PROJECT

Jeremiah Morrow Bridge

Ohio's tallest bridge spans the scenic Little Miami River

by Karen Cormier, T.Y. Lin International; Murat Aydemir, HNTB; Ryan Cocco, Kokosing Construction Company Inc.; and Daniel P. Mendel, Ohio Department of Transportation

The tallest bridge in Ohio and the first cast-in-place, concrete segmental box-girder structures owned by the Ohio Department of Transportation (ODOT) began construction over the scenic Little Miami River in June 2010. The six-span, twin bridges have three 440-ft-long main spans, one interior span of 416 ft, and side spans lengths of 229 and 270 ft. The top of deck is elevated 239 ft above the valley floor. A variable-depth, single-cell, box-girder cross section with cantilevered deck overhangs provides a 52-ft-wide bridge deck to accommodate two 12-ft-wide traffic lanes, a 12-ft-wide emergency lane, and two shoulders with widths of 6 and 10 ft. The addition of two traffic barriers results in a top flange width of 55 ft.

All pier substructure elements are outside the Little Miami River. Four of the five piers are monolithic with the box girder superstructure; one exterior pier and both bridge abutments support the superstructure on sliding bearings. The hollow-box monolithic pier sections vary in height from 24 to 129 ft, with an additional upper 65 ft section of the piers formed in a split-leaf configuration and a 25-ft-deep pier section sits on top of all four piers.

The bridge is supported on either driven steel HP piling or reinforced concrete, cast-in, drilled-hole (CIDH) shafts, depending on site geology. The HP14x89 piles were driven to an ultimate bearing of 314 tons; perimeter piles in the longitudinal direction were battered. Eight-foot-diameter drilled shafts provided end bearing capacity of 45 tons/ft^2. Smaller HP14 pile sections and 3-ft-diameter drilled shafts were utilized at the rear and forward abutments, respectively.

The new bridges replace two existing steel truss structures that were deemed too expensive to maintain and rehabilitate. Traffic flow in both directions needs to be maintained at all times on this important I-71 corridor connecting Cincinnati and Columbus. Traffic will be re-routed from the existing northbound bridge to the first bridge, which is constructed between the two existing steel structures. Demolition of the existing northbound bridge will then commence followed by construction in its place. When completed, northbound traffic will be directed onto the second bridge,

The location of these bridges over the Little Miami River, a National Scenic Waterway, necessitates an environmentally-sensitive method of construction to minimize impact to the lush river valley. The contractor also needed to meet uniform concrete appearance requirements for the structural elements. Rendering: HNTB.

profile

JEREMIAH MORROW BRIDGE/I-71 / WARREN COUNTY, OHIO

BRIDGE DESIGN ENGINEER: HNTB, Chicago, Ill.

PRIME CONTRACTOR: Kokosing Construction Company Inc., Fredericktown, Ohio

POST-TENSIONING CONTRACTOR: Schwager-Davis Inc., San Jose, Calif.

OTHER SUBCONSULTANTS AND SUBCONTRACTORS: OmniPro Services LLC, Canton, Ohio; T.Y. Lin International, San Francisco, Calif.; Corven Engineering Inc., Tallahassee, Fla.; CTL Engineering, Columbus, Ohio.

Transverse four-strand tendons in the top slab and longitudinal post-tensioning were used to achieve "zero- tension" criteria under service load conditions. Photo: Jeff Weiler, OmniPro Services.

southbound traffic onto the first bridge, and the remaining original bridge will be dismantled.

