffic on February 15, 2017, and its loss devastated the people stuck between the closed bridge to the north and a large landslide to the south. Groceries and fuel had to be helicoptered into the area. Children were no longer able to attend school, which was located on the other side of the deep canyon. The community lost its tourism-based revenue source, with State Route 1 closed on either side.

Caltrans immediately contracted with Golden State Bridge to demolish and construct a new bridge, designed by Caltrans, under an emergency force account. The team quickly determined that a temporary bridge was not feasible at this narrow mountainous site; there was no room for both a temporary and permanent bridge as well as the required equipment and staging areas. The design and construction of the new bridge became even more urgent. The team quickly determined that a single 310-ft-long composite welded-steel-plate-girder bridge would be the best replacement for the existing three-span concrete box-girder bridge. Golden State Bridge received plans for the steel plate girders less than two weeks after the damaged bridge was closed to traffic. The plans included two options for the girders: 1) hybrid girders consisting of Grade 50 steel for the top flanges and webs, and Grade 70 steel for the bottom flanges and 2) all Grade 50 steel girders. The second option won out because it had the quickest delivery of all evaluated bid packages.

The girders were designed to have unstiffened webs to simplify and speed up their fabrication. The webs were 1¼-in. thick to meet this criterion. The thicker unstiffened webs were also a benefit for launching because the shear resistance of the webs would be constant and not dependent on locations of the transverse stiffeners.

The new bridge width is 40 ft, incorporating three girder lines, and the total structure depth is 14 ft (the steel girders alone are just under 13 ft deep). Each girder line was fabricated in five segments for transport to the site and required four bolted field splices. The girders were shipped to the site lying on their sides and required four bolted field splices. The girders were on the launching bed; the catwalks were also installed while the girder assembly was proceeding correctly. This process was repeated again and again until the assembled girders reached the south abutment—and marked the state’s first bridge launch.

The launching plan involved a 14-stage process that included vertical alignment changes to raise the nose up and over the central tower and south abutment supports. The launch took three days following the very controlled and methodical launch plans. The girder assembly was pulled in 12-in. to 18-in. increments as each hydraulic strand jack piston cycled. After each pull, the team took measurements to check for deflection and alignment to ensure the process was proceeding correctly. This process was repeated again and again until the assembled girders reached the south abutment—and marked the state’s first bridge launch.

After the launch was completed, the top portion of the central temporary tower was removed along with the supporting rollers and guides. The girders were then lowered approximately 14 ft onto the abutment seats. The concrete deck was poured and then the see-through bridge railing was constructed. The new bridge opened to traffic on October 13, 2017, just eight months after the existing bridge was closed, reestablishing this vital link to Big Sur and the surrounding communities.

Steel Team
Fabricator
XKT Engineering, Inc. [inc], Vallejo, Calif.
Erector and General Contractor
Golden State Bridge [inc], Benicia, Calif.
Structural Engineer
Caltrans Structure Design, Sacramento, Calif.
Owner
Caltrans District 5, San Luis Obispo, Calif.
Bridge Stats

**Opened to traffic:** October 13, 2017

**Span length:** 310 ft

**Total length:** 315 ft

**Average width:** 40 ft

**Total structural steel:** 809 tons

**Cost:** $21.7 million

**Coating/protection:** Inorganic zinc primer undercoat with latex paint finish coat
THE NEW NY BRIDGE PROJECT produced a crossing of rather epic proportions. The $3.98 billion undertaking—one of the largest transportation design-build contracts in the United States to date—replaced the old Tappan Zee Bridge with the new 3.1-mile-long, twin-span Governor Mario M. Cuomo Bridge over the Hudson River, located approximately 20 miles north of New York City. It is designed for a 100-year service life and carries a newly enhanced regional bus service in addition to typical road traffic; the foundations are designed to carry future commuter/light rail tracks on structures erected between the two spans. The largest bridge project in New York history provides greater traffic capacity while improving operations and safety for motorists crossing one of the widest parts of the Hudson River.

The new bridge features parallel 3.1-mile-long structures, each with a 2,230-ft, cable-stayed main span and ten 1,750-ft, five-span continuous approach units composed of 350-ft steel girder spans. It provides eight general traffic lanes, plus dedicated bus lanes and shoulders for emergency access. The design team selected structure types with proven service life and efficiency in order to maximize span lengths and minimize foundation demands while engaging local trade expertise. The approach structure design maximized span lengths using a long-span steel girder sub-stringer system with an average span length of 350 ft, so fewer foundations were needed. In the deep clay area, the highest-capacity friction piles (2,100 tons) ever used in these types of soils have proven successful.

As the lead designer, HDR analyzed, designed, and detailed the approach structure steel girder sub-stringer system, which included composite steel girder design, sub-stringer design, and cross-frame design in accordance with AASHTO LRFD Bridge Design Specifications. The team created 3D finite element models to analyze the steel system as a whole and to develop demands for design. Half of the units were located on a curved alignment, which required the design of continuous curved steel girders in which the effects of torsion were considered in both the temporary and permanent state.

Design of the approach spans was based primarily on five-span continuous units. The steel framing supporting each roadway deck included five main girders and four substructures to minimize foundation loads. Overall, 110,000 tons of fabricated structural steel went into the project.

Choosing steel allowed much of the superstructure construction to be modularized. The relatively light superstructure allowed for large picks, saving time, minimizing the number of construction activities that needed to occur at elevation, and providing a safer construction process. The light steel superstructure also allowed the team to optimize the pier and foundation designs. The reduced mass and increased flexibility of the superstructure reduced the gravity loads and seismic demands, when compared with other structure types the team considered.

Most of the approach structures are founded on either 3-ft- or 4-ft-diameter steel pipe piles, and the towers, anchor piers, and approach piers adjacent to the anchor piers are founded on 6-ft-diameter steel pipe piles.
A portion of the site over Metro-North Railroad tracks, where crane access was limited, highlights the flexibility of a steel superstructure. HDR worked with the contractor to develop a steel girder system that could be launched from the Westchester abutment in multiple phases during overnight track outages. The designer worked hand-in-hand with the erection engineer up front to ensure that the design could accommodate variations in loading during launching activities, which minimized changes during the fabrication process.

**Steel Team**

**Fabricators**
- High Steel Structures LLC, Lancaster, Pa. (approach unit superstructure, also detailer)
- W&W | AFCO Steel, Greensboro, N.C. (approach unit superstructure, also detailer)
- Canam-Bridges, Point of Rocks, Md. (main span superstructure)
- L&M Fabrication and Machine, Inc., Bath, Pa. (main span superstructure)

**Additional Detailer**
- Tenca Steel Detailing, Inc., Quebec

**Structural Engineer**
HDR, New York

**Design/Builder**
- Tappan Zee Constructors, LLC, a joint venture of: Fluor, American Bridge Company, Granite Construction Northeast, and Traylor Bros., Inc.

