LOOKING TO THE FUTURE

by Dustin Thomas, Minnesota Department of Transportation

The Wakota Bridge near South St. Paul, Minn., features twin cast-in-place concrete, two-cell, segmental box girders. Completed in July, the bridge is being monitored to evaluate thermal loading in the piers and girders. All photos: Minnesota Department of Transportation.

Segmental design adapts to conditions and includes sensors to assess thermal loading for piers and girders

The new Wakota Bridge that spans the Mississippi River near South St. Paul, Minn., connects Washington and Dakota Counties, giving the bridge its name. To meet a variety of challenges, the twin structures of the bridge were designed as cast-in-place, two-cell, segmental box girders. The bridge will benefit future projects, thanks to the embedment of sensors that will provide information to evaluate thermal loading in the piers and girders.

The new side-by-side structures carry eastbound and westbound I-494 over the Mississippi River, as well as over railroad tracks, a city street, and a bike trail. With widths of 122 ft and 111 ft at the widened end spans, the twin bridges will each carry 5 lanes of traffic and are the widest in the state. The design required variable-width roadway and bridge geometry to accommodate merging entrance and exit ramps at both ends of the structures.

The side-by-side structures replace an existing four-lane, steel, tied-arch structure that no longer could carry steadily increasing traffic volumes. The initial plan was to construct two, four-lane bridges to double the volume, but a fifth lane was added to both structures early in the design process to maximize repeatability and reduce width variations. The westbound bridge, which was constructed first, also includes a pedestrian and bicycle trail with two scenic overlooks.

Each structure features parabolically haunched soffits for efficiency and to gain clearance over the navigation channel. The slope of the outer webs was held constant, creating a dramatic width variation in the bottom slab along the haunched spans.

Segmental Design Minimizes Piers

The span configuration was determined by the Minnesota Department of Transportation (Mn/DOT) bridge office during the preliminary design process. Navigational requirements dictated that the easterly most pier had to remain on the river bank, as the navigation channel along the outer easterly side of the river bends through this stretch. Placing Pier 4 at this location established it at the same spot as a pier from the old bridge. With rock elevations close to the surface on the east bank, placing a new pier here was feasible since spread footings were used for both the old and

profile

WAKOTA BRIDGE / WASHINGTON AND DAKOTA COUNTIES, MINNESOTA

BRIDGE ENGINEER: HNTB, Minneapolis, Minn.

CONSTRUCTION ENGINEER: Janssen & Spaans, Indianapolis, Ind.

CONSTRUCTION ENGINEERING & INSPECTION ASSISTANCE: Parsons Transportation Group, Minneapolis, Minn.

PRIME CONTRACTOR: Lunda Construction Co., Black River Falls, Wis.

POST-TENSIONING SUPPLIER: VSL, Grand Prairie, Tex.

CONCRETE SUPPLIER: Cemstone, Mendota Heights, Minn.

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the new pier, so pile interference was not an issue.

The U.S. Coast Guard would not allow a reduction in the width of the main navigation channel, which was 420 ft wide under the old bridge's tied-arch span. The new main navigation-channel span needed to be longer and was set at 466 ft, just clearing the footing and seal from the old bridge. This span length was feasible with cast-in-place concrete segmental construction. The next span was also set at 466 ft to match the main channel and minimize pier conflicts with existing foundations. The westerly spans were incrementally shortened and balanced with the loads from the widening roadway ramps. They were constructed on falsework placed around the in-service railroad tracks.

This efficient and balanced layout created five spans, comprising 266, 328, 466, 466, and 353 ft for each structure. The span lengths were achieved with variable-depth, twin-cell box girders ranging in depth from 24 ft at the pier tables to 12 ft at midspans. Widths vary from 99 ft and 86 ft at typical points to 122 ft and 111 ft at the widened end spans.

The concrete design will reduce long-term maintenance costs for the bridge, which is anticipated to be in service in excess of 75 years. A major factor in increasing durability was the use of a top slab that is biaxially post-tensioned to achieve the established design criteria of zero tension for service-level stresses after all prestress losses. A dense concrete overlay was applied for the wearing surface to increase the corrosion resistance of the deck. All reinforcing bars above ground were epoxy-coated to increase durability and extend service life.

