Short-Span Spliced Girders Replicate

Historic Design

by John C. Shanks Jr., Burgess & Niple, Inc.

Original historic 1915 High-Main Street Bridge.

High-Main Street Bridge over the Great Miami River in Ohio features five-span, haunched replacement bridge to replicate original arch

Precast concrete spliced-girder technology, which was developed to extend the span lengths for concrete girders, offers other advantages that many designers may not have considered. In particular, they provide a great solution for replacing shorter-span bridges, in which the new design must replicate the aesthetics of the original structure.

Replacing an existing bridge in an historic part of town creates unique challenges. Designing for the functional and logistical needs while meeting the public's aesthetic requirements creates a set of design parameters unlike other types of bridges, regardless of length. Spliced girders can provide designers with greater flexibility to customize the shape of the girders to meet a wide variety of aesthetic needs.

The High-Main Street Bridge over the Great Miami River in Hamilton, Ohio, is a good example of this technique. The structure is located in the heart of the city's historic district and carries the city's main thoroughfare across the river. The existing bridge, a spandrel-filled concrete arch structure, consisted of five 95-ft-long spans. Built in 1915 to replace yet an earlier single-span steel truss bridge, it was badly deteriorated—but also highly cherished by the community.

The existing bridge featured extra-wide sidewalks for pedestrians and cyclists and sweeping views of the river. It was built on the former site of historic Fort Hamilton (active from 1791 to 1796), and a concrete replica of the old log fort wall flanks the east bridge abutment. The four-story-tall Soldiers, Sailors and Pioneers Memorial Building and Heritage Hall—home of the McCloskey Museum—portray the city and county history and dominate the landscape at the bridge's eastern end. American flags fly on each riverbank and small plazas at the eastern end contain plaques and monuments.

Replacing such a high-profile bridge required considerable input and great sensitivity. These needs were emphasized by the bridge's eligibility for placement on the National Register of Historic Places and its position as a contributing structure in the Hamilton Civic Center Historic District. Despite this pedigree, however, the structure was structurally and functionally obsolete, requiring an immediate solution.

profile

HIGH-MAIN STREET BRIDGE / HAMILTON, OHIO

ENGINEER: Burgess & Niple, Inc., Columbus, Ohio

OTHER CONSULTANTS: Rosales Gottemoeller & Associates, Columbia, Md., and Parsons Transportation, New York City

PRIME CONTRACTOR: Kokosing Co., Fredericktown, Ohio

PRECASTER: Prestress Services Industries, Lexington, Ky., and United Precast, Inc., Mount Vernon, Ohio, PCI-Certified Producers

PRECAST CONCRETE SPECIALTY ENGINEER: Janssen & Spaans, Inc., Indianapolis, Ind.

CONCRETE SUPPLIER, PRECAST GIRDERS: Anderson Concrete Corp., Columbus, Ohio

Workshops Held for Input

Officials from the Federal Highway Administration, Ohio Department of Transportation, and the City of Hamilton entered into an agreement with the Ohio State Historic Preservation Office, in compliance with the National Historic Preservation Act. The agreement established fundamental aesthetic guidelines and mandated consultation with local historic groups before developing the final design. A workshop group was formed with state, county, city, local business, and civic groups to provide guidance, review, and comment. A series of additional workshops and public-information meetings also were held to foster a close working relationship among all involved parties.

The final design created a precast concrete spliced-girder bridge with three full elliptical-arch spans and half-arch spans at each end. The two end spans were 75.5 and 77.5 ft long, the adjacent spans were each 128 ft long and the center span length was 134 ft, totaling nearly 550 ft. The arch profiles were

The new High-Main Street Bridge over the Great Miami River in Hamilton, Ohio, used precast concrete spliced girders and deep haunches to replicate the historic design of the original bridge.

SPLICED PRECAST CONCRETE GIRDERS / OHIO DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: A five-span bridge with precast concrete girders with deep haunches spliced together to create an historic look

REINFORCING STEEL SUPPLIER: Gerdau Ameristeel, Hamilton, Ohio

POST-TENSIONING SUPPLIER: Dywidag-Systems International USA, Inc., Bolingbrook, Ill.

STRUCTURAL COMPONENTS: Eleven girder lines with variable depths and span lengths of 75.5, 128, 134, 128, and 77.5 ft

TOTAL PROJECT CONSTRUCTION COST: $16.4 million

BRIDGE CONSTRUCTION COST: $12.6 million

CONSTRUCTION SEQUENCE:

Pier segments were secured with temporary tie downs.

End span segments were then erected.

Next, interior spans were delivered for erection.

Completion of four lines of girders for Stage 1.

designed to range from about 3.5 ft deep at the apex of each span to about 15 ft deep at the piers.