**Owner**
New York State Thruway Authority, Albany, N.Y.

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**Bridge Stats**

**Opened to traffic:** September 1, 2018

**Span lengths:** Two parallel three-mile structures, each with:
- Unit 11 WB/EB: 2,230-ft cable-stayed unit composed of a 1,200-ft main span and two 515-ft anchor spans
- Unit 1 WB/EB: 388-ft two-span simply supported approach unit composed of 116-ft and 272-ft spans, respectively
- Unit 2 WB/EB: 1,000-ft three-span continuous approach unit composed of spans varying between 309 ft and 350 ft
- Unit 3 WB/EB through Unit 8 WB/EB: Six 1,750-ft five-span continuous approach units composed of 350-ft steel girder spans
- Unit 9 WB: 1,075-ft three-span continuous approach unit with spans varying between 345 ft and 365 ft
- Unit 9 EB: 1,666-ft five-span continuous approach unit with spans varying from 301 ft to 354 ft with a simple 224-ft jump span at the end
- Unit 10 WB: 745-ft three-span continuous approach unit with spans varying from 235 ft to 262 ft

**Total length:** 3.1 miles (16,368 ft) per bound

**Average width:** Westbound: 96 ft; Eastbound: 87 ft

**Total structural steel:** 110,000 tons (including steel pipe piles)

**Cost:** $3.98 billion

**Coating:** Painted weathering steel for the superstructure, galvanized rebar and specific coatings and overlay for the concrete deck

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All photos in this spread courtesy of New York State Thruway Authority.
THE ORIGINAL BROADWAY BRIDGE served the communities of Little Rock and North Little Rock, Ark., for over 90 years as both a vital crossing and a signature tribute to World War I veterans.

Built in 1922, the bridge carried nearly 24,500 vehicles into the downtown area every day. However, with the continuing trend of residential redevelopment in the two cities’ downtown areas, the increasing need for safe and efficient crossings of the river became more apparent. In 2010, the Arkansas Department of Transportation (ARDOT) made the decision to replace this functionally obsolete bridge due to it being structurally unsound as well as the lack of mobility it provided for the growing population in the area. The team of HNTB Corporation and Garver, LLC, was chosen to design the replacement bridge in 2011.

Garver developed a new layout to address the current traffic needs while increasing safety for the traveling public. Garver was responsible for improving sight distances, as well as separating motorists and pedestrians through the addition of a 16-ft-wide shared-use path, two new pedestrian-only ramps connecting the trails directly to this path, and MSE walls to reduce right-of-way impacts and overall bridge length.

Pulaski County leaders wanted the bridge to serve as a unique and pleasing experience for pedestrians and cyclists by enhancing the aesthetics of the bridge, and they contributed $20 million of the $98 million total project cost to be spent toward two signature spans over the river. These funds allowed the design to possess an enhanced aesthetic form constructed in an accelerated fashion and using a limited budget to satisfy the current and future needs of the community.

The HNTB-designed main spans of the Broadway Bridge are composed of two 448-ft network tied-arch spans with steel plate girder approaches. The lengths of the five approach spans vary from 126 ft to 227 ft. The final design consists of inclined basket-handle arches with a framed-in floor system, which lowered costs. The tied arches allowed a signature structure to be constructed on the existing alignment ahead of the anticipated 180-day bridge closure by using an accelerated bridge construction (ABC) technique to float the arches into place.

Throughout design and construction, the team took great care to observe the U.S. Federal Highway Administration’s strict guidelines for fracture-critical members. The bridge was made with ASTM A709 Grade 50 steel, which includes the Charpy V-notch Zone 3 requirements for increased toughness. This was important for the tie girder, floor beams, and hanger plates as they are all considered fracture-critical members. For the tie girder, the cross section con-
sists of a closed parallelogram box girder made up of two inclined webs and two horizontal flanges. The web plates are welded to tab plates with a double-fillet weld and then bolted to the flanges. This bolted connection isolates a potential fracture of one plate without allowing the fracture to propagate throughout the cross section. The resulting three-sided tie girder section was designed to carry the structural demands at an extreme event limit state, and this internal redundancy eliminates the potential for a catastrophic structural failure.

The construction of the arches took place on falsework floating in the river moored to the north bank of the Arkansas River. This technique provided extra space for the contractor to work within a limited construction footprint for such a large urban project. To minimize the closure period during construction, the bridge’s new foundations were strategically placed to provide clearance from the existing foundations. This allowed the contractor to use specialized equipment to construct the new drilled shafts and waterline footings beneath the existing bridge while the bridge remained open to traffic. The new tied-arch structure was floated into place once the primary structural steel framing was erected. This ABC process required only two 24-hour river closures.

Using these techniques, the team was able to open the $98 million structure to vehicular traffic after 2.5 years of construction on March 1, 2017, having removed 28 days from the anticipated 180-day closure period.

For more on the Broadway Bridge, see “Making a Signature Connection” in the July 2017 issue of Modern Steel Construction, available at www.modernsteel.com.

Steel Team
Fabricators
Veritas Steel, Palatka, Fla.
W&W | AFCO Steel, Little Rock, Ark.
Delong’s, Inc., Jefferson City, Mo.
(also detailer, south approach)

Detailers
Tensor Engineering, Indian Harbour Beach, Fla. (arch spans)
ABS Structural, Melbourne, Fla. (north approach)

Structural Engineers
HNTB, Kansas City, Mo.
Garver, North Little Rock, Ark.

Prime Contractor

Owner
Arkansas Department of Transportation, Little Rock, Ark.
Bridge Stats

**Opened to traffic:** December 11, 2017

**Span length:** 483 ft

**Total length:** 963 ft

**Average width:** 22 ft

**Total structural steel:** 4,300 tons

**Cost:** $68 million

**Coating/protection:** Paint

All photos and graphics in this spread courtesy of Modjeski and Masters
THE NEW PORTAGEVILLE BRIDGE had big shoes to fill, so to speak. The original bridge crossed the scenic Genesee River Gorge, known as the “Grand Canyon of the East,” in Letchworth State Park in Portageville, N.Y., which hosts more than a million visitors a year thanks to its stunning scenery, including three large waterfalls. The new bridge, adjacent to where its predecessor once stood, is located directly above the Upper Falls.

Built in 1875, the old viaduct bridge was considered iconic within the Park and it was expected that a new bridge would need to be as well. After nearly a decade of public meetings, stakeholder input, environmental study, and engineering analysis, the team determined that the new bridge would be a spandrel-braced arch. Nine different options went through an evaluation process defined by New York’s State Environmental Quality Review Act, which considered the project objectives and the site’s unique characteristics. Ultimately, the team concluded that removing the existing bridge and building a new bridge on a parallel alignment would be the best option.