For the substructure, a key cost savings came in designing twin-wall piers with integral pier tables. This approach eliminated the need for shoring during the balanced-cantilever construction and will minimize maintenance needs associated with bearings over the bridge's service life.

Construction Sequencing

The cantilevered spans for the eastbound structure consist of 27 segments ranging in length from 13 ft to 16.5 ft, with 6.5-ft-long closure at midspan. Falsework was used to construct the two end spans. Two sets of form travelers were used for the segmental spans in balanced cantilever construction. The segmental construction began at Pier 4 and Pier 2 at the east and west banks of the river, respectively. When construction at Pier 4 was complete, one set of form travelers was moved to Pier 3 in the middle of the river.

Each cast-in-place segment was cast monolithically. A typical segment placement required approximately 125 yd^3 of concrete and took 4 hours using two concrete pumps. Prior to casting the midspan closures for Spans 3 and 4 (both 466 ft long), they were jacked apart with 400 tons of force to reduce the long-term stresses in the fixed piers.

The westerly span of each structure was constructed on falsework over in-service railroad tracks.

TWO, FIVE-LANE, FIVE-SPAN, CAST-IN-PLACE CONCRETE SEGMENTAL STRUCTURES / MINNESOTA DEPARTMENT OF TRANSPORTATION, OWNER

GROUT SUPPLIER: Sika Corp., Lyndhurst, N.J.

POST-TENSIONING EPOXY GROUT SUPPLIER: Pilgrim Permacoat Inc., Tampa, Fla.

FORM TRAVELER SUPPLIER: Strukturas, Langesund, Norway

INSTRUMENTATION SUPPLIER: Campbell Scientific, Logan, Utah

BRIDGE DESCRIPTION: Two parallel 1892-ft-long, cast-in-place concrete segmental structures consisting of five spans each with lengths up to 466 ft each

BRIDGE CONSTRUCTION COST: $56 million

Segmental, balanced cantilevered construction began at Pier 2 (as well as Pier 4) on the west bank. The piers feature a twin-wall design with integral pier tables.

A key consideration was ensuring the project remained on track while working through the cold Minnesota winter. Heated enclosures were created around the formed wings and leading ends of the cantilevers, with blankets placed on the decks and the top of the bottom slab. Insulated forms were used under the bottom slab. Four 400,000-Btu propane heaters were placed in the box-girder cells and under each wing. Forms were heated 12 hours prior to casting and remained heated until the concrete reached its design strength of 6000 psi.

Monitoring Thermal Loads

After design work was completed, Mn/DOT officials decided to use the eastbound bridge as a test project to monitor the forces generated by thermal effects in the bridge piers and box-girder superstructure. Although such data are readily available for superstructures, much less has been gathered for substructures.

The monitoring effort, conducted by the University of Minnesota, will provide data to aid pier designs in flexible pier-bridge systems of future structures. The instrumentation was designed to isolate and capture behavior of thermal movements of the structure. The concrete components had 84 vibrating wire strain gauges with thermisters embedded in them. These gauges will allow strain changes to be correlated with temperature changes. Two linear string potentiometers also were placed to measure overall length changes.

The monitoring work will provide data to aid pier designs in flexible pier-bridge systems.

Superstructure instrumentation was placed on Spans 3 and 4, which will have the greatest stresses due to temperature variations, since they are fixed at the piers. The twin-wall piers have instrumentation embedded at two elevations, with gauges paired along the width of the wall to maintain consistency.

Greatly expanding the capacity of this bridge was sorely needed for both today and tomorrow. The additional benefits provided by monitoring the structure for thermal loading will allow engineers to improve upon design practices for future projects.

