PROJECT

Oakley C. Collins Memorial Bridge Design Development

by Dr. Steven L. Stroh, AECOM

The new Oakley C. Collins Memorial Bridge over the Ohio River between Ironton, Ohio, and Russell, Ky., replaces an aged bridge that opened in 1921. The original Ironton-Russell Bridge was a cantilever through truss bridge with a 725-ft main span. This bridge was at the end of its useful life and was rated both functionally and structurally obsolete. The bridge was restricted to vehicle widths of 7 ft 6 in. because of geometry restrictions, and was load-limited to 26 tons. Because of fatigue and fracture concerns, the bridge was continuously monitored.

In 2003, the Federal Highway Administration issued a record of decision (ROD) for a replacement bridge on a new alignment. A design was developed for a new single-tower two-span cable-stayed bridge with a steel edge girder structural system and a 950-ft main span. This design was bid in 2006. The low bid was $109.8 million, whereas the state's budget estimate was $80 million. It was decided not to award the project and to implement a value-engineering process to try to get it within budget.

Value Engineering

The value-engineering process evaluated the current design and opportunities for optimization, assessed the project criteria driving the bridge type selection, and evaluated opportunities to refine the design solution within the requirements set by the ROD.

The value-engineering team concluded that it was not possible to refine the original design solution, a single-tower cable-stayed bridge, to achieve the budget goals. A more comprehensive redesign would be required to achieve project goals. This included redesign as a balanced three-span two-tower cable-stayed bridge (which required reassessment of U.S. Coast Guard requirements on tower placement), change to a concrete superstructure, a reduction in typical section to the minimum required by the ROD, and improving the bridge alignment to facilitate the three-span bridge arrangement. As an outcome of this evaluation, the project was advertised for redesign in 2008.

Reassessment of Navigation Requirements

The original two-span cable-stayed bridge concept was driven by a navigation requirement that the pier (or tower) on the Ohio River bank could be no more than 50 ft from the bank. Because of the curving alignment as the bridge reaches the Ohio shore, a tangent alignment in the side span was precluded, which led to the decision for a two-span arrangement to keep the cable-stayed portion of the bridge out of a horizontal curve. As part of the value-engineering assessment, it was determined that with a slight realignment and, if the tower could be moved 100 ft off the Ohio-side bank, a tangent alignment for the side span for a three-span cable-stayed bridge could be accommodated.

The U.S. Coast Guard was open to this reassessment and suggested navigation simulations to determine the acceptability of the tower location. Independent simulations were performed over a two-day period with three licensed river pilots piloting a 15-barge tow under a simulated bridge under a variety of navigation conditions. These included day and night, upstream and downstream, loaded and unloaded, and various river stage, flow, and wind conditions. The control simulations were run with the existing bridge; the new bridge was then inserted in the simulation with the tower at various distances from the Ohio-side bank and with varying skew angles for the tower. All simulations were run in the presence of U.S. Coast Guard personnel.

The results of the simulation with the tower located 100 ft from the Ohio bank were favorable. Additional simulations were run with the tower 150 ft from the Ohio-side bank, which were also found to be acceptable from a river navigation viewpoint. As a result of the simulations, the U.S. Coast Guard approved the