The selected design is the first true arch bridge built for the rail industry since the late 1940s. Modjeski and Masters (M&M) led the structural design of the new 483-ft-long arch. The arch is flanked on both sides by three 80-ft-long welded girder spans, and the track is supported across the bridge with a 20-ft-wide concrete ballast deck. The welded girder spans are supported on reinforced concrete piers and abutments that are founded on micropiles.

The bridge’s span exceeded the guidance provided by the American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering, which is primarily used on simple-span bridges less than 400 ft in length, and thus required project-specific design criteria. The arch was erected in two halves, from the east and west skewback foundations, using the cantilever method. An “arch tieback system” was designed to support each arch half during cantilever erection up until arch closure. Each tieback system tied into the gusset plate at the end of top chord of the arch, and then anchored into a guy tower and backstay system with 12 cables. The guy towers transferred cable demands to a series of backstay members and directed the vertical components into the permanent approach span abutment. The backstays were connected to a grillage system anchored by 140-ft-long pretensioned rock anchors.

Each individual cable was connected to a tensioning device equipped with a jacking rod and center-hole jack, which was used to adjust the cable lengths and thus the arch geometry during erection and arch closure. The deflection of the arch and the tension in the tieback system cables were monitored throughout cantilever erection stages. Field-recorded values were compared to theoretical values obtained from a staged construction analytical model to ensure the arch closure geometry was eventually achieved. At the arch closure stage, the geometry for each half was fine-tuned using the tieback system until the bolt holes in the lower center panel point were aligned.

The gorge walls had an irregular shape and were not easily accessible. The difficult terrain would have made conventional surveying methods difficult, so the team used lidar scanning to make a preconstruction survey of the gorge walls. This preconstruction survey was used for placement of cranes and the determination of lifting radius. An additional lidar scan verified excavated quantities after the gorge pockets were completed.

The AREMA guideline for spacing trusses at 1/15 of span length was not followed, due to the unnecessary width that would be added due to the long span. The structure was proportioned such that no load combination produced uplift, except for a few combinations during construction staging. Plate thicknesses of box members were sized to preclude the need for longitudinal stiffeners. The main members were designed including in-plane and out-of-plane bending moments. As many of the applied loads can be multi-directional and thus cause moments to change direction, a conservative assumption was made to combine them in an additive manner and match the polarity of the axial loading under investigation.

A memorandum of agreement between the Federal Highway Administration; Norfolk Southern; New York State Department of Transportation; the New York State Office of Parks, Recreation, and Historic Preservation; the National Park Service; and various Indian Nations was created to produce a mutually agreed plan to avoid, minimize, or mitigate the impacts on various historic and cultural resources. The agreement stipulated that portions of the existing bridge would be salvaged and displayed to mitigate the removal of the bridge. A construction protection plan avoided impacts on other historical resources, and additional plans protected endangered species, such as northern long-eared bats, timber rattlesnakes, and bald eagles.

Steel Team
Fabricators
Canam-Bridges Point of Rocks, Md. (arch bridge)
Veritas Steel, LLC Eau Claire, Wis. (approach deck girder steel spans)

Detailer
DBM Vircon Services Port Coquitlam, B.C., Canada

Steel Erector and General Contractor
American Bridge Company, Coraopolis, Pa.

Structural Engineer
Modjeski and Masters, Mechanicsburg, Pa.

Owner
Norfolk Southern Corporation, Atlanta
THE NEW SARAH MILDRED LONG BRIDGE across the Piscataqua River between Portsmouth, N.H., and Kittery, Maine, replaces an existing span built in 1940.

Where the original bridge involved a bi-level lift span and approach bridge format, the new incarnation is a single-level lift span with bi-level approach spans. Both new and existing structures were designed to carry vehicular traffic (on the upper level) and rail traffic (on the lower level), with the new single-level lift span lowering for rail traffic and raising for maritime vessels.

The project is a complete bridge replacement including foundations, an operator's room, new traffic warning systems, a new 300-ft-long steel box girder lift span, and precast post-tensioned towers and vehicular and railroad approach segments. The team contended with several challenges, such as minimizing construction costs and construction time, a swift tidal channel with a current of approximately 5 knots and a tidal change of 8 ft, and a design vessel collision force of 6,000 tons.

On the lift span itself, the rail and roadway are on the same level, with the tracks are embedded in the median. Dual seating positions (vehicular and rail) allow the single-level lift span to match the bi-level approaches. Because the new bridge has a 56-ft vertical clearance when in its “resting” position (an increase in vertical clearance from the original configuration) there will be 68% fewer bridge openings than with the old bridge, significantly reducing the number of traffic delays. The lift span is simply lowered down to match up with the railroad bridge approaches on the relatively rare occasion when trains travel across the river.

The lift span superstructure uses a traditional twin steel tub girder design with a continuous top plate to facilitate shipping to the site by truck. This allowed the final configuration of the lift span to be fabricated at local inland facilities then assembled on-site, reducing the construction schedule and planned existing bridge closures.

The lift span girder is a multi-box steel structure with a composite concrete deck. Based on the length-to-width ratio of the structure, the entire cross section is effective in resisting global forces. Two main boxes with separate bottom flanges, two fascia box beams, and a composite concrete deck are the primary longitudinal load carrying members. In addition to contributing to the overall cross section, the composite deck is designed to transmit local loads transversely to the main longitudinal elements. Longitudinal elements are braced at discrete points along the length of the span at 12-ft increments. Transverse elements include cantilever brackets between fascia boxes and main boxes, internal box bracing, and intermediate diaphragms along the centerline of the span between main boxes, and the lift span girder is supported at each end by transverse lifting girders.
The main boxes are aligned such that the interior webs are located directly below each rail track. The track is embedded within the concrete deck, with minimal cover to the top of the steel, and the design team implemented a direct load path into the box section. In addition to providing a predictable load path, this alignment eliminated the need for supplemental track support structures and ultimately reduced the span weight.

An innovative retractable support system was developed to support the lift span at the mid-level roadway position and move out of the way to allow the lift span to lower to the rail position. Tapered steel columns founded on spherical bearings at the rail level and cylindrical bearings at the electrical room under the roadway level rotate to allow for the dual seating of the lift span.

The fatigue critical areas of the structure are primarily located along the top flange plate when subjected to transverse loading. Fatigue analysis of the deck plate required an increased plate size along the centerline of the span, below the track and extending beyond the interior web plates. Deck plate details in the longitudinal direction are not a fatigue concern, as the flange always remains in compression.

Placing the operating machinery at the base of the tower is an innovation that is relatively recent to the movable bridge industry—and one that was implemented on the new Sarah Mildred Long Bridge. The lifting machinery, mechanical systems, and electrical systems could all be installed before completing tower erection and lift span float-in because they are placed lower in the tower. This provided for quicker construction, reduced initial costs, and allows easier access for future maintenance.