The designers evaluated five systems before deciding on the precast concrete girder alternative. The precast option won out owing to a variety of factors, including its ability to eliminate falsework and its better economics. Likewise, a variety of precast concrete span configurations were considered, with some eliminated due to their depth, weight, hydraulic requirements during erection, impact of splicing prior to erection, and other factors. The short length of the bridge also did not favor the economics of segmental concrete box construction. Ultimately, spliced precast concrete girders with the chosen lengths were deemed the best solution for all the needs.

Girders Offered Benefits

The girders offered key benefits. These included the fact that they could be tailored to accommodate transportation, handling, and erection limitations caused by the site. The erection could be accomplished using conventional cranes without falsework, while the post-tensioning could be completed in a single operation. The rapid erection of the girders also would help meet the tight project schedule and limit the risks associated with potential high water during the construction.

The girders also provided the flexibility to craft special aesthetic features using specially made forms, while still realizing economies by producing multiple pieces from each form. Casting the pieces in a quality-controlled plant also ensured more uniformity of appearance and better quality.

Eleven girder lines spaced at 9.25 ft on-center were used. This spacing provided the optimum design for accommodating part-width phased construction of the bridge and for managing the contributory loading to each girder. The width was critical due to the shallow depth of the girders at midspan, which resulted from the need to hold the roadway profile grade, obtain the necessary hydraulic opening, and provide the desired architectural shape.

‘The designers evaluated five systems before deciding on the precast concrete girder alternative.’

A rectangular girder section was chosen to simplify the formwork fabrication. It also provided ample room for prestressing strands, post-tensioning ducts, end anchorages, and splice-hanger assemblies without needing to transition the web thickness at points of congestion. This would have detracted from the desired appearance. The exterior girder section includes formed relief to convey an integral bottom flange, adding to the aesthetics. The effects of this asymmetry were checked during the analysis of the girders.

Concrete compressive strength was specified at 7000 psi for the girders, with a required compressive strength at release of 5500 psi. Prestressing strands were 0.5-in. diameter, 270 ksi, low-relaxation type. Post-tensioning tendons consisted of nine, 0.6-in.-diameter, 270 ksi, low-relaxation strands.

The design was completed using Consplice PT by LEAP Software, a two-dimensional finite-element analysis program, accounting for time-dependent behavior and construction staging. An independent check was performed with IDS BD2 software, which confirmed the original design.

The massive wall-type piers and counterfort abutments with substantial pile foundations were considered as rigid supports in the modeling of the superstructure. Elastomeric bearings were modeled using appropriate spring constants.

The spliced girders were designed assuming that all post-tensioning force was applied prior to casting the deck slab, in accordance with the owner's request. The deck slab uses conventional reinforcement and contains no post-tensioning. The owner's preference for this type of design detailing was based on the desire to simplify future deck replacement work. As a result, the design analysis included an extrapolated construction staging case considering a future deck replacement.

Cranes Set on Causeway

Erection of the girder segments used ground-based crawler cranes positioned on a construction causeway in the river. The girder pier segments were first placed on permanent bearings but with temporary shim blocks to limit girder rotation. The girder pier segments then were secured to the piers using a temporary tie-down connection designed by the contractor. Each tie-down consisted of four tensioned vertical threadbars with embedded anchorages in the piers and two saddle beams over the top of the girder.

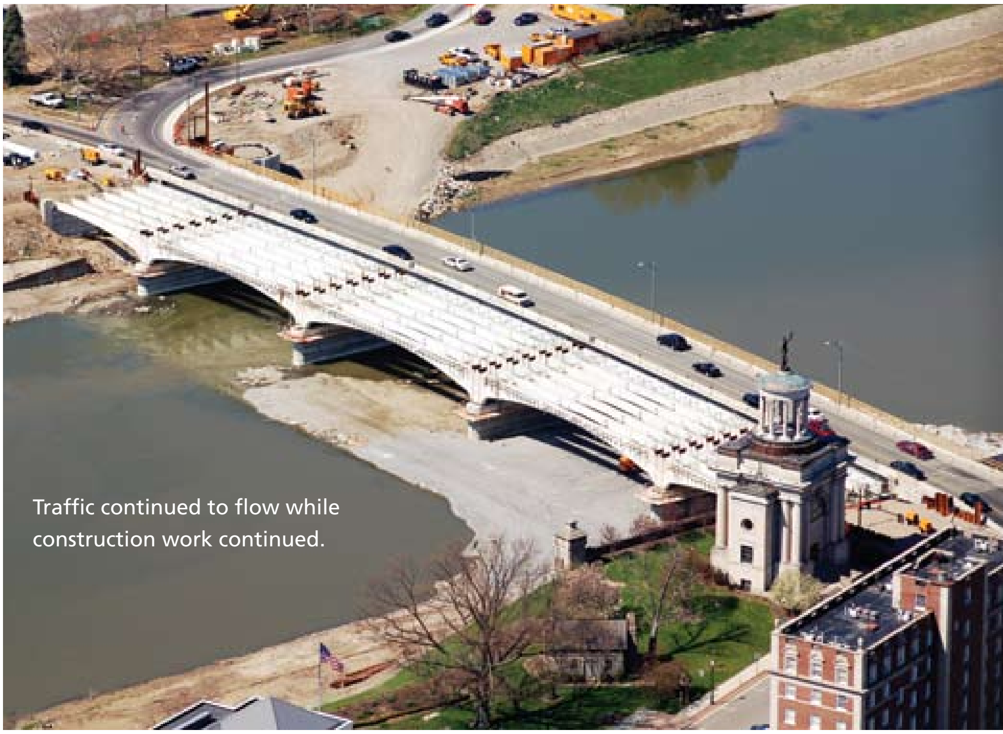
The girder end span segments then were erected, and temporary hanger assemblies and temporary bracing were secured. The drop-in segments within the next interior span were then erected using the same procedure as with the end spans. This process with the drop-in segments proceeded one span at a time until all segments were erected.