profile

OAKLEY C. COLLINS MEMORIAL BRIDGE / IRONTON, OHIO

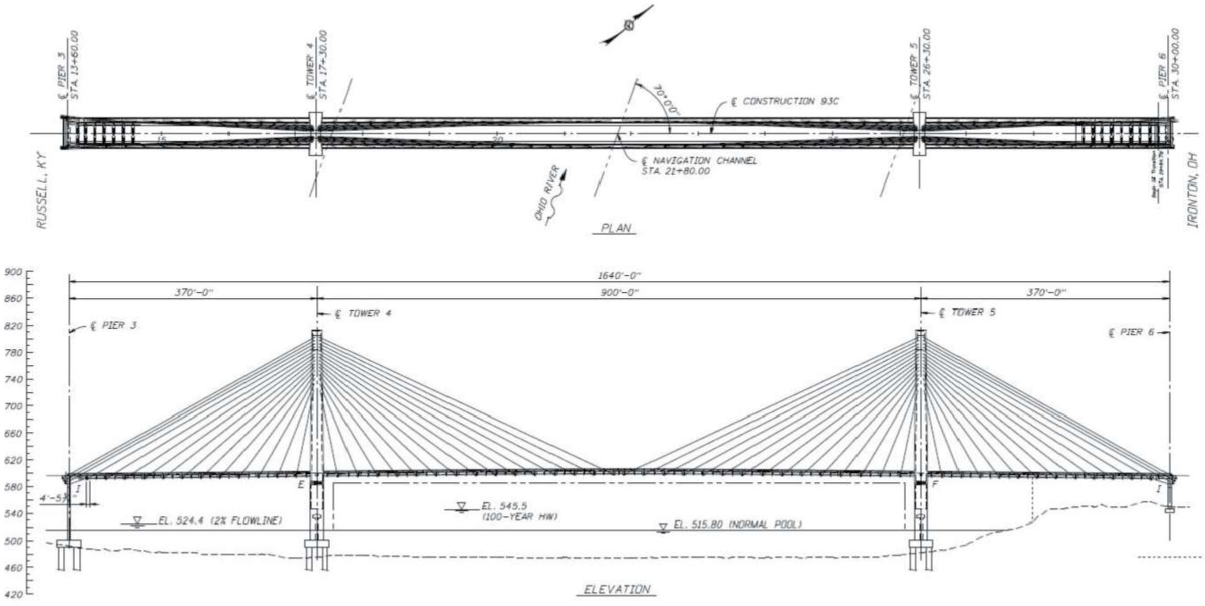
BRIDGE DESIGN ENGINEER: AECOM, Cincinnati, Ohio

NAVIGATION SIMULATIONS: Seaman's Church Institute, Paducah, Ky.

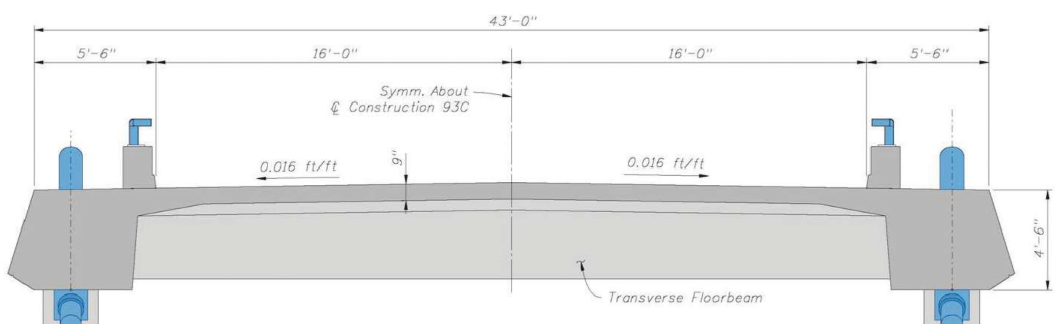
PRIME CONTRACTOR: Brayman Construction Corporation Heavy Civil & Geotechnical Contractors, Saxonburg, Pa.

CONTRACTOR CONSTRUCTION ENGINEER: Finley Engineering Group, Tallahassee, Fla.

CONSTRUCTION ENGINEERING AND INSPECTION: FIGG, Tallahassee, Fla.



Bridge plan and elevation. All Photos and Figures: AECOM.



Typical deck section, showing concrete edge girders, transverse floor beams, and deck.

location of the Ohio-side tower 150 ft off the Ohio bank, allowing two towers to be constructed perpendicular to the bridge alignment (20-degree skew to the river).

Project Design Details

The final configuration for the bridge is a symmetrical three-span cable-stayed bridge with a 900-ft main span and 370-ft side spans. The bridge is entirely on a tangent alignment. The design methodology is that the superstructure is restrained laterally and longitudinally at the Kentucky-side tower, restrained laterally but free to translate longitudinally at the Ohio-side tower, and constructed integrally at the two anchor piers. Expansion joints are provided at the two anchor-pier locations.