The lift span box girders and other lift span steel components were fabricated at Casco Bay Steel Structures in South Portland, Maine before being sent by rail to a waterfront facility and barged to the bridge site. Float-in was a complex operation that required a fixed guide barge, an adjacent push barge with two tugs, and a lift span overhanging barge. Several important steps followed the float-in, including deck placement, joint installation, finger joints, mitre rail, span guides, access, and rope connection.

The bridge was designed with long open spans, using 11 fewer piers than the old bridge. This span layout not only enhances vistas for residents and motorists, but it also enabled the new bridge to cross Market Street without a pier in the median. The new bridge serves as a gateway entrance into historic downtown Portsmouth.

**Steel Team**

**Fabricator**
Casco Bay Steel Structures, Inc. South Portland, Maine

**Detailer**
Tensor Engineering, Indian Harbour Beach, Fla.

**Steel Erector and General Contractor**
Cianbro, Pittsfield, Maine

**Structural Engineer**
Hardesty & Hanover, LLC, New York

**Owners**
Maine Department of Transportation, Augusta, Maine
New Hampshire Department of Transportation, Concord, N.H.
CSX’s Single-Track, 163-Ft-Long Bayou Sara Swing Bridge is one of the rail transportation company’s 47 movable bridges. While the approach spans had been recently replaced, the swing span was over 90 years old and was scheduled to be replaced as part of a program to upgrade all of CSX’s movable bridges. To replace this critical link on the company’s Mobile Bay line, CSX turned to HDR to design a durable replacement with remote operation, minimized maintenance, and limited rail service interruption during construction. An in-kind replacement allowed the team to reuse the substructure, simplifying construction, speeding up the schedule, and reducing permitting requirements and track outages.

During hurricanes or lunar high tide, it was common for the water to rise above the bottom flange of the girders of the old bridge, inundating the bridge machinery with brackish coastal water. Because the bridge approaches could only be raised minimally, the replacement bridge incorporated features that mitigated the effects of high water inundating the lower part of the bridge. The team placed the electrical components, hydraulic equipment, and control systems on a gantry 28 ft above the track to remain above the water even during the worst of storms. An outboard walkway and stairway provide access to the platform, away from the track. In addition to improved security and environmental resilience, the platform allowed the team to rebalance a crucial counterweight.

The mass of a swing span must be balanced for proper operation. The control houses for many swing spans, including the old Bayou Sara Bridge, are mounted to a platform along the span edge, near the pivot. This requires a counterweight on the opposite girder to transversely balance the span. Adding the platform to the design allowed the team to reduce the counterweight steel by 20 tons.

Given the challenges, collaboration was critical to project success. The decision to proceed with the grillage concept was ultimately made in September 2017, just two months prior to the target float-in date. This limited the schedule for detailed design, procurement, fabrication, and assembly. When the grillage con-
cept was first discussed, general contractor Brasfield and Gorrie immediately contacted the steel fabricator, Steward Machine, to discuss constructability and material availability. Steward provided feedback on available structural shapes, which were approved. This collaborative effort expedited shop drawing development and engineering review, which was crucial to procuring the grillage in time for installation prior to the float-in.

From the beginning of the project, CSX’s freight rail operations team allowed a 48-hour rail outage, which is a challenging window for removing a movable bridge span and installing a new one. During the construction phase, the team developed a plan to swap out the spans within this time frame, using a precast concrete pier cap to simplify construction and replace the deteriorated concrete cap.

However, as the planned outage drew near, CSX asked if the outage could be reduced so as to avoid delaying trains. The team considered several options, including temporary piles, which would have added significant costs to the project. In the end, the collaborative efforts between the owner, contractor, and engineering teams concluded that the most cost-effective solution was a structural steel support frame (grillage) suspended from the new swing span with pre-mounted rack, wedges, and pivot bearings. This steel grillage took the place of the top portion of the pivot pier, which was removed during construction. The grillage allowed the bridge machinery and bearings to be aligned and locked in their final position prior to float-in. It also provided support for all dead and live loads applied to the pivot pier, permitting rail traffic to pass almost immediately after the span float-in. The outage for marine navigation was longer than for railway traffic. This gave the team time to cast the surrounding concrete in place after the float-in phase, prior to operating the swing span.

Careful planning and pre-work paid off in the form of an accelerated swap-out of the swing spans, reducing the required track outage to only 14 hours.

Steel Team
Fabricator and Detailer
Erector and General Contractor
Brasfield and Gorrie, Birmingham, Ala.
Structural Engineer
HDR, Newark, N.J.
Owner
CSX Corporation, Jacksonville, Fla.
THE FRANCES APPLETON PEDESTRIAN BRIDGE project achieves visual transparency and lightness through a carefully selected structural steel system as it connects Boston’s Beacon Hill neighborhood to the Charles River Esplanade.

Designers had to balance the slenderness of the bridge against creating a structure that would potentially have issues with pedestrian-induced vibrations. During the design process, multiple iterations of the structural system were evaluated to achieve the maximum comfort range for pedestrians while eliminating the need for future supplemental measures, such as installing tuned mass dampers. The final design includes the creative use of a lightweight concrete deck with foam-filled, stay-in-place forms and appropriate foundation details.

The 750-ft-long multiuse walkway, adjacent to the historic landmark Longfellow Bridge, consists of a contemporary tubular steel arch with a span of approximately 226 ft over a parkway. The steel superstructure, approximately 550 ft in length, is continuous, without any joints, and its shape in plan follows a curvilinear alignment in two directions. The arch and approach spans employ a distinct architectural theme of slender steel piers and struts for visual consistency and aesthetic appeal.

The new crossing replaced an existing bridge that was too narrow and had inadequate access stairs; conflicts between pedestrians and bicyclists were common. The placement and overall geometry of the new bridge were carefully selected to comply with the ADA maximum slope requirements and avoid impacting large trees in the parkland as much as possible—and its width of 14 ft doubles that of the original bridge. Several entry points and connections to the existing network of walkways along the Esplanade are integrated into the design of the new bridge.

The major challenge of this unique bridge was the fabrication of the steel structure and its overall constructability. Its design included complex curves and welded connections. The elegant steel superstructure consists of steel girders branching into two curved staircases and a scenic overlook plaza near the river. The bridge’s steel fit-up required careful planning during the final design phase, as construction over a busy arterial road necessitated a detailed erection plan and sequencing. Stresses were evaluated in all structural members during both fabrication and erection.