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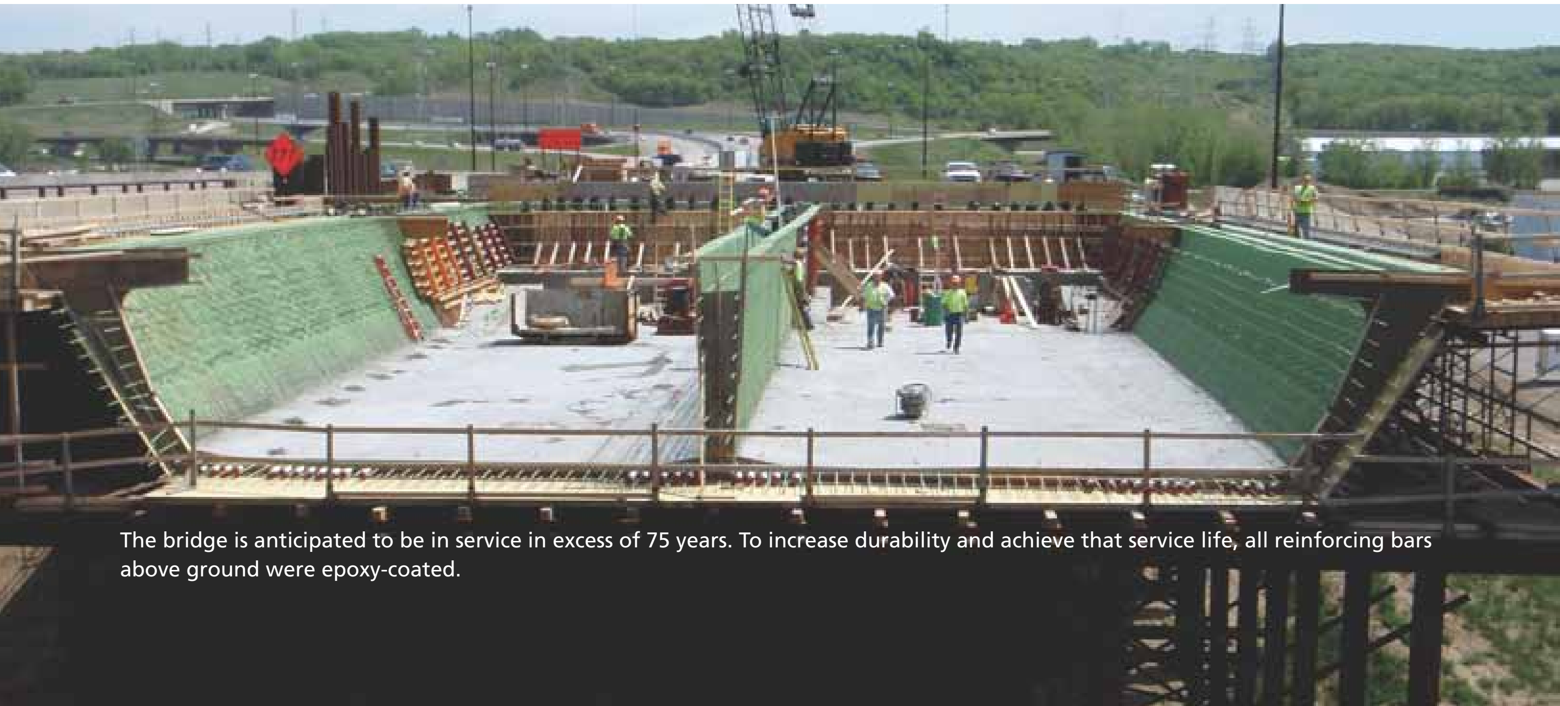
Dustin Thomas is the South Region bridge construction engineer with the bridge office of the Minnesota Department of Transportation in Oakdale, Minn.

Navigational requirements dictated that the most easterly pier (Pier 4) had to remain on the river bank. It was established in the same location as the original bridge's pier. Spread footings were used for both the old and the new pier.

Two sets of form travelers were used to construct the segmental spans using balanced cantilever construction. Work began at Piers 2 and 4. After completion of Pier 4 cantilevers, the form travelers were moved to Pier 3 in the middle of the river.

For more information on this or other projects, visit www.aspirebridge.org.



The bridge is anticipated to be in service in excess of 75 years. To increase durability and achieve that service life, all reinforcing bars above ground were epoxy-coated.

Two sets of form travelers were used to construct the segmental spans using balanced cantilever construction. Work began at Piers 2 and 4. After completion of Pier 4 cantilevers, the form travelers were moved to Pier 3 in the middle of the river.