The superstructure typical cross section is a cast-in-place concrete edge girder/floor beam arrangement. With the modest traffic demands at this site, only a two-lane roadway is required. The 32-ft-wide deck cross section provides two opposing 12-ft-wide traffic lanes and two 4-ft-wide shoulders. The superstructure was designed as a conventionally reinforced concrete member.

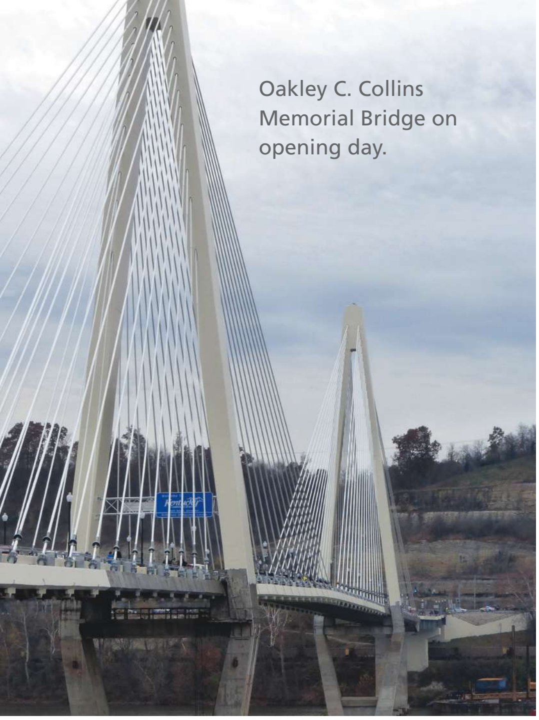
Two planes of stay cables are anchored at the edges of the concrete deck. The stay cables are arranged in a semi-fan pattern and are individually anchored at the girder and tower. The stays are spaced at 29 ft 3 in. in the main span and 28 ft 3 in. in the side spans, with three closely spaced backstay cables at the anchor piers. The cables range from fourteen to thirty-five 0.6-in.-diameter Grade 270 low-relaxation strands each.

OHIO DEPARTMENT OF TRANSPORTATION, OWNER

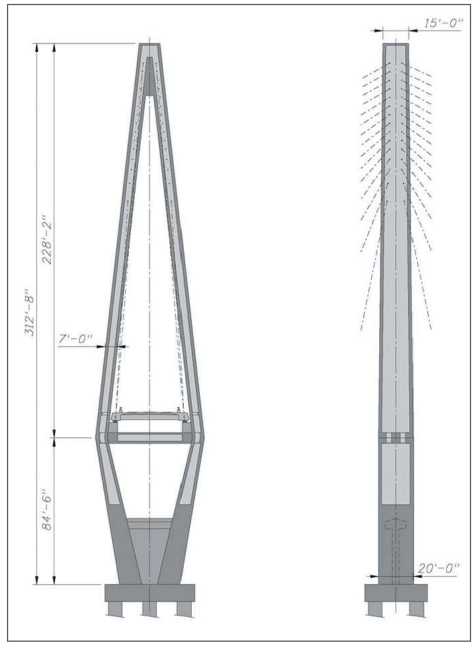
BRIDGE DESCRIPTION: Three-span concrete cable-stayed bridge with a 900-ft main span

STRUCTURAL COMPONENTS: 8.5-ft-diameter drilled shafts for foundations; cast-in-place concrete piers and towers. Superstructure is a concrete edge girder/floor beam arrangement with precast concrete components, including selected floor beams and stay-cable anchorages.