The main steel arch has a unique shape, being wider at the crown and narrower at the abutments, which helped minimize

NATIONAL AWARD Special Purpose
Frances Appleton Pedestrian Bridge, Boston
the size of the anchoring abutments at the park level. The arch also includes a series of inclined struts, creating a unique aesthetic truss effect. It is the longest bridge span over Storrow Drive, connecting the city to the riverfront. The crossing is also higher than any other existing bridge along the highway corridor, opening views and incorporating appropriate vertical clearances.

The arch was brought to the site in pieces and assembled during overnight hours to reduce traffic impacts, and it was welded in place in order to avoid using visible bolted connections. The bridge approaches include Y-shaped piers, which visually match the main architectural theme creating a visually unified structural system. Aesthetic lighting is also included to increase the sense of safety and appeal at night. The sinuous crossing is perfectly integrated into the landscape thanks to its transparency and lightness.

The new signature pedestrian bridge has quickly become a source of pride for the community due to its technical ingenuity, elegant detailing, and context-sensitive design, which perfectly integrates into Boston’s landscape and historic riverfront.

Bridge Stats

**Opened to traffic:** December 20, 2018

**Span length:** 750 ft

**Total length:** 1,500 ft

**Average width:** 24 ft

**Total structural steel:** 676 tons

**Cost:** $29 million

**Coating/protection:** PPG 68HS primer, Amercoat 399 intermediate coat, Amercoat 450H final coat (Blue Oasis)
CHICAGO’S 41ST STREET PEDESTRIAN BRIDGE design was an award winner right from the get-go.

The design team’s curving, arch-supported steel concept won an international design competition to create the bridge. The resulting span connects the city’s Bronzeville neighborhood with the trail system that runs along Lake Michigan. The bridge provides pedestrians with safe passage over Lake Shore Drive as well as the Metra Electric/CN Railroads, both of which had to stay in operation during construction. The railway sees approximately 263 trains per day while Lake Shore Drive carries approximately 100,000 vehicles per day.

Two main component round sections (36-in. and 48-in. OD induction bent pipe) tied together with built-up box girders form the main span of the pedestrian bridge. The pipe and bridge have both sweep and camber, so the pipe had to be carefully bent in order to induce both elements simultaneously. The process of induction-bending the pipe was particularly challenging, given that the actual diameter, ovality, and pipe shrinkage had to be taken into consideration prior to fabrication to ensure all of the subcomponents that tie into the pipe fit correctly. The bridge was progressively preassembled in the shop in order to ensure proper geometry and fit-up, which was especially challenging due to the large sweeping and curving geometry that required much preplanning and lots of shop floor space.

The team also had to figure out the logistics of shipping the large sections of the bridge from two fabrication shops to the project site. The bridge components were shop-welded to their fullest extent, resulting in extremely long, wide, and heavy permit loads that required significant preplanning and coordination. The largest structural piece was 62 ft long, 24 ft, 4 in. wide, and 38.3 tons, with the heaviest structural piece being just over 42 tons. The bridge was shipped to the job site in 14 built-up sections, including six approach single-pipe spine assemblies and eight main span double-pipe assemblies; the main span assemblies were more than 24 ft wide.

The arches use bolted splices as well as field welds for aesthetic purposes. The design team chose to use the end-plate bolted connection option to save time and cost during erection. Prior to delivery to the site, the structural steel was blasted and painted with a three-coat paint system in the shop.

The project came in under budget and opened six months ahead of the original contract completion date.

Steel Team
Fabricators
Hillsdale Fabricators, St. Louis
Metal Pros, LLC, Wichita, Kan. (handrails)
Erector
S&J Construction Co., Inc., Oak Forest, Ill.
Detailer
Esskay Structures, Inc., Vienna, Va.
Bender-Roller
BendTec Inc., Duluth, Minn.
(also additional fabrication)
Designer/Structural Engineer
AECOM, Chicago
General Contractor
F.H. Paschen, S.N. Nielsen and Associates LLC, Chicago
Construction Manager
TranSystems, Chicago
Owner
Chicago Department of Transportation, Chicago
THE THREE-MILE STRETCH BETWEEN Incline Village and Sand Harbor State Park on the east shore of Lake Tahoe in Nevada is, in a word, stunning. And a series of new steel-framed bridges is now an integral part of this scenic multiuse path.

The owner, the Nevada Department of Transportation (NDOT), used the construction-manager-at-risk (CMAR) delivery method for this $40 million trail project. The team faced an accelerated delivery schedule, challenging subsurface conditions and terrain, high seismicity, limited construction access, and an environmentally sensitive project location.

The three miles of new multiuse path was installed on a steep side slope between the existing State Route 28 and Lake Tahoe. The path comprises five steel bridges, totaling 809 ft. To create a structural system that could be installed with minimal disruption to traffic on the heavily used SR-28 adjacent to the trail alignment, the team designed prefabricated bridge spans composed of weathering steel girders that supported lightweight fiber-reinforced polymer (FRP) deck units. Composite Advantage manufactured the 50-ft-long pre-fabricated deck units with steel supplied by fabricator Cox Brothers Machining. The deck units were shipped to the site and placed by contractor Granite Construction during short-term road closures.

The various regulatory agencies that have jurisdiction over the area were focused on aesthetics. The project is highly visible from the lake, and it was very important to minimize visual impacts on the terrain. The steel girders and hand railings use weathering steel to minimize long-term maintenance costs associated with painted steel and to provide a surface finish that blends in with the natural terrain. The steel pipe sections used for the columns at the piers were galvanized and then coated with Natina to provide a finish that matches the weathering steel stringers.

Steel Fabricators
- Stinger Bridge and Iron, Coolidge, Ariz. (substructure elements)
- Cox Brothers Machining, Inc., Jackson, Mich. (steel stringers and diaphragms)

Steel Erector and General Contractor
Granite Construction Inc., Sparks, Nev.

Structural Engineer
Jacobs, Sacramento, Calif.

Owner
Nevada Department of Transportation, Carson City, Nev.
Bridge Stats

**Opened to traffic:** June 21, 2019

**Span length:** 50 ft

**Total length:** 809 ft

**Average width:** 11 ft

**Total structural steel:** 76.6 tons

**Cost:** $1.9 Million

**Coating/protection:** Weathering steel (girders and railings), galvanizing and Natina (pipe columns)
THE ANDY WARHOL (SEVENTH STREET) BRIDGE, an eye-bar-chain, self-anchored suspension bridge, carries Seventh Street over the Allegheny River, the Tenth Street Bypass, and the Three Rivers Heritage Trail in downtown Pittsburgh.

Named for the famed artist who hailed from Steel City, it is one of the “Three Sisters” bridges constructed from 1924 to 1928—the only trio of identical, side-by-side bridges in the world—and is the first self-anchored suspension span constructed in the United States.