Cast-in-place splice closures were then placed, cross frames were installed, temporary tie-downs and shim blocks at the piers were removed, and the post-tensioning tendons at each end of the bridge were stressed. Finally, concrete diaphragms at piers and the concrete deck were placed.

Construction on the project, which began in early spring of 2004, was completed in the fall of 2006. The awarded cost totaled $16.4 million, including demolition and construction of approach roadways, lighting, and landscaping. About $6 million of that total was attributed to the primary bridge superstructure components for a cost of $106 psf.

This example shows that, while spliced girders were originally conceived to offer benefits for long-span applications, they can be used to great advantage in other situations. The spliced girders in this design provided the desired architectural character while meeting the height and weight limitations imposed due to transportation needs. Lighting was used to highlight the arch design and details.

The spliced girders provided architectural character while meeting the limitations imposed by transportation needs.



Traffic continued to flow while construction work continued.

The use of precast girders also eliminated falsework and shoring supports that would otherwise have restricted the hydraulic opening of the bridge during construction, which was critical for this project.

As high strength concrete and other innovations continue to expand concrete's design potential, designers can look to spliced girders for more opportunities to create a structure that meets a wide range of goals. Their use can help provide more solutions that are aesthetically pleasing, quickly constructed, and cost effective.

John C. Shanks Jr. is Senior Bridge Engineer with Burgess & Niple, Inc., Columbus, Ohio.

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

Advertisers Index

AESTHETICS COMMENTARY

by Frederick Gottemoeller

The design of the High-Main Street Bridge started with the agreement between the Federal Highway Administration, Ohio Department of Transportation, City of Hamilton, and the Ohio State Historic Preservation Office that established fundamental aesthetic guidelines and mandated consultation with local historic groups. The resulting working group indicated a strong preference for a design that would emulate the best features of the existing bridge, citing as a model the Discovery Bridge in Columbus, Ohio, a flat plate arch of similar size built in the 1990s.

Normally in a situation like this, it is preferable to develop a contemporary bridge design fitting the historical and monumental context of the site. However, it is not uncommon for communities to insist, as in this case, on a more traditional structure. So, the design team resolved to use the best of modern technology to create a bridge that recalled the best features of the aging bridge.

The most positive aspects of the existing bridge were the graceful elliptical shape of the arches and the extreme thinness of the deck at midspan. Through the inspiration of Franklin County Engineer Mark Sherman and others, Ohio's precast concrete industry has built a number of similarly sized monumental bridges using custom precast concrete girders. The team decided to use this technology, but to splice the girders to make them continuous. This allowed the transfer of moment to the pier sections, so that the midspans could be kept very thin. The end spans were designed as half-arches to allow for river walks on both banks. For economy, the more complicated pier segments of the girders were made identical, and all dimensional variations were taken up in the simpler center drop-in sections. The details of the fascia girders, overlooks, and railings were all derived from the architecture of the Soldiers, Sailors and Pioneers Monument, symbolically extending its influence from the east to the west bank. The sidewalk paving patterns are the same as those used for the existing High Street sidewalks east of the bridge. The railing includes a series of bronze medallions depicting momentous events in Hamilton's history.

One of the least attractive aspects of the old bridge was the pronounced hump in its profile. By lengthening the vertical curve to about the length of the bridge the team gave the bridge a more graceful curve and improved drivers' sight distance. However, this placed additional emphasis on keeping the girders thin in order to maintain the hydraulic opening.

To extend the monumental district's presence to the west bank, a pair of raised plazas was developed with seating, flagpoles, and lighting. These replaced features that had been there before but at a grander scale. The west bank itself was regraded to create a pair of small amphitheatres flanking the plazas that provide visual and handicapped access to the river. They will also be a good location for civic celebrations, such as the annual art festival and the 4th of July fireworks. All of these features are aimed at integrating the new structure into not only the physical fabric of the monumental district but also into its daily life.

Dramatic lighting was provided at the fascia to illuminate the arch design at night and call attention to details in the design.