Design Features and Considerations

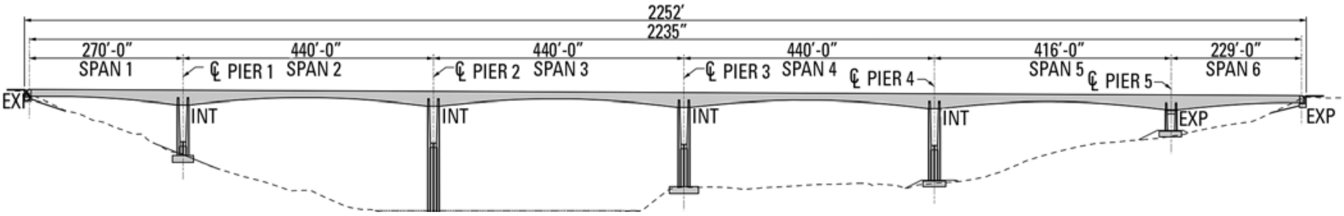
The superstructure box girder depth varies from 12 ft at midspan to 25 ft at the pier, with a bottom soffit thickness varying from 9½ in. in the midspan region to 3 ft 8 in. at the pier. The inclined box girder web walls are 1 ft 6 in. thick, and support a deck slab of variable thickness. The deck is cantilevered 12 ft 6 in. from the webs; this overhang varies in thickness, curving gently into the web/deck junction. Design 28-day concrete compressive strength for the superstructure is 6 ksi.

Under balanced cantilever construction, each 16-ft-long, box girder segment is post-tensioned with internal longitudinal cantilever tendons comprised of twelve to twenty-two 0.6-in.-diameter strands stressed from one end. Four-strand tendons in flat ducts spaced on average at 2 ft 8 in. intervals provide deck post-tensioning in the transverse direction.

Internal post-tensioning is further utilized for continuity once closure between cantilever superstructure tips is achieved. Finally, external post-tensioned tendons housed within high-density polyethylene ducts and anchored inside the box girder segment at the pier table and intermediate diaphragms are stressed to add further capacity for live load as well as time-dependent prestress losses and moment redistribution.

The bridge piers are hollow 20 by 21 ft boxes with 3-ft-thick reinforced concrete walls. A solid diaphragm serves as the transition from a hollow box to a split-leaf twin wall arrangement for the upper 65 ft of the pier columns. Base access into the pier column box allows for inspection from a permanently mounted ladder system. Inspection of the surface of the twin walls will be performed using rappelling methods from access hatches through the bottom slab of the pier table.

Tall and flexible bridge piers, monolithically connected to the superstructure, provide an element of geometric control complexity that relies on precise time-dependent deflection predictions. Long-term moment and force redistribution requires an introduction of horizontal displacement at the top of the columns to compensate for a portion of the long-term creep and shrinkage movements that will affect primarily the outer-most columns of pier 1 and 4 columns.



Bridge elevation. Drawing: HNTB.

OHIO DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: Twin six-span, post-tensioned, single-cell, cast-in-place concrete, segmental box girder structures each 2252 ft long with an elevation of 239 ft above the valley floor

STRUCTURAL COMPONENTS: Variable-depth (12 to 25 ft) box girders; one-hundred twenty-two 16-ft-long, cast-in-place segments per bridge; deck width of 55 ft; 31 million ft of 0.6-in.-diameter, seven-wire post-tensioning strand in both bridges. Tallest pier is 219 ft.

BRIDGE CONSTRUCTION COST: $90,188,005, including approach roadwork

The bridge plans indicate a horizontal jacking force and sequence of concrete closure placements that initiate from the center of span 3 and proceed to the exterior spans. The horizontal jacking force was determined from time-dependent computer modeling assuming parameters of concrete properties, schedule progression and rate of production, and estimated foundation soil spring stiffness. However, the primary goal of the horizontal jacking procedure is to initiate a somewhat arbitrary target displacement to compensate for part of the long-term losses due to creep and shrinkage.

Construction

All concrete incorporated into the structure was air-entrained and required to meet a strict permeability specification of 2500 coulombs at 60 days. The mixture proportions include a high-range water-reducing admixture and a set-retarding admixture to optimize workability. Fly ash was used as 33% of the total cementitious materials for the superstructure concrete and 50% for the substructure elements defined as mass concrete. All reinforcing steel in the structure—footings, piers, superstructure, barriers, and abutments—is epoxy coated.