The bridge required rehabilitation due to accelerating age-related deterioration. The project involved replacing the bridge deck, totally repainting the superstructure, performing structural steel substructure repairs, and applying scour protection. The Allegheny County Department of Public Works chose Michael Baker International to perform analysis and design of the rehabilitation. The design team combined recognition of historical significance with modern engineering practices to complete a structurally superior, sustainable rehabilitation that was also aesthetically relevant and pleasing.

The bridge was analyzed for the first time using a fully 3D finite element model to examine the effects of unbalanced loading and modern vehicles on the structure. Completing the rehabilitation required numerous materials that are not normally used in new bridge construction, like post-tensioned tie-down anchorages, forged steel bridge pins and nuts, permanently lubricated bronze bushings and washers, and bronze dedication plaques cast to replace missing plaques. Workers used electric shear wrenches to install thousands of ASTM F3125 Grade F1852 high-strength bolts with button heads, to mimic the look of rivets, thus improving structural capacity while being sensitive to appearance. New bridge lighting on sidewalks and pylon rooms replicates the style of the original lighting fixtures. The new roadway curb boxes are
designed to be as unobtrusive as possible while still allowing water to drain and prevent salt and debris from sitting on and corroding the stiffening girders.

The complex rehabilitation was performed as a conventional design-bid-build construction project and concurrent with road work on I-279/HOV lanes/North Shore Expressway. This necessitated well-organized traffic control for nearby PNC Park and Heinz Field (homes to the Pittsburgh Pirates and Steelers, respectively) events, maintenance of pedestrian crossings at the adjacent streets, and sustained access to riverside trails and adjacent businesses.

The bridge also had to act as its own lay-down yard, resulting in tight site conditions. Temporary underdeck shielding and coordination with the U.S. Coast Guard and local river users allowed safe river access. Notice was broadcast daily to mariners, and a monitored phone number and radio channels were established for large vessels. Temporary Duquesne Light (electrical) conduit enabled work on sidewalk brackets and replacement of electric conduits and supports. Temporary conduit in plastic corrugated pipe was placed on the sidewalk to maintain safe working conditions around energized lines, as well as to maintain a major power supply for downtown Pittsburgh.

The team used a variety of other construction innovations, including vibro-screed (air screed) and pump trucks to place the concrete deck, over-pouring the deck by ¼ in., subsequent grinding to provide correct cross slopes and longitudinal smoothness, and employing a temporary hold-down system using permanent post-tensioning rods. The new reinforced concrete deck is fully structural, using channel-type shear connectors to make the deck composite. The existing buckle plates, once the structural part of the deck, now remain as stay-in-place forms.

Steel Fabricator and Erector
Advantage Steel and Construction, Saxonburg, Pa.

Structural Engineer
Michael Baker International, Moon Township, Pa.

General Contractor
Brayman Construction, Saxonburg, Pa.

Owner
Allegheny County Department of Public Works, Pittsburgh

Bridge Stats

Opened to traffic: November 17, 2017
Span lengths: 72.80 ft, 221.36 ft, 442.08 ft, 221.36 ft, 41.95 ft, 61.45 ft
Total length: 1,061 ft
Average width: 66 ft out-to-out
Cost: $25,425,000
Coating/protection: Three-coat organic zinc-epoxy-urethane (Aztec Gold)
THE THREE-SPAN steel riveted through-truss Winona Bridge across the Mississippi River stands as a beloved landmark and vital thoroughfare for motorists traveling between Wisconsin and Minnesota. Built in 1942, it is the only pre-1946 cantilever through-truss bridge in the latter state and played a central role in sustaining the economy of Winona and facilitating the flow of defense materials during World War II.

The 2007 collapse of Minneapolis’s I-35W bridge threatened that history. Following the collapse, the Minnesota legislature provided funding and required MnDOT to develop an ambitious 10-year bridge replacement program, with a focus on fracture-critical bridges. MnDOT’s inspection team discovered corrosion and section loss on multiple truss members, resulting in a load posting that restricted heavier commercial vehicles and closed the bridge for more than a week. Immediate repairs provided a short-term solution, but they highlighted the structure’s continued importance: Wisconsinites who depended on Winona’s first-call ambulance services found their link to the town severed. Local businesses took a hit during the shutdown. Nearly 12,000 motorists per day were forced to make detours of 60 miles roundtrip to other crossings over the Mississippi.

In 2014, MnDOT engaged Michael Baker International as prime consultant and Ames Construction as prime contractor—the department’s first use of the construction manager/general contractor (CM/GC) approach—to work together to ensure the long-term reliability of the structure. Tearing down the bridge had already been ruled out; it was eligible for listing on the National Register of Historic Places and had become an iconic asset for the region, even appearing on a postage stamp celebrating the state’s sesquicentennial. So the team aimed for an ambitious goal: completely rehabilitating the bridge to resist modern permit loads, reconstructing the approach spans, rebuilding the deck, and adding internal redundancy to comply with the intent of the state statutes, all while avoiding any adverse effects as determined by the State Historic Preservation Office. By modernizing the structure, the team would establish the first through-truss bridge in the Midwest to have internal redundancy added to all its fracture-critical elements.

Accomplishing all this required creative problem-solving and complex coordination. Completing a historic bridge rehabilitation is an intricate undertaking wherever the work occurs, but doing it on budget in Minnesota’s harsh climate is a whole other matter. Long winters and road salting had fueled deterioration, making it possible the contractor would uncover even more corrosion in the field. Lead paint had to be removed, section-loss measurements taken, and the entire structure repainted. High-strength bolts and new steel plates had to be installed over tens of thousands of rivets, which had not always been installed according to the original plans. The team also had to replace the aging bridge deck and patch spalled piers to blend with the bridge’s concrete color. After analyzing

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**Bridge Stats**

**Opened to traffic:** July 1, 2019

**Span lengths:** 47 ft, 119 ft, 123 ft, 134 ft, 130 ft, 130 ft, 242 ft, 450 ft, 242 ft, 130 ft, 130 ft, 130 ft, 130 ft

**Total length:** 2,291 ft  
**Average width:** 33 ft

**Total structural steel:** 710 tons

**Coating/protection:** Inorganic zinc-rich three-coat paint system
the structure’s timber piles, the team encountered another dilemma: The piles would not stand up to the impact of a modern barge collision and would have to be strengthened as well.

Every step of the way, Michael Baker’s team worked with the project historian and MnDOT’s Bridge Office and Cultural Resources Unit (CRU) to evaluate each engineering improvement for compliance with the National Historic Preservation Act of 1966 and Minnesota’s State Historic Preservation Office. This called for extensive, detail-oriented work and intense coordination.

The CM/GC team began work on the Winona Bridge in 2014. It first generated complex 3D finite element models to analyze the fracture-critical components of the structure and formulate plans for strength and internal redundancy retrofits. These designs relied on steel plates and post-tensioning bars that strengthened the bridge and extended its service life by 50 years.