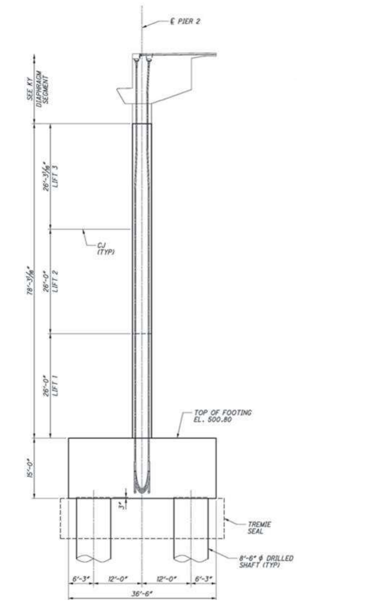
BRIDGE CONSTRUCTION COST: (low bid) $81.2 million



Oakley C. Collins Memorial Bridge on opening day.



Tower elevations.



Anchor-pier elevation.

The strands are individually greased and sheathed in a high-density polyethylene (HDPE) encasement, then are bundled together in an outer HDPE sheath. The outer sheath has a helical rib to help mitigate any wind/rain-induced cable vibrations. The design specified additional damping to be provided for each stay cable, and provided damping, power dissipation, force, displacement, and velocity parameters for each cable.

The 312-ft-tall towers are hollow, conventionally reinforced rectangular members forming a diamond shape. The cast-in-place tie element below the deck is post-tensioned with eight tendons, each consisting of nineteen 0.5-in.-diameter Grade 270 strands. The stays are anchored in fabricated steel box assemblies that constitute the inner form for the upper regions of the tower. The towers are founded on six 8-ft 6-in.-diameter drilled shafts with 8-ft-diameter rock sockets. Tower footings are submerged below the draft of barges at normal pool elevation and were constructed in cofferdam foundation forms with a bottom form and seal.

The anchor piers are integral with the cable-stayed superstructure and are slender members that flex in response to displacement demands. The anchor piers are vertically post-tensioned with U-shaped tendons that extend into the foundations. There are eight tendons, each consisting of twenty-seven 0.6-in.-diameter strands in each anchor pier providing the hold-down restraint of the superstructure. The hold-down restraint is provided by the mass of the anchor-pier assembly.

Aesthetics

The aesthetics of the Oakley C. Collins Memorial Bridge were developed following the functional requirements of the bridge, but also focused on providing good proportioning and detail. The bridge is a very tall and narrow structure, which provides certain elegance to the design. This is emphasized by providing clean, simple shapes. The towers are the dominant feature of the design and have a slender diamond shape. A transverse taper in the tower leg cross section is provided below deck level. Above deck level, the tower legs taper in the longitudinal direction, providing good visual balance for the tall tower legs. The superstructure leading-edge detail provides a slope break at middepth to provide a shadow line and accentuate the slenderness of the deck. The choice of a steel railing barrier also contributes to a slender superstructure profile. The final choice of internal stay dampers reinforces the clean lines of the structure, avoiding the clutter of external stay-anchor details.

Durability

The durability design of the Oakley C. Collins Memorial Bridge was developed based on a holistic approach to the practical decisions on material choice and detailing. Concrete was selected for the superstructure, in part due to its projected low future maintenance needs. Epoxy-coated reinforcing steel was used throughout the structure and an initial deck overlay was provided. Mass concrete was controlled to a maximum placement temperature of 180°F, and no greater than 35°F differential between the exterior surface and the core.

Construction

The Oakley C. Collins Memorial Bridge was successfully bid in January 2012. The engineer's estimate for the redesigned bridge was \$84.6 million and the low bid was \$81.2 million. The project was awarded with a notice to proceed on February 3, 2012. The contractor took advantage of flexibilities built into the design and contract documents to tailor the means and methods of construction, including some design revisions, to optimize construction.

The Oakley C. Collins Memorial Bridge was opened to traffic on November 23, 2016.

Dr. Steven L. Stroh was the lead design engineer for the Oakley C. Collins Memorial Bridge and is the national practice lead for long-span and complex bridges for AECOM in Tampa, Fla.

EDITOR'S NOTE

Details of the means and methods of construction of this project, including a discussion of the innovative precast stay anchorages that were designed by the contractor's construction engineer to help expedite construction, are covered in an article on p. 38 of this issue.