When completed, the 216-ft-long open cantilevers required a total of 52 longitudinal cantilever tendons stressed to 40,868 kips total jacking force at 75% of the ultimate tensile stress. Strict anti-corrosion measures necessitated tendons being grouted within 20 days of being placed in the ducts. Due to low ambient temperature unfavorable to grouting operations, segmental construction was not continued during the winter months.

The grouting plan provided 100% borescope inspection of all post-tensioning anchorages and high points of duct profile. The grouting crew worked in conjunction with the quality inspection team to provide consistent grout results with measures to ensure that the ducts were fully filled with sound material.

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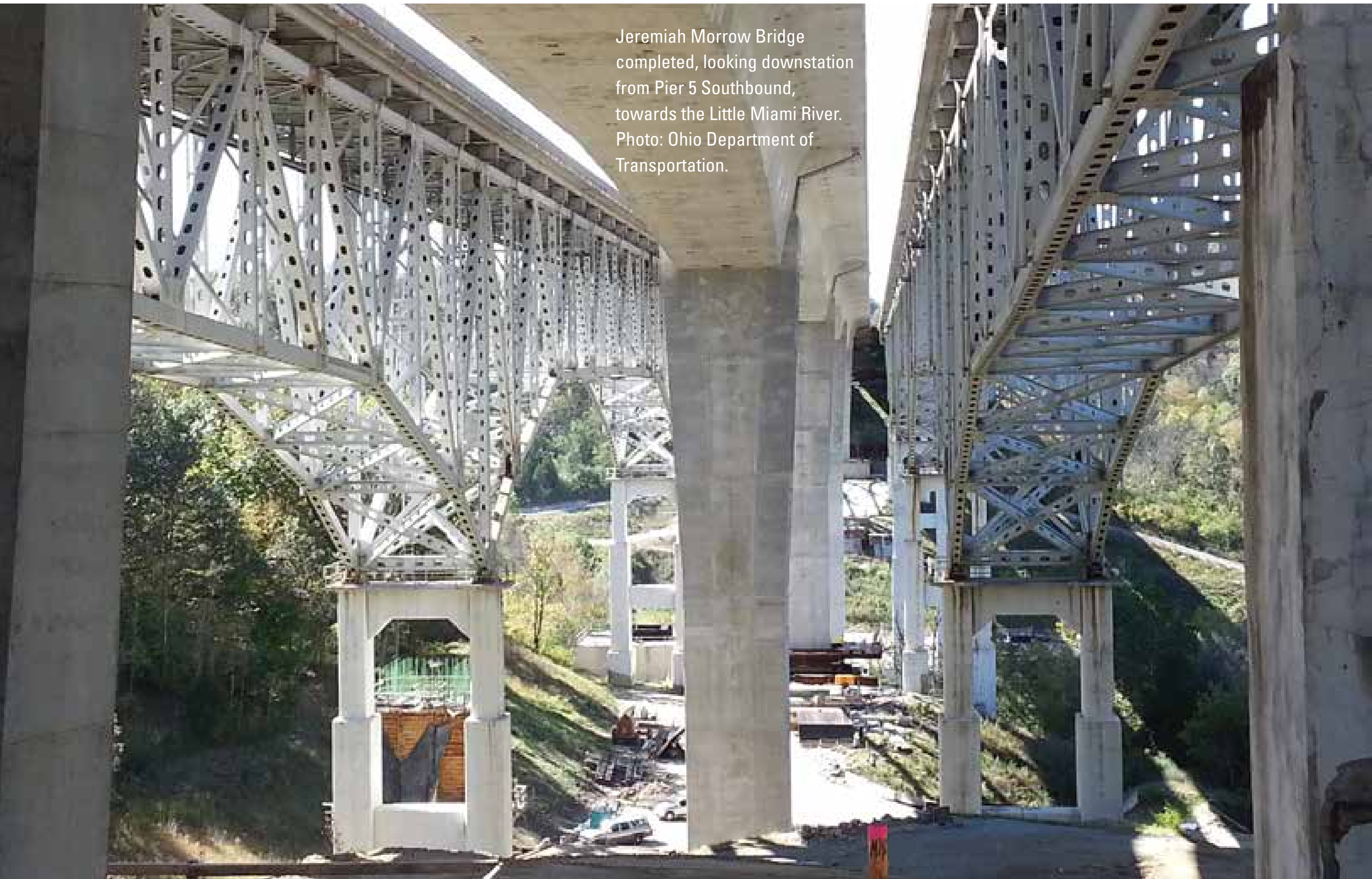
In order to ensure that the horizontal jacking displacement requirements were met, a deflection monitoring system of tiltmeters was mounted on the pier columns to measure the resulting movement in real time during the horizontal jacking procedure. The monitoring system also provided valuable pier bending and rotation data during the segmental casting cycle for casting curve adjustments.