Owing to the age of the structure and the parameters for historic designation, the team faced numerous obstacles during the rehabilitation. It solved the issues posed by the bridge’s timber piles by implementing a scour-protection system, which consisted of geobags and rip rap. Additionally, an innovative underwater strut system was designed, essentially linking the original structure to the new parallel bridge. In doing this, the team ensured that both structures would share the impact of any barge collision, distributing the force and bolstering the older bridge’s timber-pile foundations.

To rebuild the approach spans, the team installed six new steel deck truss spans and constructed 15 prestressed concrete girder spans. For the main through-truss spans, 148 truss members were reinforced with steel plates and 76 with high-strength rods. The team replaced nine concrete piers from the original design by using longer, prestressed girder approach spans, which were less expensive to fabricate and construct.

Ultimately, the CM/GC approach proved to be a massive success, providing expert oversight, comprehensive coordination, and state-of-the-art solutions. What’s more, it delivered these innovative designs with great cost certainty prior to construction and no construction cost growth, opening the bridge to traffic six months ahead of schedule.

**Steel Team**

**Fabricator and Detailer**
LeJeune Steel Company, Minneapolis

**Erector**
Danny’s Construction Company, Shakopee, Minn.

**Additional Detailer**
DBM Vircon Services, Port Coquitlam, B.C., Canada

**Structural Engineer**
Michael Baker International, Chicago

**General Contractor**
Ames Construction, Burnsville, Minn.

**Owner**
Minnesota Department of Transportation, Rochester, Minn.
WITH AN EXPECTED LIFESPAN OF A CENTURY, the newly reconstructed BNSF Wind River Bridge serves as a critical connector on BNSF’s Fallbridge Subdivision, enabling the safe and reliable crossing of both freight and passenger traffic over the mouth of the Wind River in the Columbia River Gorge in Washington State.

HNTB provided design, permitting, and construction management services for the steel bridge’s reconstruction. The new bridge consists of a 260-ft-long, single-track truss span with precast double cell box beam approaches supported on concrete pier caps with drilled shaft and driven pile foundations. The project site is located in a national scenic area between State Highway 14 and the Columbia River, resulting in limited available site access for the contractor and the need for strict environmental compliance during construction.

Because the bridge carries a large amount of freight and passenger traffic, minimizing track closures remained a priority throughout the project. An accelerated bridge construction (ABC) technique, float-in/out, provided two distinct advantages to the project. First, it reduced the need for temporary work bridge piles, which were required to be installed and removed within a dedicated in-water work window. Secondly, it minimized impacts to railroad operations by limiting the time required to remove the existing span and install the new truss span on the existing bridge alignment.

Addressing the challenges associated with the float-in/out operation was one of the greatest challenges faced during the project, due to the number of associated variables. Because the truss span was erected in Portland, Ore., roughly 60 miles west of the project site, it was critical that the contractor’s plan to float the erected truss span down the Columbia River be fully vetted. To this end, BNSF and HNTB worked with the contractor to review their proposed maritime procedure and engineering and developed a plan to coordinate water levels with the Bonneville Dam to control the pool elevations during the bridge change-out.

Because the bridge is located in the Columbia River Gorge National Scenic Area, it was critical that the aesthetics of the new structure not disturb the existing view for the public. To address this concern, BNSF and HNTB worked with the applicable regulatory agencies to review proposed span types and bridge colors. The new main span used a Warren-type truss with weathering steel to closely match the feel of the existing Pratt-style truss and its weathered patina. Concrete pier caps and approach spans were also stained with a charcoal color to better blend in with the existing landscape. The team carefully selected materials to fulfill the project’s specific aesthetic requirements while also ensuring the integrity of the new bridge’s 100-year lifespan.

In addition to meeting a variety of requirements, the bridge design also needed to be adaptable. The bridge can accommodate the heavy live loads of current freight and passenger trains, and it is also robust enough to meet demands imposed by enhanced future railroad loading.

Steel Team

Fabricator
Fought and Company, Inc.  Tigard, Ore.

Detailer
Graphics for Steel Structures  Hicksville, N.Y.

Structural Engineer
HNTB, St. Louis

General Contractor
Hamilton Construction Company, Portland, Ore.

Owner
BNSF Railway, Kansas City, Kan.
Bridge Stats

**Opened to traffic:** August 6, 2019  
**Span length:** 260 ft (main span truss)  
**Total length:** 363 ft, 4 in.  
**Average width:** 23 ft  
**Total structural steel:** 850 tons  
**Coating/protection:** Weathering steel
WHEN THE TENNESSEE DEPARTMENT OF TRANSPORTATION (TDOT) faced the urgent need to replace or repair four deficient structures over I-240 in Memphis, subjecting roadway users to another long-term construction project simply wasn’t an option. With traffic levels of approximately 180,000 vehicles per day, TDOT wanted this critical project completed quickly, with minimal impact to travelers.

The four bridges in the project, dubbed MemFix4, are two new Poplar Interchange bridges; a new Norfolk Southern Railroad (NSR) bridge; and rehabilitation of the concrete Park Avenue bridge. This $54 million project was delivered under the CM/GC delivery method—the second-ever CM/GC transportation project in the state of Tennessee. TDOT, Benesch, and Kiewit worked together in the design phase to develop innovative ideas to address the numerous site challenges and project needs while maintaining the ability to meet the project’s aggressive schedule.

The WB and EB Poplar Avenue bridge replacements required multiple innovative prefabricated bridge elements. The constructed Poplar Ave. bridges consist of a 263-ft, two-span bridge for WB Poplar and a 222-ft, two-span bridge for EB Poplar. For the replacement of these structures, extensive modeling and structural analysis was required to address high seismic conditions. The team developed several custom elements. These included custom steel bearings and framing, over 13,000 linear ft of micropiles, new substructures constructed under traffic, and modular bridge superstructures—all of which addressed site challenges while completing the project in just 18 months.

The project team used accelerated bridge construction (ABC) methods to address site constraints and the necessity for minimal impacts to traffic. This led to the Poplar Avenue bridges being built off-site at a “bridge farm,” rolled to the site using self-propelled modular transporters (SPMTs), and then lifted into place using large crawler cranes. Once the bridges were constructed, Kiewit was able to complete the planned widening of I-240 to alleviate the lane drop that the entrance ramps required.

Because the existing piers for the Norfolk Southern (NS) Rail Bridge were founded on spread footings, it was not cost-efficient to upgrade the existing bridge’s substructures to meet current seismic design standards. TDOT realized that the next project needed to replace the structures while minimizing impacts to the thousands of vehicular travelers through this interchange and the nearly 20 trains per day on the NS/I-240 overpass.

