A RECORD SEGMENTAL SPAN
KANAWHA RIVER BRIDGE

by Santiago Rodriguez, T.Y. Lin International

A 760-ft-long main span is the longest concrete box girder span in the United States.

A record concrete box girder span over the Kanawha River will soon complete the widening of a 4.3-mile section of I-64 located in Kanawha County, West Virginia. T. Y. Lin International's bridge designers, working with the West Virginia Department of Transportation, Division of Highways (WVDOH), were confronted with the challenge of creating a low-cost, durable, and aesthetically pleasing structure that would alleviate traffic congestion for commuters in the Charleston area. The resulting eight-span segmental bridge design is the first long-span segmental box girder structure built by the balanced cantilever method in West Virginia.

The existing I-64 bridge over the Kanawha River between Dunbar and South Charleston is a steel plate girder structure with a 440-ft-long main span that was completed in 1974 to carry four lanes of traffic. The preliminary design studies evaluated several alternatives for increasing the capacity of the existing Kanawha River Bridge to six lanes, including widening the existing bridge, complete bridge replacement, and construction of a new eastbound bridge. The alternative selected was the construction of a new eastbound structure on an improved nonparallel alignment carrying three travel lanes and one auxiliary lane. The existing bridge will be modified to maintain four lanes of westbound traffic.

The Kanawha River Bridge shown in this rendering has the record span in the United States for a concrete box girder at 760 ft. All photos and renderings: T.Y. Lin International.

profile

KANAWHA RIVER BRIDGE / KANAWHA COUNTY, WEST VIRGINIA

ENGINEER: T.Y. Lin International, Alexandria, Va.

GEOTECHNICAL ENGINEER: Triad Engineering Inc., St. Albans, W. Va.

PRIME CONTRACTOR: Brayman Construction Corporation, Saxonburg, Pa.

CONSTRUCTION ENGINEERS: Finley Engineering Group Inc., Tallahassee, Fla., and Michael Baker Corporation, Charleston, W. Va.

CONCRETE SUPPLIER: Arrow Concrete, Winfield, W. Va.

FORMWORK SUPPLIER: DOKA, USA Ltd., Baltimore, Md.

AWARDS: *2007 West Virginia Division of Highways Engineering Excellence Award in the Large Bridge Category*

The twin-walled piers support the main span. While strong enough to support the cantilevered construction, they are adequately flexible to accommodate longitudinal deformations.

The bridge types evaluated for the new eastbound structure included a segmental concrete box girder, steel tied arch, steel box girder, concrete cable-stayed bridge, and a steel truss. The segmental concrete box girder and steel arch alternatives were selected for the type, size, and location study. After evaluating construction costs, maintenance requirements, and constructability, final plans were developed for a segmental concrete box girder bridge.

Bridge Layout

With a total length of 2975 ft, the Kanawha River Bridge will span a railroad track operated by Norfolk Southern, Dunbar Avenue, the Kanawha River back channel, Wilson Island, the Kanawha River main channel, Riverside Drive, and MacCorkle Avenue. A 760-ft-long main span—the longest concrete box girder span in the United States—resulted from the need to locate the main piers outside the main channel of the Kanawha River in order to avoid interference with barge traffic.

The eight-span structure has span lengths of 144, 247, 295, 295, 460, 760, 540, and 209 ft for a total length between centerlines of abutment bearings of 2950 ft. Spans 1, 2, 3, 4, 5, 7, and 8 have a curved alignment including a circular curve with a 1910 ft radius and a spiral transition. The main span has a tangent alignment.

A continuous concrete box girder superstructure, using cantilever construction, was chosen for the full length of the bridge. This allowed for longer approach spans, which reduced the bridge's environmental impact.

Given the size and urban setting of the project, bridge aesthetics were an important design consideration. The bridge concept was developed to be compatible with both the existing steel plate girder bridge that will carry westbound traffic and a future twin parallel westbound bridge.