A latex-modified concrete overlay is used on the deck for additional corrosion protection.

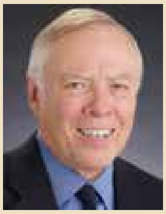
Karen Cormier is a segmental specialist with T.Y. Lin International in San Francisco, Calif. Murat Aydemir is a project engineer with HNTB in Chicago, Ill. Ryan Cocco is a project manager with Kokosing Construction Company Inc. in Fredericktown, Ohio. Daniel P. Mendel is a resident engineer with the Ohio Department of Transportation in Mason, Ohio.



Jeremiah Morrow Bridge completed, looking downstation from Pier 5 Southbound, towards the Little Miami River. Photo: Ohio Department of Transportation.

AESTHETICS COMMENTARY

by Frederick Gottemoeller



Building a major bridge over a wide and deep scenic valley is a challenge that most bridge designers would welcome. The first goal must be to place a bridge in the scene that, at the least, does not detract from the valley. The more important goal is to place a bridge that actually adds to the site's scenic quality, that becomes an asset to the site, and that fits the site so well that it looks like the bridge has always been there. The designers of the Jeremiah Morrow Bridge rose to that challenge.

Many of the positive qualities of the new bridge can be recognized by comparing it to the previous truss bridge. In most settings, and certainly in scenic ones, visual simplicity is a virtue. However, the truss superstructure is complicated, with multiple members at multiple angles to each other. Jeremiah Morrow's concrete box superstructure is a single modulated shape. The existing piers are stepped, with two columns that abruptly change thickness as they rise, connected by multiple cross struts. They call to mind tall, thin wedding cakes. Jeremiah Morrow's new piers are single tapered shapes, forked at the top. Because of this simplicity, the new bridge will not engage the eye as much as the existing bridge. The mind will be freed to engage with the scenic virtues of the site.

In a natural environment, one is surrounded by trees. Trees naturally embody the effect of the forces on them: branches are thickest at their origins and thinnest at their tips. Jeremiah Morrow's girders are thickest where the forces are the greatest—over the piers—and thinner everywhere else. Jeremiah Morrow's piers are widest where they meet the girder, then taper slightly before they head to the ground. Trees take these shapes because that uses resources as economically as possible. Jeremiah Morrow does the same, and this congruence is one source of its aesthetic appeal.

The openings at the tops of the piers are there to create some longitudinal flexibility for dealing with thermal and long-term stresses, but have the aesthetic effect of adding points of interest and a sense of lightness to the bridge. This is another of those instances when structural goals and visual goals can be served by the same feature, making for a design "twofer". The faces of the piers are divided into three vertical planes set at slightly different angles. Each plane reflects light differently. The piers are visually divided into three vertical strips of differing brightness, making the piers look thinner than they actually are.

None of the features described above could have added significant or even recognizable cost to the bridge. All are the result of careful selection of shapes and proportions for elements that had to be there anyway. Ohio has a beautiful new bridge.