To replace this bridge, a temporary shoofly structure was constructed just inches away from the existing bridge. It was composed of temporary concrete piers supported by a foundation of over 6,000 linear ft of micropiles. Leaving train traffic largely uninterrupted during construction, the permanent steel superstructure supporting a ballasted track was erected on the shoofly alignment and trains were switched onto this alignment. With trains traveling on the shoofly structure, the old bridge was demolished and
the new substructures were built. The two new 1,100-ton superstructure sections were then laterally slid 35 ft into place, one track at a time, during two weekend Interstate closures.

The Memphis area is located in the influence zone of the New Madrid Fault, which in 1811 and 1812 produced four of the most powerful earthquakes east of the Rocky Mountains in recorded history. The team spent significant effort during the design phase to ensure that solutions could be constructable while still meeting the seismic demands. Designers focused on the impacts of time during the construction phase, especially when it came to key elements that would be built during weekend closures. Benesch used finite element modeling to precisely design elements such as the bearing anchors to minimize the materials and labor required while still meeting the design requirements.


Steel Team
Fabricator and Detailer
W&W | AFCO Steel, Little Rock, Ark.

Erector and General Contractor
Kiewit Infrastructure Co., Brentwood, Tenn.

Additional Detailer
CRC Steel Detailing, LLC, Worth, Texas

Structural Engineer
Benesch, Nashville, Tenn.

Owner
Tennessee Department of Transportation, Nashville, Tenn.

Bridge Stats

Opened to traffic: June 30, 2019

Span lengths:
- WB Poplar Ave.: 150.5 ft, 113.08 ft
- EB Poplar Ave.: 88.17 ft, 134.17 ft
- Norfolk Southern Railroad Bridge: 50.83 ft, 73.5 ft, 73.5 ft, 87.5 ft, 50.83 ft

Total lengths:
- WB Poplar Ave.: 222 ft
- EB Poplar Ave.: 263 ft
- Norfolk Southern Railroad Bridge: 338 ft

Average width:
- WB Poplar Ave.: 65 ft
- EB Poplar Ave.: 72 ft
- Norfolk Southern Railroad Bridge: 36 ft

Total structural steel:
- WB Poplar Ave.: 614 tons
- EB Poplar Ave.: 287 tons
- Norfolk Southern Railroad Bridge: 948 tons
- All bridges: 1,849 tons

Cost: $28.4 million (combined structures cost)

Coating/protection: Weathering steel (WB and EB Poplar Ave.), weathering and painted steel (Norfolk Southern Railroad Bridge)
THE LIBERTY BRIDGE has been a landmark structure and Pittsburgh icon since it opened in 1928. A recent construction mishap made it an icon for the resilience of steel, too.

In the years following its five-mile-long opening parade, this bridge created the modern suburbs and quadrupled property values south of Pittsburgh. However, by 2014 the bridge, which carried 55,000 vehicles per day, was in poor condition. It could no longer carry trucks and had become a poster-child for America's infrastructure crisis, featuring prominently in a 60 Minutes profile of America's neglected infrastructure. Referring to Liberty Bridge and others like it, Ray LaHood, United States Secretary of Transportation, said plainly: “Our infrastructure is on life support right now.”

PennDOT and HDR responded with a rehabilitation project that preserved the structure while meeting current engineering and accessibility standards. PennDOT’s main goals in this rehabilitation were to remove the load posting on the bridge, ensure the bridge was accessible and safe per current codes, and secure 40 more years of use from this historic truss.

The first steel Exodermic grid deck used in Pennsylvania reduced impacts to the bridge’s thousands of daily users while a deck the size of three football fields was replaced. Sections of this deck were prefabricated in panels that could be installed during weekend closures and connected together with high-strength concrete. A custom rapid-set concrete mix was created for this project, which allowed traffic to use new deck sections just a few hours after the concrete was placed. The new deck combines the strength of steel T-beams with reinforced concrete on top, making it strong, light, and easy to overlay in the future.

The deck innovations were planned in advance, but the greatest innovations are often unplanned. When an accidental construction fire warped and buckled a main truss compression chord, forcing an immediate bridge closure, the team raced to develop a solution to fix the bridge and reopen this critical urban link. The bridge was in a perilous state; no one knew how badly the structure might be overstressed or if collapse was imminent. To assess and fix the bridge, teams of engineers worked many days and nights until the bridge reopened.

SPECIAL AWARD FOR RESILIENCE
Liberty Bridge, Pittsburgh

Bridge Stats

Opened to traffic: August 15, 2018
Span lengths: 41.5 ft, 65.75 ft, 45.5 ft, 247.25 ft, 278.75 ft, 168.5 ft, 152 ft, 470.5 ft, 152 ft, 166.25 ft, 152 ft, 274.25 ft, 242 ft, 148.5 ft, 43.25 ft, 14.5 ft
Total length: 2,663 ft
Average width: 67 ft
Total structural steel: 2,750 tons
Cost: $81.95 million
Coating/protection: Three-coat organic zinc-rich paint
The team used a 3D analysis model to assess the crippled structure, including both trusses, every bracing member, and the partially removed deck. Using hand-drafted documents from the 1920s, hundreds of unique truss and bracing members were modeled. The day following the closure, the new model showed that most of the 1,000 tons carried by the damaged chord shed into the undamaged sister truss through wind bracing. The 3D steel truss and bracing system proved redundant. No member was overstressed from the bridge dead load. This finding gave authorities confidence to open the river below the structure to commercial traffic, preventing further economic impact to river commerce.

Without a historical precedent to go by, engineers developed a steel jacking frame concept to fix the buckled member that same day. This frame would attach to the member and 2,000 tons of force could be applied with huge jacks to straighten the buckled steel. The contractor adopted the concept and their design team developed it further. The member was repaired through a combination of jacking and heat straightening only 24 days after the fire, and traffic was restored on the bridge—a momentous day for Pittsburgh commuters.

Trucks can now use the structure, with its new bridge deck and supporting stringers and after hundreds of unique steel repairs on beams, truss members, and connection plates. Replacing the bridge deck was crucial in order to preserve the bridge and allow it to function safely for another 40 years. The new deck, with modern bridge joints and drainage, provides a robust and waterproof “roof” to keep the steel below dry and corrosion-free. In addition, replacing the old stringers along with the deck eliminated many poor details that are prone to cracking over time. Holes, cuts, and welds in these beams did not meet current fatigue requirements. As years of exposure to traffic mounted, these details were a long-term liability requiring detailed documentation for each inspection. Replacing all stringers with new, properly fabricated beams, eliminated this liability.

**Steel Fabricators**
L.B. Foster Company, Pittsburgh

**Structural Engineer**
HDR, Pittsburgh

**General Contractor**
Fay, an i-iconUSA Company, Pittsburgh

**Owner**
PennDOT, Engineering District 11, Bridgeville, Pa.