Superstructure

The bridge cross-section accommodates three travel lanes, one auxiliary lane, and shoulders for a total roadway width of 64 ft. The cross section of the superstructure consists of a single cell box with inclined webs. The structural depth varies along the main span from 38 ft at the piers to 16 ft at midspan. The bottom slab thickness is variable with a maximum thickness of 5 ft at the main span piers and a minimum of 9 in. at midspan. The approach spans have a constant depth of 16 ft and a constant bottom slab thickness of 9 in., with the exception of the pier tables where the bottom slab thickness transitions to 1 ft 9 in. The webs have a constant thickness of 1 ft 6 in.

The top slab has constant dimensions for the full length of the bridge. Its thickness varies transversely from a minimum of 9 in. to a maximum of 2 ft at the intersection with the webs. The maximum 2-ft depth of the top slab is required to accommodate the cantilever tendons needed for the main span. The box girder cross section has variable superelevation from plus to minus 8%. The specified concrete compressive strength is 6500 psi at 28 days. For mass concrete, the acceptance age was extended to 56 days.

The concrete box section is post-tensioned longitudinally, transversely, and vertically. The longitudinal post-

CAST-IN-PLACE SEGMENTAL BOX GIRDER BRIDGE / WEST VIRGINIA DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: 2975-ft-long box girder bridge

STRUCTURAL COMPONENTS: 66-ft-wide single-cell box girder in eight spans ranging from 144 to 760 ft built by balanced cantilever. Five single shaft approach piers and two twin-walled main span piers. Drilled shaft foundations.

FORM TRAVELERS: STRUKTURAS, Langesund, Norway

BEARINGS: R. J. Watson Inc., Amhurst, N.Y.

EXPANSION JOINTS: Watson Bowman Acme Corporation, Amhurst, N.Y.

POST-TENSIONING: VSL, Dallas, Tex.

GROUTS: BASF, Shakopee, Minn.

BRIDGE CONSTRUCTION COST: $75 Million ($379/ft^2)

In addition to the Kanawha River, the bridge crosses three roads and a railroad. Photo: Ahmed Mongi, WVDOT.

tensioning consists of two sets of tendons. The cantilever tendons, located in the top slab, are stressed during cantilever construction shortly after a new segment is added. The span tendons, located in the bottom slab, are used in the central part of the spans to provide continuity between adjacent cantilevers. Transverse post-tensioning is utilized in the top slab. Vertical post-tensioning consisting of high strength 1 3/8-in.-diameter bars is required in the webs, in the proximity of the piers, where the shear forces are high. The post-tensioning was designed to limit the principal tensile stresses in the webs.

The continuous box girder will have expansion joints at the abutments only. The advantages of this design approach are to reduce maintenance, improve serviceability, and simplify construction, as intermediate hinges are not needed. The superstructure is fixed at the main piers and is supported on unidirectional bearings at the approach piers and abutments. The bearings restrain the transverse displacements while allowing longitudinal displacements. Two bearings are provided at each pier with vertical service capacities up to 6900 kips. The bearings will be blocked during construction and the superstructure will be temporarily fixed to the approach piers. A large modular expansion joint with a displacement capacity of 30 in. accommodates displacements caused by temperature, creep, and shrinkage at the west abutment. The east abutment requires a joint with a 16-in.-displacement capacity.

Substructure

The main span piers—Piers 5 and 6—consist of twin concrete walls, which frame into the superstructure. The twin pier walls provide the necessary strength and stiffness during cantilever construction and, at the same time, are longitudinally flexible to accommodate deformations caused by creep, shrinkage, and temperature changes. The approach piers—Piers 1, 2, 3, 4, and 7—have a rectangular section with 45-degree chamfers.

The foundations consist of reinforced concrete footings and concrete drilled shafts socketed in the underlying hard sandstone. The average length of drilled shafts is about 45 ft. Two pre-construction drilled shaft load tests, using the Osterberg method, were performed prior to final design. These tests verified the ultimate end bearing and side shear capacity to be used.

Aesthetics

The proposed segmental box girder bridge is a harmonious design with simple and consistent forms with the same basic cross section between abutments. The selected cross section, with long overhangs and inclined webs, will result in a light appearance. The shadow created by the overhang will reduce the perceived superstructure depth. The inclination of the webs will lessen the volume of the superstructure. The curved approach spans will give a sense of openness and continuity with the graceful main span. The edges of the main span piers embrace the webs of the superstructure, thus subdividing the box girder depth. The piers have a modified rectangular section, with 45-degree chamfers, which reduce the perceived width of the columns in skewed views. A textured architectural treatment is used in the transverse faces of all piers and abutments. An applied concrete finish will be used on the surfaces of the substructure and superstructure elements

Construction

This project was advertised in February 2007 using competitive bidding between the segmental concrete box girder alternative designed by T. Y. Lin International and a steel box girder superstructure with the same span arrangement that was developed by another consultant.

The contract was awarded to Brayman Construction Corp. with a low bid for the concrete alternative of $82,864,247. The low bid for the steel box alternative was $112,910,000. The construction contract includes a small amount of roadway work, MSE walls, and minor changes to the existing bridge. These items were the same for the steel and concrete alternatives. The segmental box girder superstructure was designed to be built by the balanced cantilever method using cast-in-place segments supported by two pairs of form travelers. The project has a total of 160, 16-ft-long, cast-in-place segments in seven pairs of cantilevers. Falsework is required to cast the pier tables and the end segments near the abutments.

Bridge construction—scheduled to be completed by the end of 2010—has sparked local attention, which is expected to peak in the summer of 2009 with the closure of the main span cantilevers. When completed, area commuters will enjoy significant improvements in safety and traffic capacity in this segment of I-64.

Santiago Rodriguez is an associate vice president of T.Y. Lin International, Alexandria, Va., and served as project manager and lead bridge designer for the Kanawha River Bridge Project.

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

American Coal Ash Association

ACAA

The American Coal Ash Association (ACAA) is devoted to educating engineers, concrete professionals, standards organizations, and others about coal combustion products or "CCPs"—materials produced by coal-fueled power plants. These include fly ash, bottom ash, boiler slag, and flue gas desulfurization materials. Fly ash concrete has been specified because of its high strength and durability for numerous bridge projects worldwide, including the longest cable-stayed bridge in North America, the John James Audubon Bridge near Baton Rouge, La. The I-35W bridge near Minneapolis, Minn. has been reconstructed using a unique mix design that included fly ash concrete to ensure a long-lasting, high performance structure. Caltrans required high volume fly ash mixes for the largest bridge project in its history—the San Francisco-Oakland Bay Bridge. Using innovative specifications and blending techniques, Caltrans was able to improve its workability, hardening, and permeability properties of the bridge's concrete. A number of engineering standards and specifications define CCP applications, thus ensuring high quality performance and products.

Though these materials' properties vary according to coal composition and power plant operating conditions, experts can advise on quality and determine the best mix design for most any condition and project. Mix designs exceeding 40 percent fly ash have proven successful in many projects. Experts with first-hand experience may be located by contacting ACAA. The technical, environmental and commercial advantages of CCPs contribute to global sustainability.

In addition to a myriad of core performance attributes in sustainable construction, CCP use can conserve natural resources, reduce greenhouse gas emissions and eliminate need for additional landfill space. For more information, contact ACAA at info@acaa-usa.org or call 720-870-7897.

The concrete box girder in the approach spans measures 64 ft wide and 16 ft deep. Photo: T.Y. Lin International.

The segmental box girder bridge is a harmonious design.

Comprising a total of seven approach spans, the bridge's total length is 2975 ft. Illustration: T.Y. Lin International.

Photos: T.Y. Lin International.

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Photo: Ahmed N.K. Mongi, of the WVDOT.

Work continues on the Kanawha River Bridge with completion expected by the end of 2010. Photo: Ahmed N.K. Mongi, of the WVDOT.

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